

Effects of Sport Education Model and a Ludotechnical Model hybridisation programme on motivation and intention to be physically active in Physical Education in Secondary Education

Efectos de un programa hibridado entre el Modelo de Educación Deportiva y el Modelo Ludotécnico sobre la motivación y la intención de ser físicamente activo en Educación Física en la Educación Secundaria

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Abstract

Introduction: the aim of the present study was to analyse the effect of an intervention programme delivered through the hybridisation of the Ludotechnical Model (LTM) and the Sport Education Model (SEM) on the satisfaction of Basic Psychological Needs (BPN), motivation, and intention to be physically active in the subject of Physical Education among high school students.

Method: the quasi-experimental pre-post design included 112 participants (52 boys and 60 girls), aged 11–13 years. They belonged to seven different school classes, of which five implemented the hybridisation of the models described above (experimental group), while the other two followed a traditional methodology (control group). The instrument used to measure the satisfaction of BPN was the PNSE, while the BRSQ assessed motivation, and the MIPA scale evaluated the intention to be physically active. For data analysis, a repeated measures MANCOVA test was performed.

Results: it was revealed significant differences between the groups, favouring students who received LTM/SEM hybrid teaching in the psychological mediator index (PMI), competence satisfaction, relatedness, autonomous motivation, self-determination index, and intention to be physically active. Regarding sex-based differences, improvements were observed for both boys and girls in the experimental group in the SDI and MIPA factors.

Conclusions: the application of hybrid models yields improvements in terms of satisfaction of BPN, motivation, and intention to be physically active for both sexes, compared to a traditional methodology. One of the limitations of the study was the sample selection, suggesting that future studies should use a randomized sample, representative of the target population and with a well-balanced number of participants in each group.

Keywords: pedagogical models, learning, athletics, table tennis, physical activity.

Resumen

Introducción: el objetivo del presente estudio fue analizar el efecto de un programa de intervención impartido mediante la hibridación del Modelo Ludotécnico (MLT) y el Modelo de Educación Deportiva (MED) sobre la satisfacción de las Necesidades Psicológicas Básicas (NPB), la motivación y la intención de ser físicamente activo en Educación Física en Secundaria.

Método: el diseño pre-post cuasi-experimental incluyó a 112 participantes (52 niños y 60 niñas), con edades comprendidas entre 11 y 13 años. Pertenecían a siete clases escolares diferentes, de las cuales cinco implementaron la hibridación de los modelos descritos anteriormente (grupo experimental), mientras que las otras dos siguieron una metodología tradicional (grupo control). El instrumento utilizado para medir la satisfacción de las NPB fue el PNSE, el BRSQ evaluó la motivación y la MIFA evaluó la intención de ser físicamente activo. Para el análisis de los datos, se realizó una prueba MANCOVA de medidas repetidas.

Resultados: se revelaron diferencias significativas entre los grupos, a favor del alumnado que recibió la enseñanza híbrida del MLT/MED en el índice de mediación psicológica (IMP), la satisfacción con las competencias, la relación, la motivación autónoma, el índice de auto-determinación y la intención de ser físicamente activo. Respecto a las diferencias por sexo, se observaron mejoras tanto para chicos como para chicas del grupo experimental en los factores IMP y MIFA.

Conclusiones: la aplicación de la hibridación arroja mejoras en términos con las NPB, motivación e intención de ser físicamente activo para ambos sexos, en comparación con una metodología tradicional. Una de las limitaciones ha sido la selección de la muestra, sugiri-

riendo para próximos estudios que la muestra sea aleatorizada, representativa de la población objeto de estudio y con un número bien equilibrado de participantes en cada grupo.

Palabras clave: modelos pedagógicos, aprendizaje, atletismo, tenis de mesa, actividad física.

Introduction

In recent years, numerous studies have indicated that the level of physical fitness and sporting activity among adolescents has been declining (Steene-Johannessen et al., 2020), particularly among girls (Till et al., 2022). This trend has led to an increase in sedentary lifestyles and non-hereditary diseases (Bueno-Antequera & Munguía-Izquierdo, 2023). Therefore, Physical Education (PE) is presented as an essential tool to increase physical activity levels, promote exercise adherence, reduce sedentary behaviours, improve healthy lifestyle habits, and enhance students' affective, cognitive, and social aspects (Neil-Sztramko et al., 2021; Romero Cerezo et al., 2008).

In this context, several studies have focused on the psychosocial and motivational variables that influence students to enhance their positive experiences in PE classes, aiming to increase their physical activity levels (Amaro et al., 2023). Among the existing theories, the Self-Determination Theory (SDT; Deci & Ryan, 2000) stands out. This theory posits that individuals have three innate and universal basic psychological needs (BPN): autonomy, competence, and relatedness, whose satisfaction influences intrinsic and extrinsic motivation (Vaansteenkiste et al., 2010). Accordingly, SDT posits that individuals exhibit greater autonomous motivation when they perceive higher levels of autonomy, competence, and relatedness to others (Deci & Ryan, 2000).

