TESIS DOCTORAL INTERNACIONAL/ INTERNATIONAL DOCTORAL THESIS

PROGRAMA OFICIAL DE DOCTORADO EN CIENCIAS DE LA EDUCACIÓN

Comprobación empírica de los modelos de unidades didácticas intermitentes, alternadas, irregulares y reforzadas. Implicaciones para la planificación de la Educación Física

Empirical analysis of the models of intermittent, alternated, irregular and reinforced teaching units. Implications for Physical Education planning

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DEPARTAMENTO DE EDUCACIÓN FÍSICA Y DEPORTIVA

FACULTAD DE CIENCIAS DEL DEPORTE

UNIVERSIDAD DE GRANADA

SANTIAGO GUIJARRO ROMERO

2020

A mi familia…

To my family…

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PROYECTOS DE INVESTIGACIÓN

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PROYECTOS DE INVESTIGACIÓN [RESEARCH PROJECTS]

El trabajo desarrollado y las publicaciones que componen la presente memoria de Tesis Doctoral están basados en los siguientes proyectos de investigación:

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II. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. Effect of a Physical Education-based reinforced program through outdoor physical activities and body expression on secondary school students' cardiorespiratory fitness: A cluster-randomized controlled trial. Submitted to *Science and Sports*. JCR: 0.679; Sport Sciences: Q4.

III. **Guijarro-Romero, S.**, Viciana, J., Casado-Robles, C., & Mayorga-Vega, D. Effect of inside-outside school alternated teaching units on knowledge of the environment for physical conditioning and related psychological outcomes in the Physical Education setting: A cluster randomized control trial. Submitted to *European Physical Education Review*. JCR: 2.393; Education and Educational Research: Q1.

IV. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. Effect of a Physical Education-based irregular teaching unit on high school students' cardiorespiratory fitness and related psychological outcomes: A cluster randomized control trial from a Self-Determination Theory perspective. *Draft.*

V. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. Evaluación del conocimiento del entorno para el acondicionamiento físico (CENAFI) en escolares [Assessment of the knowledge about the environment for physical conditioning (CENAFI) in schoolchildren]. Submitted to *Profesorado.* SJR: 0.318; Education: Q3.

VI. **Guijarro-Romero, S.**, Viciana, J., Casado-Robles, C., & Mayorga-Vega, D. (2020). Does a Physical Education-based fitness program benefit everyone independently of the students' physical fitness profile? A cluster-randomized controlled trial. *Journal of Physical Education and Sport*, *20*(3), 1550-1560. doi: 10.7752/jpes.2020.03213. SJR: 0.357; Q4: Sports Sciences.

VII. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. (2020). Una unidad didáctica intermitente de acondicionamiento físico solo mejora los niveles de capacidad cardiorrespiratoria de los estudiantes con un perfil no saludable de condición física [An intermittent physical fitness teaching unit only improves cardiorespiratory fitness levels of students with an unhealthy physical fitnes profile]. *Retos*, *3*, 8-15. doi: 10.47197/retos.v38i38.73605. SJR: 0.317; Q3: Education.

VIII. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. Effect of a short-term physical fitness program on students' cardiorespiratory fitness and its posterior reduction in the Physical Education setting. Submitted to *Kinesiology*. JCR: 1.225; Sport Sciences: Q4.

IX. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. (2020). Does students' self-determination motivation toward Physical Education influence the effectiveness of a fitness teaching unit? A cluster-randomized controlled trial and cluster analysis. *Psychology of Sport and Exercise, 51,* 101768. doi: 10.1016/j.psychsport.2020.101768. JCR: 2.827; Sports Sciences: Q2.

X. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. Could an intermittent Physical Education-based fitness teaching unit affect secondary school students' motivation, autotelic experience, and physical self-concept? A cluster-randomized controlled trial. Submitted to *Perceptual and Motor Skills*. JCR: 1.245; Experimental Psychology: Q4.

XI. Viciana, J., Mayorga-Vega, D., **Guijarro-Romero, S.**, & Martínez-Baena, A. (2017). Effect of two alternated teaching units of invasion team sports on the tactical learning in primary schoolchildren. *International Journal of Performance Analysis in Sport*, *17*(3), 256-270. doi: 10.1080/24748668.2017.1331575. JCR: 1.144; Sport Sciences: Q4.

XII. **Guijarro-Romero, S.**, Mayorga-Vega, D., & Viciana, J. (2018). Aprendizaje táctico en deportes de invasión en la Educación Física: Influencia del nivel inicial de los estudiantes [Tactical learning in invasion sports in Physical Education: Influence of students' baseline level]. *Movimento*, *24*(3), 889-902. doi: 10.22456/1982-8918.79839. JCR: 0.307; Education and Educational Research: Q4.

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RESUMEN/

ABSTRACT

RESUMEN

Actualmente, la capacidad cardiorrespiratoria es considerada uno de los marcadores más potentes de salud en escolares. Desafortunadamente, a nivel mundial un gran número de escolares presentan niveles bajos de capacidad cardiorrespiratoria. La asignatura de Educación Física podría ejercer un papel clave ayudando a los escolares a desarrollar y mantener niveles saludables de capacidad cardiorrespiratoria. Sin embargo, los profesores de Educación Física tienen que hacer frente a diferentes limitaciones relacionadas con la planificación para conseguir este objetivo. Consecuentemente, es necesario conocer los efectos empíricos de modelos innovadores de unidades didácticas en Educación Física que apoyen la práctica basada en la evidencia de una planificación viable y eficaz que permita el desarrollo y mantenimiento de niveles saludables de capacidad cardiorrespiratoria de los escolares, así como el resto de objetivos curriculares de la asignatura.

El objetivo general de la presente Tesis Doctoral fue examinar el efecto empírico de los modelos de unidades didácticas intermitentes, alternadas, irregulares y reforzadas en la planificación de la Educación Física. Los principales hallazgos de la presente Tesis Doctoral sugieren que: (1) Además de mejorar los niveles de capacidad cardiorrespiratoria de los estudiantes, una unidad didáctica intermitente de acondicionamiento físico permite trabajar simultáneamente durante suficiente tiempo de las clases otro objetivo curricular de Educación Física. (2) Una unidad didáctica reforzada mediante clases de actividades físicas en el medio natural y expresión corporal, no solo es eficaz manteniendo los niveles de capacidad cardiorrespiratoria de los estudiantes, sino que también permite el desarrollo simultáneo de otros objetivos relacionados con otros contenidos curriculares de la Educación Física. (3) Las unidades didácticas alternadas dentro-fuera del centro escolar son efectivas para mejorar el conocimiento sobre el entorno de los estudiantes para el trabajo de la condición física, así como sus barreras percibidas, autonomía percibida y motivación autónoma hacia la actividad física. (4) Una unidad didáctica irregular mediante programas individualizados realizados durante los recreos y tiempo extraescolar, es eficaz manteniendo los niveles de capacidad cardiorrespiratoria de los estudiantes. (5) La prueba CENAFI, es un instrumento de medida válido y fiable para recabar información sobre el conocimiento que poseen los escolares del entorno próximo para el acondicionamiento físico. (6) Aunque una unidad didáctica tradicional de acondicionamiento físico en Educación Física parece tener un efecto similar en todos los perfiles de capacidad cardiorrespiratoria de los estudiantes, aquellos con un perfil de capacidad cardiorrespiratoria no saludable se

benefician considerablemente más en los niveles de actividad física durante las clases de Educación Física; mientras que después de una unidad didáctica intermitente de acondicionamiento físico en Educación Física, solo los estudiantes con un perfil no saludable de capacidad cardiorrespiratoria incrementan la capacidad cardiorrespiratoria, a pesar de obtener similares beneficios en los niveles de actividad física durante las clases. (7) Aunque una unidad didáctica de acondicionamiento físico a corto plazo aumenta los niveles de capacidad cardiorrespiratoria de los estudiantes, después de un período de desentrenamiento de cuatro semanas, los niveles de cardiorrespiratoria de los estudiantes de los estudiantes vuelven a su valor basal. (8) Una unidad didáctica de acondicionamiento físico en Educación Física solo mejora los niveles de capacidad cardiorrespiratoria de los estudiantes con una motivación autodeterminada alta hacia la Educación Física. (9) Las unidades didácticas intermitente y tradicional de acondicionamiento físico parecen no influir negativamente en la motivación de los estudiantes hacia la Educación Física y la experiencia autotélica, ni mejorar tampoco su autoconcepto físico. (10) Una unidad didáctica alternada de deportes con los mismos elementos constitutivos mejora el aprendizaje táctico objetivo de los estudiantes gracias a la transferencia de aprendizaje entre ambas modalidades deportivas, en comparación con un tratamiento tradicional donde ambos deportes son enseñados de forma consecutiva y sin conexión. Sin embargo, los estudiantes con un nivel táctico inicial menor en deportes de invasión obtienen mayores mejoras que aquellos con mayor nivel táctico inicial después de dicha unidad didáctica alternada de deportes de invasión.

Los modelos de unidades didácticas intermitentes, alternadas, irregulares y reforzadas suponen un avance en la planificación de la Educación Física, ya que permiten lograr numerosos objetivos establecidos en el currículum educativo de la Educación Física, así como mantener los aprendizajes adquiridos previamente sin incrementar el tiempo dedicado a cada objetivo, pero distribuido de manera diferente e innovadora. Por lo tanto, estas cuatro estructuras nuevas de unidades didácticas son herramientas muy eficaces al servicio de los profesores de Educación Física permitiéndoles solucionar las diferentes limitaciones relacionadas con la planificación de la asignatura. Además, la vivencia de estas unidades didácticas innovadoras permite a los escolares transferir los aprendizajes adquiridos durante las clases de Educación Física a su tiempo libre, lo que representa un gran avance en la adquisición de un estilo de vida activo y saludable.

ABSTRACT

Currently, cardiorespiratory fitness is considered as one of the most powerful health markers in schoolchildren. Unfortunately, a large number of schoolchildren worldwide have low levels of cardiorespiratory fitness. The Physical Education subject could play a key role in helping schoolchildren develop and maintain healthy cardiorespiratory fitness levels. Nevertheless, Physical Education teachers have to face several planning-related limitations to achieve this goal. Consequently, it is necessary to know the empirical effects of innovative teaching unit models in Physical Education that support an evidence-based practice in planning a feasible and effective development and maintenance of schoolchildren's healthy cardiorespiratory fitness levels, as well as the rest of the curricular objectives of the subject.

The overall objective of the present Doctoral Thesis was to examine the empirical effect of the intermittent, alternated, irregular, and reinforced teaching units' models in the PE planning. The main findings from the present Doctoral Thesis suggest that: (1) Aside from improving students' cardiorespiratory fitness levels, an intermittent physical fitness-based teaching unit leaves enough time during the lessons to simultaneously work on another Physical Education curricular objective. (2) A reinforced teaching unit, through outdoor physical activities and body expression lessons, is not only effective for maintaining students' cardiorespiratory fitness levels, but also allows for the simultaneous development of objectives related with other Physical Education curricular contents. (3) Alternated teaching units (inside-outside the school center) are effective for improving students' knowledge of their environment to work physical fitness, as well as their perceived barriers, perceived autonomy, and autonomous motivation towards physical activity. (4) An irregular teaching unit, through individualized programs performed during school recesses and out-of-school time, is effective for maintaining students' cardiorespiratory fitness levels. (5) The CENAFI test, is a valid and reliable measuring instrument to gather information about the knowledge that schoolchildren have of their immediate environment for physical conditioning. (6) Although a Physical Education-based physical fitness teaching unit seems to have a similar effect on all the students' cardiorespiratory fitness profiles, students with unhealthy cardiorespiratory fitness profiles benefit considerably more in physical activity levels during the Physical Education lessons; while after an intermittent Physical Education-based physical fitness teaching unit, only students with unhealthy cardiorespiratory fitness profiles improve their cardiorespiratory

fitness levels, despite obtaining similar benefits in physical activity levels during the lessons. (7) Although the short-term physical fitness teaching unit increased the students' cardiorespiratory fitness levels, after a four-week detraining period students' cardiorespiratory fitness levels reverted back to the baseline. (8) A Physical Education-based physical fitness teaching unit, only improves cardiorespiratory fitness levels of students with a high baseline of self-determined motivation toward Physical Education. (9) The intermittent and traditional physical fitness teaching units seem not to negatively influence students' motivation toward Physical Education and autotelic experience, nor improve their physical self-concept. (10) An alternated teaching unit of sports with the same constitutive elements improves students' objective tactical learning thanks to the transference of learning between both sport modalities, compared to a traditional treatment where both sports are taught consecutively and unconnectedly. Nevertheless, students with lower baseline tactical levels in invasion sports obtain higher improvements than those with higher baseline tactical level after such alternated teaching unit of invasion sports.

The intermittent, alternated, irregular, and reinforced teaching units models represent an advance in Physical Education planning, because they allow for the achievement of the numerous objectives established in the Physical Education educational curriculum, as well as to maintain the learning previously acquired without increasing the time dedicated to each objective, but distributed in a different and innovative manner. Therefore, these four new structures of teaching units are effective tools at the service of Physical Education teachers allowing them to solve the different limitations related to the subject planning. Additionally, the experience of these innovative teaching units allowed schoolchildren to transfer the acquired learnings during Physical Education lessons to their free time, which represents a great advance in the acquisition of an active and healthy lifestyle.

ABBREVIATIONS

[ABREVIATURAS]

ABBREVIATIONS [ABREVIATURAS]

Abbreviation	**Definition**
AF	*Actividad física*
AFMV	*Actividad física moderada-vigorosa*
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BPNES	Basic Psychological Needs in Exercise Scale
BREQ-3	Behavioral Regulation in Exercise Questionnaire
CENAFI	Conocimiento del Entorno para el Acondicionamiento Físico
CFI	Comparative fit index
CCR	*Capacidad cardiorrespiratoria*
CRF	Cardiorespiratory fitness
EF	*Educación Física*
GFI	Goodness-of fit index
IFI	Incremental fit index
MVPA	Moderate-to-vigorous physical activity
NFI	Normalized fit index
NNFI	Non-normalized fit index
PA	Physical activity
PACE	Physician-based Assessment and Counseling for Exercise
PACSQ	Physical Activity Class Satisfaction Questionnaire
PASSES	Perceived Autonomy Support Scale for Exercise Settings
PE	Physical Education
RMSEA	Root mean square error of approximation
SDT	Self-Determination Theory
SRMR	Standardized root mean square residual
SPBPA	Self-Perceived Barriers for Physical Activity
TLI	Tucker Lewis index
TU	Teaching unit
UD	*Unidad didáctica*
VO_2max	Maximal oxygen uptake

INTRODUCTION

[INTRODUCCIÓN]

INTRODUCTION [INTRODUCCIÓN]

Cardiorespiratory fitness (CRF) is considered one of the most powerful health markers among school-age children (Lang et al., 2017; Raghuveer et al., 2020; Tomkinson et al., 2019). Among schoolchildren, higher CRF levels are associated with better academic performance (Chu et al., 2016; Ruíz-Ariza et al., 2017), mental health (Eddolls et al., 2018), as well as with better quality of life (Evaristo et al., 2019). Unfortunately, CRF has been declining during the last decades (Tomkinson et al., 2019), becoming a worldwide problem, which affects, on average, 33% of male and 46% of female schoolchildren, increasing this proportion each year of age, on average, 8% in males and 10% in females (Tomkinson et al., 2016). Therefore, promoting and facilitating the development of healthy levels of CRF should be a priority objective in contexts such as sports programs or schools (Peralta et al., 2020; Tomkinson et al., 2016; World Health Organization, 2018).

Among the different opportunities that students have to improve their CRF levels (for example, school recesses, free time, or organized physical activity (PA) in a club), there is one that plays a key role, the subject of Physical Education (PE) (Association for PE, 2015; Guijarro-Romero et al., 2019; Peralta et al., 2020) due to its compulsory character and the guidance by capable professionals (Viciana et al., 2015). In this sense, PE teachers have the opportunity to make students aware of the importance of having a healthy level of CRF and the benefits that this entails, as well as promoting and facilitating its development and maintenance during the lessons (Guijarro-Romero et al., 2019).

Main limitations related to the planning of the development and maintenance of cardiorespiratory fitness in Physical Education

Considering the importance that CRF has at school age, the educational curricular objectives of most developed countries contemplate the development and maintenance of this physical quality in schoolchildren (European Commission/EACEA/Eurydice, 2013; Hardman et al., 2014; Ministry of Education, Culture and Sport, 2014, 2015). However, planning the improvement of students' CRF levels in the PE setting is a very complex task (Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-Marban, 2014).

Firstly, PE teachers have to face the limited curriculum time allocation appointed to the PE subject (on average, worldwide only 99 minutes per week) (European Commission/EACEA/Eurydice, 2013; Guijarro-Romero et al., 2019; Hardman et al., 2014; Viciana, Mayorga-Vega, & Merino-Marban, 2014), that is, the equivalent of approximately two 50-minute lessons per week.

Secondly, there is the fact that apart from the objective of developing and maintaining students' CRF levels, PE teachers have to develop a large volume of contents during the whole academic year (e.g., games and sports, body expression, and outdoor physical activities) (European Commission/EACEA/Eurydice, 2013; Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-Marban, 2014). As a consequence, they tend to reduce the duration assigned to each teaching unit (TU) in the programming, reducing its effectiveness regarding the achievement of the PE curricular objectives (Robles et al., 2010; Viciana et al., 2016). That is, in many cases, the organization of the TUs by the teacher focuses on the mere fact of covering small spaces of time, forgetting the importance of meeting the objectives established by the educational curriculum (Delaunay & Pineau, 1989).

Thirdly, related to the short duration assigned by the PE teachers to the TUs, there are the continuous interruptions of the PE lessons due to holiday periods (e.g., Christmas or Easter), as well as because of meteorological problems (e.g., rain or extreme cold or hot), which interrupt and difficult even more the teaching period planning process (Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-Marban, 2014). Moreover, the coincidence of teachers' timetable and the need to use the same materials and facilities is another factor that many times hinders the planning of the different TUs during the school year. Consequently, teachers tend to plan few lessons to work on the same content (Guijarro-Romero et al., 2019).

Additionally, another limitation is related to the design of the tasks regarding their intensity. The Association for PE (2015) recommends that students should be involved in moderate-to-vigorous PA (MVPA) during at least 50% of the PE lesson time. Unfortunately, this recommendation is hardly ever met in PE lessons, since, on average, the PE lesson time spent on MVPA is 40.5% (Hollis et al., 2017). Moreover, many times the distribution of PE lessons is not based on the criteria related to the PA. For example, when PE lessons are given in consecutive days, there is not enough time for schoolchildren to recover from the previous lesson, or when the time appointed for PE corresponds to the first hour in the morning in which it can be very cold or schoolchildren may not have finished their digestion, or the last hour in which it can be very hot depending on the geographical area in which the school is located (Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-Marban, 2014). Considering the positive association among PE lesson time spent working in a MVPA intensity and students' CRF (Marques et al., 2015), it would be practical for PE teachers knowing if innovative structures of TUs (Viciana & Mayorga-Vega, 2016) could be effective for achieving the aforementioned PA recommendation during PE lessons (Association for PE, 2015) to improve students' CRF levels (Papers I and II).

Another PE-based planning limitation related to CRF is its expected decrease after a period of detraining (Malina et al., 2004; Mujika & Padilla, 2001). Nevertheless, currently the evidence about the effects of a detraining period on the CRF level is still limited and contradictory (Lo et al., 2011; Song, 2011; Sousa et al., 2018). More specifically in the PE setting, only two studies have examined the effect of a detraining period on student's CRF (Carrel et al., 2007; Santos et al., 2012). Carrel et al. (2007) found that, after performing a nine-month physical fitness TU 10 times a month, the students' CRF gains acquired reverted back to the baseline levels after a 12-week detraining period, such as the summer break. Conversely, Santos et al. (2012) found that, students' CRF gains acquired after an eight-week school-based resistance and endurance training TU performed four times a week (two PE lessons plus two additional lessons out of PE timetable), did not return back to baseline levels after 12-weeks detraining period. However, the effect of shorter detraining periods (i.e., four weeks) among schoolchildren after a short-term physical fitness TU in the PE setting should be also examined (Paper VIII).

Effectiveness of Physical Education-based innovative teaching units for developing and maintaining cardiorespiratory fitness in schoolchildren

PE subject has to face several planning limitations regarding the development and maintenance of students' CRF levels (Guijarro-Romero et al., 2019; Hardman et al., 2014; Viciana, Mayorga-Vega, & Merino-Marban, 2014). Despite the fact that a long-term TUs seem to be the best way to improve CRF in schoolchildren (Meyer et al., 2014), in many countries the application of a short-term physical fitness TU is one feasible option for developing students' CRF in the PE setting (Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-Marban, 2014). In this line, previous PE-based studies found that a short-term TUs carried out only twice a week can improve students' CRF levels (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016; Mayorga-Vega et al., 2013; Ramírez Lechuga et al., 2012). Nevertheless, the influence of students' CRF baseline levels on the effectives of these PE-based TUs is not deeply known yet (Papers VI and VII). Additionally, with these traditional TUs (i.e., working the whole lesson during several lesson in a row in order to reach an objective) just the objective of improving CRF would be achieved and, after that, considering the limited curriculum time appointed to the PE subject (Guijarro-Romero et al., 2019; Hardman et al., 2014; Viciana, Mayorga-Vega, & Merino-Marban, 2014), a large amount of curricular objectives would have to be developed in a reduced period of time. Furthermore, in the aforementioned TUs the learning was isolated, without links to other subject matters (Viciana & Mayorga-Vega, 2016).

A feasible solution to the above mentioned difficulties in PE could be developing CRF simultaneously with other curricular contents through the intermittent TU structure proposed by Viciana and Mayorga-Vega (2016). This innovative structure of the TU consists of developing a curricular objective using only a time band of the lesson (i.e., only a few minutes of each PE lesson for several lessons), connecting the learning of the students between different contents of the subject of PE. Thus, it allows for dividing the main part of lesson into several parts (i.e., two) and developing two or more related curricular objectives during the same lesson. An example of an intermittent TU could consist of the development of students' CRF during several minutes of the PE lessons while another learning objective such as technical-tactical skills of invasion sports could be developed during the rest of the lesson. This could provide teachers a more efficient use of the limited PE time for developing various goals during the lessons, and students the opportunity to establish relationships between different PE-related contents. The PE lessons should have two marked parts, one focused on CRF development and another focused on the technical-tactical learning in invasion sports. This structure would allow students to achieve both objectives, to relate both contents (e.g., performing physical fitness exercises to improve students' performance in technical-tactical situations), and to reduce physical fitness-related tasks developed along the main part of the lesson, which could circumvent the continuous physical effort of students (Paper I). Additionally, since the intermittent TU could be developed during more time over the academic year (i.e., during more lessons) because its distribution in shorts periods of time (e.g., from 5 to 15 minutes), this TU structure would allow PE teachers maintaining the improvements achieved in students' CRF levels over the school year avoiding its possible losses because of the detraining.

Besides the large volume of curricular contents in relation with the restricted curriculum time allocation, another PE-based planning limitation is the fact that after a period of detraining, the CRF levels decrease (Malina et al., 2004; Mujika & Padilla, 2001; Song, 2011). In this line, Viciana and Mayorga-Vega (2016) proposed that PE teachers should apply reinforced TUs after a physical fitness development TU in order to maintain the students' CRF levels during the whole academic year. These TUs, apart from maintaining the CRF levels previously acquired, might allow PE teachers to achieve objectives related to other curricular contents at the same time (e.g., outdoor PA or body expression). Consequently, knowing the empirical effects of these PE-based reinforced TUs on CRF is need to support evidence-based planning (Paper II).

On the other hand, many times the coincidence of teachers' timetable and the need to use the same materials and facilities hinders the planning of the different TUs during the school year (Guijarro-Romero et al., 2019). As a consequence, teachers tend to plan few lessons to work on the same content reducing the duration assigned to each TU in the programming and, therefore, its effectiveness regarding the achievement of the PE curricular objectives (Robles et al., 2010; Viciana et al., 2016). Taking as a reference the principle of continuity in the training of Verkhoshansky and Verkhoshansky (2011), among schoolchildren, physical fitness TUs should be applied at least from eight to 12 weeks to get an improvement in students' physical fitness levels. Additionally, promoting students' lifelong PA practice in order to develop and maintain healthy physical fitness levels is one of the fundamental purposes in most countries (European Commission/EACEA/Eurydice, 2013; Ministry of Education, Culture and Sport, 2015; SHAPE America, 2013). Due to the low weekly frequency of the subject (Hardman et al., 2014) it is not possible to achieve the daily PA recommendations only in the PE setting, therefore, the promotion of students' PA in the out-of-school setting is key. In this sense, national standards also consider transferring the learning from the classroom to students' daily life is another priority objective of PE (European Commission/EACEA/Eurydice, 2013; SHAPE America, 2013). Therefore, in order to work in this direction, the implementation of effective PA interventions in the PE setting requires an understanding of the determinant factors that influence students' PA behavior (Sheeran et al., 2017).

In this sense, PE teachers play an important role providing students with tools to become competent in practicing PA autonomously and transferring learning from the classroom to students' daily life (Viciana & Mayorga-Vega, 2018). An example of transferability of learning could consist of teaching students how to use the environment that surrounds the school center and their particular community providing them authentic an situational PA practices (Viciana & Mayorga-Vega, 2018). In this sense, the alternated TUs (Viciana & Mayorga-Vega, 2016) could be a good solution for promoting significant learning in PE. Alternated TUs consists of implementing two TUs with complementary contents while making students aware that both contents are based on the same learning's principles, avoiding, therefore, the unconnected learning perceived by students in traditional and isolated TUs (Viciana & Mayorga-Vega, 2016). Consequently, PE teachers could connect in-school physical fitness work (inside the school) with one that could be practiced in the immediate environment (outside the school), facilitating students a tool for developing and maintaining their physical fitness levels autonomously in their out-of-school time (Ferkel et al., 2014). According to the Theory of Expanded, Extended, and Enhanced Opportunities, this mechanism for promoting students' PA is called expansion, and is defined as the introduction of an entirely new PA opportunity (Beets et al., 2016). Additionally, this learning may help students to solve perceived barriers toward the PA practice (Niñerola et al., 2006), which have been shown to be associated with a higher prevalence of physical inactivity during their leisure-time (Dias et al., 2015) (Paper III). In this sense, having valid and reliable tools to assess the acquisition of this learning (i.e., knowledge of the environment for physical conditioning) seems necessary (Paper V). Furthermore, alternated TUs would allow PE teachers to solve the limitation regarding teachers' timetable coincidence and the necessity of using the same facilities and materials.

Finally, the use of extra-curricular time (i.e., school recesses, after school time, weekends or holidays) through the application of the irregular TU structure proposed by Viciana and Mayorga-Vega (2016) would allow PE teachers to increase and reinforce the active time for learning, achieving important outcomes such as increments of MVPA levels during these periods of time and to avoid the losses in physical fitness due to the detraining, especially during holidays. Consequently, it is extremely important that during PE lessons, teachers provide students with different options to perform PA, and delegating the responsibility of their autonomous development using an individualized style of teaching (e.g., individualized programs carried out in couples or in small groups) (Viciana & Mayorga-Vega, 2016). Furthermore, using the extra-curricular time may increase students' autonomy toward PA practice during their free time (González-Cutre et al., 2018), which is also another main standard of PE curriculum (European Commission/EACEA/Eurydice, 2013; SHAPE America, 2013). According to the Theory of Expanded, Extended, and Enhanced Opportunities, this is another expansion mechanism for promoting students' PA (Beets et al., 2016). In this sense, social agents such as the PE teacher, play a key role in the promotion and development of a more positive motivation toward PE and specially toward PA, through the use of autonomy-supportive teaching styles and the satisfaction of students' basic psychological needs (i.e., autonomy, competence, and relatedness), which have shown a positive influence on students' PA practice in the extra-curricular time (González-Cutre et al., 2014; González-Cutre et al., 2018; Sevil-Serrano et al., 2020; Sevil et al., 2018). Therefore, applying an innovative approach such as irregular TUs (Viciana & Mayorga-Vega, 2016) could help PE teachers to achieve all of the above-mentioned purposes, especially those related to the increment of MVPA levels and the autonomous development and maintenance of physical fitness during the extra-curricular time (Paper IV).

Influence of psychological variables mediators of active behavior in Physical Education lessons and in relation to the improvement of physical fitness

Health is a state of complete physical, mental, and social well-being, and not just the absence of disease or injury (World Health Organization, 1946), and physical fitness is considered one of the fundamental health indicators for school-age children (Lang et al., 2017; Raghuveer et al., 2020; Tomkinson et al., 2019). For this reason, schools have an ideal setting, through the PE subject, to make students aware of the benefits that having good fitness levels can have on their physical and psychological well-being (European Commission/EACEA/Eurydice, 2013). For example, during the educational years, having good physical fitness levels is positively associated with better mental health and quality of life (Eddolls et al., 2018; Evaristo et al., 2019).

Likewise, physical fitness has also shown to be positively associated with students' motivation toward PE (Martínez-Baena et al., 2016). Motivation has been defined as a psychological feature that encourages a person to act toward a desired goal (Ryan et al., 2009). The Self-Determination Theory (SDT, Deci & Ryan, 1985) is a motivational theory widely used to understand the antecedents and consequences of motivation toward PE (Ntoumanis, 2001). This theory adopts a multidimensional approach, distinguishing among reasons as to "why" individuals are encouraged to act. SDT suggests that human behavior can be characterized by three types of motivation (i.e., intrinsic motivation, extrinsic motivation, and amotivation) (Ryan et al., 2009), which could be ordered in a *continuum* according to the extent to which motivation is self-determined (or autonomous) (Deci & Ryan, 2000).

The relative autonomy index, also known as the self-determined index, is a widely used index to measure the different types of motivation (Vallerand & Ratelle, 2002). Nevertheless, this index has shown several issues when used as a measure of the continuum structure of motivation derived from SDT (Chemolli & Gagné, 2014). For this reason, Chemolli and Gagné (2014) encouraged researchers ideally to explore the person-centered motivational profiles through cluster analysis (Franco et al., 2019; Liu & Chung, 2018; Mayorga-Vega & Viciana, 2014). This method has a number of advantages, both at the theorical and practical level (Vansteenkiste et al., 2009).

Following the SDT framework, previous literature shows a positive association between autonomous forms of motivation toward PE and students' PA levels during PE lessons (Owen et al., 2014; Viciana et al., 2019). When students have high motivation toward PE, they tend to be more active during PE lessons (Lonsdale et al., 2009; Mayorga-Vega & Viciana, 2014). Mayorga-Vega et al. (2020) examined the influence of students' baseline self-determined motivation toward PE on their CRF improvement after a fitness TU. However, these authors used the relative autonomy index to create a score of students' self-determined motivation toward PE, despite the several problems derived from the measurement of this index (Chemolli & Gagné, 2014). Additionally, Mayorga-Vega et al. (2020) identified the different students motivational profiles and divided them by a statistical criterion (percentiles) based on the relative autonomy index score obtained, instead of identifying the profiles by combining the different motivational dimensions proposed by the SDT. Unfortunately, to the best of our knowledge, there are no previous studies analyzing the role of baseline self-determined motivation toward PE on the effectiveness of a physical fitness TU for improving students' CRF levels according to their motivational profiles toward PE, through a person-centered approach by cluster analyses (Paper IX).

On the other hand, higher levels of motivation in students during PE lessons have been positively associated with the experience of flow state (Stormoen et al., 2016). According to Csikszentmihalyi (1990), flow is an enjoyable psychological state that students experience when they are completely absorbed in an activity without being aware of the time. One of the most important elements of the flow state is autotelic experience which is defined as the intrinsic satisfaction produced by the task (Csikszentmihalyi, 1990; García-Calvo et al., 2008). The SDT postulates that a task is easier to perform when you feel satisfaction simply by doing it, without the need of receiving any external reward (Ryan et al., 2009). In this sense, Moreno-Murcia et al. (2014) found that students experienced less autotelic experience in PE in comparison with other context such as non-competitive physical exercises or voluntarily competitive chosen sports. This could be because the compulsory nature of the participation in PE, leads to less enjoyment than in other contexts (Moreno-Murcia et al., 2014). This is especially important with physical fitness-related contents, where the intensity should be high and students' motivation may be negatively affected from a particular moment of the TU due to the compulsory nature of their participation, consequently lowering their enjoyment more so than in other contexts (Moreno-Murcia et al., 2014).

Additionally, physical fitness has shown positive associations with physical self-concept among schoolchildren (Carraro et al., 2010; Grao-Cruces et al., 2017; Mayorga-Vega et al., 2012). Physical self-concept, which is also an important aspect for students' health (Esnaola et al., 2008; World Health Organization, 1946), refers to a judgement a person has about his or her physical abilities when interacting with the environment (Shavelson et al., 1976). During the educational years, physical self-concept acquires more importance, because significative physiological and psychological changes take place during this stage (Harter, 2012). Unfortunately, physical self-concept decreases from childhood to adolescence (Navarro-Patón et al., 2019). For this reason, one of the main national standards in PE curriculums is the promotion of a good psychological status among students (European Commission/EACEA/Eurydice, 2013).

Considering all of the abovementioned positive relationships between physical fitness and psychological aspects, as well as the physical fitness decline observed in school-age children during the last years (Tomkinson et al., 2019), the improvement of students' physical fitness levels is one of the main objectives in the educational context (European

Commission/EACEA/Eurydice, 2013; Hardman et al., 2014). In this sense, a systematic review and meta-analysis found that carrying out physical fitness activities in PE lessons is one of the most effective strategies for increasing students' MVPA levels during said lessons (Lonsdale et al., 2013) and, therefore, improving students' physical fitness (Poitras et al., 2016). However, practicing fitness activities during entire PE lesson (i.e., as worked in traditional TUs' lessons) may negatively impact students' motivation toward PE and enjoyment, leading to long-term negative effects such as sedentary behavior (Ladwig et al., 2018). Additionally, changes in students' physical self-concept as a result of a traditional PE-based physical fitness TUs lessons are still contradictory (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016; Schmidt et al., 2013; Schneider et al., 2008; Spruit et al., 2016). Therefore, it seems necessary to carry out more studies applying new TUs approaches to better understand how PE lessons could improve students' physical fitness levels without negatively influencing their motivation toward PE and autotelic experience, and without decreasing their physical self-concept (Paper X).

Effectiveness of Physical Education-based innovative teaching units on tactical learning in schoolchildren

Although the main topic of the present Doctoral Thesis was to examine the effectiveness of the innovative TUs on the development and maintenance of students' CRF, other applications of these TUs have also been examined. In this case, using a different PE content such as team sports, which is one of the most worked in PE (Robles Rodríguez et al., 2015; Ureña Ortín et al., 2009) and sued by students (Moreno & Hellín, 2007). Additionally, team sports have shown having a direct relationship with PA levels achieved during PE lessons (Hellin et al., 2019; Murillo et al., 2014; Sarradel et al., 2011).

In spite of the fact that the improvement of students' CRF levels is one of the main goals of PE subject, teachers have to achieve many other curricular objectives during the academic year such as technical-tactical learning of sports (European Commission/EACEA/Eurydice, 2013; Ministerio de Educación, Cultura y Deporte, 2015; SHAPE America, 2013). The acquisition of tactical abilities is an important issue in educational contexts (Causer & Ford, 2014; Sánchez-Mora et al., 2011; Williams & Ford, 2013). Acquiring tactical and motor skills in sports is directly related to numerous benefits among schoolchildren. For example, an increase in tactical skills levels increments the perceived sports competency (Viciana, Mayorga-Vega, & Blanco, 2014) or the physical self-concept (Papaioannou et al., 2006), which act as predisposing factors (mediational variables) towards the practice of PA (Welk, 1999). In this line, Jaakkola et al. (2016) found that students with higher tactical skills showed higher PA levels in their free time. Therefore, many countries require this kind of learning in schoolchildren in their curriculum national standards (e.g., in the United States of America, Lund & Tannehill, 2015; or United Kingdom Department for Education, 2013). For instance, the Spanish Ministry of Education, requires Spanish teachers to improve the decision-making process of students in team sport games in secondary school levels (Ministry of Education, Culture and Sport, 2015), and 100% of Spanish teachers in their educational programming include sports TUs.

The purpose of this type of learning in the educational context is to provide students an integral view of the complex decision-making process that take place during the practice of a sport, as well as equip them with numerous tactical skills that could be transferred to any team sport with the same characteristics or similar constitutive elements (Causer & Ford, 2014). Consequently, using the concept of transfer could be a good strategy in order to propose effective educational interventions in PE regarding the acquisition of tactical skills in sports (Memmert & Harvey, 2010; Yáñez & Castejón, 2011). In this sense, addressing several sports with similar tactical elements through the alternated TUs seems interesting (Viciana & Mayorga-Vega, 2016) (Paper XI). However, the influence of students' baseline tactical skills levels on the effectives of these PE-based TUs should be considered (Paper XII).

OBJETIVOS/

AIMS

OBJETIVOS

General

El objetivo general de la presente Tesis Doctoral fue examinar el efecto empírico de los modelos de unidades didácticas (UD) intermitentes, alternadas, irregulares y reforzadas en la planificación de la Educación Física (EF).

Específicos

Los objetivos específicos de la presente Tesis Doctoral fueron los siguientes:

1. Comparar el efecto de las UDs intermitente y tradicional de acondicionamiento físico en EF sobre los niveles de CCR en escolares (Artículo I).
2. Evaluar el efecto de una UD de mantenimiento (es decir, de refuerzo), con contenidos de AF en el medio natural y expresión corporal sobre el mantenimiento de los niveles objetivos de CCR en escolares (Artículo II).
3. Examinar el efecto de dos UDs alternadas dentro-fuera del centro escolar sobre el conocimiento de los escolares sobre su entorno para el acondicionamiento físico en el tiempo extraescolar, sus barreras percibidas hacia la práctica de la AF, apoyo a la autonomía del profesor y la motivación autodeterminada hacia la AF (Artículo III).
4. Evaluar el efecto de una UD irregular (es decir, de mantenimiento), a través de programas individuales realizados durante los recreos y tiempo extraescolar sobre el mantenimiento de los niveles objetivos de CCR en escolares (Artículo IV).
5. Construir y validar una prueba escrita de elección múltiple *ad hoc* para evaluar el conocimiento de los escolares sobre el entorno próximo al centro educativo para el acondicionamiento físico (Artículo V).
6. Examinar la influencia de la capacidad cardiorrespiratoria basal (saludable/no saludable) de los escolares en el efecto de una UD de acondicionamiento físico tradicional e intermitente en EF sobre sus niveles de capacidad cardiorrespiratoria (CCR) y actividad física (AF) (Artículos VI y VII).
7. Valorar el efecto de un periodo de desentrenamiento de cuatro semanas posterior a una UD de acondicionamiento físico a corto plazo en EF sobre la CCR en escolares (Artículo VIII).
8. Comparar el efecto de una UD de acondicionamiento físico en EF sobre la mejora de los niveles de CCR de los escolares con diferentes perfiles de motivación hacia la EF mediante un análisis de clústeres (Artículo IX).

9. Comparar el efecto de las UDs intermitente y tradicional de acondicionamiento físico en EF sobre los niveles de motivación, experiencia autotélica, y autoconcepto físico de los escolares (Artículo X).
10. Estudiar el efecto de una UD alternada de deportes de invasión (fútbol y baloncesto) sobre la transferencia de aprendizaje entre ambas modalidades deportivas; y examinar la influencia del nivel táctico inicial de los escolares sobre dicha transferencia de aprendizaje (Artículos XI y XII).

AIMS

Overall

The overall objective of the present Doctoral Thesis was to examine the empirical effect of the intermittent, alternated, irregular, and reinforced TUs models in the PE planning.

Specifics

The specific objectives of the present Doctoral Thesis were the following:

1. To compare the effect of the intermittent and traditional PE-based physical fitness TUs on CRF levels in schoolchildren (Paper I).
2. To evaluate the effect of a maintenance TU (i.e., of reinforcement), with outdoor PA and body expression contents on the maintenance of objective CRF levels in schoolchildren (Paper II).
3. To examine the effect of two inside-outside school alternated TUs on students' knowledge of their environment for physical conditioning in the out-of-school time, their perceived barriers toward the PA practice, teacher autonomy support, and self-determined motivation towards PA (Paper III).
4. To evaluate the effect of an irregular TU (i.e., of maintenance), through individual programs performed during school recesses and out-of-school time on the maintenance of objective CRF levels in schoolchildren (Paper IV).
5. To build and develop and *ad hoc* multiple-choice written test to assess the schoolchildren's knowledge of the environment around the educational center for physical conditioning (CENAFI) (Paper V).
6. To examine the influence of schoolchildren's CRF baseline (healthy/unhealthy) on the effect of a traditional and intermittent PE-based physical fitness TU on their CRF and PA levels (Papers VI and VII).
7. To assess the effect of a four-week detraining period after a short-term PE-based physical fitness TU on schoolchildren's CRF (Paper VIII).
8. To compare the effect of a PE-based physical fitness TU on the improvement of CRF levels of schoolchildren with different motivational profiles toward PE using a cluster analysis (Paper IX).
9. To compare the effect of the intermittent and traditional PE-based physical fitness TUs on motivation toward PE, autotelic experience, and physical self-concept levels of schoolchildren (Paper X).

10. To study the effect of an alternated TU of invasion sports (soccer and basketball) on the transfer of learning between both sport modalities; and to examine the influence of schoolchildren's baseline tactical level on such transfer of learning (Papers XI and XII).

MATERIAL AND METHODS

[MATERIAL Y MÉTODOS]

MATERIAL AND METHODS [MATERIAL Y MÉTODOS]

The material and methods section of the present Doctoral Thesis is summarized in the Table 1. This table includes the most relevant methodological features from the scientific studies that compose the present Doctoral Thesis. For further information of any study, please check the material and methods sections of the corresponding papers.

Table 1. Summary of the main methodological features of the studies of the present Doctoral Thesis

Paper	Study design	Participants	Procedure
I. Effect of a Physical Education-based intermittent teaching unit on high school students' cardiorespiratory fitness: A cluster-randomized controlled trial	Cluster-randomized controlled trial balanced by grade	126 second/third-grade secondary students (53 males and 73 females)	Traditional group: 9 weeks, 2 sessions/week, 50 min Intermittent group: 9 weeks, 2 sessions/week, 50 min
II. Effect of a Physical Education-based reinforced program through outdoor physical activities and body expression on secondary school students' cardiorespiratory fitness: A cluster-randomized controlled trial	Cluster-randomized controlled trial not balanced by grade	107 first/second-grade secondary students (55 males and 52 females)	Experimental groups 1-2: Development: 9 weeks, 2 sessions/week, 50 min Detraining: 4 weeks Experimental group 2: Maintaining: 6 weeks, 2 sessions/week, 50 min
III. Effect of inside-outside school alternated teaching units on knowledge of the environment for physical conditioning and related psychological outcomes in the Physical Education setting: A cluster randomized control trial	Cluster-randomized controlled trial balanced by grade	146 first-to-third-grade secondary students (73 males and 73 females)	Traditional group: 4 weeks, 2 sessions/week, 50 min Alternated group: 4 weeks, 2 sessions/week, 50 min

Table 1. Continued

IV. Effect of a Physical Education-based irregular teaching unit on high school students' cardiorespiratory fitness and related psychological outcomes: A cluster randomized control trial from a Self-Determination Theory perspective	Cluster-randomized controlled trial balanced by grade	128 second/third-grade secondary students (62 males and 66 females)	Traditional and Irregular groups: 9 weeks, 2 sessions/week, 50 min Irregular group: Maintaining: 6 weeks, 3 x 20-minutes school recesses + 2 x 30-minutes out-of-school periods/week
V. Assessment of the knowledge about the environment for physical conditioning (CENAFI) in schoolchildren	Validation	189 first-to-fourth-grade secondary students (94 males and 95 females)	1. Construction and definition of the structure and purpose of the test 2. Content validation by experts 3. Pilotage 4. Depuration and application of the final instrument 5. Test-retest reliability assessment 6. Discriminant validity assessment

Table 1. Continued

VI. Does a Physical Education-based fitness program benefit everyone independently of the students' physical fitness profile? A cluster-randomized controlled trial	Cluster-randomized controlled trial and *ex post facto* not balanced by grade	107 first/second-grade primary students (55 males and 52 females)	Experimental group: 9 weeks, 2 sessions/week, 50 min
VII. An intermitent physical fitness teaching unit only improves cardiorespiratory fitness levels of students with an unhealthy physical fitness profile	Cluster-randomized controlled trial and *ex post facto* balanced by grade	92 second/third-grade secondary students (34 males and 58 females)	Experimental group: 9 weeks, 2 sessions/week, 50 min
VIII. Effect of a short-term physical fitness program on students' cardiorespiratory fitness and its posterior reduction in the Physical Education setting	Cluster-randomized controlled trial balanced by grade	76 second/third-grade secondary students (31 males and 45 females)	Experimental group: 9 weeks, 2 sessions/week, 50 min Detraining: 4 weeks
IX. Does students' self-determination motivation toward Physical Education influence the effectiveness of a fitness teaching unit? A cluster-randomized controlled trial and cluster analysis	Cluster-randomized controlled trial and *ex post facto*	181 seventh-to-nineth-grade secondary students (86 males and 95 females)	Experimental groups 1-4: 9 weeks, 2 sessions/week, 55 min

Table 1. Continued

X. Could an intermittent Physical Education-based fitness teaching unit affect secondary school students' motivation, autotelic experience, and physical self-concept? A cluster-randomized controlled trial	Cluster-randomized controlled trial balanced by grade	126 second/third-grade secondary students (53 males and 73 females)	Traditional group: 9 weeks, 2 sessions/week, 50 min Innovative group: 9 weeks, 2 sessions/week, 50 min
XI. Effect of two alternated teaching units of invasion team sports on the tactical learning in primary schoolchildren	Cluster-randomized controlled trial balanced by grade	85 fourth/fifth-grade primary students (39 males and 46 females)	Traditional teaching unit group: 8 weeks, 2 sessions/week, 55 min Alternated teaching unit group: 8 weeks, 2 sessions/week, 55 min
XII. Tactical learning in invasion sports in Physical Education: Influence of students' baseline level	Cluster-randomized controlled trial balanced by grade	85 fourth/fifth-grade primary students (39 males and 46 females)	Experimental group 1-2: 8 weeks, 2 sessions/week, 55 min

Note. ANOVA: Analysis of variance; ANCOVA: Analysis of covariance; CENAFI: *Conocimiento del Entorno para el Acondic* for Physical Activity; PASSES: Perceived Autonomy Support Scale for Exercise Settings; BREQ-3: Behavioral Regula Psychological Needs in Exercise Scale; PACSQ: Physical Activity Class Satisfaction Questionnaire; PACE: Physician-based

RESULTS AND DISCUSSION

[RESULTADOS Y DISCUSIÓN]

RESULTS AND DISCUSSION [RESULTADOS Y DISCUSIÓN]

The results and discussion sections of the present Doctoral Thesis are shown as a compilation of scientific papers. They are enclosed in the form that have been published or submitted.

1. EFFECTIVENESS OF PHYSICAL EDUCATION-BASED INNOVATIVE TEACHING UNITS FOR DEVELOPING AND MAINTAINING CARDIORESPIRATORY FITNESS IN SCHOOLCHILDREN (PAPERS I-VIII)

Paper I

EFFECT OF A PHYSICAL EDUCATION-BASED FITNESS INTERMITTENT TEACHING UNIT ON CARDIORESPIRATORY FITNESS IN HIGH SCHOOL STUDENTS: A CLUSTER-RANDOMIZED CONTROLLED TRIAL

Guijarro-Romero, S., Mayorga-Vega, D. Casado-Robles, C., & Viciana, J.

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Effect of a Physical Education-based fitness intermittent teaching unit on high school students' cardiorespiratory fitness: A cluster-randomized controlled trial

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ABSTRACT

BACKGROUND: The aim of this study was to compare the effect of the intermittent and traditional physical fitness-based teaching units on cardiorespiratory fitness and physical activity levels in high school students during Physical Education sessions.

METHODS: One hundred and three high school students (M_{age} = 13.6 ± 0.7) from six classes, balanced by grade, were cluster-randomly assigned into traditional (TG), intermittent (IG), and control (CG) groups. The TG performed a fitness teaching unit twice a week for nine weeks (35-40 minutes of the main part of each session). The IG worked during the first half of the sessions' main part (18-20 minutes) similarly to the TG, and during the second half they worked on technical-tactical aspects of invasion sports. Students' cardiorespiratory fitness was measured at the beginning and at the end of the teaching unit. Physical activity levels were measured objectively through a heart rate monitor and subjectively by a self-reported scale during Physical Education sessions.

RESULTS: Both traditional and intermittent teaching units developed students' cardiorespiratory fitness levels (Δ post-pre-intervention: TG, M_{Δ} = 19.8, SE = 9.4; IG, M_{Δ} = 16.6, SE = 7.7); $p < 0.01$). Additionally, both TG (M = 86.2, SE = 9.9) and IG (M = 90.9, SE = 7.6) had higher physical activity levels than the CG (M = 76.3, SE = 13.5) ($p < 0.05$). However, no differences in physical activity levels were found between the IG and TG ($p > 0.05$).

CONCLUSIONS: The intermittent teaching unit allowed the simultaneous development of cardiorespiratory fitness and another curricular objective in the same Physical Education sessions.

Key words: Educative intervention – Health-related physical fitness – Cardiovascular endurance – Physical activity – Adolescents.

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Introduction

Cardiorespiratory fitness (CRF) is considered one of the most important health markers among adolescents.[1] Higher levels of CRF during adolescence are associated with better quality of life and academic performance.[2,3] Unfortunately, in the last decades CRF has been declining among adolescents.[4] As a consequence, a low CRF has become a worldwide problem which affects, on average, 46% of girls and 33% of boys.[1] Therefore, good CRF levels during adolescence should be included in health promotion policies in different contexts such as sport programs or schools.[1]

Among other contexts, schools and specifically Physical Education (PE) subject, have an important role in the improvement of CRF levels in adolescents.[5] In fact, several countries require in their national educational curricula the acquisition of good CRF levels.[6,7] However, achieving an improvement in students' CRF levels during PE sessions is hindered by several difficulties. Examples of these difficulties include: the great volume of contents to develop during the academic year, the heterogeneous levels of students, the limited curriculum time appointed to the PE subject (e.g., on average, worldwide only about two hours per week), or holidays.[8,9]

Despite these difficulties, previous studies have shown the effectiveness of short-term teaching units for improving students' CRF levels in the PE setting.[10,11] However, with these traditional teaching units (i.e., working the whole session during several sessions in a row in order to reach an objective) just the objective of improving CRF would be achieved and, after that, considering the limited curriculum time appointed to the PE subject,[8,9] a large amount of curriculum objectives would have to be developed in a reduced period of time. Furthermore, in the aforementioned teaching units the learning was isolated, without links to other subject matters.[12]

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A feasible solution to the above mentioned difficulties in PE could be developing CRF simultaneously with other curricular contents through the intermittent teaching unit structure proposed by Viciana and Mayorga-Vega.[12] This innovative structure of the teaching unit consists of only a few minutes of each PE session for several sessions. Thus, it allows for dividing the session into several parts (i.e., two) and developing two or more related curricular objectives during the same session. Previous empirical studies have found that this PE-based teaching unit model is effective for developing different health-related curricular objectives.[13-15] Another example of an intermittent teaching unit could consist of the development of students' CRF during several minutes of the PE sessions while another learning objective such as technical-tactical skills of invasion sports could be developed during the rest of the session. This could provide teachers a more efficient use of the limited PE time for developing various goals during the sessions, and students the opportunity to establish relationships between different PE-related contents. For instance, an intermittent teaching unit centered on the development of both students' CRF and technical-tactical learning of invasion sports could be applied. The PE sessions should have two marked parts, one focused on CRF development and another focused on the technical-tactical learning in invasion sports. This structure would allow students to achieve both objectives, to relate both contents (e.g., performing physical fitness exercises to improve students' performance in technical-tactical situations), and to reduce physical fitness-related tasks developed along the main part of the session, which could circumvent the continuous physical effort of students.

Similarly to the present study, Mayorga-Vega *et al.*[10] focused on maintaining CRF levels previously acquired through performing sports-integrated activities during 15 minutes of the main part of the session twice a week for eight weeks. However, the aforementioned authors, apart from applying a teaching unit for maintaining CRF, which is easier than developing it, did not make comparisons with a traditional teaching unit. Unfortunately, to

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our knowledge there are no previous studies examining the effect of an intermittent teaching unit on the development of students' CRF levels in the PE setting. Consequently, the main purpose of the present study was to compare the effect of the intermittent and traditional physical fitness-based teaching units on CRF levels in high school students. The secondary purpose of this study was to compare the effect of the intermittent and traditional physical fitness-based teaching units on physical activity (PA) levels during PE sessions in high school students.

Materials and methods

Study design

The present study is reported according to the current CONSORT guidelines for cluster randomized trials.[16] The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013). The Ethical Committee for human studies of the University of Granada (649/CEIH/2018) approved the present study protocol. For practical reasons and because of the nature of the present study (i.e., natural groups from an educational setting) a cluster-randomized controlled trial was used (i.e., randomization was per classes not per individuals).[11,17] Six natural classes, balanced by grade (i.e., eighth- and ninth-grade classes), were randomly assigned to form one of the following study groups: control group (CG), intermittent group (IG) or traditional group (TG). However, the students had been previously assigned randomly into classes by the school center. This study was non-blinded (treatments were not masked from the students or teachers), and parallel-group (study with three different treatment),[18] with two evaluation phases.

Participants

The head and the PE teacher of two similar state high schools (chosen by convenience) of the province of Ciudad-Real (Castilla-La Mancha Region, Spain) were contacted. They were informed about the project, and permission to conduct the study was

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requested. After the approval of the schools were obtained, all the 126 students (53 boys and 73 girls) from the eighth and ninth grade of secondary education (i.e., 13-15 years old) of the selected school centers were invited to participate in the present study. Adolescents and their legal tutors were completely informed about the features of the study. Participants' signed written informed assent and their legal guardians' signed written informed consent were obtained before taking part in the study. According to the center's reports, all the students' families had a middle socioeconomic level.

The inclusion criteria were: a) being enrolled in the eighth to ninth grades of the secondary education level; b) participating in the normal PE classes; c) being free of any health disorder such as heart diseases, uncontrolled asthma, bone/joint problems or other reasons why children should not undergo PA, d) presenting the corresponding signed consent by their parents or legal guardians; and e) presenting the corresponding signed assent by the students. The exclusion criteria were: a) not having performed correctly the CRF test in each measured moment (i.e., pre-intervention and post-intervention), and b) not having an attendance rate equal or over 85% for PE classes during the intervention period.

Sample size

Based on the main dependent variable (i.e., CRF), and assuming independency of observations as previous personal related (unpublished) studies have shown, a priori sample size calculation was estimated with the G*Power Version 3.1.9.4 for Windows. Parameters were set in a conservative manner as follows: effect size $f = 0.15$, significance level $\alpha = 0.05$, statistical power $(1 - \beta) = 0.80$, and correlation among repeated measures $r = 0.7$. A minimum final sample size of 69 was estimated.

Randomization

Recruitment was carried out in June of 2017, and the intervention was done from September to December of 2017. The six established classes, with their students, were

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randomly assigned to one of the three conditions (two interventions and one control). Before the pre-intervention evaluation was administered, an independent researcher, blinded to the study objectives, performed the allocation. Randomization was conducted at the class-level, using a computerized random number generator.

Intervention

Figure 1 shows the general scheme of the intervention. The traditional group (TG) and intermitent group (IG) students performed a physical fitness-based teaching unit during the PE sessions twice a week for nine weeks. Because of meteorological problems, in the end the TG and IG students completed a total of 16 sessions. The sessions (50 minutes each) were designed and delivered by the PE teachers of the participating high schools with the supervision of the main researcher. The PE teachers had 15 years of experience. During the warm-up (5-to-10-minutes) the students carried out low-to-moderate aerobic exercises followed by some joint mobility and stretching exercises. In the main part (35-to-40-minutes), the TG students performed traditional PE-based physical fitness sessions during the whole period (e.g., circuit training, interval training, running games or fartlek). For example, in the fartlek session students performed different kinds of fartleks (i.e., five times of: 4 minutes running soft plus 1 minute running fast) during 25 minutes, followed by team relay races for 10 minutes. At the end of the sessions there were five-minute cool-down (i.e., walking slowly around the sports court).

Although for the IG students the warm-up and cool-down phases were identical to the TG, the main part of the IG students' sessions was divided into two halfs. In the first half (18-20 minutes approximately), which had the objective of developing students' CRF levels, the IG students performed similar PE-based physical fitness exercises to the TG students (i.e., three times of: 4 minutes running soft plus 1 minute running fast, followeb by team relay races for 5 minutes). However, in the second half (18-20 minutes approximately),

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in order to make the sessions more motivating and participatory,[19] IG students developed invasion sports tasks in order to learn technical and tactical aspects of both sports (football and basketball). The PE teacher placed special emphasis on reaching a moderate-to-vigorous intensity during the whole main part (i.e., 35-40 minutes) in the TG sessions, and only during the first half of the main part (i.e., 18-20 minutes) in the IG sessions.

Regarding the control group (CG) students, they also participated in their PE sessions twice a week during the intervention period, with a similar structure as the TG and IG (i.e., 5-to-10-minute warm-up, 35-to-40-minute main part, and five-minute cool-down). The warm-up and cool-down phases were identical to the intervention groups'. Nevertheless, the content (body expression and outdoor PA) and methodology followed during the main part of the sessions were different (mostly based on the recreation and without any special focus on PA intensity). For example, during the body expression sessions, students had to make an acrosport choreography with the figures that they had previously learned, while during the outdoor PA sessions students performed different track games.

Insert Figure 1 here

Measures

Students' CRF evaluation was carried out during a PE session at the beginning (pre-intervention) and at the end (post-intervention) of the teaching unit. All evaluations were carried out under the same conditions, with the same instruments, and by the same tester. The CRF measurements were taken in an indoor sports facility with a non-slippery floor, on the same day of the week, under the same environmental conditions, and at the same time for each student. Prior to the CRF test, the participants completed a standardized warm-up consisting of five minutes of running from low-to-moderate intensity followed by some joint mobility exercises. General characteristics of the participants (i.e., age, grade, gender, body mass, body height, and habitual PA) were registered at the beginning of the study. Body

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mass and body height (and body mass index) were measured following the ISAK procedure.[20] Habitual PA was estimated by the Spanish version of the PACE questionnaire for adolescents.[21]

Cardiorespiratory fitness. The 20-meter shuttle run test was used to assess CRF.[22] Participants ran between two parallel lines placed 20 meters apart, in a progressive rhythm marked by a recorded beep until they were not able to reach the line two consecutive times. During the test each participant wore a heart rate monitor (Polar® RS300X, Finland). The total number of completed laps (n) and shuttles (timed in seconds) were retained. In order to ensure the test maximality, only the scores of those participants who reached a heart rate value equal to or higher than 90% of the estimated maximum heart rate were used.[23] The maximum heart rate was estimated by the following equation: 209 – 0.7 x age (in years).[24] The 20-meter shuttle run test has demonstrated adequate reliability and criterion-related validity among adolescents (e.g., ICC = 0.89; $r_p = 0.78$).[22,25]

Physical activity. Students' PA levels during the teaching unit sessions were measured objectively by heart rate monitors and subjectively by a self-reported scale. In each research group, five students per class were randomly selected to wear a heart rate monitor (Polar® RS300X, Finland). These five students were different in each session, for example, in the second session five students different from the first session wore the heart rate monitor, and so on until all students' work intensity of the same class were measured. Therefore, all students' PA was monitored about two or three times during the intervention period. Additionally, at the end of each PE session all the students reported their global perceived exertion using a pictorial perceived exertion scale (from 0 = ‘‘not tired at all’’ to 10 = ‘‘very, very tired’’), which has demonstrated adequate reliability and validity among adolescents (test-retest reliability, ICC = 0.95; validity, r = 0.89).[26] For the intensity control, rating of perceived exertion, average heart rate (expressed as beats per minute and

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percentage of estimated maximum heart rate), total PA and moderate-to-vigorous PA (MVPA) (percentage of total time involved in an intensity equal or over 50% and 70% of estimated maximum heart rate, respectively), and the achievement of the MVPA recommendation (at least 50% of time of the PE session in MVPA) were calculated.

Statistical analysis

Descriptive statistics (mean ± standard deviation or percentage) for the general characteristics of the included participants and dependent variables were calculated. All the statistical tests assumptions were first checked and met for each dependent variable by common procedures (e.g., histograms and normal Q-Q plots for normality). Chi-squared analyses were carried out to test the ratio differences of gender and grade between the three groups. A one-way analysis of variance (ANOVA) was conducted to examine potential differences between the three groups in terms of body mass, body height, body mass index, and habitual PA levels. The intra-class correlation coefficients (ICC, also known as intra-cluster correlation coefficients) showed empirical evidence of the independency of observations (CRF = 0.00; perceived PA = 0.38; objective PA = 0.00-0.08; Wald Z, $p > 0.05$). However, according to Li *et al.*,[27] because the unit of intervention was the class, a Mixed Multilevel Linear Model with participants nested within classes was selected. The maximum likelihood estimation method was used. According to Field's recommendation,[28] the approach was starting from "basic" models in which all the parameters were fixed and then progressively random coefficients and exploring confounding variables was followed. The – 2 log-likehood (- 2LL, i.e., comparing the change in the chi-square test) and Akaike's information criterion (AIC, i.e., absolute value) were used to compare the models fit. From all the explored potential confounding variables (i.e., gender, grade, age, body mass, body height, body mass index, habitual PA, record session time, intervention attendance, and the CRF pre-intervention scores for each particular dependent variable), CRF pre-intervention

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scores for the dependent variables CRF, and total PA were used. The *post-hoc* with the Bonferroni adjustment was used for pairwise comparisons. Effect sizes were estimated using the Cohen's *d*.

Also, the chi-square test was calculated in order to compare the percentage of students that met the MVPA recommendation during the PE sessions between the three groups. Effect sizes were estimated using the Cramer's V.[28] All statistical analyses were performed using the SPSS Version 21.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$, except for the pairwise comparisons with the chi-squared test that were set at $p < 0.017$.

Results

Final sample and general characteristics

Figure 2 shows a flow chart corresponding to the participants included in the present study. Although all the invited 126 students (57.9% girls) agreed to participate and met the inclusion criteria, finally 103 students (54.4 % girls) satisfactorily passed the exclusion criteria and were analysed. No participant was lost because of the rejection to continue in the study or change of the school. Table 1 shows the general characteristics of the included participants and differences between the three groups. The chi-square analysis showed that the three groups had an unbalanced representation of girls to boys ($p < 0.05$). However, the chi-square analysis showed that the three groups had a balanced representation of eighth-/ ninth-grade students ($p < 0.05$). Additionally, the one-way ANOVA results did not show statistically significant differences in terms of body mass, body height, body mass index, and habitual PA levels between the three groups ($p > 0.05$). The IG and TG participants obtained an average attendance of 93% and 89% in the physical fitness teaching unit, respectively.

Insert Table I here

Insert Figure 2 here

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Cardiorespiratory fitness

Figure 3 shows the effect of the intermittent and traditional physical fitness-based teaching units on CRF levels in high school students. The results of the Mixed Multilevel Linear Model (- 2LL = 1066.335; AIC = 1078.335; $F = 7.861$; $p = 0.001$), followed by the pairwise comparisons showed that the both the IG and TG students improved statistically significantly (IG, $M_{\Delta} = 16.6$, SE = 7.7, $p < 0.01$, $d = 0.18$; TG, $M_{\Delta} = 19.8$, SE = 9.4, $p < 0.01$, $d = 0.20$; CG, $M_{\Delta} = -8.3$, SE = 6.9). However, between the IG and TG no statistically significant differences were found ($p > 0.05$; $d = 0.02$).

Insert Figure 3 here

Physical activity

Table 2 shows the comparison of the perceived (i.e., RPE) and objective (i.e., average heart rate, average of the percentage of maximum heart rate, total PA and percentage of total time involved in MVPA) PA levels during the PE sessions between the three groups. The results of the Mixed Multilevel Linear Model ($p < 0.01$) followed by the pairwise comparisons showed that both the IG and TG students had statistically significantly higher objective and perceived PA levels during PE sessions than students from the CG ($p < 0.05$). However, statistically significant differences in objective and perceived PA levels during the PE sessions between the IG and TG were not found ($p > 0.05$).

Insert Table II here

Figure 4 shows the comparison of the percentage of students that met the MVPA recommendation during the PE sessions between the three groups. The results of the chi-square test ($\chi^2 = 15.134$; $p \leq 0.001$; Cramer's V = 0.383) followed by the the two x two chi-square test showed that in the IG and TG there were higher proportions of students that met the MVPA recommendation during the PE sessions than in the CG (IG vs. CG, $\chi^2 = 15.251$; $p < 0.001$; Cramer's V = 0.409; TG vs. CG, $\chi^2 = 9.041$; $p < 0.01$; Cramer's V = 0.350).

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However, between the IG and TG no statistically significant differences in the percentage of students that met the MVPA recommendation during the PE sessions were found ($\chi^2 = 0.503$; $p > 0.017$; Cramer's V = 0.077).

Insert Figure 4 here

Discussion

The main purpose of this study was to compare the effect of the intermittent and traditional physical fitness-based teaching units on CRF levels in high school students. Results showed that both types of physical fitness-based teaching units performed twice a week for only nine weeks significantly improved high-school students' CRF levels. Similarly, in previous studies short-term physical fitness teaching units have also shown to be effective for improving students' CRF during PE sessions.[10,11] In the aforementioned studies, the experimental group students only developed one PE curricular objective during the whole PE session (i.e., to increase the students' CRF) as in the TG of this study. However, since many curricular objectives have to be developed during the academic year,[8,9] this type of teaching unit, which only develops one curricular objective, seems to not be the most appropriate option to address all curricular aims. Therefore, the application of another teaching unit structure, where several PE objectives can be developed simultaneously, seems to be a good alternative in facilitating PE teachers to achieve all PE curriculum objectives. According to the structure of the intermittent teaching units proposed by Viciana and Mayorga-Vega,[12] results of the present study showed that it is possible to improve CRF only working intensely during the first 18-20 minutes of the main part of the PE session, and to dedicate the other half of the session to develop another PE objective like the learning of technical-tactical aspects of invasion sports. Similarly, Mayorga-Vega *et al.*[10] applied an intermittent teaching unit to maintain CRF levels previously acquired performing sports-integrated activities during only 15 minutes of the main part of the session during eight

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weeks. However, the aforementioned authors focused their intervention on maintaining the students' CRF instead of developing it, which is easier. To our knowledge this study is the first that examines the effectiveness of this teaching unit structure on developing CRF simultaneously with other curricular objectives during the same sessions in the PE setting, which is, consistently, an important outcome for scientists and PE teachers.

Regarding the magnitude of the effects of the teaching units on CRF, previous studies that have performed a short-term physical fitness teaching unit found similar effects in CRF (*d* = 0.07-0.47, mean *d* = 0.26)[10,11,29] as in the present study (*d* = 0.19). In spite of the magnitude of the effects being a bit small, according to Valentine and Cooper[30], it should take into account that even lower values of effect size could be considered of practical importance in educational research.

It is important to denote that the second objective of the sessions developed by the IG students, technical-tactical learning of invasion sports could influence the PA levels developed, as will be commented posteriorly in the PA section, and consequently the CRF could also be influenced. Therefore, future research could investigate the effect of intermittent teaching units centered on the increment of CRF and, as the second objective, working with any other content of the PE subject (e.g., body expression).

Regarding the second objective of the study, it was to compare the effect of the intermittent and traditional physical fitness-based teaching units on objective and perceived PA levels during PE sessions in high school students. The PE subject has an important role in students' PA levels, being an effective means to increase daily MVPA levels among adolescents.[31,32] The Association for PE[5] recommends that students should spend at least 50% of the PE session time in MVPA. Results of this study showed that during the physical fitness-based teaching units, the TG and IG students had higher average levels of MVPA than the CG (46.3%, 52%, and 24.8%, respectively). Additionally, during the PE sessions in

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the TG and IG, there was a higher proportion of students that met the MVPA recommendation during the PE sessions[5] than in the CG (39%, 55%, and 13%, respectively). Similar to this study, in their systematic review about interventions aimed to increase MVPA levels during PE sessions, Lonsdale *et al.*[33] found that only interventions specifically designed for this purpose achieved an increment of the time involved in MVPA. However, if a specific intervention is not applied, the average proportion of PE session time spent in MVPA (40,5%) is lower than recommended.[34] As regards perceived exertion levels, results showed that the TG and IG students reported higher perceived exertion levels than the CG students, similar to the results found by Mayorga-Vega *et al.*[10]. Despite the fact that TG students maintained a continuous effort during the whole session in comparison with the IG students, who had more pauses during the sessions (in order to explain and organize them), both groups stated similar levels of perceived exertion. This could be because team sports have shown to be one of the contents that causes a more intense student participation in the PE subject.[35]

Regarding the magnitude effects of the intervention, the present study showed similar results to previous studies focused on the increment of MVPA levels during PE sessions (d = 1.18-1.50 vs. 0.13-2.81, respectively).[33] Moderate-to-high magnitude effects were obtained, indicating that the physical fitness based-teaching units applied were effective in increasing MVPA levels during PE sessions.

Finally, although the IG students only worked physical fitness specifically during 18-20 minutes of the main part of the session, the difference found in MVPA between the TG and IG students (46.3 % and 52 % of PE session time, respectively) may be because team sports have been shown as being a PE content with higher levels of MVPA in comparison with others.[35]

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This study had some limitations that should be considered. The main limitation was that the technical-tactical learning was not measured because of feasibility issues. In Spain, the time destined for PE is limited (only two hours per week) and the academic year is interrupted by holidays about every three months. Therefore, since the objective technical-tactical learning assessment would have needed more evaluation sessions, it could not be performed. Secondly, instead of applying a true randomized control trial, a cluster-randomized control trial was applied. However, because of the nature of the context and with the objective of keeping the ecological validity, this design was more appropriate. The third limitation was that the study was not balanced by gender. However, when gender had an effect, it was statistically controlled. Future research studies that do not have this time restriction should also measure technical-tactical learning in order to examine if an intermittent teaching unit, in addition to the improvement in CRF levels, also improves students' technical-tactical skills.

Conclusions

Besides improving students' CRF levels, an intermittent teaching unit simultaneously leaves enough time during the sessions to work on another PE objective. Moreover, another important outcome of this study is the fact that this new structure of teaching unit increased the sessions' intensity in a similar way to a traditional teaching unit, also achieving the recommendations of 50% of PE sessions time involved in MVPA levels. Therefore, an intermittent teaching unit of physical fitness and invasion sports seems to be an effective way to achieve various objectives in the PE setting.

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Authors' contributions.–– Santiago Guijarro-Romero contributed to the study design, conducted the study, and drafted and edited the manuscript. Daniel Mayorga-Vega contributed to the study design, carried out the data analysis, and supervised the final manuscript drafting; Carolina Casado-Robles contributed in data collection, study design and final manuscript. Jesús Viciana contributed to the study design, supervised all aspects of its implementation, and revised the manuscript drafting.

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Table I.–– *General characteristics of the included participants and differences between the three groups*

	Total (n = 103)	CG (n = 38)	IG (n = 42)	TG (n = 23)	p^a
Age (years)	13.6 (0.7)	13.6 (0.7)	13.8 (0.8)	13.5 (0.6)	-
Grade (8th/ 9th)	42.7/ 57.3	47.4/ 52.6	38.1/ 61.9	43.5/ 56.6	0.702
Gender (girls/ boys)	54.4/ 45.6	68.4/ 31.6	52.4/ 47.6	34.8/ 65.2	0.036
Body mass (kg)	54.1 (11.1)	54.2 (9.0)	54.7 (12.7)	52.8 (11.3)	0.810
Body height (cm)	162.5 (7.9)	160.8 (7.6)	163.2 (7.8)	163.8 (8.3)	0.270
Body mass index (kg/ m^2)	20.4 (3.5)	21.0 (3.4)	20.4 (3.8)	19.5 (3.0)	0.290
Habitual PA (days/ week)	2.9 (1.7)	2.4 (1.5)	2.9 (1.7)	3.4 (2.1)	0.107

Note. Data are reported as mean (standard deviation) for age, body mass, body height, body mass index and habitual physical activity variables, or percentage for grade and gender variables; CG = Control group; IG = Intermittent group; TG = Traditional group; PA = Physical activity.

[a] Significance level from the one-way analysis of variance for body mass, body height, body mass index and habitual PA, and from the chi squared test for the gender and grade ratios.

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Table II.—– *Comparison of perceived and objective physical activity levels during the Physical Education sess*

	CG	IG	TG	Mixed Multilevel Linear Model[a]			
	(*n* = 38)	(*n* = 42)	(*n* = 23)	- 2LL	AIC	*F*	*p*
RPE	3.0 (0.8)	5.9 (0.8)***	6.4 (0.5)***	192.183	202.183	29.362	0.00
Heart rate (bpm)	121.3 (12.8)	141.6 (13.0)**	143.0 (11.3)**	810.096	820.096	26.503	0.00
Heart rate (%)[b]	61.1 (6.5)	71.3 (6.5)**	71.9 (5.7)**	669.408	679.408	25.413	0.00
Total PA (%)[c]	76.3 (13.5)	90.9 (7.6)***	86.2 (9.9)***	766.154	778.154	25.909	< 0.00
MVPA (%)[d]	24.8 (18.2)	52.0 (17.8)*	46.3 (14.0)*	871.654	881.654	13.981	0.00

Note. Data are reported as mean (standard deviation); CG = Control group; IG = Intermittent group; TG = Traditional group. RPE = R physical activity; MVPA = Moderate-to-vigorous physical activity.

[a] Mixed Multilevel Linear Model with the *post hoc* analysis with Bonferroni adjustment: Difference statistically significant betwee ***$p < 0.001$). [b] Percentage of estimated maximum heart rate calculated according to the formula 209 – 0.7 x age (in years) durin total time of Physical Education sessions involved in an intensity equal or over 50% of estimated maximum heart rate. [d] Percentag involved in an intensity equal or over 70% of estimated maximum heart rate.