Although SDT assumes that boys and girls have the same BPN, previous research has shown that subjects of different sexes may respond differently to the same learning environment (Xiang et al., 2018). Various studies reveal discrepancies; for instance, girls tend to perceive themselves as more competent and motivated in tasks traditionally regarded as more "feminine," such as dance and gymnastics (Xiang et al., 2018; Shen et al., 2003). Moreover, Chu et al. (2019) found that the need for relatedness was a stronger predictor of adaptive cognitive outcomes for girls than for boys. Similarly, Van Aert et al. (2017) found that girls' perceived competence and boys' peer relatedness were significant predictors of autonomous motivation. Likewise, recent studies suggest that when students feel that there is a climate that supports their BPN, more autonomous forms of motivation, characterised by enjoyment and appreciation of activities, may emerge (González-Cutre et al., 2016). Thus, SDT has been selected in a wide variety of interventions in the school context, directly influencing schoolchildren's motivation and positive outcomes through BPN satisfaction and dissatisfaction (Mossman et al., 2022).

Multiple research studies demonstrate that innovative pedagogical models of teaching and learning possess characteristics that enhance opportunities for adolescents of both sexes to improve their psychosocial variables, motivation, and intention to engage in physical activity (Metzler, 2011; Rodríguez-Macías et al., 2021; Pérez Piña et al., 2017). Specifically, the Ludotechnical Model (LTM; Valero-Valenzuela & Conde, 2003) offers a pedagogical alternative for sports initiation. This model employs playful formats and modified games to encourage individuals to practice individual disci-

plines (Valero-Valenzuela et al., 2019). Meanwhile, the Sport Education Model (SEM), designed and developed by Siedentop and collaborators (Siedentop et al., 2011), has shown that students of both sexes perceive a better motivational climate in the classroom, a more developed sports culture, and greater competence when this model is applied (Hastie & Casey, 2014). Furthermore, systematic reviews have identified additional benefits of SEM, such as improvements in student responsibility, social skills, enjoyment, and autonomy in learning (Bessa et al., 2019). Similarly, LTM contributes to the development of decision-making, motor creativity, and affective engagement, fostering a positive and meaningful learning experience in PE (Valero-Valenzuela et al., 2019). These benefits highlight the pedagogical potential of each model and support their implementation in diverse educational contexts

Despite the benefits of each model independently, the scientific literature suggests that hybrid models combining aspects of multiple pedagogical approaches could be an effective mechanism to achieve greater improvements compared to the implementation of individual pedagogical models (Casey & MacPhail, 2018; González-Víllora et al., 2018; Gutiérrez et al., 2019). In this regard, combining SEM and LTM could be justified by the complementary pedagogical objectives of both models. While SEM focuses on providing realistic sports experiences outside the school context, helping students develop motor and social skills through active roles in structured contexts (Siedentop et al., 2011), LTM emphasises the learning of technique and divergent thinking through play and problem-solving during different phases of a session (Valero-Valenzuela et al., 2019; Pizarro et al., 2024).

Consequently, the aim of the present study was to analyse the effect of a long-term intervention programme, incorporating two learning situations (athletics and table tennis), delivered through the hybridisation of LTM and SEM, on BPN, motivation, and the intention to be physically active among high school students. It was hypothesised that boys and girls taught using the hybrid LTM/SEM model would report: a) higher satisfaction of BPN; b) greater levels of autonomous motivation; and c) a higher intention to be physically active after the intervention, compared to students taught using a traditional model.

Methods

Design

The study followed a quasi-experimental pre-test and post-test research design (Thyer, 2012). The research was divided into three phases. In the first phase, the intervention program was designed, and approval was obtained from both the ethics committee and the participating institution. In the second phase, the intervention was carried out: the experimental group (EG) participated in a hybrid unit (LTM + SEM), while the control group (CG) followed a traditional instructional unit. Both programs were implemented simultaneously over a 12-week period, with two 55-minute sessions per week, following a pre-established plan (see Table 1). In the final phase, student perceptions were gathered through questionnaires.