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Figure 1.––*General scheme of the intervention.*

Figure 2.–– *Flow chart of the school classes and students of the present study. All numbers are school classes [students].*

Figure 3.–– *Effect of the intermittent and traditional physical fitness-based teaching units on cardiorespiratory fitness in high school students. The bars represent the adjusted mean (difference value = post-intervention - pre-intervention) and the error bars represent the standard error. The results of the Mixed Multilevel Linear Model ($F = 7.861$; $p = 0.001$) followed by the pairwise comparisons with the Bonferroni adjustment (Control vs. Intermittent/ Traditional groups: **$p < 0.01$).*

Figure 4.–– *Comparison of the percentage (number represented with the bars) of students that met the moderate-to-vigorous physical activity (MVPA) recommendation during the Physical Education sessions between the three groups (Control vs. Intermittent/ Traditional groups: **$p < 0.01$; ***$p < 0.001$).*

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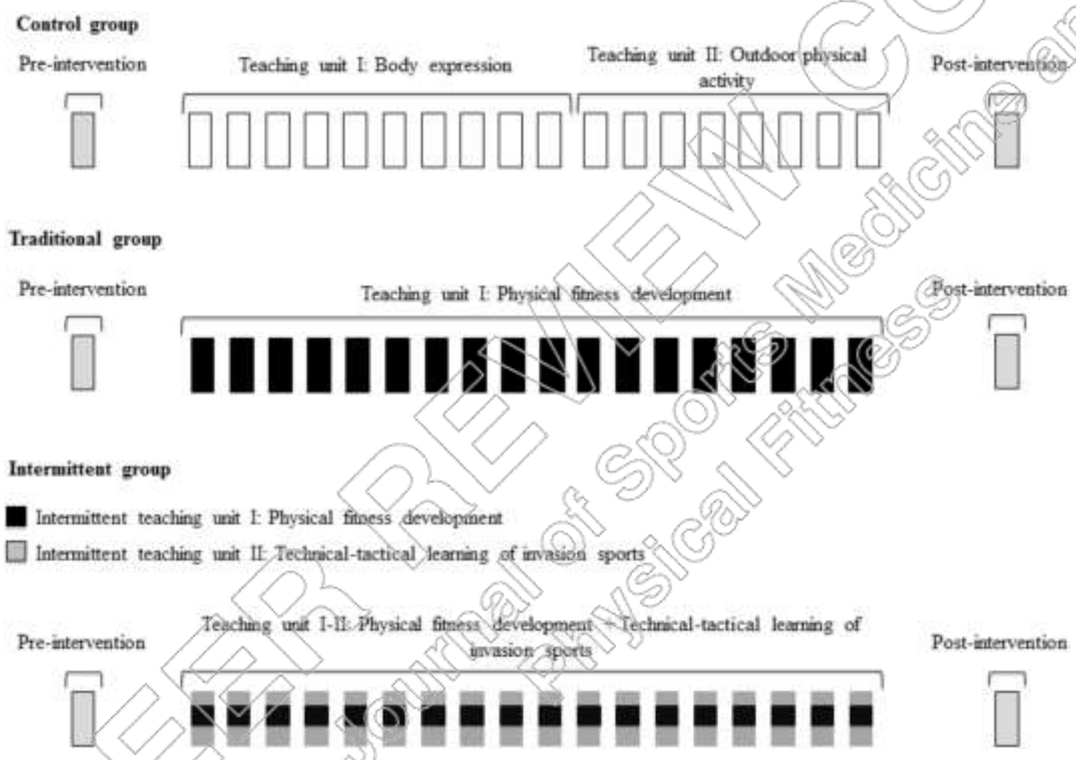

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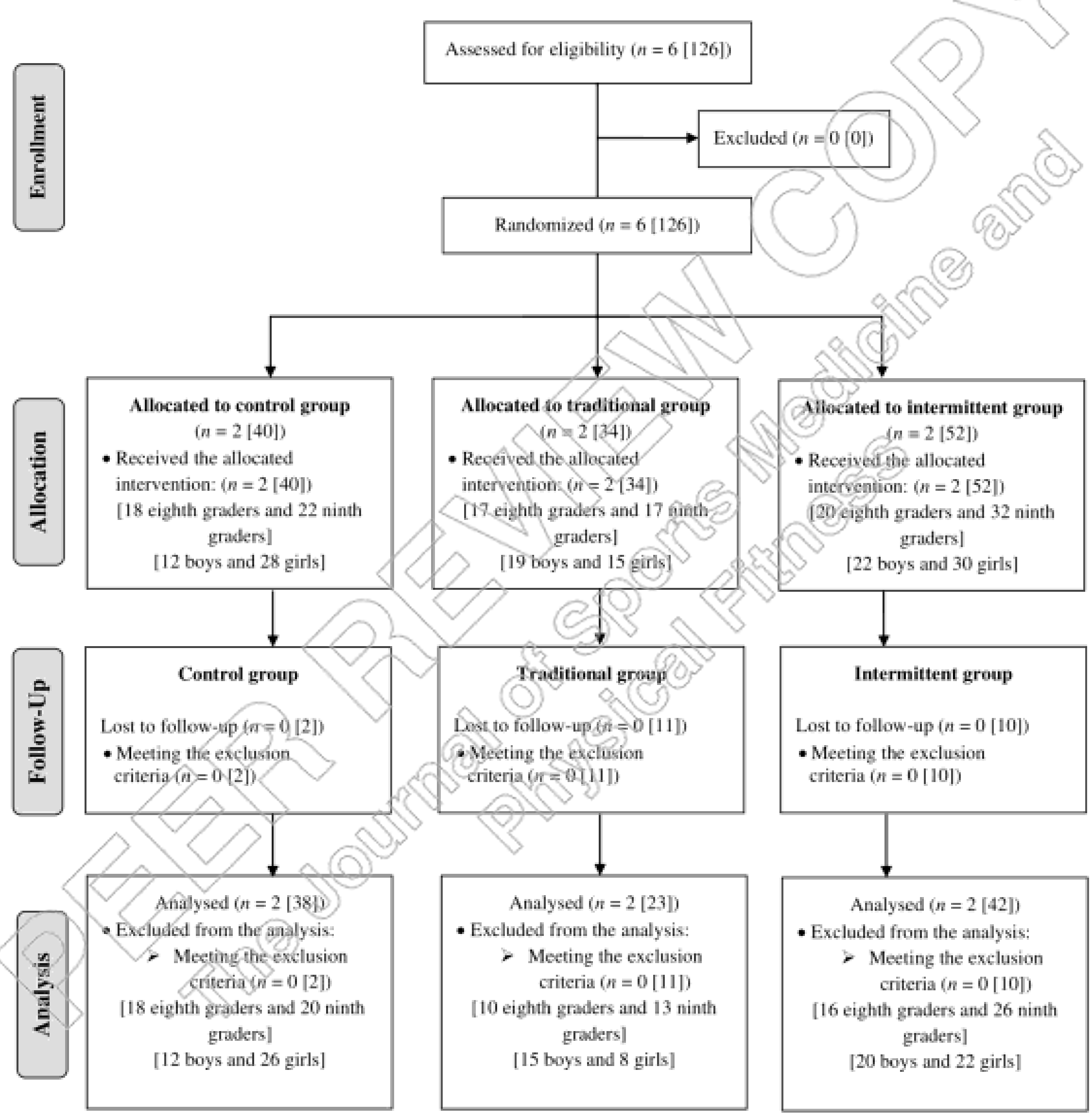

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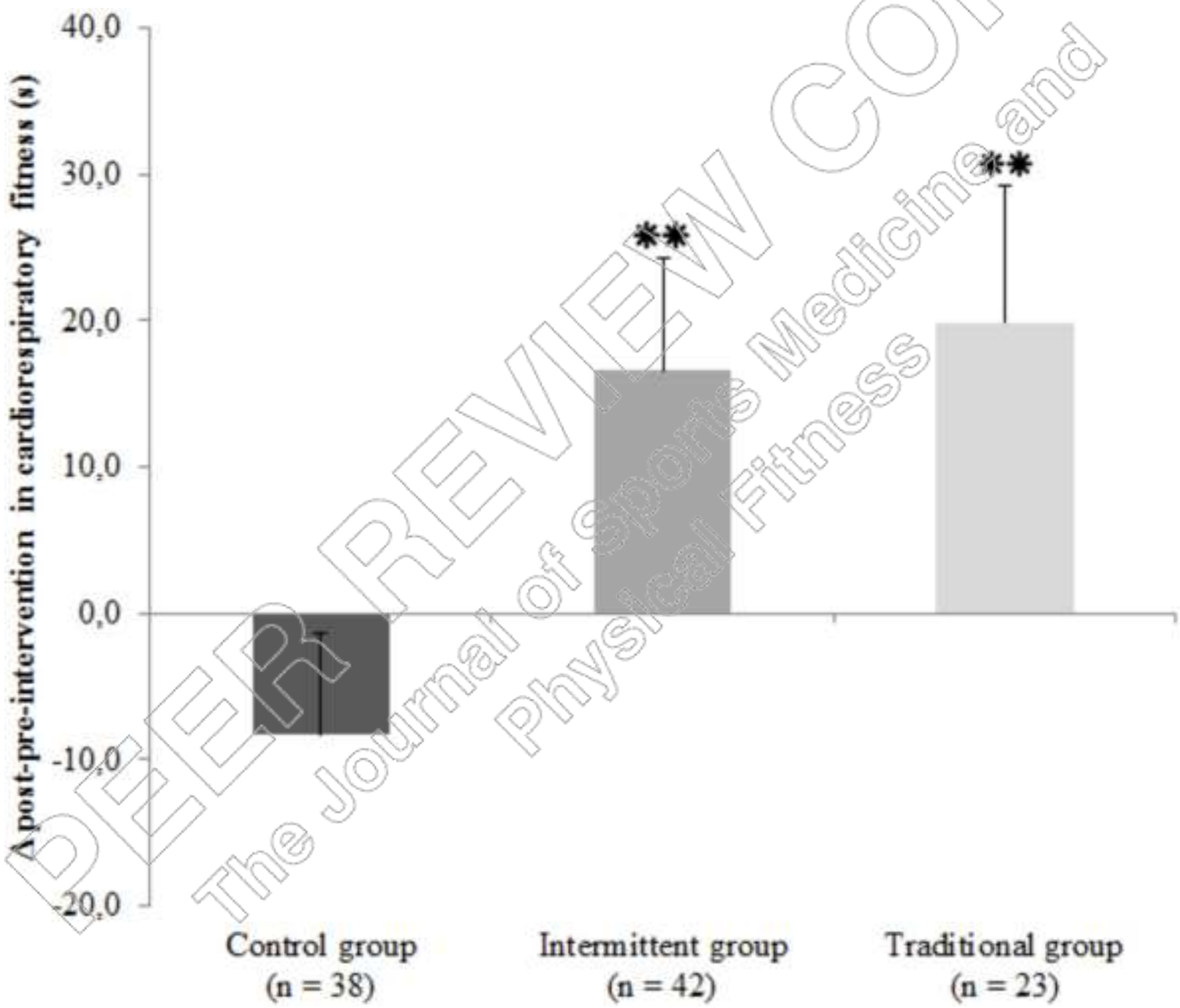

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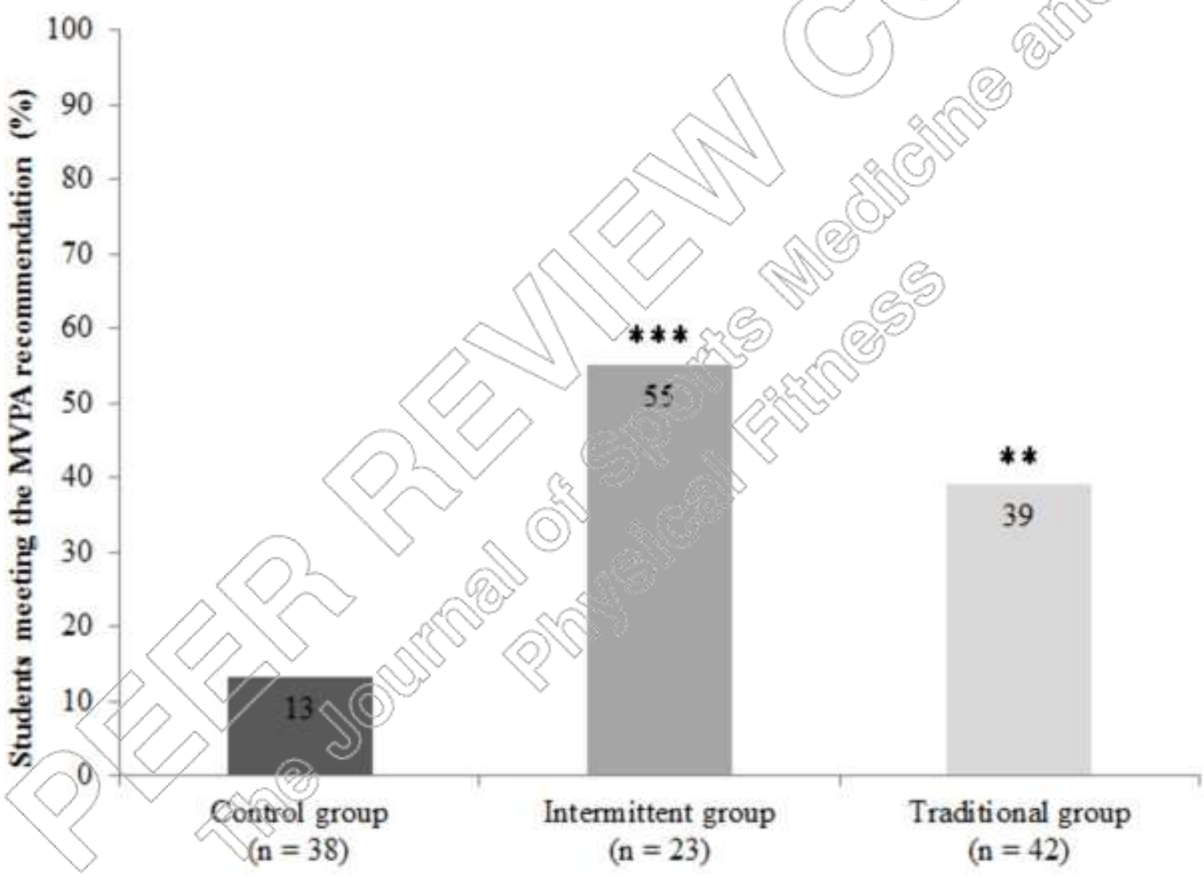

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Paper II

EFFECT OF A PHYSICAL EDUCATION-BASED REINFORCED PROGRAM THROUGH OUTDOOR PHYSICAL ACTIVITIES AND BODY EXPRESSION ON SECONDARY SCHOOL STUDENTS' CARDIORESPIRATORY FITNESS: A CLUSTER-RANDOMIZED CONTROLLED TRIAL

Guijarro-Romero, S., Mayorga-Vega, D. Casado-Robles, C., & Viciana, J.

Science and Sports

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Effect of a Physical Education-based reinforced program through outdoor physical activities and body expression on secondary school students' cardiorespiratory fitness: A cluster-randomized controlled trial

--Manuscript Draft--

Manuscript Number:	
Article Type:	Full Length Article
Keywords:	Educative intervention; Health-related physical fitness; Cardiovascular endurance; Physical activity; Adolescents
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	Daniel Mayorga-Vega
	Carolina Casado-Robles
	Jesús Viciana
Abstract:	Summary Objective: The main aim was to examine the effects of a Physical Education-based reinforced program through outdoor physical activities and body expression on cardiorespiratory fitness in secondary students. A secondary aim was to analyze the physical activity levels during the Physical Education-based development and reinforced programs. Methods: A sample of 92 secondary students (M age 12.4 ± 0.7 years), from five classes, were cluster-randomly assigned into experimental group 1, experimental group 2, and control group. The experimental groups students performed a physical fitness development program twice a week for nine weeks. Then, the experimental group 2 completed a reinforced program through outdoor physical activities and body expression twice a week for six weeks. Students' cardiorespiratory fitness was measured at the beginning and at the end of the development program, as well as at the end of the reinforced program. Physical activity levels were measured objectively through a heart rate monitor and subjectively by a self-reported scale during Physical Education sessions. Results: The experimental group 2 students maintained their cardiorespiratory fitness levels through reinforced program of outdoor physical activities and body expression ($p < 0.001$). Additionally, both experimental groups had higher physical activity levels than the control group during the development program ($p < 0.05$). Moreover, the experimental group 2 had higher physical activity levels during the reinforced program than the control group and experimental group 1 ($p < 0.01$). Conclusion: Reinforced programs allow Physical Education teachers to maintain students' cardiorespiratory fitness levels and achieve other standards of the Physical Education subject.
Secondary Full Title:	Effet d'un programme renforcé basé sur l'éducation physique par des activités physiques en plein air et l'expression du corps sur la condition cardiorespiratoire des élèves du secondaire: un essai contrôlé randomisé en grappes
Secondary Abstract:	Résumé Objectifs: Le but principal était d'examiner les effets d'un programme renforcé basé sur l'éducation physique à travers des activités physiques en plein air et l'expression du corps sur la condition cardiorespiratoire chez les élèves du secondaire. Un objectif secondaire de cette étude était d'analyser les niveaux d'activité physique pendant le développement basé sur l'éducation physique et les programmes renforcés. Méthodes: Un échantillon de 92 élèves du secondaire (âge moyen = 12,4 ± 0,7 ans), de cinq classes, ont été répartis au hasard dans le groupe expérimental 1, le groupe

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	expérimental 2 et le groupe témoin. Les étudiants des groupes expérimentaux ont effectué un programme de développement de la condition physique deux fois par semaine pendant neuf semaines. Puis, le groupe expérimental 2 a achevé un programme renforcé par des activités physiques en plein air et l'expression corporelle deux fois par semaine pendant six semaines. La condition cardiorespiratoire des étudiants a été mesurée au début et à la fin du programme de développement, ainsi qu'à la fin du programme renforcé. Les niveaux d'activité physique ont été mesurés objectivement par un moniteur de fréquence cardiaque et subjectivement par une échelle autodéclarée pendant les séances d'éducation physique. Résultats: Les étudiants du groupe expérimental 2 ont maintenu leur niveau de condition cardiorespiratoire à travers de un programme renforcé d'activités physiques en plein air et d'expression corporelle ($p < 0.001$). De plus, les deux groupes expérimentaux avaient des niveaux d'activité physique plus élevés que le groupe témoin pendant le programme de développement ($p < 0.05$). De plus, le groupe expérimental 2 avait des niveaux d'activité physique plus élevés pendant le programme renforcé que le groupe témoin et le groupe expérimental 1 ($p < 0.01$). Conclusion: Des programmes renforcés permettent aux professeurs d'éducation physique de maintenir le niveau de condition cardiorespiratoire des élèves et d'atteindre d'autres normes en matière d'éducation physique.
Secondary Keywords:	Intervention éducative; Condition physique liée à la santé; Endurance cardiovasculaire; Activité physique; Adolescents

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Short tittle: Reinforced program and cardiorespiratory fitness

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Summary

Objective: The main aim was to examine the effects of a Physical Education-based reinforced program through outdoor physical activities and body expression on cardiorespiratory fitness in secondary students. A secondary aim was to analyze the physical activity levels during the Physical Education-based development and reinforced programs.

Methods: A sample of 92 secondary students (M_{age} 12.4 ± 0.7 years), from five classes, were cluster-randomly assigned into experimental group 1, experimental group 2, and control group. The experimental groups students performed a physical fitness development program twice a week for nine weeks. Then, the experimental group 2 completed a reinforced program through outdoor physical activities and body expression twice a week for six weeks. Students' cardiorespiratory fitness was measured at the beginning and at the end of the development program, as well as at the end of the reinforced program. Physical activity levels were measured objectively through a heart rate monitor and subjectively by a self-reported scale during Physical Education sessions.

Results: The experimental group 2 students maintained their cardiorespiratory fitness levels through reinforced program of outdoor physical activities and body expression ($p < 0.001$). Additionally, both experimental groups had higher physical activity levels than the control group during the development program ($p < 0.05$). Moreover, the experimental group 2 had higher physical activity levels during the reinforced program than the control group and experimental group 1 ($p < 0.01$).

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Key words: Educative intervention; Health-related physical fitness; Cardiovascular endurance; Physical activity; Adolescents

Résumé

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Méthodes: Un échantillon de 92 élèves du secondaire (âge moyen = 12,4 ± 0,7 ans), de cinq classes, ont été répartis au hasard dans le groupe expérimental 1, le groupe expérimental 2 et le groupe témoin. Les étudiants des groupes expérimentaux ont effectué un programme de développement de la condition physique deux fois par semaine pendant neuf semaines. Puis, le groupe expérimental 2 a achevé un programme renforcé par des activités physiques en plein air et l'expression corporelle deux fois par semaine pendant six semaines. La condition cardiorespiratoire des étudiants a été mesurée au début et à la fin du programme de développement, ainsi qu'à la fin du programme renforcé. Les niveaux d'activité physique ont été mesurés objectivement par un moniteur de fréquence cardiaque et subjectivement par une échelle autodéclarée pendant les séances d'éducation physique.

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1. Introduction

Cardiorespiratory fitness (CRF) is considered one of the most important health markers among adolescents [1]. Higher CRF levels during adolescence have been associated with better quality of life and academic performance [2,3]. Unfortunately, in the last decades CRF has been declining among adolescents [4]. As a consequence, the high prevalence of adolescents having an unhealthy CRF level has become a worldwide problem (on average, 46% of females and 33% of males between the ages of 10 and 17) [1]. Therefore, health promotion policies should promote the acquisition of healthy CRF levels in adolescence through different contexts such as sports programs or in school [1].

The school context, and specifically the Physical Education (PE) subject, is considered a crucial setting for improving CRF levels in adolescents [5]. Developed countries require in their national PE curricula the acquisition of good CRF levels among adolescents [6]. Consequently, the PE subject plays an important role in developing and maintaining healthy CRF levels among adolescents [6]. To ensure the achievement of this objective, the Association for PE recommends that students should be involved in moderate-to-vigorous physical activity (MVPA) during at least 50% of the PE session time [5]. Unfortunately, this recommendation is hardly ever met [7], except when interventions are specifically designed to improve MVPA levels during PE sessions [8]. In this line, Maziero et al. [9] found a positive association among PE session time spent working in a MVPA intensity and students' CRF.

However, achieving an increment in students' CRF levels through PE is hindered by several limitations. Examples of these limitations include: the great volume of contents to deliver during the academic year, the limited curriculum time appointed to the PE subject (e.g., on average, worldwide only about two hours per week), school holidays, or the heterogeneous levels of students [10,11]. Despite the fact that long-term programs seem to be the best way to improve CRF in adolescents [12], other studies have showed that short-term programs applied twice a week can improve CRF as well [6,13].

In addition to all of the aforementioned limitations, another PE-based planning limitation is the fact that after a period of detraining, the CRF levels decrease [14,15]. In this sense, Viciana and Mayorga-Vega [16] proposed that PE teachers should apply reinforced programs after a physical fitness development program in order to maintain the students' CRF levels during the whole academic year. For example, after four weeks of detraining, Mayorga-Vega et al. [13] showed the effectiveness of a PE-based four-week reinforced program to maintain CRF levels previously achieved, through applying alternated sessions of physical fitness and traditional games. However, with these kinds of reinforced programs a high amount of PE time is consumed (i.e., one out of every two sessions of the week), and may interfere with the normal development of the rest of the PE curricular contents [6].

A possible solution to this issue could be planning the physical fitness reinforced program through other PE curricular contents (e.g., sports, outdoor physical activity (PA) or body expression). These programs, apart from maintaining the CRF levels previously acquired, might allow PE teachers to achieve objectives related to other curricular contents at the same time. For instance, Mayorga-Vega et al. [6] observed that, after carrying out a physical fitness development program, a team sports-based fitness reinforced program was effective in maintaining students' CRF. Another possibility could be planning a reinforced program with outdoor PA and body expression contents. Outdoor PA refers to activities where the students are allowed to learn about the environment that surrounds them and the possibilities of carrying out different PA within it (e.g., track games or orientation races) [17]. Additionally, outdoor PA favors CRF development, because the activities carried out in natural environments require walking or running [17]. These kinds of activities can be carried out in natural areas such as parks, or in schools that have green areas within the school grounds [18,19]. Regarding body expression, the term refers to activities which allow the students to improve their creativity and ability to express oneself through body movement within a choreography [20,21]. Furthermore, previous studies have shown that body expression interventions are effective in improving CRF levels among adolescents [22]. To our knowledge, no previous studies were found examining the CRF maintenance through outdoor PA and body expression contents in the PE context. Consequently, the main aim of the present study was to examine the effects of a PE-based reinforced program, through outdoor PA and body expression sessions on CRF in secondary school students. A secondary purpose of this study was to analyze the perceived and objective PA levels during the PE-based development and reinforced programs.

2. Method

2.1. Study design

The present study is reported according to the current CONSORT guidelines for cluster randomized trials [23]. The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013). The Ethical Committee for human studies of the University of [omitted for blind review] approved the present study protocol. Recruitment of participants was carried out in June of 2016, and the intervention was done from September 2016 to February 2017. For practical reasons and because of the nature of the present study (i.e., established classes from an educational setting) a cluster-randomized controlled trial was used (i.e., randomization was per classes not per individuals) [6,24]. This study was non-blinded (treatments were not masked from the students or teachers), and parallel-group (study with three different treatments) [25], with three evaluation phases.

2.2. Participants

The principal and the PE teacher of a state high school (chosen by convenience) from an urban area situated in [omitted for blind review] were consulted for the implementation of the study. They were informed about the project, and permission to conduct the study was requested. After the school approvals were obtained, all the 107 students (55 males and 52 females) from the seventh to eighth grade of secondary education (i.e., 12-14 years old) of the selected school center were invited to participate in the present study. Adolescents and their legal guardians were fully informed about the features of the study. Participants' signed written informed assent and their legal guardians' signed written informed consent were obtained before taking part in the study. According to the center's reports, all the students' families had a middle socioeconomic level.

The inclusion criteria were: a) being enrolled in the seventh to eighth grades of the secondary education level; b) participating in the normal PE sessions; c) being exempt of any health problem such as bone/joint problems, uncontrolled asthma, heart illnesses, or other motives why children should not undergo PA; d) presenting the corresponding signed consent by their legal guardians, and e) presenting the corresponding signed assent by the students. The exclusion criteria were: a) not having performed all the dependent variables correctly following their rules of administration, and b) not having an attendance rate equal to or over 80% for PE sessions during both the development and reinforced programs.

2.3. Sample size

Based on the main dependent variable (i.e., CRF), and assuming independency of observations as previous personal related (unpublished) studies have shown, a priori sample size calculation was estimated with the F-test ANOVA function by the G*Power Version 3.1.9.4 for Windows. Parameters were set in a conservative manner as follows: effect size $f = 0.15$, significance level $\alpha = 0.05$, statistical power $(1 - \beta) = 0.95$, and correlation among repeated measures $r = 0.7$. A minimum final sample size of 87 was estimated.

2.4. Randomization

Randomization was conducted at the class-level, using a computerized random number generator. Before the pre-intervention evaluation was administered, five established classes of the selected school center (three 7th and two 8th grade classes) were randomly assigned by an independent researcher, blinded to the study objectives to form one of the following study groups: control group (CG, one seventh-grade class), experimental group 1 (EG1, two classes, one seventh- and one eighth-grade) or experimental group 2 (EG2, two classes, one seventh- and one eighth-grade). However, according to the education rules, prior to the start of the scholar year the students who composed each of these five classes had been assigned randomly by the school center following the criterion that the classes should be balanced between males and females (i.e., each class should have the same proportion of males and females).

2.5. Intervention

Fig. 1 shows the general scheme of the intervention. The PE teacher of the participating school performed all of the experimental and control sessions with the supervision of the main researcher. Prior to each program, the main researcher provided the PE teacher with guidelines to correctly giving the sessions of each program (e.g., "during the development physical fitness program, it is important that students achieve a moderate-to-vigorous intensity as long as possible during the sessions"). The PE teacher had 15 years of experience teaching the PE subject.

First, the EG1 and EG2 received a physical fitness-based development program twice a week for nine weeks. Due to meteorological problems, in the end only 16 sessions were completed by the two EGs. Then, after a four-week detraining period, the EG2 participants completed a reinforced program twice a week for six weeks.

The duration of each PE session was approximately 50 minutes and consisted of a 5-to-10-minute warm-up, performing low-to-moderate aerobic activities followed by some joint mobility and stretching exercises; a main part of 35-to-40-minutes carrying out sessions such as running games, interval training, fartlek or circuit training, and ending with team games; and a five-minute cool-down. For example, in the circuit training session students carried out a circuit with eight stations three times during 25 minutes, followed by team relay races for 10 minutes. Each station consisted of an exercise lasting 30 seconds (push-ups, squats, abs, skipping, zig-zag between cones, heels to the buttocks, lateral race between cones, and skipping rope) followed by 20 seconds of rest between exercises. Between circuits students rested for one minute. During the work time the students should complete as many repetitions as possible in a controlled manner [14]. The PE teacher placed special emphasis on reaching a MVPA intensity during the development sessions.

Regarding the reinforced program, both the EG1 and EG2 carried out an outdoor PA program twice a week for three weeks as well as a body expression program twice a week for three weeks. Prior to these programs, students had not received any exposure on these topics. The main difference between the two EGs was the intensity of the sessions of the reinforced programs. Regarding the EG2, the reinforced sessions were designed to reach a MVPA intensity (e.g., carrying out different track games with a short time limit to finish the task in the outdoor PA sessions, or performing zumba choreographies in the body expression sessions). The difficulty was increased by incrementing the number of tracks to find or increasing the number of choreographies to perform, respectively for the two reinforced programs. Regarding the EG1, they carried out track games and choreographies as well, but without a special focus on reaching a MVPA intensity during sessions (e.g., carrying out different track games without a time limit, where the most important thing was to follow the tracks and finish them, in the outdoor PA sessions, or performing figure and brief story representations in the body expression sessions).

Regarding the CG students, they also carried out two PE sessions a week during the intervention period, with a similar structure as the two EGs (i.e., 5-to-10-minute warm-up, 35-to-40-minute main part, and five-minute cool-down). However, the contents and methodology (based on technique-learning practices and recreation) developed in the main part of the sessions were different. During the development program period, the CG carried out basketball and hockey sessions instead of physical fitness. Finally, during the reinforced program period, the CG carried out alternative games (e.g., indiaca or frisbee). Table 1 shows the scope and instructions given during the Physical Education-based development and reinforced programs for the three groups. Supplementary Tables 1 and 2 show an in depth description of the main part of the sessions during the Physical Education-based development and reinforced programs, respectively.

Insert Figure 1 here

Insert Table 1 here

2.6. Measures

Students' CRF evaluation was carried out during a PE session at the beginning and at the end of the developmental program (pre-intervention and post-intervention, respectively), as well as at the end of the reinforced program (post-maintenance). All evaluations were carried out under the same conditions, with the same instruments and by the same tester. The CRF measurements were taken in an indoor sports facility with a non-slippery floor, under the same environmental conditions, on the same day of the week and at the same time for each student. Prior to the CRF test, the participants completed a standardized warm-up consisting of five minutes of running from low to moderate intensity followed by some joint mobility exercises. General characteristics of the participants (i.e., age, grade, gender, body mass, body height, and habitual PA) were registered at the beginning of the study. Body mass and body height (and body mass index) were measured following the international standards for anthropometric assessment [26]. Habitual PA was estimated by the Spanish version of the PACE questionnaire for adolescents [27].

Cardiorespiratory fitness. The 20-meter shuttle run test was used to assess CRF [28]. Participants ran between two parallel lines placed 20 meters apart, in a progressive rhythm marked by a recorded beep until they were not able to reach the line two consecutive times. During the test, each participant wore a heart rate monitor (Polar® RS300X, Finland). The total number of completed laps (n) and shuttles (time in seconds) were retained. In order to ensure the test maximality, only the scores of those participants who reached a heart rate value equal to or higher than 90% of the estimated maximum heart rate [29] were used. The maximum heart rate was estimated by the following equation: 209 – 0.7 x age (in years) [30]. Then, the maximum oxygen uptake (VO_{2max}, in ml/ kg/ min) was estimated using the following equation: 31.025 + 3.238 x speed - 3.248 x age + 0.1536 x speed x age [28]. Finally, participants were categorized as having a healthy or unhealthy CRF status according to the maximum oxygen uptake cut-off points [31]. The 20-meter shuttle run test has demonstrated adequate reliability and criterion-related validity among adolescents (e.g., ICC = 0.89; r_p = 0.78) [28,32].

Physical activity. According to the procedure followed in previous studies [6] students' PA levels during the development and reinforced programs sessions were measured objectively by heart rate monitors and subjectively by a self-reported scale. In each research group, five students per class were randomly selected to wear a heart rate monitor (Polar RS300X, Finland). These five students were different in each session, for example, in the second session five students different from the first session wore the heart rate monitor, and so on until all students' work intensity of the same class were measured. Therefore, all students' PA was monitored about two or three times during the intervention period. Additionally, at the end of each PE session all the students reported their global perceived exertion using a pictorial perceived exertion scale (from 0 = ‘‘not tired at all’’ to 10 = ‘‘very, very tired’’). The pictorial perceived exertion scale has demonstrated adequate reliability and validity among adolescents (ICC = 0.95; *r* = 0.89) [33]. For the intensity control, rating of perceived exertion, average heart rate (expressed as beats per minute and percentage of estimated maximum heart rate), total PA (percentage of total time involved in an intensity equal to or over 50% of the estimated maximum heart rate), MVPA (percentage of total time involved in an intensity equal to or over 70% of the estimated maximum heart rate), and the achievement of the MVPA recommendation (at least 50% of time of the PE session in MVPA) were calculated.

2.7. Statistical analysis

Descriptive statistics (mean ± standard deviation/ error or percentage) for the general characteristics of the included participants and dependent variables were calculated. All the statistical tests' assumptions were first checked and met for each dependent variable by common procedures. It should be highlighted that despite the sample size being unbalanced between the experimental arms because of the availably of the classes in the present study, both graphic exploration and the Levene test showed that the homoscedasticity assumption was met. On the other hand, although in the present study the unit of intervention was the class (i.e., the independency of observations could be violated), the intra-class correlation coefficients (ICC, also known as intra-cluster correlation coefficients) showed empirical evidence of the independency of observations (ICC, CRF = 0.00-0.01; PA = 0.12-0.13; Wald Z, $p > 0.05$). Similarly, the results of the Runs test showed that the observations were independent and random ($p > 0.05$). Therefore, a General Linear Model procedure was followed [34]. After exploring if any recorded descriptive variable would contaminate in the analysis of variance (ANOVA) models (i.e., age, grade, gender, body mass, body height, body mass index, habitual PA, attendance and the pre-intervention scores of each particular variable), only those that showed a contamination effect were used as covariates. Chi-squared analyses were carried out to test the ratio differences of gender and grade between the three groups. A one-way ANOVA was conducted to examine potential differences between the three groups in all measured variables. Then, the effect of the development and reinforced programs on CRF was examined using a mixed two-way (3 x 3) analysis of covariance (ANCOVA), with the between-subjects factor *group* (CG, EG1, EG2) and the within-subjects factor *time* (pre-intervention, post-intervention and post-maintenance) as fixed effects, and gender/ attendance rate as covariates. The *post-hoc* with the Bonferroni adjustment was used for pairwise comparisons. The exacted McNemar's test was calculated in order to examine if the PE-based development program increased the proportion of students with a healthy CRF profile.

A one-way ANOVA (and a one-way ANCOVA with grade as covariance when the PA variables for the development program were analyzed) was used to compare the average obtained in the objective/perceived PA levels between the three groups. The *post-hoc* with the Bonferroni adjustment was used for the pairwise comparisons. Additionally, the chi-square test was calculated in order to compare the percentage of students that met the MVPA recommendation during the PE sessions in both the development and reinforced programs. Effect sizes were estimated using the partial eta squared (η^2_p) and Cohen's *d* for the overall and pairwise comparisons, respectively (except for the percentage of students that met the MVPA recommendation during the PE sessions where the Cramer's V was used) [35]. Finally, although all the statistical tests' assumptions were met, due to the fact that for practical issues the final sample was quite small, for the continuous variables the robust ANOVA (trimmed mean = 10%; bootstrap = 1,000 samples) [36] and non-parametric Kruskal-Wallis test followed by the Mann-Whitney U test (for the CRF variables the post-intervention – pre-intervention and post-maintenance – pre-intervention changes were used)

[35] were performed as sensitivity analyses (Supplementary Tables 3-4). All statistical analyses were performed using the SPSS Version 21.0 for Windows (IBM® SPSS® Statistics), except for the sensitivity analyses where the R Studio 3.6.1 for Windows (R Core Team) was used instead. The statistical significance level was set at $p < 0.05$.

3. Results

3.1. Final sample and general characteristics

Fig. 2 shows a flow chart corresponding to the participants included in the present study. Although all the invited 107 students (48.6% females) agreed to participate and met the inclusion criteria, finally 92 students (52 % females) satisfactorily passed the exclusion criteria and were analysed. No participant was lost because of the rejection to continue in the study or change of the school. Table 2 shows the general characteristics of the included participants and differences between the three groups. The three groups had an unbalanced representation of males and females ($p < 0.05$). Additionally, the EG2 students were taller in a statistically significant manner than those from the CG ($p < 0.01$). However, there were no statistically significant differences in terms of body mass, body mass index, habitual PA or CRF baseline between the three groups ($p > 0.05$). The EG1, EG2, and CG participants obtained an average attendance of 95%, 97%, and 89% in the development and reinforced programs, respectively.

Insert Figure 2 here

Insert Table 2 here

3.2. Cardiorespiratory fitness

Table 3 shows the effect of the PE-based development and reinforced programs on CRF levels. The results showed a significant interaction effect between the *group* and *time* variables for CRF levels ($p < 0.001$). Subsequently, both the EG1 and EG2 increased statistically significantly from pre-intervention to post-intervention ($p < 0.01$). However, while the EG2 retained the CRF levels with the reinforced program (post-intervention vs. post-maintenance, $p > 0.05$; pre-intervention vs. post-maintenance, $p < 0.001$), the EG1's values returned to the baseline (post-intervention vs. post-maintenance, $p < 0.001$; pre-intervention vs. post-maintenance, $p > 0.05$). For the CG no statistically significant differences were found ($p > 0.05$). Sensitivity analyses with both robust ANOVA and non-parametric tests found the same outcomes (Supplementary Table 3).

Insert Table 3 here

Moreover, results showed that for the EGs there was a statistically significant increase on the proportion of students with a healthy CRF level from pre-intervention to post-intervention (78% vs. 89%, respectively) ($p < 0.01$). However, for the CG statistically significant differences were not found ($p > 0.05$).

3.3. Physical activity

Overall statistically significant differences between the three groups ($p < 0.01$) are shown in Table 4 for the objective and perceived PA levels in the development and reinforced programs. Both the EG1 and EG2 had statistically significant higher PA levels during the development program than the CG ($p < 0.05$). However, statistically significant differences between the EG1 and EG2 were not found ($p > 0.05$). Moreover, the EG2 had statistically significant higher PA levels during the reinforced program than the CG and EG1 ($p < 0.01$), and there were no statistically significant differences between the CG and EG1 ($p > 0.05$). Sensitivity analyses with both robust ANOVA and non-parametric tests found the same outcomes (except for the robust ANOVA for the total PA during the development program that p was equal to 0.073) (Supplementary Table 4).

Insert Table 4 here

Regarding the percentage of students that met the recommendation (≥ 50% of the PE session time in MVPA) during the development program, there was a higher proportion of students that met this recommendation in the EG1 and EG2 than in the CG (53%, 63% and 5% respectively; $\chi^2 = 19.627$; $p < 0.001$; Cramer's V = 0.462). Regarding the reinforced program, there was a higher proportion of students that met this recommendation in the EG2 than in the CG and EG1 (50%, 5% and 0% respectively; $\chi^2 = 30.074$; $p < 0.001$; Cramer's V = 0.575).

4. Discussion

The main aim of the present study was to examine the effects of a PE-based reinforced program, through outdoor PA and body expression sessions, on CRF in secondary school students. Long-term physical fitness programs seem to be the best way to improve students' CRF levels [12]. However, several PE-based planning limitations such as the great volume of curricular contents that have to be delivered during the academic year, the limited curriculum time appointed to the PE subject, school holidays, or the heterogeneous levels of students [10,11], hindered the acquisition and maintenance of good CRF levels among students. Therefore, because physical fitness programs cannot last the whole academic year or a large part of it, short-term physical fitness programs need to be verified in the PE setting as a possible solution to the abovementioned PE limitations [10,11]. Results of the present study show that it is possible to significantly improve CRF in students with a PE-based physical fitness program performed twice a week for only nine weeks as shown by previous research [6,13]. Moreover, the present study showed an increase of the proportion of students with a healthy cardiorespiratory status after the development program according to the maximum oxygen uptake cut-off points [31].

However, previous studies found that after a detraining period, CRF gains were considerably reduced [14,15]. Therefore, the application of PE-based reinforced programs is necessary for maintaining the students' CRF levels during the rest of the academic year [16]. Likewise, other PE contents such as outdoor PA, body expression, or sports could be applied at the same time in order to help PE teachers to achieve the rest of the curriculum standards. For example, Mayorga-Vega et al. [13] found that a PE-based reinforced program carried out once a week during four weeks alternating physical fitness sessions with sports sessions, allowed students to maintain their previously acquired CRF levels. Nevertheless, in the aforementioned study, the reinforced program was carried out with physical fitness contents instead of through other PE contents such as in the present study. Consequently, the total amount of sessions delivered with physical fitness contents consumed too much time considering the limited time allocation for PE [10,11]. Thus, this kind of reinforced programs would interfere in the teaching of the rest of the PE curricular contents. Similar to the present study, Mayorga-Vega et al. [6] found that after a development physical fitness program (through sports contents) was effective in avoiding the loss of students' CRF previously acquired, as well as to develop other curricular contents such as sports at the same time. To our knowledge the present study is the first in which the students maintained their CRF levels through outdoor PA and body expression, which is, consequently, an important outcome for PE teachers. Therefore, this finding might help PE teachers to design programs that would allow for an effective and feasible development and maintenance of CRF during PE sessions, without neglecting other curricular contents and objectives.

Regarding the magnitude of the effects of the intervention, previous studies carried out with a short-term physical fitness development program found lower effects on CRF (d = 0.07-0.47, mean d = 0.26) [6,13,37] than in the present study (d = 0.47-0.64). Regarding the reinforced program, nevertheless, to our knowledge there are no previous studies examining the effect of a PE-based reinforced program through outdoor PA and body expression sessions. However, Mayorga-Vega et al. [6] carried out a reinforced program twice a week during nine weeks showing similar effects as in the present study after the reinforced program (d = -0.06 vs. d = 0.08).

Regarding the second aim of this study, it was to analyze the perceived and objective PA levels during the PE-based development and reinforced programs. The PE subject is considered to be a good opportunity for adolescents to contribute to achieving the daily MVPA levels recommended by the World Health Organization [38,39], due to it being a compulsory subject in the students' academic curriculum [11]. Results of the present study showed that the EGs achieved the recommendation of the Association for PE (at least 50% of the PE session time in MVPA) [5] during the development program. In addition, this amount of time was higher (53.7% to 59.5%) than in the CG (15.2%). However, during the reinforced program, EG2 students showed higher levels of MVPA (47.8%) than the EG1 (12.1%) and CG (17.4%). Likewise, Mayorga-Vega et al. [6] found similar MVPA levels during their intervention (57.6% to 59.3%).

Furthermore, in the present study, the proportion of students that complied with the recommended MVPA levels during the development program was 57% of the EG1 students, and 63% of the EG2 students; while during the reinforced program, only 50% of the EG2 students complied with this recommendation. However, the proportion of students who meet this recommendation is practically zero when the PE sessions are not specifically designed to achieve this goal [40]. Therefore, this is another good contribution of the present study to the PE subject, showing the achievement of 50% of the PE session time involved in MVPA through outdoor PA and body expression contents. Similar to the present study, in their systematic review of interventions with the objective to increase MVPA levels, Lonsdale et al. [8] found that there is only an increment of the time involved in MVPA during PE sessions when the intervention is specifically designed for that goal. Nevertheless, the average proportion of PE session time spent in MVPA (40.5%) is lower than recommended when a specific intervention for this purpose is not applied [7].

Regarding perceived PA, results showed that both EGs reported higher perceived PA levels than the CG during the development program. However, during the reinforced program, the EG2 reported higher perceived PA levels than the EG1 and CG, as only this group continued the emphasis on reaching a MVPA intensity during the sessions. Similar results were found in the study of Mayorga-Vega et al. [6]. Finally, the present study has shown similar results regarding the magnitude effects of the intervention to previous studies focused on the increment of MVPA levels during PE sessions (d = -0.30 to 1.90 vs. 0.13 to 2.81) [8].

Some limitations should be considered in the present study. The main limitation was that the loss in CRF after the detraining period was not checked for practical reasons, seeing as too many evaluations would suppose an excessive effort for students. However, EG1 was used to control and contrast what could happen without the reinforced program. The second limitation is that the study was not balanced by gender and grade/group sizes due to the nature of the study and the natural groups' availability, respectively. However, for the CRF and PA variables these potential confounders were statistically controlled when necessary. Additionally, sensitivity analyses with both robust ANOVA and non-parametric tests found the same outcomes. Future research studies should examine the effects of PE-based reinforced programs through other PE contents.

In conclusion, to our knowledge this is the first study that examines the effects of a short-term physical fitness program followed by a reinforced program through outdoor PA and body expression sessions in the PE setting. The results of the present study suggest that it is possible to maintain CRF through outdoor PA and body expression in a PE setting. Furthermore, another important outcome of the present study is the fact that the development and reinforced programs increased the perceived and objective PA levels, achieving the 50% of PE sessions time involved in MVPA levels recommended. Therefore, findings of this study might help PE teachers to design programs that would allow for an effective and more complete development of the total PE curriculum objectives.

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[Omitted for blind review]

Disclosure statement

The authors declare that they have no competing interest.

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Table 1 Scope and instructions given during the Physical Education-based development and reinforced programs for th

		Development program	
Control group	*Scope*	Technical learning of basketball and hockey	Alternative games
	Instructions	To focus attention on the learning of the technical gestures of basketball and hockey and to perform them correctly; Feedback centered on specific sport skills	To enjoy playing the g play in groups; To kno Feedback centered on g
Experimental group 1	*Scope*	Cardiorespiratory fitness work	Concepts and skills of o
	Instructions	To reach a moderate-to-vigorous intensity the greatest possible time of the Physical Education sessions (reaching the highest motor engagement time as possible); Feedback focused on active participation through delivering rewards and encouraging students to maintain a high intensity of physical activity	To learn concepts and expression; To work i physical activities and b
Experimental group 2	*Scope*	Cardiorespiratory fitness work	Cardiorespiratory fitnes physical activities and b

Instructions	To reach a moderate-to-vigorous intensity the greatest possible amount of time during the Physical Education sessions; (reaching the highest motor engagement time as possible); Feedback focused on active participation through delivering rewards and encouraging students to maintain a high intensity of physical activity	To reach a moderate activities; To learn con and body expression; centered on outdoor ph together with encourag physical activity

Table 2 General characteristics of the included participants and differences between the three groups.

	Total (n = 92)	CG (n = 19)	EG1 (n = 34)	EG2 (n = 39)	p^a
Age (years)	12.4 (0.7)	11.8 (0.7)	12.5 (0.7)	12.5 (0.7)	-
Grade (7th/8th)	55/ 45	100/ 0	41/ 59	46/ 54	< 0.001
Gender (males/females)	48/ 52	47/ 53	68/ 32	39/ 62	0.045
Body mass (kg)	48.8 (10.6)	49.5 (9.9)	46.8 (7.5)	50.2 (12.9)	0.377
Body height (cm)	148.7 (7.6)	144.9 (6.0)	147.6 (7.4)	151.5 (7.5)**	0.004
Body mass index (kg/ m^2)	21.9 (3.7)	23.5 (4.1)	21.4 (2.8)	21.6 (4.1)	0.120
Habitual PA (days/week)	3.2 (1.8)	2.7 (1.5)	3.7 (2.0)	2.9 (1.7)	0.056
20-m shuttle run test (s)[b]	295.0 (118.4)	253.0 (119.7)	326.6 (104.4)	287.8 (124.6)	0.083
VO_2max (ml/kg/min)[b]	43.5 (5.0)	42.5 (5.4)	44.6 (4.3)	43.1 (5.4)	0.271

Note. Data are reported as mean (standard deviation) or percentage; CG = Control group; EG1 = Experimental group 1; EG2 = Experimental group 2; PA = Physical activity; VO_2max = Maximum oxygen uptake.

[a] Significance level from the one-way analysis of variance and the chi squared test for the continous and categorical variables, respectively. [b] Pre-intervention values.

**p < 0.01 in the pairwise comparison with Bonferroni adjustment between the CG and EG2.

Table 3 Effect of the Physical Education-based development and reinforced programs on cardiorespiratory fitness.

	Pre-intervention (1)	Post-intervention (2)	Post-maintenance (3)	Two-way ANCOVA[a]		
	M (SE)	M (SE)	M (SE)	*F*	*p*	η^2_p
20-m shuttle run test (s)				11.926	< 0.001	0.21
CG (*n* = 19)	244.9 (26.3)	231.9 (28.6)	232.1 (28.0)			
EG1 (*n* = 34)	313.5 (18.9)	348.2 (20.6)**	288.2 (20.1)†††			
EG2 (*n* = 39)	303.2 (17.9)	361.7 (19.4)***	355.6 (19.0)***			
VO_2 max (ml/ kg/ min)				9.962	< 0.001	0.18
CG (*n* = 19)	42.4 (1.1)	41.8 (1.2)	41.6 (1.2)			
EG1 (*n* = 34)	43.9 (0.8)	45.6 (0.9)**	42.9 (0.9)†††			
EG2 (*n* = 39)	43.7 (0.8)	46.2 (0.8)***	46.0 (0.8)***			

Note. M = Mean adjusted by the gender and attendance rate covariables; SE = standard error; CG = Control group; EG1 = Experimental gro

[a] Two-way analysis of covariance (with gender and attendance rate as covariables) with the *post hoc* analysis with Bonferroni adjustment: C

to post-development/ post-maintenance (***p* < 0.01, ****p* < 0.001) and from post-development to post-maintenance (†††*p* < 0.01).

Table 4 Comparison of perceived and objective physical activity levels during the Physical Education-based

between the three groups.

	CG	EG1	EG2	One-way ANOVA[a]		
	(n = 19)	(n = 34)	(n = 39)	F	p	η
Development program						
RPE	2.3 (0.2)	5.7 (0.2)***	5.4 (0.2)***	67.289	< 0.001	0.6
Heart rate-average (bpm)	120.4 (3.4)	142.6 (2.3)***	149.0 (2.2)***	24.418	< 0.001	0.3
Heart rate-average (%)	60.3 (1.7)	71.5 (1.2)***	74.7 (1.1)***	24.529	< 0.001	0.3
Total PA (%)	75.3 (3.7)	89.1 (2.6)*	88.5 (2.4)*	4.933	0.009	0.1
MVPA (%)	22.6 (4.3)	51.3 (3.0)***	58.0 (2.7)***	23.433	< 0.001	0.3
Reinforced program						
RPE	2.8 (0.3)	2.5 (0.2)†††	5.0 (0.2) ***	44.337	< 0.001	0.5
Heart rate-average (bpm)	115.4 (3.3)	111.1 (2.5) †††	141.2 (2.3)***	43.875	< 0.001	0.4
Heart rate-average (%)	57.7 (1.7)	55.7 (1.2) †††	70.8 (1.2)***	44.657	< 0.001	0.5
Total PA (%)	62.9 (5.5)	62.7 (4.1) †††	85.6 (3.9)**	10.189	< 0.001	0.1
MVPA (%)	17.4 (3.7)	12.1 (2.8)†††	47.8 (2.6)***	48.138	< 0.001	0.5

Note. Data are reported as mean/ mean adjusted by the covariable grade in the development program (standard error); CG = Contro

Experimental group 2. RPE = Rating of perceived exertion; Total PA = Total physical activity; MVPA = Moderate-to-vigorous physic

[a] One-way analysis of variance (and analysis of covariance with the covariance grade for all the variables in the development progra

adjustment: Difference statistically significant between the CG and EG1/ EG2 (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$) and EG1 and EG

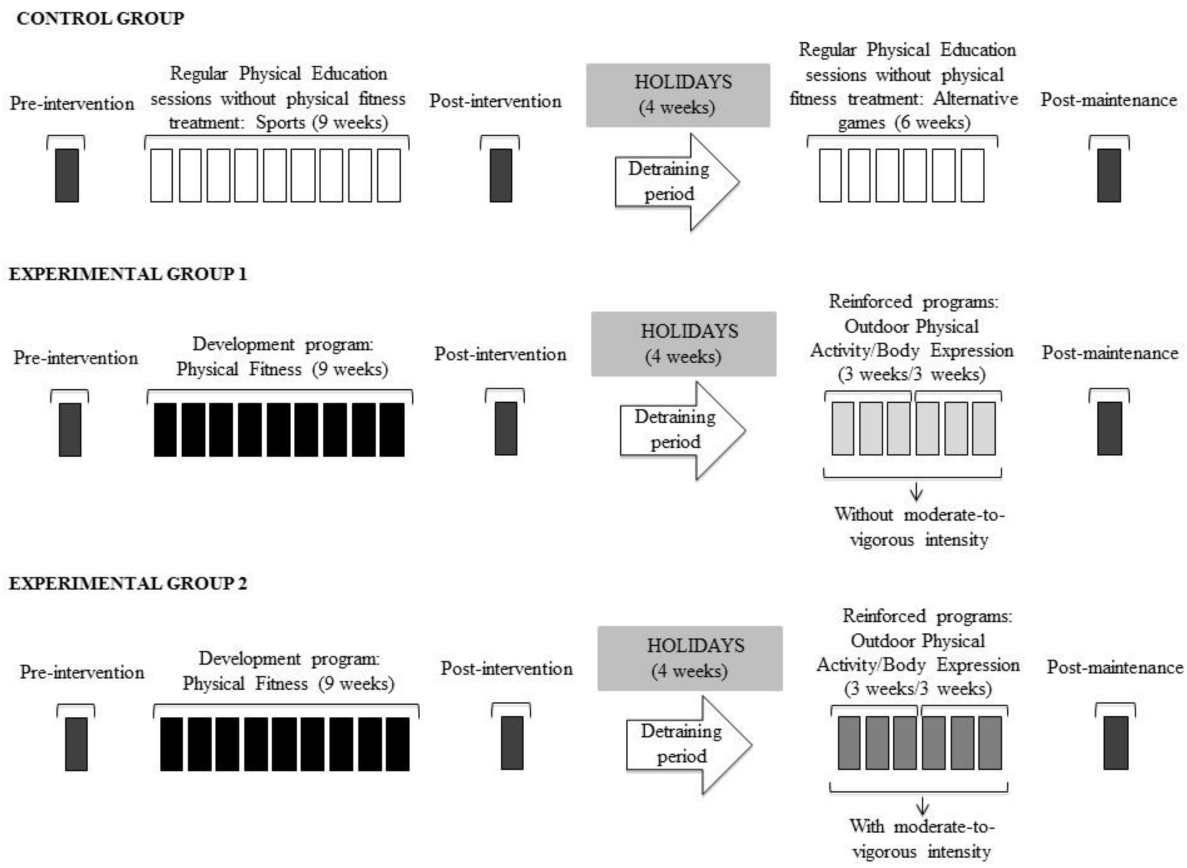

Figure 1 General scheme of the intervention.

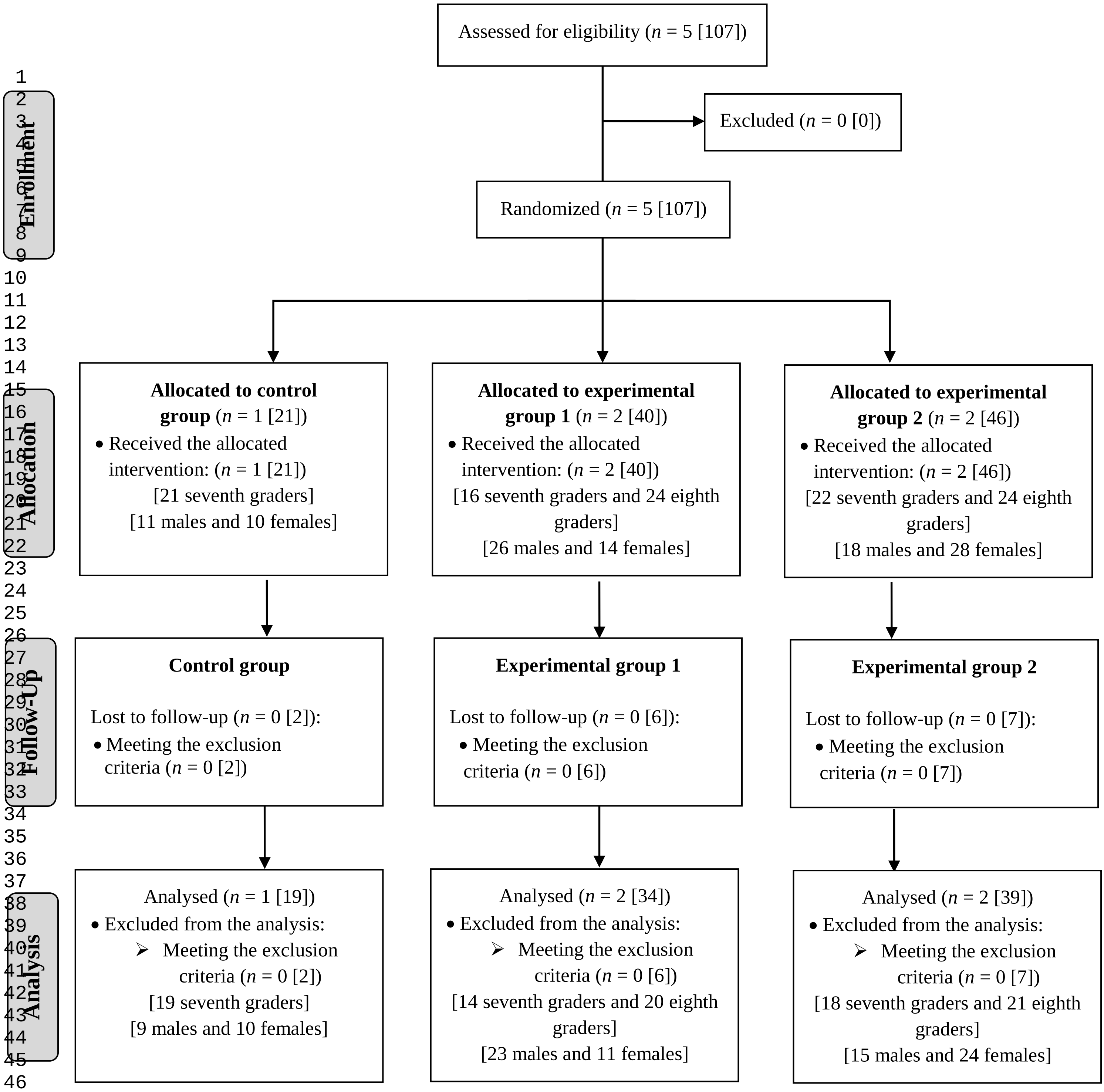

Figure 2 Flow chart of the school classes and students of the present study. All numbers are school classes [students].

Supplementary Table 1

Main part of the sessions during the Physical Education-based developmental programs of the three groups

Sessions	Experimental groups 1 and 2	
1	- 25 minutes: Four series of five minutes of continuous running with a rest of one minute between series. - 10 minutes: 10 team passing game.	- 25 minutes: Ball dribbling e hands). - 10 minutes: Ball dribbling g
2	- 25 minutes: Circuit-training: Push-ups, squats, abs, skipping, zig-zags between cones, heels to the buttocks, lateral race between cones, and skipping rope. 30 seconds of work in each station plus 20 seconds of rest between stations. Between circuits there was a rest of one minute. - 10 minutes: Team relay races.	- 25 minutes: Ball dribbling e circuit marked with cones). - 10 minutes: Ball dribbling g game).
3	- Continuous run during seven minutes. - 18 minutes: Five series of two minutes and a half of individual skipping rope. One minute of rest between series. - 10 minutes: Dodgeball game with one ball.	- 25 minutes: Stationary pass overhead pass, baseball pas - 10 minutes: Star game with
4	- 23 minutes: Five series of three minutes of sprints with two minutes of	- 25 minutes: Active passing

		rest between series.		overhead pass, baseball pas
	-	12 minutes: Ultimate game.	-	10 minutes: Star game with
5	-	20 minutes: Fartlek with rhythm changes.	-	25 minutes: Stationary thro
	-	15 minutes: Colpbol game (a Spanish invasion game composed of two teams of seven players where points are achieved by hitting a ball with the hand and introducing it in the goal).	-	10 minutes: KO game.
6	-	25 minutes: Three series of seven and a half minutes of continuous running with a one minute rest between series.	-	25 minutes: Active throwin
			-	10 minutes: Game of 3 on 3
	-	10 minutes: Game of tag in pairs.		
7	-	25 minutes: Circuit-training: Squats, abs, lateral race between cones, high knee bench toe touches, jumping jacks, zig-zag between cones, skipping rope, and burpees. 30 seconds of work in each station plus 20 seconds of rest between stations. Between circuits there was a one minute rest.	-	35 minutes: Review session (e.g., dribbling, passing, an
	-	10 minutes: 10 team passing game with a rugby ball.		
8	-	20 minutes: Six series of two and a half minutes of individual skipping rope. One minute of rest between series.	-	35 minutes: Competition of basketball aspects learned d

	- 15 minutes: Dodgeball game with two balls.	passes, the handkerchief wi
9	- 25 minutes: Five series of three minutes of sprints with two minutes of rest. - 10 minutes: Ultimate game.	- 25 minutes: Ball dribbling e between two lines marked w - 10 minutes: Ball driving ga the stick).
10	- 25 minutes: Fartlek with different terrains (steps and slopes). - 10 minutes: Colpbol game.	- 25 minutes: Ball driving ex following a circuit marked - 10 minutes: Ball driving ga
11	- 25 minutes: Two series of twelve minutes of continuous running with a rest of two minute between series. - 10 minutes: Matball game.	- 25 minutes: Stationary pass pairs changing the pass dist - 10 minutes: Precision game
12	- 25 minutes: Circuit-training: Climbers punches, lateral race between cones, high knee bench toe touches, heels to the buttocks, jumping jacks, zig-zag between cones, skipping rope, and burpees. 30 seconds of work in each station plus 20 seconds of rest between stations. Between circuits there was a rest of one minute. - 10 minutes: Game of cops and robbers.	- 25 minutes: Active pass and pairs performing a pick and - 10 minutes: Precision game objective with cones).

13	- 23 minutes: Six series of three minutes of individual skipping rope. One minute of rest between series. - 12 minutes: Team relay races.	- 25 minutes: Shooting exerc point shooting to the goal). - 10 minutes: Game of 2 on 2
14	- 30 minutes: Continuous run test. - 10 minutes: Matball game.	- 25 minutes: Shooting exerc pick and roll, and from a m the ball to the goal). - 10 minutes: Game of 3 on 3
15	- 25 minutes: Fartlek with rhythm changes and different terrains (steps and slopes). - 10 minutes: Ultimate game.	- 35 minutes: Review session driving, passes, and shootin
16	- 35 minutes: Body combat.	- 35 minutes: Competition of hockey aspects learned duri 4 on 4).

Supplementary Table 2

Supplementary Table 2

Main part of the sessions during the Physical Education-based reinforced programs of the three groups

Sessions	Experimental group 1	Experimental group 2	
1	- 20 minutes: Hide and Seek with groups of five. - 15 minutes: Tug of war game in groups of five.	- 20 minutes: Cops and robbers game in pairs. - 15 minutes: Dodgeball game with four balls.	-
2	- 20 minutes: In groups of four, students had to find the clues that the teacher proposed for them (e.g., a symbol painted in the wall of the school center). There was no time limit to find the clues. - 15 minutes: Parachute game.	- 20 minutes: In groups of four, students had to find the clues that the teacher proposed for them (e.g., a symbol painted in the wall of the school center). There was a time limit to find the clues. - 15 minutes: Flag catch game per groups.	-
3	- 20 minutes: In pairs, students had to find the clues that the teacher proposed for them (e.g., specific element of the school center). There was no time limit to find the clues.	- 20 minutes: In pairs, students had to find the clues that the teacher proposed for them (e.g., specific element of the school center). There was a time limit to find the clues.	-

	-	15 minutes: Knotting game.	-	15 minutes: Team relay races.	
4	-	35 minutes: Individual orientation race without a limited time to find the clues. Each student had a different map. Students had to find different figures inside envelopes in various places around the school center.	-	35 minutes: Individual orientation race with a limited time to find the clues. Each student had a different map. Students had to find different figures inside envelopes in various places around the school center.	-
5	-	35 minutes: Individual orientation race without a limited time to find the clues. Each student had a different map. Students had to find different words of a same sentence inside envelopes in various places around the school center.	-	35 minutes: Individual orientation race with a limited time to find the clues. Each student had a different map. Students had to find different words of a same sentence inside envelopes in various places around the school center.	-
6	-	35 minutes: Individual orientation race without a limited time to find the clues. Each student had a different map. Students had to find different elements of the school center indicated on the map.	-	35 minutes: Individual orientation race with a limited time to find the clues. Each student had a different map. Students had to find different elements of the school center indicated on the map.	-

7	-	35 minutes: Short story presentations in groups of five. The teacher gave the students a card with a story they had to present. They were then given a small amount of time to prepare before presenting it.	-	35 minutes: Zumba choreographies with different songs (approximately three and a half minutes each song). Between songs there was a two minute rest.	-
8	-	35 minutes: Learning and implementation of different individual and pair figures of acrosport.	-	35 minutes: Zumba choreographies with different songs (approximately three and a half minutes each song). Between songs there was a two minute rest.	-
9	-	35 minutes: Learning and implementation of different group figures of acrosport.	-	35 minutes: Zumba choreographies with different songs (approximately three and a half minutes each song). Between songs there was a one and a half minute rest.	-
10	-	35 minutes: Creation of an acrosport choreography in groups of eleven-twelve components.	-	35 minutes: Zumba choreographies with different songs (approximately three and a half minutes each song). Between songs there was a one and a half minute rest.	-

11	-	35 minutes: Creation of an acrosport choreography in groups of eleven-twelve components.	-	35 minutes: Zumba choreographies with different songs (approximately three and a half minutes each song). Between songs there was a one minute rest.	-
12	-	35 minutes: Review and presentation of the different acrosport choreographies.	-	35 minutes: Zumba choreographies with different songs (approximately three and a half minutes each song). Between songs there was a one minute rest.	-

Supplementary Table 3

Effect of the Physical Education-based development and reinforced programs on cardiorespiratory fitness using sen

	Pre-intervention (1)	Post-intervention (2)	Post-maintenance (3)	Robust two-way ANOVA[a]			Kru
	M (SE)	M (SE)	M (SE)	*F*	*p*	Comp.	*H*
20-m shuttle run test (s)				11.798	< 0.001	Overall	22.
CG (*n* = 19)	239.4 (19.1)	212.7 (19.5)	204.4 (20.1)			EG1-CG	3.
EG1 (*n* = 34)	328.3 (15.0)	365.0 (16.8)*	310.4 (18.3)†			EG2-CG	4.
EG2 (*n* = 39)	281.3 (17.8)	344.5 (19.3)*	338.0 (19.4)*			EG2-EG1	1.
VO_2 max (ml/ kg/ min)				8.047	< 0.001	Overall	17.
CG (*n* = 19)	41.8 (0.9)	40.7 (0.9)	40.4 (0.9)			EG1-CG	3.
EG1 (*n* = 34)	44.5 (0.6)	46.5 (0.7)*	44.0 (0.8)†			EG2-CG	4.
EG2 (*n* = 39)	42.9 (0.7)	45.7 (0.8)*	45.5 (0.8)*			EG2-EG1	0.

Note. M = 10% trimmed mean; SE = 10% trimmed standard error; CG = Control group; EG1 = Experimental group 1; EG2 = Experimental

[a] Robust two-way mixed analysis of variance using trimmed means. *Post hoc* analysis: Change statistically significant from pre-interventio

0.05) and from post-development to post-maintenance (†$p < 0.05$). [b] Kruskal-Wallis test (overall, statistical significance level: $p < 0.05$) fol

comparisons (statistical significance level: $p < 0.017$).

Supplementary Table 4

Supplementary Table 4

Comparison of perceived and objective physical activity levels during the Physical Education-based

programs between the three groups using sensitivity analyses

	CG	EG1	EG2	Robust one-way ANC	
	(*n* = 19)	(*n* = 34)	(*n* = 39)	*F*	*p*
Development program					
RPE	1.9 (0.1)	5.8 (0.2)***	5.5 (0.1)***	141.197	< 0.0
Heart rate-average (bpm)	115.3 (2.7)	145.1 (2.1)***	150.9 (1.6)***	40.694	< 0.0
Heart rate-average (%)	57.7 (1.3)	72.7 (1.1)***	75.7 (0.8)***	41.220	< 0.0
Total PA (%)	77.6 (4.5)	91.4 (1.0)**[c]	90.2 (1.4)*[d]	3.175	0.0
MVPA (%)	12.7 (2.8)	54.6 (3.1)***	59.9 (2.1)***	47.054	< 0.0
Reinforced program					
RPE	2.7 (0.3)	2.4 (0.2)	4.8 (0.1)***/†††	36.978	< 0.0
Heart rate-average (bpm)	114.9 (3.3)	111.1 (1.8)	140.6 (1.4)***/†††	49.740	< 0.0

Heart rate-average (%)	57.5 (1.6)	55.7 (0.9)	70.5 (0.7)***/†††	50.423	< 0.0
Total PA (%)	64.4 (7.4)	64.1 (4.1)	87.3 (1.9)*/†††	10.567	< 0.0
MVPA (%)	14.3 (2.5)	9.9 (1.5)	47.6 (2.6)***/†††	51.232	< 0.0

Note. Data are reported as 10% trimmed mean (10% trimmed standard error); CG = Control group; EG1 = Experimental grou

RPE = Rating of perceived exertion; Total PA = Total physical activity; MVPA = Moderate-to-vigorous physical activity.

[a] Bootstrap version of the heteroscedastic one-way analysis of variance for trimmed means. *Post hoc* analysis: Difference statis and EG1/ EG2 (*$p < 0.05$, ***$p < 0.001$) and EG1 and EG2 (†††$p < 0.001$). [b] Kruskal-Wallis test (overall, statistical significan Mann-Whitney U test for the pairwise comparisons (statistical significance level: $p < 0.017$; pairwise comparisons showe ANOVA, except otherwise it is pointed out: [c] $p < 0.017$, [d] $p > 0.017$).

Paper III

EFFECT OF INSIDE-OUTSIDE SCHOOL ALTERNATED TEACHING UNITS ON KNOWLEDGE OF THE ENVIRONMENT FOR PHYSICAL CONDITIONING AND RELATED PSYCHOLOGICAL OUTCOMES IN THE PHYSICAL EDUCATION SETTING: A CLUSTER RANDOMIZED CONTROL TRIAL

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European Physical Education Review

Submited

Effect of inside-outside school alternated teaching units on knowledge of the environment for physical conditioning and related psychological outcomes in the Physical Education setting: A cluster randomized control trial

Journal:	*European Physical Education Review*
Manuscript ID	Draft
Manuscript Type:	Original Manuscript
Keywords:	Innovative program, indoor-outdoor, physical fitness, high school students, learning, autonomy

Abstract:	The main aim was to examine the effect of inside-outside alternated teaching units on students' environmental knowledge for physical conditioning outside of school, their perceptions of barriers, autonomy support, and motivation towards physical activity (PA). A secondary aim was to examine the effect of alternated teaching units on students' intention to be physically active, their habitual and extracurricular PA, and the regular use of their environment for practicing PA in the Physical Education setting. One hundred and forty-six high school students (50% females) aged 11-15 years old participated in the study. Six pre-established classes, balanced by grade, were cluster-randomly assigned into the alternated group (n = 75) or traditional group (n = 71). The alternated group students performed two fitness-based teaching units twice a week for four weeks, alternating lessons inside and outside the school. Meanwhile, the traditional group students performed a fitness teaching unit solely having lessons inside the school center. All variables were measured before and after the intervention by validated questionnaires. Results of the Multilevel Linear Model showed that the alternated teaching units improved students' knowledge of their environment for physical conditioning, autonomy support, and autonomous motivation toward PA, as well as decreased perceived barriers ($p < 0.05$; $d = -0.35-1.42$), while the rest of variables were not affected ($p > 0.05$). In conclusion, short-term inside-outside school alternated teaching units improve students' key predisposition variables of habitual PA, but not the practice in itself. Some ideas are discussed in order to improve future Physical Education programs.

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Effect of inside-outside school alternated teaching units on knowledge of the environment for physical conditioning and related psychological outcomes in the Physical Education setting: A cluster randomized control trial

For Peer Review

Abstract

The main aim was to examine the effect of inside-outside alternated teaching units on students' environmental knowledge for physical conditioning outside of school, their perceptions of barriers, autonomy support, and motivation towards physical activity (PA). A secondary aim was to examine the effect of alternated teaching units on students' intention to be physically active, their habitual and extracurricular PA, and the regular use of their environment for practicing PA in the Physical Education setting. One hundred and forty-six high school students (50% females) aged 11-15 years old participated in the study. Six pre-established classes, balanced by grade, were cluster-randomly assigned into the alternated group (n = 75) or traditional group (n = 71). The alternated group students performed two fitness-based teaching units twice a week for four weeks, alternating lessons inside and outside the school. Meanwhile, the traditional group students performed a fitness teaching unit solely having lessons inside the school center. All variables were measured before and after the intervention by validated questionnaires. Results of the Multilevel Linear Model showed that the alternated teaching units improved students' knowledge of their environment for physical conditioning, autonomy support, and autonomous motivation toward PA, as well as decreased perceived barriers ($p < 0.05$; d = -0.35-1.42), while the rest of variables were not affected ($p > 0.05$). In conclusion, short-term inside-outside school alternated teaching units improve students' key predisposition variables of habitual PA, but not the practice in itself. Some ideas are discussed in order to improve future Physical Education programs.

Keywords: Innovative program, indoor-outdoor, physical fitness, high school students, learning, autonomy

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Introduction

Physical fitness is considered a powerful health marker among adolescents (Tomkinson et al., 2016). During adolescence, higher levels of physical fitness are positively associated with better quality of life and mental health (Eddolls et al., 2018). Unfortunately, adolescents' physical fitness has been declining during the last decades (Tomkinson et al., 2019), becoming a global problem which affects, on average, 46% of female and 33% of male adolescents (Tomkinson et al., 2016). Worldwide, more than 80% of adolescents do not meet the daily physical activity (PA) recommendation (Guthold et al., 2020).This is why, PA is considered a key element for improving physical fitness (Lang et al., 2016), and consequently, the promotion of better physical fitness levels through an increment in adolescents' PA levels is a priority public health objective (World Health Organization, 2018).

Schools, and specifically the Physical Education (PE) subject, is considered an ideal context to acquire healthy physical fitness levels through the promotion of health-enhancing PA levels (World Health Organization, 2018). In fact, one of the main PE national standards worldwide is the acquisition of healthy physical fitness levels, as well as the promotion of lifelong PA to maintain them (European Commission/EACEA/Eurydice, 2013; SHAPE America, 2013). Due to the low weekly frequency of the subject (Hardman et al., 2014) it is not possible to achieve the daily PA recommendations only in the PE setting, therefore, the promotion of students' PA in the out-of-school setting is key. In this sense, national standards also consider transferring the learning from the classroom to students' daily life is another priority objective of PE (European Commission/EACEA/Eurydice, 2013; SHAPE America, 2013). Therefore, in order to work in this direction, the implementation of effective PA interventions in the PE setting requires an understanding of the determinant factors that influence students' PA behavior (Sheeran et al., 2017).

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PE teachers play an important role providing students with tools to become competent in practicing PA autonomously (Viciana and Mayorga-Vega, 2018). The Social Cognitive Theory (Bandura, 2004) postulates that health-related fitness knowledge (e.g., fitness and PA knowledge) is a core determinant on the design of PA interventions in order to promote an improvement in physical fitness. This knowledge, which can be easily acquired by students, represents the first step toward generating a behavior change (Bandura, 2004). Demetriou et al. (2015) found that school-based PA interventions can improve students' health-related fitness knowledge levels, and the acquisition of this knowledge may lead to a change in students' out-of-school PA (Ennis, 2015; Wang and Chen, 2020). Additionally, transferring this learning from the classroom to students' daily life would make students even more autonomous in their PA practice in the out-of-school time (Viciana and Mayorga-Vega, 2018). For instance, the transferability of learning could consist of teaching students how to use the environment that surrounds the school center and their particular community providing them authentic and situational PA practices (Viciana and Mayorga-Vega, 2018). This transference of learning could be achieved through the application of alternated teaching units (Viciana and Mayorga-Vega, 2016). The alternated teaching units method is an innovative teaching proposal that consists of implementing two teaching units with complementary contents while making students aware that both contents are based on the same learning's principles, avoiding, therefore, the unconnected learning perceived by students in traditional and isolated teaching units (Viciana and Mayorga-Vega, 2016). Consequently, PE teachers could connect in-school physical fitness work (inside the school) with one that could be practiced in the immediate environment (outside the school), facilitating students a tool for developing and maintaining their physical fitness levels autonomously in their out-of-school time (Ferkel et al., 2014). According to the Theory of Expanded, Extended, and Enhanced Opportunities, this mechanism for promoting students'

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PA is called expansion, and is defined as the introduction of an entirely new PA opportunity (Beets et al., 2016). Additionally, this learning may help students to solve perceived barriers toward the PA practice such as the lack of facilities (Niñerola et al., 2006), which have been shown to be associated with a higher prevalence of physical inactivity during their leisure-time (Dias et al., 2015).

Furthermore, the teaching style used by the PE teacher is another key determinant factor that can also have important consequences for students' PA behavior, determining their motivation toward PA, as well as their interest in remaining active in the out-of-school setting (Sevil-Serrano et al., 2020). The Self-Determination Theory (SDT, Deci and Ryan, 1985) postulates that autonomy support is an important factor for encouraging higher levels of autonomous motivation. The autonomy-supportive teaching style is characterized by making students feel that they can participate in their own learning (Ryan and Deci, 2020). For example, providing students the opportunity of having a choice, different opportunities to do PA, promoting the sense of initiative, considering their opinions about PA practice, or justifying the aim of the tasks (Ryan and Deci, 2020). Previous studies in the PE setting have shown that autonomy-supportive teaching styles are effective for improving students' self-determined motivation toward PA, as well as their intention to continuous practicing of PA out-of-school (Cheon and Reeve, 2013; Yli-Piipari et al., 2018). Therefore, in addition to the effectiveness shown by autonomy-supportive settings in PE for promoting students' PA practice out-of-school (Cheon and Reeve, 2013; Yli-Piipari et al., 2018), the improvement of students' knowledge of the possibilities offered by the environment for PA practice during the out-of-school time might be a key tool in continuing the autonomous development and maintenance of physical fitness levels (Ferkel et al., 2014; Wang and Chen, 2020). Unfortunately, to the best of our knowledge, no previous studies have examined the effect of two alternated teaching units on the environmental knowledge for the development and

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maintenance of physical fitness, perceived barriers toward PA practice, motivation, and PA participation transferred from the PE class to real-life settings. Consequently, the main aim of the present study was to examine the effect of two PE-based inside-outside alternated teaching units on students' knowledge of their environment for physical conditioning in the out-of-school time, their perceived barriers toward the PA practice, teacher autonomy support, and self-determined motivation towards PA. A secondary aim of this study was to examine the effect of two PE-based inside-outside alternated teaching units on students' intention to be physically active, their habitual and extracurricular PA, and the regular use of their environment for practicing PA.

Method

Study design

The present study is reported according to the CONSORT for cluster randomized trials guidelines (Campbell et al., 2012). The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013) and it was approved by the Ethical Committee for Human Studies at the University of [omitted]. Recruitment of participants was carried out in June of 2019, and the intervention was done from September 2019 to December 2019. For practical reasons and due to the nature of the present study (i.e., pre-established classes in a school setting), a cluster randomized controlled trial design was used (Guijarro-Romero et al., 2020a). This study was non-blinded (treatments were not masked from the students or teacher), parallel-grouped (study with two different treatments; Spieth et al., 2016), and had two evaluation phases. However, although the study treatments could not be blinded, none of the participants, regardless of the study group to which they belonged, were informed of the specific objective of the study to prevent subject-expectancy effects on study outcomes.

Participants

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The principal and the PE teachers of a state high-school center in the city of [omitted] chosen by convenience were contacted and informed about the study, requesting its permission to conduct it. After obtaining the approval to carry out the present study, all 146 students (50% female) from the seventh to ninth grades of secondary education (i.e., aged 11–15 years old) were invited to participate in it. Adolescents and their legal tutors were fully informed about the study features. Participants' signed written informed assent and their legal tutors' signed written informed consent were obtained before taking part in the study. According to the center's reports, all of the students' families had a middle class socioeconomic level.

The inclusion criteria were: a) being enrolled in the seventh to ninth grade at the secondary education level (grades in which approval of the school was obtained); b) participating in the normal PE classes; c) being exempt of any health problem that would make them unable to engage in PA normally; d) presenting the corresponding signed written consent by their legal tutors, and e) presenting their own corresponding signed written assent. The exclusion criterion was defined as not having performed the evaluation of the dependent variables correctly at the beginning and/or at the end of the intervention program following the administration rules (being removed only for incomplete variables and not for the overall study).

Sample size

A priori sample size calculation was estimated with the Optimal Design Plus Empirical Evidence Software Version 3.01 for Windows. Parameters were set as follows: significance level $\alpha = 0.05$, number of participants per cluster $n = 25$, effect size $\delta = 0.50$, intra-class correlation coefficient $\rho = 0.01$, and statistical power $(1 - \beta) = 0.80$. A total number of six clusters was estimated.