Table 1

Plan of the hybrid (LTM/SEM) and traditional athletics and table tennis units

Methodological strategies				
Nº	Contents	CG	EG	
			Ludotechnical Model (LTM)	Sport Education Model (SEM)
1	Introduction to athletics Initial evaluation	Introduction to athletics Adapted athletics mini-competition (races, relays and long jump)	Introducing the disciplines Detection of previous ideas	INTRODUCTION Create teams and calendars Assign roles and spaces
2-6	Flat races, hurdles, long jump, high jump and shot put	Progression for technique through analytical exercises (e.g., for the high jump: the teacher stands on the mat with a ball in his hand. The students will run out with a circular trajectory and will perform the jump when reaching the teacher trying to touch the ball with the hand opposite to the foot with which they are jumping)	Challenge question (e.g., high jump, with which leg do you perform the jump?) Ludotechnical proposals: game of "the shoe from behind" (for the technical action of running) Global proposal: real high jump game Sharing: with the leg farthest from the bar	PRESEASON Team work, learning and implementation of roles Physical trainer: warm up Kit manager: material manager Coach: manage the team Captain: mediating in conflict Scorer: keeping scores Referee: rules of discipline
7-10	Practise the modalities and carry out competitions	Analytical training (e.g., long jump: a jump is performed with a constant pace and frequency of steps, increasing the amplitude on the penultimate support) Individual competitions	Global proposal: adapted (e.g., one-legged standing jump) and real competitions (e.g., long jump) Sharing (e.g. feedback on the most relevant technical aspects of the jump run)	REGULAR COMPETITION First: autonomous practice by teams (development of all roles except scorer and referee) Second: competition (e.g., team A organises and B, C and D compete)
11-12	Combined tests Evaluation End of athletics	Championships between individual students Hetero-evaluation (teacher-student)	Global proposal: competitions in the different disciplines in teams Sharing (e.g., discussing how the unit has worked and how it can be improved)	FINAL STAGE Inter-team championships Intergroup co-evaluation Awards ceremony and festivities
13	Introduction of table tennis Initial evaluation	Introduction of table tennis Initial motor assessment (e.g., individual touching of a ball)	Introducing table tennis Detection of ideas	INTRODUCTION Create teams and calendars Assign roles and spaces

Methodological strategies				
Nº	Contents	CG	EG	
			Ludotechnical Model (LTM)	Sport Education Model (SEM)
14-18	Learn the technical aspects (grip, serve, forehand, etc.), tactical (4-corner theory, looking for the feint and backhand, etc.) and regulatory aspects of table tennis	Teaching progression for learning table tennis through analytical exercises (e.g., for the forehand stroke: one partner stands next to the other to drop the ball with the hand for the other to hit it) Tactics: move the opponent (e.g., a variant of the previous game is performed, having to send the ball each time to one side of the field)	Challenge question (e.g., forehand, at what height is it best to hit the ball?) Ludotechnical proposals: each team is placed in single file so that the last one passes the racquet to the teammate in front until it reaches the first one (for the technical action of the forehand and body positioning) Tactics: move the opponent (e.g., send the ball to one side of the field at a time) Global proposal: match Sharing: at the top of the rebound	PRESEASON Teamwork and role-playing Physical trainer: warm up Kit manager: material manager Coach: manage the team Captain: mediating in conflict Scorer: keeping scores Referee: rules of the sport
19-22	Table tennis practice and competitions	Training of the learned aspects in an analytical way (e.g., for the forehand: in pairs, each in a field, they perform forehand strokes) Individual competitions	Global proposal: adapted competitions (e.g., the team with the most forehands in a row wins) and real competitions (e.g., team competitions). Sharing (e.g., feedback on the most relevant aspects)	REGULAR COMPETITION First: autonomous practice by teams (development of all roles except scorer and referee) Second: competition (e.g., Team A organises and B, C and D compete)
23-24	Competitions Evaluation End of table tennis	Championships between individual students Hetero-evaluation (teacher-student)	Global proposal: team competitions Sharing (e.g., Discussing how the unit has worked and how it can be improved)	FINAL STAGE Inter-team championships Intergroup co-evaluation Awards ceremony and festivities

Note. CG = control group; EG = experimental group; LTM = Ludotechnical Model; SEM = Sport Education Model. Sample

A total of 112 students (52 boys and 60 girls) aged 11–13 years ($M = 12.09$; $SD = .29$) from a Spanish high school participated in the study (82 students in the hybrid model and 30 students in the traditional methodology). The seven classes of the public school in Spain were involved. The sample of students was selected on the basis of accessibility and convenience. No students had prior experience with the LTM or SEM models. All participants belonged to middle-class sociodemographic and cultural backgrounds. The researcher possessed prior experience with both pedagogical models, having implemented them throughout his teaching career. This experience was further supported by his academic background in Physical Activity and Sport Sciences, as well as specialized training through various professional development courses.

Instruments

The Psychological Need Satisfaction in Exercise Scale (PNSE), validated in the Spanish context by Moreno-Murcia et al. (2011). This instrument contains 18 items, six to assess each of the needs: competence, autonomy and relatedness with others. Cronbach's Alphas for the pre- and post-test were respectively for autonomy $\alpha = .608$ and $\alpha = .875$, competence $\alpha = .615$ and $\alpha = .904$, and relatedness with others $\alpha = .606$ and $.800$. The psychological mediators index (PMI; Bartholomew et al., 2010) was calculated considering the three BPN as a single variable ($\alpha = .727$ pretest and $\alpha = .751$ post-test).

The Behavioural Regulation in Sport Questionnaire (BRSQ), validated in Spanish by Moreno-Murcia et al. (2007a), which is composed of 19 items that measure the stages of the self-determination continuum. The pre- and post-test values of Cronbach's Alpha were for intrinsic regulation $\alpha = .800$ and $\alpha = .937$, for identified regulation $\alpha = .863$ and $\alpha = .806$, for introjected regulation $\alpha = .721$ and $\alpha = .870$, for external regulation $\alpha = .716$ and $\alpha = .817$ and for demotivation $\alpha = .672$ and $\alpha = .896$. The self-determination index (SDI), was calculated using the following formula: $2 \times \text{intrinsic regulation} + \text{identified regulation} - (\text{external regulation} + \text{introjected regulation}) / 2 - (2 \times \text{demotivation})$ (Vallerand, 1997). Indices of autonomous motivation (mean of intrinsic regulation and identified regulation) (Madonia et al., 2014) and controlled motivation (mean of external and introjected regulation) were calculated separately (Vallerand & Rousseau, 2001).

The Measure of Intention to be Physically Active (MIPA) questionnaire, validated in the Spanish context by Moreno-Murcia et al. (2007b) was used. This questionnaire is composed of 5 items. The pretest and post-test reliability values were $\alpha = .764$ and $\alpha = .895$ respectively.

Procedure

To conduct this research, ethical approval was first obtained from the Ethics Committee of the University of Murcia (reference number 3812/2022). The school's management team was then contacted, the objectives of the study were explained, and their collaboration was requested. Additionally, informed consent was obtained from the legal guardians of the students who participated in the project.

All the questionnaires were administered before the intervention, with participants encouraged to respond honestly and assured that their answers would remain anonymous and would not influence their academic scores. After the intervention, the same questionnaires were administered again.

Throughout the process, a member of the research team was present to provide a brief explanation of the study, give instructions on how to complete the questionnaires, and address any doubts or questions from the participants. The estimated time to complete the forms was approximately 30 minutes.

The hybrid unit for athletics and table tennis: the unit had three phases: (a) a learning phase (lessons 2 to 6); (b) a formal competition phase (lessons 7 to 10); and (c) a final event (lessons 11 and 12). The unit was designed according to the characteristics of the SEM (affiliation, season, formal competition, record keeping, final event and festivity).

In the first session, students in each class were divided into four teams of six or seven members (mixed by sex and ability), following the guidelines of Siedentop et al. (2011). These teams remained the same throughout the season and were encouraged to develop their own identity (e.g., team name, colour, etc.).

From lessons 2 to 6, a warm-up was conducted at the beginning of each session by the physical trainer. Afterwards, the session structure followed the phases established by the LTM (Valero & Conde, 2003), which include: (1) challenge question, where the discipline was introduced along with a problem to solve; (2) ludotechnical proposals, involving modified games that focused on technical skill development; (3) global proposal, consisting of more integrated and realistic situations that simulated the actual sport context; and (4) sharing, where students discussed the initial challenge and shared their learning experiences. In relation to the SEM, these sessions were developed by working in teams and putting into practice the assigned roles and responsibilities.

During the formal competition phase (sessions 7-10), in accordance with the characteristics of the SEM, sessions began with an autonomous practice by teams (development of all roles except scorer and judge); and the competition between the teams took place in the second part.

The final phase was held after the formal competition phase. In this phase, following the SEM, championships between the teams, a final celebration and an awards ceremony were held. During the competitions, the format of global proposals identified by the LTM was respected.

The traditional unit for athletics: the unit had three phases: (a) a learning phase (lessons 2 to 6); (b) a phase to practise the modalities (lessons 7 to 10); and (c) a competition phase (lessons 11 and 12).

During lessons 2 to 6, following Metzler (2011), a teaching approach focused on decision-making by the teacher was applied, using a traditional teaching methodology. This learning is based on the repetition of technical drills assigned by the teacher, focusing on order and task. The structure of these sessions consists of three distinctly different parts: (1) warm-up 5-10 minutes, (2) main part of the session 30-35 minutes, and (3) cool-down 7-10 minutes.

As for the modalities practice phase (sessions 7-10), students trained the modalities during the first part of the session, and then performed them with different levels of difficulty, according to the characteristics and interests of each student.

In the last sessions (11-12), a competition was held between the students on the different modalities that had been practised during the unit.

Taking into account that effective implementation of an educational programme necessitates targeted training for teachers (Lee & Choi, 2015), the teacher in charge of the intervention of both groups was the main researcher, who undertook the following training: (1) two courses of 10 hours each, on the methodological use and implementation of LTM and SEM, (2) reading scientific articles on hybrid models (e.g., Gil-Arias et al., 2021).

Fidelity of implementation

Following Hastie and Casey (2014), validating an intervention programme requires a detailed evaluation based on established models or strategies. To assess the fidelity of implementation, a self-questionnaire was developed to evaluate the teacher's adherence to the educational programme. This questionnaire was reviewed by an expert in sports sciences and consisted of items sourced from: the methodological actions questionnaire linked to the LTM (items 1-5) from Valero-Valenzuela et al. (2012) and

the pedagogical behaviours questionnaire for the SEM (items 6–12), adapted into Spanish by Calderón et al. (2013).