Randomization

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Randomization was conducted at the class-level, using a computerized random number generator, even though the school center had already assigned the students randomly and balanced by gender to each class, before starting the scholar year. This was done before the pre-intervention evaluation was administered, and the six pre-established classes (i.e., two 7th, two 8th and two 9th grade classses) were randomly assigned, balanced by grade, by an independent researcher blinded to the study aim, and following a 1:1 ratio into the traditional group (TG) or alternated group (AG).

Intervention

Figure 1 shows the general scheme of the intervention. Before the intervention, the PE teacher (16 years of experience) responsible for teaching all of the control and experimental lessons received two teacher-training sessions regarding the specific features of the teaching units. Both teaching units were carefully designed by the research group, providing guidelines to the PE teacher for correctly delivering the lessons. The main researcher supervised all the lessons and made sure all guidelines were taken into account during the program (Table 1).

Table 1. Strategies applied during the intervention.

	Alternated Group	Traditional Group
Warm-up	-Implementation of low-to-moderate aerobic activities and joint mobility exercises is performed	
Main part	-Interrogative feedbacks are given with the aim of making students reflect on the similarities between the elements of inside-outside contexts regarding the work of endurance and strength	-Instructional feedbacks are given regarding how to perform the endurance and strength exercises
	-Individualized tasks are given according to students' level	-No individualized tasks are given
	-Physical activity benefits are explained	-Physical activity benefits are not explained

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	-Daily physical activity habits are asked, empathizing and showing concern regarding students' difficulties for practicing physical activity outside the class	☐	-Daily physical activity habits are not asked	☐
	-References regarding the physical activity barriers are mentioned and solved	☐	-There are no references regarding physical activity barriers	☐
	-Improving fitness levels applying lesson tasks in the free time is encouraged	☐	-There are no references in regard to leisure time physical activity	☐
	-Music chosen by the students is used	☐	-No music is used	☐
Cool-down	-Interrogative feedbacks are given with the aim of making students reflect on the similarities between the elements of inside-outside contexts regarding the work of flexibility	☐	-Instructional feedbacks are given regarding how to perform the flexibility exercises	☐
	-Students are expressing themselves about what they think about the lesson	☐	-Students do not have the opportunity to express their thinking	☐

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Both TG and AG students carried out a physical fitness-based teaching unit twice a week for four weeks. Each PE lesson lasted approximately 50 minutes and consisted of the following parts: a 5-to-10-minute warm-up (performing low-to-moderate aerobic activities followed by some joint mobility); a 35-to-40-minute main part; and a five-minute cool-down (performing stretching exercises).

The AG students carried out two alternated teaching units (Viciana and Mayorga-Vega, 2016) for the work of inside and outside school physical fitness (specifically of the basic physical capacities of endurance, strength, and flexibility). It consisted of delivering one inside lesson (i.e., in school teaching unit, using conventional school facilities like a sports courts or a gym) followed by another outside lesson in the immediate environment (i.e., out-of-school teaching unit, using green zones, outside facilities and features, or a municipal sports center) during the whole program (four of each modality). The main part of the lessons was focused on the work of physical fitness (e.g., fartlek, continuous running, or circuit-training methods). During both in-school and out-of-school lessons of the same week, students worked the same contents (i.e., tasks and methods for working physical fitness). The main difference was the space and the material used in each of them. This teaching unit structure was developed with the purpose of establishing a learning transference from the PE class to the out-of-school context, making the immediate environment known to the students for the autonomous development and maintenance of their physical fitness. That is, during inside PE lessons, the teacher explained to students how they could do the same exercises in the out-of-school context using the elements of their immediate environment. In addition to the connection between inside-outside school contexts, the teaching methodology was focused on motivational strategies and support of students' autonomy in order to encourage PA participation through the increase of autonomous motivation (See Table 1; Teixeira et al., 2020; Wang and Chen, 2020).

Regarding the TG students, they received similar contents, lesson structure, and tasks as the AG. Similar to the AG, the main part of the lesson was focused on improving physical fitness. Nevertheless, unlike the AG, students only received in-school lessons using conventional school materials and facilities. Thus, no transference of learning from the PE context to the out-of-school context in the immediate environment was promoted. Moreover, the teaching methodology followed more of an instructional character (Metzler, 2017).

[insert Figure 1.]

Measures

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Prior to carrying out the intervention, general characteristics of the participants (i.e., age, grade, gender, body mass, and body height) were registered during one PE lesson. Body mass and body height were measured following the ISAK protocol (Stewart et al., 2011). Then, the body mass index was calculated as body mass divided by body height squared (kg/m2). Finally, students' body weight status was categorized by the body mass index thresholds (Cole et al., 2000).

Afterward, three PE lessons were used to administrate the knowledge test and questionnaires at the beginning (pre-intervention) and at the end of the teaching unit (post-intervention). Each evaluation was carried out by the same tester, instruments, protocols, and conditions. The students filled out the knowledge test and questionnaires in an ordinary classroom under silent conditions. Students were asked for their maximum sincerity, and they were guaranteed the confidentiality of the obtained data. Although instructions on how to correctly respond to the questionnaire were printed at the top, the researcher was present during the entire evaluation session to clarify any question that might arise. The measurement protocol followed with each variable is detailed below.

Knowledge of the environment for the practice of physical fitness test. Students' knowledge was measured through the Knowledge about the Environment for Physical Conditioning in schoolchildren test (CENAFI; Guijarro-Romero et al., 2020b). It consisted of 30 questions with four possible answers where only one was correct (e.g., "In which of the following spaces could you work endurance using a distance and terrain fartlek?"). The three knowledge dimensions (i.e., declarative, procedural, and causal) and contents were balanced (10 questions for each knowledge dimension: two about the basic physical capacity of endurance, four on strength and four on flexibility). The Spanish version of the CENAFI test has shown adequate reliability and validity among high-school students (ICC = 0.65;

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adequate difficulty and discrimination indices; discriminant validity, intervention vs. control: *p* < 0.001, *d* = 1.41) (Guijarro-Romero et al., 2020b).

Barriers toward physical activity. Students' perceived barriers toward PA practice were measured through the Spanish version of the Self-Perceived Barriers for Physical Activity (SPBPA) questionnaire (Niñerola et al., 2006). It consists of 17 items that measure specific barriers in PA in relation to four dimensions. Due to the purpose of the present study, only the environment and facilities dimension was used (e.g., "Being too far from the place where I can exercise"). The items were preceded by the sentence: "I do not usually do physical exercise because...". A 10-point Likert-type scale, ranging from 1 ("Low probability") to 10 ("High probability") was used in order to facilitate the evaluation of the items, making them similar to the qualifications that Spanish school-aged children receive in their scholar marks (Guijarro-Romero et al., 2020a). The Spanish version of the SPBPA has shown adequate psychometric properties among high school students (Cronbach's α = 0.69) (Niñerola et al., 2006).

Perceived autonomy support. The PE teacher autonomy-support was assessed through the Spanish version of the Perceived Autonomy Support Scale for Exercise Settings (PASSES, Moreno et al., 2008). It consists of 12 items (e.g., "My PE teacher understands why I decide to do physical exercise in my free time") that evaluate a single factor of autonomy support. The items were preceded by the sentence: "In my PE classes...". A 10-point Likert-type scale, ranging from 1 ("Totally disagree") to 10 ("Totally agree") was used. The Spanish version of PASSES has shown adequate psychometric properties among high-school students (CFI = 0.92; IFI = 0.92; TLI = 0.90; SRMR = 0.04; RMSEA = 0.08; Cronbach's α = 0.91) (Moreno et al., 2008).

Self-determined motivation towards physical activity. Students' motivation towards PA was measured using the Spanish version of the Behavioral Regulation in

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Exercise Questionnaire (BREQ-3, González-Cutre et al., 2010). It consists of 23 items (e.g., "Because it agrees with my way of life") distributed into six dimensions (intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation, and amotivation). The questionnaire was preceded by the sentence: "I do PA...". A 10-point Likert-type scale, ranging from 1 ("Not true for me") to 10 ("Very true for me") was used. The autonomous (i.e., averaging intrinsic, integrated, and identified regulation) and controlled (i.e., averaging introjected and external) motivations were also calculated (Chemolli and Gagné, 2014). The Spanish version of the BREQ-3 has shown adequate psychometric properties among high-school students (CFI = 0.91; IFI = 0.91; RMSEA = 0.06; SRMR = 0.06; Cronbach's α = 0.66-0.87) (González-Cutre et al., 2010).

Intention to be physically active. Students' intention to be physically active during their free time was measured using the Spanish version of the Intention to partake in leisure-time PA questionnaire (Granero-Gallegos et al., 2014). It is composed of three items. Due to the purpose of the study, the original items were slightly modified (e.g., "I intend to do physical exercise *using the urban environment* at least three times a week next month"). The items were preceded by the sentence: "In my free time, outside of high-school...". A 10-point Likert-type scale, ranging from 1 ("very unlikely") to 10 ("most likely") was used. The Spanish version of this questionnaire has shown adequate psychometric properties among high-school students (GFI = 1.00; RMR = 0.02; NFI = 1.00; NNFI = 0.99; CFI = 1.00; RMSEA = 0.03; Cronbach's α = 0.93; modified version: Cronbach's α = 0.94) (Granero-Gallegos et al., 2014).

Habitual physical activity. Students' habitual PA was measured using the Physician-based Assessment and Counseling for Exercise (PACE) questionnaire (Martínez-Gómez et al., 2009). It consists of two questions that measure how many days in the last week (PACE 1, "In the last 7 days, how many days did you do physical activity for 60 minutes or more?)

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and in a habitual week (PACE 2, “In a normal week, how many days do you do physical activity for 60 minutes or more?) at least 60 minutes of PA are performed. A 7-point Likert-type scale, ranging from 0 to 7 was used. The PACE questionnaire has shown adequate convergent validity (accelerometer) among high-school students (r = 0.43) (Martínez-Gómez et al., 2009).

Extracurricular physical activity. Students’ extracurricular hours of PA practice were measured through the enKid questionnaire (Martínez-Gómez et al., 2009). It consists of one question: “How many hours do you spend on extracurricular sport activities weekly?”. A 7-point Likert-type scale, ranging from 0 to “more than 5” was used. The enKid questionnaire has shown convergent validity (accelerometer) properties among high-school students (r = 0.43) (Martínez-Gómez et al., 2009).

Habitual use of the environment for practicing physical activity. Students habitual use of the environment for practicing PA was measured using a modified version of the PACE questionnaire. It consists of two questions that measure how many days in the last week (“In the last 7 days, how many days did you use the nearby urban environment to practice PA autonomously?) and in a habitual week (“In a normal week, how many days do you use the nearby urban environment to practice PA autonomously?) the urban environment is used to practice PA autonomously. A 7-point Likert-type scale, ranging from 0 to 7 was used. Reliability of this questionnaire was adequate (Cronbach’s α = 0.87).

Statistical analysis

Descriptive statistics (mean ± standard deviation or percentage) for the general characteristics of the participants and dependent variables were calculated. Statistical test assumptions were checked and met by common procedures (e.g., histograms and normal Q-Q plots for normality). The one-way analyses of variance (ANOVA) (continuous variables) and the chi-squared test (categorical variables) were conducted to examine potential differences in terms

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of general characteristics between the two groups. The internal consistency of the dependent variables measured by the questionnaires was examined with the Cronbach's alpha.

All the participants were included in the statistical analyses regardless of adherence to the protocol (i.e., intention-to-treat approach). All the participants that did not follow protocol had failed to sustain a 100% attendance rate. Because the unit of intervention was the class, a Multilevel Linear Model (MLM) with participants nested within classes was selected (Li et al., 2017). According to Field's (2017) recommendation, the approach started from "basic" models in which all the parameters were fixed and then progressively more random coefficients and exploring confounding variables were followed. The maximum likelihood estimation method was used. The –2 log-likelihood was used to compare the models fit (i.e., comparing the change in the chi-square test). From all the potential confounding variables explored (i.e., gender, age, body mass, body height, body mass index, habitual PA, and intervention attendance), age was used as a covariable for declarative knowledge, extracurricular PA, and perceived barriers toward the environment/facilities; body height was used as covariable for controlled motivation; and habitual PA was used as covariable for habitual PA. Effect sizes were estimated using the Cohen's d for pairwise comparisons. Finally, although an intention-to-treat approach was followed in the present study, as a sensitivity analyses, all the above-mentioned analyses were also carried out with a per-protocol approach (i.e., including the participants, taking into consideration their adherence to the protocol, that is, eight lessons). All statistical analyses were performed using the SPSS version 25.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

Results

Final sample and general characteristics

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Figure 2 shows the flow chart of the participants included in the present study. All the invited 146 students (50.0% females) agreed to participate and satisfactorily met the inclusion and exclusion criteria. No participants were lost because of the rejection to continue in the study or change of school. Table 2 shows the general characteristics of the participants. The results of the one-way ANOVA and the chi-square test did not show statistically significant differences in terms of general characteristics between the two groups ($p > 0.05$). Regarding the attendance rate, the AG and TG participants obtained an average of 98.3% and 98.4%, respectively (overall = 98.4%). The results of the chi-square test did not show statistically significant differences on the percentage of students with attendance equal or not to 100% (i.e., 8 lessons) between the AG (92.0%) and TG (88.7%) ($\chi^2 = 0.449$, $p = 0.503$). In the sample of the present study, the internal consistency of all the dependent variables measured by dimensional questionnaires was above 0.70 (except for the knowledge test, $\alpha = 0.65$; controlled motivation, $\alpha = 0.53$; and environment/facilities perceived barriers, $\alpha = 0.54$).

Table 2. General characteristics of the participants and differences between the two groups.

	Total ($N = 146$)	Alternated ($n = 75$)	Traditional ($n = 71$)	F/χ^2	p^a
Age (years)	13.1 (1.0)	13.1 (1.0)	13.1 (1.0)	0.140	0.709
Gender (females/males)	50.0/50.0	48.0/52.0	52.1/47.9	0.247	0.619
Grade ($7^{th}/8^{th}/9^{th}$)	31.5/31.5/37.0	32.0/33.3/34.7	31.0/29.6/39.4	0.400	0.819
Body mass (kg)	52.9 (11.8)	52.8 (13.2)	52.9 (10.2)	0.001	0.977
Body height (cm)	160.6 (8.9)	160.3 (9.9)	160.9 (7.7)	0.181	0.672
Body mass index (kg/m^2)	20.4 (3.9)	20.4 (4.2)	20.4 (3.5)	0.002	0.961
Overweight-obese (no/yes)	78.1/21.9	77.3/22.7	78.9/21.1	0.051	0.822
Habitual PA (days/week)	3.2 (1.7)	3.3 (1.7)	3.1 (1.6)	0.255	0.615

Note. Continous variables (i.e., age, body mass, body height, body mass index, and habitual PA) are

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reported as mean (standard deviation) and categorical variables (i.e., gender, grade and overweight-obese) as percentage.

[a] Significance level from the one-way analysis of variance for continous variables and the chi squared test for categorical variables.

[insert Figure 2.]

Knowledge of the environment for the practice of physical fitness

Table 3 shows the effect of inside-outside alternated teaching units on students' knowledge of the environment for physical conditioning. The MLM results showed that the AG participants had a statistically significant improvement to their declarative, procedural, and overall knowledge compared with those from the TG (p < 0.01; d = 0.96-1.42). However, for the causal knowledge statistically significant difference were not found (p > 0.05).

Table 3. Effect of the inside-outside alternated teaching units on knowledge about their environment for physical conditioning.

Variable	Group	Pre-intervention	Post-intervention	Difference	Multilevel Lineal Model			ES
		M (SE)	M (SE)	M (SE)	-2LL	F	p	d
Declarative	Alternated	3.3 (0.2)	5.8 (0.2)	2.7 (0.2)	579.024	53.356	< 0.001	1.42
	Traditional	3.4 (0.2)	3.9 (0.2)	0.5 (0.2)				
Procedural	Alternated	4.5 (0.2)	6.4 (0.2)	1.9 (0.2)	625.155	21.198	< 0.001	0.96
	Traditional	4.7 (0.2)	5.0 (0.2)	0.3 (0.2)				
Causal	Alternated	4.0 (0.2)	5.7 (0.2)	1.7 (0.2)	614.946	2.175	0.188	0.32
	Traditional	3.3 (0.2)	4.4 (0.2)	1.2 (0.3)				
Overall	Alternated	11.8 (0.4)	17.9 (0.5)	6.0 (0.5)	792.307	34.155	0.001	1.24
	Traditional	11.4 (0.4)	13.3 (0.4)	1.9 (0.5)				

Note. ES = Effect size; M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; d = Cohen's d effect size; Alternated, n = 75, Traditional, n = 71.

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Perceived barriers, perceived autonomy support, and self-determined motivation toward physical activity

Table 4 shows the effect of inside-outside alternated teaching units on environment/facilities perceived barriers, perceived autonomy support in PE, and self-determined motivation toward PA. The MLM results showed that the AG participants had a statistically significant improvement to their environment/facilities perceived barriers (d = -0.35), perceived autonomy support (d = 1.40), integrated regulation (d = 0.24), amotivation (d = -0.35), and autonomous motivation (d = 0.19) compared with those from the TG ($p < 0.05$). However, for the intrinsic motivation, identified, introjected, and external regulations, and controlled motivation statistically significant differences were not found ($p > 0.05$) (Supplementary File 1).

Table 4. Effect of the inside-outside alternated teaching units on perceived barriers, perceived autonomy support, and self-determined motivation toward physical activity[a].

Variable	Group	Pre-intervention	Post-intervention	Difference	Multilevel lineal model			ES
		M (SE)	M (SE)	M (SE)	- 2LL	*F*	*p*	*d*
Perceived barriers								
Environment/	Alternated	2.4 (0.2)	1.7 (0.1)	-0.6 (0.1)	427.436	12.286	0.001	-0.35
Facilities	Traditional	1.9 (0.1)	2.0 (0.1)	0.1 (0.1)				
Perceived autonomy support								
Autonomy	Alternated	7.2 (0.2)	8.2 (0.2)	0.9 (0.2)	537.169	53.618	< 0.001	1.40
	Traditional	7.1 (0.2)	5.7 (0.2)	-1.4 (0.2)				
Self-determined motivation								
Autonomous	Alternated	7.8 (0.2)	7.9 (0.2)	0.0 (0.1)	403.434	4.089	0.045	0.19
	Traditional	8.0 (0.2)	7.7 (0.2)	-0.3 (0.1)				
Controlled	Alternated	3.0 (0.2)	2.9 (0.2)	-0.1 (0.1)	440.554	0.216	0.643	-0.05

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Traditional	2.7 (0.2)	2.7 (0.2)	-0.1 (0.1)

Note. ES = Effect size; M = Mean; SD = Standard deviation; - 2LL = -2 log-likelihood; d = Cohen's d effect size; Alternated, n = 75, Traditional, n = 71.

[a]Variables that do not appear in this table are reported in the Supplementary File 1.

Intention to be physically active, habitual and extracurricular physical activity, and habitual environment use for practicing physical activity

Supplementary File 2 shows the effect of inside-outside alternated teaching units on intention to be physically active, habitual and extracurricular physical activity, and habitual environment use for practicing PA. The MLM results did not show statistically significant differences for intention to be physically active, habitual and extracurricular PA, and habitual environment use for practicing PA, between the AG and TG students ($p > 0.05$).

Sensitivity analysis

The sensitivity analysis (i.e., per-protocol approach) found the same outcomes as the main analysis (i.e., intention-to-treat approach) in 15 out of 18 variables. Specifically, for the integrated regulation and autonomous motivation statistically significant differences between AG and TG were not found ($p = 0.031$ vs. $p = 0.060$ and $p = 0.045$ vs. $p = 0.050$, respectively), while statistically significant differences between both groups in intrinsic motivation were found ($p = 0.074$ vs. $p = 0.010$) (Supplementary File 3).

Discussion

The main objective of the present study was to examine the effect of two PE-based inside-outside alternated teaching units on students' knowledge of their environment for physical conditioning in the out-of-school time, their perceived barriers toward PA practice, teacher autonomy support, and self-determined motivation towards PA. Results showed that overall, the alternated teaching units significantly improved AG students' knowledge on how to use their immediate surroundings for improving physical fitness. These findings represent an

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important contribution to the field of the promotion of autonomous physical fitness in the out-of-school context. According to Bandura (2004), the acquisition of knowledge represents the first step toward generating a behavior change in PA practice. Previous studies pointed out the importance of students' knowledge of how to work physical fitness and how to practice PA out-of-school (Ennis, 2015; Wang and Chen, 2020). In this sense, the alternated teaching units allowed students to transfer the learning from the PE class to their daily life (European Commission/EACEA/Eurydice, 2013; SHAPE America, 2013; Viciana and Mayorga-Vega, 2018), improving, therefore, their knowledge and making them more autonomous and capable to work on physical fitness autonomously in the out-of-school context. Previous studies have shown the importance of providing students with fitness knowledge during PE lessons to encourage the PA practice during the out-of-school time (e.g., Hodges et al., 2016). Nevertheless, these studies were mainly focused on the knowledge of fitness training principles. To our knowledge, this is the first study that examines the effectiveness of this innovative teaching unit structure on students' knowledge about their nearby environment for physical conditioning. However, it should be highlighted that causal knowledge did not improve. This could be because the feedback given during the lessons was only focused on making students reflect on the similarities between the elements of both contexts, but it did not delve into the understanding of why a particular exercise performed in a specific element of the environment allows for working one physical capacity or another. Consequently, future studies should provide more specific feedback that facilitates students to reason and understand why a fitness capacity can be worked or not in a specific element, space, or environment.

Regarding perceived barriers toward PA practice, results of this study showed that the alternated teaching units reduced the AG students' perceived barriers related to environment/facilities. This could be because the knowledge acquired by the students led

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them to understand how they can use their nearby environment for physical conditioning, as well as to perceive the autonomy support from their PE teacher, which was also increased in AG students after the intervention. The effect of the various strategies used in the teaching unit could produce this outcome: (1) the continuous meaningful reasons provided during the innovative teaching unit explaining why it is important to maintain an active and healthy behavior (e.g., having good fitness levels) (Dobbins et al., 2013; Reeve, 2009); (2) the teaching methodology used, mainly based on fostering students' autonomous motivation (e.g., considering students' opinion, encouraging them to put in practice what they have learned in PE lessons) (Reeve, 2009); and (3) the use of the out-of-school context (i.e., nearby environment) for delivering some PE lessons, where the students could experience authentic and situational PA practices transferable to their daily life (Viciana and Mayorga-Vega, 2018). These results are in line with previous studies that have applied similar autonomy-supportive strategies (Cheon and Reeve, 2013; Yli-Piipari et al., 2018). Additionally, as a consequence of applying these aforementioned strategies, innovative teaching units have also shown a positive effect on students' autonomous motivation toward PA, as well as a decrease in their amotivation. It is in line with the autonomy support fostered by the SDT (Deci and Ryan, 1985), as well as with previous studies in which autonomy supportive teaching styles have been applied (e.g., González-Cutre et al., 2018). This increase in autonomous motivation could be associated with the students' increment in competence and autonomy, as a consequence of the improvement of the knowledge about the environment for working on physical fitness (Wang and Chen, 2020).

Regarding the secondary aim of this study it was to examine the effect of two PE-based inside-outside alternated teaching units on students' intention to be physically active, their habitual and extracurricular PA, and the regular use of their environment for practicing PA. Results of this study showed that the alternated teaching units did not influence any of

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these variables. Although AG students knew how they might use their knowledge about the environment to practice physical conditioning, and they perceived higher autonomy support, as well as increased their autonomous motivation, this was not translated into an improvement in their present PA behavior nor an increase in the future intention of doing it. Unlike the present study, previous studies carried out in the PE setting that have also applied autonomy-supportive teaching styles found that students intention to be physically active increased (Cheon and Reeve, 2013; Yli-Piipari et al., 2018). This could be due to the fact that AG students were specifically asked for their intention to practice PA autonomously using the immediate environment. Moreover, the short length of the intervention (four weeks) could also be a limitation to achieving better results in the aforementioned actual PA variables. Previous literature suggests applying longer school-based PA interventions (around 12 weeks and up) in order to attain changes in PA behavior (Dobbins et al., 2013). However, the large number of curricular objectives that have to be developed during the scholar year, together with the low frequency of the PE subject (only two hours per week) (Hardman et al., 2014), make the application of longer interventions difficult for a specific educational objective. Additionally, it is possible that the applied motivational and autonomy-supportive strategies were not enough to achieve a more specific intentionality such as using the environment to practice PA autonomously. Therefore, future studies that do not have this time restriction should apply longer interventions (Dobbins et al., 2013), incorporating other strategies such as Epstein's TARGET principles, which have shown to be effective for improving specifically adolescents' intention to be physically active in the out-of-school time (Cecchini et al., 2014). Furthermore, according to the expansion mechanism of the Theory of Expanded, Extended, and Enhanced Opportunities, complementing the intervention with an extracurricular program where the students could put in practice the learnings acquired during

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PE lessons with their peers may help them to achieve more easily a PA behavioral change during the out-of-school time (González-Cutre et al., 2018).

The main strength of the present study was that, to the best of our knowledge, this is the first study that examines the effect of two inside-outside alternated teaching units on: 1) students' environmental knowledge for physical conditioning in the out-of-school context, their perceived barriers, perceived autonomy support, and motivation toward PA; and 2) students' intention to be physically active, their habitual and extracurricular PA, and the regular use of their environment for practicing PA. Additionally, because of the nature of the context (i.e., school) and with the objective of keeping the ecological validity, the use of a cluster-randomized controlled trial design (balanced by grade) was more appropriate for the present research objective (Campbell et al., 2012). Furthermore, the comparison with a TG that also worked physical fitness, but only inside the school, allows us to check that the innovative teaching units are more effective than the traditional practice for achieving the main study objective. Finally, the evaluation of the effect of the teaching unit with a Mixed Multilevel Linear Model with participants nested within classes, represents an advancement with respect to the commonly applied analyses (Li et al., 2017).

This study also has some limitations that should be acknowledged. Firstly, the non-probabilistic and relatively small sample size provides a lower generalization power. This limits the generalizability of the obtained outcomes to the particular studied population and context. However, due to human and material resource restrictions, a probabilistic and larger sample could not be examined. Additionally, the present innovative teaching units were developed with a very specific content (physical fitness), which is one of the more worked globally in PE (Hardman et al., 2014) and could be the most applicable to students' free-time (individually or in small groups with friends), but these effects should also be studied with other PE contents. Moreover, the teaching unit length could have been a limitation to

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achieving greater effects on the PA variables. However, considering the large volume of objectives that have to be developed throughout the academic year with a very limited time for the PE subject (Hardman et al., 2014), the purpose was to carry out a real study that would be feasible to perform in the context of PE.

In conclusion, the results of the present study showed that inside-outside alternated teaching units are effective for improving students' knowledge about the environment for physical conditioning, their perceived barriers, perceived autonomy, and autonomous motivation towards PA. However, these innovative teaching units did not change students' intention to be physically active, their habitual and extracurricular PA, nor their regular use of the environment for practicing PA. Future research studies should examine if longer indoor-outdoor alternated teaching units might have an effect on students' intention to be physically active.

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Figure 1. General scheme of the intervention.

Figure 2. Flow chart of the school classes and students of the present study. All numbers are school classes [students].

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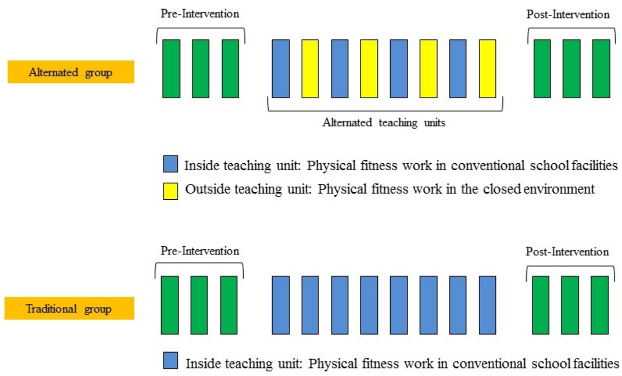

Figure 1. General scheme of the intervention.

338x190mm (96 x 96 DPI)

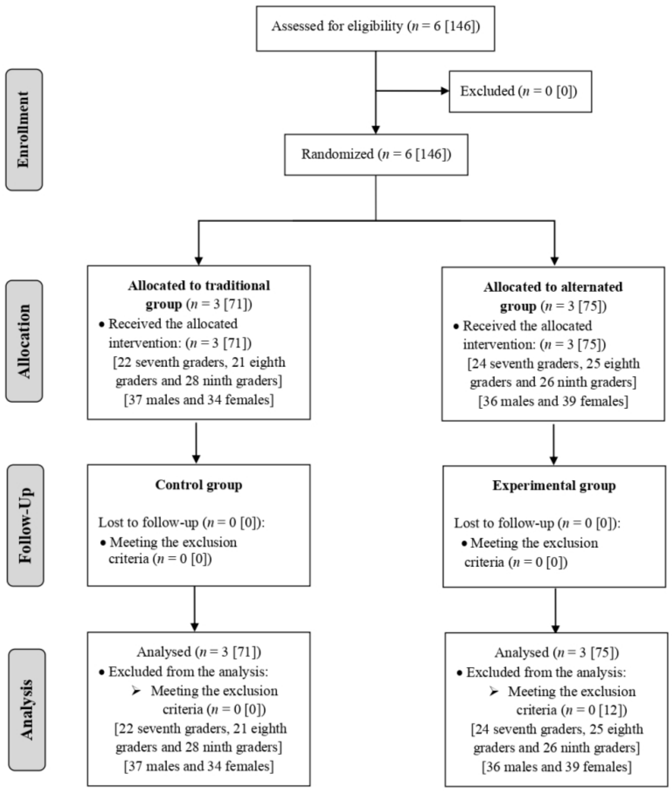

Figure 2. Flow chart of the school classes and students of the present study. All numbers are school classes [students].

210x297mm (150 x 150 DPI)

Supplementary File 1. Effect of the inside-outside alternated teaching units on self-determined motivation toward physical activity.

Variable	Group	Pre-intervention	Post-intervention	Difference	Multilevel lineal model			ES
		M (SE)	M (SE)	M (SE)	- 2LL	*F*	*p*	*d*
Intrinsic	Alternated	8.1 (0.2)	8.3 (0.2)	0.1 (0.1)	412.998	4.637	0.074	0.26
	Traditional	8.5 (0.2)	8.1 (0.2)	-0.4 (0.1)				
Integrated	Alternated	7.5 (0.2)	7.5 (0.3)	0.1 (0.2)	514.655	4.760	0.031	0.24
	Traditional	7.6 (0.3)	7.2 (0.3)	-0.4 (0.2)				
Identified	Alternated	8.0 (0.2)	8.0 (0.2)	0.0 (0.2)	494.869	0.050	0.824	0.03
	Traditional	7.8 (0.2)	7.8 (0.2)	-0.1 (0.2)				
Introjected	Alternated	3.7 (0.3)	3.8 (0.3)	0.0 (0.2)	524.698	0.060	0.806	0.03
	Traditional	3.4 (0.3)	3.4 (0.3)	-0.1 (0.2)				
External	Alternated	2.3 (0.2)	1.9 (0.2)	-0.4 (0.2)	445.428	1.322	0.293	-0.17
	Traditional	2.0 (0.1)	1.9 (0.2)	-0.1 (0.1)				
Amotivation	Alternated	2.1 (0.2)	1.7 (0.2)	-0.4 (0.1)	424.185	7.838	0.006	-0.35
	Traditional	1.6 (0.1)	1.7 (0.1)	0.1 (0.1)				

Note. ES = Effect size; M = Mean; SD = Standard deviation; - 2LL = -2 log-likelihood; *d* = Cohen's *d* effect size; Alternated, *n* = 75, Traditional, *n* = 71.

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Supplementary File 2. Effect of the inside-outside alternated teaching units on intention to be physically active, habitual and extracurricular physical activity, and habitual environment use for practicing physical activity.

Variable	Group	Pre-intervention	Post-intervention	Difference	Multilevel lineal model			ES
		M (SE)	M (SE)	M (SE)	- 2LL	*F*	*p*	*d*
Intention	Alternated	5.1 (0.3)	5.6 (0.3)	0.5 (0.5)	734.826	2.538	0.166	0.37
	Traditional	4.8 (0.4)	4.2 (0.4)	-0.6 (0.5)				
Habitual PA	Alternated	3.3 (0.2)	3.4 (0.2)	0.2 (0.1)	427.773	0.009	0.923	-0.01
	Traditional	3.1 (0.2)	3.3 (0.2)	0.2 (0.1)				
Extracurricular PA	Alternated	3.3 (0.2)	3.6 (0.2)	0.2 (0.1)	425.905	0.200	0.655	0.04
	Traditional	3.3 (0.2)	3.4 (0.2)	0.1 (0.1)				
Environment use	Alternated	1.9 (0.2)	2.2 (0.2)	0.3 (0.2)	522.364	2.290	0.186	0.28
	Traditional	1.6 (0.2)	1.3 (0.2)	-0.2 (0.2)				

Note. PA = Physical activity; ES = Effect size; M = Mean; SD = Standard deviation; - 2LL = -2 log-likelihood; *d* = Cohen's *d* effect size; Alternated, *n* = 75, Traditional, *n* = 71.

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Supplementary File 3. Effect of the inside-outside alternated teaching units on knowledge about their environment for physical conditioning, perceived barriers, perceived autonomy support, self-determined motivation toward physical activity, intention to be physically active, habitual and extracurricular physical activity, and habitual environment use for practicing physical activity.

Variable	Group	Pre-intervention	Post-intervention	Difference	Multilevel lineal model			ES
		M (SE)	M (SE)	M (SE)	- 2LL	*F*	*p*	*d*
Knowledge about the environment								
Declarative	Alternated	3.3 (0.2)	5.9 (0.2)	2.7 (0.2)	529.316	42.967	< 0.001	1.28
	Traditional	3.3 (0.2)	4.0 (0.2)	0.6 (0.2)				
Procedural	Alternated	4.5 (0.2)	6.5 (0.2)	2.0 (0.3)	559.552	15.446	0.007	0.98
	Traditional	4.7 (0.2)	5.0 (0.2)	0.4 (0.3)				
Causal	Alternated	4.0 (0.2)	5.8 (0.2)	1.7 (0.3)	562.503	1.844	0.223	0.33
	Traditional	3.3 (0.2)	4.4 (0.2)	1.2 (0.3				
Overall	Alternated	11.8 (0.4)	18.2 (0.5)	6.1 (0.6)	717.226	23.773	0.002	1.25
	Traditional	11.3 (0.4)	13.4 (0.4)	2.1 (0.6)				
Perceived barriers								
Environment/	Alternated	2.4 (0.2)	1.6 (0.1)	-0.6 (0.1)	393.705	13.192	< 0.001	-0.52
Facilities	Traditional	1.9 (0.1)	2.1 (0.2)	0.1 (0.1)				
Perceived autonomy support								
Autonomy	Alternated	7.2 (0.2)	8.3 (0.2)	1.0 (0.2)	485.049	67.107	< 0.001	1.51
	Traditional	7.2 (0.2)	5.7 (0.3)	-1.5 (0.2)				
Self-determined motivation								
Intrinsic	Alternated	8.3 (0.2)	8.5 (0.2)	0.1 (0.1)	370.399	6.841	0.010	0.28
	Traditional	8.5 (0.2)	8.2 (0.2)	-0.4 (0.1)				
Integrated	Alternated	7.5 (0.3)	7.6 (0.3)	0.1 (0.2)	471.934	3.613	0.060	0.22

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	Traditional	7.6 (0.3)	7.2 (0.3)	-0.4 (0.2)				
Identified	Alternated	8.0 (0.2)	8.1 (0.2)	0.0 (0.2)	450.230	0.233	0.630	0.06
	Traditional	7.9 (0.3)	7.8 (0.3)	-0.2 (0.2)				
Introjected	Alternated	3.7 (0.3)	3.9 (0.3)	0.0 (0.2)	472.948	0.019	0.891	-0.02
	Traditional	3.4 (0.3)	3.5 (0.3)	0.0 (0.2)				
External	Alternated	2.2 (0.2)	1.8 (0.2)	-0.4 (0.1)	391.152	2.776	0.145	-0.23
	Traditional	2.0 (0.2)	2.0 (0.2)	0.0 (0.1)				
Amotivation	Alternated	2.1 (0.2)	1.6 (0.1)	-0.4 (0.1)	390.138	7.582	0.007	-0.39
	Traditional	1.6 (0.2)	1.8 (0.2)	0.1 (0.1)				
Autonomous	Alternated	7.9 (0.2)	8.1 (0.2)	0.0 (0.1)	368.132	3.899	0.050	0.20
	Traditional	8.0 (0.2)	7.7 (0.2)	-0.3 (0.1)				
Controlled	Alternated	3.0 (0.2)	2.9 (0.2)	-0.1 (0.1)	396.320	0.887	0.348	-0.12
	Traditional	2.7 (0.2)	2.8 (0.2)	0.1 (0.1)				
Physical activity								
Intention	Alternated	5.1 (0.4)	5.8 (0.4)	0.6 (0.5)	664.420	2.793	0.150	0.39
	Traditional	4.8 (0.4)	4.2 (0.4)	-0.6 (0.5)				
Habitual PA	Alternated	3.3 (0.2)	3.4 (0.2)	0.2 (0.1)	380.195	0.141	0.708	0.04
	Traditional	3.2 (0.2)	3.3 (0.2)	0.1 (0.1)				
Extracurricular PA	Alternated	3.3 (0.3)	3.6 (0.2)	0.2 (0.1)	384.733	0.642	0.424	0.05
	Traditional	3.5 (0.2)	3.5 (0.2)	0.0 (0.1)				
Environment use	Alternated	1.8 (0.2)	2.2 (0.2)	0.3 (0.2)	457.765	3.331	0.123	0.30
	Traditional	1.5 (0.2)	1.2 (0.2)	-0.2 (0.2)				

Note: PA = Physical activity; ES = Effect size; M = Mean; SD = Standard deviation; - 2LL = -2 log-likelihood; *d* = Cohen's *d* effect size; Alternated, *n* = 68, Traditional, *n* = 63.

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Paper IV

EFFECT OF A PHYSICAL EDUCATION-BASED IRREGULAR TEACHING UNIT ON HIGH SCHOOL STUDENTS' CARDIORESPIRATORY FITNESS AND RELATED PSYCHOLOGICAL OUTCOMES: A CLUSTER RANDOMIZED CONTROL TRIAL FROM A SELF-DETERMINATION THEORY PERSPECTIVE

Guijarro-Romero, S., Mayorga-Vega, D. Casado-Robles, C., & Viciana, J.

Draft

Effect of a Physical Education-based irregular teaching unit on high school students' cardiorespiratory fitness and related psychological outcomes: A cluster randomized control trial from a Self-Determination Theory perspective

Abstract

The main aim was to examine the effect of a Physical Education (PE)-based fitness irregular unit on the maintenance of high school students' cardiorespiratory fitness. Secondarily, this study was aimed at examining the effect of the intervention on: 1) students' satisfaction of the basic psychological needs, autonomy support, motivation toward physical activity (PA), health improvement and fun and enjoyment satisfaction, intention to be physically active, and their habitual and extracurricular PA; and 2) perceived and objective PA levels during PE lessons. A sample of 128 high school students (51.6% females; M_{age} 12.4 ± 0.7) participated in the study. Six pre-established classes, balanced by grade, were cluster-randomly assigned into the irregular (IG), traditional (TG), or control groups (CG). The IG and TG performed a fitness development unit twice a week for nine weeks. Then, the IG completed a fitness irregular unit (three 20-minutes school recesses plus two 30-minutes out-of-school periods per week) for six weeks. All variables were measured before and after the development unit, as well as at the end of the irregular unit. PA levels were measured objectively through a heart rate monitor and subjectively by a self-reported scale during PE lessons. The IG maintained their cardiorespiratory fitness levels through the irregular unit (p < 0.001). Furthermore, the intervention improved IG autonomy support, basic psychological needs, and autonomous motivation toward PA (p < 0.05). Additionally, both IG and TG had higher PA levels than the CG during the development unit (p < 0.001). No differences were found for the rest of variables (p > 0.05). Irregular units allow P teachers to maintain students' cardiorespiratory fitness levels and achieve other objectives of the PE subject.

Keywords: Innovative intervention, cardiovascular endurance, secondary school students, autonomy, basic psychological needs, physical activity.

Introduction

Cardiorespiratory fitness (CRF) is considered a powerful health marker among adolescents (Raghuveer et al., 2020). During adolescence, higher levels of CRF are positively associated with mental health and quality of life (Eddolls et al., 2018). Unfortunately, adolescents' CRF has been declining during the last decades (Raghuveer et al., 2020), becoming a worldwide problem which affects, on average, 46% of female and 33% of male adolescents (Tomkinson et al., 2016). Consequently, the promotion of healthy CRF levels among adolescents' through different contexts like sport programs or in schools, is a priority public health objective (Tomkinson et al., 2016).

Schools and specifically the Physical Education (PE) subject is considered an ideal context to acquire healthy CRF levels (Association for PE, 2015). In fact, one of the main national standards of PE worldwide is the acquisition and maintenance of healthy CRF levels (European Commission/EACEA/Eurydice, 2013; Hardman, Murphy, Routen, & Tones, 2014; SHAPE America, 2013). To achieve this purpose, the Association for PE (2015) recommends that students should be involved in moderate-to-vigorous physical activity (MVPA) for at least 50% of the PE lessons time. However, achieving an increment in students' CRF levels through PE lessons is hindered by several limitations. Examples of these limitations include: the limited curriculum time appointed to the PE subject (e.g., on average, worldwide only about two hours per week), the great volume of contents to deliver during the academic year, the heterogeneous levels of students, or school holidays (Guijarro-Romero, Casado-Robles, & Mayorga-Vega, 2019; Hardman et al., 2014). Despite these limitations, previous studies have shown the effectiveness of short-term teaching units (TU) for improving students' CRF levels in the PE context (Mayorga-Vega, Montoro-Escaño, Merino-Marban, & Viciana, 2016; Mayorga-Vega, Viciana, & Cocca, 2013).

Additionally, another PE-based planning limitation is the fact that after a period of detraining, the CRF levels decrease (Mujika & Padilla, 2001). In this sense, Viciana and Mayorga-Vega (2016) suggested that PE teachers should apply maintenance teaching units after a fitness development TU in order to maintain the students' CRF levels during the whole academic year. Previous studies have shown the effectiveness of several types of maintenance units during PE lessons (Mayorga-Vega et al., 2016; Mayorga-Vega, Viciana, & Cocca, 2013). Nevertheless, with these type of maintenance TU, PE lesson time has to be used. Therefore, considering the low weekly frequency of the subject (Guijarro-Romero et al., 2019; Hardman et al., 2014), the available time to achieve the rest of PE curricular objectives is reduced.

A possible alternative could be maintaining students' CRF by using the extra-curricular time such as school recesses or out-of-school time applying the irregular TU structure proposed by Viciana and Mayorga-Vega (2016). This innovative structure of TU would allow PE teachers to increase and reinforce the active time for learning, achieving important outcomes such as increments of MVPA levels during these periods of time and to maintain students' CRF over the scholar year (Viciana & Mayorga-Vega, 2016). Consequently, it is extremely important that during PE lessons, teachers provide students with different options to perform physical activity (PA), and delegating the responsibility of their autonomous development using an individualized style of teaching (e.g., individualized programs carried out in couples or in small groups) (Viciana & Mayorga-Vega, 2016). Furthermore, using the extra-curricular time may increase students' autonomy toward PA practice during their free time (González-Cutre, Sierra, Beltrán-Carrillo, Peláez-Pérez, & Cervelló, 2018), which is also another main standard of PE curriculum (European Commission/EACEA/Eurydice, 2013; SHAPE America, 2013). According to the Theory of Expanded, Extended, and Enhanced Opportunities, this mechanism for promoting students'

PA is called expansion, and is defined as the introduction of an entirely new PA opportunity (Beets et al., 2016).

Additionally, in order to achieve better outcomes with the intervention, it should be based on theoretical frameworks in order to design and apply specific and effective guidelines to promote the PA practice (Biddle, Mutrie, Gorely, & Blamey, 2012). The Self-Determination Theory (SDT) is a motivational theory widely used to understand the antecedents and consequences of motivation toward PA (Ryan, Williams, Patrick, & Deci, 2009). The SDT postulates that everyone has three basic psychological needs (autonomy, competence, and relatedness) whose satisfaction leads students to acquire more autonomous forms of motivation toward PA (Ryan et al., 2009). The SDT also postulates that PE teacher autonomy support in PE plays a key role in the development of a more autonomous motivation toward PA (Ryan et al., 2009), which is positively associated with the interest in remaining active in the out-of-school time (Sevil-Serrano, Aibar, Abós, Generelo, & García-González, 2020). The autonomy-supportive teaching style is characterized by making students feel that they can participate in their own learning (Ryan & Deci, 2020). For example, providing students different opportunities to do PA, the opportunity of having a choice, considering their opinions about PA practice, promoting the sense of initiative, or justifying the aim of the tasks (Ryan & Deci, 2020). In this sense, students' satisfaction with PE lessons or extra-curricular programs is positively associated with more time spent on an activity, commitment, and intention to continue (Sicilia, Ferriz, Trigueros, & González-Cutre, 2014).

Similarly to this study, González-Cutre et al. (2018), based in SDT principles, examined the effect of a fitness TU during PE lessons as well as an extra-curricular program on students' daily self-reported PA levels. These authors found that the intervention improved students' self-reported daily PA levels, as well as motivational aspects such as their perceived autonomy support, basic psychological needs, and motivation toward PA. However, González-Cutre et al. (2018) were focused on the promotion of PA levels instead of on the effect of the intervention on students' CRF levels. Furthermore, the extra-curricular program was completely directed by the PE teacher and performed in a specific timetable. This may reduce the promotion of autonomy of students regarding the possibility to choose the more appropriate timetable to perform the program according to their extra-curricular activities. Additionally, the school recess, whose contribution to students' recommended daily MVPA levels is approximately 33% (Viciana, Mayorga-Vega, & Martínez-Baena, 2016), was not used to carry out the extra-curricular PA. Unfortunately, to the best of our knowledge, no previous studies have examined the effect of a fitness irregular TU, performed autonomously by students during school recesses and out-of-school time and based on SDT principles, on the maintenance of students' CRF levels. Consequently, the main aim of the present study was to examine the effect of a PE-based fitness irregular TU on the maintenance of high school students' CRF. Secondarily, this study was aimed at: 1) examining the effect of the fitness development and irregular TUs on students' satisfaction of the basic psychological needs, perceived teacher autonomy support, motivation toward PA, health improvement and fun and enjoyment satisfaction, intention to be physically active, and their habitual and extracurricular PA; and 2) analyzing the perceived and objective PA levels during PE lessons.

Methods

Study design

The present study is reported according to the CONSORT for cluster randomized trials guidelines (Campbell et al., 2012). The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013) and it was approved by the Ethical Committee for Human Studies at the University of [omitted]. Recruitment of participants was carried out in September of 2018, and the intervention was done from January 2019 to May 2019. For practical reasons and due to the nature of the present study (i.e., pre-established classes in a school setting), a cluster randomized controlled trial design was used (Guijarro-Romero, Mayorga-Vega, Casado-Robles, & Viciana, 2020). This study was non-blinded (treatments were not masked from the students or teacher), and parallel-grouped (study with three different treatments; Spieth et al., 2016), with three evaluation phases. However, none of the participants, regardless of the study group to which they belonged, were informed of the specific objective of the study to prevent subject-expectancy effects on study outcomes.

Participants

The principal and the PE teachers of two state high-school centers of [omitted] chosen by convenience were contacted and informed about the study, requesting its permission to conduct it. After obtaining the approval to carry out the present study, all 128 students (51.6% females) from the eighth and ninth grades of secondary education (i.e., 13–15 years old) were invited to participate in it. Adolescents and their legal tutors were fully informed about the study features. Participants' signed written informed assent and their legal tutors' signed written informed consent were obtained before taking part in the study. According to the center's reports, all the students' families had a middle socioeconomic level.

The inclusion criteria were: a) being enrolled in the eighth to ninth grade at the secondary education level (grades in which approval of the school was obtained); b) participating in the normal PE classes and in individual programs; c) being exempt of any health problem that would make them unable to engage in PA normally; d) presenting the corresponding signed written consent by their legal tutors, and e) presenting their own corresponding signed written assent. The exclusion criterion was not having performed the evaluation of the dependent variables correctly in each measured moment (i.e., pre-intervention, post-intervention, and post-maintenance) following the administration rules (being removed only for incomplete variables and not for the overall study).

Sample size

A priori sample size calculation was estimated with the Optimal Design Plus Empirical Evidence Software Version 3.01 for Windows. Parameters were set as follows: significance level $\alpha = 0.05$, number of participants per cluster $n = 25$, effect size $\delta = 0.50$, intra-class correlation coefficient $\rho = 0.01$, and statistical power $(1 - \beta) = 0.80$. A total number of six clusters (123 participants) was estimated.

Randomization

Randomization was conducted at the class-level, using a computerized random number generator, even though the school center had already assigned the students randomly and balanced by gender to each class, before starting the scholar year. This was done before the pre-intervention evaluation was administered, and the six pre-established classes (i.e., three 8^{th} and three 9^{th} grade classses) were randomly assigned, balanced by grade, by an independent researcher blinded to the study aim, and following a 1:1:1 ratio into the traditional group (TG), irregular group (IG), or control group (CG).

Intervention

Figure 1 shows the general scheme of the intervention. Before the intervention, the PE teachers (15 years of experience) responsible for teaching the control and experimental lessons were instructed about how to give the lessons in each study group. In the TG and CG, the teachers were simply told to teach the lessons the same way they usually taught. However, the teacher of IG lessons was trained during two sessions (2 hours each one) over one week in motivational and autonomy-supportive strategies to foster satisfaction of students' basic psychological needs during the whole intervention period. The main researcher supervised all the lessons and made sure all guidelines were taken into account during the intervention (Table 1).

Firstly, the TG and IG received a fitness-based development TU twice a week for nine weeks. Then, the IG students completed an irregular TU for six weeks consisting of five individual programs per week: three 20-minutes school recesses plus two 30-minutes out-of-school periods.

Each development lesson lasted 50 minutes approximately and consisted of: a 5-to-10-minute warm-up (performing low-to-moderate aerobic activities followed by some joint mobility and stretching exercises); a main part of 35-to-40-minutes (performing traditional fitness lessons such as interval training, skipping rope, running games, circuit training or fartlek, finishing with team games); and a five-minute cool-down (performing stretching exercises). In the first IG development lesson, benefits and recommendations of practicing regular PA were explained to students, placing a poster of them in the PE classroom. Furthermore, both teacher and IG students signed a contract named “I improve my fitness” in which students compromised to actively participate in the whole intervention to develop and maintain their CRF, and the teacher to help them to get this goal. During the development TU, the PE teacher progressively provided more autonomy to IG students to perform the lessons autonomously by themselves. Firstly, after five lessons completely given by the teacher, students started to perform the warm-up by themselves. Then, during the last four development lessons, the next step was to perform some parts of the main part of the lessons, and finally the whole lesson, always with the help of the teacher if it was necessary. The PE teacher placed special emphasis on reaching a MVPA intensity during the development lessons. Additionally, in order to promote PA participation through the increase of autonomous motivation, motivational and autonomy support strategies were applied during the lessons to satisfy IG students' basic psychological needs (See Table 1; Teixeira et al., 2020).

Regarding the irregular TU, the IG students worked during three 20-minutes school recesses plus two 30-minutes out-of-school periods per week for six weeks on individual programs chosen by them which were related with the contents worked in the development TU. The activities were: competitions of ten passes game and soccer by small groups created by students, and challenge of getting 2000 steps during the recesses, and three series of eight minutes of continuous running with two minutes of rest between series during the out-of-school periods. Before the beginning of the irregular TU, during one tutoring hour, each student was given an individual form with the programs systematized per days (as a orientation), a diary in which they had to write down information about the programs performed to self-monitoring their progress, and all doubts about the irregular TU were solved. A poster with the rules and schedule of the competitions was placing in the bulletin board of the school center. During the cool-down of PE lessons of this intervention period, as well as during one tutoring hour every two weeks, reflections about the progress achieved, difficulties and doubts to performed the programs, their possible solutions, as well as positive reinforcement were commented. Furthermore, according to Ludwig, Arthur, Sculthorpe, Fountain, and Buchan (2018) five text messages were individually sent every week, one each day that students had to perform an individual program. These messages, reviewed by a SDT specialist, were also focused on promoting students' satisfaction of the basic psychological needs (e.g., "You make the decisions how far you can go"). Additionally, each IG student wore a PA wristband (Xiaomi mi band 3) from Monday to Saturday during the whole irregular TU in order to: 1) control that the individual programs were performed, since students had to select the option "exercise" every time they performed a program; and 2) be another motivational factor (Nuss, Moore, Nelson, & Li, 2020) that encourage students to perform the individual programs, since the options of inactivity alert, achieved goal alert, and event reminders were activated. Before the irregular TU, students were familiarized with the use of the wristbands, as well as with the “MiFit” application (official application of the used wristband) where students could check their PA progress over the intervention.

Regarding the CG students, they also carried out two PE lessons a week during the intervention period, with a similar structure as the TG and IG (i.e., 5-to-10-minute warm-up, 35-to-40-minute main part, and five-minute cool-down). However, the contents (acrosport and volleyball) and methodology (based on recreation and technique-learning practices) developed in the main part of the lessons were different during the development TU period. Finally, during the irregular TU period, the CG worked the same contents during PE lessons as TG and IG (i.e., juggle and basketball).

Insert Table 1

Insert Figure 1

Measures

Prior to carrying out the intervention general characteristics of the participants (i.e., age, grade, gender, body mass, body height, and organized extra-curricular activities) were registered during one PE lesson. Body mass and body height were measured following the ISAK protocol (Stewart et al., 2011). Then, the body mass index was calculated as body mass divided by body height squared (kg/m2). Finally, students’ body weight status was categorized by the body mass index thresholds (Cole et al., 2000).

Afterward, two PE lessons and one tutoring hour were used to evaluate students’ CRF (1^{st} lesson) and questionnaires (2^{nd} and 3^{rd} lessons) at the beginning (pre-intervention) and at the end (post-intervention) of the developmental TU, as well as at the end of the irregular TU (post-maintenance). All evaluations were carried out under the same conditions, with the same instruments and by the same tester. The CRF measurements were taken in an indoor sports facility with a non-slippery floor, under the same environmental conditions, on the same day of the week and at the same time for each student. Prior to the CRF test, the participants completed a standardized warm-up consisting of five minutes of running from low to moderate intensity followed by some joint mobility exercises. The researcher was present during all evaluation sessions in order to clarify any question that might arise.

Cardiorespiratory fitness. The 20-meter shuttle run test was used to assess CRF (Léger et al., 1988). Participants ran between two parallel lines placed 20 meters apart, in a progressive rhythm marked by a recorded beep until they were not able to reach the line two consecutive times. During the test, each participant wore a heart rate monitor (Polar® RS300X, Finland). In order to ensure the test maximality, only the scores of participants who reached a heart rate value equal to or higher than 90% of their estimated maximum heart rate (Mahar et al., 2018) were used. The maximum heart rate was estimated by the following equation: 209 – 0.7 x age (in years) (Shargarl et al., 2015). The total number of completed laps (n) and time (in seconds) were retained. Then, the maximal oxygen uptake (in ml/kg/min) was using the following equation: 31.025 + 3.238 x speed - 3.248 x age + 0.1536 x speed x age (speed expressed in km/h and age in the lower rounded integer) (Léger et al., 1988). Finally, participants were categorized as having a healthy or unhealthy CRF status according to the maximum oxygen uptake cut-off points (Ruiz et al., 2015). The 20-meter shuttle run test has demonstrated adequate reliability and criterion-related validity among high school students (e.g., ICC = 0.89; r_p = 0.78) (Léger et al., 1988; Mayorga-Vega, Aguilar-Soto, & Viciana, 2015).

Basich psychological needs. Students' perceptions of autonomy, competence, and relatedness satisfaction in PE and physical exercise were assessed using the Spanish version of the Basic Psychological Needs in Exercise Scale (BPNES, Sánchez & Núñez, 2007). It consists of 12 items (four items per factor) that assessed: autonomy (e.g., "I feel very strongly that I have the opportunity to make choices with respect to the way I exercise"), competence (e.g., "I feel that I execute very effectively the exercises of my training program") and relatedness (e.g., "I feel that I associate with the other exercise participants in a very friendly way") introduced by the stem "When I do PA…". To adapt the scale of the questionnaire to the Spanish students' school grades a 10-point Likert-type scale, ranging from 1 ("Totally disagree") to 10 ("Totally agree") was used according to previous studies (Guijarro-Romero et al., 2020). The Spanish version of BPNES has shown adequate psychometric properties among high-school students (CFI = 0.95; IFI = 0.95; SRMR = 0.05; RMSEA = 0.08; Cronbach's α = 0.74-0.87) (Sánchez & Núñez, 2007).

Perceived autonomy support. The PE teacher autonomy-support was assessed through the Spanish version of the Perceived Autonomy Support Scale for Exercise Settings (PASSES, Moreno, Parra, & González-Cutre, 2008). It consists of 12 items (e.g., "My PE teacher understand why I decide to do physical exercise in my free time") that evaluate a single factor of autonomy support. The items were preceded by the sentence: "In my PE classes...". A 10-point Likert-type scale, ranging from 1 ("Totally disagree") to 10 ("Totally agree") was used. The Spanish version of PASSES has shown adequate psychometric properties among high-school students (CFI = 0.92; IFI = 0.92; TLI = 0.90; SRMR = 0.04; RMSEA = 0.08; Cronbach's α = 0.91) (Moreno et al., 2008).

Self-determined motivation towards physical activity. Students' motivation towards PA was measured using the Spanish version of the Behavioral Regulation in Exercise Questionnaire (BREQ-3, González-Cutre, Sicilia, & Fernández, 2010) consists of 23 items (e.g., "Because it agrees with my way of life") distributed into six dimensions (intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation, and amotivation). The questionnaire was preceded by the sentence: "I do PA...". A 10-point Likert-type scale, ranging from 1 ("Not true for me") to 10 ("Very true for me") was used. The autonomous (i.e., averaging intrinsic, integrated, and identified regulation) and controlled (i.e., averaging introjected and external) motivations were also calculated (Chemolli & Gagné, 2014). The Spanish version of the BREQ-3 has shown adequate psychometric properties among high-school students (CFI = 0.91; IFI = 0.91; RMSEA = 0.06; SRMR = 0.06; Cronbach's α = 0.66-0.87) (González-Cutre et al., 2010).

Health improvement and fun and enjoyment satisfaction. Students' health improvement and fun and enjoyment satisfaction was measured using the Spanish version of the Physical Activity Class Satisfaction Questionnaire (PACSQ, Sicilia, Ferriz, Trigueros, & González-Cutre, 2014). It consists of 45 items that measure satisfaction in relation to nine dimensions. In the present study, the improvement of health and fitness and fun and enjoyment dimensions were used. The questionnaire was preceded by the sentence: "Indicate your satisfaction level with the PE lessons received regarding...". A 10-point Likert-type scale, ranging from 1 ("Not true for me") to 10 ("Very true for me") was used. The Spanish version of the PACSQ has shown adequate psychometric properties among high-school students (CFI = 0.90; IFI = 0.90; RMSEA = 0.065; SRMR = 0.00519; Cronbach's α = 0.88-0.92) (Sicilia et al., 2014).

Intention to be physically active. Students' intention to be physically active in their free time was measured using the Spanish version of the Intention to partake in leisure-time PA questionnaire (Granero-Gallegos, Baena-Extremera, Pérez-Quero, Ortiz-Camacho, & Bracho-Amador, 2014). It is composed of three items (e.g., "I intend to do physical exercise at least three times a week next month"). The items were preceded by the sentence: "In my free time, both at school recess and after school (from Monday to Friday)...". A 10-point Likert-type scale, ranging from 1 ("very unlikely") to 10 ("most likely") was used. The Spanish version of this questionnaire has shown adequate psychometric properties among high-school students (GFI = 1.00; RMR = 0.02; NFI = 1.00; NNFI = 0.99; CFI = 1.00; RMSEA = 0.03; Cronbach's α = 0.93) (Granero-Gallegos et al., 2014).

Habitual physical activity. Students' habitual PA was measured using the Physician-based Assessment and Counseling for Exercise questionnaire (PACE) (Martínez-Gómez et al., 2009). It consists of two questions that measure how many days in the last week (PACE 1, "In the last 7 days, how many days did you do physical activity during 60 minutes or more?) and in a habitual week (PACE 2, "In a normal week, how many days do you do physical activity during 60 minutes or more?) at least 60 minutes of PA are performed. A 7-point Likert-type scale, ranging from 0 to 7 was used. The PACE questionnaire has shown adequate psychometric properties among high-school students (r = 0.43) (Martínez-Gómez et al., 2009).

Extracurricular physical activity. Students' extracurricular hours of PA practice were measured through the enKid questionnaire (Martínez-Gómez et al., 2009). It consists of one question: "How many hours do you spend on extracurricular sport activities weekly?". A 7-point Likert-type scale, ranging from 0 to "more than 5" was used. The enKid questionnaire has shown adequate psychometric properties among high-school students (r = 0.43) (Martínez-Gómez et al., 2009).

Objective and perceived physical activity. According to the procedure followed in previous studies (Mayorga-Vega et al., 2016) students' PA levels during the intervention lessons were measured objectively by heart rate monitors and subjectively by a self-reported scale. In each research group, five students per class were randomly selected to wear a heart rate monitor (Polar RS300X, Finland). These five students were different in each session, for example, in the second session five students different from the first session wore the heart rate monitor, and so on until all students' work intensity of the same class were measured. Therefore, all students' PA was monitored about two or three times during the intervention period. Additionally, at the end of each PE lesson all the students reported their global perceived exertion using a pictorial perceived exertion scale (from 0 = ‘‘not tired at all’’ to 10 = ‘‘very, very tired’’). The pictorial perceived exertion scale has demonstrated adequate reliability and validity among adolescents (ICC = 0.95; *r* = 0.89) (Pfeiffer, Pivarnik, Womack, Reeves, & Malina, 2002). For the intensity control, rating of perceived exertion, average heart rate (expressed as beats per minute and percentage of estimated maximum heart rate), total PA (percentage of total time involved in an intensity equal to or over 50% of the estimated maximum heart rate), and MVPA (percentage of total time involved in an intensity equal to or over 70% of the estimated maximum heart rate).

Statistical analysis

Descriptive statistics (means and standard deviation/standard error or percentage) for general characteristics of the participants and dependent variables were calculated. Statistical tests assumptions were checked by common procedures (e.g., histograms and Q-Q plots for normality). First, as exploratory analyses, the chi-squared analyses for categorical variables and the one-way analyses of variance (ANOVA) for continuous variables were conducted to examine potential differences between the three groups. Additionally, internal consistency of the questionnaires with the present sample was examined with Cronbach’s alpha.

Afterward, the effect of a PE-based irregular TU on students’ CRF, psychological variables, present PA and future intention of PA was examined. An intention-to-treat approach was followed, that’s means, all the participants were included in the statistical analyses regardless of adherence to the protocol (all the participants that did not follow the protocol was because they did not have an attendance rate equal to the 100%). Because the unit of randomization and intervention was the class, a Multilevel Linear Model (MLM) with participants nested within classes was selected (i.e., two-way mixed nested ANOVA) (Li, Xiang, Chen, Xie, & Li, 2017). The maximum likelihood estimation method was used. The –

2 log-likelihood (- 2LL, i.e., comparing the change in the chi-square test) was used to compare the model's fit. From all the potential confounding variables explored (i.e., gender, grade, body mass, body height, body mass index, extra-curricular activities, habitual PA, and attendance rate), covariables were used when they were necessary (see Note in Tables 3-5). Finally, for the *post-hoc* analyses, the within-group pairwise comparisons with the Bonferroni adjustment was used for each group independently. The exacted McNemar's test was calculated for each group independently in order to examine if the PE-based irregular TU increased the proportion of students with a healthy CRF profile.

Similarly, regarding the effect of a PE-based irregular TU on students' PA levels during PE lessons was examined, a MLM with participants nested within classes was selected (i.e., one-way nested ANOVA). From all the potential confounding variables explored, covariables were used when they were necessary (see Note in Table 6). Effect sizes were estimated using the Cohen's d for pairwise comparisons. Finally, although an intention-to-treat approach was followed in the present study, as sensitivity analyses, all the above-mentioned analyses were also carried out with a per-protocol approach (i.e., including the TG/IG participants considering their adherence to the protocol ≥ 90% in both periods). All statistical analyses were performed using the SPSS version 25.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

Results

Final sample and general characteristics

Figure 2 shows the flow chart corresponding to the participants included in the present study. All the invited 128 students (51.6% females) agreed to participate, and satisfactorily met the inclusion and exclusion criteria. No participants were lost because of the rejection to continue in the study or change of school. Table 2 shows the general characteristics of the participants. The results of the one-way ANOVA and the chi-square test did not show statistically significant differences in terms of general characteristics between the three groups ($p > 0.05$). However, the IG students had a lower attendance rate during the development period than those from the CG and TG ($p < 0.01$). Moreover, during the maintenance period, the IG students had higher attendance rate than those from both the CG and TG ($p < 0.001$), as well as the TG students was a higher value than for those from the CG ($p < 0.001$). In the sample of the present study, the internal consistency of all the dependent variables measured by dimensional questionnaires was above 0.70 (except for amotivation, $\alpha = 0.58$; and controlled motivation, $\alpha = 0.59$).

Insert Table 2

Insert Figure 2

Cardiorespiratory fitness

Table 3 shows the effect of the intermittent teaching unit on cardiorespiratory fitness. The MLM results showed a statistically significant interaction effect between the *group* and *time* variables for CRF levels ($p < 0.001$). Subsequently, the within-group pairwise comparisons showed that both the TG and IG students increased statistically significantly from pre-intervention to post-development ($p < 0.001$; $d = 0.29$-0.36). However, while the IG students retained or improved the CRF levels with the maintenance program (post-development vs. post-maintenance, $p > 0.05$ for performance and $p < 0.05$ for VO_2max; pre-intervention vs. post-maintenance, $p < 0.001$; $d = 0.49$), the TG students' values were back to the baseline (post-development vs. post-maintenance, $p < 0.001$; pre-intervention vs. post-maintenance, $p > 0.05$). For the CG students no statistically significant differences were found ($p > 0.05$).

In Figure 3, the results showed that for the IG there was a statistically significant increase on the proportion of students with a healthy CRF level from pre-intervention to post-maintenance ($p < 0.001$). However, for the TG and CG statistically significant differences were not found ($p > 0.05$).

Insert Table 3

Insert Figure 3

Basic psychological needs, perceived autonomy support, and self-determined motivation toward physical activity

Table 4 shows the effect of the irregular TU on basic psychological needs (i.e., autonomy, competence, and relatedness), perceived autonomy support in PE, self-determined motivation toward PA, health improvement and fun and enjoyment satisfaction. The MLM results showed a statistically significant interaction effect between the *group* and *time* variables for autonomy, competence, perceived autonomy support in PE (p < 0.001), relatedness (p < 0.05), identified regulation (p < 0.05), autonomous motivation (p < 0.05), and health improvement satisfaction (p < 0.01). Subsequently, the within-group pairwise comparisons showed that IG students increased statistically significantly to their autonomy, competence, perceived autonomy support, autonomous motivation, and health improvement satisfaction from pre-intervention to post-development (p < 0.05; d = 0.30-1.48). Additionally, the IG students retained or improved their autonomy, competence, perceived autonomy support, and health improvement satisfaction with the maintenance program (post-development vs. post-maintenance, p > 0.05; pre-intervention vs. post-maintenance, p < 0.01; d = 0.69-1.95). Regarding the TG students, they had a statistically significantly decreased in autonomy, relatedness, and perceived autonomy support, from post-development to post-maintenance (p < 0.05; d = -0.44-0.75), and from pre-intervention to post-maintenance (p < 0.05; d = -0.25-1.96). Additionally, TG students decreased statistically significantly their identified regulation from pre-intervention to post-maintenance (p < 0.05; d = -0.30-0.50). As regard the CG students, they had a statistically significantly decreased in competence from pre-intervention to post-development (p < 0.05; d = 0.44-1.10), and in perceived autonomy support and competence from pre-intervention to post-maintenance (p < 0.001; d = -0.02-

1.95). Finally, for the intrinsic motivation, integrated, introjected, and external regulations, amotivation, and controlled motivation statistically significant effects were not found (p > 0.05) (Supplementary Table 1).

Insert Table 4

Intention to be physical active, habitual and extracurricular physical activity

Table 5 shows the effect of the irregular TU on intention to be physically active, habitual and extracurricular PA. The MLM results did not show a statistically significant interaction effect between the *group* and *time* variables for intention to be physically active, habitual and extracurricular PA (p > 0.05).

Insert Table 5

Physical activity during the Physical Education lessons

Table 6 shows the comparison of perceived (i.e., RPE) and objective (i.e., average heart rate, average of the percentage of maximum heart rate, total PA, and percentage of total time involved in MVPA) PA levels during the PE lessons between the three groups. The results of the MLM (p < 0.001) followed by the pairwise comparisons showed that both the TG and IG had statistically significant higher PA levels during the development TU than the CG (p < 0.001; d = 1.27-7.30). However, statistically significant differences between the TG and IG were not found (p > 0.05). Moreover, both TG and IG had statistically significant higher average heart rate and average of the percentage of maximum heart rate during the maintenance period than the CG (p < 0.001; d = 2.11-2.15). Additionally, the IG had statistically significant higher perceived PA levels during the maintenance period than the CG (p < 0.05; d = 1.57), and there were no statistically significant differences between the IG and TG (p > 0.05).

Insert Table 6

Sensitivity analyses

The sensitivity analysis (i.e., per-protocol approach) found the same outcomes as the main analysis (i.e., intention-to-treat approach) in 24 out of 31 variables. Specifically, for the autonomy and relatedness needs of the TG statistically significant differences from post-development to post-maintenance and from pre-intervention to post-maintenance were not found ($p = 0.004$ vs. $p = 0.581$ and $p = 0.032$ vs. $p = 0.404$; $p = 0.003$ vs. $p = 0.229$ and $p = 0.040$ vs. $p = 0.892$, respectively). Additionally, for the amotivation of the IG, statistically significant differences from post-development to post-maintenance were found ($p = 0.161$ vs. $p = 0.011$), while statistically significant differences for IG health improvement satisfaction from pre-intervention to post-development were not found ($p = 0.046$ vs. $p = 0.583$). For identified regulation and autonomous motivation a statistically significant interaction effect between the *group* and *time* variables was not found ($p = 0.038$ vs. $p = 0.086$ and $p = 0.047$ vs. $p = 0.084$, respectively). Finally, a statistically significant difference between the CG and TG session time in the maintenance period was found ($p = 0.068$ vs. $p = 0.018$) (Supplementary Tables 2-5).

Discussion

The main aim of the present study was to examine the effect of a PE-based fitness irregular TU on the maintenance of high school students' CRF. Results showed that both TG and IG improved their CRF levels after a short-term fitness development TU performed twice a week for nine weeks as shown by previous research (Mayorga-Vega et al., 2016; Mayorga-Vega, Viciana, & Cocca, 2013). Furthermore, the present study showed an increase of the proportion of students with a healthy CRF status after the irregular TU according to the maximum oxygen uptake cut-off points (Ruiz et al., 2015).

Nevertheless, previous studies found that after a detraining period, CRF improvements were considerably reduced (Mujika & Padilla, 2001). Consequently, the application of PE-based maintenance units is necessary for maintaining the students' CRF levels during the rest of the scholar year. Previous studies in the PE setting have shown the effectiveness of different structures of maintenance units performed during PE lessons (Mayorga-Vega et al., 2016; Mayorga-Vega, Viciana, & Cocca, 2013). However, with these type of maintenance units, PE lesson time has to be used. Therefore, considering the low weekly frequency of the subject (Hardman et al., 2014), the available time to achieve the rest of PE curricular objectives is reduced. In this sense, the application of the irregular TU structure (Viciana & Mayorga-Vega, 2016) where the extra-curricular periods such as school recesses or ouf-of-school time can be used to perform PA, seems to be a good alternative in facilitating PE teachers the maintenance of students' CRF. Results of the present study showed that an irregular fitness TU consisted of three 20-minutes of school recesses plus two 30-minutes out-of-school periods was effective in maintaining students' CRF levels. To our knowledge the present study is the first in which the students maintained their CRF levels through a fitness irregular TU performed autonomously in school recesses and out-of-school time, which is, consequently, an important outcome for PE teachers. Therefore, this finding could help PE teachers to design TUs that would allow for an effective and feasible development and maintenance of CRF during the whole academic year, without neglecting other curricular objectives.

A secondary purpose of the study was to examine the effect of the fitness development and irregular TUs on students' satisfaction of the basic psychological needs, perceived autonomy support, motivation toward PA, health improvement and fun and enjoyment satisfaction, intention to be physically active, and their habitual and extracurricular PA. Results of this study shown that both development and irregular TUs improved IG students' autonomy and competence needs and perception of autonomy support from the PE teacher. This could be due to the autonomy-supportive climate created during PE lessons and tutoring hours, together with the motivational strategies applied mainly focused on satisfying students' basic psychological needs (Teixeira et al., 2020). Moreover, the continuous meaningful reasons provided explaining why it is important to achieve and to maintain healthy CRF levels (Dobbins, Husson, Decorby, & Larocca, 2013), text messages received (Ludwig et al., 2018), the use of a diary, as well as the activity wristband and its application where students could check their progress, might have promote students sense of autonomy and competence (Nuss et al., 2020). However, it should be highlighted that IG relatedness need did not change over the intervention although specific strategies were also applied to this basic need. This result might also be considered positive, since TG, who work the same contents during the intervention, but did not receive any relatedness strategy, show a decrease over the intervention in this variable.

Additionally, as a consequence of applying the above-mentioned strategies, IG students' have also shown a positive effect on their autonomous motivation toward PA during the development TU, which was maintained after the irregular TU. It is in line with the postulates of the SDT (Ryan et al., 2009) regarding the fact that autonomy-supportive teaching styles together with the satisfaction of students' basic psychological needs leads students to develop higher autonomous motivation (Ryan et al., 2009). These results are in line with previous studies that have applied similar autonomy-supportive and motivational strategies both during PE lessons and during extra-curricular time (González-Cutre et al., 2018; Yli-Piipari, Layne, Hinson, & Irwin, 2018). Furthermore, as a result of the improvement and maintenance of CRF and motivational variables, IG students perceived higher health improvement satisfaction after both development and irregular TUs. This health improvement satisfaction due to PE lessons and individual programs may be translated into more time spent on an activity, commitment, and intention to continue (Sicilia et al., 2014).

Regarding fun and enjoyment satisfaction, intention to be physically active, and habitual and extracurricular PA, the results of this study showed that the intervention did not influence none of these variables. Despite the fact that IG students improve all of their motivational outcomes and perceived an improvement in their health status after the intervention, maybe the lack of fun and enjoyment satisfaction could be due to the required intensity of the tasks performed during both development and irregular TUs to achieve the main objective (i.e., to maintain CRF). That is, these tasks had to be performed with high to very high intensity, which may provoke that IG students did not enjoy because of the big effort they had to do it. Additionally, although IG students improved the above-mentioned motivational variables, this was not translated into an increment in their present PA behavior nor an increase in the future intention of doing it. These results are in line to previous studies that have applied a similar autonomy-supportive intervention in the PE setting (Barkoukis, Chatzisarantis, & Hagger, 2020). On the contrary, other previous studies that have also applied autonomy-supportive teaching styles in the PE setting, found that students intention to be physically active increased (Sevil-Serrano et al., 2020; Yli-Piipari et al., 2018). A possible reason why current intervention did not have an effect on this variable could be that the applied autonomy-supportive and motivational strategies were not strong enough to encourage a change on students' intentionality to practice PA (Barkoukis et al., 2020). Additionally, the teacher's training was relatively brief compared to previous studies (Sevil-Serrano et al., 2020; Yli-Piipari et al., 2018). In this sense, the duration of the teacher training may act as a moderator of the effectiveness of autonomy support interventions (Barkoukis et al., 2020).

Regarding the last secondary purpose of this study, it was to analyze the perceived and objective PA levels during the intervention. The PE subject is considered to be a key opportunity for students to contribute to achieve the daily MVPA levels recommended by the

World Health Organization (Mayorga-Vega, Martínez-Baena, & Viciana, 2018), due to it being a compulsory subject in the students' academic curriculum (Hardman et al., 2014). Results of the present study showed that both TG and IG students had higher MVPA levels (47.0% to 49.5%) during the development TU than the CG (8.8%). However, during the maintenance period, these levels were lower in all study groups (24.5% to 32.2%). Similarly to the present study, in their systematic review of interventions with the objective to increase MVPA levels, Lonsdale et al. (2013) found that there is only an increment of the time involved in MVPA during PE lessons when the intervention is specifically designed for that goal. However, the average proportion of PE lesson time spent in MVPA (40.5%) is lower than recommended when a specific intervention for this purpose is not applied (Hollis et al., 2017).

Regarding perceived PA, results showed that both TG and IG students reported higher perceived PA levels than the CG during the development TU as a consequence of the high MVPA levels reached during the lessons. Additionally, during the maintenance period, although the three study groups worked the same contents and activities, the IG reported higher perceived PA levels than the CG. This may be an overestimation of the effort of the IG, since no differences in MVPA were found in this period of time. Finally, the present study has shown similar results regarding the magnitude effects of the intervention to previous studies focused on the increment of MVPA levels during PE lessons (d = -0.26 to 4.91 vs. 0.13 to 2.81) (Lonsdale et al., 2013).