The self-assessment questionnaire was completed at the start of each phase of the SEM-based intervention. It was used to identify strengths and weaknesses in the implementation process, analyse the methodology employed, and verify alignment with the intended intervention design. While not all proposed items were fully met, the essential factors identified by Hastie and Casey (2014) as critical and immutable were adhered to. Compliance with these factors ensured fidelity in the application of the educational programme.

Data analysis

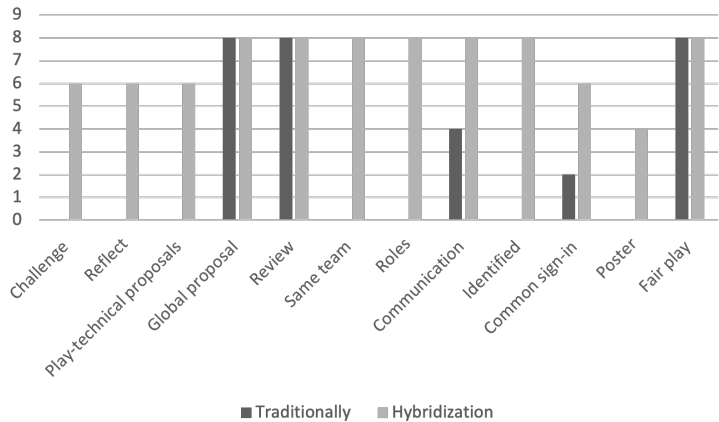
After including the results in the statistical software IBM SPSS Statistic 28.0.1.1 (New York: USA), the reliability of the instruments was verified by checking the internal consistency of both the pre-test and the post-test of each of the scales, using Cronbach's Alpha test. Then, an analysis of the normal distribution of the different variables was carried out using the Kolmogorov-Smirnoff test. For the items related to the reliability of implementation, a count was made of the number of times the behaviour appeared in the total number of sessions analysed. And for the variables derived from the different questionnaires, a repeated measures MANCOVA (multivariate analysis of variance) was performed on the 8 variables, adding sex as a covariate.

Results

Figure 1 shows the pedagogical behaviours in order to know the degree of implementation of the different methodological strategies. It shows the values extracted according to each group, revealing higher values for the EG in the items of challenge, reflect, play-technical proposals, same team, roles, communication and identify (items 1, 2, 3, 6, 7, 8 and 9). In addition, in the common sign-in item, a difference was also obtained with respect to the EG (item 10).

Figure 1

Implementation fidelity results



Effects produced by the programme on students

The results show that there were significant differences at the inter-subject level for the factor Sex (Wilks' Lambda = .831, $F(8,101) = 2.561$, $p = .014$) and for the factor Group (Wilks' Lambda = .632, $F(8,101) = 7.360$, $p < .001$). Also, significant differences were found at the within-subject level for the interaction Time (Wilks' Lambda = .653, $F(8,101) = 6.709$, $p < .001$) and Time and Group (Wilks' Lambda = .732, $F(8,101) = 4.612$, $p < .001$).

As there were interactions between the factors Time and Group in many of the variables, it was considered appropriate to carry out an analysis of the differences between the control and EG, both in the pre-test and post-test, independently. In the pre-test, no significant differences were identified between the control and EG, indicating homogeneity in relation to the variables of interest. In contrast, at the post-test, significant differences ($p < .05$) in favour of the EG were evident for satisfaction with competence ($p = .007$), relatedness ($p = .012$), PMI ($p = .009$), autonomous motivation ($p < .001$), SDI ($p = .010$) and MIPA ($p < .001$) (Table 2).

Table 2
Multivariate analysis by group

		Pre-Test		Post-Test		Difference Pre-Post	
	Group	Mean	SD	Mean	SD	p-value	Dif (SD)
Competence	CG	3.878	1.187	4.283	1.277	.052	.406 (.206)
	EG	3.960	.867	4.878	.961	< .001**	-.891 (.125)
	p-value + Dif	.516	-.119	.007*	-.604		
Autonomy	CG	3.883	1.109	3.467	1.277	.162	-.417 (.296)
	EG	3.801	.992	3.815	1.267	.975	.006 (.180)
	p-value + Dif	.723	.078	.201	-.344		
Relatedness	CG	3.850	.872	4.000	1.045	.499	.150 (.221)
	EG	4.0367	.22	4.590	1.082	< .001**	-.548 (.134)
	p-value + Dif	.272	-.181	.012*	-.579		

		Pre-Test		Post-Test		Difference Pre-Post	
PMI	CG	3.870	.849	3.917	1.048	.793	.046 (.176)
	EG	3.942	.559	4.428	.870	< .001**	.481 (.107)
	p-value + Dif	.591	-.074	.009*	-.509		
Autonomous Motivation	CG	4.490	1.379	4.623	.933	.444	.133 (.174)
	EG	4.894	.906	5.146	.609	.014*	.264 (.106)
	p-value + Dif	.091	-.390	< .001**	-.520		
Controlling Motivation	CG	3.141	1.430	3.346	1.240	.519	.204 (.316)
	EG	2.956	1.169	3.185	1.592	.260	.679 (1.421)
	p-value + Dif	.458	.198	.567	.185		
SDI	CG	3.428	4.926	4.107	5.283	.634	.679 (1.421)
	EG	4.777	4.733	8.907	5.792	< .001**	4.139 (.863)
	p-value + Dif	.187	-1.366	< .001**	-4.826		
MIPA	CG	3.620	.839	3.127	1.026	.023*	-.493 (.214)
	EG	3.868	.746	4.244	.784	.004*	-.381 (.130)
	p-value + Dif	.139	-.248	< .001**	-1.122		

Note. * $p < .05$; ** $p < .01$; SDI = self-determination index; PMI = psychological mediator index; MIPA = measure of intention to be physically active; SD = standard deviation, Dif = difference in means; CG = control group; EG = experimental group.