The main strength of the present study was that this is the first study that examines the effect of a PE-based fitness irregular TU on the maintenance of high school students' CRF. Additionally, because of the nature of the context (i.e., school) and with the objective of keeping the ecological validity, the use of a cluster-randomized controlled trial design (balanced by grade) was more appropriate for the present research objective (Campbell, Piaggio, Elbourne, & Altman, 2012). Furthermore, the use of this research design with three different groups adds quality to the present study in comparison with studies conducted with a single-group design. Apart from allowing for the comparison of the obtained outcomes from the irregular TU with the CG, it also allows for comparing them with the TG that also performed a fitness development TU, but not the maintenance with the irregular TU. Finally, the evaluation of the effect of the teaching unit with a Mixed Multilevel Linear Model with participants nested within classes, represents an advance with respect to the commonly applied analyses (Li et al., 2017). Nevertheless, this study also has some limitations that should be acknowledged. Firstly, the relatively brief PE teacher training compared to similar previous studies (Sevil-Serrano et al., 2020; Yli-Piipari et al., 2018), which could limit the obtained outcomes in students' PA behavior outside the school, an issue that it has been referenced previously in the discussion. Secondly, the non-probabilistic and relatively small sample size provides a lower generalization power. This limits the generalizability of the obtained outcomes to the particular studied population and context. However, due to human and material resource restrictions, a probabilistic and larger sample could not be examined. Future studies should increase the duration of autonomy-support teacher training to achieve larger effects on students' PA behavior. Moreover, applying other strategies such as Epstein's TARGET principles, which have shown to be effective for improving specifically adolescents' intention to be physically active in the out-of-school time (Cecchini et al., 2014) could help to get better results in this variable. Finally, new applications of the irregular TUs in a collaborative project together with students' families or school teachers might also help to promote easily a PA behavioral change during the out-of-school time (González-Cutre et al., 2018; Sevil-Serrano et al., 2020).

In conclusion, as far as we know, this is the first study that examines the effects of a PE-based fitness irregular TU on the maintenance of high school students' CRF. This innovative TU structure, consisting of three 20-minutes of school recesses plus two 30-minutes out-of-school periods (in the case of the present study), showed being effective for maintaining students' CRF. Furthermore, another important outcome of the present study is the fact that the development and irregular TUs are effective for improving students' basic psychological needs, perceived autonomy, and autonomous motivation towards PA. Nevertheless, these innovative TUs did not change students' intention to be physically active, and heir habitual and extracurricular PA. Additionally, the development TU increased perceived and objective PA levels showing the importance of placing emphasis on increasing the intensity of the lessons when the goal is to improve students' CRF. Therefore, findings of this study might help PE teachers to design TUs that would allow for an effective and more complete development of the total PE curriculum objectives.

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Table 1. Motivational strategies applied during the intervention

	Irregular Group		Traditional and Control Groups	
Autonomy	-Non-controlling language is used	☐	-Controlling language is used	☐
	-Meaningful rationales are provided	☐	-No meaningful rationales are provided	☐
	-Students are expressing themselves about what they think about the lesson	☐	-Students have not the opportunity to express their thinking	☐
	-Physical activity choice is provided	☐	-Physical activity choice is not provided	☐
Competence	-Music chosen by the students is used	☐	-No music is used	☐
	-Affective feedbacks are given	☐	-Instructional feedback is given	☐
	-Self-monitoring is provided	☐	-Self-monitoring is not provided	☐
	-Individualized tasks are given according to students' level	☐	-No individualized tasks are given	☐
Relatedness	-Tasks with a common goal are provided	☐	-No tasks with a common goal are provided	☐
	-Flexible and heterogeneous groupings are used	☐	-No flexible and heterogeneous groupings are used	☐
Teacher autonomy support	-Daily physical activity habits are asked, empathizing and showing concern regarding students' difficulties to practice physical activity outside the class	☐	-Daily physical activity habits are not asked	☐
	-References regarding the physical activity barriers are mentioned and solved	☐	-There are not references regarding physical activity barriers	☐
	-Reflections on own progress throughout the lessons are performed	☐	-No reflections on own progress are performed	☐
	-Confidence in their improvement capacity is shown	☐	-No confidence in their improvement capacity is shown	☐

Table 2. General characteristics of the participants and attendance rate to the intervention

	Total	Control	Traditional	Irregular	ANOVA/Chi-squared test[a]	
	(N = 128)	(n = 37)	(n = 47)	(n = 44)	F/χ^2	p
Age (years)	13.7 (0.6)	13.7 (0.6)	13.7 (0.6)	13.8 (0.7)	0.235	0.791
Grade (2nd/3rd)	39.8/60.2	35.1/64.9	44.7/54.3	38.6/61.4	0.828	0.661
Gender (females/males)	51.6/48.4	59.5/40.5	42.6/57.4	54.5/45.5	2.608	0.271
Body mass (kg)	55.6 (10.3)	55.5 (10.5)	55.7 (9.0)	55.6 (11.7)	0.003	0.997
Body height (cm)	164.2 (8.3)	163.0 (7.7)	165.2 (7.6)	164.2 (9.5)	0.750	0.474
Body mass index (kg/m^2)	20.5 (2.8)	20.8 (3.3)	20.3 (2.5)	20.5 (2.9)	0.348	0.707
Overweight-obese (no/yes)	84.4/15.6	83.8/16.2	85.1/14.9	84.1/15.9	0.032	0.984
Habitual PA (days/week)	2.5 (1.6)	2.5 (1.7)	2.4 (1.5)	2.6 (1.5)	0.097	0.908
Extracurricular activities (no/yes)	9.4/90.6	8.1/91.9	10.6/89.4	9.1/90.9	0.162	0.922
Development attendance rate (%)	98.3 (3.4)	99.7 (1.4)	98.4 (2.4)	96.4 (4.5)***/††	12.179	< 0.001
Maintenance attendance rate (%)	85.1 (9.3)	74.3 (5.0)	86.4 (4.9)***	92.7 (6.9)***/†††	106.576	< 0.001

Note. Data are reported as mean (standard deviation) for continous variables (i.e., age, body mass, body heigh, body mass index, habitual physical activity, and attendance rate) and percentage for categorical variables (i.e., grade, gender, weight status, and extracurricular activities); PA = Physical activity; [a] One-way analysis of variance for continous variables and the chi squared test for categorical variables. Difference statistically significant between the control and traditional/irregular groups (***p < 0.001) and between the traditional and irregular groups (†† p < 0.01, ††† p < 0.001).

Table 3. Effect of the development and irregular teaching units on cardiorespiratory fitness levels

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal Mode		
	M (SE)	M (SE)	M (SE)	- 2LL	*F*	
20-m shuttle run test (s)[b]						
Control (*n* = 37)	304.2 (14.8)	308.7 (14.8)	308.7 (14.8)	4,180.785	15.131	< (
Traditional (*n* = 47)	308.4 (13.3)	353.3 (13.3)***	301.5 (13.3)†††			
Irregular (*n* = 44)	311.9 (13.5)	358.1 (13.5)***	373.7 (13.5)***			
VO_2 max (ml/kg/min)[b]						
Control (*n* = 37)	41.8 (0.7)	42.1 (0.7)	42.2 (0.7)	1,852.874	16.343	< (
Traditional (*n* = 47)	42.1 (0.6)	44.4 (0.6)***	42.0 (0.6)†††			
Irregular (*n* = 44)	42.1 (0.6)	44.0 8 (0.6)***	45.0 (0.6)***/†			

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group; [a] M within classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni adjustr intervention to post-development/post-maintenance (****p* < 0.001) and from post-development to post-maintenance (†*p* < 0.05, †††*p* < 0.001) activities were used as covariables.

Table 4. Effect of the development and irregular teaching units on basic psychological needs, perceived autonomy supp

physical activity, and health improvement and fun and enjoyment satisfaction

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal Model		
	M (SE)	M (SE)	M (SE)	- 2LL	*F*	*p*
Autonomy need (1-10)[b]						
Control (*n* = 37)	6.9 (0.3)	6.5 (0.3)	6.4 (0.3)	1,374.871	11.568	< 0.
Traditional (*n* = 47)	6.8 (0.2)	6.9 (0.2)	6.1 (0.2)*/†			
Irregular (*n* = 44)	7.0 (0.3)	8.3 (0.3)***	8.4 (0.3)***			
Competence need (1-10)[b]						
Control (*n* = 37)	7.3 (0.3)	6.5 (0.3)*	6.3 (0.3)***	1,305.488	15.375	< 0.
Traditional (*n* = 47)	6.8 (0.2)	6.8 (0.3)	6.3 (0.3)			
Irregular (*n* = 44)	7.2 (0.3)	8.3 (0.3)***	8.4 (0.3)***			
Relatedness need (1-10)[b]						
Control (*n* = 37)	7.8 (0.3)	7.7 (0.3)	7.7 (0.3)	1,357.403	2.975	0.0
Traditional (*n* = 47)	7.7 (0.3)	7.9 (0.3)	7.1 (0.3)*/†			
Irregular (*n* = 44)	8.3 (0.3)	8.7 (0.3)	8.6 (0.3)			

Autonomy (1-10)[b]						
Control (*n* = 37)	6.9 (0.3)	6.1 (0.3)	5.6 (0.3)***	1,466.571	32.526	< 0.
Traditional (*n* = 47)	5.7 (0.3)	5.5 (0.3)	4.3 (0.3)***/†††			
Irregular (*n* = 44)	6.8 (0.3)	9.0 (0.3)***	9.3 (0.3)***			
Autonomous motivation (1-10)[b]						
Control (*n* = 37)	7.1 (0.3)	7.0 (0.3)	7.2 (0.3)	1,149.296	2.444	0.0
Traditional (*n* = 47)	7.6 (0.2)	7.6 (0.2)	7.3 (0.2)			
Irregular (*n* = 44)	7.5 (0.2)	8.0 (0.2)*	7.7 (0.2)			
Controlled motivation (1-10)						
Control (*n* = 37)	1.9 (0.2)	2.1 (0.2)	2.3 (0.2)	1,125.405	1.095	0.3
Traditional (*n* = 47)	2.7 (0.2)	3.2 (0.2)	3.4 (0.2)			
Irregular (*n* = 44)	2.7 (0.2)	3.2 (0.2)	3.3 (0.2)			
Health improvement satisfaction (1-10)[b]						
Control (*n* = 37)	6.3 (0.3)	5.8 (0.3)	6.0 (0.3)	1,416.237	4.842	0.00
Traditional (*n* = 47)	6.7 (0.3)	6.6 (0.3)	6.3 (0.3)			
Irregular (*n* = 44)	6.5 (0.3)	7.2 (0.3)*	7.5 (0.3)**			

Fun and enjoyment satisfaction (1-10)[b]						
Control (*n* = 37)	7.9 (0.4)	7.9 (0.4)	8.3 (0.4)	1,471.070	1.428	0.22
Traditional (*n* = 47)	7.5 (0.3)	7.3 (0.3)	7.4 (0.4)			
Irregular (*n* = 44)	7.4 (0.3)	7.9 (0.3)	8.1 (0.3)			

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group; [a] Mu within classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni adjustm intervention to post-development/post-maintenance (*$p < 0.05$, **$p < 0.05$, ***$p < 0.001$) and from post-development to post-maintenance (†$p <$ (was used as covariable for all variables, except for health improvement and fun and enjoyment satisfaction where gender and attendance were usec

Table 5. Effect of the development and irregular teaching units on intention to be physically active, and habitual and e

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal Mo	
	M (SE)	M (SE)	M (SE)	- 2LL	*F*
Intention to be physically active (1-10)[b]					
Control (*n* = 37)	7.7 (0.4)	7.8 (0.4)	6.8 (0.4)	1,643.771	0.872
Traditional (*n* = 47)	7.8 (0.4)	8.1 (0.4)	7.7 (0.4)		
Irregular (*n* = 44)	8.3 (0.4)	8.8 (0.4)	8.3 (0.4)		
Habitual physical activity (0-7)[b]					
Control (*n* = 37)	2.5 (0.3)	2.6 (0.3)	2.7 (0.3)	1,310.085	1.433
Traditional (*n* = 47)	2.4 (0.2)	2.8 (0.2)	2.8 (0.2)		
Irregular (*n* = 44)	2.6 (0.2)	3.2 (0.2)	2.6 (0.2)		
Extracurricular physical activity (1-More than 5)[b]					
Control (*n* = 37)	3.3 (0.3)	3.5 (0.3)	2.6 (0.3)	1,435.716	2.384
Traditional (*n* = 47)	3.4 (0.3)	3.1 (0.3)	3.1 (0.3)		
Irregular (*n* = 44)	3.1 (0.3)	3.5 (0.3)	3.3 (0.3)		

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group; [a]

within classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni adjustment;

for intention to be physically active, and extracurricular activities and gender were used as covariable for habitual and extracurricular physical

Table 6. Comparison of perceived and objective physical activity levels during the Physical Education-b

periods between the three groups

	Control	Traditional	Irregular	Multilevel Lineal Model		
	(n = 37)	(n = 47)	(n = 44)	- 2LL	F	
Development period						
RPE[b]	1.8 (0.1)	5.9 (0.1)***	6.0 (0.1)***	204.655	390.480	< 0
Heart rate-average (bpm)[b]	106.9 (1.8)	140.8 (1.6)***	141.3 (1.6)***	956.032	130.610	< 0
Heart rate-average (%)[b]	53.9 (0.9)	70.9 (0.8)***	71.2 (0.8)***	783.528	130.216	< 0
Total PA (%)[b]	52.0 (0.4)	81.8 (2.2)***	83.0 (2.2)***	1,032.456	57.103	< 0
MVPA (%)	8.8 (2.1)	49.5 (1.9)***	47.0 (2.0)***	1,003.626	121.286	< 0
Session time (min)[b]	42.2 (0.3)	42.1 (0.3)	42.8 (0.3)	393.669	2.112	0.
Maintenance period						
RPE[c]	3.2 (0.2)	4.1 (0.2)	4.2 (0.2)*	277.992	7.461	0.
Heart rate-average (bpm)[c]	107.5 (2.3)	141.4 (2.0)***	140.7 (2.1)***	936.299	77.375	< 0
Heart rate-average (%)	54.1 (1.2)	71.3 (1.0)***	70.9 (1.1)***	779.576	76.163	< 0
Total PA (%)	69.3 (2.9)	73.0 (2.6)	74.6 (2.7)	993.039	0.942	0.

MVPA (%)	27.3 (3.3)	24.5 (3.0)	32.2 (2.1)	1,206.784	1.640	0.
Session time (min)[c]	43.3 (0.3)	42.4 (0.4)	43.1 (0.3)	477.163	2.930	0.0

Note. Data are reported as mean (standard error); CG = Control group; TG = Traditional group 1; IG = Irregular group. RPE = Ra physical activity; MVPA = Moderate-to-vigorous physical activity; [a] Multilevel Linear Model with participants nested within clas *post hoc* analysis with Bonferroni adjustment: Difference statistically significant between the CG and TG/IG (**p* < 0.05, ****p* < 0 were used as covariables for RPE, gender was used as covariable for heart rate-average (bpm and %) and for sesion time, and hab in the development program. [c] Grade and extracurricular activities were used as covariables for RPE, grade was was used as covari and habitual PA were used as covariables for sesion time.

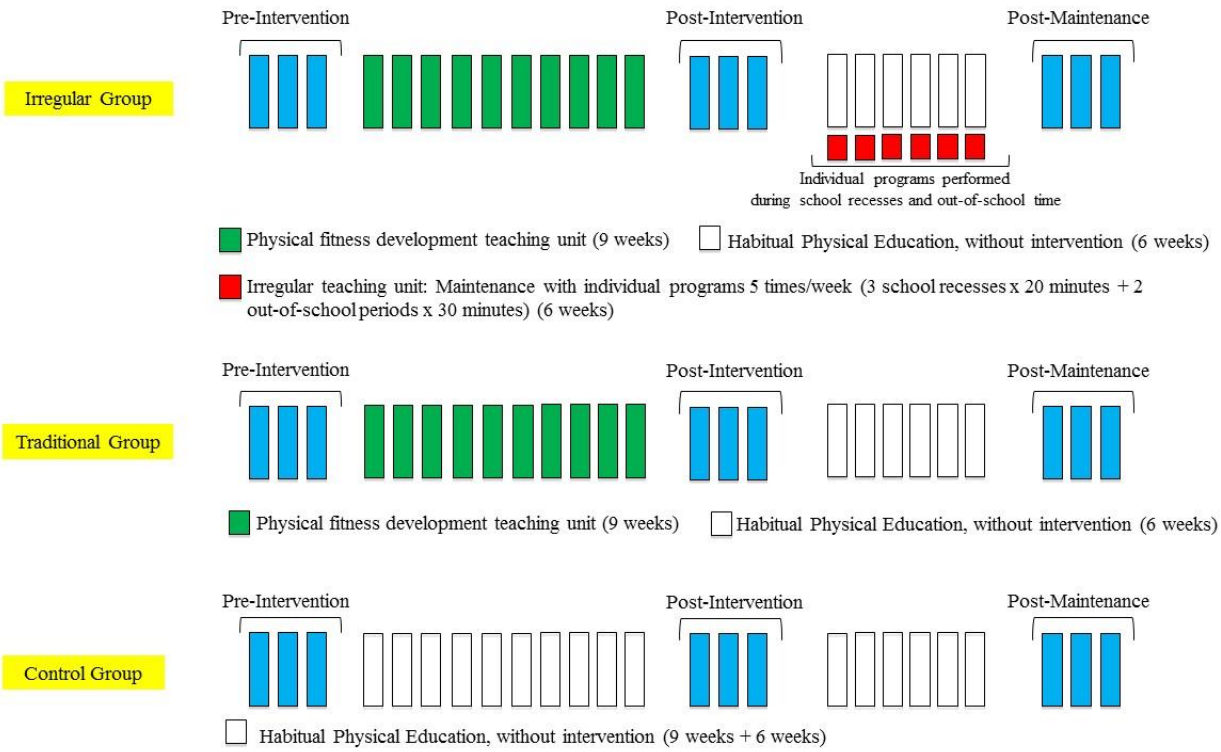

Figure 1. General scheme of the intervention.

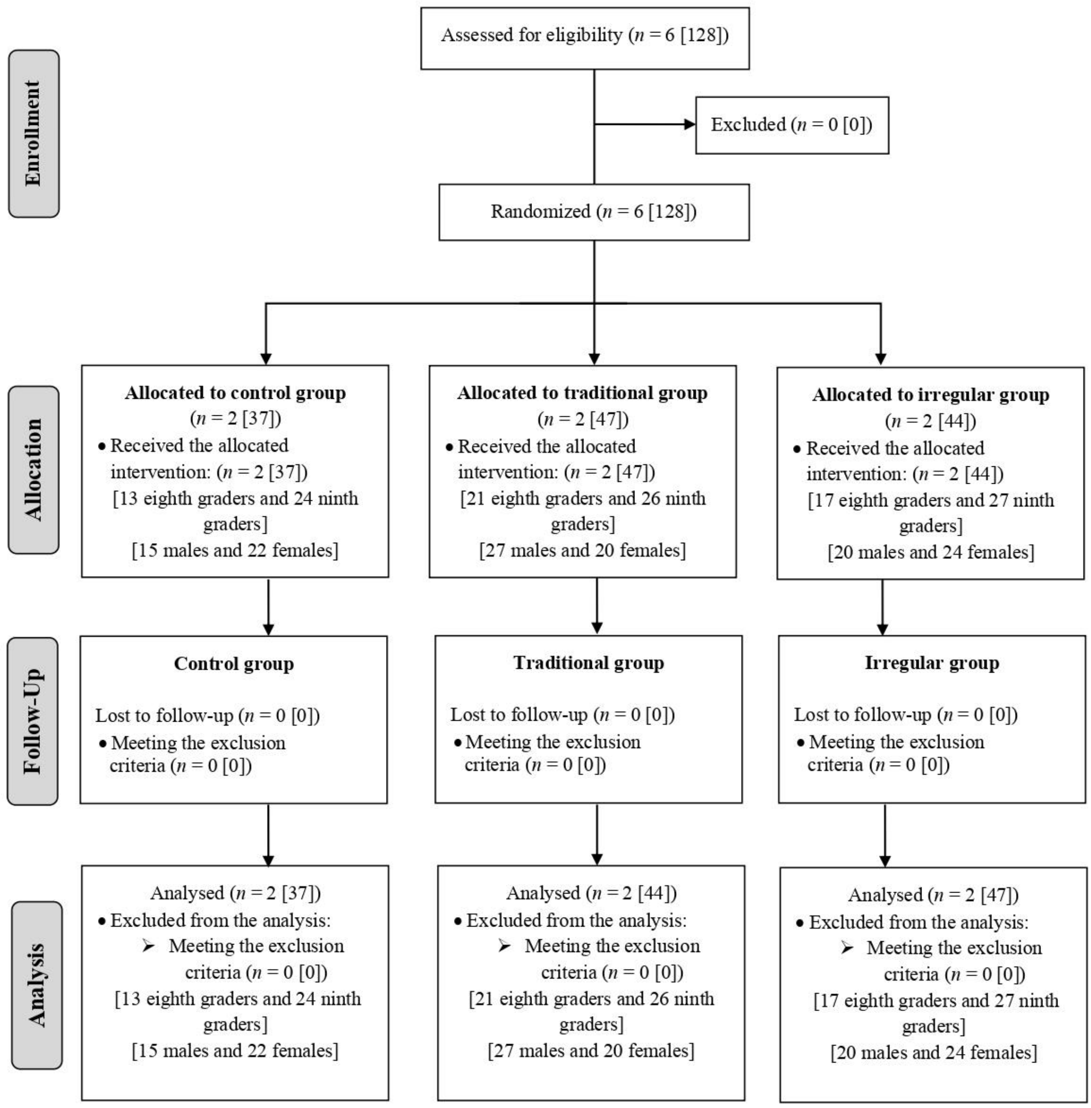

Figure 2. Flow chart of the school classes and students of the present study. All numbers are school classes [students].

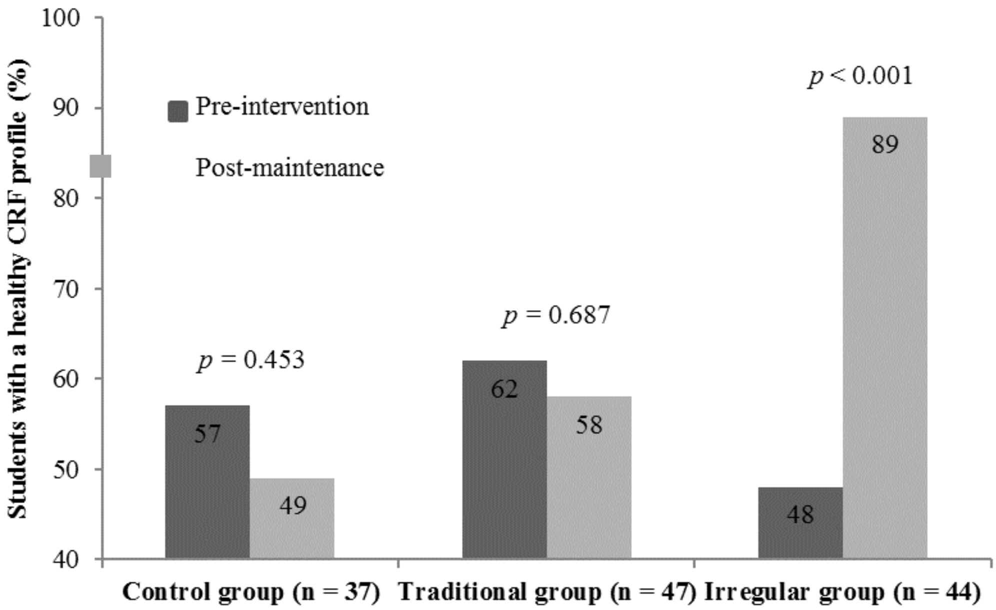

Figure 3. Effect of the Physical Education-based development and irregular teaching units on the percentage of students with a healthy cardiorespiratory fitness (CRF) profile. The *p* values correspond to the rests of the exact McNemar's test.

Supplementary Table 1. Effect of the development and irregular teaching units on self-determined motivation toward p

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal M	
	M (SE)	M (SE)	M (SE)	- 2LL	*F*
Intrinsic motivation (1-10)[b]					
Control (*n* = 37)	7.7 (0.3)	7.9 (0.3)	7.9 (0.3)	1,200.676	2.140
Traditional (*n* = 47)	7.9 (0.2)	8.0 (0.2)	7.5 (0.2)		
Irregular (*n* = 44)	7.8 (0.2)	8.2 (0.2)	7.9 (0.2)		
Integrated regulation (1-10)[b]					
Control (*n* = 37)	6.5 (0.3)	6.5 (0.3)	6.7 (0.3)	1,351.758	1.390
Traditional (*n* = 47)	6.8 (0.3)	7.0 (0.3)	6.9 (0.3)		
Irregular (*n* = 44)	7.1 (0.3)	7.6 (0.3)	7.3 (0.3)		
Identified regulation (1-10)[b]					
Control (*n* = 37)	7.5 (0.3)	7.1 (0.3)	7.4 (0.3)	1,290.892	2.576
Traditional (*n* = 47)	7.9 (0.2)	7.4 (0.2)	7.2 (0.2)*		
Irregular (*n* = 44)	7.7 (0.2)	7.9 (0.2)	7.9 (0.2)		
Introjected regulation (1-10)					

Control (*n* = 37)	2.3 (0.3)	2.4 (0.3)	2.9 (0.3)	1,369.328	1.779
Traditional (*n* = 47)	3.1 (0.3)	4.0 (0.3)	4.1 (0.3)		
Irregular (*n* = 44)	3.4 (0.3)	4.4 (0.3)	4.3 (0.3)		
External regulation (1-10)					
Control (*n* = 37)	1.6 (0.2)	1.7 (0.2)	1.8 (0.2)	1,180.030	0.470
Traditional (*n* = 47)	2.3 (0.2)	2.5 (0.2)	2.7 (0.2)		
Irregular (*n* = 44)	2.0 (0.2)	2.1 (0.2)	2.4 (0.2)		
Amotivation (1-10) [b]					
Control (*n* = 37)	1.8 (0.2)	1.7 (0.2)	1.7 (0.2)	1,002.170	1.483
Traditional (*n* = 47)	1.4 (0.2)	1.6 (0.2)	1.8 (0.2)		
Irregular (*n* = 44)	1.7 (0.2)	1.6 (0.2)	1.9 (0.2)		

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group; [a] M classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni adjustment: Ch post-development/post-maintenance (*$p < 0.05$); [b] Extracurricular activities was used as covariable for all variables except for for introyecte Additionally gender was used as covariable for integrated regulation and grade was used as covariable for intrinsic motivation and introyected

Supplementary Table 2. Effect of the development and irregular teaching units on cardiorespiratory fitness levels

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal M	
	M (SE)	M (SE)	M (SE)	- 2LL	*F*
20-m shuttle run test (s)[b]					
Control (*n* = 37)	299.9 (14.3)	304.5 (14.3)	304.4 (14.3)	3,241.882	11.232
Traditional (*n* = 47)	302.5 (14.1)	348.8 (16.2)***	297.5 (16.2)†††		
Irregular (*n* = 44)	309.2 (15.1)	350.3 (15.1)***	369.7 (15.1)***		
VO_2 max (ml/kg/min)[b]					
Control (*n* = 37)	41.6 (0.7)	42. (0.7)	42.0 (0.7)	1,441.506	11.804
Traditional (*n* = 47)	41.5 (0.8)	43.9 (0.8)***	41.4 (0.8)†††		
Irregular (*n* = 44)	41.9 (0.7)	43.7 (0.7)***	44.9 (0.9)***/†		

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group within classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni ac intervention to post-development/post-maintenance (***$p < 0.001$) and from post-development to post-maintenance (†$p < 0.05$, †††$p <$ 0 activities were used as covariables.

Supplementary Table 3. Effect of the development and irregular teaching units on basic psychological needs, pe

motivation toward physical activity, and health improvement and fun and enjoyment satisfaction

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal M	
	M (SE)	M (SE)	M (SE)	- 2LL	*F*
Autonomy need (1-10)[b]					
Control (*n* = 37)	7.0 (0.3)	6.6 (0.3)	6.4 (0.3)	1,065.298	8.661
Traditional (*n* = 47)	6.8 (0.3)	6.8 (0.3)	6.4 (0.3)		
Irregular (*n* = 44)	7.0 (0.3)	8.4 (0.3)***	8.4 (0.3)***		
Competence need (1-10)[b]					
Control (*n* = 37)	7.3 (0.3)	6.6 (0.3)*	6.4 (0.3)***	1,013.037	12.301
Traditional (*n* = 47)	6.8 (0.3)	6.6 (0.3)	6.4 (0.3)		
Irregular (*n* = 44)	7.3 (0.3)	8.4 (0.3)***	8.3 (0.3)***		
Relatedness need (1-10)[b]					
Control (*n* = 37)	7.9 (0.3)	7.7 (0.3)	7.7 (0.3)	1,052.182	1.204
Traditional (*n* = 47)	7.7 (0.3)	7.9 (0.3)	7.4 (0.3)		
Irregular (*n* = 44)	8.5 (0.3)	8.7 (0.3)	8.8 (0.3)		

Autonomous motivation (1-10)[b]					
Control (*n* = 37)	7.1 (0.3)	7.1 (0.3)	7.2 (0.3)	912.261	2.087
Traditional (*n* = 47)	7.6 (0.3)	7.6 (0.3)	7.4 (0.3)		
Irregular (*n* = 44)	7.4 (0.3)	7.9 (0.3)	7.7 (0.3)		
Autonomy (1-10)[b]					
Control (*n* = 37)	6.9 (0.3)	6.2 (0.3)	5.6 (0.3)***	1,147.187	29.419
Traditional (*n* = 47)	5.7 (0.4)	5.2 (0.4)	4.0 (0.4)***/†		
Irregular (*n* = 44)	6.7 (0.3)	9.0 (0.3)***	9.4 (0.3)***		
Controlled motivation (1-10)					
Control (*n* = 37)	1.9 (0.2)	2.1 (0.2)	2.3 (0.2)	842.428	2.177
Traditional (*n* = 47)	2.5 (0.2)	3.4 (0.2)	3.4 (0.2)		
Irregular (*n* = 44)	2.5 (0.2)	3.0 (0.2)	3.1 (0.2)		
Intrinsic motivation (1-10)[b]					
Control (*n* = 37)	7.6 (0.3)	7.9 (0.3)	7.9 (0.3)	942.781	1.177
Traditional (*n* = 47)	7.9 (0.3)	8.0 (0.3)	7.6 (0.3)		
Irregular (*n* = 44)	7.6 (0.3)	8.1 (0.3)	7.9 (0.3)		

Integrated regulation (1-10)[b]					
Control (*n* = 37)	6.5 (0.3)	6.5 (0.3)	6.7 (0.3)	1,068.022	1.731
Traditional (*n* = 47)	6.8 (0.4)	6.9 (0.4)	7.0 (0.4)		
Irregular (*n* = 44)	6.8 (0.4)	7.6 (0.4)	7.2 (0.4)		
Identified regulation (1-10)[b]					
Control (*n* = 37)	7.6 (0.3)	7.2 (0.3)	7.4 (0.3)	1,012.412	2.072
Traditional (*n* = 47)	7.9 (0.3)	7.6 (0.3)	7.4 (0.5)		
Irregular (*n* = 44)	7.6 (0.3)	7.9 (0.3)	7.7 (0.3)		
Introjected regulation (1-10)					
Control (*n* = 37)	2.2 (0.3)	2.4 (0.3)	2.9 (0.3)	1,053.546	2.174
Traditional (*n* = 47)	3.0 (0.3)	4.2 (0.3)	4.2 (0.3)		
Irregular (*n* = 44)	3.4 (0.3)	4.1 (0.3)	4.1 (0.3)		
External regulation (1-10)					
Control (*n* = 37)	1.6 (0.2)	1.7 (0.2)	1.8 (0.2)	867.860	0.916
Traditional (*n* = 47)	2.0 (0.2)	2.5 (0.2)	2.5 (0.2)		
Irregular (*n* = 44)	1.7 (0.2)	1.9 (0.2)	2.1 (0.2)		

Amotivation (1-10 [b]					
Control (n = 37)	1.8 (0.2)	1.7 (0.2)	1.7 (0.2)	764.375	2.510
Traditional (n = 47)	1.3 (0.2)	1.6 (0.2)	1.7 (0.2)		
Irregular (n = 44)	1.6 (0.2)	1.4 (0.2)	1.9 (0.2)†		
Health improvement satisfaction (1-10) [b]					
Control (n = 37)	6.4 (0.3)	5.9 (0.3)	6.1 (0.3)	1,090.132	2.867
Traditional (n = 47)	6.6 (0.3)	6.0 (0.3)	6.2 (0.3)		
Irregular (n = 44)	6.7 (0.3)	7.0 (0.3)	7.4 (0.3)*		
Fun and enjoyment satisfaction (1-10)					
Control (n = 37)	7.5 (0.3)	7.5 (0.3)	7.8 (0.3)	1,149.465	0.306
Traditional (n = 47)	7.5 (0.4)	7.5 (0.4)	7.8 (0.4)		
Irregular (n = 44)	7.7 (0.3)	8.1 (0.3)	8.3 (0.3)		

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group; [a] M classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni adjustment: Ch post-development/post-maintenance (*p < 0.05, ***p < 0.001) and from post-development to post-maintenance (†p < 0.05); [b] Extracurricu except for for introyected and external regulations, controlled motivation, health improvement and fun and enjoyment satisfaction; Additio regulation and health improvement satisfaction; and grade was used as covariable for intrinsic motivation.

Supplementary Table 4. Effect of the development and irregular teaching units on intention to be physically active, an

activity

Group	Pre-intervention (1)	Post-development (2)	Post-maintenance (3)	Multilevel Lineal M	
	M (SE)	M (SE)	M (SE)	- 2LL	*F*
Intention to be physically active (1-10)[b]					
Control (*n* = 37)	7.7 (0.4)	7.9 (0.4)	6.9 (0.4)	1,270.803	0.575
Traditional (*n* = 47)	8.1 (0.5)	8.4 (0.5)	7.7 (0.5)		
Irregular (*n* = 44)	8.3 (0.4)	8.8 (0.4)	8.3 (0.4)		
Habitual physical activity (0-10)[b]					
Control (*n* = 37)	2.5 (0.3)	2.6 (0.3)	2.7 (0.3)	987.080	1.735
Traditional (*n* = 47)	2.2 (0.3)	2.8 (0.3)	2.9 (0.3)		
Irregular (*n* = 44)	2.5 (0.3)	3.1 (0.3)	2.6 (0.3)		
Extracurricular physical activity (1-More than5)[b]					
Control (*n* = 37)	3.3 (0.3)	3.5 (0.3)	2.6 (0.3)	1,127.840	1.994
Traditional (*n* = 47)	3.3 (0.4)	3.2 (0.4)	3.2 (0.4)		
Irregular (*n* = 44)	3.1 (0.4)	3.3 (0.4)	3.2 (0.4)		

M = Adjusted mean; SE = Standard error; - 2LL = -2 log-likelihood; CG = Control group; TG = Traditional group; IT = Irregular group

within classes and measures within participants (i.e., two-way mixed nested ANOVA) with the *post hoc* analysis with Bonferroni adjustme

for intention to be physically active, and extracurricular activities and gender were used as covariable for habitual and extracurricular physic

Supplementary Table 5. Comparison of perceived and objective physical activity levels during the Physica

maintenance periods between the three groups

	Control	Traditional	Irregular	Multilevel Lineal Model		
	(*n* = 37)	(*n* = 47)	(*n* = 44)	- 2LL	*F*	
Development period						
RPE[b]	1.8 (0.1)	5.8 (0.1)***	6.0 (0.1)***	165.051	506.615	< 0
Heart rate-average (bpm)[b]	107.1 (1.8)	139.9 (2.1)***	139.6 (1.9)***	746.475	102.939	< 0
Heart rate-average (%)[b]	53.9 (0.9)	70.5 (1.0)***	70.4 (1.0)***	612.345	102.886	< 0
Total PA (%)[b]	52.2 (0.6)	81.7 (3.0)***	82.9 (2.8)***	819.343	41.678	< 0
MVPA (%)	8.8 (2.1)	47.9 (2.5)***	44.8 (2.2)***	776.403	100.338	< 0
Session time (min)[b]	42.2 (0.2)	41.8 (0.2)	42.8 (0.2)	298.184	4.105	0.
Maintenance period						
RPE	3.2 (0.2)	4.1 (0.2)	4.3 (0.2)*	212.738	7.991	0.
Heart rate-average (bpm)	107.5 (2.3)	140.8 (2.5)***	138.8 (2.4)***	742.256	66.313	< 0
Heart rate-average (%)	54.1 (1.1)	70.9 (1.3)***	69.9 (1.2)***	614.543	66.490	< 0

Total PA (%)	69.3 (2.9)	74.1 (3.2)	74.2 (3.0)	789.512	0.880	0.4
MVPA (%)	23.4 (3.3)	22.5 (3.7)	29.0 (3.5)	816.417	0.866	0.4
Session time (min)[c]	43.3 (0.3)	42.0 (0.4)*	43.0 (0.3)	376.049	4.210	0.0

Note. Data are reported as mean (standard error); CG = Control group; TG = Traditional group 1; IG = Irregular group. RPE = Ra physical activity; MVPA = Moderate-to-vigorous physical activity; [a] Multilevel Linear Model with participants nested within clas *post hoc* analysis with Bonferroni adjustment: Difference statistically significant between the CG and TG/IG (*$p < 0.05$, ***p < RPE, gender was used as covariable for heart rate-average (bpm and %) and for sesion time, and habitual PA was used as covariab

[c] Grade was used as covariable for sesion time in the maintenance program.

Paper V

EVALUACIÓN DEL CONOCIMIENTO DEL ENTORNO PARA EL ACONDICIONAMIENTO FÍSICO (CENAFI) EN ESCOLARES

[ASSESSMENT OF THE KNOWLEDGE ABOUT THE ENVIRONMENT FOR PHYSICAL CONDITIONING (CENAFI) IN SCHOOLCHILDREN]

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EVALUACIÓN DEL CONOCIMIENTO DEL ENTORNO PARA EL ACONDICIONAMIENTO FÍSICO (CENAFI) EN ESCOLARES

Assessment of the knowledge about the environment for physical conditioning (CENAFI) in schoolchildren

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Resumen:

El objetivo del presente estudio fue construir y validar una prueba escrita de elección múltiple *ad hoc* para evaluar el conocimiento de los escolares sobre el entorno próximo al centro educativo para el acondicionamiento físico (CENAFI). Un total de 189 estudiantes (95 mujeres) de primer a cuarto curso de Educación Secundaria Obligatoria (edad media = 13,57 ± 1,3 años) participaron en el estudio. Las fases de la validación de la prueba fueron: (1) Construcción y definición de la estructura y finalidad de la prueba; (2) validación de contenido por expertos; (3) pilotaje; (4) depuración y aplicación del instrumento definitivo; (5) evaluación de la fiabilidad test-retest; y (6) evaluación de la validez discriminante. La prueba final consistió en 30 preguntas objetivas de elección múltiple con una dificultad global moderada (media = 11,60 puntos sobre 30). Todos los índices cuantitativos fueron adecuados en dificultad, discriminación y cumplieron con los criterios cualitativos establecidos por los expertos. La fiabilidad test-retest de la prueba fue adecuada (CCI = 0,65) y los estudiantes que vivenciaron el programa de intervención obtuvieron una puntuación mayor que los del grupo control, mostrando, por tanto, una validez discriminante igualmente adecuada. Los resultados demuestran que es un instrumento de medida válido y fiable para obtener

información sobre el conocimiento de los escolares del entorno próximo para el acondicionamiento físico. El presente estudio representa una contribución valiosa para la literatura científica y con importantes repercusiones prácticas para la asignatura de Educación Física.

Palabras clave: ***Capacidades físicas básicas*, *Educación Física*, *Educación Secundaria Obligatoria*, *estudiantes*, *prueba objetivo de elección múltiple***

Abstract:

The purpose of the present study was to build and develop and *ad hoc* multiple-choice written test to assess the schoolchildren's knowledge of the environment around the educational center for physical conditioning (CENAFI). A total of 189 students (95 females) from first to fourth grades of Compulsory Secondary Education (M_{age} = 13.57 ± 1.3 years) participated in the study. The phases of the test validation were: (1) Construction and definition of the structure and purpose of the test; (2) content validation by experts; (3) piloting; (4) depuration and application of the definitive instrument; (5) test-retest reliability assessment; and (6) discriminant validity assessment. The final test consisted of 30 objective multiple-choice questions with moderate global difficulty (average = 11.60 points out of 30). All quantitative indices were adequate in difficulty, discrimination, and met the qualitative criteria established by the experts. The test-retest reliability of the test was adequate (ICC = 0.65) and the students who experienced the intervention program obtained a higher score than those of the control group, thus showing equally adequate discriminant validity. The results show that it is a valid and reliable measuring instrument in order to obtain information on schoolchildren's knowledge of their immediate environment for physical conditioning. The present study represents a valuable contribution to scientific literature and has important practical repercussions for the Physical Education subject.

Key Words: ***Basic physical capacities*, *Physical Education*, *Compulsory Secondary Education*, *students*, *objective multiple-choice exam***

1. Presentación y justificación del problema

La condición física (CF) es considerada un potente marcador de salud en niños en edad escolar (Tomkinson, Lang, y Tremblay, 2017). Durante la edad escolar niveles saludables de CF están fuerte y positivamente asociados con una mejor calidad de vida (Evaristo et al., 2019), así como con un mejor rendimiento académico (Chu, Chen, Pontifex, Sun, y Chang, 2016). Desafortunadamente, durante las últimas décadas la CF de los escolares ha ido disminuyendo (Tomkinson et al., 2017), convirtiéndose en un problema que afecta de media a nivel mundial al 33% de los varones y al 46% de las mujeres (Tomkinson et al., 2016). En este sentido, la actividad física (AF) es considerada un elemento clave para modificar la CF (Lang, Tremblay, Léger, Olds, y Tomkinson, 2016). Poitras et al. (2016) observaron cómo mejores niveles de AF en los escolares estaban positivamente asociados a mejores niveles de CF. Se recomienda que los escolares realicen al menos 60 minutos al día de AF moderada-vigorosa (Organización Mundial de la Salud [OMS], 2010). Desafortunadamente, en la actualidad esta recomendación raramente se cumple, ya que a nivel mundial más del 80% de los escolares presentan unos niveles de AF insuficientes (Guthold, Stevens, Riley, y Bull, 2019).

Consecuentemente, la promoción de la mejora de la CF mediante el incremento de los niveles de AF en los escolares es un objetivo prioritario de salud pública (OMS, 2018). La asignatura de Educación Física (EF) es considerada un contexto ideal para la adquisición de unos niveles saludables de CF (OMS, 2018). De manera similar a la mayoría de los países de nuestro entorno (European Commission/EACEA/Eurydice, 2013), en España el currículum educativo de la asignatura de EF establece como uno de sus objetivos principales el desarrollo de un nivel saludable de CF en la etapa de Educación Secundaria Obligatoria (ESO). Además, otro objetivo fundamental es el reconocimiento de las posibilidades que ofrece el entorno para la práctica de actividades físico-deportivas que permitan adquirir un estilo de vida activo manteniendo las mejoras en la CF adquiridas durante las clases de EF (Ministerio de Educación, Cultura y Deporte [MECD], 2015). Igualmente, la institución *Society of Health and Physical Educators* (SHAPE America, 2013) señala que la asignatura de EF tiene un rol importante en la mejora de la "alfabetización física" de los estudiantes. Por ello, se sugiere a los profesores de EF que incidan en su promoción mediante la mejora de la motivación y competencia física de los estudiantes, así como del conocimiento necesario para mantener un estilo de vida activo (SHAPE America, 2013).

El sistema educativo actual está basado en el aprendizaje por competencias (MECD, 2013), siendo uno de sus pilares esenciales el principio de transferibilidad de los aprendizajes del aula a la vida cotidiana del alumno (Miklos, 1999). Específicamente, la asignatura de EF se propone el desarrollo de la competencia motriz como objetivo principal. Para conseguirlo, se precisa inculcar al alumnado un nivel saludable de CF y el aprendizaje del uso del entorno para la adquisición de un estilo de vida activo, así como para mantener altos niveles de CF practicándola de manera autónoma, y reduciendo progresivamente la dependencia del alumno respecto del profesor (MECD, 2015). En este sentido, uno de los tres ejes fundamentales del reciente modelo de planificación de la EF propuesto por Viciana y Mayorga-Vega (2018) es la dotación progresiva de autonomía al alumnado. El incremento progresivo de autonomía permitirá al alumno establecer fuertes conexiones entre el conocimiento adquirido durante las clases de EF y las experiencias de la vida real, facilitando de esta forma su alfabetización física (Ennis, 2011). De hecho, uno de los objetivos fundamentales de la EF más allá de la mera práctica de AF durante las clases, es la adquisición e integración de conocimientos (MECD, 2015).

Considerando todas las razones anteriormente mencionadas, cabe destacar que uno de los ámbitos más importantes dentro de la evaluación de la asignatura de EF debería ser el conocimiento que tienen los estudiantes sobre su entorno próximo para el acondicionamiento físico autónomo. Gracias a este conocimiento los estudiantes podrían utilizar fuera del horario escolar los elementos de su entorno próximo para realizar las mismas tareas de acondicionamiento físico que en las clases de EF, continuando de esta forma la mejora y mantenimiento de la CF en su tiempo libre (Ferkel, Judge, Stodden, y Griffin, 2014). Al mismo tiempo, se podría producir un aumento de la práctica de AF en el tiempo libre, facilitándose el cumplimiento de las recomendaciones diarias (OMS, 2010).

La herramienta más común para evaluar la adquisición de aspectos cognitivos es mediante una prueba de conocimiento escrita (Baumgartner, Jackson, Mahar, y Rowe, 2015). Estudios previos en el contexto de la EF han construido y validado pruebas de evaluación del conocimiento técnico, táctico y reglamentario de los deportes (Moreno, Del Villar, García-González, García-Calvo, y Moreno, 2013; Serra-Olivares y García-López, 2016), conocimiento del balance energético (Chen, Zhu, y Kang, 2017) o del conocimiento de la aptitud física (Chen, Chen, Sun, y Zhu, 2013). Desafortunadamente, de lo que conocemos, y a pesar de la demanda social de esta cuestión reflejada en los currículos educativos actuales, no hay estudios previos que hayan desarrollado y validado pruebas para evaluar el conocimiento que poseen los escolares sobre su entorno próximo para el desarrollo y mantenimiento de la CF. Consecuentemente, el objetivo del presente estudio fue construir y someter a un proceso de validación una prueba escrita de respuesta múltiple *ad hoc* para crear una herramienta válida y fiable para la evaluación del conocimiento del entorno próximo para el acondicionamiento físico (CENAFI) en estudiantes de ESO.

2. Método

2.1. Participantes

El protocolo del estudio fue primero aprobado por el Comité de Ética de la Universidad de [omitido]. Después, se contactó con el director y profesor de EF de un centro público de ESO seleccionado por conveniencia. Se les informó de las características principales del proyecto y se les solicitó permiso para llevar a cabo el estudio. Tras obtener la aprobación del centro, los estudiantes y sus tutores legales fueron informados sobre las características del proyecto. Antes de participar en el estudio, se obtuvieron los consentimientos y asentimientos informados por escrito firmados por los tutores legales y los escolares, respectivamente. El reclutamiento se realizó en junio de 2019 y la toma de datos entre octubre y noviembre de 2019.

Ciento ochenta y nueve estudiantes matriculados en los cursos 1º-4º de ESO (12-16 años) del centro seleccionado fueron invitados a participar en el estudio. El centro educativo estaba ubicado en el área urbana de [omitido]. Según los informes del centro, todas las familias de los estudiantes tenían un nivel socioeconómico medio. Los criterios de inclusión fueron: (a) Estar matriculado en los cursos 1º-4º de ESO; (b) no padecer ningún trastorno de salud que les impida realizar AF con normalidad; (c) presentar el asentimiento informado por escrito firmado por los escolares; y (d) presentar el consentimiento informado por escrito firmado por sus padres o tutores legales. El criterio de exclusión fue: (a) no haber contestado a todas las preguntas de la prueba (todos los estudios); y (b) no tener una tasa de asistencia al programa igual o superior al 85% durante el periodo de intervención (estudio de validez discriminante).

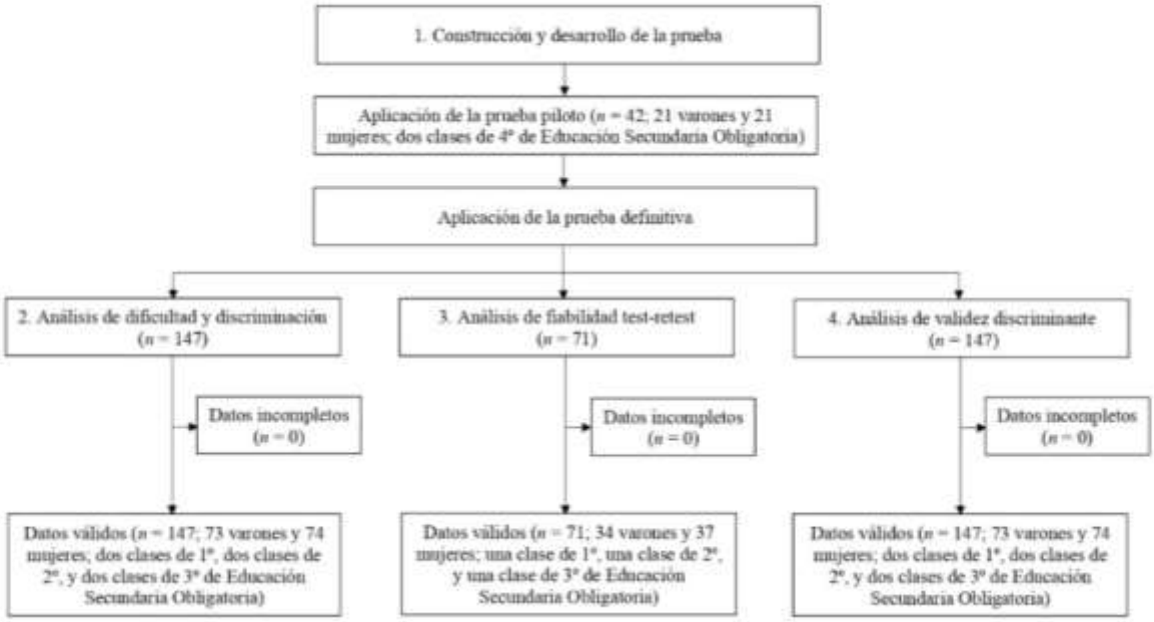

Figura 1. Diagrama de flujo de los participantes incluidos en cada estudio.
Fuente: Elaboración propia.

La Figura 1 muestra el diagrama de flujo de los participantes incluidos en cada estudio. Todos los estudiantes invitados en cada estudio aceptaron voluntariamente participar y cumplieron con los criterios de inclusión. La muestra utilizada para llevar a cabo el estudio piloto y los índices de dificultad y discriminación del instrumento definitivo cumplimentaron una vez la prueba. Posteriormente, para el estudio de la fiabilidad del instrumento definitivo, se utilizó una submuestra (submuestra fiabilidad) que repitió la prueba 10 semanas más tarde. Para estudiar la validez discriminante del instrumento definitivo, seis clases pre-establecidas por el centro educativo fueron distribuidas de forma aleatoria y balanceadas por curso al grupo intervención o control. Al finalizar la intervención, ambos grupos cumplimentaron la prueba. La Tabla 1 muestra las características generales de los participantes incluidos.

Tabla 1
Características generales de los estudiantes analizados[a].

	Piloto (*n* = 42)	Dificultad y discriminación (*n* = 147)	Fiabilidad (*n* = 71)	Validez discriminante (*n* = 147)
Edad (años)	15,19 (0,4)	13,11 (1,0)	13,06 (1,0)	13,11 (1,0)
Edad (rango)	15-16	13-15	13-15	13-15
Curso (1º/2º/3º/4º)	0/0/0/42	46/46/55/0	22/21/28/0	46/46/55/0
Género (mujeres/varones)	21/21	74/73	37/34	74/73

Nota. [a] Los datos están reportados como frecuencia o media (desviación estándar).
Fuente: Elaboración propia.

Previamente a la realización de cada estudio, se estimó el tamaño muestral de la siguiente manera: (a) Para el estudio piloto de la prueba se siguió la recomendación de utilizar al menos 25-50 participantes (Fontes, García-Gallego, Garriga-Trillo, Pérez-Llantada, y Sarriá, 2007); (b) para la obtención de unos resultados válidos y fiables en el análisis de dificultad y discriminación de las preguntas definitivas, se siguió la recomendación de utilizar una muestra mayor a 100 participantes (Baumgartner et al., 2015); (c) para obtener un coeficiente de correlación intraclase (CCI) superior a 0,6 en la fiabilidad test-retest, considerando $\alpha = 0,05$ y $1 - \beta = 0,80$, se estimó un mínimo de 45 participantes (Walter, Eliasziw, y Donner, 1998); y (d) respecto al estudio de la validez discriminante, el tamaño mínimo de muestra (128 participantes) se estimó con la función *F* del ANOVA de un factor mediante el programa G*Power versión 3.1.9.4 para Windows. Los parámetros se establecieron como: $f = 0,25$, $\alpha = 0,05$, $1 - \beta = 0,80$ y número de grupos = 2.

2.2. Desarrollo de la prueba

El procedimiento seguido para la construcción de la prueba se basó en los criterios sugeridos por la literatura previa (Baumgartner et al., 2015; Eignor, 2013), descritos a continuación.

2.2.1. Paso 1. Construcción de la prueba

Para la recogida de información se diseñó una prueba escrita *ad hoc* objetiva y de elección múltiple titulada "Prueba sobre el conocimiento de tu entorno para el acondicionamiento físico (CENAFI)", con el propósito de evaluar el conocimiento que posee el alumnado de ESO sobre ese conocimiento específico. Para establecer la estructura de la prueba se llevaron a cabo los siguientes pasos: (a) Una revisión bibliográfica sobre el término "conocimiento", ya que al ser un concepto multidimensional se debía decidir una clasificación de sus dimensiones de acuerdo con el objetivo del estudio; y (b) un análisis por parte de un panel de expertos formado por investigadores y doctores en EF sobre para qué tipo de actividades utilizan los escolares el entorno y cómo podrían utilizarlo para su acondicionamiento físico.

Para la selección de la estructura del conocimiento a evaluar, se tomó como referencia la clasificación propuesta por Zack (1999) como la más oportuna según el objetivo del estudio, dividiéndose el conocimiento en tres tipos: (a) Causal, referido a la relación causa-efecto de las acciones (saber "por qué" ocurre algo); (b) declarativo, referido a la descripción de un hecho y el conocimiento explícito de conceptos (saber "el qué" de algo); y (c) procedimental, referido a cómo se realiza algo mediante el desarrollo de procedimientos o técnicas para el logro de un fin (saber "cómo" hacer algo). En segundo lugar, respecto a los componentes de la CF solicitados en el área de EF en ESO se dividió la prueba en tres grandes bloques: (a) Resistencia; (b) fuerza; y (c) flexibilidad. Todos ellos estaban enfocados al conocimiento sobre ejercicios y metodologías de trabajo que podrían realizar haciendo uso de su entorno próximo para el desarrollo y mantenimiento de la CF desde un enfoque saludable. La prueba final estuvo compuesta por 30 preguntas, con

10 preguntas para cada dimensión del conocimiento (causal, declarativo y procedimental) siendo dos preguntas sobre la capacidad física básica de resistencia, cuatro sobre fuerza y cuatro sobre flexibilidad.

Una vez determinado el objetivo de la prueba, así como su división en bloques de conocimiento, se decidió la naturaleza de la prueba. Siguiendo las instrucciones de Baumgartner et al. (2015), finalmente se optó por una prueba de tipo objetiva y de elección múltiple con cuatro opciones de respuesta (Raymond, Stevens, y Bucak, 2019) y una única opción correcta para todas las preguntas. A continuación, se llevó a cabo una revisión bibliográfica sobre el tema para la elaboración de las preguntas desarrollándose una batería de 46 preguntas iniciales. Además, se elaboró el encabezado con una breve introducción de presentación e instrucciones para completar correctamente la prueba, así como un agradecimiento por su participación. En dichas instrucciones se hacía especial hincapié en que los estudiantes debían contestar todas las preguntas, ya que no había ninguna penalización por respuestas incorrectas.

2.2.2. Paso 2. Validación de contenido por expertos

Una vez elaborada la batería inicial de preguntas, un panel de expertos en EF evaluó la validez de contenido, es decir, el grado en que un instrumento cumple con el propósito de su construcción y mide lo que realmente quiere medir para poder considerar válida la prueba (Eignor, 2013). El procedimiento seguido fue el juicio de expertos, siguiendo el método *Delphi*. Esta técnica se basa en la opinión de expertos cualificados capaces de emitir juicios y valoraciones sobre el tema. Tomando como referencia las indicaciones de Corral (2009) y Escobar-Pérez y Cuervo-Martínez (2008), los pasos seguidos fueron:

1. Una vez realizada la revisión bibliográfica y elaborada una batería de 46 preguntas, se seleccionaron los expertos para validar el contenido de la prueba. Tres docentes e investigadores con experiencia científica y académica en el área de EF fueron seleccionados para garantizar la idoneidad y contribución de este análisis.

2. Se informó detalladamente a cada experto sobre el objetivo del instrumento, su estructura y los indicadores sobre los que realizar su análisis. Posteriormente, calificaron las preguntas como adecuadas/inadecuadas, fundamentando su evaluación en cuatro categorías: (a) adecuación y complejidad (la pregunta está formulada adecuadamente según los destinatarios a evaluar); (b) coherencia o pertinencia con los objetivos a evaluar (recoge información relevante al conocimiento del entorno); (c) claridad en la redacción (se comprenden fácilmente y la relación semántica y sintáctica es adecuada); y (d) existencia de sesgo en la formulación (si una de las respuestas es sugerida o no). Además, se comprobó que la introducción e instrucciones fueran claras, así como que no hubiese errores gramaticales en toda la prueba. Luego, cada experto emitió su juicio individual y sin contacto con el resto de expertos para evitar sesgos.

3. Tras obtener el informe de los expertos, el investigador responsable de elaborar la prueba revisó las preguntas basándose en los juicios emitidos y generó un informe con todas las respuestas para analizar los datos y tomar decisiones. Aquellas preguntas con 100% de coincidencia favorable (adecuadas)/desfavorables (inadecuadas) entre los jueces quedaron incluidas/excluidas. Posteriormente, el investigador responsable se reunió con los expertos para debatir sobre las opiniones de otros participantes y volver a analizar las preguntas con su retroalimentación. Esto se realizó durante tres rondas, para revisar, reformular y/o sustituir aquellas preguntas en las que no había una coincidencia total entre expertos en los indicadores evaluados. Finalmente, tras realizar las modificaciones oportunas, basándose en la responsabilidad compartida de los participantes, se editó de forma definitiva la batería de 46 preguntas.

2.2.3. Paso 3. Pilotaje

Se diseñó una prueba piloto atendiendo de forma equitativa a las tres dimensiones del conocimiento establecidas para valorar la comprensión de las preguntas y respuestas, así como calcular la dificultad de la mismas. La prueba piloto fue administrada a una muestra de 4º curso de ESO en las mismas condiciones en las que se realizaría posteriormente la prueba definitiva (Fontes, García-Gallego, Garriga-Trillo, Pérez-Llantada, y Sarriá, 2007). Además, se recogieron cualitativamente las dudas planteadas por los participantes en el pilotaje para poder subsanar posibles errores antes de configurar la prueba definitiva. El alumnado empleó un tiempo medio de 43 minutos y 37 segundos (25-60 minutos) en finalizar la prueba. Por último, para valorar la prueba los participantes respondieron a un cuestionario compuesto por 10 preguntas con una escala tipo Likert de cinco puntos que iba desde 1 "Absolutamente en desacuerdo" hasta 5 "Absolutamente de acuerdo" (Tabla 2).

Tabla 2
Resultados de la escala de valoración de la prueba piloto.

	Media (DE)
1. He entendido perfectamente las instrucciones para cumplimentar la prueba	4,45 (0,8)
2. He entendido perfectamente todas las palabras utilizadas en la prueba	4,07 (0,9)
3. He comprendido perfectamente las preguntas de la prueba	3,90 (1,0)
4. He entendido cómo debía contestar a las distintas preguntas	4,57 (0,9)
5. He sabido utilizar el sistema de respuesta según las respuestas "a/b/c/d" con sólo una respuesta correcta	4,69 (0,7)
6. El tema que trata la prueba me ha resultado interesante	3,98 (0,9)
7. Todas las preguntas me han parecido importantes para el tema que trata la prueba	4,02 (1,0)
8. La presentación de la prueba me ha parecido clara, me ha resultado fácil leer las preguntas	4,07 (1,0)
9. La prueba no me ha resultado liosa, cansada o pesada	3,31 (1,1)
10. En conjunto la prueba no presenta ningún problema	3,88 (0,9)
Global	4,10 (0,9)

Nota. DE = Desviación estándar.

Fuente: Elaboración propia.

A continuación, se calcularon los índices cuantitativos de dificultad y discriminación relativos a cada pregunta en una hoja de Microsoft Office Excel 2019 (Microsoft® Corporation) (Baumgartner et al., 2015). No obstante, los índices relativos a la prueba global (es decir, dificultad y fiabilidad de la prueba completa) no se calcularon porque la prueba piloto aplicada tenía un número de preguntas mayor que la prueba definitiva, para poder seleccionar aquellas que obtuviesen mejores índices y configurar la prueba final. Los índices calculados fueron los planteados por Baumgartner et al. (2015), comparándose los resultados para el 27% de participantes que obtuvo la peor puntuación (grupo bajo) y mejor puntuación (grupo alto). Concretamente, se calcularon los siguientes índices: (a) *Índice de discriminación*: Cómo discrimina cada pregunta entre el grupo que peor y mejor realiza la prueba. Es un valor numérico entre -1 y +1. Las preguntas que presenten una discriminación positiva entre 0 y 1 son las que mejor discriminan. Por el contrario, si la discriminación es 0 o negativa, esa pregunta debería ser revisada. Fórmula: [(Numero de respuestas correctas en el grupo alto – Número de respuestas correctas en el grupo bajo)/Número de estudiantes en cada grupo]; (b) *Dificultad de la pregunta*: Porcentaje de personas que aciertan cada pregunta. La pregunta es más difícil cuanto más se acerque al 0% de aciertos. Fórmula: [(Respuestas correctas en el grupo bajo + Respuestas correctas en el grupo alto)/(Número de estudiantes en el grupo bajo + Número estudiantes en el grupo alto)] x 100.

Finalmente, se seleccionaron las 30 preguntas que presentaban mejores índices comprobando que cumplieran con los estándares establecidos por Baumgartner et al. (2015): (a) Menos del 5% de preguntas deben tener un índice de dificultad menor al 10% y menos del 5% un índice de dificultad mayor al 90%; (b) menos del 5% de las preguntas deben tener índices de dificultad negativos; (c) más del 15% de las preguntas deben tener índices de discriminación entre 0 y 0,20; (d) más del 25% de las preguntas deben tener índices de discriminación entre 0,21 y 0,39; (e) más del 25% de las preguntas deben tener índices de discriminación mayores a 0,4; y (f) en cada pregunta, todas las posibles respuestas (es decir, A, B, C y D) deben haber sido escogidas por al menos el 5% de los participantes.

Por lo tanto, 16 preguntas fueron eliminadas por los siguientes motivos: (a) una pregunta por presentar un índice de dificultad muy bajo; (b) seis preguntas por índices de discriminación iguales a cero o negativos; (c) siete preguntas porque alguna respuesta no fue escogida por ningún participante; y (d) dos preguntas para mantener una distribución equitativa en cada uno de los bloques de conocimiento-contenido. Por esta razón, en determinados casos, a pesar de que los resultados cuantitativos de las preguntas escogidas fueran relativamente peores que en otras, se seleccionaron para cubrir equitativamente todas las dimensiones. Los resultados obtenidos con las 30 preguntas seleccionadas respetaron los criterios expuestos en el párrafo anterior, excepto en cuatro preguntas.

2.2.4. Paso 4. Depuración de la prueba y aplicación del instrumento definitivo

Tras la aplicación de la prueba piloto, se revisaron las cuatro preguntas que no cumplían el estándar cuantitativo “f”, pero sí cumplían con el análisis cualitativo de los expertos. Además, en una pregunta había una respuesta que no fue escogida por ningún participante. En estos casos, los expertos consideraron que podría deberse a que una de las cuatro posibles respuestas a estas preguntas era demasiado obvia de ser incorrecta y, por ello, se modificaron para incrementar su verosimilitud en la prueba definitiva.

Por último, se consideraron las anotaciones cualitativas recogidas en la prueba piloto de aquellas preguntas que habían suscitado dudas en los escolares, con el fin de incluir las aclaraciones necesarias y mejorar su claridad y comprensión (por ejemplo, definición del tren inferior en la pregunta: “¿Cómo podrías trabajar la fuerza del tren inferior (parte inferior de nuestro cuerpo desde la cintura hasta abajo) en la grada del campo de fútbol de Membrilla?”). Incluidas estas pequeñas modificaciones (dos preguntas), se realizó una última reunión con los expertos para valorar la validez de contenido de las preguntas modificadas siguiendo los pasos explicados previamente, comprobándose su adecuación para ser incluidas en la prueba final.

La recogida de datos se realizó bajo las mismas condiciones en las que se había realizado la prueba piloto, es decir, durante las clases de EF de los participantes, en su aula habitual, en silencio y garantizando el anonimato de sus respuestas. Antes de que los participantes comenzasen la prueba, el investigador principal realizó una breve introducción en la que se explicaron las instrucciones para cumplimentar correctamente la misma. Posteriormente, los estudiantes tuvieron 60 minutos para completar la prueba.

2.2.5. Paso 5. Submuestra fiabilidad

La fiabilidad de la prueba fue calculada posteriormente con una submuestra mediante el método test-retest para establecer la estabilidad temporal o consistencia entre las puntuaciones de la prueba aplicada en dos momentos diferentes sobre el mismo grupo (Eignor, 2013; Serra-Olivares y García-López, 2016). Se utilizó el CCI y su intervalo de confianza al 95% (95% IC) con un modelo mixto de dos factores de tipo acuerdo absoluto y basado en las medidas promedio (Koo y Li, 2016). Los valores de CCI < 0,50 son indicativos de una fiabilidad pobre, 0,50-0,75 moderada, 0,75-0,90 fiabilidad buena, y > 0,90 fiabilidad excelente (Koo y Li, 2016). Además de la fiabilidad de la prueba global, se calculó la fiabilidad de cada una de las dimensiones independientes (Eignor, 2013). Los análisis estadísticos se realizaron utilizando el programa SPSS versión 23.0 para Mac (IBM® SPSS® Statistics).

2.2.6. Paso 6. Submuestra intervención

Para comprobar la validez discriminante de la prueba, con la submuestra intervención se aplicó un programa de intervención para mejorar el conocimiento del entorno para el acondicionamiento físico. La validez discriminante es un indicador de la capacidad para distinguir entre diferentes subgrupos, en este caso, entre la submuestra de intervención tras finalizar el programa y un grupo control.

El programa de intervención aplicado consistió en una unidad didáctica alternada de acondicionamiento físico *indoor* y *outdoor* (Viciana y Mayorga-Vega, 2016). La unidad didáctica estaba compuesta de cuatro sesiones *indoor* y cuatro *outdoor*. Para llevar a cabo la unidad didáctica se siguió la dinámica de impartir una clase dentro del centro escolar (*indoor*) seguida de otra utilizando el entorno próximo (*outdoor*) durante todo el programa, con el propósito de establecer una conexión en el aprendizaje de tareas y métodos para el acondicionamiento físico en ambos contextos y dar a conocer el entorno próximo a los alumnos. Se trabajaron específicamente las capacidades físicas básicas de resistencia, fuerza y flexibilidad. Las clases *indoor* se llevaron a cabo utilizando materiales tradicionales del aula de EF (por ejemplo, picas, espalderas o bancos suecos) y espacios comunes dentro del centro educativo (pista polideportiva y gimnasio). Respecto a las clases *outdoor,* fueron desarrolladas aprovechando los recursos materiales y espacios que ofrecía el entorno próximo al centro educativo tales como las instalaciones polideportivas municipales y las escaleras, bancos o árboles de un parque periurbano. Las clases tuvieron una duración de 50 minutos y consistieron en 5-10 minutos de calentamiento, 35-40 minutos de parte principal y 5 minutos de vuelta a la calma. Durante la parte principal de las clases, los estudiantes realizaron ejercicios tradicionales de acondicionamiento físico (por ejemplo, entrenamiento en circuito, carrera continua, juegos de carrera o fartlek).

Se utilizó el análisis de la varianza (ANOVA) de un factor (grupo experimental, grupo control) sobre los valores de la prueba CENAFI (dimensiones y global). El tamaño del efecto se estimó mediante la eta al cuadrado parcial (η^2_p) y la *d* de Cohen (Field, 2017). Los valores del tamaño del efecto de $d < 0{,}20$ se consideran trivial, 0,20-0,49 pequeño, 0,50-0,79 moderado y ≥ 0,80 grande (Field, 2017). Los análisis estadísticos se realizaron utilizando el programa SPSS versión 23.0 para Mac (IBM® SPSS® Statistics). El nivel de significación estadística se estableció en $p < 0{,}05$.

3. Resultados

A continuación, se muestran los resultados obtenidos tras la aplicación de la prueba definitiva.

3.1. Análisis de las preguntas

En la Tabla 3 se observan los resultados obtenidos respecto a los índices referentes a las preguntas. Los resultados obtenidos muestran que la prueba cumplía con todos los criterios cuantitativos expuestos, habiéndose solventado en las cuatro preguntas que en la prueba piloto no se cumplieron. Además, la prueba definitiva presentaba una distribución adecuada de preguntas difíciles, moderadas y fáciles.

Tabla 3
Criterios cuantitativos de las preguntas incluidas en la prueba definitiva (n = 147).

	% preguntas (número)	Criterio correcto
Índice de dificultad mayor al 90%	0,0 (0 preguntas)	< 5%
Índice de dificultad menor al 10%	0,0 (0 preguntas)	< 5%
Índice de discriminación mayor a 0,40	26,7 (8 preguntas)	> 25%
Índice de discriminación entre 0,21 y 0,39	50,0 (15 preguntas)	> 25%
Índice de discriminación entre 0 y 0,20	23,3 (7 preguntas)	> 15%
Índice de discriminación negativo	0,0 (0 preguntas)	< 5%
Alguna respuesta no escogida por al menos el 5% de participantes	0,0 (0 preguntas)	0%

Fuente: Elaboración propia.

3.2. Análisis de la prueba global

En cuanto a los índices referentes a la prueba global, se calcularon: (a) La dificultad mediante la puntuación media del grupo en la prueba; y (b) la variabilidad mediante la desviación estándar. Cuanto mayor es la desviación estándar, la prueba tiene mayor sensibilidad y discrimina mejor entre diferentes niveles de conocimiento. La prueba completa obtuvo una puntuación media de 11,60 ± 3,30 puntos sobre 30. La puntuación en la dimensión de conocimiento declarativo fue de 3,31 ± 1,52 puntos sobre 10. En el conocimiento procedimental fue de 4,61 ± 1,64 puntos sobre 10. Por último, en el conocimiento causal obtuvo 3,68 ± 1,60 puntos sobre 10.

3.3. Análisis de la fiabilidad

La Tabla 4 muestra los resultados de fiabilidad obtenidos, siendo moderada para la prueba global, y las dimensiones del conocimiento declarativo y procedimental, mientras que el causal obtuvo una fiabilidad pobre.

Tabla 4
Fiabilidad test-retest de la prueba definitiva (n = 71).

Variable	Puntuación 1 (DE)	Puntuación 2 (DE)	CCI (95% IC)
Global	11,44 (3,4)	13,34 (3,2)	0,65 (0,32-0,80)
Declarativo	3,38 (1,6)	3,90 (1,4)	0,56 (0,31-0,73)
Procedimental	4,72 (1,8)	5,04 (1,6)	0,57 (0,31-0,73)
Causal	3,34 (1,4)	4,39 (1,8)	0,21 (0,00-0,48)

Nota. DE = Desviación estándar; CCI = Coeficiente de correlación intraclase; 95% IC = Intervalo de confianza al 95%.
Fuente: Elaboración propia.

3.4. Análisis de la validez discriminante

La Tabla 5 muestra el efecto de la intervención sobre las puntuaciones en la prueba CENAFI. Los resultados del ANOVA de un factor mostraron que los estudiantes del grupo de intervención obtuvieron una mejor puntuación de forma estadísticamente significativa respecto al grupo control tanto para la prueba global como para todas las dimensiones de forma independiente ($p < 0{,}001$).

Tabla 5
Efecto del programa de intervención sobre el conocimiento del entorno para el acondicionamiento físico (n = 147).

Variable	Grupo	Post-intervención	ANOVA			TE
		M (DE)	F	p	η^2_p	d
Global	Intervención (*n* = 76)	17,93 (4,2)	55,156	< 0,001	0,28	1,41
	Control (*n* = 71)	13,34 (3,3)				
Declarativo	Intervención (*n* = 76)	5,82 (1,8)	47,608	< 0,001	0,25	1,30
	Control (*n* = 71)	3,90 (1,5)				
Procedimental	Intervención (*n* = 76)	6,42 (1,9)	21,649	< 0,001	0,13	0,83
	Control (*n* = 71)	5,04 (1,7)				
Causal	Intervención (*n* = 76)	5,70 (1,7)	20,127	< 0,001	0,12	0,73
	Control (*n* = 71)	4,39 (1,8)				

TE = Tamaño del efecto; M = Media; DE = Desviación estándar; ANOVA = Análisis de la varianza; TE = Tamaño del efecto *d* de Cohen.
Fuente: Elaboración propia.

4. Discusión

El objetivo del estudio fue construir y someter a un proceso de validación una prueba escrita de respuesta múltiple *ad hoc* para crear una herramienta válida y fiable para la evaluación del conocimiento del entorno próximo para el acondicionamiento físico en estudiantes de ESO. De acuerdo con los criterios recomendados por la literatura previa para la construcción y validación de pruebas escritas (Baumgartner et al., 2015; Eignor, 2013), la prueba CENAFI se ha configurado con una estructura final de 30 preguntas dividida en tres dimensiones del conocimiento (declarativo, procedimental y causal). Los resultados del presente estudio, demuestran la validez de la CENAFI como instrumento de medida del conocimiento del entorno próximo para el acondicionamiento físico. Además, cumple con los criterios de calidad cuantitativos expuestos por Baumgartner et al. (2015), así como con los cualitativos establecidos por los expertos. Igualmente, los resultados demuestran que la fiabilidad de la prueba es moderada, excepto para la dimensión de conocimiento causal que es pobre.

Para su diseño y validación inicial se utilizó la metodología de panel de expertos, así como la aplicación de una prueba piloto. Dichas metodologías han sido ampliamente utilizadas en estudios previos sobre diseño y validación de pruebas escritas para evaluar el conocimiento sobre un aspecto determinado [por ejemplo, conocimiento táctico en fútbol (Serra-Olivares y García-López, 2016) o conocimiento declarativo en voleibol (Moreno et al., 2013)] con el fin de garantizar una adecuada validez de contenido. El *feedback* aportado por los jueces fue aprovechado para revisar las preguntas y realizar las correcciones oportunas, obteniéndose una batería de preguntas con una adecuada, coherente y clara redacción. La mayor parte de estas correcciones estuvieron relacionadas con cambios en la redacción de las preguntas, de las respuestas a cada pregunta para asegurar que éstas perteneciesen a una dimensión del conocimiento y no a otra, así como cambios en las fotografías por no tener la suficiente nitidez, o por representar una respuesta excesivamente obvia. Por otro lado, la realización de la prueba piloto permitió eliminar las dificultades presentes en la batería inicial de preguntas, facilitando que el 100% de los participantes que realizaron posteriormente la prueba definitiva pudiesen finalizarla, y empleando un tiempo adecuado según los índices establecidos en la literatura previa (Argimón y Jiménez, 2000).

Por otro lado, analizar la dificultad de las preguntas es un aspecto importante en el diseño y validación de pruebas escritas. Una prueba con preguntas demasiado difíciles o fáciles no tendría sentido para un nivel educativo determinado, ya que la mayoría de los estudiantes que la cumplimentasen podrían obtener una mala o buena puntuación, respectivamente, lo cual no es sensible al efecto de aprendizaje (Zhu et al., 2011). En este sentido, el análisis de dificultad de las preguntas realizado en el presente estudio resultó esencial y se debe hacer especial hincapié en que las edades de los participantes fue la correspondiente a la ESO. Una prueba adecuada debe tener una dificultad global media moderada, es decir, estar compuesta por preguntas de diferentes niveles de dificultad que permitan diferenciar entre niveles de conocimiento de los estudiantes (Zhu et al., 2011). De manera similar, estudios previos que han desarrollado pruebas escritas de conocimiento también han obtenido una distribución de preguntas difíciles, moderadas y fáciles (por ejemplo, Chen et al., 2017). Los resultados del presente estudio mostraron que la dificultad global de la prueba construida fue adecuada, ya que aquellos estudiantes que no realizaron ningún programa de intervención obtuvieron una media de aciertos de 11,60 sobre 30 preguntas (es decir, 38,6% de acierto), mientras que cuando se llevó a cabo un programa de intervención, la media global de aciertos en la prueba fue de 17,93 sobre 30 preguntas (es decir, 59,7% de acierto). Considerando los resultados hallados en el presente estudio, se recomienda que los profesores de EF presten especial interés a la adquisición del conocimiento relacionado con las posibilidades que ofrece el entorno para el trabajo autónomo de la CF por parte del alumnado. Para ello, resulta esencial la inclusión de programas de formación específicos en estos contenidos para evaluar el conocimiento que tienen los escolares sobre su entorno para el acondicionamiento físico. Sin embargo, a pesar de que la adquisición de este conocimiento es un objetivo requerido por el currículo educativo de EF (MECD, 2015), los estudiantes del presente estudio que no realizaron intervención presentaron unos niveles bajos. La falta de este conocimiento podría ser uno de los factores causantes de los altos niveles de inactividad física presentes en los niños en edad escolar (Guthold et al., 2019), especialmente en su tiempo libre, y consecuentemente de la disminución producida en sus niveles de CF durante las últimas décadas (Tomkinson et al., 2017).