On the other hand, if we compare the variables between the pre-test and post-test for each group over time, we can see that for the CG there were significant differences for the MIPA ($p = .023$), produced by a decrease in the data. Whereas, for the EG scores increased significantly for the variables of competence satisfaction ($p < .001$), relatedness ($p < .001$), IMP ($p < .001$), autonomous motivation ($p = .014$), SDI ($p < .001$), and MIPA ($p = .004$).

Regarding differences at the level of Sex, Group and Time, significant differences were found at the pre-test for autonomous motivation in the girls ($p = .004$), while at the post-test there were differences in the girls for the variables of competence satisfaction ($p < .001$), autonomy ($p = .018$), relatedness ($p < .001$), PMI ($p < .001$), autonomous motivation ($p < .001$), SDI ($p = .002$) and the MIPA ($p < .001$). With regard to the boys, there were differences at post-test for the variables SDI ($p = .016$), and MIPA ($p = .033$) (Table 3).

Table 3
Multivariate analysis by sex

		Pre-test		Post-test		Difference Pre-Post	
		Boys	Girls	Boys	Girls	Boys	Girls
		Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	p-value	p-value
Competence	CG	4.22 (.96)	3.53 (1.32)	4.82 (1.00)	3.74 (1.32)	.042*	.471
	EG	4.07 (.70)	3.92 (.73)	4.99 (.88)	4.79 (1.02)	< .001**	< .001**
	p-value	.568	.131	.600	< .001**		
Autonomy	CG	4.08 (.97)	3.69 (1.23)	3.98 (1.30)	2.96 (1.06)	.811	.082
	EG	3.85 (1.03)	3.76 (.97)	3.77 (1.26)	3.85 (1.29)	.761	.702
	p-value	.473	.819	.589	.018*		
Relatedness	CG	4.02 (.76)	3.68 (.97)	4.34 (1.16)	3.66 (.82)	.305	.943
	EG	3.97 (.72)	4.09 (.73)	4.47 (1.14)	4.69 (1.03)	.013*	< .001**
	p-value	.819	.072	.704	.001*		
PMI	CG	4.10 (.72)	3.63 (.92)	4.38 (.98)	3.45 (.92)	.273	.467
	EG	3.96 (.57)	3.92 (.56)	4.40 (.92)	4.44 (.84)	.006*	< .001**
	p-value	.467	.131	.922	< .001**		
Autonomous motivation	CG	4.86 (1.12)	4.12 (1.55)	4.90 (.89)	4.34 (.92)	.866	.362
	EG	4.72 (.88)	5.03 (.91)	5.12 (.65)	5.16 (.58)	.014*	.339
	p-value	.684	.004*	.305	< .001**		

		Pre-test		Post-test		Difference Pre-Post	
Controlling motivation	CG	3.36 (1.30)	2.93 (1.56)	3.44 (1.33)	3.25 (1.19)	.852	.468
	EG	2.82 (.93)	3.07 (1.33)	2.92 (1.48)	3.40 (1.67)	.722	.199
	p-value	.161	.703	.262	.739		
SDI	CG	3.98 (5.02)	2.98 (4.94)	4.94 (6.15)	3.28 (4.30)	.632	.845
	EG	4.97 (4.40)	4.62 (5.03)	9.20 (5.98)	8.67 (5.69)	< .001**	< .001**
	p-value	.503	.228	.016*	.002*		
MIPA	CG	3.70 (.85)	3.53 (.85)	3.52 (.90)	2.73 (1.02)	.538	.009*
	EG	3.86 (.80)	3.88 (.71)	4.30 (.71)	4.20 (.84)	.027*	.062
	p-value	.522	.143	.033*	< .001**		

Note. * $p < .05$; ** $p < .01$; SDI = self-determination index; PMI = psychological mediator index; MIPA = measure of intention to be physically active; SD = Standard deviation; CG = control group; EG = experimental group

As for the differences at Group and Sex level over time, significant differences were found in the CG over time for the boys in competence satisfaction ($p = .042$) and for the girls in MIPA ($p = .009$), in this second case, by a decrease in the values. With regard to the EG and for the boys, differences were found for satisfaction with competence ($p < .001$), relatedness ($p = .013$), PMI ($p = .006$), autonomous motivation ($p = .014$), SDI ($p < .001$) and MIPA ($p = .027$). Continuing with the EG and in the girls, differences were found for satisfaction with competence ($p < .001$), relatedness ($p < .001$), PMI ($p < .001$) and SDI ($p < .001$).

Discussion

The aim of this study was to analyse the effect of an intervention programme delivered through the hybridisation of the LTM and the SEM on the satisfaction of BPN, motivation, and intention to be physically active among high school students in PE classes, with an analysis based on sex differences. Overall, the results revealed significant differences between groups, favouring students who participated in the hybrid LTM/SEM intervention. The discussion will address the findings according to the proposed hypotheses, both at a general level and segregated by sex.

The first hypothesis suggested that students taught through the hybrid LTM/SEM unit would report higher levels of BPN satisfaction compared to those taught using a traditional methodology. The results indicated significant improvements over time and between groups in the PMI, which combines autonomy, competence, and relatedness satisfaction. Significant increases were observed in competence and relatedness satisfaction, but not in autonomy satisfaction, leading to a partial acceptance of the hy-

pothesis. These findings align with the study by Menéndez and Fernández-Río (2016), which hybridised SEM with the Personal and Social Responsibility Model, and with the study by Valero-Valenzuela et al. (2019), both of which reported improvements in competence and relatedness satisfaction but no changes in autonomy satisfaction. Partial agreement is also found with the research by Gil-Arias et al. (2021), which showed increases in all three BPN after implementing a programme combining SEM and the Teaching Games for Understanding (TGfU) model. Furthermore, the results partially align with those of Yupa-Pintado and Heredia-León (2020), which evaluated the application of LTM in adolescent athletes aged 9 to 18 in an extracurricular context, reporting improvements in all three BPN analysed. Regarding other studies focusing on LTM, this research closely mirrors findings from Perlman (2010), where groups exposed to LTM interventions achieved higher levels of autonomy, competence, and relatedness satisfaction.

The findings regarding competence satisfaction are consistent with previous studies highlighting the importance of role selection in fostering students' perception of competence. Allowing students to choose roles that align with their interests and strengths, such as coach or referee, enhances their sense of competence (Gil-Arias et al., 2021; Hastie & Casey, 2014). In this study, students were encouraged to select multiple roles, which could have provided diverse opportunities to experience competence (Gil-Arias et al., 2021; Perlman, 2012). Additionally, research on the SEM emphasises its ability to create a task-oriented motivational climate, strongly linked to competence perception (Wallhead & Ntoumanis, 2004). Similar results are reported in studies where the SEM was implemented, leading to improved competence satisfaction (Cuevas et al., 2015; Siedentop, 2011). From the perspective of the LTM, teaching through ludotechnical proposals could explain this improvement, as such approaches make learning more engaging and enjoyable (Valero & Conde, 2003). Another contributing factor may be the cognitive dissonance triggered by challenge-based questions, which require students to explore and evaluate solutions through interrogative feedback from the teacher, promoting deeper engagement and understanding (Drost & Todorovich, 2017).

The increase in relatedness satisfaction aligns with previous research on the SEM, which consistently shows improvements in this area (Perlman & Goc Karp, 2010). The SEM fosters a climate of collaboration and communication among students, their peers, and teachers (Perlman & Goc, 2010). Factors such as consistent team membership and adherence to fair play rules may further enhance this sense of connectedness (Casey & MacPhail, 2018; Gil-Arias et al., 2017). Regarding the LTM, the use of challenge questions may facilitate better teacher-student interactions, while gamified learning forms appear to cultivate a more positive classroom environment compared to repetitive, drill-based exercises (Valero & Conde, 2003).

When examining sex differences, both boys and girls showed significant improvements in PMI, competence satisfaction, and relatedness satisfaction, aligning partially with findings from Gil-Arias et al. (2021), where both sexes improved across all three BPN in a hybrid TGfU/SEM unit. Focusing specifically on relatedness satisfaction, Perlman et al. (2010) suggest that mixed-sex teams within the SEM framework promote feelings of affiliation and social connection among students. Additionally, using split-court activities rather than invasion games may have facilitated stronger social bonds by reducing competition and fostering collaboration (Mandigo et al., 2008).

Over time, significant improvements in all three BPN were observed exclusively among girls. This aligns with findings from Farias et al. (2022), suggesting that girls

may place higher value on social relatedness or respond more positively to the inclusive and equitable opportunities provided by the SEM. Characteristics such as a sense of belonging and contribution to the group, as well as taking on leadership roles like coach-student, may empower girls and enhance their satisfaction (Bessa et al., 2019).

The second hypothesis proposed that students taught through the hybrid LTM/SEM unit would report higher scores on the self-determination index (SDI) and autonomous motivation post-intervention compared to students taught through the traditional unit. In this regard, students who experienced the hybrid programme obtained significantly higher values on the post-intervention measure and between groups on both factors, with no improvement in controlling motivation, so that, with the data obtained, the hypothesis put forward could be accepted.