En línea con lo comentado anteriormente, el porcentaje de aciertos medio post-intervención fue mayor en el grupo que realizó la intervención enfocada a la mejora del conocimiento del entorno para el acondicionamiento físico que en el grupo control (tamaño del efecto moderado-grande tanto en cada una de las dimensiones por separado como en la prueba global), confirmándose así la validez discriminante de la prueba para distinguir correctamente entre diferentes grupos de nivel. Desafortunadamente, hasta la fecha no se han encontrado estudios previos que analicen el efecto de una intervención sobre el conocimiento del entorno para el acondicionamiento físico. De manera similar, estudios previos han encontrado que tras la aplicación de un programa de intervención enfocado a la mejora del conocimiento de diferentes contenidos del currículo de EF, los escolares mejoraron dicho conocimiento (evaluado a través de una prueba escrita) (Chen, Zhu, Androzzi, y Nam, 2018; Demetriou, Sudeck, Thiel, y Höner, 2015).

Respecto a la fiabilidad test-retest, la prueba ha mostrado mejores resultados de fiabilidad para la prueba completa que para cada dimensión por separado. Esto podría deberse a diferentes factores. En primer lugar, la longitud de la prueba, es decir, el número de preguntas que la componen. De acuerdo con Lacy y Williams (2018), cuanto menor es el número de preguntas que componen una prueba, más baja es su fiabilidad. En el caso de la prueba validada en el presente estudio, una posible causa de la pobre fiabilidad obtenida en la dimensión causal del conocimiento pudo ser que del total de 30 preguntas, tan solo 10 evaluaban el conocimiento causal. Sin embargo, un mayor número de preguntas podría haber saturado a los alumnos y, por tanto, haber afectado a la correcta cumplimentación de la prueba (Argimón y Jiménez, 2000; Díaz, Batanero, y Cobo, 2003). En segundo lugar, cuanto mayor es la dispersión de las puntuaciones, mayor es la fiabilidad y viceversa. En este sentido, los resultados del presente estudio mostraron una menor dispersión en las puntuaciones de la dimensión causal (DE = 1,4) en comparación con las dimensiones declarativa (DE = 1,6) y procedimental (DE = 1,8), pudiendo ser otra de las causas de la pobre fiabilidad obtenida en esta dimensión del conocimiento.

4.1. Fortalezas y limitaciones

Las fortalezas del estudio fueron: a) Es el primer estudio que ha desarrollado y validado una prueba escrita para evaluar el conocimiento que poseen los escolares sobre el entorno para el acondicionamiento físico; b) el diseño, construcción y validación de la prueba ha sido realizado siguiendo estrictamente los estándares indicados por la literatura científica para el desarrollo de pruebas escritas en el contexto educativo (Baumgartner et al., 2015; Eignor, 2013); y c) a diferencia de estudios previos que han desarrollado pruebas para evaluar el conocimiento de aspectos relacionados con la asignatura de EF (Chen et al., 2013; Chen et al., 2017; Moreno et al., 2013; Serra-Olivares y García-López, 2016), la prueba CENAFI se ha diseñado teniendo en cuenta las tres dimensiones del conocimiento (declarativo, procedimental y causal). Respecto a las limitaciones, la principal limitación del estudio fue que la prueba fue validada en un entorno muy específico, lo cual dificulta la generalización de los resultados a otros contextos. Estudios futuros deberían diseñar y validar una prueba escrita de conocimiento del entorno para el acondicionamiento físico utilizando entornos y espacios generales (es decir, centrar las preguntas en objetos o entornos que estén presentes en todas las ciudades como, por ejemplo, rampas, escaleras, bancos, cuestas, o avenidas, sin especificar su localización), permitiendo así una mayor aplicabilidad de la prueba construida.

4.2. Implicaciones prácticas

La prueba diseñada y validada en el presente estudio supone una contribución importante para la literatura científica, pero sobre todo para la asignatura de EF. Teniendo en cuenta el objetivo establecido en el currículum de EF referente a conocer las posibilidades que ofrece el entorno para el acondicionamiento físico (MECD, 2015), disponer de una herramienta válida para evaluar dicho conocimiento nos permitiría comprobar si desde la asignatura de EF los profesores están contribuyendo a su adquisición en el alumnado. Consecuentemente, se les dotaría de mayor autonomía para ser activos fuera del horario escolar (Ferkel et al., 2014; Viciana y Mayorga-Vega, 2018). Igualmente, dado el descenso producido en las últimas décadas en los niveles de CF de los niños en edad escolar (Tomkinson et al., 2017), disponer de una herramienta válida para evaluar el conocimiento del entorno para el acondicionamiento físico, permitiría realizar estudios futuros que examinen la efectividad de la aplicación de programas de intervención extraescolares para el mantenimiento autónomo de la CF en el tiempo libre. Por último, debido a la especificidad del entorno sobre el que se ha centrado la prueba, el presente estudio podría servir de preámbulo para desarrollar adaptaciones de la prueba que pudieran aplicarse en otros contextos concretos o incluso en todas las zonas geográficas.

5. Conclusiones

De lo que conocemos, este es el primer estudio que ha construido y validado una prueba escrita para evaluar el conocimiento del entorno próximo para el acondicionamiento físico en estudiantes de ESO. Los resultados del presente estudio demuestran que la prueba CENAFI es un instrumento de medida válido y fiable para recabar información sobre el conocimiento que poseen los escolares del entorno próximo para el acondicionamiento físico. Consecuentemente, el estudio representa una contribución valiosa para la literatura científica y con importantes repercusiones prácticas para la asignatura de EF.

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Paper VI

DOES A PHYSICAL EDUCATION-BASED FITNESS PROGRAM BENEFIT EVERYONE INDEPENDENTLY OF THE STUDENTS' PHYSICAL FITNESS PROFILE? A CLUSTER-RANDOMIZED CONTROLLED TRIAL

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Original Article

Does a Physical Education-based fitness program benefit everyone regardless of the students' physical fitness profile? A cluster-randomized controlled trial

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Abstract:
The objective of the present study was to compare the effect of a Physical Education-based physical fitness program on physical fitness and physical activity levels among secondary school students with healthy and unhealthy physical fitness profile. One hundred and seven students (final sample 95, 48% females; M_{age} = 12.39 ± 0.75) from five pre-established classes of 7th-8th grade of Secondary Education were cluster-randomly assigned into control group (n = 19) or experimental group (n = 76). Then, according to students' cardiorespiratory fitness baseline, the experimental group was divided into healthy and unhealthy physical fitness profiles. The experimental group students performed a physical fitness program twice a week for nine weeks. The control group worked a different content during the same time and with the same frequency, but without emphasizing on the physical fitness improvement. Before and after the physical fitness program, students' physical fitness was objectively measured by the 20-meter shuttle run test. Participants' physical activity levels were objectively measured through a heart rate monitor (Polar RS300X, Finland) during Physical Education sessions. Results of the one-way analysis of variance showed that both students with healthy and unhealthy physical fitness profiles statistically significantly improved their physical fitness levels after the program (p < 0.01) and had higher statistically significantly physical activity levels during the Physical Education sessions (p < 0.01). Although a Physical Education-based physical fitness program seems to have a similar effect on students with different physical fitness profiles, students with an unhealthy profile obtain more benefits on physical activity levels during the Physical Education sessions.
Key Words: Educative intervention, Physical activity, cardiorespiratory endurance, adolescents, baseline level.

Introduction

Physical activity (PA) is considered an important life-style factor for health promotion during adolescence (World Health Organization, 2014). Among adolescents, moderate-to-vigorous PA (MVPA) is strongly and positively associated with numerous health markers such as adiposity, cardiometabolic biomarkers (e.g., insulin resistance or cholesterol), or bone health; with physical fitness (Poitras et al., 2016), as well as with better mental health (Biddle, Ciaccioni, Thomas, & Vergeer, 2019). Adolescents should achieve at least 60 min of MVPA daily (World Health Organization, 2014). However, on average, this recommendation is only met by approximately 19% of adolescents worldwide (22% of males and 16% of females) (Guthold, Stevens, Riley, & Bull, 2020; World Health Organization, 2014).

Schools, and specifically Physical Education (PE) subject, are considered a key setting for increasing students' PA levels, and its consequent benefit on their physical fitness levels (Association for PE, 2015), due to its compulsory character and the guidance by capable professionals (Viciana, Martínez-Baena, & Mayorga-Vega, 2015). Previous studies have shown that students had higher MVPA levels on school days with PE than on non-PE days (Calahorro-Cañada, Torres-Luque, López-Fernández, & Carnero, 2016; Mayorga-Vega, Martínez-Baena, & Viciana, 2018; Viciana, Mayorga-Vega, & Parra-Saldías, 2017). The Association for PE recommends that students should be implicated in at least 50% of the PE session time in MVPA (Association for PE, 2015). Unfortunately, in secondary education this recommendation is hardly ever met (on average, students are involved in MVPA 40.5% of the session time, Hollis et al., 2017), except when the PE sessions are concretely designed to improve students' MVPA levels (Lonsdale et al., 2013).

MVPA is positively associated with adolescents' physical fitness (Marques, Santos, Ekelund, & Sardinha, 2015). During adolescence, higher physical fitness levels are associated with better quality of life (Evaristo et al., 2019) and academic performance (Ruíz-Ariza, Grao-Cruces, de Loureiro, & Martínez-López, 2017). Unfortunately, nowadays unhealthy physical fitness is a worldwide issue which affects a high proportion

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of adolescents (on average, 33% of males and 46% of females), increasing this proportion considerably every year (8% and 10% for males and females, respectively) (Piccino & Colella, 2014; Tomkinson et al., 2016). Thus, healthy physical fitness levels during adolescence should be promoted through different settings such as sports programs or in school (Tomkinson et al., 2016). In this sense, PE plays an important role in the increasing of students' physical fitness levels (Guijarro-Romero, Casado-Robles, & Mayorga-Vega, 2019). However, several problems make it difficult to achieve an increase in physical fitness levels in the PE setting (e.g., large volume of curricular contents to deliver during de scholar year, limited curriculum time allocation to PE subject, or heterogeneous level of the students) (Guijarro-Romero et al., 2019; Hardman, Murphy, Routen, & Tones, 2014). Despite these limitations, previous studies have shown that it is possible to improve average students' physical fitness levels during PE (Costa et al., 2016; Mayorga-Vega, Montoro-Escaño, Merino-Marban, & Viciana, 2016; Minatto, Barbosa Filho, Berria, & Petroski, 2016).

Nevertheless, due to the heterogeneity of the classes related to educational context (Mayorga-Vega & Viciana, 2015), PE-based fitness programs applied in the aforementioned studies (Mayorga-Vega et al., 2016; Minatto et al., 2016) could not benefit all students in terms of PA and physical fitness levels. For instance, the magnitude effect of a PA program is negatively associated to the physical fitness baseline (Resaland, Andersen, Mamen, & Anderssen, 20011). Likewise, Mayorga-Vega and Viciana (2015) found that after a physical fitness program, only students with lower physical fitness levels improved. However, these authors divided the experimental group by a statistical criterion (i.e., percentile 50) instead of divide them based on students' healthy or unhealthy physical fitness profile. Additionally, they did not examine the effect on students' PA levels. To our knowledge there are no previous studies that examine the effect of a PE-based physical fitness program on both physical fitness and PA levels among students with healthy and unhealthy physical fitness levels. Consequently, the aims of this study were to compare the effect of a PE-based physical fitness program on physical fitness levels achieved and PA levels during the PE sessions among secondary school students with healthy and unhealthy physical fitness profiles.

Material & methods

Study design

The present study is reported according to the current CONSORT guidelines for cluster randomized trials (Campbell, Piaggio, Elbourne, & Altman, 2012). The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013). The Ethical Committee for human studies of the University of Granada approved the present study protocol. Recruitment was carried out in June of 2017, and the intervention was done from September to December of 2017. For practical reasons and because of the nature of the present study (i.e., established classes from an educational setting) a cluster-randomized controlled trial was used (i.e., randomization was per classes not per individuals) (Guijarro-Romero, Mayorga-Vega, & Viciana, 2018; Mayorga-Vega et al., 2016). This study was non-blinded (treatments were not masked from the students or teachers), and parallel-group (study with two different treatments; Spieth et al., 2016), with two evaluation phases.

Participants

The principal and the PE teacher of a state secondary school chosen by convenience of the city of Membrilla (Castilla-La Mancha, Spain) were consulted for the implementation of the study. They were informed about the study, and permission to conduct it was requested. After school approvals were obtained, all the 107 students (55 males and 52 females) from the seventh to eighth grade of secondary education (i.e., 12-14 years old) of the selected school center were invited to participate in the present study. Adolescents and their legal guardians were fully informed about the characteristics of the project. Before taking part in the study, participants' signed written informed assent and their legal guardians' signed written informed consent were obtained. According to the center's reports, all the students' families had a middle socioeconomic level.

The inclusion criteria were: (1) being enrolled in the first to second grades of the secondary education level; (2) participating in normal PE sessions; (3) being free of any health disorder or other reasons why students should not undergo PA; (4) presenting the corresponding signed consent by their parents or legal tutors, and (5) presenting the corresponding signed assent by the students. The exclusion criteria were: (1) not having performed all the dependent variables correctly following their rules of administration, and (2) not having an attendance rate equal to or over 85% during the fitness program.

Sample size

Based on the main dependent variable (i.e., cardiorespiratory fitness), and assuming independency of observations as previous personal related (unpublished) studies have shown, a priori sample size calculation was estimated with the G*Power Version 3.1.9.4 for Windows. Parameters were set in a conservative manner as follows: effect size $f = 0.15$, significance level $\alpha = 0.05$, statistical power $(1 - \beta) = 0.80$, and correlation among repeated measures $r = 0.7$. A minimum final sample size of 69 was estimated.

Randomization

Randomization was conducted at the class-level, using a computerized random number generator. Before the pre-intervention evaluation was administered, five established classes of the selected school center (three 7th and two 8th grade classes) were randomly assigned by an independent researcher, blinded to the study objectives to form the study groups: control group (CG, one seventh-grade class) or experimental group (EG, four classes, two seventh- and two eighth-grade). However, according to the education rules, prior to the start of the scholar year the students who composed each of these five classes had been assigned randomly by the school center following the criterion that the classes should be balanced between males and females (i.e., each class should have the same proportion of males and females).

Later, the experimental group students were divided by their maximal oxygen uptake baseline (e.g., healthy or unhealthy fitness zone according to the gender and age-adjusted cut-point values; e.g., 40.3 ml/kg/min for males at the age of 12 years) into two sub-groups: Healthy group (HG) (i.e., ≥ healthy fitness zone score), and unhealthy group (UG) (i.e., < healthy fitness zone) (Welk, Laurson, Eisenmann, & Cureton, 2011).

Intervention

The EG carried out a physical fitness program twice a week for nine weeks during the PE sessions. Because of educational contingencies (e.g., meteorological problems), in the end the EG students completed a total of 16 sessions. The sessions were designed and delivered by the PE teacher (15 years of experience) with the supervision of the main researcher according to the established curriculum approved by the school center.

Each intervention session lasted 50 minutes and consisted of a 5-to-10-minute warm-up, 35-to-40-minute main part, and five-minute cool-down. During the warm-up the students carried out low-to-moderate aerobic activities followed by some joint mobility and stretching exercises. In the main part, the EG carried out commonly used PE-based physical fitness sessions (e.g., running games, interval training, fartlek or circuit training) followed by some team games. For example, in the fartlek session students performed different kinds of fartleks (i.e., four times of: five minutes running soft plus one minute running fast) during 25 minutes, followed by team relay races for 10 minutes. In the cool-down students carried out low intensity exercises (e.g., walking slowly around the sports court). The PE teacher placed special emphasis on reaching a moderate-to-vigorous intensity during the main part of the sessions.

With regard to the CG students, they also carried out PE sessions twice a week during the intervention period, with a similar structure as EG (i.e., 5-to-10-minute warm-up, 35-to-40-minute main part, and five-minute cool-down). However, the content (basketball and hockey instead of physical fitness) and methodology followed during the main part of the sessions were different (mostly based on technique-learning practice and/or recreation, and without any special focus on PA intensity). For example, during both basketball and hockey sessions, students had to learn how to perform correctly technical aspects such as passing or throwing the ball.

Measures

Data collection was carried out during the PE session time by the same tester, instruments, and protocols. Prior to carried out the intervention, students' gender and age information were obtained from the school reports. Additionally, students' anthropometric measures were taken. Regarding physical fitness evaluation, it was carried out during a PE session inmediately before (pre-intervention) and after (post-intervention) the physical fitness program. The physical fitness measurements were taken on the same day of the week, at the same time for each student, in an indoor sports facility with a non-slippery floor. Prior to the evaluation, the participants completed a standardized warm-up consisting of five minutes of running from low-to-moderate intensity followed by some joint mobility exercises.

Anthropometric. Participants' body mass and height were measured in shorts, T-shirts, and barefoot following the *International Standards for Anthropometric Assessment* protocol (Stewart, Marfell-Jones, Olds, & De Ridder, 2011). For measuring body mass, the participant stood in the center of the scale (Seca, Ltd., Hamburg, Germany; accuracy = 0.1 kg) without support and with the weight distributed evenly on both feet. For the body height assessment, participants stood with their feet together with the heels, buttocks and upper part of the back touching the stadiometer (Holtain Ltd., Crymmych, Pembs, United Kingdom; accuracy = 0.1 cm), and with the head placed in the Frankfort plane. Two measurements of both body mass and height were performed and the average of each was calculated. Then, the body mass index was calculated as body mass divided by body height squared (kg/m^2).

Physical fitness. Cardiorespiratory fitness was assessed through the 20-meter shuttle run test (Léger, Mercier, Gadoury, & Lambert, 1988). Participants ran between two parallel lines placed 20 meters apart, in a progressive rhythm marked by a recorded beep until they were not able to reach the line two consecutive times. During the test each participant wore a heart rate monitor (Polar® RS300X, Finland). In order to ensure the test maximality, only the scores of participants who reach a heart rate value equal to or higher than 90% of estimated maximum heart rate (Mahar, Welk, & Rowe, 2018) were used. The maximum heart rate was estimated by the following equation: 209 – 0.7 x age (in years) (Shargarl et al., 2015). The total number of completed laps (n) and time (in seconds) were retained. Then, the maximal oxygen uptake (in ml/ kg/ min) was estimated using the following equation: 31.025 + 3.238 x speed - 3.248 x age + 0.1536 x speed x age (speed expressed in km/h and age in the lower rounded integer) (Léger et al., 1988).

Finally, the absolute (post-intervention – pre-intervention) and relative [((post-intervention – pre-intervention) x 100)/ pre-intervention] change scores of the maximal oxygen uptake, and total time-based performance were calculated. The 20-meter shuttle run test has demonstrated adequate reliability and criterion-related validity among secondary students (e.g., ICC = 0.89; $r_p = 0.78$) (Léger et al., 1988; Mayorga-Vega, Aguilar-Soto, & Viciana, 2015).

Physical activity. The students' heart rates were monitored during the PE sessions (Hellin, Garcia-Jimenez, & Garcia-Pellicer, 2019; Martínez-López, Moreno-Cerceda, Suárez-Manzano, & Ruiz-Ariza, 2018; Szakály et al., 2016) according to the protocol followed in previous studies (Mayorga-Vega et al., 2016). In each research group, five students per class were randomly selected to wear a heart rate monitor (Polar RS300X, Finland). These five students were different in each lesson, for example, in the second lesson five students different from the first lesson wore the heart rate monitor, and so on until all students' work intensity of the same class were measured.

Therefore, all students' PA was monitored about two or three times during the intervention period. Average heart rate (beats per minute and percentage of estimated maximum heart rate), total PA (percentage of total time involved in an intensity equal to or over 50% of estimated maximum heart rate) and MVPA (percentage of total time involved in an intensity equal to or over 70% of estimated maximum heart rate) were calculated. Then, students were also categorized as meeting or not the recommendation of achieving at least 50% of the PE session time in MVPA (Association for PE, 2015).

Statistical analysis

Data were reported as mean (standard deviation), and displayed as mean (standard error) in the Figures. All the statistical tests' assumptions were first checked and met for each dependent variable by common procedures (e.g., histograms and normal Q-Q plots for normality). After exploring if recorded descriptive variables would contaminate in the analysis of variance (ANOVA) models (i.e., grade, age, gender, body height, body mass, body mass index, and attendance), none of them showed a contamination effect. Then, one-way ANOVA were used to examine the effect of the PE-based fitness program on physical fitness and PA levels between the students from the three groups (CG, HG, UG).

Subsequently, the *post-hoc* with the Bonferroni adjustment was used for pairwise comparisons. The chi-square test was calculated to analyze the effect of the program on the percentage of students that met the MVPA recommendation during the PE sessions between the three groups. Effect sizes were estimated using the partial eta squared (η^2_p)/ Cohen's *d* and Cramer's V for continuous and dichotomous variables, respectively (Field, 2017). All statistical analyses were carried out using the SPSS Version 21.0 for Windows (IBM® SPSS® Statistics) setting the statistical significance level at $p < 0.05$.

Results

Final sample and general characteristics

Figure 1 shows a flow chart corresponding to the participants included in the present study. Although all the invited 107 students (48.6% females) agreed to participate and met the inclusion criteria, finally 95 students (48% females) satisfactorily passed the exclusion criteria and were analysed. No participant was lost because of the rejection to continue in the study or change of the school.

Table 1 shows the general characteristics of the included participants. The HG, UG, and CG participants obtained an average attendance of 95%, 94%, and 89% in the fitness program, respectively.

Table 1. General characteristics of the included participants.

	Control group (n = 19)	Unhealthy group (n = 20)	Healthy group (n = 56)	Total (N = 95)
Age (years)	11.84 (0.69)	12.55 (0.69)	12.52 (0.71)	12.39 (0.75)
Gender (males/females)	53/47	25/75	61/39	52/48
Body height (m)	1.45 (0.06)	1.51 (0.09)	1.49 (0.07)	1.49 (0.08)
Body mass (kg)	49.49 (9.93)	56.76 (14.04)	46.02 (7.73)	48.98 (10.58)
Body mass index (kg/m^2)	23.49 (4.13)	24.82 (4.32)	20.52 (2.48)	22.02 (3.75)

Note. Data are reported as mean (standard deviation) for age, body height, body mass and body mass index variables, or percentage for gender variable.

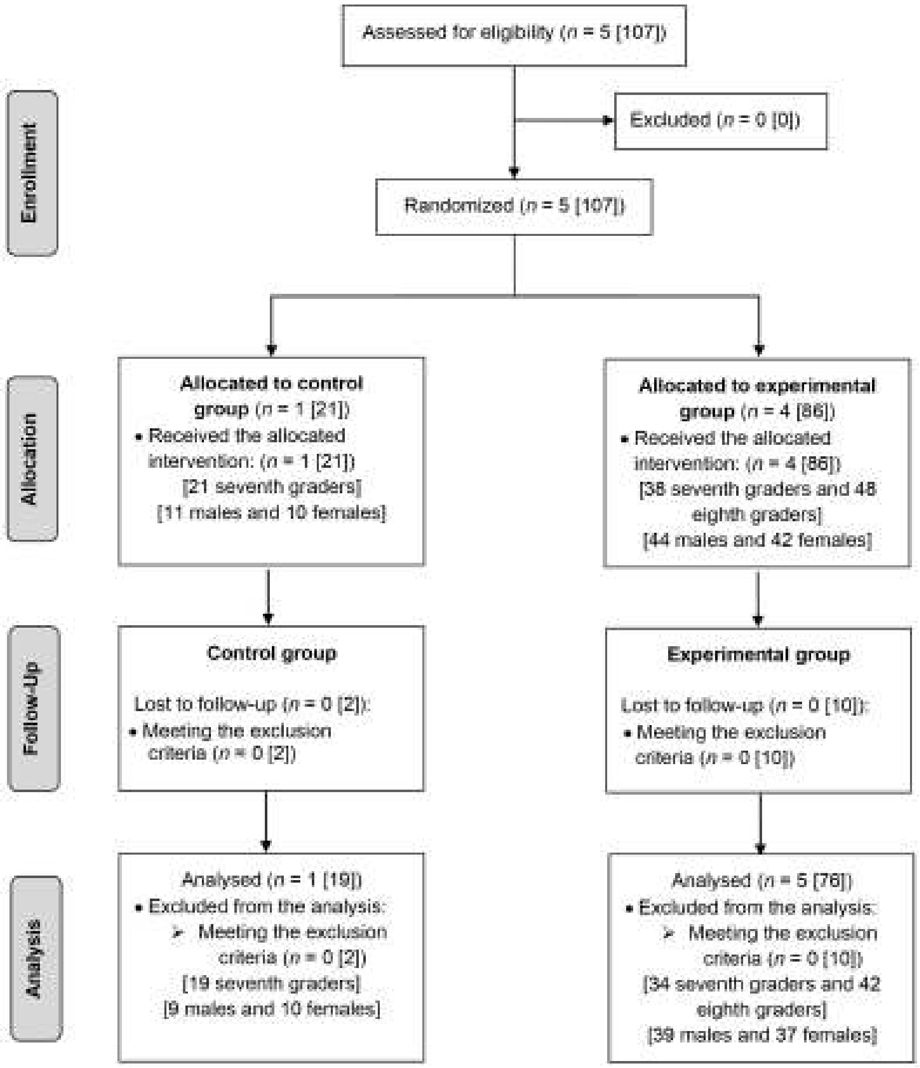

Figure 1. Flow chart of the school classes and participants of this study. All numbers are school classes [students].

Physical fitness

Figure 2 shows the comparison of the effect of a PE-based fitness program on physical fitness levels between the three groups. Results of the one-way ANOVA showed overall statistically significant differences between the three groups [maximal oxygen uptake (ml/kg/min): $F_{2,92} = 10.104$; $p < 0.001$; $\eta^2_p = 0.180$; maximal oxygen uptake (%): $F_{2,92} = 10.881$; $p < 0.001$; $\eta^2_p = 0.191$; total time-based performance (s): $F_{2,92} = 11.881$; $p < 0.001$; $\eta^2_p = 0.205$; total time-based performance (%): $F_{2,92} = 15.034$; $p < 0.001$; $\eta^2_p = 0.246$].

Subsequently, *post-hoc* analyses showed that both the students with healthy and unhealthy physical fitness profiles statistically significantly improved their physical fitness levels [maximal oxygen uptake (ml/ kg/ min), maximal oxygen uptake (%), total time-based performance (s), and total time-based performance (%)] compared with the control group students (HG vs. CG, $p < 0.001$, $d = 0.62$, 0.62, 0.58 and 0.63; UG vs. CG, $p < 0.01$, $d = 0.57$, 0.64, 0.49 and 0.84).

However, statistically significant differences between the students with healthy and unhealthy physical fitness profiles were not found (HG vs. UG, $p > 0.05$, $d = 0.05$, - 0.02, 0.09 and – 0.22).

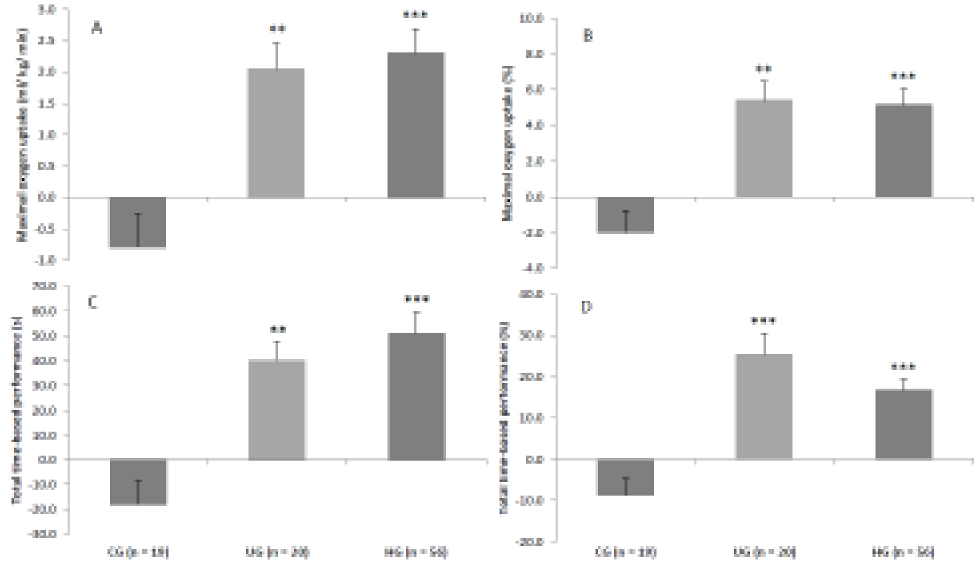

Figure 2. Comparison of the effect of the Physical Education-based fitness program on maximal oxygen uptake (ml/ kg/ min, A; %, B) and total time-based performance levels (s, C; %, D) between the three groups. CG = Control group; UG = Unhealthy physical fitness profile group; HG = Healthy physical fitness profile group. Results of the one-way analysis of variance (all p < 0.001) followed by the pairwise comparisons with the Bonferroni adjustment: UG/ HG vs. CG (*** $p < 0.001$, ** $p < 0.01$).

Physical activity

Figure 3 shows the comparison of the effect of the PE-based fitness program on PA levels in PE sessions between the three groups. Results of the one-way ANOVA showed overall statistically significant differences between the three groups [heart rate (bpm): $F_{2,92} = 42.416$; $p < 0.001$; $\eta^2_p = 0.480$; heart rate (%): $F_{2,92} = 42.795$; $p < 0.001$; $\eta^2_p = 0.482$; total PA: $F_{2,92} = 10.156$; $p < 0.001$; $\eta^2_p = 0.181$; MVPA: $F_{2,92} = 47.268$; $p < 0.001$; $\eta^2_p = 0.507$]. Subsequently, *post-hoc* analyses showed that both the students with healthy and unhealthy physical fitness profiles had statistically significant higher PA levels [heart rate (bpm), heart rate (%), total PA (%), and MVPA (%)] than the control group students (HG vs. CG, $p < 0.01$, d = 2.01, 2.04, 0.55, and 2.46; UG vs. CG, $p < 0.001$, d = 2.56, 2.60, 0.76, and 3.34) during the PE sessions. Additionally, the students with an unhealthy physical fitness profile had a statistically significant higher MVPA levels than those with healthy levels ($p < 0.05$, $d = 0.88$). However, for heart rate (bpm and %), and total PA (%), statistically significant differences between the students with healthy and unhealthy physical fitness profiles were not found ($p > 0.05$, d = 0.55, 0.56, and 0.21).

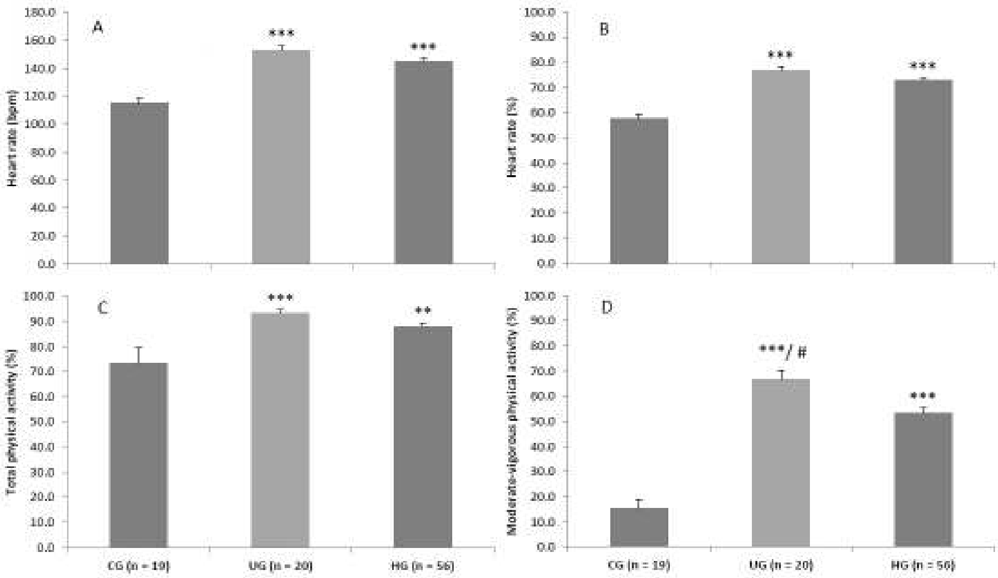

Figure 3. Comparison of the effect of the Physical Education-based fitness program on heart rate (bpm, A; %, B), total physical activity (%, C), and moderate-to-vigorous physical activity levels (%, D) during the Physical

Education sessions between the three groups. CG = Control group; UG = Unhealthy physical fitness profile group; HG = Healthy physical fitness profile group. Results of the one-way analysis of variance (all $p < 0.001$) followed by the pairwise comparisons with the Bonferroni adjustment: UG/ HG vs. CG (*** $p < 0.001$, ** $p < 0.01$) and UG vs. HG (# $p < 0.05$).

Figure 4 shows the comparison of the effect of the PE-based fitness program on the percentage of students that met the MVPA recommendation during the PE sessions between the three groups. Results of the chi-square test on the percentage of students meeting the MVPA recommendation during the PE sessions showed overall statistically significant differences between the three groups ($\chi^2_{2,1} = 22.688$; $p < 0.001$; Cramer's V = 0.489). Subsequently, the results of the two x two chi-square test showed that there was a higher percentage of students with the healthy and unhealthy physical fitness levels that met the MVPA recommendation during the PE sessions than in the CG (HG vs. CG, $\chi^2_{1,1} = 13.653$; $p < 0.001$; Cramer's V = 0.427; UG vs. CG, $\chi^2_{2,1} = 22.133$; $p < 0.001$; Cramer's V = 0.753). In addition, a higher percentage of students with unhealthy physical fitness levels met the MVPA recommendation during the PE sessions than those with healthy levels ($\chi^2_{1,1} = 4.308$; $p < 0.05$; Cramer's V = 0.238).

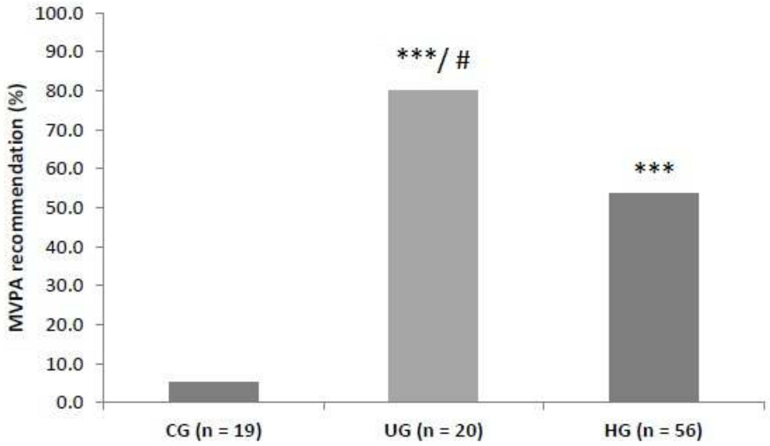

Figure 4. Comparison of the effect of the Physical Education-based fitness program on the percentage of students that met the moderate-to-vigorous physical activity (MVPA) recommendation during the Physical Education sessions between the three groups. CG = Control group; UG = Unhealthy physical fitness profile group; HG = Healthy physical fitness profile group. Results of the chi-squared test (overall $p < 0.001$) followed by the two x two chi-square test comparisons: UG/ HG vs. CG (*** $p < 0.001$) and UG vs. HG (# $p < 0.05$).

Dicussion

The first aim of this study was to compare the effect of a PE-based physical fitness program on physical fitness levels among secondary school students with healthy and unhealthy physical fitness profiles. Results of the present study show that both students with healthy and unhealthy physical fitness profiles improved their physical fitness levels after the program. Previous studies have shown that, a short-term fitness program increases average physical fitness levels among adolescents (Mayorga-Vega et al., 2016; Mayorga-Vega, Viciana, & Cocca, 2013). However, the magnitude effect of these programs has been negatively associated to the physical fitness baseline (Resaland et al., 2011). Similarly to this study, Mayorga-Vega and Viciana (2015) examined the effect of a physical fitness program during PE sessions performed twice a week, taking into account the initial physical fitness level. These authors found that only students with low baseline physical fitness improved it after the fitness program. Nevertheless, Mayorga-Vega and Viciana (2015) divided the EG students according to their physical fitness baseline statistically by percentiles (i.e., under P_{50} and equal or over P_{50}). Additionally, they did not consider if these levels were healthy or not. Therefore, the improvements obtained in students' physical fitness could be insufficient to get a healthy fitness profile because they were initially classified by percentiles instead of by criterion-referenced standards (Tomkinson et al., 2016; Welk et al., 2011). Also, they did not examine the time that students spent in MVPA, meaning, the intensity of the sessions could have not been enough for students with a higher baseline level to improve their physical fitness after the fitness program. Thus, it was possible that the aforementioned authors obtained similar results in students with lower baseline levels, but not in those with a higher baseline level.

Resaland et al. (2011) carried out a PA program performed daily during two years with the purpose of showing if students improved their physical fitness levels taking into account their baseline level. They observed that their program produced a higher impact in students with a lower baseline level. However, the frequency of this program was totally different from the time appointed to PE in most countries (i.e., two hours per week) (Hardman et al., 2014). Regarding the magnitude of the effects, the intervention effect size was moderate both for students with healthy and unhealthy profiles (*d* = 0.62 and 0.57, respectively). Mayorga-Vega and Viciana (2015) found similar values, but only in students with low baseline levels (*d* = 0.45).

The second purpose was to compare the effect of the PE-based fitness program on PA levels during PE sessions among secondary students with healthy and unhealthy physical fitness profiles. Results of this study showed that after the fitness program, students with healthy and unhealthy physical fitness profiles improved their PA levels (average heart rate, total PA, and MVPA) during PE sessions. However, students with unhealthy physical fitness profile had higher MVPA levels during the PE sessions than those with a healthy physical fitness profile, as well as there being a tendency to significance in the average heart rate and total PA (*p* = 0.082 and 0.077, respectively). Calahorro-Cañada et al. (2016) analyzed the differences in PA levels during PE sessions regarding students' physical fitness status. Unlike the present study, these authors found that students with healthy physical fitness were more active during PE sessions than those with unhealthy physical fitness. However, these authors carried out a descriptive measure of the students' PA levels, and they did not apply any fitness program.

On the other hand, international recommendations suggest 60 min a day of MVPA (World Health Organization, 2014), and 50% of the PE sessions time involved in MVPA (Association for PE, 2015) for adolescents. Regarding this, previous studies have shown that school days with PE had higher MVPA levels than non-PE days, so that, PE could be considered an important promoter of a healthy lifestyle (Calahorro-Cañada et al., 2016; Mayorga-Vega et al., 2018; Viciana et al., 2017). Results of the present study showed that students spent between 55-70% of PE sessions' time in MVPA. Additionally, results of the present study are in accordance with previous studies that have shown that carrying out a fitness program during PE sessions can improve, on average, 24% of the time that students are involved in MVPA (Lonsdale et al., 2013). However, in most of these studies, the frequency of the intervention was three or more sessions per week, moving away from the most common worldwide educational setting. Moreover, these studies did not differentiate among students with healthy or unhealthy physical fitness profiles and, consequently, the improvements in MVPA levels could be produced in students with both profiles or only in one. Unfortunately, the percentage of PE session time involved in MVPA is lower than the recommended (40.5%) when PE sessions are not specifically designed to improve students' MVPA levels (Hollis et al., 2017).

Regarding the proportion of students who met the recommended of being involved at least 50% of the PE sessions time in MVPA, the present results showed that a higher percentage of students with an unhealthy physical fitness profile met the MVPA recommendations than those with a healthy profile (80% and 50%, respectively). However, the proportion of students who met this recommendation is practically zero when a specific intervention is not designed for this purpose (Viciana et al., 2015). This is a good contribution of the present study (showing the achievement of 50% of the PE session time involved in MVPA through the fitness program). Nevertheless, results regarding the MVPA levels achieved by the healthy and unhealthy students point to the conclusion that individualized teaching is a crucial aspect in PE tasks designs oriented to the increase of students' physical fitness and PA. Moreover, different intensities applied to healthy (higher intensity) and unhealthy (lower intensity) students during the program could cause a similar time involved in MVPA during the sessions and also presumably similar increments of their physical fitness. An example of this individualization could be observed in the circuit organized by Mayorga-Vega et al. (2013), composed by eight tasks with two levels of intensities each. Finally, regarding the intervention effect sizes, the present study showed a similar range of results as previous studies focused on the increase of MVPA levels during PE sessions (*d* = 2.46 to 3.34, 0.13 to 2.81, respectively) (Lonsdale et al., 2013).

The strengths of this study were that: a) It is the first study in which students' were divided into healthy or unhealthy physical fitness profiles based on their maximal oxygen uptake baseline (Welk et al., 2011), instead of by statistic criteria such as in Mayorga-Vega and Viciana (2015); and b) this study showed the improvements in PA by physical fitness profiles, differentiating among the healthy or unhealthy physical fitness profiles. Additionally, the present study showed the percentage of students who met the MVPA recommendations during PE sessions. Regarding the limitations, the main limitation was that the maximal oxygen uptake was estimated through a validated equation because it was not feasible to measure it directly. Secondly, the present study was carried out only in a secondary school of a particular place. This particularity limits the possibility of generalization of the obtained results to similar contexts. The third limitation was related with the research design. Due to the fact that for the first independent variable (i.e., fitness program) a cluster-randomized control trial was applied instead of a true randomized control trial (i.e., participants are randomly assigned to groups) and the design used with the second independent variable (i.e., *ex-post-facto*) does not allow for causal relationships, the outcomes of this study should be interpreted with caution (Thomas, Nelson, & Silverman, 2015). Nevertheless, because of the nature of the context (i.e., school) and second independent variable (i.e., cardiorespiratory fitness could not be manipulated), as well as with the objective of keeping the ecological validity, this design was more appropriate for the present research purpose. Future studies could measure maximal oxygen uptake with a portable gas analyzer with the purpose of having a direct measurement of this parameter, and could add information regarding different samples characteristics in order to generalize results.

Conclusions

To our knowledge this is the first study that compares the effect of a PE-based fitness program on physical fitness and PA levels among secondary school students with healthy and unhealthy physical fitness profiles. Although a PE-based fitness program seems to have a similar effect on all the students' physical fitness profiles, students with unhealthy physical fitness profiles benefit considerably more in PA levels during the PE sessions. Furthermore, the students with unhealthy physical fitness profile had higher average MVPA levels during the PE sessions than those with a healthy profile. Additionally, a higher percentage of students with an unhealthy physical fitness profile met the MVPA recommendation during the PE sessions than those with a healthy profile.

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Conflicts of interest - The authors declare that there is no conflict of interest.

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Paper VII

UNA UNIDAD DIDÁCTICA INTERMITENTE DE ACONDICIONAMIENTO FÍSICO SOLO MEJORA LOS NIVELES DE CAPACIDAD CARDIORRESPIRATORIA DE LOS ESTUDIANTES CON UN PERFIL NO SALUDABLE DE CONDICIÓN FÍSICA

[AN INTERMITTENT PHYSICAL FITNESS TEACHING UNIT ONLY IMPROVES CARDIORESPIRATORY FITNESS LEVELS OF STUDENTS WITH AN UNHEALTHY PHYSICAL FITNES PROFILE]

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Una unidad didáctica intermitente de acondicionamiento físico solo mejora los niveles de capacidad cardiorrespiratoria de los estudiantes con un perfil no saludable de condición física
An intermittent physical fitness teaching unit only improves cardiorespiratory fitness levels of students with an unhealthy physical fitness profile

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Resumen. El objetivo del presente estudio fue comparar el efecto de una unidad didáctica intermitente de acondicionamiento físico en Educación Física sobre los niveles de actividad física y capacidad cardiorrespiratoria entre estudiantes con un perfil saludable/no saludable de capacidad cardiorrespiratoria. Ochenta estudiantes de 2º-3º curso de Educación Secundaria fueron asignados aleatoriamente al grupo control y grupo experimental. El grupo experimental, dividido en perfiles saludable/no saludable, realizó una unidad didáctica intermitente de acondicionamiento físico para mejorar la capacidad cardiorrespiratoria. El grupo control trabajó un contenido diferente durante el mismo tiempo y con la misma frecuencia, pero sin hacer hincapié en la mejora de la capacidad cardiorrespiratoria. Antes y después de la intervención, la capacidad cardiorrespiratoria se evaluó objetivamente mediante el test de ida y vuelta de 20 metros. Los niveles de actividad física fueron medidos objetivamente a través de un pulsómetro durante las clases de Educación Física. Ambos perfiles tuvieron mayores niveles de actividad física durante las clases de Educación Física que el grupo control ($p < .001$). Sin embargo, solo los estudiantes con un perfil no saludable mejoraron significativamente sus niveles de capacidad cardiorrespiratoria tras la unidad didáctica ($p < .01$). Aunque una unidad didáctica intermitente de acondicionamiento físico parece tener un efecto similar en los niveles de actividad física de todos los perfiles de capacidad cardiorrespiratoria de los estudiantes, solo mejora la capacidad cardiorrespiratoria de los estudiantes con un perfil no saludable.
Palabras clave: Capacidad cardiorrespiratoria, actividad física, intervención educativa, Educación Física, adolescentes, nivel inicial.

Abstract. The purpose of the present study was to compare the effect of a Physical Education-based physical fitness intermittent teaching unit on physical activity levels and cardiorespiratory fitness among students with healthy/unhealthy cardiorespiratory fitness profile. Eighty students from 2º-3º grades of Secondary Education were randomly assigned to the control group and experimental group. The experimental group, divided into healthy/unhealthy profiles, performed a physical fitness intermittent teaching unit to improve the cardiorespiratory fitness. The control group worked a different content during the same time and with the same frequency, but without emphasizing cardiorespiratory fitness improvement. Before and after the teaching unit, students' cardiorespiratory fitness was objectively measured by the 20-meter shuttle run test. Participants' physical activity levels were measured objectively using a heart rate monitor during Physical Education lessons. Students from both profiles had higher physical activity levels during Physical Education lessons than the control group ($p < .001$). However, only students with an unhealthy cardiorespiratory fitness profile statistically improved their cardiorespiratory fitness levels after the teaching unit ($p < .01$). Although an intermittent physical fitness teaching unit seems to have similar effect on physical activity levels of students from all cardiorespiratory fitness profiles, it only improves the cardiorespiratory fitness of those with an unhealthy one.
Keywords: Cardiorespiratory fitness, physical activity, educational intervention, Physical Education, adolescents, baseline.

Introducción

Durante la adolescencia, la actividad física moderada-vigorosa (AFMV) está fuerte y positivamente asociada con numerosos marcadores relacionados con la salud como la adiposidad, salud ósea y biomarcadores metabólicos (como el colesterol o la resistencia a la insulina); con la condición física (Poitras, et al., 2016); así como con una mejor salud mental (Biddle, Ciaccioni, Thomas, & Vergeer, 2018). La Organización Mundial de la Salud recomienda que los adolescentes acumulen diariamente al menos 60 minutos de AFMV (World Health Organization, 2014). Desafortunadamente, aproximadamente el 81% de los adolescentes a nivel mundial no cumplen esta recomendación (Oviedo, Sánchez, Castro, Calvo, Sevilla, Iglesias, & Guerra, 2013; World Health Organization, 2014).

El contexto escolar, y específicamente la asignatura de Educación Física (EF), es considerado un entorno clave para la promoción y mejora de los niveles de actividad física (AF) de los estudiantes (Association for Physical Education, 2015), debido a su carácter obligatorio en el currículum educativo y a que es desarrollada por profesionales cualificados (Viciana, Martínez-Baena, & Mayorga-Vega, 2015). Estudios previos han mostrado que, en los días con EF, los estudiantes acumulan mayores niveles de AFMV que durante los días sin EF (Mayorga-Vega, Martínez-Baena, & Viciana, 2018; Viciana, Mayorga-Vega, & Parra-Saldías, 2017). La Asociación para la EF recomienda que los estudiantes deben estar implicados en AFMV al menos el 50% del tiempo de las clases de EF (Association for Physical Education, 2015). Sin embargo, en Educación Secundaria casi nunca se cumple esta recomendación (de media, los estudiantes están involucrados el 40.5% de la clase en AFMV, Hall-López, Ochoa Martínez, Zuñiga Burruel, Monreal Ortiz, & Sáenz-López Buñuel, 2017; Hollis et al., 2017; Mayorga-Vega, Saldías, & Viciana, 2020), excepto cuando las clases de EF son específicamente diseñadas para mejorar los niveles de AFMV de los estudiantes (Lonsdale et al., 2013).

La AFMV está positivamente asociada con la condición física de los adolescentes (Marques, Santos, Ekelund, & Sardinha, 2015). Dentro de la condición física, la capacidad cardiorrespiratoria (CCR) es considerada el marcador de salud más potente en los adolescentes (Tomkinson et al., 2016). Durante la adolescencia, niveles más altos de CCR están

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relacionados con una mejor calidad de vida (Evaristo et al., 2019), así como con mayores niveles de rendimiento académico y cognitivo (Ruíz-Ariza, Grao-Cruces, de Loureiro, & Martínez-López, 2017). Desafortunadamente, la prevalencia de una baja CCR entre adolescentes es alta a nivel mundial (de media, el 46% de las mujeres y el 33% de los hombres), aumentando dicha proporción cada año de edad de media un 10% en las mujeres y un 8% en los hombres (Tomkinson et al., 2016). Por lo tanto, es importante que en contextos escolares se promueva y facilite la adquisición de unos niveles saludables de CCR (Tomkinson et al., 2016), siendo esencial la EF en este sentido (Viciana, Mayorga-Vega, & Merino-Marban, 2014). Sin embargo, aspectos como el gran volumen de contenidos curriculares a desarrollar durante el curso académico, el nivel heterogéneo de los estudiantes, o el tiempo limitado asignado a la asignatura de EF, dificultan conseguir un incremento en los niveles de CCR de los estudiantes (Hardman, Murphy, Routen, & Tones, 2014). A pesar de estas limitaciones, estudios previos han demostrado que es posible incrementar los niveles de CCR de los estudiantes en la EF (por ejemplo, Mayorga-Vega, Montoro-Escaño, Merino-Marban, & Viciana, 2016; Mayorga-Vega, Viciana, & Cocca, 2013).

Sin embargo, debido a la heterogeneidad interna de los grupos educativos (Mayorga-Vega & Viciana, 2015), las unidades didácticas de condición física aplicadas en los estudios mencionados anteriormente (Mayorga-Vega et al., 2016; Mayorga-Vega et al., 2013), podrían no incrementar en la misma medida los niveles de CCR y AF de todos los estudiantes. Por ejemplo, Resaland, Andersen, Mamen, y Anderssen (2011) demostraron que el efecto de un programa de AF está asociado negativamente con el nivel inicial de CCR. Igualmente, Mayorga-Vega y Viciana (2015) constataron que sólo los estudiantes con un nivel inicial más bajo de CCR mejoraron tras una unidad didáctica de acondicionamiento físico. Sin embargo, estos autores dividieron el grupo experimental según un criterio estadístico (percentil 50) en lugar de dividirlos según un perfil saludable/no saludable de CCR. Además, los autores previos tampoco comprobaron el efecto sobre los niveles de AF de los estudiantes.

Por otro lado, tras las intervenciones escolares mencionadas anteriormente solo se consiguió el objetivo de mejorar la CCR de los estudiantes, teniendo que desarrollar después una gran cantidad de objetivos curriculares en un tiempo limitado (Viciana et al., 2014). En este sentido, Viciana y Mayorga-Vega (2016) proponen diferentes modelos de unidades didácticas innovadoras en función de su distribución temporal, entre la que cabe destacar la unidad didáctica intermitente como una buena solución. Este modelo de unidad didáctica innovadora consiste en trabajar un objetivo curricular solo durante una franja de tiempo de cada clase de EF durante varias clases. Por lo tanto, permitiría dividir la clase de EF en varias partes (por ejemplo, dos), desarrollando dos o más objetivos curriculares en franjas temporales independientes de la clase. Mayorga-Vega et al. (2016) aplicaron este modelo de unidad didáctica para mantener los niveles de CCR previamente adquiridos mediante la realización de actividades de deporte durante solo los primeros 15 minutos de la parte principal de las clases de EF dos veces a la semana durante ocho semanas, mientras el resto de las clases de esta unidad didáctica se destinaron a otros contenidos/objetivos de EF. Igualmente, varios estudios previos han aplicado este modelo de unidad didáctica innovadora para desarrollar y mantener la flexibilidad, utilizando para ello solo el calentamiento o la vuelta a la calma de las clases de EF (Becerra-Fernandez, Merino-Marban, & Mayorga-Vega, 2016; Mayorga-Vega, Merino-Marban, Redondo-Martín, & Viciana, 2017; Merino-Marban, Mayorga-Vega, Fernandez-Rodriguez, Estrada, & Viciana, 2015). Otro ejemplo de unidad didáctica intermitente, podría consistir en desarrollar la CCR de los estudiantes durante solo unos minutos de la parte principal de las clases, dedicando el resto a desarrollar otro objetivo curricular como, por ejemplo, el aprendizaje técnico-táctico de los deportes. Desafortunadamente, no se han encontrado estudios previos analizando el efecto de una unidad didáctica intermitente de estas características sobre el incremento de los niveles de AF y CCR de los estudiantes. Consecuentemente, los objetivos del presente estudio fueron: 1) comparar el efecto de una unidad didáctica intermitente de acondicionamiento físico sobre los niveles de AF durante las clases de EF en estudiantes de Educación Secundaria con un perfil saludable y no saludable de CCR; y 2) comparar el efecto de una unidad didáctica intermitente de acondicionamiento físico sobre los niveles de CCR adquiridos en estudiantes de Educación Secundaria con un perfil saludable y no saludable de CCR.

Material y método

Participantes

El protocolo del presente estudio fue aprobado por el Comité Ético de la Universidad de Granada (Referencia: 649/CEIH/2018). Dos centros públicos de Educación Secundara de la ciudad de Membrilla (Castilla-La Mancha, España) fueron invitados a participar. La muestra inicial estuvo compuesta por un total de 92 estudiantes (34 varones y 58 mujeres) que aceptaron participar en el presente estudio y cumplían los criterios de inclusión. Tras aplicar los criterios de exclusión, 80 estudiantes (32 varones y 48 mujeres) conformaron la muestra final. Los criterios de inclusión fueron: a) estar matriculado en segundo o tercer curso de Educación Secundaria; b) participar en las clases de EF; c) no padecer ninguna enfermedad o lesión que les impidieran realizar AF con normalidad; d) presentar el consentimiento informado firmado por sus padres o tutores legales, y e) presentar el asentimiento informado por parte de los escolares. Los criterios de exclusión fueron: a) no tener un registro válido de todas las variables de estudio (AF y CCR); y b) no tener una tasa de asistencia al programa igual o superior al 85% durante el periodo de intervención.

Debido a la naturaleza del presente estudio, se empleó un diseño cluster-randomized controlled trial (Campbell & Stanley, 1963). Las cuatro clases naturales, balanceadas por curso, se asignaron aleatoriamente al grupo control (GC) y grupo experimental (GE). Posteriormente, los estudiantes del GE fueron clasificados en dos subgrupos (saludable (GS) y no saludable (GNS)) de acuerdo con el nivel inicial de CCR (Welk, Laurson, Eisenmann, & Cureton, 2011). Los participantes del GE tuvieron una asistencia media al programa del 92.6% (92.4% y 92.8% para los subgrupos saludable y no saludable, respectivamente). La Tabla 1 muestra las características generales de los participantes incluidos en el presente estudio.

Tabla 1
Características generales de los participantes analizados

	Total (n = 80)	Control (n = 38)	No saludable (n = 19)	Saludable (n = 23)	p^a
Edad (años)	13.7 (.7)	13.6 (.6)	13.9 (.8)	13.7 (.7)	-
Curso (2º/ 3º)	42.5/ 57.5	47.4/ 52.6	42.1/ 57.9	34.8/ 65.2	.628
Género (varones/mujeres)	40.0/ 60.0	31.6/ 68.4	42.1/ 57.9	52.2/ 47.8	.276
Masa corporal (kg)	54.5 (11.0)	54.2 (9.0)	62.2 (14.6)*	48.5 (6.2) †††	< .001
Talla (cm)	162.1 (7.8)	160.8 (7.6)	163.7 (7.8)	162.8 (7.9)	.372
Índice de masa corporal (kg/ m^2)	20.7 (3.6)	21.0 (3.4)	23.0 (4.2)	18.3 (1.6)**/ †††	< .001
AF extraescolar (horas/ semana)	2.9 (2.0)	2.6 (2.0)	2.2 (1.9)	4.0 (1.8)*/ ††	.003
AF habitual (días/ semana)	2.7 (1.6)	2.4 (1.5)	2.3 (1.6)	3.5 (1.5)*/ †	.018

Nota. Datos reportados como media (desviación estándar) o porcentaje. AF = actividad física. [a] Nivel de significación del análisis de la varianza de un factor (variables continuas) y de la prueba chi-cuadrado (variables categóricas). Comparación por pares con el ajuste de Bonferroni: Control vs. No saludable/ Saludable (* $p < .05$, ** $p < .01$ y *** $p < .001$) y No saludable vs. Saludable († $p < .05$, †† $p < .01$ y ††† $p < .001$).

Medidas

Antropometría. Las medidas antropométricas se evaluaron al inicio del estudio siguiendo el protocolo de la *International Standards for Anthropometric Assessment* (Stewart, Marfell-Jones, Olds, & De Ridder, 2011). Primero se midió la masa corporal (Seca, Ltd., Hamburg, Alemania; precisión = .1 kg) y la talla (Holtain Ltd., Crymmych, Pembs, Reino Unido; precisión = .1 cm), Las medidas se realizaron con los participantes en pantalón corto, camiseta y descalzos. Se realizaron dos mediciones de la masa corporal y la talla, calculándose el promedio de cada una de ellas. Posteriormente, se calculó el índice de masa corporal (kg/m^2).

Actividad física extraescolar. Las horas de práctica de AF extraescolar fueron medidas a través de la pregunta enKid (Martínez-Gómez et al., 2009). El cuestionario consiste en una única cuestión: «¿Cuántas horas dedicas a actividades deportivas extraescolares semanales?». Se empleó una escala tipo Likert de 7 puntos que iba de 0 a «Más de 5». El cuestionario enKid ha demostrado una correlación estadísticamente significativa en adolescentes (r = .43) (Martínez-Gómez et al., 2009).

Actividad física habitual. La actividad física habitual fue medida con el cuestionario PACE (*Physician-based Assessment and Counseling for Exercise*). Este cuestionario consiste en dos preguntas, una que valora cuántos días en la última semana (PACE 1, «En los últimos 7 días, ¿cuántos días hiciste actividad física 60 minutos o más?») y en una semana habitual (PACE 2, «En una semana normal, ¿cuántos días haces actividad física 60 minutos o más?») se realiza al menos 60 minutos de actividad física. El cuestionario PACE ha demostrado una correlación estadísticamente significativa en adolescentes (r = .43) (Martínez-Gómez et al., 2009).

Actividad física objetiva. La frecuencia cardíaca de los estudiantes fue monitorizada durante las clases de EF mediante pulsómetros (Hellin, Garcia-Jimenez, & Garcia-Pellicer, 2019; Martinez-López, Moreno-Cerceda, Suarez-Manzano, & Ruiz-Ariza, 2018; Sarradel, Generelo, & Zaragoza, 2011; Yuste, García-Jiménez, & García-Pellicer, 2015) de acuerdo con el protocolo seguido en estudios previos (Mayorga-Vega et al., 2016). Brevemente, en cada grupo del estudio, se seleccionaron aleatoriamente cinco estudiantes para llevar un monitor de frecuencia cardíaca (Polar RS300X, Finlandia). Todos los estudiantes se midieron dos o tres veces al final del proceso. Se calcularon la frecuencia cardíaca media (latidos por minuto y porcentaje de la frecuencia cardíaca máxima estimada), AF total (porcentaje del tiempo total involucrado en una intensidad igual o superior al 50% de la frecuencia cardíaca máxima estimada) y AFMV (porcentaje del tiempo total involucrado en una intensidad igual o superior al 70% de la frecuencia cardíaca máxima estimada). Posteriormente, los estudiantes fueron categorizados según cumpliesen o no la recomendación de conseguir al menos el 50% de la clase de EF en AFMV (Association for Physical Education, 2015). La frecuencia cardíaca máxima estimada fue calculada utilizando la siguiente ecuación: 209 – .7 x edad (años) (Shargarl, Kislev-Cohen, Zigel, Epstein, Pilz-Bursten, & Tenenbaum, 2015).

Capacidad cardiorrespiratoria. La CCR fue evaluada al principio y al final de la intervención mediante el test de 20 metros ida y vuelta (velocidad inicial de 8.5 km/h e incremento de 0.5 km/h cada minuto) (Léger, Mercier, Gadoury, & Lambert, 1988). Todas las mediciones se realizaron bajo las mismas condiciones ambientales, en una instalación deportiva cubierta con un piso no resbaladizo, el mismo día de la semana y en el mismo periodo de tiempo para cada estudiante. Durante el test cada participante llevó puesto un monitor de frecuencia cardíaca (Polar RS300X, Finlandia) para controlar la implicación fisiológica (debiendo ser igual o superior al 90% de la frecuencia cardíaca máxima). Se registraron el número total de vueltas completadas (n) y el tiempo (en segundos). El volumen máximo de oxígeno (en ml/kg/min) fue estimado usando la siguiente ecuación: 31.025 + 3.238 x velocidad – 3.248 x edad + .1536 x velocidad x edad (velocidad expresada en km/h y edad en el número entero redondeado inferior) (Léger et al., 1988). El test de 20 metros ida y vuelta ha demostrado unos valores adecuados de fiabilidad y validez en adolescentes (por ejemplo, ICC = .89; r_p = .78) (Léger et al., 1988; Mayorga-Vega, Aguilar-Soto, & Viciana, 2015).

Procedimiento

La Figura 1 muestra el esquema general de la intervención. Los estudiantes del GE realizaron una unidad didáctica intermitente de acondicionamiento físico durante las clases de EF dos veces a la semana durante nueve semanas. Finalmente, debido a contingencias educativas tales como días lluviosos, los estudiantes del GE completaron un total de 16 clases. Las clases fueron diseñadas e impartidas por el profesor de EF con la supervisión del investigador principal de acuerdo con el currículum aprobado establecido por el centro.

Cada sesión duró 50 minutos y consistió en cinco a diez minutos de calentamiento, 35-40 minutos de parte principal y cinco minutos de vuelta a la calma. Durante el calentamiento los estudiantes realizaron ejercicios aeróbicos de baja a moderada intensidad seguidos de ejercicios de movilidad articular y estiramientos. Debido a la programación del profesor y con el objetivo de hacer las sesiones más participativas y motivadoras para los estudiantes (Arantes da Costa, Borsato Passos, Matías de Souza, & Vieira, 2017), la parte principal de las sesiones estuvo dividida en dos mitades de aproximadamente 18-20 minutos cada una. Durante la primera mitad, los estudiantes del GE realizaron ejercicios tradicionales de condición física (por ejemplo, entrenamiento interválico, entrenamiento en circuito, fartlek, juegos de carrera o trabajo con combas). Por ejemplo, en la clase con combas los estudiantes realizaban durante diez minutos diferentes saltos a la comba en series de dos minutos y medio con 30 segundos de descanso, seguido del juego de los diez pases por equipos durante diez minutos. Durante la segunda mitad de la clase, los estudiantes del GE trabajaron deportes de invasión (fútbol-sala y baloncesto). Los ejercicios realizados durante esta segunda mitad se caracterizaron por: (a) ser continuos, con las mínimas pausas posibles, y globales; y (b) ser motivantes y basados en situaciones reducidas de juego, tales como el 1x1, 2x1 y 2x3.

El GC realizó dos clases de EF a la semana durante el periodo de intervención y con una estructura similar a la del GE. Sin embargo, la metodología estuvo principalmente basada en la recreación y sin ningún énfasis en la intensidad de la AF. Respecto a los contenidos, el GC trabajó expresión corporal (por ejemplo, ejecución de diferentes figuras de acrosport y montajes con música) y actividades en el medio natural (por ejemplo, juegos de pistas y carreras de orientación).

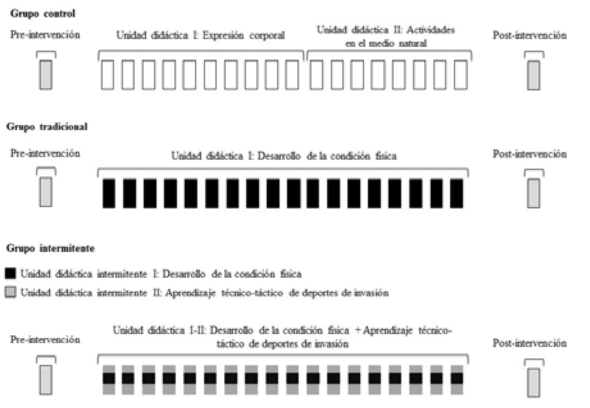

Figura 1. Esquema general de la intervención.

Análisis estadísticos

Los datos fueron reportados como media (desviación estándar), y mostrados como media (error estándar) en las Figuras. El análisis de la varianza (ANOVA) de un factor (variables continuas) y la prueba de chi-cuadrado (variables categóricas) se utilizaron para examinar diferencias potenciales en términos de características generales entre los estudiantes de los tres grupos. Se utilizó el ANOVA de un factor sobre las variables dependientes [frecuencia cardíaca (ppm), frecuencia cardíaca (%), AF total, AFMV], incluyendo *grupo* como variable independiente (GC, GNS, GS) para examinar el efecto de la unidad didáctica intermitente de acondicionamiento físico sobre los niveles de AF. Se utilizó el análisis de covarianza de dos factores (ANCOVA) sobre las variables dependientes [consumo máximo de oxígeno (ml/kg/ min), rendimiento total basado en el tiempo (s)], con edad como covariable, incluyendo *grupo* como variable independiente (GC, GNS, GS), y *tiempo* como variable dependiente (pre-intervención, post-intervención) para examinar el efecto de la unidad didáctica intermitente de acondicionamiento físico sobre los niveles de CCR. Posteriormente, las comparaciones por pares se ajustaron con la corrección de Bonferroni. Por otro lado, se calculó la prueba de chi-cuadrado para analizar el efecto de la unidad didáctica sobre el porcentaje de estudiantes que cumplieron la recomendación de AFMV durante las clases de EF entre los tres grupos. Los tamaños del efecto fueron estimados mediante la eta al cuadrado parcial ($ç^2_p$)/ *d* de Cohen y V de Cramer para las variables continuas y dicotómicas, respectivamente (Field, 2017). Todas las asunciones de las pruebas estadísticas aplicadas fueron comprobadas y satisfechas. Todas las covariables potenciales estudiadas (es decir, género, edad, curso, masa corporal, talla, índice de masa corporal, AF extra-escolar, AF habitual, y asistencia al programa) fueron examinadas para ver si debían ser tenidas en cuenta. Todos los análisis estadísticos se realizaron con el programa SPSS, versión 21.0 para Windows (IBM® SPSS® Statistics). El nivel de significación se estableció en valores de $p < .05$, excepto para la prueba 2x2 chi-cuadrado que fue establecido en $p < .017$.

Resultados

Actividad física

La Figura 2 muestra la comparación del efecto de la unidad didáctica intermitente de acondicionamiento físico sobre los niveles de AF en las clases de EF entre los tres grupos. Los resultados del ANOVA de un factor mostraron diferencias significativas entre los tres grupos [frecuencia cardíaca (ppm): $F = 25.322$; $p < .001$; $ç^2_p = .397$; frecuencia cardíaca (%): $F = 25.357$; $p < .001$; $ç^2_p = .397$; AF total: $F = 18.223$; $p < .001$; $ç^2_p = .321$; AFMV: $F = 23.967$; $p < .001$; $ç^2_p = .384$]. Posteriormente, las comparaciones por pares mostraron que los estudiantes con un perfil saludable y no saludable de CCR tuvieron estadísticamente mayores niveles de AF durante las clases de EF que los estudiantes del GC [frecuencia cardíaca (ppm), $p < .001$, $d = 1.75$ y 1.46; frecuencia cardíaca (%), $p < .001$, $d = 1.75$ y 1.44; AF total (%), $p < .001$, $d = 1.16$ y 1.01; AFMV (%), $p < .001$, $d = 1.73$ y 1.31]. Sin embargo, no se encontraron diferencias entre los estudiantes con un perfil saludable y no saludable [frecuencia cardíaca (ppm), $p = 1.00$, $d = .30$; frecuencia cardíaca (%), $p = .956$, $d = .31$; AF total (%), $p = 1.000$, $d = .14$; AFMV (%), $p = .521$, $d = .42$].

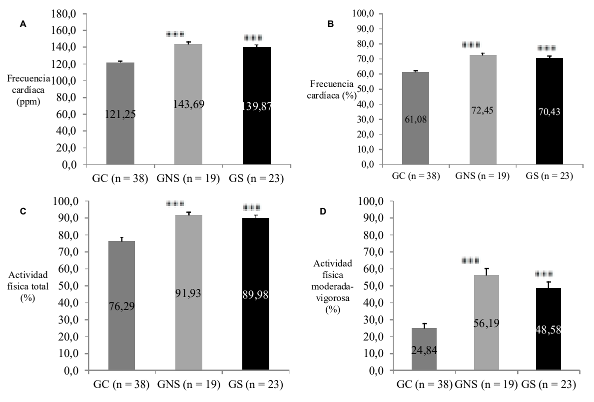

Figura 2. Comparación del efecto de la unidad didáctica intermitente de acondicionamiento físico sobre la frecuencia cardíaca (ppm, A; %, B), actividad física total (%, C), y niveles de actividad física moderada-vigorosa (%, D) durante las clases de Educación Física entre los tres grupos. Las barras representan la media y las barras de error representan el error estándar. GC = Grupo control; GNS = Grupo con un perfil no saludable; GS = Grupo con un perfil saludable. Los resultados del ANOVA de un factor (todas $p < .05$) seguido por las comparaciones por pares con el ajuste de Bonferroni: GNS/ GS vs. GC (*** $p < .01$).

La Figura 3 muestra la comparación del efecto de la unidad didáctica intermitente de acondicionamiento físico sobre el porcentaje de estudiantes que cumplieron la recomendación de AFMV durante las clases de EF entre los tres grupos. Los resultados de la prueba chi-cuadrado sobre el porcentaje de estudiantes cumpliendo la recomendación de AFMV mostraron diferencias estadísticamente significativas entre los tres grupos ($÷^2$ = 16.254; p < .001; V de Cramer = .451). Posteriormente, el resultado de la prueba 2 x 2 de chi-cuadrado mostró que hubo un porcentaje mayor de estudiantes con un perfil saludable y no saludable que cumplieron la recomendación de AFMV en clases de EF que en el GC (GS vs. GC, $÷^2$ = 15.130; p < .001; V de Cramer = .515; GS vs. GC, $÷^2$ = 8.900; p = .003; V de Cramer = .382). Sin embargo, no se encontraron diferencias significativas entre los estudiantes con un perfil saludable y no saludable ($÷^2$ = .987; p = .320; V de Cramer = .153).

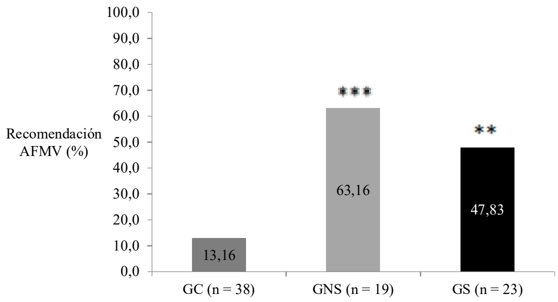

Figura 3. Comparación del efecto de la unidad didáctica intermitente de acondicionamiento físico sobre el porcentaje de estudiantes que cumplieron la recomendación de actividad física moderada-vigorosa (AFMV) durante las clases de Educación Física entre los tres grupos. GC = Grupo control; GNS = Grupo con un perfil no saludable; GS = Grupo con un perfil saludable. Los resultados del ANOVA de un factor (todas p < .05) seguido por las comparaciones por pares con el ajuste de Bonferroni: GNS/ GS vs. GC (*** p < .001, ** p < .01).

Capacidad cardiorrespiratoria

La Figura 4 muestra la comparación del efecto de la unidad didáctica intermitente de acondicionamiento físico sobre los niveles de CCR entre los tres grupos. Los resultados del ANCOVA de dos factores mostraron efectos de interacción estadísticamente significativos entre las variables *grupo* y *tiempo* para los niveles de CCR [consumo máximo de oxígeno (ml/ kg/ min): F = 4.842; p = .010; $ç^2_p$ = .113; rendimiento total basado en el tiempo (s): F = 6.338; p = .003; $ç^2_p$ = .143;]. Posteriormente, las comparaciones por pares mostraron que los estudiantes con un perfil no saludable de CCR mejoraron de manera estadísticamente significativa sus niveles de CCR en comparación con sus valores iniciales [consumo máximo de oxígeno (ml/ kg/ min), pre-intervención (M = 37.28, DE = 1.11), post-intervención (M = 38.86, DE = 1.12), p = .003, d = .32; rendimiento total basado en el tiempo (s), pre-intervención (M = 198.58, DE = 24.93), post-intervención (M = 232.86, DE = 24.67), p = .001, d = .33]. Sin embargo, para los estudiantes con un perfil saludable y los estudiantes del GC no se

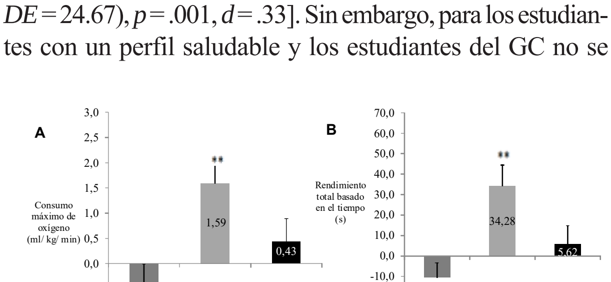

Figura 4. Comparación del efecto de la unidad didáctica intermitente de acondicionamiento físico sobre el volumen máximo de oxígeno (ml/ kg/ min, A) y niveles de rendimiento total basado en el tiempo (s, B) entre los tres grupos. Las barras representan la media ajustada (valor de la diferencia = post-intervención – pre-intervención) y las barras de error representan el error estándar. GC = Grupo control; GNS = Grupo con un perfil no saludable; GS = Grupo con un perfil saludable. Los resultados del ANOVA de dos factores (todas p < .05) seguido por las comparaciones por pares con el ajuste de Bonferroni: ** p < .01.

encontraron diferencias estadísticamente significativas [consumo máximo de oxígeno (ml/ kg/ min), pre-intervención (M = 38.91, DE = .78 (GC); M = 46.59, DE = 1.00 (GS)), post-intervención (M = 38.54, DE = .783 (GC); M = 47.02, DE = 1.00 (GS)), p > .05, d = .13; rendimiento total basado en el tiempo (s), pre-intervención (M = 246.47, DE = 17.49 (GC); M = 408.23, DE = 22.36 (GS)), post-intervención (M = 235.94, DE = 17.32 (GC); M = 413.85, DE = 22.10 (GS)), p > .05, d = .12].

Discusión

El primer objetivo del presente estudio fue comparar el efecto de una unidad didáctica intermitente de acondicionamiento físico sobre los niveles de AF durante las clases de EF entre estudiantes de Educación Secundaria con un perfil saludable y no saludable de CCR. Los resultados mostraron que después de la unidad didáctica, los estudiantes con ambos perfiles incrementaron sus niveles de AF durante las clases de EF. De manera similar, Calahorro-Cañada, Torres-Luque, López-Fernández, y Carnero (2016) en un estudio descriptivo analizaron las diferencias en los niveles de AF en estudiantes de Educación Secundaria y encontraron que los estudiantes con un perfil saludable de CCR eran más activos que aquellos con un perfil no saludable. Desafortunadamente no se encontraron estudios previos de intervención que comparasen el efecto de una unidad didáctica intermitente de acondicionamiento físico sobre los niveles de AF durante las clases de EF entre estudiantes de Educación Secundaria con un perfil saludable y no saludable de CCR.

Por otro lado, los resultados del presente estudio mostraron que los estudiantes acumularon entre el 50-55% del tiempo de la clase de EF en AFMV. Estudios previos han mostrado que se puede mejorar hasta en un 24% el tiempo que los estudiantes están involucrados en AFMV durante las clases de EF (Lonsdale et al., 2013). Sin embargo, el porcentaje del tiempo de la clase de EF dedicado a AFMV es menor que el recomendado (40.5%) cuando las clases de EF no están específicamente diseñadas para mejorar los niveles de AFMV de los estudiantes (Hollis et al., 2017).

En cuanto a la proporción de estudiantes que cumplieron con la recomendación de acumular al menos el 50% de las clases de EF en AFMV, los resultados del presente estudio mostraron que el 50% de los estudiantes con un perfil saludable de CCR y el 60% de los que tenían un perfil no saludable de CCR, cumplieron dicha recomendación. Sin embargo, la proporción de estudiantes que cumple esta recomendación es prácticamente cero cuando las clases de EF no están específicamente diseñadas para conseguir este objetivo (Viciana et al., 2015). Finalmente, respecto al tamaño del efecto, los resultados del presente estudio (d = 1.31 hasta 1.73) fueron similares a los de estudios previos centrados en la mejora de los niveles de AFMV durante las clases de EF (.13 hasta 2.81, Lonsdale et al., 2013).