Several investigations suggest that the increase in BPN satisfaction is subject to an improvement in autonomous motivation (Deci & Ryan, 2000; Gil-Arias et al., 2017; Ntoumanis & Standage, 2009). For Perlman (2012) the relatedness is the main factor for this increase. Models such as SEM favour BPN satisfaction and, thus, greater self-determination of motivation (Mandigo et al., 2008), creating climates in which students' individual development, pleasure and growth are fostered. For other authors, SEM characteristics such as longer seasons or cohesive teams favour increased motivation (Perlman, 2012, Wallhead & Ntoumanis, 2004). The results are consistent with several studies in which an intervention with SEM/TGfU hybridisations was conducted (Gil-Arias et al., 2017, 2020). On the other hand, autonomous motivation may have been enhanced by the LTM approach to provide engaging and stimulating experiences for students. Previous research in other fields of PE and sport also revealed increased intrinsic motivation following the use of LTM (Yupa-Pintado & Heredia-León, 2020).

At the sex level, the results show that there were significant differences for the intervention group over time and between groups in the SDI in both sexes. In terms of autonomous motivation, there were significant improvements over time for boys, although it should be noted that between-group differences existed in both the pre-test and post-test. These data differ from some previous studies in which differences are shown in both sexes with the SEM (Bessa et al., 2019), or in hybridisations of models (Fernández-Río & Iglesias, 2022; Gonzalez-Víllora et al., 2018). On the contrary, the CG, did not show benefits in terms of motivational variables so its application may be questionable in the context of high-quality PE positioning (Dudley et al., 2022).

The third hypothesis stated that students who were taught through the hybrid LTM/SEM unit would report higher scores on intention to be physically active post-intervention compared to students who were taught through the traditional unit. In this regard, students who experienced the hybrid programme obtained significantly higher values on the post-intervention measure in both groups, increasing in the experimental and decreasing in the control, so the hypothesis put forward can be accepted.

These results are consistent with other studies in which hybridisations of TGfU/SEM models have been performed and have been shown to improve MIPA (Gil-Arias et al., 2017). The improvement of this factor was possible because, according to some studies, autonomous motivation is a predictor of high levels of MIPA in students (Ntoumanis, 2005). Similarly, other research found higher levels of MIPA in self-determined profiles, coinciding with studies such as those of Valero-Valenzuela et al. (2019). Other investigations indicate that the perception of competence (a factor that has increased significantly after the intervention) represents one of the aspects that most affect MIPA at the end of the high school (Cuevas et al., 2015).

With regard to sex, the results show that there were significant differences for the intervention group over time in boys. It should be noted that in the CG there were also significant differences in the case of girls, but in this case, it was produced by a decrease in values. Regarding sex and between groups, both presented significant differences in favour of the EG. The improvement of MIPA is supported by several studies in which after applying a hybridised SEM/TGfU programme it improves in both sexes (Gil-Arias et al., 2017).

Despite the strengths, several limitations and future research directions should be considered. First, in this study we examined the joint effects of a long-term hybrid programme, where the contents addressed were different (table tennis + athletics). Consequently, it would be valuable to analyse the effect of an intervention across the two included units that make up the programme and the phases within each unit. Other aspects to consider include the lack of randomization of the sample and control of confounding factors, which could have introduced bias and influenced the interpretation of the results, as well as the unequal number of participants in the CG and in the EG. Moreover, the lack of representativeness of the sample and the specific setting in which the research was carried out may influence the generalisability of the results and the replicability of the study in other contexts. Also, it should be noted that the analysis of reliability assessment was not completely objective because the process used here was based on qualitative analysis, in which data analysis may be biased by the way they interpret the data.

Future proposals include using larger samples across different high schools in the city, with well-balanced groups, involving a greater number of PE teachers, and including students from diverse socioeconomic backgrounds. Moreover, it is recommended to involve schools from other countries in order to assess the cross-cultural applicability and generalisability of the findings. In addition, a post-intervention follow-up should be carried out to analyse the long-term effects of the intervention. It would also be interesting to carry out other studies in which other didactic units of target and target sports, collaboration or invasion are developed to refute the extracted data.

Conclusion

The present study shows that a hybrid programme between LTM/SEM of long duration produced improvements at a general level compared to a traditional methodology in satisfaction with competence, relatedness, PMI, autonomous motivation, SDI and MIPA. In terms of sex, there were improvements between groups for both boys and girls in favour of the EG for the variables SDI and MIPA, and only for the girls in satisfaction of competence, autonomy, relatedness, PMI and autonomous motivation. These last aspects seem to indicate that this hybridisation helps the inclusion of girls in the subject of PE compared to a traditional methodology. It should also be acknowledged that no single pedagogical model is universally effective across all contexts and content areas. Therefore, the flexibility provided by combining models allows for better alignment with students' interests and needs. Future research in this area is necessary to expand the scientific knowledge available to PE teachers, helping them improve their instructional programs and training in such methodologies. Ultimately, this could enhance their ability to support students' BPN, increase motivation levels, and foster greater intention to engage in physical active.

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