El segundo objetivo fue comparar el efecto de una unidad didáctica intermitente de acondicionamiento físico sobre los niveles de CCR adquiridos entre estudiantes de Educación Secundaria con un perfil saludable y no saludable de CCR. Los resultados del presente estudio mostraron cómo solo los estudiantes con un perfil no saludable de CCR mejoraron sus niveles de CCR después de la unidad didáctica. En cambio, los estudiantes con un perfil saludable de CCR no tuvieron incremento. Estudios previos han demostrado que una intervención a corto plazo puede mejorar los niveles de CCR en los adolescentes (por ejemplo, Mayorga-Vega et al., 2016, Mayorga-Vega et al., 2013). Sin embargo, el efecto de una unidad didáctica de condición física está asociado negativamente con el nivel inicial de CCR (Resaland et al., 2011). De manera similar al presente estudio, Mayorga-Vega y Viciana (2015) examinaron el efecto de una unidad didáctica de condición física realizada durante las clases de EF (dos veces por semana) teniendo en cuenta el nivel inicial de CCR de los estudiantes. Estos autores encontraron que solo los estudiantes con un bajo nivel inicial de CCR mejoraron después de la unidad didáctica. Sin embargo, Mayorga-Vega y Viciana (2015) dividieron a los estudiantes del GE estadísticamente por percentiles del nivel inicial de CCR (por debajo del P_{50} e igual o superior al P_{50}), sin tener en cuenta si los niveles de CCR eran saludables o no. Por consiguiente, las mejoras obtenidas por los estudiantes pudieron no ser suficientes para adquirir unos niveles saludables de CCR, ya que inicialmente fueron clasificados por percentiles en lugar de en función de un criterio de referencia relacionado con la salud (Welk et al., 2011). Igualmente, Resaland et al. (2011) observaron que la aplicación de un programa de AF diario durante dos años tuvo mayor impacto en los estudiantes con un nivel inicial bajo de CCR. Sin embargo, la frecuencia y duración total de este programa fue totalmente diferente al tiempo designado para la asignatura de EF en la mayoría de los países (dos horas a la semana) (Hardman et al., 2014).

Por otro lado, en los estudios mencionados anteriormente que aplicaron una unidad didáctica de acondicionamiento físico a corto plazo (Mayorga-Vega et al., 2016, Mayorga-Vega & Viciana, 2015; Mayorga-Vega et al., 2013), solo consiguieron mejorar la CCR de los estudiantes, teniendo que desarrollar después otros objetivos curriculares en un tiempo limitado (Hardman et al., 2014). En este sentido, otro resultado importante del presente estudio, es que además de mejorar los niveles de CCR de los estudiantes con un perfil de CCR no saludable, al mismo tiempo, se trabajaron otros objetivos curriculares como aspectos técnico-tácticos de deportes de invasión (fútbol-sala y baloncesto).

Respecto a la magnitud del efecto, en el presente estudio el tamaño del efecto fue moderado (d = .32) para los estudiantes con un perfil de CCR no saludable y muy bajo (d = .13) para los estudiantes con un perfil saludable de CCR. De manera similar, Mayorga-Vega y Viciana (2015) encontraron también un efecto moderado para los estudiantes con menor nivel de CCR (d = .44) y muy bajo para aquellos que tenían mayor nivel de CCR (d = .07). Posiblemente, la razón por la que los estudiantes con un perfil saludable de CCR no mejoraron sus niveles de CCR después de la intervención, pudo ser que las clases realizadas no fuesen estímulo suficiente debido a la baja frecuencia semanal de la asignatura de EF en España, similar a la mayoría de los países de nuestro entorno (Hardman et al., 2014).

Las fortalezas de este estudio fueron: 1) es el primer estudio que analiza el efecto de una unidad didáctica intermitente de acondicionamiento físico dividiendo a los estudiantes por perfiles de acuerdo a su nivel inicial de consumo máximo de oxígeno (Welk et al., 2011), en lugar de por un criterio estadístico como en el estudio de Mayorga-Vega y Viciana (2015); 2) muestra el efecto en los niveles medios de AF diferenciando por perfiles de CCR; y 3) el porcentaje de estudiantes que cumplieron la recomendación de AFMV durante las clases de EF. Respecto a las limitaciones, la principal limitación del estudio fue que el aprendizaje técnico-táctico no fue medido debido a problemas de viabilidad. En España, el tiempo destinado a Educación Física es limitado (solo dos horas a la semana) y el año académico es interrumpido por las vacaciones aproximadamente cada tres meses. Por lo tanto, dado que la evaluación objetiva de aprendizaje técnico-táctico habría necesitado más sesiones de evaluación, no se pudo realizar. En segundo lugar, el consumo máximo de oxígeno fue estimado a través de una ecuación validada, ya que su medición directa no era viable por razones prácticas. Estudios futuros, podrían medir el consumo máximo de oxígeno de forma directa con un analizador de gases portátil con el fin de obtener una medida objetiva de este parámetro.

Aplicaciones prácticas

La asignatura de EF tiene un enorme potencial sobre los estudiantes para la adquisición de los 60 minutos diarios de AFMV (Mayorga-Vega, Martínez-Baena, & Viciana, 2018). Por tanto, conseguir que los alumnos estén involucrados al menos el 50% del tiempo de la clase de EF en AFMV (Association for Physical Education, 2015) resulta un aspecto clave. Planificar unidades didácticas intermitentes de acondicionamiento físico a través de ejercicios tradicionales de condición física y de deportes colectivos, podría ser una buena herramienta para los profesores de EF con el fin de aumentar los niveles de AFMV durante sus clases. Además de mejorar los niveles de AFMV durante las clases de EF, este tipo de unidades didácticas permitirían solucionar los problemas de planificación presentes en la asignatura de EF a la hora de desarrollar una cualidad física tan importante en la adolescencia como la capacidad cardiorrespiratoria (Hardman et al., 2014; Viciana et al., 2014). Incluso, con objeto de mejorar esta cualidad física en ambos perfiles de estudiantes (saludable/no saludable), los profesores de EF podrían planificar unidades didácticas intermitentes de acondicionamiento físico estableciendo diferentes niveles de intensidad dentro de la misma clase. De esta forma, se conseguiría un estímulo de trabajo suficiente para mejorar esta cualidad física en todos los estudiantes.

Conclusiones

De lo que conocemos este es el primer estudio que compara el efecto de una unidad didáctica intermitente de acondicionamiento físico sobre los niveles de CCR adquiridos y los niveles de AF durante las clases de EF entre estudiantes de Educación Secundaria con un perfil saludable y no saludable de CCR. Ambos perfiles de estudiantes tuvieron mayores niveles de AFMV tras la aplicación de la unidad didáctica intermitente. Además, hubo un mayor porcentaje de alumnos en ambos perfiles que cumplieron con la recomendación de AFMV durante las clases de EF. Sin embargo, una unidad didáctica intermitente de acondicionamiento físico de dos sesiones por semana solo mejora la CCR de los estudiantes con un perfil no saludable de CCR. Por lo tanto, con el propósito de incrementar la CCR de todos los estudiantes, parece necesario aumentar la carga lectiva de la asignatura de EF, por ejemplo, mediante un aumento de la frecuencia semanal.

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Paper VIII

EFFECT OF A SHORT-TERM PHYSICAL FITNESS PROGRAM ON STUDENTS' CARDIORESPIRATORY FITNESS AND ITS POSTERIOR REDUCTION IN THE PHYSICAL EDUCATION SETTING

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Kinesiology

Submited

Effect of a short-term physical fitness program on students' cardiorespiratory fitness and its posterior reduction in the Physical Education setting

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Abstract

The aim of this study was to examine the effect of a four-week detraining period after a short-term physical fitness program on students' cardiorespiratory fitness levels in the Physical Education setting. Seventy-six secondary students (34 boys and 58 girls; mean age = 13.7 ± 0.8 years) were cluster-randomly assigned to a control group (n = 36) or experimental group (n = 40). The experimental group performed a physical fitness program twice per week during nine weeks in the Physical Education setting. Students' cardiorespiratory fitness was measured by the 20-meter shuttle run test at the beginning and at the end of the physical fitness program, and after the four-week detraining period. Results showed that the experimental group students improved their cardiorespiratory fitness levels after the physical fitness program ($p < 0.05$). However, students' cardiorespiratory fitness values reverted back to the baseline after the detraining period ($p > 0.05$). Although in the Physical Education setting a short-term physical fitness program increased the students' cardiorespiratory fitness levels, after a four-week detraining period students' levels reverted back to the baseline. Physical Education teachers should apply maintenance programs or plan longer physical fitness programs with an intermittent teaching unit (15 intense minutes every session) along the scholar year to maintain students' cardiorespiratory fitness levels.

Keywords: intervention program, health-related physical fitness, detraining, high school students

Introduction

Cardiorespiratory fitness (CRF) is a well-recognized health marker among adolescents (Lang et al., 2017). During adolescence, higher levels of CRF are related to a better quality of life, lower risk of cardiovascular diseases such as metabolic syndrome, and lower risk of all-cause mortality later in life (Högström, Nordström, & Nordström, 2014; Mintjens et al., 2018; Rosa-Guillamón, García-Cantó, Rodríguez-García, & Pérez-Soto, 2016). Unfortunately, in the last decades CRF has been declining among adolescents (Tomkinson, Lang, & Tremblay, 2017). As a consequence, nowadays a low CRF is a worldwide problem which affects, on average, 46% of girls and 33% of boys (Tomkinson et al., 2016). Hence, health-related CRF levels should be promoted during adolescence (Ruiz et al., 2016).

Schools, and more specifically the Physical Education (PE) subject, play an important role in promoting a health-related CRF level among adolescents (Association for PE, 2015). For example, many European countries require in their national educational standards that the PE subject should develop and maintain health-related CRF levels among students (Association for PE, 2015; European Commission/EACEA/Eurydice, 2013). Therefore, PE teachers should work this physical fitness component into their PE sessions with the double objective of developing and maintaining it through the whole academic year (Giannaki, Aphamis, Tsouloupas, Ioannou, & Hadjicharalambous, 2016; Mayorga-Vega, Montoro-Escaño, Merino-Marban, & Viciana, 2016; Mayorga-Vega, Viciana, & Cocca, 2013).

Previous studies have shown that it is possible to improve students' CRF levels performing a short-term physical fitness program in the PE setting (Giannaki et al., 2016; Mayorga-Vega et al, 2016; Mayorga-Vega et al., 2013; Ramírez Lechuga et al., 2012). However, a big difficulty in the PE setting is the fact that the academic year is constantly interrupted by several holiday periods (Hardman, Murphy, Routen, & Tones, 2014; Viciana, Mayorga-Vega, & Merino-Marban, 2014), some of them with a considerable duration, such as Christmas or summer. Therefore, during these periods of time, gains achieved in CRF levels may be reduced to a baseline level (Carrel, Clark, Peterson, Eickhoff, & Allen, 2007; Mujika & Padilla, 2001).

Currently, the evidence about the effects of a detraining period on the CRF level is still limited and contradictory (Lo, Lin, Yao, & Ma, 2011; Song, 2011; Sousa et al., 2018). More specifically in the PE setting, only two studies have examined the effect of a detraining period on student's CRF (Carrel et al., 2007; Santos, Marinho, Costa, Izquierdo, & Marques, 2012). Carrel et al. (2007) found that, after performing a nine-month physical fitness program 10 times a month, the students' CRF gains acquired reverted back to the baseline levels after a 12-week detraining period, such as the summer break. Conversely, Santos et al. (2012) found that, students' CRF gains acquired after an eight-week school-based resistance and endurance training program performed four times a week (two PE sessions plus two additional sessions out of PE timetable), did not return back to baseline levels after 12-weeks detraining period.

However, in the aforementioned studies, apart from the fact that the physical fitness programs were performed with higher frequency (Santos et al., 2012) or longer duration (Carrel et al., 2007) than those commonly developed in the PE setting (European Commission/EACEA/Eurydice, 2013; Hardman et al., 2014; Viciana, Mayorga-Vega, & Mompeán Campillo, 2016), the detraining period was longer too. Unfortunately, to our knowledge there are no previous studies examining the effect of a short detraining period (i.e., four weeks) among adolescents after a short-term physical fitness program in the PE setting. Therefore, the aim of the present study was to examine the effect of a four-week detraining period after a nine weeks physical fitness program on students' CRF levels in the PE setting.

Methods

Participants

First, the Ethical Committee of the University of [omitted for blind review] approved the study protocol. Then, two public high schools from an urban area situated in [omitted for blind review] were consulted for the implementation of the study. After the schools´ approvals were obtained, all the students from the second and third grade of secondary education (i.e., aged 13–15 years old) were invited to participate in the present study. For practical reasons and due to the nature of the present study (natural classes in a school setting) a cluster-randomized controlled trial was used (Mayorga-Vega et al., 2016; Viciana, Mayorga-Vega, Guijarro-Romero, & Martínez-Baena, 2017). Hence, the four established classes, balanced by grade (i.e., second- and third-grade classes), were assigned randomly to form the control group (CG) or the experimental group (EG). The inclusion criteria were: a) being enrolled in the second to third grades of the secondary education level (the grades for which the schools allowed); b) participating in the normal PE classes; c) being free of any health disorder such as heart diseases, uncontrolled asthma, bone/joint problems or other reasons why students should not undergo physical activity; and d) presenting the corresponding written signed consent/ assent by their parents or legal guardians/ adolescents. The exclusion criteria were: a) not having performed correctly all the dependent variables, and b) not having an attendance rate equal to or over 85% for PE classes during the intervention period. The initial sample was composed of 92 students (34 boys and 58 girls) who agreed to participate and met the inclusion criteria. After applying the exclusion criteria, 76 students (31 boys and 45 girls) satisfactorily passed to become the final sample group (Figure 1). For general characteristics of the participants, see the Results section.

“Insert Figure 1 here”

Measures

General characteristics of the participants (i.e., age, grade, gender, body mass, body height and habitual physical activity) were registered at the beginning of the study. Body mass and body height were first measured with participants in shorts, T-shirts and barefoot following the ISAK procedure (International Society for the Advancement of Kinanthropometry, 2001) and, then, the body mass index was calculated as body mass/ body height squared (kg/ m^2). Habitual physical activity was estimated by the adapted and validated Spanish version of the PACE questionnaire for adolescents (Martínez-Gómez et al., 2009).

The CRF evaluation was carried out during the PE classes at the beginning and at the end of the physical fitness program (pre-intervention and post-intervention, respectively) and after the Christmast break four-week detraining period (post-detraining). Each evaluation was carried out under the same conditions, using the same instruments and by the same tester. The measurements were taken in an indoor sports facility with a non-slippery floor, on the same day of the week and at the same time for each student. Prior to the CRF test, the participants completed a standardized warm-up consisting of five minutes of running from low-to-moderate intensity followed by some joint mobility exercises.

The CRF was assessed by the 20-meter shuttle run test. The participants ran between two parallel lines placed 20 meters apart, in the rhythm marked by a recorded beep. The starting speed was 8.5 km/h and it increased 0.5 km/h every minute. The test ended when the participants stopped running because of fatigue or failed to reach the line before the next signal for two consecutive times. During the test each participant wore a heart rate monitor (Polar® RS300X, Finland). Participants were allowed to perform the test once and the total time in seconds was retained. However, only the scores of those participants who reached a heart rate value equal to or higher than 90% of estimated maximum heart rate were used. The maximum heart rate was estimated by the following equation: 209 – 0.7 x age (in years)

(Shargarl et al., 2015). The 20-meter shuttle run test has shown adequate reliability and criterion-related validity among adolescents (e.g., ICC = 0.89; r_p = 0.78) (Léger, Mercier, Gadoury, & Lambert, 1988; Mayorga-Vega, Aguilar-Soto, & Viciana, 2015).

Procedures

Figure 2 shows the general scheme of the intervention. The EG students performed a physical fitness-based program during the PE sessions twice a week for nine weeks. Because of educational contingencies (i.e., excursions), in the end the EG students completed a total of 16 sessions. The sessions were designed and delivered by the PE teacher with the supervision of the main researcher. Each session lasted 50 minutes and consisted of a 5-to-10-minute warm-up, 35-to-40-minute main part and 5-min cool-down. During the warm-up the students carried out low-to-moderate aerobic exercises followed by some joint mobility and stretching exercises. Because of the teacher's programming and with the aim of making the sessions more motivating and participatory for the students (Arantes da Costa, Borsato Passos, Matías de Souza, & Vieira, 2017), the main part of the sessions were divided into two halfs of approximately 18-20 minutes each one. During the first half, the EG students performed traditional PE-based physical fitness exercises (e.g., circuit training, interval training, running games or fartlek). For example, in the circuit training session students performed a circuit with five stations twice for 12 minutes, followed by team relay races for 8 minutes. Each station consisted of an exercise lasting 30 seconds (push-ups, skipping, crunches heels to buttocks, and lateral race between cones) followed by 30 seconds of rest between exercises. Between circuits students rested for one minute. During the work time the students should complete as many repetitions as possible in a controlled manner (Mayorga-Vega et al., 2013). In the second half, the EG students worked with invasion sports tasks. These tasks were mainly characterizied for being continuous, global, motivating and for being based on superiority, inferiority, or equality numerical situations such as the 2 x 2 or 3 x 2 achieving a moderate-to-vigorous intensity.

Regarding the CG students, they also participated in their PE sessions twice a week during the intervention period, with a similar structure as the EG. However, the methodology followed during the main part of the sessions (mostly based on the recreation and without any special focus on PA intensity) and the contents worked (outdoor physical activities and body expression) were different. For example, during the oudoor physical activity sessions, students performed different track games, while during the body expression sessions, students learned different acrosport forms that they had to use after for making an acrosport choreography with the help of the PE teacher.

"Insert Figure 2 here"

Statistical analysis

Descriptive statistics for the general characteristics of the included participants and dependent variables were calculated. Chi-squared analyses were carried out to test the ratio differences of gender and grade between the two groups. A one-way analysis of variance (ANOVA) was conducted to examine potential differences between the two groups in terms of body mass, body height, body mass index, and habitual physical activity levels. Then, the effect of the short-term physical fitness program followed by the four-week detraining period on students' CRF levels was examined using a two-way analysis of covariance (ANCOVA; with gender as covariance) applied over the dependent variable (CRF), including *group* as an independent variable (EG, CG) and *time* as a dependent variable (pre-intervention, post-intervention, post-detraining). Subsequently, for the *post-hoc* within-group pairwise comparisons, the Bonferroni adjustment was used. Effect sizes were estimated using the partial eta squared (η^2_p) and Cohen's *d* for the overall and pairwise comparisons, respectively

(Field, 2017). All statistical analyses were performed using the SPSS Version 21.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

Results

General characteristics

Table 1 shows the general characteristics of the included participants and differences between the two groups. The chi-square analysis showed that the EG and CG had an unbalanced representation of girls and boys ($p < 0.05$). However, the chi-square analysis showed that the two groups had a balanced representation of second- and third-grade students ($p < 0.05$). Additionally, the one-way ANOVA results did not show statistically significant differences in terms of body mass, body height, body mass index, and habitual physical activity levels between the EG and the CG ($p > 0.05$). The EG participants obtained an average attendance of 93%.

"Insert Table 1 here"

Cardiorespiratory fitness

Table 2 shows the effect of the short-term fitness program followed by the four-week detraining period on students' CRF levels. The results of the two-way ANCOVA on the average obtained in the students' CRF levels showed a significant interaction effect between the *group* and *time* variables ($p < 0.05$). Subsequently, for the *post-hoc* within-group pairwise comparisons, the ANOVA with the Bonferroni adjustment showed that, although the EG students' CRF levels increased statistically significantly after the fitness program (pre-intervention vs. post-intervention, $p < 0.05$), the EG students' values were back to the baseline after the detraining period (post-intervention vs. post-detraining, $p < 0.001$; pre-intervention vs. post-detraining, $p > 0.05$). For the CG students no statistically significant differences were found ($p > 0.05$).

"Insert Table 2 here"

Discussion and conclusions

To our knowledge, the present study was the first to have examined the effect of a four-week detraining period after a short-term physical fitness program on students' CRF levels in the PE setting. The results of this study showed that students' CRF levels significantly improved after performing a physical fitness program twice a week during nine weeks. This finding is in agreement with previous studies that have performed a short-term physical fitness program with adolescents in the PE setting, having shown to be effective for improving students' CRF levels (Giannaki et al., 2016; Mayorga-Vega et al, 2016; Mayorga-Vega et al., 2013; Ramírez Lechuga et al., 2012). Regarding the magnitude effects of the program, results of the present study are similar to those studies that have performed a short-term physical fitness program in the PE setting (Mayorga-Vega et al, 2016; Mayorga-Vega et al., 2013; Ramírez Lechuga et al., 2012; Schmidt, Valkanover, Roebers, & Conzelmann, 2013) (d = 0.25 vs. mean d = 0.33). Hence, and considering that the magnitude effects of this study on students' CRF were moderate, it can be concluded that the physical fitness program performed was effective for improving students' CRF.

However, the PE subject is hindered by several difficulties that teachers have to face in order to maintain the students' CRF gains acquired (i.e., the great volume of contents to develop during the academic year or holidays) (European Commission/EACEA/Eurydice, 2013; Hardman et al., 2014; Viciana et al., 2014). In general, PE teachers specifically work CRF during a few weeks, and then, when they finish, they start working other objectives (e.g., related to sports, body expression, or outdoor physical activity), without considering how long the effect of the applied physical fitness programs on students' CRF level will last (Viciana et al., 2016). Therefore, a big obstacle in PE planning is that CRF starts to decrease after a period of detraining (Carrel et al., 2007). Results of the present study showed that, after performing a short-term physical fitness program, students' CRF returned back to baseline levels in a four-week detraining period. Specifically in the PE setting, only two studies have examined the effect of a detraining period on students' CRF level (Carrel et al., 2007; Santos et al., 2012). However, the conclusions are still limited and contradictory. On the one hand and similar to the present study, Carrel et al. (2007) found that after performing a physical fitness program 10 times a month for nine months, middle school students lost CRF gains acquired after a period of detraining such as the summer break, whose duration was 12 weeks. On the other hand, Santos et al. (2012) found that students' CRF gains acquired after an eight-week school-based resistance and endurance training program performed four times a week (two PE sessions plus two additional sessions outside PE timetable), did not return back to baseline levels after a 12-week detraining period. However, it should be noticed that in the aforementioned studies, the physical fitness programs were performed with higher frequency (Santos et al., 2012) and longer duration (Carrel et al., 2007) than those commonly developed in the PE setting (European Commission/EACEA/Eurydice, 2013; Hardman et al., 2014; Viciana et al., 2016). Additionally, the detraining period was longer than in the present study. Unfortunately, the detraining effect on CRF has been poorly studied in adolescents in the PE setting. Hence, knowing if shorter detraining periods (i.e., four weeks) during the academic year produce a decrease in students' CRF gains previously acquired with a physical fitness program could be useful for PE teachers to know how long the effect of a physical fitness program will last. Therefore, the main finding of this study was the verification that students' CRF returns back to the baseline level after a detraining period of four weeks.

Because of the losses found in students' CRF levels after a four-week detraining period, PE teachers should continue working CRF in order to maintain the gains previously acquired with intermittent reinforcements (Le Ny, 1980). For instance, Mayorga-Vega et al. (2013) showed that an intermittent reinforcement program performed once a week during four weeks was effective for maintaining students' CRF gains previously acquired with a short-term physical fitness program. Another alternative available for PE teachers with the aim of avoiding the loss of CRF could be the application of the intermittent teaching units proposed by Viciana and Mayorga-Vega (2016). This intermittent teaching unit consists of several PE session minutes along the year where students are involved in high intensity exercises, while the rest of the session is focused on another learning objective. This could allow teachers to develop the students' CRF during the whole year, instead of a short teaching period, and also could allow students to be involved in high intensity activities for a short period of the session instead of during the whole session. Consequently, the decrease caused by detraining periods is not experienced during the scholar year, only in the summer holidays between scholar years. Regarding holidays such as Christmas or summer where there are no PE sessions, another alternative for maintaining CRF gains, could be performing individual programs (Fernández-Río, Medina Gómez, Garro García, & Pérez González, 2001). These individual programs consist of a group of exercises designed by the PE teacher individually for each student according to their initial physical fitness level. For instance, we could apply these individual programs using the extra-curricular periods (i.e., recesses, after school time or weekends) following the irregular teaching unit proposal of Viciana and Mayorga-Vega (2016). Finally, another alternative for longer periods of detraining such as summer, could be summer school programs (Park & Lee, 2015).

The main strength of the present study was that it is the first study that has examined the effect of a short detraining period on students' CRF levels in the PE setting. Regarding the limitations, examining the effects of detraining on students' CRF levels with small samples allows for a lower power of generalization in comparison with larger-sized studies, and consequently further studies should take this consideration into account and continue studying the effects of the detraining period on students' CRF in PE. Secondly, the study was not balanced by gender. However, when gender had an effect, it was statistically controlled. Future research studies in the PE setting, should measure other detraining periods with a shorter duration than in this study, with the goal of knowing when may be the exact moment in which CRF starts to decrease after having performed a physical fitness program.

In conclusion, to our knowledge this is the first study that examines the effects of a four-week detraining period after a short-term physical fitness program on students' CRF levels in the PE setting. Although the short-term physical fitness program increased the students' CRF levels, after a four-week detraining period students' CRF levels reverted back to the baseline. Therefore, Physical Education teachers should apply maintenance programs or plan longer physical fitness programs with an intermittent teaching unit (15 intense minutes every session) along the scholar year to maintain students' cardiorespiratory fitness levels as well as promote a healthy life style during holidays.

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Table 1

General characteristics of the included participants and differences between the two groups

	Total (n = 76)	Experimental (n = 40)	Control (n = 36)	p^a
Age (years)	13.7 (0.8)	13.9 (0.9)	13.6 (0.7)	-
Grade (2nd/ 3rd)	39.5/ 60.5	35.0/ 65.0	44.4/ 55.6	0.400
Gender (girls/ boys)	59.2/ 40.8	47.5/ 52.5	72.2/ 27.8	0.029
Body mass (kg)	54.6 (11.1)	55.2 (12.9)	53.8 (8.7)	0.581
Body height (cm)	162.1 (8.1)	163.3 (8.2)	160.7 (7.8)	0.157
Body mass index (kg/ m^2)	20.7 (3.6)	20.6 (3.8)	20.9 (3.3)	0.737
Habitual PA (days/ week)	2.7 (1.6)	3.0 (1.7)	2.4 (1.5)	0.086

Note. Data are reported as mean (standard deviation) or percentage; PA = Physical activity.

[a] Significance level from the one-way analysis of variance for body mass, body height, body mass index and habitual PA, and from the chi squared test for the gender and grade ratios.

Table 2

Effect of the short-term physical fitness program followed by a four-week detraining period on students' card

	Pre-intervention (1)	Post-intervention (2)	Post-detraining (3)	ANCOV	
Group	Mean (SD)	Mean (SD)	Mean (SD)	*F*	*p*
Experimental (*n* = 40)	307.9 (115.6)	327.8 (109.6)*	286.1 (101.9)†††	4.207	0.019
Control (*n* = 36)	255.5 (115.8)	246.4 (109.8)	239.1 (102.1)		

Note. SD = standard deviation.

[a] Two-way analysis of covariance (gender as covariable) followed by the within-group pairwise comparisons with the Bonferroni a

from pre-intervention to post-intervention (***p* < 0.05) and from post-intervention to post-detraining (†††*p* < 0.001).

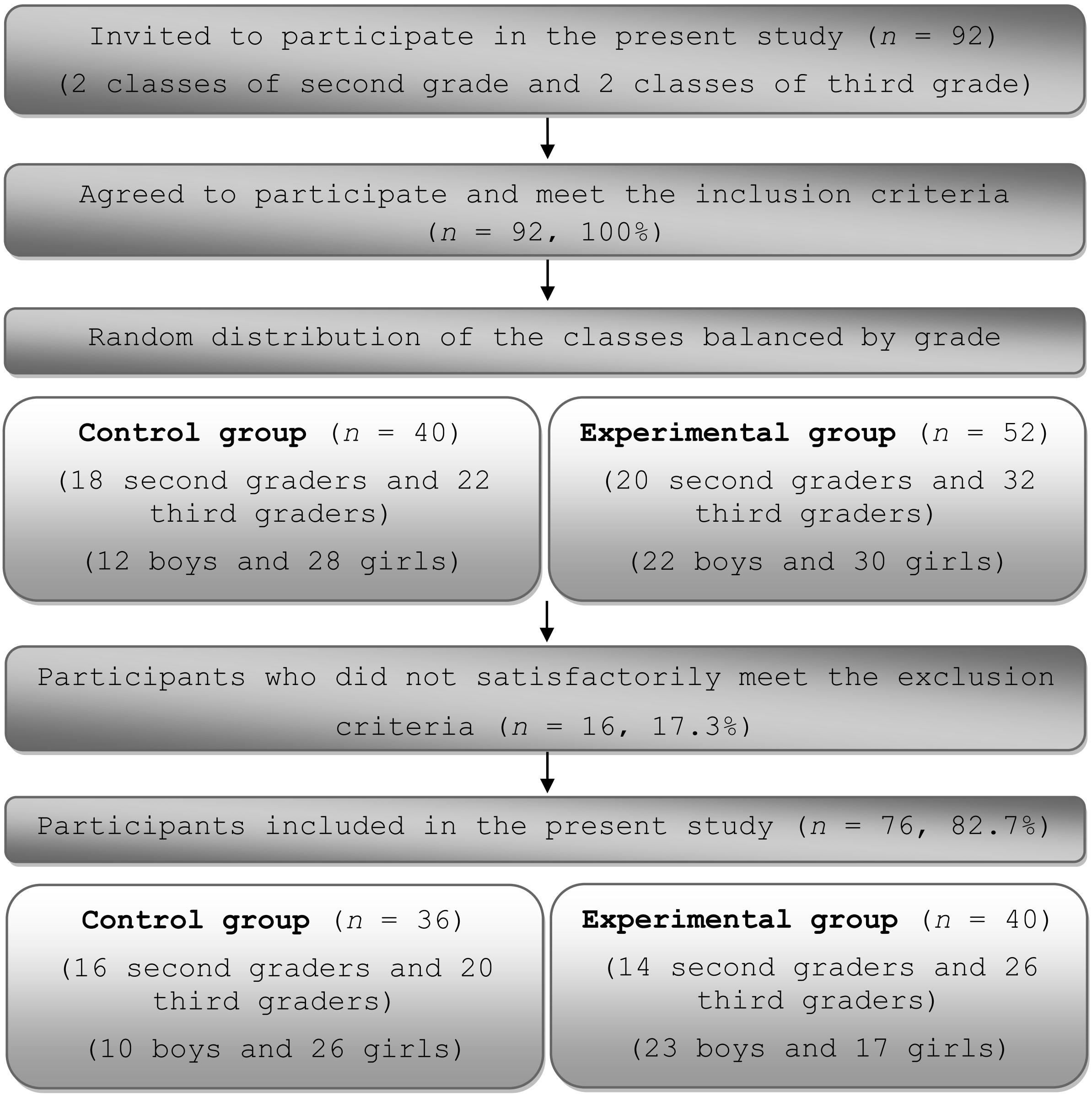

Figure 1. Flow chart corresponding to the participants included in the present study.

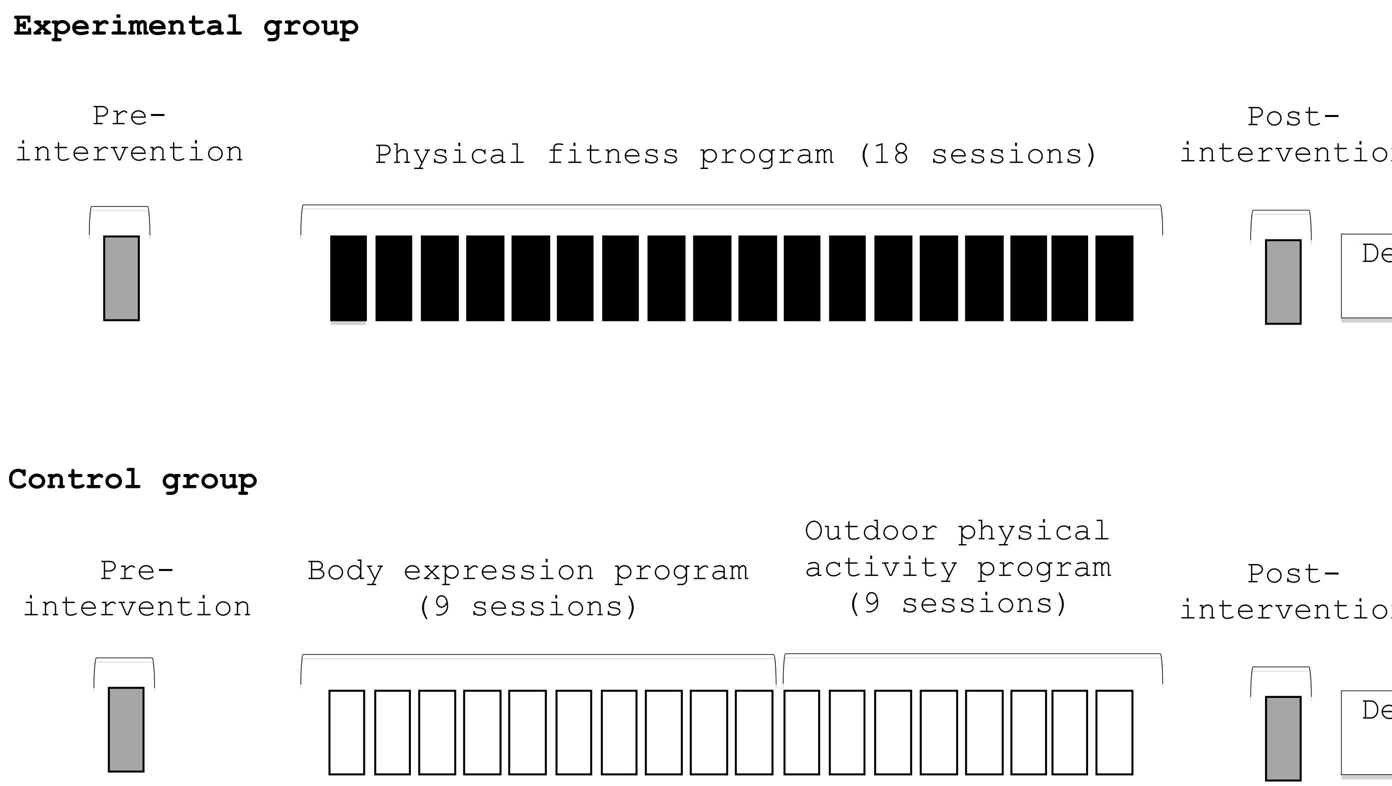

Figure 2. General scheme of the intervention.

2. INFLUENCE OF PSYCHOLOGICAL VARIABLES MEDIATORS OF ACTIVE BEHAVIOR IN PHYSICAL EDUCATION LESSONS AND IN RELATION TO THE IMPROVEMENT OF PHYSICAL FITNESS (PAPERS IX-X)

Paper IX

DOES STUDENTS' SELF-DETERMINATION MOTIVATION TOWARD PHYSICAL EDUCATION INFLUENCE THE EFFECTIVENESS OF A FITNESS TEACHING UNIT? A CLUSTER-RANDOMIZED CONTROLLED TRIAL AND CLUSTER ANALYSIS

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Does students' self-determined motivation toward Physical Education influence the effectiveness of a fitness teaching unit? A cluster-randomized controlled trial and cluster analysis

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ABSTRACT

Objective: The aim was to compare the effect of a Physical Education (PE)-based fitness teaching unit to improve cardiorespiratory fitness levels between students' motivational profiles toward PE in high-school students using cluster analysis.
Method: One hundred and eighty-one high school students (final sample 165, 52.1% females; $M_{age} = 12.9 \pm 0.9$) from nine pre-established classes were cluster-randomly assigned into an experimental group ($n = 120$) and control group ($n = 61$). The experimental group performed a fitness teaching unit twice a week for nine weeks. Students' baseline of self-determined motivation toward PE was measured by the Spanish version of the Perceived Locus of Causality-II Scale. Cardiorespiratory fitness was measured before and after the intervention through the 20-m shuttle run test.
Results: Based on a two-stage cluster analysis approach, four clusters were identified in both groups. Results showed that the experimental group students within the high self-determined motivational profiles toward PE (i. e., clusters 2 and 4) statistically significantly improved their cardiorespiratory fitness levels compared with the control group students in cluster 2 (i.e., those with moderate self-determined motivational profile toward PE) ($p < 0.05$; $d = 0.37$–0.48). However, statistically significant differences between the students with a moderate autonomous motivation profile toward PE (i.e., cluster 3 of the experimental group) and the control group students in clusters 2 and 3 were not found ($p > 0.05$). **Conclusions**: With the objective of increasing all students' cardiorespiratory fitness levels, PE teachers should encourage students' motivation toward PE applying specific motivational strategies during PE lessons.

Nowadays, cardiorespiratory fitness (CRF) is considered one of the most powerful health indicators among school-aged children (Tomkinson et al., 2019). Among schoolchildren, higher CRF levels are associated with better academic performance (Ruíz-Ariza, Grao-Cruces et al., 2017), quality of life (Evaristo et al., 2019), as well as with better mental health (Eddolls et al., 2018). Unfortunately, CRF has been declining during the last decades (Tomkinson et al., 2017), becoming a worldwide problem, which affects, on average, 33% of male and 46% of female schoolchildren (Tomkinson et al., 2016).

Therefore, health promotion policies should promote good CRF levels among school-age children in different contexts like sport programs or schools (Tomkinson et al., 2019; World Health Organization, 2014). Schools, and specifically the Physical Education subject (PE), play an important role in the promotion of good CRF levels among students (Association for PE, 2015). In many countries, educational curriculums require PE teachers to carry out physical fitness teaching units with the purpose of improving students' CRF levels (European Commission/EACEA/Eurydice, 2013; Hardman et al., 2014). To achieve this purpose, it is recommended that students are involved in moderate-to-vigorous physical activity (MVPA) for at least 50% of the PE lessons time (Association for PE, 2015).

Nevertheless, the limited curriculum time appointed during the scholar year or the heterogeneous level of students restrict the potential of the PE subject to improve students' CRF levels (European

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Commission/EACEA/Eurydice, 2013; Hardman et al., 2014). Additionally, students' motivation to actively participate in PE lessons could also affect the improvement process of students' CRF levels (Ntoumanis, 2001). Motivation is a psychological characteristic that encourages a person to act toward a desired objective; therefore, it is the psychological cause of any action (Ryan et al., 2009).

Self-Determination Theory (SDT, Deci & Ryan, 1985) is a motivational theory widely used to understand the antecedents and consequences of motivation toward PE (Ntoumanis, 2001). This theory adopts a multidimensional approach, distinguishing among reasons as to "why" individuals are encouraged to act. SDT suggests that human behavior can be characterized by three types of motivation: intrinsic motivation, extrinsic motivation, and amotivation (Ryan et al., 2009). Intrinsic motivation is related to the inherent pleasure and satisfaction provided by an activity. In contrast, extrinsic motivation, refers to the reasons why people take part in a certain activity such as obtaining tangible rewards, avoiding punishments, or attaining recognition/approval. SDT also identifies four types of extrinsic motivation which vary in degree of self-determination: integrated regulation, identified regulation, introjected regulation, and external regulation. Finally, amotivation is characterized by no intention of an individual to act due to different reasons such as lack of certain skills or knowledge necessary to act (Ryan et al., 2009). According to SDT, these types of motivation could be ordered in a *continuum* according to the extent to which motivation is self-determined (or autonomous): autonomous motivation (i.e., intrinsic motivation integrated and identified regulations), controlled motivation (i.e., introjected and external regulations) or amotivation (Deci & Ryan, 2000).

The relative autonomy index, also known as the self-determined index and whose validity has been well documented, is a widely used index to measure the different types of motivation (Vallerand & Ratelle, 2002). Nevertheless, this index has shown several issues when used as a measure of the continuum structure of motivation derived from SDT (Chemolli & Gagné, 2014). For example, because the relative autonomy index is a difference score, students with the same index score could have different motivational profiles that are likely to yield different patterns of behavior. Therefore, conclusions drawn from results obtained with the relative autonomy index could hide important information that may serve to make important decisions (Chemolli & Gagné, 2014).

Considering these arguments against the relative autonomy index, as an alternative motivational scoring method, Chemolli and Gagné (2014) encouraged researchers ideally to explore the person-centered motivational profiles through cluster analysis (e.g., Franco et al., 2019; Mayorga-Vega & Viciana, 2014). Similar to the relative autonomy index, cluster analysis also has its own disadvantages. For example, one of the most common is that there are no rigorous guidelines to aid in the selection of a solution (Pastor et al., 2007). Moreover, this procedure tends to produce clusters of equal sizes (Meyer et al., 2013). However, this method has an important number of advantages, both at the theorical and practical level (Vansteenkiste et al., 2009). From a theorical viewpoint, person-centered analysis may provide additional information for the internal validity of SDT. Whereas from a practical viewpoint, it allows for the comprehension of the different students' motivational profiles and the percentage of students characterized by each profile. Moreover, cluster assignment reflects a particular combination of SDT motivational dimensions, which is likely to give more practical information than separate motivational dimensions (Vansteenkiste et al., 2009).

Following SDT framework, previous literature shows a positive association between autonomous forms of motivation toward PE and students' physical activity (PA) levels during PE lessons (Owen et al., 2014; Viciana et al., 2019). Similarly to the present study, Mayorga-Vega et al. (2020) examined the influence of students' baseline self-determined motivation toward PE on their CRF improvement after a fitness teaching unit. The aforementioned authors found that only students with moderate-to-high self-determined motivation toward PE improved their CRF levels after the fitness teaching unit. However, these authors used the relative autonomy index to create a score of students' self-determined motivation toward PE, despite the several above-mentioned problems derived from the measurement of this index (Chemolli & Gagné, 2014). Additionally, Mayorga-Vega et al. (2020) identified the different students motivational profiles and divided them by a statistical criterion (percentiles) based on the relative autonomy index score obtained, instead of identifying the profiles by combining the different motivational dimensions proposed by SDT. Unfortunately, to our knowledge, there are no previous studies analyzing the role of baseline self-determined motivation toward PE on the improvement of students' CRF levels according to their motivational profiles toward PE, through a person-centered approach by cluster analyses. The present study expands this area of research and complements previous literature by investigating how students' CRF improvements during PE lessons could be affected by their baseline self-determined motivation toward PE profiles based on SDT and identified by cluster analysis. This knowledge may guide PE teachers in their intervention during lessons making them aware of the importance of the motivation fostered in their lessons. Consequently, the aim of the present study was to compare the effect that a PE-based fitness teaching unit has on improving CRF levels of high school students with different motivational profiles toward PE using a cluster analysis.

1. Method

1.1. Study design

The present study is reported according to the current CONSORT guidelines for cluster randomized trials (Campbell et al., 2012). The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013). The Ethical Committee for human studies of the University of Granada approved the present study protocol. Due to human and material resource restrictions, data were collected in two waves in the same part of the year, one year apart. Recruitment of participants was carried out in June of 2016 (wave 1) and 2017 (wave 2), and the intervention was done from September to December of 2016 (wave 1) and 2017 (wave 2). In both waves, the length of the intervention was nine weeks, and the data was collected in September one week prior to the beginning of the intervention (baseline) and in December one week after the intervention (follow-up). Figure 1 shows the general scheme of the intervention followed in the two waves. For practical reasons and because of the nature of the present study (i.e., established classes from an educational setting) a cluster-randomized controlled trial was used (i.e., randomization was per classes not per individuals) (Mayorga-Vega et al., 2016; Viciana et al., 2017). This study was non-blinded (treatments were not masked from the students or teachers), and parallel-grouped (study with two different treatments; Spieth et al., 2016), with two evaluation phases. The only knowledge that students from both study groups had was that they were going to participate in a study, and because of the objective of the study some classes started the academic year working one PE content and other classes another PE content. However, none of the participants, regardless of the study group to which they belonged, were informed of the specific objective of the study in order to prevent subject-expectancy effects on study outcomes. Then, in the statistical analysis (and not during the intervention) students from the experimental group (EG) were also divided into four profiles according to their baseline self-determined motivation toward PE (i.e., conditions of the independent variable not manipulated; *ex post facto* design).

1.2. Participants

Firstly, the principal and the PE teachers of two state high schools of the province of Ciudad-Real (Castilla-La Mancha Region, Spain) chosen

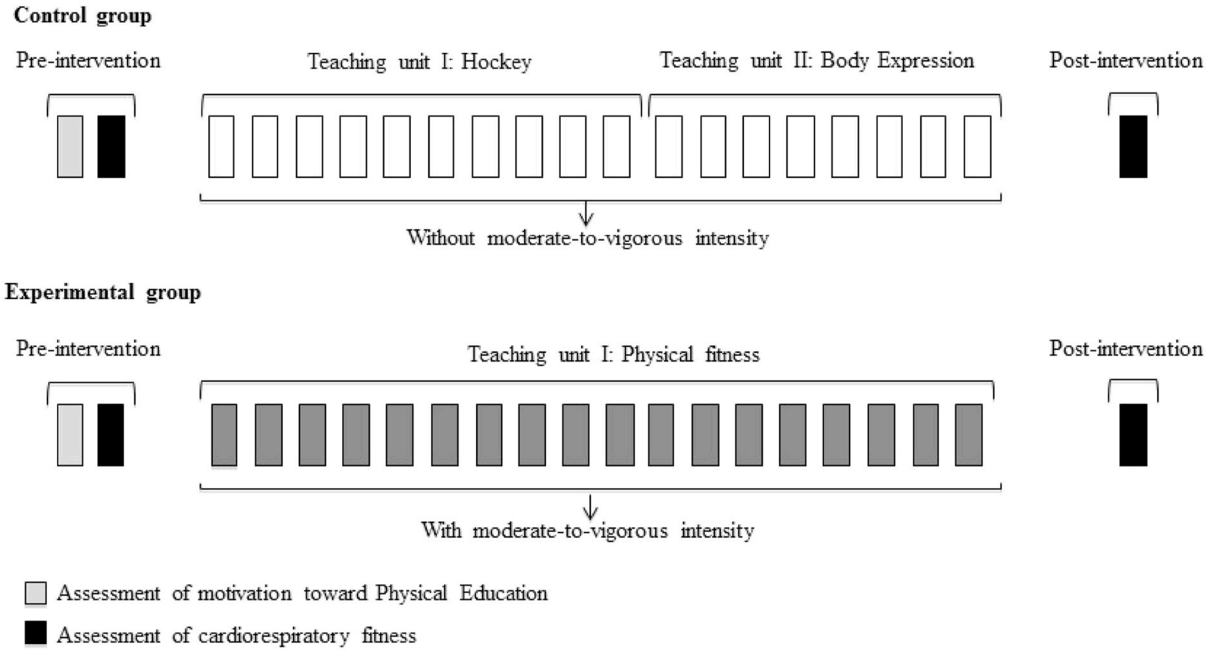

Figure 1. General scheme of the intervention.

by convenience were contacted. They were informed about the project and the permission to conduct the study was requested. After the approval of the schools was obtained, all the students and their legal guardians were fully informed about the features of the present project. One hundred and eighty-one high school students, 86 males and 95 females, from the seventh to ninth grades (i.e., 11–15 years old), were invited to participate in the present study. According to the center's reports, all the students' families had a middle socioeconomic level. The inclusion criteria were: a) participating in the normal PE classes; b) being free of any health disorder such as heart diseases, uncontrolled asthma, bone/joint problems or other reasons as to why students should not undergo PA, c) presenting the corresponding signed written consent by their parents or legal guardians; and d) presenting the corresponding signed written assent by the students. The only exclusion criterion for the cluster analysis was not having completed correctly the motivation toward PE questionnaire; while for the analysis of the main objective, the exclusion criteria were: (a) not having an attendance rate equal or over 85% for PE classes during the intervention period, and (b) not having correctly performed the CRF test in each measured moment (i.e., pre-intervention and post-intervention).

1.3. Sample size

A priori sample size calculation was estimated with the Optimal Design Plus Empirical Evidence Software Version 3.01 for Windows. Parameters were set as follows: significance level $\alpha = 0.05$, number of participants per cluster $n = 20$, effect size $\delta = 0.60$, intra-class correlation coefficient $\rho = 0.001$, and statistical power $(1 - \beta) = 0.80$. A minimum final sample size of 180 (9 clusters) was estimated. Although there is not a specific calculation for cluster analysis, the recommended minimum sample size equal of 2^k was also taken into account (Dolnicar, 2002).

1.4. Randomization

Randomization was conducted at the class-level using a computerized random number generator. Due to the fact that a higher dropout in the EG was expected because of the treatment applied (Rutterford et al., 2015), a 2:1 ratio was followed. Before the pre-intervention evaluation was administered, the nine established classes of the selected school centers (three 7th, four 8th, and two 9th grade classes) were randomly assigned by an independent researcher, blinded to the study objectives to form one of the following study groups: EG (six classes, two seventh-three eight-, and one ninth-grade) or control group (CG, three classes, one seventh-one eight- and one ninth-grade).

1.5. Intervention

The EG students performed a physical fitness-based teaching unit during the PE lessons twice a week for nine weeks. Because of meteorological problems, in the end the EG students completed a total of 16 lessons. The lessons were designed and delivered by the PE teachers (15 years of experience) of the participating high schools with the supervision of the main researcher. The duration of each PE lesson was 50 min approximately and consisted of the following: a 5-to-10-min warm-up (performing low-to-moderate aerobic activities followed by some joint mobility and stretching exercises); a main part of 35-to-40-min (performing traditional fitness lessons such as skipping rope, running games, interval training, fartlek or circuit training, finishing with team games); and a 5-min cool-down (performing stretching exercises). For example, in the skipping rope lesson students carried out five series of three minutes each skipping rope with one minute rests between series, followed by the colpbol game during 15 min. During the main parts of the lessons, the PE teachers placed special emphasis on reaching a moderate-to-vigorous PA intensity. To control the intensity, five students of each class wore a heart rate monitor (Polar® RS300X, Finland), shifting those five students in each of the following classes.

Regarding the CG students, they also carried out two PE lessons a week during the intervention period, with a similar structure to the EG (i.e., 5-to-10-min warm-up, 35-to-40-min main part, and 5-min cool-down). The warm-up and cool-down phases were identical to the EG. However, the content (hockey and body expression) and methodology followed during the main part of the lessons were different (mostly based on technique-learning practices and recreation without any special focus on PA intensity). For example, during the hockey lessons, CG students had to learn technique aspects like driving, passing, or shooting the ball with the stick, and during the body expression lessons, students had to make an acrosport choreography with the figures that they had previously learned.

1.6. Measures

Data collection was carried out during the PE lesson time by the same tester, instruments, and protocols. Prior to carrying out the intervention, students' gender and age information were obtained from school reports. Additionally, the students' anthropometric measures were taken. Then, the students filled out the motivation toward PE questionnaire in an ordinary classroom under silent conditions. Students were asked for their maximum sincerity, and they were guaranteed the confidentiality of the obtained data. Although instructions on how to correctly respond to the questionnaire were printed at the top, the researcher was present during the whole evaluation session to clarify any question that might arise. The CRF evaluation was carried out during a PE lesson right before (pre-intervention) and right after (post-intervention) the fitness teaching unit. The CRF measurements were taken in an indoor sports facility with a non-slippery floor, on the same day of the week and at the same time for each student. Prior to the evaluation, the participants completed a standardized warm-up consisting of five minutes of running from low-to-moderate intensity followed by some joint mobility exercises.

Anthropometric. Participants' body mass and height were measured in shorts, T-shirts, and barefoot. For the body mass measure, the student stood in the center of the scale (Seca, Ltd., Hamburg, Germany; accuracy = 0.1 kg) without support and with the weight distributed evenly on both feet. For the body height assessment, participants stood with their feet together with the heels, buttocks, and upper part of the back touching the stadiometer (Holtain Ltd., Crymmych, Pembs, United Kingdom; accuracy = 0.1 cm), and with the head placed in the Frankfort plane. Two measurements of both body mass and height were performed and the average of each was calculated (Stewart et al., 2011). Then, the body mass index was calculated as body mass divided by body height squared (kg/m^2). Finally, students' body weight status was categorized by the body mass index cut-points as overweight/obese (i.e., gender- and age-adjusted cut-point values equal to or higher than the equivalent value of 25 kg/m^2 at the age of 18 years) or non-overweight/obese (i.e., lower than the above-mentioned cut-point values) (Cole et al., 2000). Body mass index has shown high validity for assessing body composition among high school students (Castro-Piñero et al., 2010).

Motivation toward Physical Education. Participants' self-determined motivation toward PE was measured by the Spanish version of the *Perceived Locus of Causality-II Scale* (PLOC-II) (Ferriz et al., 2015). This questionnaire was preceded by the statement "I participate in PE lessons …" and is comprised of a total of 24 items spread over six dimensions (four items each) that measure intrinsic motivation (e.g., "Because PE is fun"), integrated regulation (e.g., "Because it is consistent with life goals"), identified regulation (e.g., "Because I want to improve in sport"), introjected regulation (e.g., "Because I want the teacher to think I am a good student"), external regulation (e.g., "Because that is the norm"), and amotivation (e.g., "But I do not really know why"). To adapt the scale of the questionnaire to the Spanish students' school grades a 10-point Likert scale ranging from 1 ("Totally disagree") to 10 ("Totally agree") was used according to previous studies (e.g.,Viciana et al., 2017). The Spanish version of the PLOC-II has shown adequate psychometric properties among high school students (CFI = 0.92; TLI = 0.91; IFI = 0.92; SRMR = 0.065 RMSEA = 0.065; Cronbach's alpha = 0.69–0.93) (Ferriz et al., 2015).

Cardiorespiratory fitness. The 20-m shuttle run test was used to assess CRF (Léger et al., 1988). Participants ran between two parallel lines placed 20 m apart, in a progressive rhythm marked by a recorded beep until they were not able to reach the line two consecutive times. During the test, each participant wore a heart rate monitor (Polar® RS300X, Finland). In order to ensure the test maximality, only the scores of participants who reached a heart rate value equal to or higher than 90% of their estimated maximum heart rate (Mahar et al., 2018) were used. The maximum heart rate was estimated by the following equation: 209–0.7 x age (in years) (Shargarl et al., 2015). The total number of completed laps (n) and time (in seconds) were retained. Then, the maximal oxygen uptake (in ml/kg/min) was indirectly measured using the following equation: 31.025 + 3.238 x speed - 3.248 x age + 0.1536 x speed x age (speed expressed in km/h and age in the lower rounded integer) (Léger et al., 1988). Finally, the absolute (post-intervention – pre-intervention) and relative [((post-intervention – pre-intervention) x 100)/pre-intervention] change scores of the maximal oxygen uptake, and total time-based performance were calculated. The 20-m shuttle run test has demonstrated adequate reliability and criterion-related validity among high school students (e.g., ICC = 0.89; r_p = 0.78) (Léger et al., 1988; Mayorga-Vega et al., 2015; Tomkinson et al., 2019).

1.7. Statistical analysis

Descriptive statistics (mean ± standard deviation/standard error or percentage) for the study variables were calculated. Firstly, statistical tests assumptions were checked and met. Then, as the exploratory analyses, the one-way analysis of variance (ANOVA) (continuous variables) and chi-squared test (for categorical variables) were conducted to examine potential differences between the EG and CG participants in all the measured general characteristics variables. Additionally, internal consistency of the motivation toward PE dimensions was examined with Cronbach's alpha. Alpha values < 0.40 were considered poor, 0.40–0.59 fair, 0.60–0.74 good, and 0.75–1.00 excellent (Hernaez, 2015).

Afterward, to identify students' motivational profiles toward PE, two-stage cluster analyses were carried out. The total sample (i.e., all the students that met satisfactorily all the inclusion criteria and the exclusion criterion a, N = 181) was randomly split into two similar subsamples (approximately 50% of the total sample). Firstly, as an exploratory analysis to identify the motivational profiles toward PE in the first subsample, a hierarchical cluster analysis was conducted. The Ward's method with the similarity measure squared Euclidean distance was used. The number of clusters was explored by the dendrogram. Secondly, as a confirmatory analysis to verify the motivational profiles toward PE in the second subsample, a K-means cluster analysis with the number of clusters identified in the exploratory analysis was conducted. Finally, a K-means cluster analysis with the EG and CG participants that met satisfactorily all the exclusion criteria (i.e., n = 108 and 57, respectively) was conducted (Hair et al., 2018).

Because the unit of intervention was the class, in order to examine the main study purpose of comparing the effects of the PE-based fitness teaching unit on students' CRF levels according to their baseline motivational profiles toward PE, a Multilevel Linear Model with participants nested within classes was selected (Li et al., 2017). According to Field's (2017) recommendation, the approach was to start from "basic" models in which all the parameters were fixed and then progressively random coefficients and exploring confounding variables were followed. The maximum likelihood estimation method was used. The −2 log-likelihood was used to compare the model's fit (i.e., comparing the change in the chi-square test). From all the potential confounding variables explored (i.e., gender, age, grade, body mass, body height, body mass index, baseline CRF, and intervention attendance), only their respective CRF baselines had to be used as a covariable for both relative CRF variables. The *post-hoc* pairwise comparison with the Bonferroni adjustment was carried out. Effect sizes were estimated using the Cohen's d for pairwise comparisons. Because clusters 1 and 4 from the CG had low sample sizes (i.e., n = 3 and 7, respectively), Multilevel Linear Model analyses were carried out without those clusters. Finally, although a per-protocol approach was followed in the present study, as sensitivity analyses, all the above-mentioned analyses were also carried out with an intention-to-treat approach (i.e., including all the participants, regardless of adherence to the protocol). The results from the intention-to-treat analysis can be consulted in the Supplementary File 1.

However, since implementation of the missing data requires strong assumptions that are hard to justify, "complete case" analyses including only those whose outcomes were known were used (i.e., excluding the participants that did not satisfactorily meet the exclusion criterion "b") (Streiner, 2008). Missing data was very low (5.5%). All statistical analyses were performed using the SPSS version 25.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

2. Results

2.1. Final sample and general characteristics

Figure 2 shows the flow chart corresponding to the participants included in the present study for the main objective. Out of the 181 students who agreed to participate and met the inclusion criteria, all 181 (86 males and 95 females) satisfactorily passed the exclusion criterion for the preliminary cluster analysis, and 165 students (79 males and 86 females) satisfactorily passed the exclusion criteria "a" and "b" for the analysis of the main objective of the study. Six participants (2 males and 4 females) did not pass the exclusion criteria "a"; and 10 additional

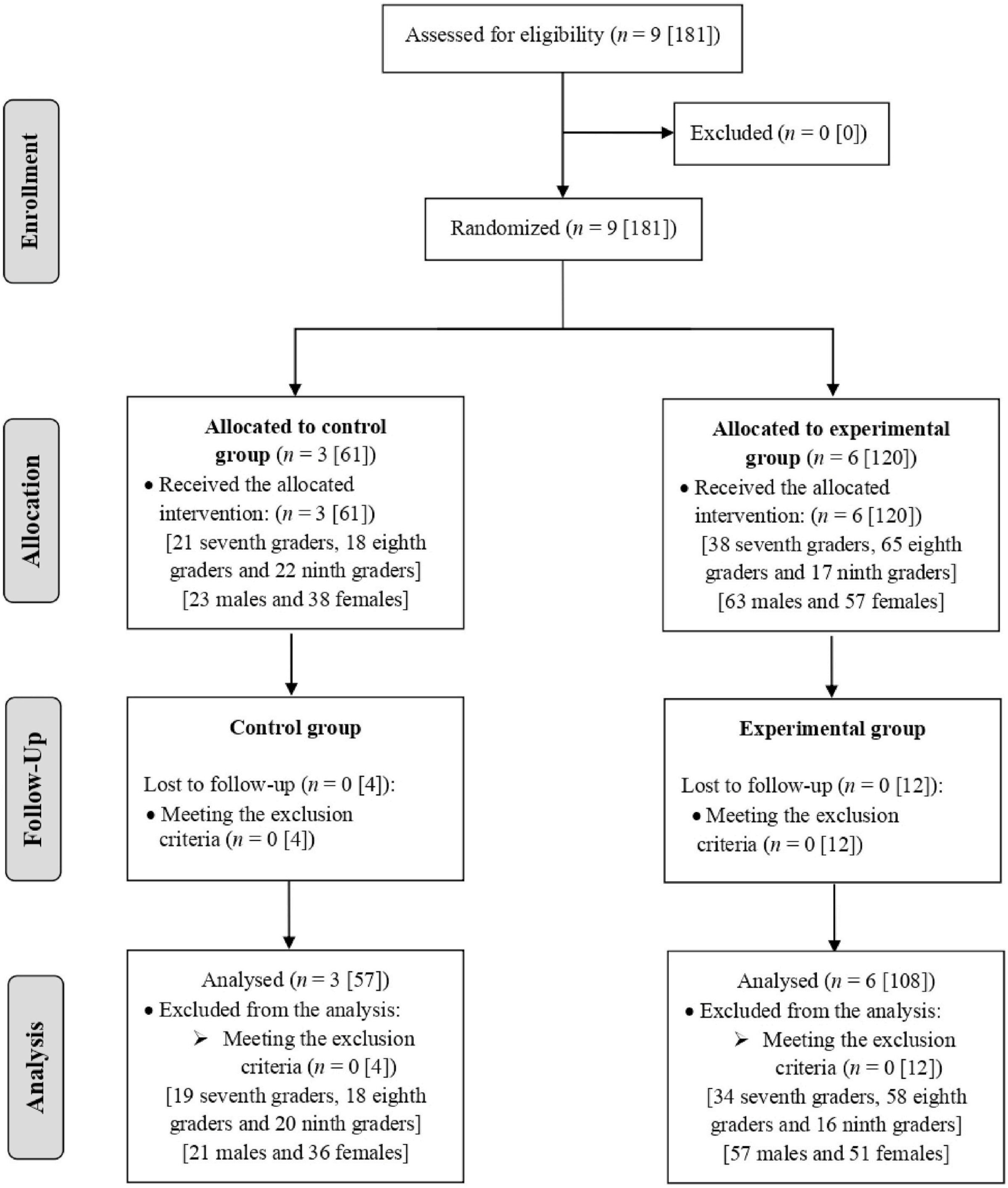

Figure 2. Flow chart of the school classes and students of the present study. All numbers are school classes [students].

participants (6 males and 4 females) did not pass the exclusion criteria "b" or both "a" and "b". No participants were lost because of the rejection to continue in the study or change of the school. Table 1 shows the general characteristics of the included participants in each sample. The EG and CG did not have statistically significant differences in the ratio of females/males ($p = 0.083$) and non-overweight and overweight/obese students ($p = 0.196$). Additionally, there were no statistically significant differences in terms of age ($p = 0.296$), body mass ($p = 0.125$), body height ($p = 0.227$), body mass index ($p = 0.239$), or motivation toward PE (intrinsic motivation, $p = 0.516$; integrated regulation, $p = 0.369$; identified regulation, $p = 0.511$; introjected regulation, $p = 0.480$; external motivation, $p = 0.087$; amotivation, $p = 0.406$) between the two groups. However, it should be pointed out that the comparisons of the ratio of females/males and external regulation between the EG and CG have a tendency to be different in a statistically significant manner. The same outcomes were found for the intention-to-treat sample (i.e., $n = 171$). The included EG participants obtained an average attendance in the physical fitness teaching unit of 95.8% (cluster 1 = 94.1%; cluster 2 = 96.7%; cluster 3 = 96.4%; cluster 4 = 95.2%). The internal consistency of the motivation toward PE dimensions was good to excellent (Cronbach's alpha: intrinsic motivation = 0.79; integrated regulation = 0.86; identified regulation = 0.76; introjected regulation = 0.70; external regulation = 0.68; amotivation = 0.68).

2.2. Motivational profiles toward Physical Education

The hierarchical cluster analysis carried out with the first subsample ($n = 88$) identified the following four motivational profiles toward PE: cluster 1, $n = 37$, 42.0%; cluster 2, $n = 14$, 15.9%; cluster 3, $n = 20$, 22.7%; cluster 4, $n = 17$, 19.3%. Secondly, the K-means cluster analysis using the second subsample ($n = 93$) confirmed the four-cluster structure: cluster 1, $n = 18$, 19.4%; cluster 2, $n = 38$, 40.9%; cluster 3, $n = 17$, 18.3%; cluster 4, $n = 20$, 21.5%. Finally, the K-means cluster analysis with the EG participants that met satisfactorily all the exclusion criteria ($n = 108$) also identified the same four clusters.

Figure 3 shows the motivational profiles toward PE for the included EG and CG students. Regarding the EG, cluster 1 was labeled as "High autonomous, moderate controlled, and a motivational profile toward PE" ($n = 18$, 16.7%) and included students with a high autonomous motivation (i.e., intrinsic motivation, integrated regulation, and identified regulation), and moderate controlled motivation (i.e., introjected and external regulations) and amotivation. Cluster 2 was labeled as "Moderate self-determined motivational profile toward PE" ($n = 45$, 41.7%) and included students with a high autonomous motivation, moderate controlled motivation, and low amotivation. Cluster 3 was labeled as "Moderate motivational profile toward PE" ($n = 14$, 13.0%) and included students with a moderate autonomous motivation, controlled motivation, and amotivation. Cluster 4 was labeled as "High self-determined motivational profile toward PE" ($n = 31$, 28.7%) and included students with a high autonomous motivation, and low controlled motivation and amotivation.

As regards the CG participants, cluster 1 was labeled as "Non self-determined motivational profile toward PE" ($n = 3$, 5.3%) and included students with a moderate autonomous motivation, and high controlled motivation and amotivation. Cluster 2 was labeled as "Moderate self-determined motivational profile toward PE" ($n = 33$, 57.9%) (i.e., the same as cluster 2 from the EG). Cluster 3 was labeled as "High self-determined motivational profile toward PE" ($n = 14$, 24.6%) (i.e., the same as cluster 4 from the EG). Cluster 4 was labeled as "Moderate motivational profile toward PE" ($n = 7$, 12.3%) (i.e., similar to cluster 3 from the EG). Finally, regarding the popularity and patterns of the emerged profiles with the intention-to-treat sample (i.e., $n = 171$), while the EG obtained a very similar popularity and patterns (i.e., percentage was 15.8, 41.2, 14.0 and 28.9, respectively), the CG clusters did not change at all.

2.3. Effect of the physical fitness teaching unit by students' motivational profiles toward Physical Education

Figure 4 shows the comparison of the effect of the PE-based physical fitness teaching unit on CRF levels between the six groups (maximal oxygen uptake was indirectly measured). The results of the Multilevel Linear Model showed overall statistically significant differences [maximal oxygen uptake (ml/kg/min): 2LL = 741.057; AIC = 755.057; $F = 4.538$; $p = 0.001$; maximal oxygen uptake (%): 2LL = 996.975; AIC = 1012.975; $F = 5.9084$; $p < 0.001$; total time-based performance (s): 2LL = 1671.547; AIC = 1685.547; $F = 5.729$; $p < 0.001$; total time-based performance (%): 2LL = 1370.633; AIC = 1386.633; $F = 8.2235$; $p < 0.001$]. Subsequently, *post-hoc* analyses showed that the EG students in clusters 2 and 4 (i.e., those with a self-determined motivational profile toward PE) statistically significantly improved their CRF levels compared with the CG students within cluster 2 (i.e., those with a moderate self-determined motivational profile toward PE) [maximal oxygen uptake (ml/kg/min): $p = 0.002$ and 0.032, $d = 0.44$ and 0.38; maximal oxygen uptake (%): $p < 0.001$ and $p = 0.007$, $d = 0.48$ and

Table 1
General characteristics of the included participants.

	Whole sample	Total	Experimental	Control	ANOVA/Chi-squared test[a]	
	($N = 181$)	($n = 165$)	($n = 108$)	($n = 57$)	F/χ^2	p
Age (years)	12.9 (0.9)	12.9 (0.9)	12.8 (0.9)	13.0 (1.0)	1.100	0.296
Gender (females/males)	52.5/47.5	52.1/47.9	47.2/52.8	61.4/38.6	3.007	0.083
Body mass (kg)	51.4 (10.6)	50.9 (10.3)	50.0 (10.7)	52.6 (9.5)	2.384	0.125
Body height (cm)	154.4 (9.8)	154.2 (9.9)	153.6 (9.6)	155.5 (10.3)	1.473	0.227
Body mass index (kg/m^2)	21.5 (3.8)	21.4 (3.6)	21.1 (3.5)	21.8 (3.8)	1.396	0.239
Overweight/obese (no/yes)	65.7/34.3	67.9/32.1	71.3/28.7	61.4/38.6	1.675	0.196
Intrinsic motivation (1-10)	7.9 (1.5)	7.9 (1.5)	8.0 (1.4)	7.8 (1.8)	0.425	0.516
Integrated regulation (1-10)	7.3 (1.8)	7.4 (1.8)	7.4 (1.8)	7.2 (1.9)	0.811	0.369
Identified regulation (1-10)	7.9 (1.6)	8.0 (1.5)	8.0 (1.5)	7.9 (1.6)	0.434	0.511
Introjected regulation (1-10)	5.8 (2.2)	5.9 (2.1)	5.8 (2.1)	6.1 (2.1)	0.501	0.480
External motivation (1-10)	5.1 (2.1)	5.2 (2.1)	5.0 (2.0)	5.6 (2.1)	2.960	0.087
Amotivation (1-10)	2.8 (1.8)	2.8 (1.8)	2.7 (1.7)	3.0 (2.0)	0.695	0.406
Maximal oxygen uptake (ml/kg/min)[b]	42.4 (5.5)	42.4 (5.5)	43.7 (5.2)	40.1 (5.3)	17.159	<0.001
Total time-based performance (s)	289.8 (122.8)	290.8 (121.9)	314.3 (120.4)	246.3 (112.9)	12.430	0.001

Note. Data are reported as mean (standard deviation) for all variables, except for gender and overweight/obese variables, which are reported as percentage.
[a] Comparison between the experimental and control groups with the one-way analysis of variance (ANOVA) for all variables, except for gender and overweight/obese variables where the chi-squared test was used instead.
[b] Maximal oxygen uptake was indirectly measured through the Léger et al. (1988) equation (31.025 + 3.238 x speed - 3.248 x age + 0.1536 x speed x age (speed expressed in km/h and age in the lower rounded integer)).

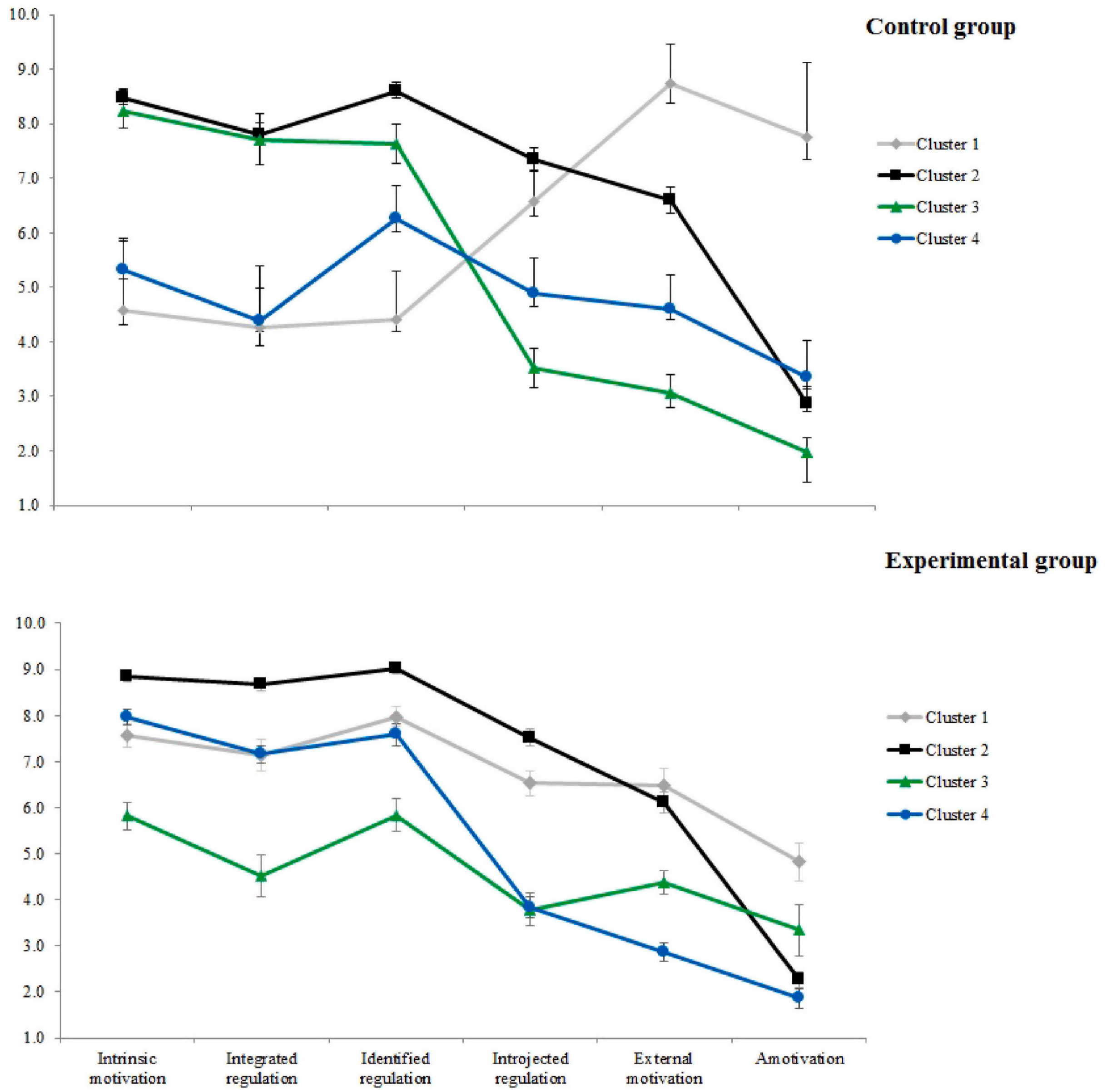

Figure 3. Motivational profiles toward Physical Education (Experimental group: cluster 1, $n = 18$; cluster 2, $n = 45$; cluster 3, $n = 14$; cluster 4, $n = 31$; Control group: cluster 1, $n = 3$; cluster 2, $n = 33$; cluster 3, $n = 14$; cluster 4, $n = 7$). Values are reported as means and error bars as standard error.

0.42; total time-based performance (s): $p < 0.001$ and $p = 0.003$, $d =$ 0.43 and 0.42; total time-based performance (%): $p < 0.001$ and $p =$ 0.001, $d = 0.53$ and 0.50]. Additionally, the EG students in cluster 1 improved their CRF levels in comparison with the CG students in cluster 2, as did the EG cluster 2 students in comparison with the CG cluster 3 [maximal oxygen uptake (%): $p = 0.034$ and 0.006, $d = 0.43$ and 0.53; total time-based performance (s): $p = 0.018$ and 0.045, $d = 0.42$ and 0.40; total time-based performance (%): $p = 0.004$ and $p < 0.001$, $d =$ 0.52 and 0.66] (except for the absolute variable of maximal oxygen uptake). Moreover, the EG students in cluster 4 improved their relative maximal oxygen uptake and time-based performance compared with the CG students in cluster 3 [maximal oxygen uptake (%): $p = 0.038$, $d =$ 0.47; total time-based performance (%): $p = 0.004$, $d = 0.63$]. Finally, for the relative time-based performance the EG students in cluster 1 improved compared to the CG students in cluster 3 [total time-based performance (%): $p = 0.003$, $d = 0.65$]. However, statistically significant differences between the EG students in cluster 3 (i.e., those with a lower motivational profile toward PE) and CG students in clusters 2 and 3 were not found (all $p > 0.05$). Additionally, statistically significant differences between the four clusters of the EG were not found (all $p >$ 0.05). The sensitivity analyses (i.e., intention-to-treat approach; Supplementary File 1) found the same outcomes as the main analyses (i.e., per-protocol approach), except that for the *post-hoc* analyses statistically significant differences between the EG students in cluster 2 and CG students in cluster 3 were not found ($p = 0.063$ vs. $p = 0.045$), and statistically significant differences between the EG students in cluster 3 and CG students in cluster 3 were found ($p = 0.037$ vs. $p = 0.141$).

3. Discussion

The aim of the present study was to compare the effect that a PE-based fitness teaching unit has on improving CRF levels of high school students with different motivational profiles toward PE using a cluster analysis. Results of the present study showed how only students with a high baseline of self-determined motivation toward PE improved their CRF levels. However, the intervention did not improve the CRF levels of students with a moderate baseline of self-determined motivation toward PE. To our knowledge, only Mayorga-Vega et al. (2020) had previously

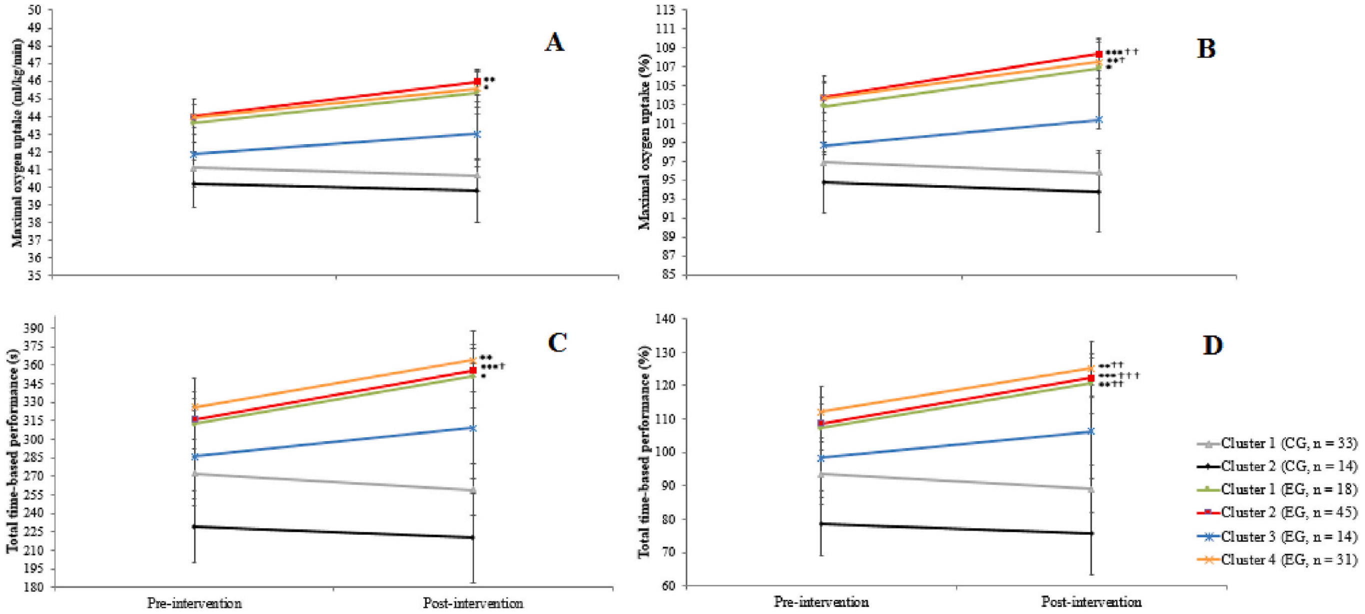

Figure 4. Comparison of the effect of the Physical Education-based physical fitness teaching unit on maximal oxygen uptake (ml/kg/min, A; %, B) indirectly measured through the Léger et al. (1988) equation (31.025 + 3.238 x speed - 3.248 x age + 0.1536 x speed x age (speed expressed in km/h and age in the lower rounded integer)) and total time-based performance levels (s, C; %, D) between the six groups. CG = Control group; EG = Experimental group. Lines represent the pre-intervention and post-intervention means and error bars represent the standard error. Results of the Multilevel Linear Model (all $p \leq 0.001$) followed by the pairwise comparisons with the Bonferroni adjustment compared with the control group students (cluster 2: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; cluster 3: †$p < 0.05$; ††$p < 0.01$; †††$p < 0.001$).

examined the influence of baseline self-determined motivation toward PE on the effectiveness of a physical fitness teaching unit (twice a week for 22 weeks) to improve students' CRF levels. Similar to the present study, these authors found that only students with moderate-to-high baseline of self-determined motivation toward PE improved their CRF levels. However, Mayorga-Vega et al. (2020) identified the students' self-determined motivation toward PE profiles dividing the sample by tertiles according to the relative autonomy index scores. According to Chemolli and Gagné (2014), the relative autonomy index has shown to have several issues when used as a measure of the continuum structure of motivation derived from SDT. For example, since the relative autonomy index is a difference score, students with the same index score could have different self-determined motivational profiles toward PE that are likely to yield different patterns of PA levels during PE lessons. Therefore, classifying the students' self-determined motivational profiles toward PE by tertiles (low, moderate, and high) based on their score in the relative autonomy index seems not to be suitable because of the above-mentioned reasons. In this sense, the cluster-analysis with separate dimensions used in the present study as a motivational scoring method provides us more useful information about the different students' self-determined motivational profiles toward PE.

Regarding the magnitude of the effects, the teaching unit showed a moderate effect on CRF ($d = 0.41$) for students with a high baseline of self-determined motivation toward PE. However, the magnitude of the effect was low ($d = 0.29$) for students with a moderate baseline of self-determined motivation toward PE. Similarly, Mayorga-Vega et al. (2020) found a moderate effect on the students with a profile of higher baseline self-determined motivation toward PE ($g = 0.42$) and a low effect for those with a profile of lower self-determined motivation toward PE ($g = 0.08$). Therefore, the results of the present study suggest that a PE-based physical fitness teaching unit is effective for those students with a high baseline of self-determined motivation toward PE. However, it should be acknowledged that in the present study, similarly to previous studies carried out in the PE context (Mayorga-Vega et al., 2016; Mayorga-Vega et al., 2020), the necessity of sophisticated and costly instrumentation, qualified technicians, and time constraints due to the characteristics of the setting in which the study was performed (i.e., large groups of students), the CRF levels had to be indirectly measured and maximum oxygen uptake had to be estimated through a validated equation. However, these methods have shown to be valid and reliable for the population who participated in the present study (Léger et al., 1988; Mayorga-Vega et al., 2015; Tomkinson et al., 2019).

Previous literature shows that, among school-age children better CRF levels have been positively associated with better PA levels (Poitras et al., 2016). In addition, preceding studies shows that autonomous forms of motivation toward PE are positively associated ($r_p = 0.25$, 0.19–0.31) with students' PA levels during PE lessons (Owen et al., 2014; Viciana et al., 2019). Lonsdale et al. (2009) and Mayorga-Vega and Viciana (2014), following a cross-sectional design, compared students' objective PA levels during PE lessons by their self-determined motivation profiles toward PE. These authors also found that students with a higher self-determined motivation profile toward PE were more active during PE lessons than those with a lower self-determined motivation profile toward PE. On the other hand, the research of González-Cutre et al. (2016), based in SDT, examined the effect of a fitness teaching unit during PE lessons as well as an extracurricular program on students' daily self-reported PA levels. These authors found that the intervention improved students' daily PA levels, as well as some motivational aspects such as perceived autonomy support or the satisfaction of basic psychological needs. However, González-Cutre et al. (2016) were focused on the effect of the intervention on PA levels throughout the whole day instead of on PA levels during PE lessons. Moreover, this study was centered on the promotion of self-determined motivation toward PE among other motivational aspects instead of examining the effect of baseline levels. Regrettably, in the present study only five students' PA were measured every two PE lessons to have a feedback of the intensity of the lessons. Because of practical reasons (i.e., not spending too much PE lessons' time putting and removing heart rate monitors), every student's PA could not be measured during each PE lesson. Therefore, the influence of baseline self-determined motivation toward PE on student's PA levels during PE lessons could not be studied.

PE teachers are required to apply physical fitness teaching units to improve their students' CRF levels. However, the effectiveness of these teaching units might be affected by students' motivation toward PE. Therefore, to achieve better results with the application of a physical fitness teaching unit, previously PE teachers should apply different motivational strategies to encourage students' motivation for actively participating during PE lessons (González-Cutre, 2017). For example, PE teachers could apply the following motivational strategies: a) Designing and teaching the lessons based on the principles of the task-involving motivational climate of the TARGET-model (Cecchini et al., 2019), b) using a Teaching Games for Understanding or Sport Education approach during PE lessons (Gil-Arias et al., 2017), c) satisfying students' basic psychological needs such as, giving them the opportunity to choose the activities, taking into account their feedback about PE lessons, empathizing with their perspective, supporting cooperation or establishing peer-learning groups (Bechter et al., 2019), or d) using autonomy-supportive techniques such as, acknowledging the students' feelings and perspectives on the activity, providing a meaningful rationale expressing the importance of partaking in that activity (e.g., health benefits), or using language that conveys choice, rather than control (e.g., "you may want to", as opposed to "you have to") (Ntoumanis & Standage, 2009; Vasconcellos et al., 2019).

The main strength of the present study was that, to our knowledge, it is the first that compares the effect of baseline self-determined motivation toward PE on the effectiveness of a fitness teaching unit through different motivational profiles following a SDT-based person-centered approach. Unlike dividing the sample by tertiles according to the relative autonomy index scores like in the study of Mayorga-Vega et al. (2020), the identification of students' self-determined motivation toward PE profiles by using cluster analysis with each dimension separately has demonstrated to yield a large number of advantages (see Vansteenkiste et al., 2009). Additionally, because of the nature of the context (i.e., school) and with the objective of keeping the ecological validity, the use of a cluster-randomized controlled trial design was more appropriate for the present research purpose (Campbell et al., 2012). However, the present study also has some limitations that should be acknowledged. Firstly, the non-probabilistic and relatively small sample size provides a lower generalization power. This limits the generalizability of the obtained outcomes to the particular studied population and context. However, due to human and material resource restrictions (i.e., data collection had to be done in two waves), a probabilistic and larger sample could not be examined. Secondly, the randomization procedure followed an imbalanced ratio 2:1. Although an imbalanced ratio could represent a limitation, due to the fact that a higher dropout in the EG was expected because of the treatment applied (Rutterford et al., 2015) this initial allocation ratio seemed more appropriate for the research purpose. Regarding the abovementioned feasibility issues, due to the relatively low number of participants for the cluster analyses, males and females had to be analyzed together. However, during the statistical analysis it was checked that gender did not have to be used as a covariable. Finally, regarding the research design used with the second independent variable (i.e., *ex-post-facto*), the outcomes of the present study should be interpreted with caution as this design does not allow for causal relationships (Thomas & Nelson, 2007). Future studies should include a probabilistic and larger sample, which provide a higher generalization of the obtained outcomes. Additionally, it would be interesting to reproduce the present study with the monitorization of all students' PA levels during all PE lessons. This could provide us the opportunity of examining the relationship among the baseline level of self-determined motivation toward PE, PA levels during PE lessons, and CRF improvement. Moreover, it would also be interesting reproducing this study and measuring students' motivation after the intervention to check the effect of the intervention on it.

In conclusion, as far as we know, the present study is the first that compares the effect of a fitness teaching unit on students' CRF levels by their baseline of self-determined motivation toward PE profiles following a SDT-based and person-centered approach. Results of the present study suggest that after a PE-based fitness teaching unit, only students with a high baseline of self-determined motivation toward PE improve their CRF levels. However, the intervention was not effective in students with a moderate baseline of self-determined motivation toward PE profile. These findings point out the importance that, with the objective of increasing all students' CRF levels, PE teachers should encourage students' motivation toward PE when they carry out a fitness teaching unit. From an applied perspective the knowledge of the motivational profiles that have emerged in this study, what motivational dimensions compose each profile, and how each of them has improved or not CRF after a fitness intervention, could help PE teachers to plan and apply specific strategies during PE lessons to foster a more self-determined motivation toward PE in those students that do not have this motivational profile. For example, giving them the opportunity to choose the activities, taking into account their interests and feedback about PE lessons, setting goals in the short term, or recognizing their individual progress (González-Cutre, 2017).

CRediT authorship contribution statement

Santiago Guijarro-Romero: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing - original draft, Writing - review & editing. **Daniel Mayorga-Vega:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Visualization, Writing - original draft, Writing - review & editing. **Carolina Casado-Robles:** Conceptualization, Data curation, Methodology, Writing - review & editing. **Jesús Viciana:** Conceptualization, Investigation, Methodology, Visualization, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2020.101768.

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Paper X

COULD AN INTERMITTENT PHYSICAL EDUCATION-BASED FITNESS TEACHING UNIT AFFECT SECONDARY SCHOOL STUDENTS' MOTIVATION, AUTOTELIC EXPERIENCE, AND PHYSICAL SELF-CONCEPT? A CLUSTER-RANDOMIZED CONTROLLED TRIAL

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Perceptual and Motor Skills

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Could an intermittent Physical Education-based fitness teaching unit affect secondary school students' motivation, autotelic experience, and physical self-concept? A cluster-randomized controlled trial

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Short title: Intermittent program and psychological variables

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Abstract

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Introduction

Health is a state of complete physical, mental, and social well-being, and not just the absence of disease or injury (World Health Organization, 1946), and physical fitness is considered one of the fundamental health indicators for school-age children (Tomkinson, Lang, Blanchard, et al., 2019). For this reason, schools have an ideal setting, through the Physical Education (PE) subject, to make students aware of the benefits that having good fitness levels can have on their physical and psychological well-being (European Commission/EACEA/Eurydice, 2013). For example, during the educational years, having good physical fitness levels is positively associated with better mental health and quality of life (Eddolls et al., 2018; Evaristo et al., 2019).

Likewise, physical fitness has also shown to be positively associated with students' motivation toward PE (Martínez-Baena et al., 2016). Motivation has been defined as a psychological feature that encourages a person to act toward a desired goal (Ryan, Williams, Patrick, & Deci, 2009). According to the Self-Determination Theory (SDT, Deci & Ryan, 1985) motivation is conceptualized as a multidimensional construct that may be ordered in a *continuum* according to the extent to which motivation is self-determined: amotivation (non-intentional), extrinsic motivation, or intrinsic motivation (self-determined) (Deci & Ryan, 2000). Amotivation is characterized by no intention of a student to act due to different reasons such as a lack of knowledge or certain skills necessary to act. Extrinsic motivation refers to external

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reasons why people take part in a certain activity such as to avoid punishments, achieve tangible rewards, or attain recognition/approval. In contrast, intrinsic motivation refers to the inherent satisfaction and pleasure provided by an activity (Ryan et al., 2009).

Students' motivation toward PE has shown to be positively associated with their physical activity (PA) levels during PE lessons (Owen et al., 2014). When students have high motivation toward PE, they tend to be more active during PE lessons (Mayorga-Vega & Viciana, 2014). Additionally, higher levels of motivation in students during PE lessons have been positively associated with the experience of flow state (Stormoen et al., 2016). According to Csikszentmihalyi (1990), flow is an enjoyable psychological state that students experience when they are completely absorbed in an activity without being aware of the time. One of the most important elements of the flow state is autotelic experience (Csikszentmihalyi, 1990; García-Calvo et al., 2008). Autotelic experience is defined as the intrinsic satisfaction produced by a task (Csikszentmihalyi, 1990; García-Calvo et al., 2008). The SDT postulates that a task is easier to perform when you feel satisfaction simply by doing it, without the need of receiving any external reward (Ryan et al., 2009). In this sense, Moreno-Murcia et al. (2014) found that students experienced less autotelic experience in PE in comparison to other contexts such as non-competitive physical exercises or voluntarily chosen competitive sports. This could be because the compulsory nature of the participation in PE, leads to less enjoyment than in other contexts (Moreno-Murcia et al., 2014). This is especially

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important with physical fitness-related contents, where the intensity should be high and students' motivation may be negatively affected from a particular moment of the teaching unit due to the compulsory nature of their participation, consequently lowering their enjoyment more so than in other contexts (Moreno-Murcia et al., 2014).

Additionally, physical fitness has shown positive associations with physical self-concept among school-age children (Carraro et al., 2010; Mayorga-Vega et al., 2012). Physical self-concept, which is also an important aspect for students' health (Esnaola et al., 2008; World Health Organization, 1946), refers to a judgment a person has about his or her own physical abilities when interacting with the environment (Shavelson et al., 1976). During the educational years, physical self-concept acquires more importance, because of the significative physiological and psychological changes that take place during this stage (Harter, 2012). Unfortunately, physical self-concept decreases from childhood to adolescence (Navarro-Patón et al., 2019). For this reason, one of the main national standards in PE curriculums is the promotion of a good psychological status among students (European Commission/EACEA/Eurydice, 2013).

Considering all of the abovementioned positive relationships between physical fitness and psychological aspects, together with the physical fitness decline observed in school-age children during the last years (Tomkinson, Lang, & Tremblay, 2019), the improvement of students' physical fitness levels is one of the main objectives in the educational context (European Commission/EACEA/Eurydice, 2013). In this sense, a

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systematic review and meta-analysis found that carrying out physical fitness activities in PE lessons is one of the most effective strategies for increasing students' moderate-to-vigorous PA levels during said lessons (Lonsdale et al., 2013) and therefore, improving students' physical fitness (Poitras et al., 2016). However, practicing fitness activities during the entire PE lesson (i.e., as worked in traditional teaching units' lessons) may negatively impact students' motivation toward PE and enjoyment, leading to long-term negative effects such as sedentary behavior (Ladwig et al., 2018). Additionally, changes in students' physical self-concept as a result of a traditional PE-based physical fitness teaching unit are still contradictory (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016; Schmidt et al., 2013; Spruit et al., 2016). Therefore, it seems necessary to carry out more studies applying new teaching unit approaches to better understand how PE lessons could improve students' physical fitness levels without negatively influencing their motivation toward PE and autotelic experience, and without decreasing their physical self-concept. In this sense, Viciana and Mayorga-Vega (2016) proposed the intermittent teaching units as a novel teaching unit structure to facilitate the achievement of the PE curricular objectives. This innovative teaching unit structure consists of working a few minutes of each PE lesson for several lessons focused on one curricular objective, letting PE teachers divide the lesson into several parts (e.g., two) and develop two or more related curricular objectives in the same lesson. For instance, an intermittent teaching unit could consist of the development of students' physical

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fitness during several minutes of the PE lesson, and then working on invasion sports' learning (i.e., basketball and soccer) for the rest of the lesson. Working sports in the second part of PE lessons would allow for achieving high levels of moderate-to-vigorous PA (Hellin et al., 2019), as well as making them more attractive and participatory for students (Arantes da Costa et al., 2017). These may positively influence their motivation toward PE and autotelic experience, as well as improve their physical self-concept as they would not be so monotonous. Unfortunately, to our knowledge there are no previous studies examining the effect of an intermittent teaching unit on these psychological variables. Consequently, the main purpose of the present study was to compare the effect of the intermittent and traditional PE-based physical fitness teaching units on motivation toward PE, autotelic experience, and physical self-concept in secondary school students.

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Methods

Study design

The CONSORT guidelines for cluster randomized trials was followed to report the present study (Campbell et al., 2012). The protocol conforms to the Declaration of Helsinki statements (64th WMA, Brazil, October 2013). The Ethical Committee for Human Studies of the University of [omitted for blind review] provided ethical approval for the present study protocol. Recruitment of participants was performed in June of 2017, and the intervention was done from September to December of 2017. For practical reasons and because of the nature of the present study (i.e., natural groups from an educational setting) a cluster-randomized controlled trial was used (i.e., randomization was per classes not per individuals) (Guijarro-Romero et al., 2018; Mayorga-Vega et al., 2016). This study was non-blinded (treatments were not masked from the teachers or students) and parallel-group(ed) (study with three different treatments; Spieth et al., 2016), with two evaluation phases.

Participants

First, the principals and the PE teachers of two similar state secondary schools chosen by convenience of the province of [omitted for blind review] were contacted. Both school centers were informed about the project and the permission to conduct the study was requested. After the approval of the schools was obtained, students and their legal tutors were completely informed about the characteristics of the study. A sample of 126 students (57.9% females) from the eighth and ninth grade of secondary education (i.e., 13-15 years old) were invited to participate in the present study. According to the center's reports, all the students' families had a middle socioeconomic level.

The inclusion criteria were: a) being enrolled in the eighth to ninth grades of the secondary education level (grades in which approval of the school was obtained); b) participating in normal PE classes; c) being free of any health disorder causing children to not undergo PA, d) presenting the corresponding signed written consent by their legal tutors, and e) presenting the corresponding signed written assent by the students. The

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exclusion criteria were: a) not having completed correctly the motivation toward PE, autotelic experience, and physical self-concept questionnaires in each measured moment (i.e., pre-intervention and post-intervention), and b) not having an attendance rate equal to or over 85% for PE classes during the intervention period.

Sample size

A priori sample size calculation was estimated with the G*Power Version 3.1.9.4 for Windows. Parameters were set in a conservative manner as follows: effect size $f = 0.15$, significance level $\alpha = 0.05$, statistical power $(1 - \beta) = 0.80$, and correlation among repeated measures $r = 0.7$. A minimum final sample size of 69 participants was estimated for this study.

Randomization

Randomization was conducted at the class-level, using a computerized random number generator. Before the pre-intervention evaluation was administered, the six established classes, with their students, balanced by grade (i.e., eighth- and ninth-grade classes) were randomly assigned following a 1:1:1 ratio to one of the two intervention arms [traditional (TG) or innovative group (IG)] or to the control group (CG) by an independent researcher blinded to the study objectives. However, according to the education rules, prior to the start of the scholar year the students who composed each of these six classes had been assigned randomly by the school center following the

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criterion that the classes should be balanced between males and females (i.e., each class should have the same proportion of males and females).

Intervention

Both TG and IG students carried out a physical fitness-based teaching unit during the PE lessons twice a week for nine weeks. Due to educational contingencies (e.g., meteorological problems), in the end the TG and IG students completed a total of 16 lessons. The lessons were designed and delivered by experienced PE teachers (15 years of experience) of the participating schools, with the supervision of the main researcher, and according to the approved curriculum established by the centers.

Each lesson lasted 50 minutes and consisted of: a 5-to-10-minute warm-up, a 35-to-40 minute main part, and a 5-minute cool-down. During the warm-up, students performed low-to-moderate aerobic exercises followed by some joint mobility and stretching exercises. In the main part, the TG students performed traditional PE-based physical fitness lessons during the whole period (e.g., interval training, circuit training, skipping rope, fartlek or running games). For example, in the interval training lesson students performed five series of three minutes of sprints with two minutes of rest between series followed by the game of tag in pairs for 10 minutes. Finally, during the five-minute cool-down students performed low intensity exercises such as walking slowly around the sports court.

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Regarding the IG students' lessons, the warm-up and cool-down phases were identical to the TG. However, the main part of this study group's lessons was divided into two halves, approximately 18-20 minutes each. In the first half, the IG students performed PE-based physical fitness exercises similar to the TG students (i.e., three series of three minutes of sprints with two minutes of rest between series, followed by five minutes of the game of tag in pairs). Nevertheless, in the second half, in order to make the lessons more participatory and motivating (Arantes da Costa et al., 2017), IG students carried out invasion sports tasks with the objective of learning technical and tactical elements of the worked sports (basketball and soccer). The PE teacher placed special emphasis on reaching a moderate-to-vigorous intensity during the whole main part (*i.e.*, 35-40 minutes) in the TG lessons, and only during the first half of the main part (*i.e.*, 18-20 minutes) in the IG lessons. Additionally, according to previous studies that have shown that feedback positively influences physical self-concept (Schmidt et al., 2013; Spruit et al., 2016) each student of the TG and IG received affective positive feedback (e.g., "well done" or "continue working as well as now") at least once per lesson during the teaching units.

Regarding the CG students, they also performed two PE lessons twice a week during the intervention period, with a similar structure to the TG and IG (i.e., 5-to-10-minute warm-up, 35-to-40-minute main part, and 5-minute cool-down). The warm-up and cool-down phases were similar to the intervention groups. However, the content

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(outdoor PA and body expression) and methodology followed during the main part of the lessons (focused on the recreation and without any special focus on PA intensity) were different. For example, during the outdoor PA lessons students performed different activities in the natural environment (e.g., track games or orientation races), while during the body expression lessons, students had to learned different acrosport figures to make an acrosport choreography.

Measures

Data collection was carried out during the PE lesson time at the beginning (pre-intervention) and at the end (post-intervention) of the teaching unit. Each evaluation was performed during one PE lesson in a controlled manner, that is, under the same conditions, with the same instruments, by the same tester and during the same day of the week. General characteristics of the participants (i.e., age, gender, grade, body height, body mass, and habitual PA) were registered at the beginning of the study. Body height and body mass (and body mass index) were measured following the *International Standards for Antrophometric Assesment* procotol (Stewart et al., 2011). Habitual PA was estimated by the Spanish version of the PACE questionnaire for adolescents (Martínez-Gómez et al., 2009). Students' motivation toward PE and physical self-concept were assessed before and after the intervention, while autotelic experience only after the intervention as the objective with this variable was to evaluate students' satisfaction experienced especifically during the teaching units given.

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Motivation toward Physical Education. Participants' self-determined motivation toward PE was measured by the Spanish version of the *Perceived Locus of Causality-II Scale* (PLOC-II) (Ferriz et al., 2015). This questionnaire was preceded by the statement "I participate in PE lessons…" and is comprised of a total of 24 items spread over six dimensions (four items each) that measure intrinsic motivation (e.g., "Because PE is stimulating"); integrated regulation (e.g., "Because I consider PE to be part of me"); identified regulation (e.g., "Because I want to learn sport skills"); introjected regulation (e.g., "Because I want the teacher to think I am a good student"); external regulation (e.g., "Because that is the norm"), and amotivation (e.g., "But I do not understand why we should have PE"). The autonomous (i.e., averaging intrinsic motivation, integrated regulation, and identified regulation), and controlled motivations (i.e., averaging introjected, and external regulations) were also calculated (Chemolli & Gagné, 2014). The Spanish version of the PLOC-II has shown adequate psychometric properties among secondary school students (CFI = 0.92; TLI = 0.91; IFI = 0.92; SRMR = 0.065; RMSEA = 0.065; Cronbach's alpha = 0.69-0.93) (Ferriz et al., 2015).

Autotelic experience. Students' satisfaction regarding the teaching units was measured by the autotelic experience dimension of the Spanish version of the *Flow State Scale* (García-Calvo et al., 2008), which is composed of four items (e.g., "I found the experience very valuable and comforting"). The Spanish version of the *Flow State Scale* has shown adequate psychometric properties among secondary school students

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(CFI = 0.91; TLI = 0.90; RMSEA = 0.054; SRMR = 0.051; Cronbach's alpha = 0.73) (García-Calvo et al., 2008).

Physical self-concept. The Spanish version of the short form of the *Physical Self-Description Questionnaire* (PSDQ-S) (Marsh et al., 2010) was used to measure physical self-concept. This questionnaire consists of 40 items that measure nine specific, and two global components of physical self-concept. Due to the purpose of the present study (i.e., teaching units focused on cardiorespiratory fitness improvement), only the endurance (three items; e.g., "I can run a long way without stopping"); global physical self-concept (three items; e.g., "Physically, I am happy with myself"), and self-esteem (five items; e.g., "Overall, I am no good") dimensions were used. The Spanish version of the PSDQ-S has shown adequate psychometric properties among secondary school students (TLI = 0.975; CFI = 0.978; RMSEA = 0.046; Cronbach's alpha = 0.80, 0.88 and 0.70 for endurance, global physical self-concept, and self-esteem dimensions, respectively) (Marsh et al., 2010).

To adapt the scale of the three aforementioned questionnaires to the Spanish students' school grades, a 10-point Likert-type scale from 1 ("Totally disagree") to 10 ("Totally agree") was used according to previous studies (e.g., Guijarro-Romero et al., 2018).

Statistical analysis

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Descriptive statistics (mean ± standard deviation or percentage) for the general characteristics of the included participants and dependent variables were calculated. All the statistical tests assumptions were first checked and met for each dependent variable by common procedures (e.g., histograms and normal Q-Q plots for normality). Additionally, for the main analyses all the potential contaminant variables (i.e., gender, grade, body height, body mass, body mass index, and habitual PA) were examined in order to be used as covariables if necessary. Chi-squared analyses were carried out to test the ratio differences of gender and grade between the three groups. A one-way analysis of variance (ANOVA) was conducted to examine potential differences between the three groups in terms of body height, body mass, body mass index, and habitual PA levels. Additionally, the internal consistency of the measured dimensions was examined with Cronbach's alpha.

Then, the effect of the physical fitness-based teaching units on motivation toward PE, and physical self-concept were examined using a two-way ANOVA applied over the dependent variables [and a two-way analysis of covariance (ANCOVA) with gender and grade as covariances when the integrated and autonomous motivation variables were analyzed], including *group* as an independent variable (CG, IG and TG) and *time* as a dependent variable (pre-intervention and post-intervention). Subsequently, for the *post hoc* analyses, the Bonferroni adjustment was used for both the multiple comparisons and the within-group pairwise comparisons. A one-way ANCOVA with

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grade as covariance was used to compare the average obtained in the autotelic experience between the three groups, and later for the *post hoc* analyses, the between-group pairwise comparisons with the Bonferroni adjustment were used. Effect sizes were estimated using the partial eta squared (η^2_p) and Cohen's *d* for the overall and pairwise comparisons, respectively (Field, 2017). All statistical analyses were performed using the SPSS Version 21.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

Results

Final sample and general characteristics

Figure 1 shows a flow chart corresponding to the participants included in the present study. Out of the 126 students (57.9% females) who agreed to participate and met the inclusion criteria, definitively 103 students (54.4 % females) satisfactorily passed the exclusion criteria and were analysed. No participant was lost because of the rejection to continue in the study or the change of school. Table 1 shows the general characteristics of the included participants and the differences between the three groups. The one-way ANOVA results did not show statistically significant differences in terms of body height, body mass, body mass index, and habitual PA levels between the three groups ($p > 0.05$). Additionally, the chi-square analysis showed that the three groups had a balanced representation of eighth-/ninth-grade students ($p > 0.05$). However, the chi-square analysis showed that the three groups had an unbalanced representation of

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females to males ($p < 0.05$). The TG and IG participants obtained an average attendance of 89% and 93%, respectively. The internal consistency of the measured dimensions with data of the present study was adequate (Cronbach's alpha: intrinsic motivation = 0.84; integrated regulation = 0.86; identified regulation = 0.78; introjected regulation = 0.75; external regulation = 0.73; amotivation = 0.76; autotelic experience = 0.95; endurance = 0.92; global physical self-concept = 0.94; self-esteem = 0.73).

Table 1. General characteristics of the included participants and differences between the three groups.

	Total (n = 103)	CG (n = 38)	IG (n = 42)	TG (n = 23)	p^a
Age (years)	13.6 (0.7)	13.6 (0.7)	13.8 (0.8)	13.5 (0.6)	-
Gender (females/males)	54.4/45.6	68.4/31.6	52.4/47.6	34.8/65.2	0.036
Grade ($8^{th}/9^{th}$)	42.7/57.3	47.4/52.6	38.1/61.9	43.5/56.6	0.702
Body height (cm)	162.5 (7.9)	160.8 (7.6)	163.2 (7.8)	163.8 (8.3)	0.270
Body mass (kg)	54.1 (11.1)	54.2 (9.0)	54.7 (12.7)	52.8 (11.3)	0.810
Body mass index (kg/m^2)	20.4 (3.5)	21.0 (3.4)	20.4 (3.8)	19.5 (3.0)	0.290
Habitual PA (days/week)	2.9 (1.7)	2.4 (1.5)	2.9 (1.7)	3.4 (2.1)	0.107

Note. Data are reported as mean (standard deviation) for age, body height, body mass, body mass index and habitual PA, or percentage for gender and grade; CG = Control group; IG = Innovative group; TG = Traditional group; PA = Physical activity.

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[a] Significance level from the one-way analysis of variance for body height, body mass, body mass index and habitual PA, and from the chi squared test for the grade and gender ratios.

Insert Figure 1

Motivation toward Physical Education

Table 2 shows the effect of the intermittent and traditional physical fitness-based teaching units on motivation toward PE levels in secondary school students. The results of the two-way ANOVA/ANCOVA on the average obtained in the values of the integrated, introjected, autonomous, and controlled motivation showed a statistically significant interaction effect between the *group* and *time* variables ($p < 0.05$). Subsequently, the *post-hoc* multiple comparisons showed that both the IG and TG were statistically significantly different from the CG ($p < 0.05$). However, between the IG and TG no statistically significant differences were found ($p > 0.05$). Finally, the *post-hoc* within-group pairwise comparisons showed that the CG decreased statistically significantly from pre-intervention to post-intervention ($p < 0.05$). However, for the IG and TG no statistically significant differences were found from pre-intervention to post-intervention ($p > 0.05$). Regarding the intrinsic, identified, external, and amotivation dimensions, the results of the two-way ANOVA did not show any significant interaction effect between the *group* and *time* variables ($p > 0.05$).

Table 2. Effect of the intermittent and traditional physical fitness-based teaching units on motivation toward Physical Education in secondary school students.

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	Pre-intervention	Post-intervention	Two-way ANOVA[a]			Effect size	
	Mean (SD)	Mean (SD)	*F*	*p*	η^2_p	Comp.	*d*
Intrinsic motivation			1.196	0.307	0.023		
CG (*n* = 38)	7.7 (1.7)	7.3 (2.0)				IG-CG	0.20
IG (*n* = 42)	7.1 (1.5)	7.0 (1.7)				TG-CG	0.32
TG (*n* = 23)	7.1 (1.4)	7.3 (1.4)				TG-IG	0.12
Integrated motivation[b]			3.562	0.032	0.067		
CG (*n* = 38)	7.1 (1.8)	6.6 (2.3)*				IG-CG	0.38
IG (*n* = 42)	6.6 (2.0)	6.7 (1.8)				TG-CG	0.44
TG (*n* = 23)	6.5 (1.9)	6.7 (2.0)				TG-IG	0.05
Identified motivation			0.739	0.480	0.015		
CG (*n* = 38)	7.8 (1.5)	7.5 (1.8)				IG-CG	0.22
IG (*n* = 42)	7.0 (1.6)	7.0 (1.6)				TG-CG	0.06
TG (*n* = 23)	7.0 (1.6)	6.8 (1.8)				TG-IG	-0.16
Introjected motivation			3.329	0.040	0.062		
CG (*n* = 38)	6.3 (2.1)	5.6 (2.0)*				IG-CG	0.60
IG (*n* = 42)†	4.7 (1.8)	5.0 (1.7)				TG-CG	0.24
TG (*n* = 23)††	4.6 (2.0)	4.3 (2.2)				TG-IG	-0.36

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External motivation			1.478	0.233	0.029		
CG (n = 38)	5.8 (1.8)	5.2 (2.0)*				IG-CG	0.40
IG (n = 42)	4.5 (2.1)	4.5 (2.0)				TG-CG	0.25
TG (n = 23)	4.5 (2.1)	4.2 (2.1)				TG-IG	-0.14
Amotivation			0.144	0.866	0.003		
CG (n = 38)	2.8 (1.8)	2.8 (2.0)				IG-CG	0.05
IG (n = 42)	3.0 (2.1)	3.0 (2.0)				TG-CG	0.14
TG (n = 23)	1.9 (1.1)	2.1 (1.3)				TG-IG	0.10
Autonomous motivation[b]			3.303	0.041	0.063		
CG (n = 38)	7.5 (1.5)	7.1 (1.9)**				IG-CG	0.27
IG (n = 42)	6.9 (1.6)	6.9 (1.5)				TG-CG	0.27
TG (n = 23)	6.9 (1.4)	6.9 (1.6)				TG-IG	0.01
Controlled motivation			3.141	0.048	0.059		
CG (n = 38)	6.1 (1.8)	5.4 (1.8)**				IG-CG	0.50
IG (n = 42)†	4.6 (1.7)	4.8 (1.6)				TG-CG	0.25
TG (n = 23)††	4.5 (1.9)	4.3 (1.8)				TG-IG	-0.25

Note. SD = standard deviation; CG = Control group; IG = Innovative group; TG = Traditional group.

[a] Two-way analysis of variance with the *post hoc* analysis with Bonferroni adjustment: Multiple comparisons between the IG/TG and CG (†$p < 0.05$, ††$p < 0.01$) and within-group pairwise comparisons from pre-intervention to post-intervention (*$p < 0.05$, **$p < 0.01$). [b] *Post hoc* multiple comparisons could not be performed with covariables.

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Autotelic experience

The one-way ANCOVA conducted for the autotelic experience variable did not show statistically significant differences between the three groups (M ± SD, CG = 6.8 ± 2.4, IG = 7.1 ± 1.7, TG = 7.7 ± 1.6; $F = 1.715$, $p = 0.185$, $\eta^2_p = 0.033$).

Physical self-concept

Table 3 shows the effect of the intermittent and traditional physical fitness-based teaching units on physical self-concept in secondary school students. The results of the two-way ANOVA on the average obtained in the endurance, global physical self-concept, and self-esteem values did not show statistically significant interaction effects between the *group* and *time* variables ($p > 0.05$).

Table 3. Effect of the intermittent and traditional physical fitness-based teaching units on physical self-concept in secondary school students.

	Pre-intervention	Post-intervention	Two-way ANOVA			Effect size	
	Mean (SD)	Mean (SD)	*F*	*p*	η^2_p	Comp.	*d*
Endurance			1.576	0.212	0.031		
CG (*n* = 38)	6.7 (2.4)	6.3 (2.4)				IG-CG	0.12
IG (*n* = 42)	6.6 (2.1)	6.6 (2.1)				TG-CG	0.31
TG (*n* = 23)	6.6 (2.5)	7.0 (2.6)				TG-IG	0.18
Global physical self-concept			1.054	0.352	0.021		
CG (*n* = 38)	6.9 (2.2)	6.7 (2.6)				IG-CG	0.17

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IG (*n* = 42)	6.8 (2.4)	7.0 (2.3)				TG-CG	0.29
TG (*n* = 23)	7.7 (1.6)	8.1 (1.1)				TG-IG	0.11
Self-esteem			0.324	0.724	0.006		
CG (*n* = 38)	7.2 (1.5)	6.9 (2.3)				IG-CG	0.08
IG (*n* = 42)	7.1 (1.6)	7.0 (1.8)				TG-CG	0.19
TG (*n* = 23)	7.9 (1.1)	8.0 (1.0)				TG-IG	0.11

Note. SD = standard deviation; CG = Control group; IG = Innovative group; TG = Traditional group, ANOVA = Analysis of variance

Discussion

The purpose of the present study was to compare the effect of the intermittent and traditional PE-based physical fitness teaching units on motivation toward PE, autotelic experience, and physical self-concept in secondary school students. Results of the present study showed that students' motivation toward PE was not negatively affected by traditional or intermittent physical fitness-based teaching units. To our knowledge this is the first study that compares the effect of intermittent and traditional physical fitness-based teaching units on students' motivation toward PE. Previous studies in the PE setting (e.g., Rokka et al., 2019) have examined the effect of aerobic dance teaching units on students' intrinsic motivation. Unlike in the present study, in both above-mentioned studies students increased their intrinsic motivation after the intervention. This could be due to several reasons such as the content used (i.e., dance) or the use of music during the lessons. According to Hassandra et al. (2003), the lesson content is an

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important factor that can influence students' motivation toward PE. In this sense, dance has shown to be an entertaining and pleasant way to improve physical fitness among secondary school students (Rokka et al., 2019). Secondly, the use of music during PE lessons has also been shown to be another important factor that can enhance students' motivation toward PE (Terry et al., 2020).

On the other hand, physical fitness activities have been shown as being effective for achieving good moderate-to-vigorous PA levels during PE lessons (Lonsdale et al., 2013). Nevertheless, these traditional physical fitness exercises carried out with high intensity during the whole teaching unit could have produced a lack of interest for the contents taught in both experimental groups. This lack of interest may lead students to perceive PE lessons as less motivating (Moreno and Hellín, 2007). However, the reason why motivation was not negatively affected after the intervention could be the continuous affective feedback given to the students to keep the intensity during the lessons (Viciana et al., 2007). Additionally, although the IG worked invasion sports during the second half of the lessons in order to make them more participatory and motivating (Arantes da Costa et al., 2017), the worked sports (basketball and soccer) are two of the most common in secondary PE (Robles Rodríguez et al., 2015). Therefore, their novelty for students was low and it could have influenced their motivation toward PE (Hassandra et al., 2003). In this sense, González-Cutre and Sicilia (2019) suggest that introducing novel contents in the PE lessons can contribute to enhancing students'

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motivation. Further research should investigate further into this issue (using alternative sports for instance at the second part of the lesson; Hernández Martínez et al., 2019) in order to clarify if an intermittent teaching unit could positively affect the motivation toward PE due to the change of content during the lessons in contrast to a traditional physical fitness teaching unit.

Regarding autotelic experience, results of the present study showed that neither traditional nor intermittent physical fitness-based teaching units negatively affected the autotelic experience, but there were no differences between students from the IG and TG. Moreno-Murcia et al. (2014) found that students tend to experience less autotelic experience in the PE setting than in other contexts such as non-competitive physical exercises or voluntarily chosen competitive sports, mainly because they have to do something compulsory instead of for pleasure. In this sense, not only did the PE setting suppose a compulsory context for the two groups of students in this research, but also the positive feedback delivered by the teacher during the PE sessions was administered in a similar way to both groups in order to achieve a high level of physical activity during the PE classes. Another factor that could influence the level of autotelic experienced by students from the IG and TG is their interest for the delivered PE contents (Cheng & Wang, 2017), unfortunately, this was not measured. Possibly, comparable initial levels of interest and predisposition to action of students in regard to PE delivered contents might influence on the similar autotelic experience registered

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after the intervention in both groups. Future research studies should control this initial predisposition of students toward a specific content in order to register all possible factors that could affect the outcomes. Also, future research should apply some methodological strategies (e.g., autonomy support, small sided games, or involvement) at the second part of the lesson with the aim of showing if they could positively affect students' autotelic experience (Sierra-Daz et al., 2019).

National standards of PE curriculums also require the promotion of a good psychological status among students (European Commission/EACEA/Eurydice, 2013). Consequently, improving students' physical self-concept should also be an important target in the PE setting. Unfortunately, the results of this study showed that both traditional and intermittent physical fitness-based teaching units did not improve students' physical self-concept variables. Previous literature shows that the effects of PE-based physical fitness teaching units on physical self-concept are still contradictory (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016; Schmidt et al., 2013; Spruit et al., 2016). Similarly, previous studies with short-term physical fitness teaching units did not find any influence on students' physical self-concept (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016). On the contrary, Spruit et al. (2016) showed that physical fitness interventions are effective for improving students' physical self-concept. However, these authors pointed out that the effect of physical fitness teaching units on physical self-concept is moderated by the type of physical activity carried out during the

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lessons and the focalization of the students' attention to the improvement of the execution of these activities. In this sense, the absence of differences in physical self-concept after both types of teaching units (i.e., traditional and intermittent) could be because students were more focused on the competitive element of the tasks performed (e.g., making more repetitions than my classmates) instead of perceiving their physical improvements in the performed tasks (Spruit et al., 2016). Additionally, the values in both experimental groups were moderately high from the beginning, which were at least maintained after the intervention, similar to other short-term teaching units carried out in previous studies in the PE context (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016). Regarding the magnitude of the effects of the teaching units on students' physical self-concept, the present study showed similar results (d = 0.08-0.31) to previous studies that have performed a short-term physical fitness teaching unit (d = -0.03-0.24) (Mayorga-Vega et al., 2012; Mayorga-Vega et al., 2016). Therefore, short-term teaching units, independently of their structure, seem not to have a negative influence on students' physical self-concept. Future interventions should incorporate other strategies such as using semi-structured diaries focused to register the process in which the students are involved, and encouraging self-reflection about their improvement process (Schmidt et al., 2013).

The main strength of the present study was that, to our knowledge, this is the first study that compares the effect of the intermittent and traditional PE-based physical

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fitness teaching units on motivation toward PE, autotelic experience, and physical self-concept in secondary school students. Secondly, because of the nature of the context (i.e., school) and with the objective of keeping the ecological validity, the use of a cluster-randomized controlled trial design (balanced by grade) was more appropriate for the present research objective (Campbell et al., 2012). Furthermore, the use of this research design with three different groups adds quality to the present study. Apart from allowing for the comparison of the obtained outcomes from the intermittent teaching unit with the CG, it also allows for comparing them with the TG that works the physical fitness improvement objective in a traditional way. Nevertheless, this study also has some limitations that should be acknowledged. Firstly, due to human, time, and material resource restrictions, a probability and larger sample could not be examined. This fact could limit the generalizability of the obtained outcomes to the particular studied setting and population. Additionally, the study was not balanced by gender. However, when gender had an effect, it was statistically controlled.

In conclusion, results of this study suggest that both intermittent and traditional physical fitness teaching unit seem not to negatively influence students' motivation toward PE and autotelic experience. Moreover, neither of the two types of short-term teaching units applied in the present study improved students' physical self-concept. These findings suggest that regardless of the teaching unit structure applied (i.e., traditional or intermittent), it could be necessary that PE teachers apply specific

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strategies for improving students' psychological variables. Finally, it would be interesting for future studies to examine the influence of other variables such as students' preferences, perception of competence, and personality which could act as mediators of students' motivation (Barić et al., 2014; Huang et al., 2007; Rikard, 2006). The relation of these variables with the obtained outcomes in the present study and future similar studies, may help PE teachers and the scientific community to understand the complex framework of psychological variables that can affect student's motivation and therefore their learning acquisition process.

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Figure 1. Flow chart of the school classes and students of the present study. All numbers are school classes [students].

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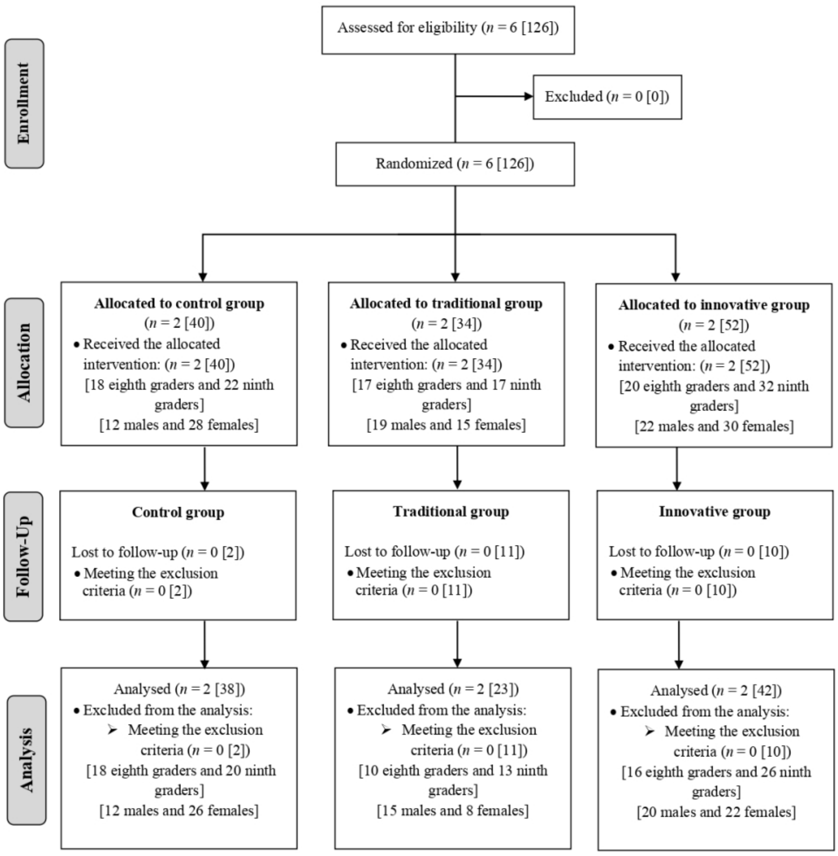

Figure 1. Flow chart of the school classes and students of the present study. All numbers are school classes [students].

215x279mm (150 x 150 DPI)

3. EFFECTIVENESS OF PHYSICAL EDUCATION-BASED INNOVATIVE TEACHING UNITS ON TACTICAL LEARNING IN SCHOOLCHILDREN (PAPERS XI-XII)

Paper XI

EFFECT OF TWO ALTERNATED TEACHING UNITS OF INVASION TEAM SPORTS ON THE TACTICAL LEARNING IN PRIMARY SCHOOLCHILDREN

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International Journal of Performance Analysis in Sport

2017, *17*(3), 256-270.

Effect of two alternated teaching units of invasion team sports on the tactical learning in primary schoolchildren

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Abstract

The "alternated teaching units" (ATU) is an innovative proposal that consists of delivering two related contents alternatively during the Physical Education (PE) classes, making students aware that both contents are based on the same learning's principles, increasing the students' global learning time, and making the students perceive one unique learning. This study aimed to compare the use of ATU with traditional teaching units (TTU) on the achieved tactical learning for invasion team sports in primary school students. The sample consisted of 104 students (49 girls and 55 boys; average age = 10.62 ± 0.62 years). Ten PE lessons of soccer and basketball were consecutively (TTU) and alternatively (ATU) delivered. Results showed that the ATU participants had a statistically significant increase in the scores of adjust, guard/mark, and general performance indices in basketball, soccer and overall invasion sports compared with the TTU participants ($r = 0.24$ to 0.64; $p < 0.05$). Additionally, the ATU participants had a statistically significant higher change of scores in decision-making index in overall invasion sports than the TTU participants ($r = 0.25$; $p < 0.05$). ATU applied to related sports should be considered instead of delivering consecutively and unconnectedly blocks of teaching in PE.

Key words: physical education, game performance, soccer, basketball, decision-making.

1. Introduction

The acquisition of tactical abilities is an important issue in sport and educational contexts (Causer and Ford, 2014; Sánchez-Mora *et al*., 2011; Williams and Ford, 2013). Acquiring tactical and motor skills in sports is directly related to numerous benefits on its practitioners, not only in sport settings. Thus, an increase of tactical skills levels may increment the perceived sports competency (Viciana *et al.*, 2014), the physical self-concept (Mayorga-Vega *et al.*, 2012), or even the amount of physical activity individuals achieve in their free time, being a predictor variable of the daily physical activity of schoolchildren (Jaakkola *et al.*, 2016). In fact, in Welk's (1999) Youth Physical Activity Promotion Model, tactical ability is a crucial factor in promoting healthy behaviour in youth, and the more capable a player is, the more competent he will feel, and the more that will influence in his habitual physical activity. Therefore, numerous authors and scientists are interested in promoting tactical skills (Chatzipanteli *et al.*, 2016; Gutiérrez and García-López, 2012; Gutiérrez *et al.*, 2011), and many countries require this kind of learning in schoolchildren in their curriculum national standards (e.g., in the United States of America, Lund and Tannehill, 2015; or United Kingdom, Department for Education, 2013). The Spanish Ministry of Education for instance, requires Spanish teachers to improve the decision-making process of students in team sport games in primary and secondary school levels (Ministry of Education, Culture and Sport, 2014, 2015), and 100% of Spanish teachers in their educational programs include sports teaching units.

On one hand, the purpose of this type of learning in the educational context is to provide students an integral view of the complex process of tactical skills, improving the general decision-making process in all team sport modalities (e.g., knowledge about play actions, being with and without ball possession; positioning and deciding; as well as actuation in changing situations during the play). This generic learning could allow students to acquire higher tactical abilities transferable to any kind of situations belonging to team sports with the same characteristics or similar constitutive elements (Causer and Ford, 2014). Consequently, using the concept of transfer seems to be a good strategy in order to propose effective educational interventions in Physical Education (PE) regarding the acquisition of tactical skills in sports (Memmert and Harvey, 2010; Yáñez and Castejón, 2014). Specifically, and based on the idea of "identical elements" of Thorndike (1914), motor, perceptual, and conceptual variables shared by a group of sport modalities classified in the same group of sports (e.g., basketball and soccer are in "invasion" team sports in the classification of Thorpe *et al.*, 1984), could be learned (Roca *et al.*, 2011) and transferred from one situation (sport context) to another (i.e. from basketball to soccer and vice-versa) (Yáñez and Castejón, 2014).

On the other hand, some interventions have been carried out in order to improve the sport decision-making process in PE (Contreras *et al.*, 2005; Yáñez and Castejón, 2014). Some studies have compared traditional (instructional or skill execution-approaches) with alternative (game-approaches or game-situations) interventions (García-López *et al.*, 2009; Iserbyt et al., 2016; Wahl-Alexander and Moorehead, 2017); and other researchers have verified the efficiency of an isolated game-approach program (Mesquita *et al.*, 2012; Yáñez and Castejón, 2014). However, all of these studies were developed regarding one particular sport modality and with a traditional distribution of the time in PE (i.e., sessions consecutively delivered). In fact, García-López *et al.* (2009) commented that "…given the transfer shown in procedural knowledge and decision-making (…) it could be suggested that a way to distribute the games in the curriculum would be to place sports belonging to the same category consecutively. Thus, knowledge acquired in initial experiences can be utilized, applied and extended in subsequent experience" (García-López *et al.*, 2009, p. 58). In regard to the search of quality, effectiveness, authentic interventions in PE, and avoiding unconnected learning perceived by students, Viciana and Mayorga-Vega (2016) proposed an innovative way of implementing teaching units regarding complementary contents (such as two sports that share tactical elements), instead of allocating the learning time in the traditional form applied by other authors (e.g., Robles *et al.*, 2011; Valera *et al.*, 2010). This innovative proposal was called "alternated teaching units" (ATU) and consists of delivering two related contents alternatively during the PE classes, making students aware that both contents are based on the same learning's principles, increasing the students' global learning time through adding the time where students are involved in both contents, and making the students perceive one unique learning (Figure 1).

Unfortunately, to our knowledge there are no previous studies that examine the efficacy of this innovative intervention.

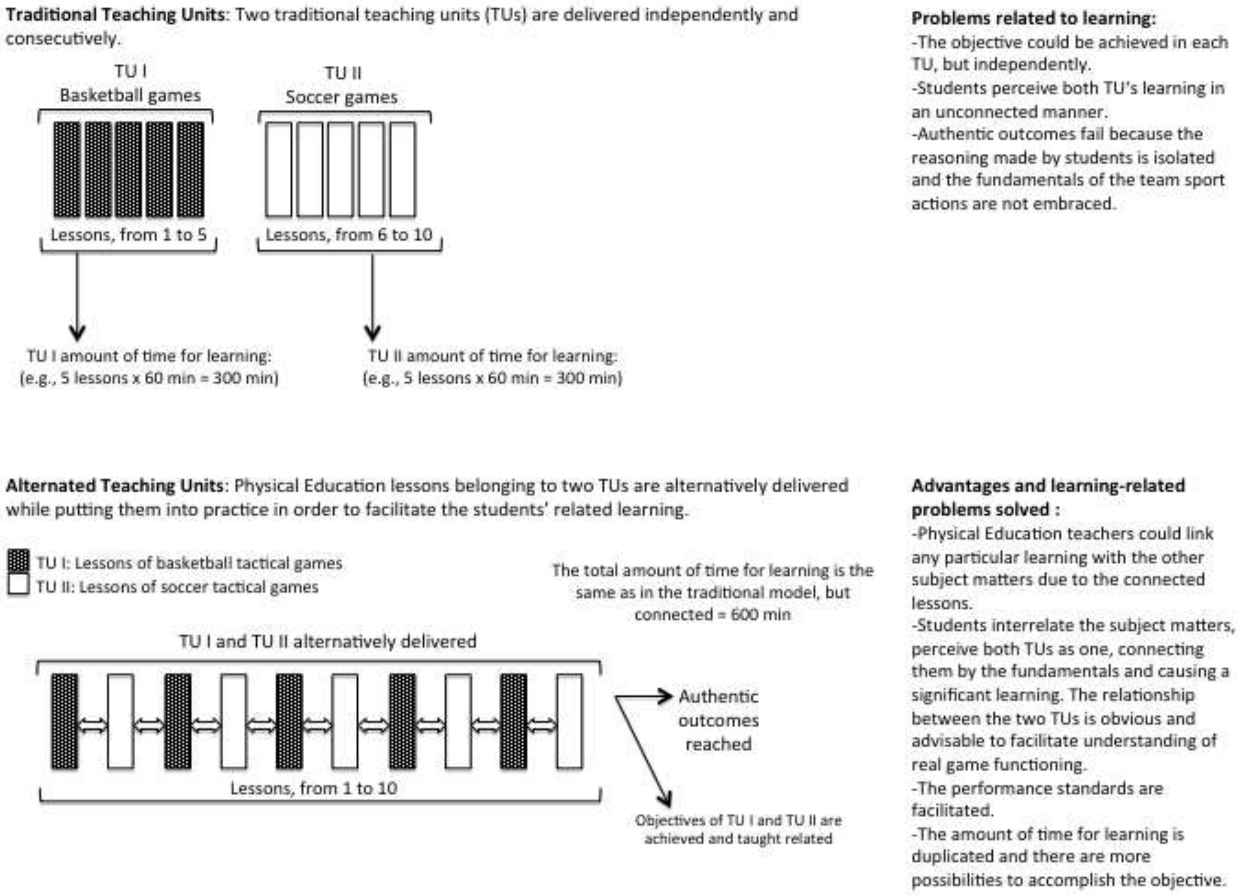

Figure 1. Alternated teaching units model versus traditional teaching units (adapted from Viciana and Mayorga-Vega, 2016:146).

Consequently, based on the alternated teaching units proposed by Viciana and Mayorga-Vega (2016), the aim of the present study was to examine if mixing two educational treatments of similar invasion team sports (ATU of soccer and basketball) could produce an increment of perceived, conceptual, and behavioural tactical skills compared with two independent treatments consecutively implemented (traditional teaching units, TTU) in primary schoolchildren.

2. Methods

2.1. Participants

A sample of 104 primary schoolchildren, 49 boys and 55 girls (average age = 10.63 ± .64 years old) from 5th-6th grade PE classes of a public primary school participated in this study. For practical reasons and the nature of the present study (natural groups from an educational setting) a cluster randomized controlled design was used (Merino-

Marbán *et al.*, 2015). Natural classes were assigned randomly to constitute two study groups: TTU group, with two sports modalities consecutively delivered in two independent teaching units) and ATU, with two sports modalities alternately delivered. A real control group (without treatment) was not used due to the obligatory compliance of delivering the sport content in the PE curriculum programmed in the school center.

All the participants were free of any medical or legal impediment to participate in the PE classes of this study. The inclusion criteria were: (a) to have an attendance rate of eight or more PE classes during the intervention period, and (b) to participate in the pre and post-intervention evaluations. Children and their legal guardians were fully informed about all the features of the study and were required to sign an informed consent document. The study protocol was approved by the Ethical Committee of the University of [removed for anonymity reasons] (code number 187/CEIH/2016).

2.2. Measurements

2.2.1. Perceived tactical skills

The Spanish version of the Tactical Skills Inventory for Sports for the school context was used (Viciana *et al.*, 2016), which comes from the original English version of Elferink-Gemser *et al.*, (2004). It has 17 items and four dimensions that include all the more relevant aspects of the tactical team sports skills (dimension 1: positioning and deciding, with eight items; dimension 2: knowing about ball actions, with three items; dimension 3: knowing about others, with three items; and dimension 4: acting in changing situations, with three items). Dimensions 1 and 4 measure the perceived procedural knowledge and are focused on choosing the right actions during the game, while dimensions 2 and 3 measure the perceived declarative knowledge and are focused on the knowledge of the game. Moreover, the questionnaire distinguishes on-the-ball tactical moves (offense, dimensions 1 and 2) and off-the-ball tactical moves (defense, dimensions 3 and 4). As such, its four factors covered the main tactical actions that take place during invasion sports. A Likert-type scale from 1 to 10 (from “very poor” to “excellent”; or from “almost never” to “always”) was used. The Spanish version of this inventory demonstrated good reliability (Cronbach’s α = from 0.72 to 0.83) and validity (GFI = 0.955; RMSEA = 0.044; CFI = 0.974) among children (Viciana *et al.*, 2016).

2.2.2. Conceptual tactical knowledge

The declarative and procedural tactical knowledge was measured by the *Invasion Games Knowledge Test* (Sánchez-Mora *et al.*, 2011). This questionnaire is composed of 16 questions with three possible answers and only one correct, being eight questions regarding the declarative knowledge and eight regarding the procedural knowledge. Declarative knowledge deals with a particular sport situation and its generalization to a new situation in the same sport modality (Raab, 2007). In contrast, procedural knowledge is linked with the execution, and it is the result of a complex process of knowledge production regarding the concurrent situation and past events, combined with the ability of the athlete to execute the skill (García-López *et al*., 2010). This questionnaire was validated among children, showing a good coefficient of test-retest reliability (Cronbach’s α = 0.88) (Sánchez-Mora *et al*., 2011).

2.2.3. Behavioral tactical skills

The *Game Performance Assessment Instrument* (GPAI) was used in order to evaluate the behavioral tactical learning, which is the more used observational instrument in PE for assessing game tactic actions (Arias-Estero and Castejón, 2014). Oslin *et al.* (1998), creators of the instrument, distinguished several components regarding the game performance that compose the GPAI. In this study, technical and tactical abilities were evaluated during the game according to the six following variables (the two first variables corresponding to on-the-ball situations, and the last four corresponding to off-the-ball situations): (a) Decision-making (DM) consists of selecting the type of movement or ability in response to a tactical problem (e.g., in team sports, the player should to decide between passing to a teammate, progressing across the field/court, or shooting to goal/basket. These three actions were evaluated in each play according to the best option available in each case); (b) Skill execution (SE) consists of executing efficiently selected skills during the game. In this category, the effectiveness of passing, shooting, and interception of the ball were evaluated (e.g., a teammate receives the ball after passing, or scoring a goal after shooting); (c) Base (BA) refers to the position to which players should move back to after performing an action or technical execution. In this category, the defensive retreat was measured, in which the player had to come back to his defensive position in order to avoid the progression of the rival players; (d) Adjust (AJ) refers to the capacity of a player to perform movements and displacements depending on the game demands, in both attack and defense phases of the game (e.g., the player is positioned oriented toward the goal and the teammate who possesses the ball, or the player moves forward to the goal after passing the ball to a teammate); (e) Support (SU) refers to serving as help to a teammate who possesses the ball by being positioned in a good place to receive a possible pass; and (f) Guard/Mark (GM) consists of movements without ball possession in defense situations, avoiding opponent reception of the ball, or avoiding progression through the field/court if the opponent has the ball. The reliability and validity of GPAI have been verified in several previous studies among children (e.g., Oslin *et al*., 1998; Simon, 2007).

The frequency of all of these categories was registered for each player (participant) in appropriate and inappropriate actions. One trained observer (with a PE and sports bachelor degree) participated registering all categories by video-analysis. The intra-observer training was carried out with four sessions, coding the actions of all participants during one randomly selected game (six minutes in total, three of soccer and three of basketball), and obtaining more than the 80% of coincidence required between two measures performed one week apart. The two first sessions were carried out with all categories, confirming a high percentage of coincidence of SE, BA, SU, but GM, AJ and DM required one more session in order to register all actions consistently, and a fourth session for verifying an adequate percentage of coincidence.

The game performance formulas suggested by Oslin *et al.* (1998) for the GPAI consisted of an index, which is calculated by a division between appropriate actions (numerator) / inappropriate actions (denominator) (e.g., DMindex = appropriate actions of DM / inappropriate actions of DM), and the general index of game performance [GP = (DMindex + SEindex + BAindex + AJindex + SUindex + GMindex) / 6]. However, some errors of these formulas have been detected (Memmert and Harvey, 2008) when there are no inappropriate actions or appropriate actions registered in a particular category for some participant/s, resulting "0" the numerator/denominator of the formula. Thus, in order to avoid the appearance of this error, in this study the following formula was used [as proposed by Memmert and Harvey (2008)]: appropriate actions /

(appropriate + inappropriate actions), resulting an index between 0 and 1, where the closer the value of this index is to 1, the higher level of tactical actions is performed by the participant. “1” means that the participant performed all actions evaluated appropriately; “0.5” means that the participant performed as many inappropriate actions as appropriate; and “0” means that the participant did not perform any appropriate action.

2.3. Procedures

Two groups were distributed according to the previously planned treatments (Figure 2). The ATU group developed an alternated implementation of basketball and soccer teaching units in PE. It consisted of delivering one session of each sport followed by the other one during all the sessions of the program (two PE sessions a week during eight weeks), focusing on connecting both type of tasks and learning during the 16 sessions programmed (eight of each sport modality). This initial program was modified due to the usual school contingencies (rain days, festivities, and one day with an organized excursion out of the school center), a total of 10 sessions remained. Tasks were centered on the tactical game teaching approach (Griffin and Butler, 2005) and on the inquiry-based teaching model in PE (Darst *et al.*, 2014). The TTU group developed a similar program, but the two sport modalities were consecutively delivered. First, the students of the TTU received all sessions of the soccer unit, and afterwards all sessions of the basketball unit. In the ATU group the PE teacher made emphasis on the connection of these two modalities of sports and maintained the structure of the tasks from the session of one sport modality to the other (next day), making students aware of the similar elements that these two sports modalities had, as well as the similar executions of the tactical actions that occur during both games. On the contrary, TTU students received tasks with a more instructional character and one-sport modality-centered (without connecting the two modalities of sports), which is the more frequently applied treatment by Spanish PE teachers in their curriculum (Robles *et al*., 2011; Valera *et al*., 2010). However, the structure of the sessions was the same for ATU and TTU groups. A warm up of 8-10 minutes with running games were developed, introducing the ball and specific basketball and soccer games. The main part of the PE session had five-six tasks centered on tactical games in small-sided conditions. Students developed tactical actions from 1x1 to 3x3 games. TTU students received instructional feedback about the specific actions performed in the sessions (basketball or soccer), while ATU students received instructional and interrogative feedbacks in order to make students reflect on the relationship between the two modalities of sport implemented. Finally, five minutes to cool the students down at the end of the session were applied.

Evaluation was carried out during two PE lessons at the beginning and at the end of the intervention program (pre-intervention and post-intervention, respectively). The conceptual questionnaire was applied during a first PE session, and the perceived tactical skills inventory for sports and the measurement of behavioural tactical skill were applied in a second PE lesson. Each evaluation was carried out by the same tester, using the same instruments and under the same conditions. Prior to the GPAI, the participants completed a standardized warm-up consisting of 10 min of articular mobility and progressive running games. Then, a 3x3 game, balancing the gender as a team-grouping criterion, was performed. The behavioural evaluation consisted of three minutes of free soccer game (with goals delimited by cones) and three minutes of basketball game (with mini-basket goals), both in a reduced dimensional field/court of

10m x 20m. All students were identified by numbers worn on their back in order to facilitate the posterior video analysis.

2.4. Statistical analyses

Descriptive statistics for the general characteristics of the participants and the dependent variables were calculated. Chi-squared analyses were carried out to examine if the ATU and TTU groups were balanced in terms of age, grade, gender, participation in extracurricular invasion sports, and federated in extracurricular sports, as well as the potential differences in the attendance rate in the intervention program. Afterward, the effect of the PE-based intervention program on conceptual, perceived, and behavioral tactical skills in invasion sports was examined using the Mann-Whitney U test, including group as an independent variable (TTU, ATU) and change of scores (post-intervention – pre-intervention) as dependent variables. Moreover, the r effect sizes were calculated to examine the magnitude of the PE-based intervention program (Field, 2009). All statistical analyses were performed using the SPSS version 21.0 for Windows (IBM® SPSS® Statistics). The statistical significance level was set at $p < 0.05$.

3. Results

Figure 2 shows the flow chart corresponding to the participants included in the present study. From the 104 students that participated in the present study, 85 participants (82%) met the inclusion criteria. Table 1 shows the general characteristics of the studied participants, as well as the differences between TTU and ATU groups. Results of the chi-square test showed that the two groups were balanced according to age, grade, gender, participation in extracurricular invasion sports, and federated in extracurricular sports ($p > 0.05$). However, the chi-square results showed that the ATU participants had a statistically significant lower attendance rate in the intervention program than the TTU participants (8/ 9-10 sessions: ATU = 22/ 21 and TTU = 4/ 38) ($\chi2 = 17.350$, $p < 0.001$). The ATU and TTU participants obtained an average attendance of 89% and 96% in the intervention program, respectively.

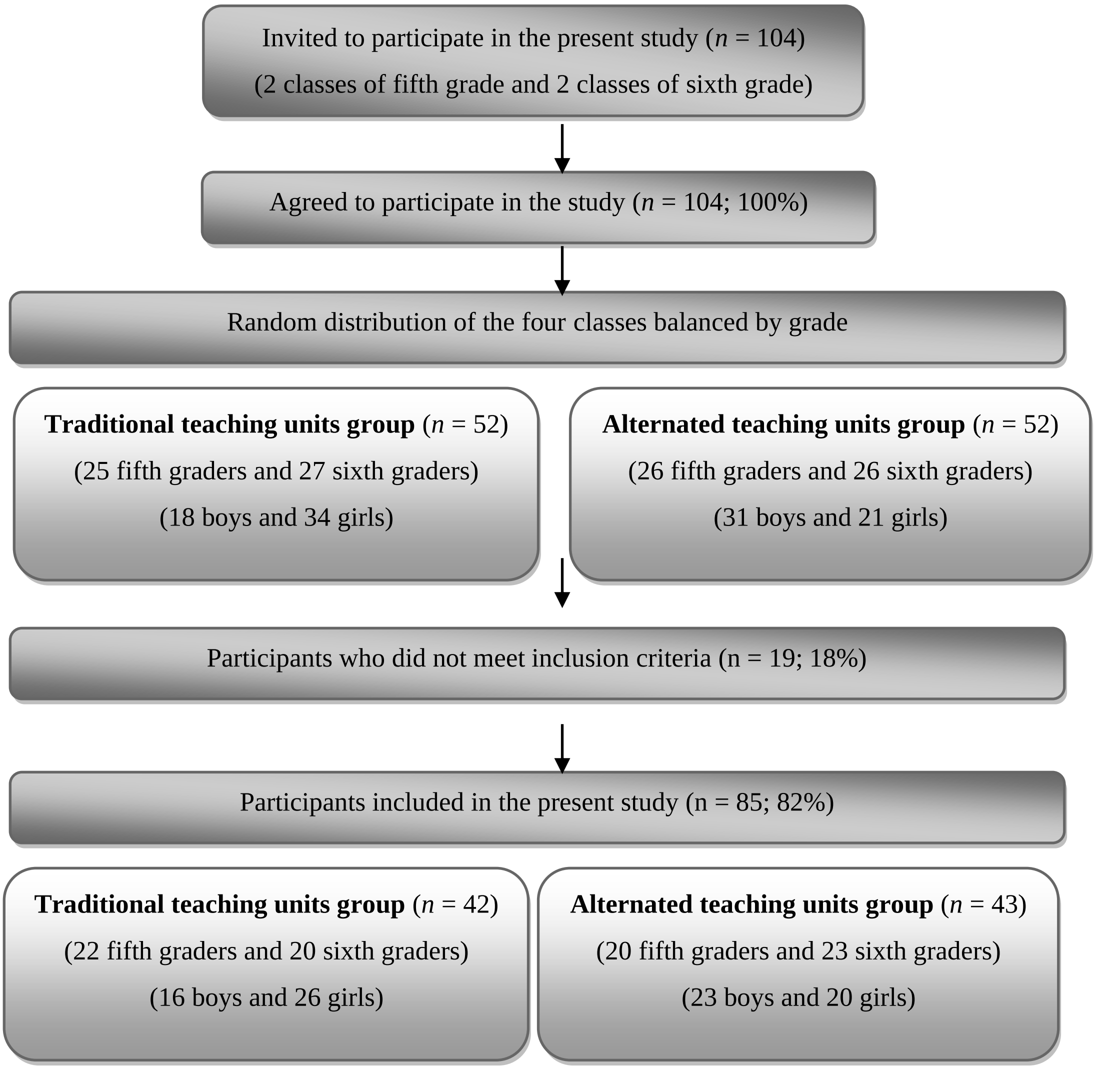

Figure 2. Flow chart corresponding to the participants included in the present study.

Table 1. General characteristics (frequency) of the analysed participants and differences between traditional teaching units (TTU) and alternated teaching units (ATU) groups.

	Sample	TTU	ATU	Chi squared test	
	(n = 85)	(n = 42)	(n = 43)	χ^2	p
Age (10/11-12 years)	39/ 46	20/ 22	19/ 24	0.111	0.751
Grade (5^{th}/ 6^{th})	42/ 43	22/ 20	20/ 23	0.293	0.588
Gender (boys/ girls)	39/ 46	16/ 26	23/ 20	2.028	0.154
Extracurricular invasion sports (yes/ no)	40/ 45	19/ 23	21/ 22	0.110	0.740
Federated-extracurricular sport (yes/ no)	37/ 48	18/ 24	19/ 24	0.015	0.902

3.1. Behavioral tactical skills in invasion sports

The results of the Mann-Whitney U test showed that the ATU participants had a statistically significant increase in the scores of AJindex, MGindex, and GP in basketball, soccer and overall invasion sports compared with the TTU participants ($r = 0.24$ to 0.64; $p < 0.05$). Additionally, the results of the Mann-Whitney U test also showed that the ATU participants had a statistically significant higher change of scores in DMindex in overall invasion sports than the TTU participants ($r = 0.25$; $p < 0.05$). For the other behavioral tactical dimensions no statistically significant differences between the ATU and TTU were found ($p > 0.05$) (Tables 2-4).

Table 2. Effect of the physical education-based intervention program on behavioural tactical skills in basketball

Variable	Group	Pre-intervention	Post-intervention	Difference	Mann-Whitney test		ES
		M (Q_3-Q_1)	M (Q_3-Q_1)	M (Q_3-Q_1)	*Z*	*p*	*r*
Skill-execution index	ATU	0.56 (0.24)	0.56 (0.17)	-0.05 (0.22)	0.461	0.644	-0.05
	TTU	0.63 (0.23)	0.61 (0.18)	-0.01 (0.25)			
Support index	ATU	0.42 (0.51)	0.43 (0.40)	-0.04 (0.28)	1.156	0.248	-0.13
	TTU	0.39 (0.51)	0.46 (0.46)	0.08 (0.46)			
Base index	ATU	0.40 (0.45)	0.56 (0.58)	0.00 (0.47)	0.004	0.996	0.00
	TTU	0.50 (0.51)	0.59 (0.48)	0.00 (0.37)			
Adjust index	ATU	0.42 (0.31)	0.75 (0.29)	0.25 (0.37)	5.397	< 0.001	0.59
	TTU	0.50 (0.33)	0.47 (0.28)	-0.02 (0.23)			
Mark index	ATU	0.33 (0.60)	0.50 (0.42)	0.00 (0.63)	2.234	0.025	0.24
	TTU	0.33 (0.54)	0.20 (0.50)	0.00 (0.52)			
Decision-making index	ATU	0.50 (0.80)	0.75 (0.50)	0.15 (0.40)	1.884	0.060	0.20
	TTU	0.71 (0.36)	0.67 (0.67)	0.00 (0.60)			
Game performance	ATU	0.47 (0.26)	0.58 (0.24)	0.09 (0.26)	2.496	0.013	0.27
	TTU	0.50 (0.22)	0.47 (0.22)	0.00 (0.19)			

Note. M = Median; Q_3-Q_1 = Interquartile range; ES = Effect size; ATU = Alternated teaching units group ($n = 43$); TTU = Traditional teaching units group ($n = 42$).

Table 3. Effect of the physical education-based intervention program on behavioural tactical skills in soccer

Variable	Group	Pre-intervention	Post-intervention	Difference	Mann-Whitney test		ES
		M (Q_3-Q_1)	M (Q_3-Q_1)	M (Q_3-Q_1)	*Z*	*p*	*r*
Skill-execution index	ATU	0.50 (0.30)	0.47 (0.42)	0.00 (0.45)	0.259	0.795	-0.03
	TTU	0.50 (0.25)	0.50 (0.36)	0.01 (0.35)			
Support index	ATU	0.18 (0.67)	0.00 (0.50)	0.00 (0.40)	0.419	0.675	0.05
	TTU	0.22 (0.37)	0.24 (0.50)	0.00 (0.25)			
Base index	ATU	0.50 (0.80)	0.67 (0.50)	0.03 (0.75)	0.270	0.787	0.03
	TTU	0.50 (1.00)	0.50 (0.69)	0.00 (0.50)			

Adjust index*	ATU	0.50 (0.33)	0.78 (0.28)	0.27 (0.39)	4.294	< 0.001	0.47
	TTU	0.60 (0.52)	0.60 (0.29)	-0.05 (0.53)			
Mark index*	ATU	0.50 (0.55)	0.67 (0.50)	0.03 (0.40)	2.383	0.017	0.26
	TTU	0.75 (0.50)	0.50 (0.67)	-0.04 (0.83)			
Decision-making index	ATU	0.25 (0.56)	0.50 (0.47)	0.23 (0.50)	1.387	0.165	0.15
	TTU	0.27 (0.50)	0.42 (1.00)	0.00 (0.68)			
Game performance	ATU	0.49 (0.21)	0.52 (0.25)	0.12 (0.29)	2.224	0.026	0.24
	TTU	0.49 (0.21)	0.48 (0.25)	0.03 (0.29)			

Note. M = Median; Q_3-Q_1 = Interquartile range; ES = Effect size; ATU = Alternated teaching units group ($n = 43$); TTU = Traditional teaching units group ($n = 42$).
* $p < 0.05$ with the Mann-Whitney U test for the pre-intervention values comparisons.

Table 4. Effect of the physical education-based intervention program on behavioural tactical skills in invasion sports (overall)

Variable	Group	Pre-intervention	Post-intervention	Difference	Mann-Whitney test		ES
		M (Q_3-Q_1)	M (Q_3-Q_1)	M (Q_3-Q_1)	*Z*	*p*	*r*
Skill-execution index	ATU	0.55 (0.22)	0.52 (0.12)	-0.01 (0.21)	0.457	0.648	-0.05
	TTU	0.57 (0.18)	0.56 (0.17)	0.03 (0.22)			
Support index	ATU	0.33 (0.50)	0.40 (0.39)	0.01 (0.30)	0.554	0.580	-0.06
	TTU	0.36 (0.35)	0.41 (0.39)	0.06 (0.32)			
Base index	ATU	0.50 (0.37)	0.58 (0.32)	0.05 (0.30)	0.616	0.538	0.07
	TTU	0.54 (0.43)	0.61 (0.42)	0.02 (0.30)			
Adjust index	ATU	0.48 (0.26)	0.72 (0.23)	0.25 (0.23)	5.885	< 0.001	0.64
	TTU	0.52 (0.31)	0.50 (0.23)	-0.05 (0.24)			
Mark index	ATU	0.50 (0.37)	0.57 (0.38)	0.19 (0.40)	3.609	< 0.001	0.39
	TTU	0.50 (0.38)	0.33 (0.21)	-0.09 (0.45)			
Decision-making index*	ATU	0.50 (0.34)	0.67 (0.24)	0.17 (0.33)	2.313	0.021	0.25
	TTU	0.59 (0.37)	0.62 (0.48)	0.05 (0.46)			
Game performance	ATU	0.48 (0.21)	0.57 (0.18)	0.10 (0.18)	3.657	< 0.001	0.40
	TTU	0.52 (0.17)	0.47 (0.22)	-0.01 (0.22)			

Note. M = Median; Q_3-Q_1 = Interquartile range; ES = Effect size; ATU = Alternated teaching units group ($n = 43$); TTU = Traditional teaching units group ($n = 42$).
* $p < 0.05$ with the Mann-Whitney U test for the pre-intervention values comparisons.

There were no differences between ATU and TTU groups in the game situations assessed, as the Mann-Whitney test regarding the overall game involvement index of the GPAI reflected ($Z = 1.499$; $p = 0.134$).

3.2. Perceived tactical skills and conceptual tactical knowledge in invasion sports

The results of the Mann-Whitney U test did not show statistically significant differences in the change of scores in perceived tactical skills, or conceptual (declarative / procedural) knowledge of invasion sports between ATU and TTU participants ($p > 0.05$) (Table 5).

Table 5. Effect of the physical education-based intervention program on perceived and conceptual tactical skills in invasion sports

Variable	Group	Pre-intervention	Post-intervention	Difference	Mann-Whitney test		ES
		M (Q_3-Q_1)	M (Q_3-Q_1)	M (Q_3-Q_1)	*Z*	*p*	*r*
Perceived tactical skills in invasion sports							
Positioning and deciding	ATU	7.50 (1.88)	7.88 (2.20)	0.38 (1.00)	0.985	0.325	-0.11
	TTU	7.39 (1.91)	8.19 (1.63)	0.69 (1.38)			
Knowing about ball actions	ATU	7.33 (2.67)	8.00 (2.00)	0.33 (2.17)	0.044	0.965	-0.00
	TTU	8.33 (2.13)	9.00 (2.00)	0.50 (1.67)			
Knowing about others	ATU	6.67 (2.33)	7.33 (1.67)	1.00 (1.67)	0.009	0.993	0.00
	TTU	6.67 (3.42)	7.83 (2.17)	1.00 (2.42)			
Acting in changing situations	ATU	6.67 (2.33)	7.33 (2.00)	0.33 (2.33)	1.066	0.286	-0.12
	TTU	7.00 (3.00)	8.00 (1.67)	0.75 (1.83)			
Conceptual tactical in invasion sports							
Declarative knowledge*	ATU	6.00 (2.00)	6.00 (2.00)	0.00 (1.25)	0.807	0.419	0.09
	TTU	7.00 (1.50)	7.00 (1.25)	0.00 (2.00)			
Procedimental knowledge	ATU	5.00 (2.00)	6.00 (1.50)	0.50 (2.00)	1.307	0.191	0.14
	TTU	6.00 (1.00)	6.00 (2.00)	0.00 (2.00)			

Note. M = Median; Q_3-Q_1 = Interquartile range; ES = Effect size; ATU = Alternated teaching units group (*n* = 43); TTU = Traditional teaching units group (*n* = 42).
* $p < 0.05$ with the Mann-Whitney U test for the pre-intervention values comparisons.

4. Discussion

The aim of the study was to examine if alternating two educational treatments of similar invasion team sports could produce an increment of perceived, conceptual, and behavioural tactical skills compared with two independent treatments consecutively implemented in primary schoolchildren. Results demonstrated that the behavioural tactical skills were higher in the ATU participants, while the perceived tactical skills or conceptual tactical knowledge were not affected. ATU participants showed better punctuations in AJ, MG, and GP indices as much in soccer as in basketball and in overall invasion sports. Moreover, DMindex was also higher in ATU participants in overall invasion sports.

According to these results, ATU have demonstrated to be a more effective treatment than TTU consecutively delivered in the PE setting. Previous studies verified that the transfer between sports modalities with the same constitutive elements (e.g., invasion sports) is possible and desirable (Causer and Ford, 2014; Contreras *et al.*, 2005; Memmert and Harvey, 2010; Yáñez and Castejón, 2011). The main conclusions until now were to consider delivering sports modalities with similar elements consecutively or in the same moment of the school year. However, none of those previous studies proposed an alternated implementation of two sports modalities during the PE lessons in order to facilitate the connection perceived by the students; increasing the total learning time involved in common elements of the game shared by basketball and soccer in this case (e.g., occupation of space, defence support, or decision-making on and off-the-ball); and verifying the model of Viciana and Mayorga-Vega (2016) as an effective teaching method regarding the behavioural tactical skills in invasion team sports.

However, no differences were found regarding pre-post-intervention assessment of perceived tactical skills and conceptual tactical knowledge. Participants did not perceive themselves with better abilities regarding tactical behaviour in the sport games after the program, but they were, as the objective measurement of behavioural tactical skills demonstrated, which is an interesting result that teachers should consider in PE. As previous research detected in early ages, tactical knowledge is not an accurate indicator of participants' game performance, which supposes that a better performance is not associated with higher tactical knowledge, and vice-versa, probably because the initial stages of games learning is a period in which participants have difficulties in using their prior knowledge to come up with action plans in a games scenario (Sanchez-Mora *et al.*, 2011). The lack of gain regarding the tactical knowledge in the present study could have occurred due to the short-term program applied, or due to the sensibility of the measurement (*Invasion Game Knowledge Test*, Sanchez-Mora *et al.*, 2011). In the study of Gil-Arias *et al.* (2015) both elements were different (the duration of the program was 11 weeks, and the measurement instrument was video analysis). Their results showed an improvement of tactical knowledge in terms of complexity, structuration, and sophistication of the participants' reasoning of the game. Authors recognized that the verbalization of the reasoning regarding the game led to the participants displaying a more tactical approach to the game, predicting actions, selecting correct alternatives, and concluding a more correct tactical reasoning. Future studies might consider changing the questionnaire for a more complex measurement of tactical knowledge in order to increase the sensibility of the instrument, such as video analysis or discussion groups (Gray and Sproule, 2011).

The contingencies around the educational context, such as rain days, holidays, or organised excursions caused a statistical difference in the attendance ratio between groups (in favour of TTU participants). On one hand, this fact reinforces the validity of the ATU applied in this study because despite the difference in the attendance ratio between groups the results were favourable to ATU participants. On the other hand, the loss of PE days along with the application of the program makes us consider the necessity of incrementing the number of planned lessons for future interventions in the PE setting. Considering previous results in literature regarding tactical learning in invasion team sports with primary schoolchildren, where 10-13 PE lessons have been enough for achieving a statistical increase in students' learning (Harvey *et al.*, 2007; Moreno *et al.*, 2016), future studies should consider planning longer interventions (around 16-18 lessons approximately) in order to avoid the consequences of the loss of lessons and to assure greater gains in the tactical elements of the play (e.g., Mesquita *et al.*, 2012).

Nevertheless, despite the loss of PE lessons for the ATU participants, results needing to demonstrate that an ATU treatment was effective, and the GPAI measurement was sensible enough to detect the changes in behavioural tactical skills produced in primary schoolchildren. Previous studies carried out a behavioural tactical skills assessment with small-sided games and modified game situations (Gutiérrez and García-López, 2012; Sánchez-Mora *et al*., 2011). Probably, 2x2 and 3x3 represent the first and second levels of tactical games complexity (Gutiérrez *et al.*, 2014), due to the fact that the number of students involved in the game led them to develop different tactical actions (in on-the-ball and off-the-ball situations), but in the end, the game is not too complex to be developed by 5th-6th grade students. The present study has shown that the six minute long 3x3 free game could also lead to researchers identifying differences in behavioural tactical skills after the intervention program, even when this intervention was relatively shorter than foreseen (8-10 PE lessons). Moreover, when participants are involved in the whole game it supposes an improvement regarding the limitations of measurements with analytic game situations applied in previous studies (Gutiérrez *et al.,* 2014; Yáñez and Castejón, 2011), due to participants need to demonstrate their tactical abilities in the complexity of the game and not in particular situations of it.

To our knowledge, this is the first study that applies the ATU model proposed by Viciana and Mayorga-Vega (2016) to PE in regard to tactical skills. Nevertheless, as previous studies stated, age, gender, and experience of participants could influence on conceptual and behavioural learning regarding tactical sport games (Serra-Olivares, 2014). Thus, future research should examine this complex relationship in the PE setting, verifying the findings of this study in several other contexts (i.e., sports modalities, older and earlier ages of participants, or taking into account the prior level of behavioural and conceptual baggage of the students).

It is reasonable to conclude that an innovative treatment consisting of changing the time allocation of the teaching units in the PE curriculum, alternating sports with the same constitutive elements (such as invasion sports) instead of being delivered consecutively and unconnectedly, should be considered. Moreover, greater differences in the results of future studies, with better attendance ratio in the ATU group participants and with longer treatments, are expected.

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Paper XII

APRENDIZAJE TÁCTICO EN DEPORTES DE INVASIÓN EN LA EDUCACIÓN FÍSICA: INFLUENCIA DEL NIVEL INICIAL DE LOS ESTUDIANTES

[TACTICAL LEARNING IN INVASION SPORTS IN PHYSICAL EDUCATION: INFLUENCE OF STUDENTS' BASELINE LEVEL]

Guijarro-Romero, S., Mayorga-Vega, D., & Viciana, J.

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ARTIGOS ORIGINAIS

APRENDIZAJE TÁCTICO EN DEPORTES DE INVASIÓN EN LA EDUCACIÓN FÍSICA: INFLUENCIA DEL NIVEL INICIAL DE LOS ESTUDIANTES

APRENDIZAGEM TÁTICA EM ESPORTES DE INVASÃO NA EDUCAÇÃO FÍSICA: INFLUÊNCIA DO NÍVEL INICIAL DE ALUNOS

TACTICAL LEARNING IN INVASION SPORTS IN PHYSICAL EDUCATION: INFLUENCE OF STUDENTS' BASELINE LEVEL

Santiago Guijarro-Romero[*], Daniel Mayorga-Vega[**], Jesús Viciana[*]

Palabras clave:
Aptitud.
Deportes.
Técnicas.
Estudiantes.
Educación Física.

Resumen: El objetivo del presente estudio fue comparar el efecto de un programa de deportes de invasión durante las clases de Educación Física sobre el aprendizaje táctico objetivo en función del nivel inicial de los estudiantes. 85 estudiantes de 5º y 6º curso de educación primaria realizaron dos unidades didácticas de fútbol sala y baloncesto durante las clases de Educación Física. El grupo de control realizó las unidades didácticas siguiendo un enfoque tradicional técnico-táctico y el grupo experimental siguiendo un enfoque táctico. Los estudiantes del grupo experimental fueron divididos según la habilidad táctica inicial en baja ($< P_{50}$) y alta ($\geq P_{50}$). Antes y después de la intervención se evaluó la habilidad táctica objetiva en deportes de invasión. Los resultados mostraron que solo los estudiantes con bajo nivel inicial mejoraron significativamente su habilidad táctica en deportes de invasión tras un programa a corto plazo.

Palavras chave:
Aptidão.
Esportes.
Técnica.
Estudantes.
Educação Física.

Resumo: O objetivo do presente estudo foi comparar o efeito de um programa de esportes de invasão durante as aulas de Educação Física sobre a aprendizagem tática objetiva em função de no nível inicial de alunos. 85 estudantes de 5º - 6º ano da educação primária fizeram duas unidades didáticas de futsal e basquete durante as aulas de Educação Física. O grupo de controle realizou as unidades didáticas seguindo uma abordagem técnico-tática tradicional e o grupo experimental seguindo uma abordagem tática. Os estudantes do grupo experimental foram divididos de acordo com a habilidade tática inicial em baixa ($< P_{50}$) e alta ($\geq P_{50}$). Antes e depois da intervenção, a habilidade tática objetiva em esportes de invasão foi avaliada. Os resultados mostraram que apenas estudantes com baixo nível inicial melhoraram significativamente sua habilidade tática em esportes de invasão após um programa de curto prazo.

Keywords:
Aptitude.
Sports.
Techniques.
Students.
Physical Education.

Abstract: The purpose of the present study was to compare the effect of an invasion sports program during Physical Education lessons on objective tactical learning according to students' baseline skill level. Eighty-five students from 5th to 6th grade of primary education attended two teaching units of futsal and basketball during Physical Education lessons. The control group performed the teaching units following a traditional technical-tactical approach while the experimental group followed a tactical approach. Students in the experimental group were divided in low ($< P_{50}$) and high ($\geq P_{50}$) according to their baseline tactical skills. Objective tactical skills in invasion sports were assessed before and after the intervention. Results showed that only students with low baseline level significantly improved their tactical skills in invasion sports after a short-term program.

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1 INTRODUCCIÓN

La táctica es un elemento esencial del juego deportivo porque proporciona a los participantes mayor capacidad para tomar decisiones y practicar con facilidad y destreza un deporte determinado (CAUSER; FORD, 2014; WILLIAMS; FORD, 2013) Por ello, además de conseguir un aprendizaje del componente técnico de los deportes (entendiendo aprendizaje como la adquisición de conocimientos y/o habilidades por parte de los estudiantes a través del estudio, la práctica o la experiencia), es importante que los estudiantes adquieran también un buen aprendizaje táctico que les permita en situaciones reales de juego tomar decisiones correctas en cada situación en función del resto de elementos intervinientes (por ejemplo, el posicionamiento de los compañeros o los adversarios). Williams y Ford (2013) definieron la toma de decisiones en el deporte como la habilidad de utilizar la información de la situación actual de juego, así como el conocimiento propio para seleccionar la acción o conjunto de acciones que mejor se orienten hacia la meta a conseguir según el deporte que se esté practicando. La literatura previa ha mostrado que la adquisición de habilidades tácticas trae consigo numerosos beneficios como mejoras en los niveles de competencia deportiva percibida (VICIANA; MAYORGA-VEGA; BLANCO, 2014) o el autoconcepto físico (PAPAIOANNOU *et al.*, 2006), que actúan como factores de predisposición (variables mediacionales) hacia la práctica de actividad física (WELK, 1999). Por ejemplo, en la reciente investigación realizada por Jaakkola *et al.* (2016) los estudiantes con mayor habilidad táctica mostraron mayores niveles de actividad física en su tiempo libre.

Por ello, numerosos países requieren este tipo de aprendizaje en el currículum nacional de sus estudiantes (por ejemplo, en los Estados Unidos de América, LUND; TANNEHILL, 2015). En España, el Ministerio de Educación, Cultura y Deporte (2014) requiere que los profesores de educación física (EF) desarrollen el aprendizaje táctico de los deportes en los estudiantes de educación primaria y secundaria.

Por otro lado, la enseñanza de los deportes de invasión desde un punto de vista táctico (entendiendo enseñanza como el proceso por el que el profesor transmite conocimientos referentes a una materia a los estudiantes), tiene como objetivo fundamental proporcionar a los estudiantes una visión global del complejo proceso de toma de decisiones que tiene lugar durante la práctica de un deporte, así como dotarlos de numerosas habilidades tácticas que podrían ser transferidas a otros deportes de invasión con elementos constitutivos parecidos, facilitándose el aprendizaje de sucesivos deportes similares (CAUSER; FORD, 2014) En este sentido, el uso del concepto de “transferencia” podría ser una buena idea para proponer intervenciones educativas eficaces en EF con el objetivo de aprender las habilidades tácticas de los deportes (MEMMERT; HARVEY, 2010). Por eso, abordar varios deportes con la misma estructura táctica en una misma unidad didáctica parece interesante (VICIANA; MAYORGA-VEGA, 2016; YÁÑEZ; CASTEJÓN, 2011).

Hasta la fecha, se han realizado diferentes intervenciones con el objetivo de mejorar el aprendizaje táctico de los deportes de invasión en los estudiantes en el contexto de la EF (MESQUITA; FARIAS; HASTIE, 2012; YÁÑEZ; CASTEJÓN, 2011) comprobándose que el nivel táctico de los estudiantes mejoraba tras la aplicación de un programa de deportes de invasión basado en un enfoque táctico. Sin embargo, los autores anteriores no tuvieron en cuenta en sus análisis, la influencia del nivel inicial en los deportes (GUTIÉRREZ *et al.*, 2011).

Por el contrario, otros estudios sí que tuvieron en cuenta el nivel de habilidad táctica de los estudiantes a la hora de comprobar la efectividad de los programas aplicados para la mejora del aprendizaje táctico de los deportes en los estudiantes (ARAÚJO *et al.*, 2015; MAHEDERO *et al.*, 2015; PEREIRA *et al.*, 2015). En todos ellos, se observó cómo los estudiantes con menor nivel de habilidades mejoraban más que los que tenían un mayor nivel. Desafortunadamente, todos los estudios anteriores fueron realizados con deportes como voleibol, mini-voleibol y habilidades de pista como salto de longitud, no encontrándose estudios previos con deportes de invasión. Consecuentemente, el objetivo principal del presente estudio fue comparar el efecto de un programa de deportes de invasión durante las clases de EF sobre el aprendizaje táctico objetivo en función del nivel de inicial de los estudiantes.

2 MÉTODO

2.1 Participantes

Un total de 85 estudiantes de quinto y sexto curso de educación primaria (edad: 10-12 años) participaron en el presente estudio. Por razones prácticas y debido a la naturaleza del presente estudio, se empleó un diseño *cluster-randomized controlled trial* (CAMPBEL; STANLEY, 1963). En el contexto educativo, al trabajarse con clases naturales indivisibles, dicho diseño es más ecológico (es decir, presenta mayor validez externa), de ahí que es el que se usa comúnmente en este contexto (MAYORGA-VEGA; VICIANA, 2015). El diseño *cluster-randomized controlled trial* consiste en tomar a las clases naturales completas (y no los estudiantes individualmente como en el *randomized controlled trial*) como "unidad" para asignar aleatoriamente a los grupos experimentales y control. Además, la asignación de las clases a los grupos se realizó de forma balanceada por curso. Luego, de igual forma que en un diseño *randomized controlled trial*, en cuanto a la variable independiente, a todos los participantes del grupo experimental se les aplicó una intervención experimental y a los del grupo control una tradicional; y en cuanto a la variable dependiente, a todos los participantes se les evaluó antes y después de la intervención siguiendo el mismo procedimiento. Todas estas cuestiones permitieron controlar la validez interna del presente estudio. Por ello, las clases naturales, balanceadas por curso, se asignaron aleatoriamente al grupo control (GC) y el grupo experimental (GE). Posteriormente, durante los análisis estadísticos, cada GE fue dividido a su vez en dos subgrupos según el nivel táctico inicial de los estudiantes (GE1 $< P_{50}$, con bajo nivel; y GE2 $\geq P_{50}$, con alto nivel). Las agrupaciones se realizaron independientemente de acuerdo al valor inicial de cada variable. Los criterios de inclusión fueron: a) estar matriculado en quinto o sexto curso de la escuela seleccionada; b) no padecer ninguna enfermedad o lesión que les impidieran realizar actividad física con normalidad; c) presentar el consentimiento informado firmado por sus padres o tutores legales, y d) presentar el asentimiento informado por parte de los escolares. Los criterios de exclusión fueron: a) tener una asistencia al programa de intervención de al menos ocho sesiones, y b) realizar correctamente la evaluación antes y después del programa. El protocolo del presente estudio respetaba el acuerdo actual de la Declaración de Helsinki sobre principios éticos para la investigación en seres humanos y fue aprobado por el Comité Ético de la Universidad de Granada.

2.2 Medidas

La evaluación se realizó antes y después del programa de intervención durante dos sesiones de EF. Todas las evaluaciones fueron realizadas por los mismos evaluadores, instrumentos y condiciones. En la primera de ellas, se solicitaron las características generales (edad, género, deporte de invasión extracurricular y federado en deporte extracurricular) y se aplicó el cuestionario de clima tarea con una breve introducción y explicando las instrucciones de cómo cumplimentarlo correctamente. En la segunda, se midió la habilidad táctica objetiva en deportes de invasión (fútbol-sala y baloncesto) a través de partidos de tres contra tres, balanceando el género en la composición de los equipos. Las situaciones de evaluación consistieron en tres minutos de un partido de baloncesto con una única mini canasta a 260 cm de altura y tres minutos de un partido de fútbol-sala con dos porterías de 200 cm de ancho delimitadas por conos y sin portero. Ambos partidos se realizaron en un campo de dimensiones reducidas (10 m x 20 m). Todos los estudiantes llevaban un dorsal en la espalda con el fin de facilitar el posterior análisis de vídeo.

Clima tarea en educación física. Se empleó la versión adaptada y validada al español del *Cuestionario de Percepción del Clima Motivacional en el Deporte-2* (PMCSQ-2) adaptado a la EF (GONZÁLEZ-CUTRE; SICILIA; MORENO-MURCIA, 2008). Este cuestionario está compuesto por 33 ítems agrupados en dos factores de orden superior (clima ego, 16 ítems) y clima tarea (17 ítems). A su vez cada factor está compuesto por tres subescalas; el clima ego estaba compuesto por castigo por errores (6 ítems), reconocimiento desigual (7 ítems) y rivalidad (3 ítems), y clima tarea por aprendizaje cooperativo (4 ítems), esfuerzo/mejora (8 ítems) y papel importante (5 ítems). En el presente estudio se utilizaron las tres subescalas del clima tarea. El cuestionario estaba precedido del encabezado “Durante las clases de EF…”. Se empleó una escala tipo Likert de 10 puntos que iba de “Totalmente en desacuerdo” a “Totalmente de acuerdo”. La versión española del cuestionario PMCSQ-2 adaptada a la EF ha demostrado unas propiedades psicométricas adecuadas en escolares (CFI = 0,90; RMSEA = 0,04; Alfa de Cronbach = 0,84) (GONZÁLEZ-CUTRE; SICILIA; MORENO-MURCIA, 2008).

Habilidad táctica objetiva. El *Game Performance Assesment Instrument* (GPAI) fue empleado con el fin de medir la habilidad táctica objetiva en deportes de invasión. Oslin, Mitchell, y Griffin (1998), creadores del instrumento, diferenciaron varios elementos con respecto al rendimiento del juego que componen el GPAI. En el presente estudio, las habilidades técnico-tácticas fueron evaluadas durante el desarrollo del juego teniendo en cuenta las siguientes seis variables (las dos primeras relacionadas con las situaciones en posesión del balón, y las cuatro últimas relacionadas con movimientos o acciones sin posesión del balón): a) Toma de decisiones. El jugador en posesión del balón tiene que decidir si pasar a un compañero, progresar hacia la meta contraria o realizar un lanzamiento. Estas tres acciones fueron evaluadas en cada juego según la mejor opción disponible en cada caso; b) Ejecución técnica. En esta categoría fueron evaluados el pase, la interceptación y el lanzamiento (por ejemplo, interceptar un pase del oponente); c) Base. En esta categoría se analizó el repliegue, donde el jugador tiene que volver a su posición de base defensiva dificultando la progresión del adversario; d) Ajuste. Se refiere a la capacidad del jugador de ejecutar en ataque o en defensa el movimiento adecuado según el desarrollo del juego (por ejemplo, avanzar hacia meta contraria una vez realizado el pase a un compañero o realizar ayudas defensivas a un compañero al que ha sobrepasado el contrario con el balón); e) Apoyo. Se refiere a servir de ayuda a un compañero de equipo en posesión del balón, situándose en una posición adecuada para recibir un posible pase de éste, y f) Marcaje. Consiste en movimientos sin la posesión del balón en situaciones defensivas, evitando que el oponente reciba el balón, o la progresión de éste si está en posesión del balón. La fiabilidad y validez del GPAI ha sido ampliamente comprobada en estudios previos (Alfa de Cronbach = 0,84-0,99; diferencia de rendimiento deportistas con nivel elevado vs. bajo, $p < 0{,}05$) (por ejemplo, OSLIN; MITCHEL; GRIFFIN, 1998; ROBERTS, 2007).

La frecuencia de todas estas categorías fue registrada para cada jugador (participante), en ambos casos (acciones apropiadas e inapropiadas). Un observador entrenado participó registrando todas las categorías mediante el análisis de video. El entrenamiento intra-observador se llevó a cabo con cuatro sesiones, codificando las acciones de todos los participantes durante un partido seleccionado aleatoriamente (seis minutos en total, tres de un partido de fútbol y tres de un partido de baloncesto), y obteniendo un porcentaje de coincidencia requerido mayor del 80% entre dos medidas realizadas con una semana de diferencia (ANGUERA, 1988). Las dos primeras sesiones se llevaron a cabo con todas las categorías, confirmando un elevado porcentaje de coincidencia de todas ellas, requiriéndose una sesión adicional con el fin de clarificar algunos aspectos de registro, y una cuarta para verificar un adecuado porcentaje de coincidencia.

Las fórmulas de rendimiento en el juego utilizadas por el GPAI consistieron en un índice calculado de la siguiente manera: acciones correctas/(acciones correctas+acciones incorrectas) (MEMMERT; HARVEY, 2010), resultando un número entre cero y uno, donde "uno" significa que el participante realizó todas las acciones evaluadas correctamente (mayor nivel de habilidad táctica), "cero coma cinco" significa que el participante realizó el mismo número de acciones correctas que incorrectas (nivel medio de habilidad táctica) y "cero" significa que el participante no realizó ninguna acción correcta (menor nivel de habilidad táctica). Por ejemplo, para el índice de ejecución se calculó de la siguiente fórmula: acciones correctas de ejecución/(acciones correctas de ejecución+acciones incorrectas de ejecución). Posteriormente, se calculó el índice de rendimiento en el juego [(índice toma de decisiones+índice ejecución técnica+índice base+índice ajuste+índice apoyo+índice marcaje)/6] (ARIAS-ESTERO; CASTEJÓN, 2014; OSLIN; MITCHEL; GRIFFIN, 1998). Finalmente, se calcularon los índices de habilidad táctica en deportes de invasión mediante el promedio de los índices separados de fútbol-sala y baloncesto.

2.3 Procedimiento

Durante las clases de EF, todos los participantes realizaron dos unidades didácticas de deportes de invasión (fútbol-sala y baloncesto) durante dos sesiones a la semana durante ocho semanas. El programa inicial fue modificado debido a diferentes contingencias habituales en la escuela como días lluviosos y festivos; quedando finalmente un total de diez sesiones (cinco de cada deporte). La estructura de las sesiones fue igual para ambos grupos. Primero, un calentamiento de diez minutos con actividades de carrera y otras más específicas de fútbol-sala/baloncesto que fueran introduciendo el uso del balón. Segundo, la parte principal estaba compuesta por cuatro-cinco tareas de ocho minutos cada una aproximadamente. Al final, había cinco minutos de vuelta a la calma donde se hacía una puesta en común de los aspectos trabajados y aprendidos durante la sesión.

Los estudiantes del GE realizaron un programa de intervención mediante el modelo de unidades didácticas alternadas de fútbol-sala y baloncesto basado en un enfoque táctico de los deportes (VICIANA; MAYORGA-VEGA, 2016). La intervención consistió en realizar una sesión de un deporte (fútbol-sala) seguida de otra del otro deporte (baloncesto) durante todo el programa, centrándose en establecer una conexión en el aprendizaje de ambos deportes. El profesor de EF puso especial énfasis en establecer una conexión en la enseñanza de las dos modalidades deportivas y en el mantenimiento de la estructura de las tareas de las sesiones entre ambas modalidades. Para ello, el profesor mostraba a los estudiantes la conexión entre el aprendizaje técnico-táctico de ambas modalidades deportivas debido a la presencia de elementos comunes a ambas (por ejemplo, una finta o una ocupación de espacios libres). Los estudiantes del GE recibían un *feedback* tanto instructivo (por ejemplo, "para evitar el avance del equipo contrario debes colocarte en línea de pase e intentar interceptar el balón") como interrogativo (por ejemplo, "¿qué podrías hacer para evitar que los contrarios avancen hacia tu portería?") con el propósito de hacerlos reflexionar sobre las tareas que estaban realizando a la vez que se buscaba una conexión entre las dos modalidades que se estaban trabajando.

Los participantes del GE primero realizaron un calentamiento de diez minutos compuesto por actividades de carrera que progresivamente iban introduciendo el uso del balón como por ejemplo un "pilla-pilla" con balón cuyas reglas son: Cada jugador tiene un balón; uno de ellos se la queda y tiene que pillar a otro jugador; cuando un jugador es pillado se cambian los roles, el que pilla pasa a ser pillado y viceversa; mientras dura el juego todos los jugadores tienen que ir conduciendo el balón. Luego, durante la parte principal de la sesión, se realizaron cuatro-cinco tareas basadas en juegos y situaciones tácticas de las diferentes modalidades deportivas. La progresión de las acciones tácticas de juego iba del uno contra uno hasta el tres contra tres. Los aspectos trabajados fueron la protección del balón, el marcaje y desmarcaje, la ocupación de espacios libres, la interceptación del balón, el repliegue (individual y colectivo), la transición ataque-defensa y viceversa, y la toma de decisiones. Específicamente, desde la primera a la sexta sesión, los estudiantes trabajaron los aspectos tácticos mencionados a través de diferentes tareas grupales que iban aumentando su nivel de dificultad (por ejemplo, dos contra dos con la norma de que para marcar gol había que dar un mínimo de tres pases, luego cinco y así sucesivamente). Desde la sesión séptima a novena, además de seguir trabajando los aspectos tácticos mencionados, al final de la sesión se incluyó una tarea que iba desde el tres contra tres al seis contra seis, donde los estudiantes ponían en práctica los aspectos tácticos aprendidos en situación real de juego. Finalmente, una sesión décima en la que se llevaron a cabo diferentes partidos de tres contra tres con el fin de afianzar los aspectos trabajados durante todo el programa. Por último, en la vuelta a la calma, el profesor preguntaba a los estudiantes qué habían aprendido durante la sesión y si encontraban aspectos y/o acciones iguales o parecidas en la otra modalidad deportiva que estaban trabajando.

Por su parte, los estudiantes del GC realizaron consecutivamente dos unidades didácticas de fútbol-sala y baloncesto basadas en un enfoque tradicional técnico-táctico. Las tareas administradas al GC tuvieron un carácter más instructivo y focalizadas en el aprendizaje aislado y sin conexión de una modalidad deportiva a otra. Los estudiantes del GC recibían un feedback totalmente instructivo durante las diferentes sesiones.

Los participantes del GC primero realizaron un calentamiento de diez minutos compuesto por actividades de carrera que progresivamente iban introduciendo el uso del balón como, por ejemplo, un "rondo" cuyas reglas son: los jugadores se disponen formando un círculo; el jugador que tiene que robar el balón se coloca en medio del círculo; cuando el jugador del centro intercepta un pase de uno de los jugadores que forman el círculo se intercambian los roles. A continuación, durante la parte principal de la sesión se realizaron cuatro-cinco tareas basadas en aspectos técnicos y una tarea final que consistía en partidos de tres contra tres donde se ponían en práctica los aspectos trabajados durante la sesión en el juego real. Los aspectos trabajados fueron el control del balón, el pase, la conducción, el lanzamiento, la protección del balón, la interceptación del balón, las fintas y la transición ataque-defensa y viceversa. Por último, en la vuelta a la calma se realizaban actividades de menor intensidad vinculadas a los aspectos trabajados en las diferentes sesiones como, por ejemplo, derribar conos mediante un lanzamiento suave del balón.

2.4 Análisis estadístico

Se calcularon estadísticos descriptivos de las variables medidas. Se utilizó la prueba chi cuadrado para comparar si los tres grupos estaban balanceados en cuanto a la edad, género, participación en deportes de invasión extracurricular, estar federado en algún deporte extracurricular y asistencia al programa. Se usó la prueba Kruskal-Wallis para estudiar las posibles diferencias en los valores pre-intervención y cambio (post-intervención - pre-intervención) de las dimensiones clima tarea en EF entre los tres grupos. El efecto del programa de intervención se estudió mediante un ANOVA de un factor, incluyendo *grupo* como factor fijo y *cambio* (post-intervención - pre-intervención) como variable dependiente. Para los análisis *post hoc*, se realizaron comparaciones por pares con la corrección de Bonferroni. Nótese que aunque algunas variables como el género o la asistencia al programa mostraron diferencias estadísticamente significativas entre los grupos, no se controlaron estadísticamente (es decir, usándolas como covariables) porque no revelaron un efecto estadísticamente significativo. El tamaño del efecto eta al cuadrado parcial (η^2_p) y *d* de Cohen se utilizó para estimar la magnitud del efecto del programa de intervención (FIELD, 2013). Todos los análisis estadísticos se realizaron con el programa SPSS, versión 21.0 para Windows (IBM® SPSS® Statistics). El nivel de significación se estableció en valores de $p < 0,05$.

3 RESULTADOS

La Tabla 1 muestra las características generales de los participantes analizados y las diferencias entre los grupos de acuerdo con la variable rendimiento en el juego. Como puede observarse en la tabla, se encontraron diferencias significativas entre los grupos en términos de género, asistencia al programa, participación en deportes de invasión y estar federado en algún deporte extracurricular. En cambio, los tres grupos estaban balanceados en términos de edad. Además, los resultados no mostraron diferencias significativas en las dimensiones clima tarea en EF después de la intervención. Los estudiantes obtuvieron una asistencia media de 9,5, 8,7 y 9,3 sesiones para el GC, GE1 y GE2, respectivamente.

Tabla 1- Características generales de los participantes analizados y diferencias entre los grupos [a]

	GC	GE1	GE2	Prueba chi cuadrado	
	(n = 42)	(n = 23)	(n = 20)	X^2	p
Edad (10/11-12 años)	48/52	61/39	25/75	5,644	0,059
Género (varones/mujeres)	38/62	30/70	80/20	12,612	0,002
Deporte de invasión extracurricular (sí/no)	45/55	22/78	80/20	14,685	0,001
Federado en deporte extracurricular (sí/no)	43/57	26/74	65/35	6,605	0,037
Asistencia (8-9/10 sesiones)	33/67	70/30	40/60	8,127	0,017
Aprendizaje cooperativo (pre-intervención)	8,8(1,6)	9,0(1,8)	8,4(1,2)	2,987	0,225
Esfuerzo/mejora(pre-intervención)	9,3(1,5)	9,0(1,6)	8,8(1,0)	1,726	0,422
Papel importante (pre-intervención)	8,8(1,4)	8,8(2,4)	8,6(1,2)	0,055	0,973
Aprendizaje cooperativo (cambio)	0,0(1,1)	0,0(1,3)	-0,3(1,8)	0,378	0,828
Esfuerzo/mejora (cambio)	0,1(1,3)	0,0(1,1)	-0,2(1,1)	0,025	0,988
Papel importante (cambio)	0,2(1,4)	0,2(1,0)	-0,3(1,2)	2,607	0,272

Fuente: datos de los autores

Nota. GC = Grupo control; GE1 = Grupo experimental 1 (bajo nivel inicial); GE2 = Grupo experimental 2 (alto nivel inicial).

[a] Los grupos reportados se han tomado en base a la variable rendimiento en el juego. Todas las agrupaciones mostraron resultados similares.

La Tabla 2 muestra el efecto del programa de intervención sobre el aprendizaje táctico objetivo en deportes de invasión de acuerdo al nivel inicial de los estudiantes. Los resultados mostraron que tras el programa de intervención, el GE1 obtuvo mejoras significativas en su habilidad base, ajuste, marcaje, toma de decisiones y rendimiento en el juego con respecto al GC. En cambio, el GE2 solo mejoró su habilidad de ajuste con respecto al GC. Además, el GE1 obtuvo mejoras significativas en la habilidad ejecución técnica, apoyo, base, ajuste, marcaje y rendimiento en el juego con respecto al GE2.

Tabla 2- Efecto del programa de intervención sobre los niveles de habilidad táctica en deportes de invasión

	Pre-intervención	Post-intervención	Cambio	ANOVA		TE
	Media (DE)	Media (DE)	Media (DE)	Comp.	p	η^2_p/d
Ejecución técnica				ANOVA	0,020	0,09
GC (n = 42)	0,56(0,17)	0,56(0,14)	0,01(0,17)	GE1-GC	0,601	0,33
GE1 (n = 21)	0,41(0,12)	0,47(0,10)	0,06(0,16)	GE2-GC	0,158	-0,50
GE2 (n = 22)	0,65(0,09)	0,57(0,10)	-0,07(0,1)	GE1-GE2	0,018	0,83
Apoyo				ANOVA	0,011	0,10
GC (n = 42)	0,41(0,25)	0,45(0,26)	0,03(0,23)	GE1-GC	0,371	0,41
GE1 (n = 19)	0,16(0,10)	0,28(0,21)	0,13(0,20)	GE2-GC	0,152	-0,49
GE2 (n = 24)	0,63(0,21)	0,55(0,27)	-0,08(0,21)	GE1-GE2	0,009	0,90
Base				ANOVA	0,002	0,15
GC (n = 42)	0,48(0,31)	0,53(0,29)	0,04(0,28)	GE1-GC	0,018	0,76
GE1 (n = 17)	0,24(0,14)	0,50(0,21)	0,26(0,25)	GE2-GC	0,528	-0,32
GE2 (n = 26)	0,69(0,16)	0,64(0,23)	-0,05(0,25)	GE1-GE2	0,001	1,08
Ajuste				ANOVA	< 0,001	0,48
GC (n = 42)	0,54(0,20)	0,50(0,17)	-0,04(0,19)	GE1-GC	< 0,001	1,69
GE1 (n = 21)	0,33(0,11)	0,69(0,14)	0,37(0,17)	GE2-GC	< 0,001	0,78
GE2 (n = 22)	0,61(0,09)	0,76(0,13)	0,15(0,15)	GE1-GE2	< 0,001	0,91

Continúa en la siguiente página...

... continuación de la tabla 2.

Marcaje				ANOVA	< 0,001	0,30
GC (n = 42)	0,51(0,26)	0,41(0,26)	-0,10(0,32)	GE1-GC	< 0,001	1,31
GE1 (n = 21)	0,20(0,13)	0,54(0,23)	0,34(0,22)	GE2-GC	1,000	0,17
GE2 (n = 22)	0,63(0,11)	0,59(0,25)	-0,04(0,27)	GE1-GE2	< 0,001	1,14
Toma de decisiones				ANOVA	0,005	0,12
GC (n = 42)	0,57(0,29)	0,59(0,31)	0,02(0,41)	GE1-GC	0,004	0,89
GE1 (n = 18)	0,18(0,16)	0,53(0,34)	0,35(0,35)	GE2-GC	1,000	0,19
GE2 (n = 25)	0,65(0,16)	0,73(0,15)	0,09(0,22)	GE1-GE2	0,058	0,70
Rendimiento en el juego				ANOVA	< 0,001	0,23
GC (n = 42)	0,51(0,16)	0,51(0,14)	-0,01(0,16)	GE1-GC	< 0,001	1,13
GE1 (n = 23)	0,36(0,11)	0,52(0,13)	0,16(0,12)	GE2-GC	0,285	0,41
GE2 (n = 20)	0,59(0,05)	0,65(0,09)	0,05(0,09)	GE1-GE2	0,027	0,73

Fuente: datos de los autores

Nota. TE = Tamaño del efecto; GC = Grupo control; GE1 = Grupo experimental 1 (bajo nivel inicial); GE2 = Grupo experimental 2 (alto nivel inicial).

4 DISCUSIÓN

El objetivo principal del presente estudio fue comparar el efecto de un programa de deportes de invasión durante las clases de EF sobre el aprendizaje táctico objetivo en función del nivel de inicial de los estudiantes. Los resultados del presente estudio mostraron cómo un programa en EF de dos sesiones semanales durante ocho semanas solo mejora el nivel táctico en deportes de invasión (excepto ejecución técnica y apoyo) de aquellos estudiantes con menor nivel inicial. En cambio, en los estudiantes con un nivel táctico inicial mayor, el programa de intervención solo mejoró la variable ajuste. Entre otras muchas tareas, los profesores de EF deben llevar a cabo programas de intervención con el fin de mejorar la capacidad de respuesta de los alumnos ante diferentes retos tácticos planteados relacionados con juegos y deportes, haciendo uso de los diferentes principios y reglas implícitas en ellos (ESPAÑA, 2014).

Hasta la fecha, se han realizado diferentes intervenciones con el objetivo de mejorar el aprendizaje táctico de los deportes de invasión en los estudiantes en el contexto de la EF (MESQUITA; FARIAS; HASTIE, 2012; YÁÑEZ; CASTEJÓN, 2011), comprobándose que el nivel táctico de los estudiantes mejoraba tras la aplicación de un programa de deportes de invasión basado en un enfoque táctico.

Desafortunadamente, a pesar de que el nivel táctico inicial de los estudiantes podría influir en la efectividad de los programas aplicados (GUTIÉRREZ *et al.*, 2011), los autores anteriores no tuvieron en cuenta dicho factor. Algunos estudios previos sí han tenido en cuenta el nivel táctico inicial de los estudiantes a la hora de evaluar la mejora del aprendizaje táctico en los deportes tras un programa en EF (ARAÚJO *et al.*, 2015; MAHEDERO *et al.*, 2015; PEREIRA *et al.*, 2015). De modo similar al presente estudio, los estudios anteriores observaron que los alumnos con un nivel más bajo eran los que más se beneficiaban de los programas aplicados. Respecto a la mejora no tan notable en aquellos estudiantes con un nivel inicial más alto, de acuerdo con los autores mencionados anteriormente, pudo ser debido a que las tareas diseñadas fueron las mismas para todos los grupos, al igual que en el presente estudio, por lo que aquellos estudiantes que tuvieran un nivel inicial más alto pudieron sufrir lo que se denomina "efecto techo" (ARAÚJO *et al.*, 2015; MAHEDERO *et al.*, 2015; PEREIRA *et al.*, 2015). Por lo tanto, la aplicación de estilos de enseñanza individualizadores como el trabajo por grupos de nivel (DELGADO, 1991), podría ser una solución efectiva a este problema, ya que a través de diferentes progresiones de tareas adaptadas al nivel inicial de los estudiantes podría progresarse hacia conceptos y procedimientos más avanzados para aquellos estudiantes más aventajados inicialmente.

De manera similar al presente estudio, Mesquita, Farias, y Hastie (2012) examinaron el efecto de un programa híbrido Modelo de Educación Deportiva (*Sport Education Model*)-Modelo Competencia en Juegos de Invasión (*Invasion Games Competence Model*) sobre el aprendizaje táctico de los estudiantes de educación primaria. Además de en función del género, estos autores analizaron los efectos del programa independientemente para alumnos con bajo, medio y alto nivel táctico inicial. Por un lado, los autores observaron que los estudiantes con bajo nivel táctico inicial mejoraron significativamente su ejecución de las habilidades defensivas; los estudiantes con un nivel medio mostraron mejoras significativas en el total de las decisiones de acciones sin balón y en las acciones defensivas sin balón, así como en la ejecución de las habilidades defensivas; en cuanto a los estudiantes con mayor nivel táctico inicial solo se observaron mejoras significativas en las acciones defensivas sin balón. A diferencia del presente estudio, Mesquita, Farias, y Hastie (2012) obtuvieron una mejora después del programa en todos los estudiantes independientemente del nivel inicial. Sin embargo, es importante señalar que la duración del programa aplicado por estos autores fue de 22 sesiones, es decir, más del doble que la intervención aplicada en el presente estudio, por lo que la duración de la intervención podría explicar los resultados obtenidos. Por lo tanto, otra posible solución a la mejora no tan significativa de los estudiantes con mayor nivel inicial, podría ser la aplicación de un programa más prolongado en el tiempo que junto con la individualización por niveles anteriormente citada, podría producir mejoras en los deportes trabajados en todos los estudiantes.

En el contexto de la educación española, Práxedes *et al.* (2016) comprobaron si un programa de enseñanza comprensiva basado en el modelo de *Teaching Games for Understanding* podía mejorar la toma de decisiones, así como la ejecución del pase y la conducción en fútbol-sala en el contexto educativo. Para ello, 21 alumnos de primero de educación secundaria realizaron siete sesiones de fútbol-sala siguiendo dicho modelo. Los resultados de este estudio mostraron cómo aquellos estudiantes sin experiencia federada en fútbol-sala mostraron diferencias significativas en la toma de decisiones referentes al pase, no ocurriendo lo mismo para la toma decisiones referentes a la conducción o para la ejecución de los elementos técnicos seleccionados. En cuanto a los estudiantes con experiencia federada, no se observaron diferencias significativas ni en la toma de decisiones ni en la ejecución del pase y la conducción tras el programa de intervención. En línea con los resultados del presente estudio, estos autores observaron cómo solo los estudiantes que no tenían ninguna experiencia federada en el deporte practicado (fútbol-sala) mejoraban significativamente tras la aplicación del programa. De acuerdo con estos autores, además del factor referente al diseño inadecuado de las tareas según el nivel de los estudiantes, otro factor determinante de las diferencias obtenidas en los resultados pudo ser el hecho de que los estudiantes practicasen fútbol en el horario extraescolar, tal y como sucede en el presente estudio, donde el número de estudiantes del grupo con mayor nivel inicial que practica deportes de invasión extracurricularmente fue superior que en el grupo de menor nivel. Debido a esta práctica extraescolar, los estudiantes podrán llegar a clase con un mayor nivel inicial, produciéndose nuevamente el efecto techo citado anteriormente.

En cuanto a la magnitud del efecto de la intervención, después del programa de deportes de invasión el tamaño del efecto del presente estudio fue moderado/alto (*d* = 0,76-1,69) para los estudiantes con bajo nivel táctico inicial en todas las variables menos en las de ajuste y ejecución técnica donde fue bajo (*d* = 0,33-0,41) con respecto a los estudiantes del grupo control. En el caso del grupo con alto nivel táctico inicial el tamaño del efecto fue trivial (*d* = -0,50-0,19) en todas las variables menos en la de rendimiento de juego que fue bajo (*d* = 0,41) y en la de ajuste que fue moderado (*d* = 0,78) en comparación con los estudiantes del grupo control. En cuanto a los dos grupos experimentales entre sí, el tamaño del efecto fue moderado/alto (*d* = 0,73- 1,14) para los estudiantes con bajo nivel táctico inicial en todas las variables menos en la de toma de decisiones con respecto a los estudiantes con alto nivel táctico inicial. Estos hallazgos indican que el programa de intervención del presente estudio fue más efectivo para aquellos alumnos con menor nivel inicial. De modo similar, Mesquita, Farias y Hastie (2012) encontraron un efecto alto tras la aplicación del programa en la variable rendimiento en el juego para los estudiantes con menor nivel inicial en comparación con los de un nivel medio (*d* = 0,99) y alto (*d* = 1,74). Respecto a los estudiantes con un nivel medio, el tamaño del efecto fue moderado (*d* = 0,75) en comparación con los de mayor nivel.

Este efecto podría verse apoyado por dos hechos fundamentales citados anteriormente: por un lado el diseño inadecuado de las tareas al nivel inicial de los estudiantes (ARAÚJO *et al.*, 2015; MAHEDERO *et al.*, 2015; PEREIRA *et al.*, 2015; PRÁXEDES *et al.*, 2016); y por otro, el hecho de que en el grupo con mayor nivel táctico inicial había más estudiantes que participaban en deportes de invasión extracurricular así como, más estudiantes federados en deportes extracurriculares que en el grupo con menor nivel táctico inicial. Ello podría dar lugar a que el efecto de un mismo programa sea menor en aquellos estudiantes cuyo nivel táctico de partida sea mayor. En cambio, a pesar de que la heterogeneidad del nivel de los alumnos es una realidad en el contexto de la EF, y que el empleo de estilos de enseñanza individualizadores como los grupos de nivel podría suponer una solución a este problema, debido a cuestiones prácticas en la mayoría de las ocasiones hay que optar por plantear las mismas tareas para todos. Por último, en el presente estudio otros factores como, por ejemplo, el clima tarea no influyeron puesto que no se encontraron diferencias estadísticamente significativas entre los grupos.

5 CONCLUSIONES

Los resultados del presente estudio sugieren que, durante las clases de EF, aquellos estudiantes con un nivel táctico inicial menor en deportes de invasión obtienen mayores mejoras que aquellos con mayor nivel táctico después de un programa de deportes de invasión. De acuerdo con los resultados de este estudio, con el objeto de conseguir un aprendizaje de la táctica deportiva en todos los alumnos, los profesores de EF deberían tener en cuenta el nivel inicial de sus alumnos, llevando a cabo programas en función de dicho nivel, por ejemplo, con estilos de enseñanza individualizadores (DELGADO, 1991). Además, con objeto de controlar posibles efectos mediacionales por parte del alumno en el proceso de aprendizaje, se recomienda el uso de instrumentos cualitativos de interrogación, como diarios y entrevistas, que pregunten al alumnado sobre su motivación, su manera de aprender, sus dificultades en el aprendizaje, y su opinión de la enseñanza ofrecida por el profesor, aspectos que podrían tener influencia en el aprendizaje táctico de los deportes de invasión.

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LIMITATIONS AND FUTURE RESEARCH STUDIES

[LIMITACIONES Y ESTUDIOS FUTUROS]

LIMITATIONS AND FUTURE RESEARCH STUDIES [LIMITACIONES Y ESTUDIOS FUTUROS]

The main limitations and future research studies of the present Doctoral Thesis are summarized below. For further information of any study, please check the corresponding section of each paper.

Papers I-IV, VI-XII: In the intervention studies there were some potential limitations that it should be acknowledged. Firstly, the non-probabilistic and relatively small sample size provides a lower generalization power. This fact could limit the generalizability of the obtained outcomes to the particular studied population and context. However, due to human and material resource restrictions, a probabilistic and larger sample could not be examined. Secondly, regarding the study design, the randomized control trial is often considered the "gold standard" to test the effectiveness of an intervention (Thomas et al., 2015). However, because of the nature of the context (i.e., school) and with the objective of keeping the ecological validity a cluster-randomized controlled trial was used instead. Since the main objective of the present intervention studies was to examine the effect of the PE-based interventions in order to obtain direct practical applications in the PE setting, performing the TUs in natural groups was a must (Campbell et al., 2012). Therefore, although the cluster-randomized controlled trial is a quasi-experimental design where the randomization is performed by natural groups instead of individuals such as in a true experimental design, the external validity is markedly greater (Thomas et al., 2015). Additionally, it must be pointed out that according to the education rules, the school centers assigned the students randomly and balanced by grade to each class, before starting the scholar year. However, in the case of the papers II, VI, VIII, and X, after applying the corresponding exclusion criteria, they were not balanced by gender. Even, the paper II was also not balanced by grade/group sizes because of the natural groups' availability. Nevertheless, these potential confounders were statistically controlled when necessary.

Likewise, in papers VI, VII, and IX, besides the manipulated variable by the researcher (i.e., the intervention program), because of the nature of the variable (i.e., *ex-post-facto* design) the second condition could not be manipulated. *Ex post facto* is a quasi-experimental design examining how an independent variable, present prior to the study, affects a dependent variable. That it is to say, *ex-post-facto* design does not include any form of manipulation before the fact occurs, as it is the case of a true experimental design. Therefore, although this design has to be applied as a substitute for true experimental research to test hypotheses about cause-and-effect relationships in situations in which it is not possible or ethically acceptable to manipulate as in the above mentioned papers, readers should be caution with these cause-and-effect relationships established (Thomas et al., 2015).

Other important limitations of the intervention studies were related to the evaluation. The first weakness was associated with the selection of the test used. CRF can be valid and accurately measured through laboratory tests (Baumgartner et al., 2015). Nevertheless, since laboratory testing requires sophisticated and expensive equipment, qualified examiners, and long testing sessions, this technique is not feasible in PE setting (Meredith & Welk, 2010). Therefore, in the present studies CRF field tests (i.e., 20-meter shuttle run test) with a demonstrated acceptable criterion-related validity among school-age children were used instead (Raghuveer et al., 2020). Additionally, the maximal oxygen uptake (VO_2max) was estimated through a validated equation (Léger et al., 1988) because it was not feasible to measure it directly. When practical reasons allow doing it, future research studies could examine the effect of similar intervention programs measuring maximal oxygen uptake by objective instruments such as portable gas analyzers, and could add information regarding different samples characteristics in order to generalize results.

Another important limitation of the intervention studies was the fact of not performing a blind evaluation. Due to the restricted human resources available for the most studies, a blind evaluation was not simply possible. However, several other measures were always taken into account in order to avoid extraneous variables. For instance, each evaluation was carried out by the same tester, using the same instruments and under the same conditions. The CRF measurements were taken in an indoor sports facility with a non-slippery floor, on the same day of the week, at the same time for each student, and under the same environmental conditions. The questionnaires were filled out in an ordinary classroom under silent conditions. When practical reasons allow it, future research studies should evaluate the effectives of these PE-based interventions through a single-blind cluster-randomized controlled trial design.

The last important limitation in the study with a reinforced TU (i.e., paper II) was the fact that the post-detraining values were not measured. Although CRF improvements are expected to decrease after a period of detraining (Kenney et al., 2015; Malina et al., 2004; Mujika & Padilla, 2001), a PE-based planning limitation is the fact that the academic year is frequently interrupted by several holiday periods, excursions, and other organized educational activities (Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-

Marban, 2014). For instance, the experimental group students performed the development TU during the first semester and then, after a period of detraining coinciding with the Christmas holidays, the students completed the reinforced TU during the second semester. Unfortunately, in the current study the detraining effect previous to the reinforced TU could not be examined for practical reasons, seeing as too many evaluations would suppose an excessive effort for students. However, a second experimental group who did not performed the reinforced TU after the development TU was used to control and contrast what could happen without the reinforced TU.

Paper V: The main limitation of the study about the validation of the CENAFI test was that it was validated in a specific setting. This may limit its generalizability and applicability to other contexts. Future research studies should design and validate a written test of knowledge of the environment for physical conditioning using general environments and spaces. That is, focusing the questions on objects or environments, which are present in every places or cities such as ramps, stairs, banks, slopes, or avenues, without specifying their location. This would allow a higher applicability of the built test.

Generally, it would be beneficial for PE teachers to know how to develop the big amount of PE curricular objectives during the scholar year through TUs that provide authentic outcomes, without the necessity of diminishing the learning time dedicated to each of them. Additionally, it would be very useful to know how long it takes to lose the improvements achieved after such TUs, and how could PE facilitate the maintenance of these acquired improvements over the time (i.e., not only during the academic year, but also during the out-of-school time; Guijarro-Romero et al., 2019; Viciana, Mayorga-Vega, & Merino-Marban, 2014). Consequently, in order to support evidence-based practice in PE for planning PE curriculum objectives, a deep examination of many additional related issues should be studied. For example, future research studies that do not have time restrictions in the PE subject (i.e., only two hours per week) (European Commission/EACEA/Eurydice, 2013; Hardman et al., 2014) should test if innovative TUs structures allow to acquire learnings of two or more PE objectives worked simultaneously during the same development TU (e.g., physical fitness and technical-tactical skills of sports). Moreover, future research studies should also examine if PE-based innovative TUs with other duration, frequency, and/or type would be also effective in students with high skills baseline levels. Examining in depth the effect of PE-based innovative TUs on additional health-related psychological markers is also required.

On the other hand, future research interventions should continue examining the effect of different detraining periods among schoolchildren. For example, knowing in depth when may be the exact moment in which CRF starts to decrease after having performed a physical fitness TU is necessary. Regarding the reinforced TUs among schoolchildren, future research interventions should examine their effects through different PE contents, thus facilitating different options for PE teachers to perform the reinforcement. Furthermore, future research interventions should also examine the effectiveness of interventions that encourage students to perform PA outside the PE setting through the application of motivational strategies such as Epstein's TARGET principles (Epstein, 1989), thus promoting lifelong PA in order to maintain healthy physical fitness levels. Further, knowing how to use the environment and its elements to practice PA autonomously applying different PE contents learned, not only the traditional physical fitness exercises. In this sense, it is necessary that future studies validate new and more general tests or even adapt the validated test of the present Doctoral Thesis (i.e., paper V) to other contexts, in order to allow PE teachers from different places can assess the acquisition of the knowledge about how to use the environment for the autonomous PA practice. Moreover, new applications of the irregular TUs in a collaborative project together with students' families may be examined. For instance, during weekends or even during long holidays periods such as Christmas or summer. Additionally, future research studies should examine in depth the effects of maintenance intervention programs with different combinations of duration, frequency, and/or type in order to retain the CRF gains obtained previously. Finally, future research studies should include a probabilistic and larger sample, which provide a higher generalization of the obtained outcomes. All of this knowledge could help and guide PE teachers to design TUs that allow a feasible and effective development and maintenance of students' health-related CRF in the PE setting, as well as the development and achievement of the rest of curricular objectives of the subject.

CONCLUSIONES/

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Específicas

Las conclusiones específicas de la presente Tesis Doctoral fueron las siguientes:

1. Además de mejorar los niveles de CCR de los estudiantes, una UD intermitente de acondicionamiento físico permite trabajar simultáneamente durante suficiente tiempo de las clases otro objetivo curricular de EF. Incluso, esta novedosa estructura de UD aumenta la intensidad de las clases de manera similar a una UD tradicional, logrando también la recomendación de involucrar a los estudiantes el 50% del tiempo de las clases de EF en niveles de AFMV. Por lo tanto, una UD intermitente de acondicionamiento físico y deportes de invasión parece ser una forma efectiva de lograr varios objetivos en el contexto de la EF (Procedente del artículo I).
2. Una UD reforzada mediante clases de AF en el medio natural y expresión corporal, es efectiva para mantener la CCR de los estudiantes en el contexto de la EF. Además, este tipo de UD reforzada no solo es eficaz manteniendo los niveles de CCR de los estudiantes, sino que también permite el desarrollo simultáneo de otros objetivos relacionados con otros contenidos curriculares de la EF como son las AF en el medio natural y la expresión corporal. Igualmente, la UD reforzada aumenta los niveles de AF, logrando también la recomendación de involucrar a los estudiantes el 50% del tiempo de las clases de EF en niveles de AFMV. Consecuentemente, los hallazgos de este estudio podrían ayudar a los profesores de EF a diseñar UDs que permitan un desarrollo y mantenimiento efectivo y más completo de todos los objetivos curriculares de la EF (Procedente del artículo II).
3. Las UDs alternadas dentro-fuera del centro escolar son efectivas para mejorar el conocimiento sobre el entorno de los estudiantes para el trabajo de la condición física, las barreras percibidas, la autonomía percibida y la motivación autónoma hacia la AF. Por lo tanto, la aplicación de una UD alternada podría ser una forma efectiva de asegurarse que los escolares sean lo suficientemente competentes para trabajar su condición física autónomamente en su tiempo libre (Procedente del artículo III).
4. Una UD irregular mediante programas individualizados realizados durante los recreos y tiempo extraescolar, es eficaz manteniendo los niveles de CCR de los escolares. Además de facilitar a los profesores de EF un mayor y más efectivo

desarrollo de los objetivos curriculares de la EF, este tipo de UD irregular permite abordar la AF en los recreos mostrando a los escolares una nueva oportunidad para realizar AF, y contribuyendo a la recomendación diaria de AF establecida para adolescentes (Procedente del artículo IV).

5. La prueba CENAFI diseñada, es un instrumento de medida válido y fiable para recabar información sobre el conocimiento que poseen los escolares del entorno próximo para el acondicionamiento físico. Disponer de una herramienta válida para evaluar dicho conocimiento nos permite comprobar si los profesores de EF están contribuyendo a su adquisición en el alumnado (Procedente del artículo V).
6. Aunque una UD tradicional de acondicionamiento físico en EF parece tener un efecto similar en la CCR de todos los perfiles de CCR de los estudiantes, aquellos con un perfil de CCR no saludable se benefician considerablemente más en los niveles de AF durante las clases de EF. Por el contrario, después de una UD intermitente de acondicionamiento físico en EF, solo los estudiantes con un perfil no saludable de CCR incrementan la CCR. Además, ambos perfiles de estudiantes tienen mayores niveles de AFMV tras la aplicación de la UD intermitente. Con el fin de incrementar la condición física y niveles de AF de todos los estudiantes de forma similar cuando se realiza una UD de acondicionamiento físico (tradicional o intermitente) en EF, los profesores deberían aplicar estilos de enseñanza individualizadores (Procedente de los artículos VI y VII).
7. Aunque una UD de acondicionamiento físico a corto plazo aumenta los niveles de CCR de los estudiantes, después de un período de desentrenamiento de cuatro semanas, los niveles de CCR de los estudiantes vuelven a su valor basal. Por lo tanto, los profesores de EF deberían aplicar UDs de mantenimiento o planificar programas de acondicionamiento físico más largos con una UD intermitente (15 minutos intensos cada clase) a lo largo del año escolar para mantener los niveles de CCR de los estudiantes, así como promover un estilo de vida saludable durante las vacaciones (Procedente del artículo VIII).
8. Una UD de acondicionamiento físico en EF solo mejora los niveles de CCR de los estudiantes con una motivación autodeterminada alta hacia la EF. Por tanto, con el objetivo de aumentar los niveles de CCR de todos los estudiantes, los profesores de EF deben fomentar la motivación de los estudiantes hacia la EF cuando realizan una UD de acondicionamiento físico. Desde una perspectiva aplicada, el conocimiento de los perfiles motivacionales, qué dimensiones motivacionales

componen cada perfil y cómo cada uno de ellos mejora o no la CCR después de una UD de acondicionamiento físico, podría ayudar a los profesores de EF a planificar y aplicar estrategias específicas durante las clases de EF para fomentar una motivación más autodeterminada hacia la EF en aquellos estudiantes que no tienen este perfil motivacional (Procedente del artículo IX).

9. Ambas UDs intermitente y tradicional de acondicionamiento físico parecen no influir negativamente en la motivación de los estudiantes hacia la EF y la experiencia autotélica. Además, ninguno de los dos tipos de UDs a corto plazo mejora el autoconcepto físico de los estudiantes. Independientemente de la estructura de la UD aplicada (es decir, tradicional o intermitente), podría ser necesario que los profesores de EF apliquen estrategias específicas para mejorar las variables psicológicas de los estudiantes (Procedente del artículo X).
10. Una UD alternada de deportes con los mismos elementos constitutivos (como los deportes de invasión fútbol y baloncesto) mejora el aprendizaje táctico objetivo de los estudiantes gracias a la transferencia de aprendizaje entre ambas modalidades deportivas, en comparación con un tratamiento tradicional donde ambos deportes son enseñados de forma consecutiva y sin conexión. Sin embargo, los estudiantes con un nivel táctico inicial menor en deportes de invasión obtienen mayores mejoras que aquellos con mayor nivel táctico inicial después de una UD alternada de deportes de invasión. Consecuentemente, con el objeto de conseguir un aprendizaje de la táctica deportiva en todos los alumnos, los profesores de EF deberían tener en cuenta el nivel inicial de sus alumnos, llevando a cabo UDs en función de dicho nivel, por ejemplo, con estilos de enseñanza individualizadores (Procedente de los artículos XI y XII).

General

La efectividad de los modelos de UDs intermitentes, alternadas, irregulares y reforzadas en la planificación de la EF ha sido demostrada en los diferentes estudios de esta Tesis Doctoral logrando numerosos objetivos establecidos en el currículum educativo de la EF, y manteniendo los aprendizajes adquiridos previamente sin incrementar el tiempo dedicado a cada objetivo, pero distribuido de manera diferente e innovadora. Por lo tanto, estas cuatro estructuras nuevas de UD son herramientas muy eficaces al servicio de los profesores de EF permitiéndoles solucionar las diferentes limitaciones relacionadas con la planificación de la asignatura. Además, la vivencia de estas UDs innovadoras permite a los escolares transferir los aprendizajes adquiridos durante las clases de EF a su tiempo libre, lo que representa un gran avance en la adquisición de un estilo de vida activo y saludable.

CONCLUSIONS

Specifics

The specific conclusions of the present Doctoral Thesis were the following:

1. Besides improving students' CRF levels, an intermittent physical fitness-based TU simultaneously leaves enough time during the lessons to work on another PE curricular objective. Even, this novel structure of TU increased the lessons' intensity in a similar way to a traditional TU, also achieving the recommendations of 50% of PE lessons time involved in MVPA levels. Therefore, an intermittent TU of physical fitness and invasion sports seems to be an effective way to achieve various objectives in the PE setting (From the paper I).
2. A reinforced TU through outdoor PA and body expression lessons, is effective in increasing and maintaining students' CRF in the PE setting. Furthermore, this type of reinforced TU is not only effective for maintaining students' CRF levels in PE setting, but also allows the simultaneous development of other objectives related with other PE curricular contents such as outdoor PA and body expression. Likewise, reinforced TU increase the PA levels, also achieving the recommendation of involving students 50% of PE lessons time in MVPA levels. These findings might help PE teachers to design TUs that would allow for an effective and more complete development and maintenance of the total PE curriculum objectives (From the paper II).
3. Alternated inside-outside school Tus are effective for improving students' knowledge about the environment to work physical fitness, perceived barriers, perceived autonomy, and autonomous motivation towards PA. Therefore, the application of an alternated TU could be an effective way of making sure that schoolchildren are competent enough to work their physical fitness autonomously in their own free time (From the paper III).
4. An irregular TU through individualized programs performed during school recesses and out-of-school time, is effective for maintaining students' CRF levels. In addition to facilitate PE teachers a greater and more effective development of PE curricular objectives, this type of irregular TU allows for addressing PA in recesses by showing schoolchildren a new opportunity to practice PA, and contributing to the established daily PA recommendation for adolescents (From the paper IV).

5. The designed CENAFI test, is a valid and reliable measuring instrument to gather information about the knowledge that schoolchildren have of their immediate environment for physical conditioning. Having a valid tool to assess this knowledge allows us to check whether the PE teachers are contributing to this knowledge acquisition in students (From the paper V).
6. Although a PE-based physical fitness TU seems to have a similar effect on all the students' CRF profiles, students with unhealthy CRF profiles benefit considerably more in PA levels during the PE lessons. On the contrary, after an intermittent PE-based physical fitness TU, only students with unhealthy CRF profile improve CRF levels. Moreover, both students' profiles have higher MVPA levels after the application of the intermittent TU. In order to increase all students' physical fitness and PA levels in a similar way when performing a PE-based physical fitness TU (traditional or intermittent), teachers should apply individualized teaching styles (From the papers VI and VII).
7. Although the short-term physical fitness TU increased the students' CRF levels, after a four-week detraining period students' CRF levels reverted back to the baseline. Therefore, PE teachers should apply maintenance TUs or plan longer physical fitness programs with an intermittent TU (15 intense minutes every lesson) along the scholar year to maintain students' CRF levels, as well as promote a healthy life style during holidays (From the paper VIII).
8. A PE-based physical fitness TU, only improves CRF levels of students with a high baseline of self-determined motivation toward PE. Therefore, with the objective of increasing all students' CRF levels, PE teachers should encourage students' motivation toward PE when they carry out a physical fitness TU. From an applied perspective, the knowledge of the motivational profiles, what motivational dimensions compose each profile, and how each of them improve or not CRF after a physical fitness TU, could help PE teachers to plan and apply specific strategies during PE lessons to foster a more self-determined motivation toward PE in those students that do not have this motivational profile (From the paper IX).
9. Both intermittent and traditional physical fitness TUs seem not to negatively influence students' motivation toward PE and autotelic experience. Moreover, neither of the two types of short-term TUs improve students' physical self-concept. Regardless of the TU structure applied (i.e., traditional or intermittent), it could be

necessary that PE teachers apply specific strategies for improving students' psychological variables (From the paper X).

10. An alternated TU of sports with the same constitutive elements (like soccer and basketball invasion sports) improves students' objective tactical learning thanks to the transference of learning between both sport modalities, compared to a traditional treatment where both sports are taught consecutively and unconnectedly. However, students with lower baseline tactical levels in invasion sports obtain higher improvements than those with higher baseline tactical level after an alternated TU of invasion sports. Consequently, in order to achieve a sports tactical learning in all students, PE teachers should take into account the baseline level of their students, carrying out TUs according to such level, for example, with individualized teaching styles (From the papers XI and XII).

Overall

The effectiveness of intermittent, alternated, irregular, and reinforced TUs models on PE planning have been shown in the different studies of this Doctoral Thesis achieving numerous objectives established in the PE educational curriculum, and maintaining the learning acquired previously without increasing the time dedicated to each objective, but distributed in a different and innovative manner. Therefore, these four new structures of TU are effective tools at the service of PE teachers allowing them to solve the different limitations related to the subject planning. Additionally, the experience of these innovative TUs allowed schoolchildren to transfer the acquired learnings during PE lessons to their free time, which represents a great advance in the acquisition of an active and healthy lifestyle.

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ANEXO

[ANNEX]

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1. Carta de aprobación del protocolo del estudio por el Comité de Ética de la Universidad de Granada.

COMITE DE ETICA EN INVESTIGACION DE LA UNIVERSIDAD DE GRANADA

La Comisión de Ética en Investigación de la Universidad de Granada, visto el informe preceptivo emitido por la Presidenta del Comité en Investigación Humana, tras la valoración colegiada del Comité en sesión plenaria, en el que se hace constar que la investigación propuesta respeta los principios establecidos en la legislación internacional y nacional en el ámbito de la biomedicina, la bioteconología y la bioética, así como los derechos derivados de la protección de datos de carácter personal,
Emite un Informe Favorable en relación a la investigación titulada: 'COMPROBACIóN EMPíRICA DE LOS MODELOS DE UNIDADES DIDáCTICAS INTERMITENTES, ALTERNADAS, IRREGULARES Y REFORZADAS. IMPLICACIONES PARA LA PLANIFICACIóN DE LA EDUCACIóN FíSICA' que dirige D./Dña. SANTIAGO GUIJARRO ROMERO, con NIF 71.720.896-L, quedando registrada con el nº: 649/CEIH/2018.

Granada, a 10 de Julio de 2018.

EL PRESIDENTE
Fdo: Enrique Herrera Viedma

EL SECRETARIO
Fdo: Fernando Cornet Sánchez del Águila

CURRICULUM VITAE RESUMIDO

[SHORT CV]

CURRICULUM VITAE RESUMIDO [SHORT CV]

DATOS PERSONALES

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ResearcherID: AAO-7533-2020
SCOPUS ID: 57195396480
GoogleScholar: https://scholar.google.es/citations?user=D-PSMkkAAAAJ&hl=es&oi=ao

ACTIVIDAD ACADÉMICA

Formación académica

2016-actual. Doctorado en Ciencias de la Educación, Departamento de Educación Física y Deportiva, Facultad de Ciencias del Deporte, Universidad de Granada, España.

2015-2016 Máster Universitario en Profesorado de Enseñanza Secundaria Obligatoria y Bachillerato, Formación Profesional y Enseñanza de Idiomas (Especialidad: Educación Física; 9.297/10). Facultad de Ciencias de la Actividad Física y del Deporte, Universidad de Granada, España.

2011-2015 Grado en Ciencias de la Actividad Física y del Deporte (9.135/10). Facultad de Ciencias de la Actividad Física y del Deporte, Universidad de Granada, España.

Formación complementaria

2015-actual. Más de 50 de cursos universitarios de formación permanente sobre investigación, docencia, entrenamiento deportivo, y asistencia a congresos científicos nacionales e internacionales.

Estancias de investigación

2020 Estancia de investigación en el extranjero. Centro: *Instituto Universitário da Maia (ISMAI)* (Portugal). Entidad financiadora: Vicerrectorado de Investigación y Transferencia, Universidad de Granada. Fecha: Desde 01/02/2020 hasta 30/04/2020 (3 meses).

2018 Estancia de investigación en el extranjero. Centro: *Faculty of Sport and Health Sciences (Department of Sport Sciences, University of Jyväskylä)* (Finlandia). Entidad financiadora: Ministerio de Educación, Cultura y Deporte. Fecha: Desde 01/03/2018 hasta 31/05/2018 (3 meses).

ACTIVIDAD INVESTIGADORA

Publicaciones científicas

Nota: El doctorando ha publicado (o tiene aceptado para publicación) 6 artículos en revistas científicas contempladas en la JCR (*Journal Citation Reports – ISI Web of Knowledge*^{TM}-), 9 artículos en revistas científicas contempladas en el SJR (*SCImago Journal Rank – Scopus*-), LATINDEX y/o similar, 56 *abstracts* de congresos científicos internacionales, y 2 capítulos de libro indexado en SPI. Además, 8 artículos adicionales se encuentran en proceso de revisión. Sus publicaciones acumulan 24 citas desde 2015 y presenta un índice h igual a 3 (fuente Google Schoolar). Solo las publicaciones contempladas en la JCR publicadas o aceptadas para su publicación se citan a continuación:

6. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. (2020). Does students' self-determination motivation toward Physical Education influence the effectiveness of a fitness teaching unit? A cluster-randomized controlled trial and cluster analysis. *Psychology of Sport and Exercise*, *51,* 101768. doi: 10.1016/j.psychsport.2020.101768.

5. Casado-Robles, C., Mayorga-Vega, D., **Guijarro-Romero, S.**, & Viciana, J. (2020). Sport Education-based irregular teaching unit and students' physical activity during school recess. *The Journal of Educational Research*. Advance online publication. doi: 10.1080/00220671.2020.1806014

4. **Guijarro-Romero, S.**, Mayorga-Vega, D., Casado-Robles, C., & Viciana, J. (2020). Effect of a Physical Education-based fitness intermittent teaching unit on cardiorespiratory fitness in high school students: A cluster-randomized controlled

trial. *Journal of Sports Medicine and Physical Fitness, 60*(5), 700-708. doi: 10.23736/S0022-4707.20.10328-1.

3. **Guijarro-Romero, S.**, Mayorga-Vega, D., & Viciana, J. (2018). Aprendizaje táctico en deportes de invasión en la Educación Física: Influencia del nivel inicial de los estudiantes. *Movimento*, *24*(3), 889-902. doi: 10.22456/1982-8918.79839.

2. Viciana, J., Mayorga-Vega, D., **Guijarro-Romero, S.**, Martínez-Baena, A., & Blanco, H. (2017). The Spanish adaptation of the Sport Motivation Scale-II in adolescent athletes. *Psychological Reports*, *120*(5), 943-965. doi: 10.1177/0033294117709261.

1. Viciana, J., Mayorga-Vega, D., **Guijarro-Romero, S.**, & Martínez-Baena, A. (2017). Effect of two alternated teaching units of invasion team sports on the tactical learning in primary schoolchildren. *International Journal of Performance Analysis in Sport*, *17*(3), 256-270. doi: 10.1080/24748668.2017.1331575.

Proyectos de investigación

5. Título del proyecto: Validez de medida de las PULSeras de fitness y efecto de una intervención escolar en Educacion Fisica sobre la actividad fisica habitual y conducta sedentaria en Educacion Secundaria (PULSEF). Referencia: 64. Entidad financiadora: Vicerrectorado de Investigación y Transferencia, Universidad de Granada. Tipo de convocatoria: Universidad de Granada. Modalidad: Plan Propio de Investigación 2019 Programa de Proyectos de Investigación Precompetitivos para Jóvenes Investigadores. Duración: Desde 01/01/2020 hasta 31/12/2021. Número de meses: 24. Investigador principal: Carolina Casado Robles. Número de investigadores participantes: 4. Importe total del proyecto: 1.500€. Grado de responsabilidad del solicitante: Miembro del equipo de investigación. Dedicación al proyecto: Completa.

4. Título del proyecto: "Gender in Dance": (Re)moviendo estereotipos en los centros educativos. Referencia: PPJI2018-09. Entidad financiadora: Vicerrectorado de Investigación y Transferencia, Universidad de Granada. Tipo de convocatoria: Universidad de Granada. Modalidad: Plan Propio de Investigación 2019 Programa de Proyectos de Investigación Precompetitivos para Jóvenes Doctores. Duración: Desde 01/12/2018 hasta 31/12/2019. Número de meses: 13. Investigador principal: Alejandro César Martínez Baena. Número de investigadores participantes: 5. Importe total del proyecto: 1500€. Grado de responsabilidad del solicitante: Investigador colaborador. Dedicación al proyecto: Completa.

3. Título del proyecto: Equipamiento avanzado para investigación orientada hacia el desarrollo del concepto de smart cities/healthy cities en el Instituto Mixto Universitario Deporte y Salud. Ref.: EQC2018-004702-P. Entidad financiadora**:** Convocatoria 2018 de Ayudas para la Adquisición de Equipamiento Científico-Técnico del Subprograma Estatal de Infraestructuras de Investigación y Equipamiento Científico-Técnico (Plan Estatal de I+D+i 2017-2020) del Ministerio de Ciencia, Innovación y Universidades. Tipo de convocatoria: Nacional. Duración**:** Desde 01/01/2018 hasta 31/12/2019, con una prórroga concedida hasta 31/12/2020 (3 años). Número de meses: 24. Investigador principal: Víctor Manuel Soto Hermoso. Número de investigadores participantes: 3. Importe total del proyecto: 826,125.70€. Grado de responsabilidad del solicitante: Investigador colaborador. Dedicación al proyecto: Completa.

2. Título del proyecto: Comprobación empírica de los modelos de unidades didácticas intermitentes, alternadas, irregulares y reforzadas. Implicaciones para la planificación de la Educación Física. Referencia: FPU15/02387. Entidad financiadora: Ministerio de Educación, Cultura y Deporte. Tipo de convocatoria: Nacional. Duración: Desde 31/10/2016 hasta 31/10/2020. Número de meses: 48. Investigador principal: Jesús Viciana Ramírez y Daniel Mayorga Vega. Número de investigadores participantes: 3. Importe total del proyecto: 65.688€. Grado de responsabilidad del solicitante: Investigador colaborador. Dedicación al proyecto: Completa.

1. Título del proyecto: Efecto de la aplicación de unidades didácticas alternadas en educación física sobre la transferencia en el aprendizaje, la autonomía, la motivación, el clima de aula y la percepción del estilo de vida en escolares de Primaria. Entidad financiadora: Ministerio de Educación, Cultura y Deporte. Tipo de convocatoria: Nacional. Duración: Desde 28/10/2014 hasta 30/06/2015. Número de meses: 8. Investigador principal: Jesús Viciana Ramírez y Alejandro César Martínez Baena. Número de investigadores participantes: 4. Importe total del proyecto/contrato: 2.000€. Grado de responsabilidad del solicitante: Investigador colaborador. Dedicación al proyecto: Completa

ACTIVIDAD DOCENETE

Docencia universitaria

4. Profesor Universitario. Asignatura: Fundamentos de las Habilidades Motrices. Titulación: Grado en Ciencias de la Actividad Física y del Deporte. Institución:

Facultad de Ciencias del Deporte, Departamento de Educación Física y Deportiva, Universidad de Granada. Lugar: Granada (España). Fecha: Curso 2019/20. Horas: 30.

3. Profesor Universitario. Asignatura: Intervención Docente en la Enseñanza de la Actividad Física y el Deporte. Titulación: Grado en Ciencias de la Actividad Física y del Deporte. Institución: Facultad de Ciencias del Deporte, Departamento de Educación Física y Deportiva, Universidad de Granada. Lugar: Granada (España). Fecha: Curso 2019/20. Horas: 15.

2. Profesor Universitario. Asignatura: Intervención Docente en la Enseñanza de la Actividad Física y el Deporte. Titulación: Grado en Ciencias de la Actividad Física y del Deporte. Institución: Facultad de Ciencias del Deporte, Departamento de Educación Física y Deportiva, Universidad de Granada. Lugar: Granada (España). Fecha: Curso 2018/19. Horas: 60.

1. Profesor Universitario. Asignatura: Intervención Docente en la Enseñanza de la Actividad Física y el Deporte. Titulación: Grado en Ciencias de la Actividad Física y el Deporte. Institución: Facultad de Ciencias del Deporte, Departamento de Educación Física y Deportiva, Universidad de Granada. Lugar: Granada (España). Fecha: Curso 2017/18. Horas: 60.

PREMIOS

2016 Premio Mejor Expediente Fin de Grado en Ciencias de la Actividad Física y el Deporte. (Promoción 2011-2015).

AGRADECIMIENTOS

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AGRADECIMIENTOS [ACKNOWLEDGMENTS]

Durante los últimos 4 años de mi vida, diferentes sentimientos han inundado mi cabeza, unos buenos, otros menos buenos, pero de todos he sacado algo positivo. El último de ellos es el que me lleva a entender que la presente Tesis Doctoral es la conjunción no solo de la contribución de grandes profesionales, sino también de grandes y maravillosas personas que de una u otra forma han dejado huella en mí para toda la vida. Por ello, no podría cerrar esta tesis sin agradeceros lo mucho que me habéis dado durante estos últimos años:

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