

Relationship between cardiorespiratory fitness and English performance as foreign language

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ABSTRACT: The aim of the present study was to examine the relationship between cardiorespiratory fitness and foreign language score, among primary and secondary education students in a group of 223 students (111 of primary school and 122 of secondary school) from Balears region, Spain, aged between 9 and 16 years old that participated in the study. A statistical regression analysis was carried out for the comparison of the two variables (cardiorespiratory fitness and English subject score) in primary and secondary education. Physical fitness was assessed using the 6-minute walk test (6MWT) and the values obtained were shown in $VO2_{max}$. English subject scores were collected at the end of the year prior to the test. The results obtained did not reveal any correlation between $VO2_{max}$ and final English score in primary school ($r=.04$, $p=.65$). However, dataset revealed a positive small correlation between $VO2_{max}$ and final English score in secondary school ($r=.26$, $p=.01$). These findings suggest that while physical activity may have some positive effect on final score, the relationship is complex and may be influenced by various other factors. Further research is needed to better understand the relationship between physical activity and learning, as well as the potential moderating factors involved.

Key words: physical fitness; cardiorespiratory fitness; language learning; physical activity; primary school; secondary school

Relación entre la aptitud cardiorrespiratoria y el rendimiento en inglés como lengua extranjera

RESUMEN: El objetivo del presente estudio fue el de examinar la relación existente entre la aptitud cardiorrespiratoria y el aprendizaje del inglés como lengua extranjera entre los estudiantes de educación primaria y secundaria en un grupo de 223 estudiantes (111 estudiantes de educación primaria y 112 estudiantes de educación secundaria) de la región de Baleares, España, con edades comprendidas entre los 9 y los 15 años participaron en el presente estudio. Se llevó a cabo un análisis estadístico de regresión para la comparación de las dos variables (aptitud cardiorrespiratoria y puntuación en la asignatura de inglés) en educación primaria y educación secundaria. La aptitud física se evaluó mediante la prueba de caminata de 6 minutos (6MWT) y los valores obtenidos se mostraron en $VO2_{max}$. Las notas de la asignatura de inglés se recogieron al acabar el curso anterior a la realización de la prueba. Los resultados obtenidos no revelaron ninguna correlación entre el $VO2_{max}$ y la puntuación final de inglés en educación primaria. Sin embargo, el conjunto de datos reveló

una pequeña y positiva correlación entre el $VO_{2\max}$ y la puntuación final en inglés educación secundaria. Estos hallazgos sugieren, si bien la actividad física puede tener algún efecto positivo en el rendimiento académico, la relación es compleja y puede estar influenciada por diversos factores. Por todo ello, se necesita más investigación para comprender mejor la relación entre la actividad física el rendimiento académico, así como los posibles factores moderadores involucrados.

Palabras clave: condición física; condición cardiorrespiratoria, aprendizaje de idiomas, actividad física, educación primaria, educación secundaria.

1. INTRODUCTION

Physical fitness has irreplaceable health benefits as it maintains, strengthens or improves good health. It is a major factor in shaping the proper development of children and adolescents, as well as the main stimulator of psychomotor development. Likewise, educationally, when analysing the results of studies that use active teaching methodologies to improve physical fitness, positive results are observed on cognitive performance, attention and concentration, so it is also important to take into account the quantitative and qualitative characteristics of the active methodologies used to improve physical fitness in higher education students (Rodríguez-García, et al., 2022). Adapted to the needs of the body, physical fitness increases its overall efficiency, increases muscle mass and increases resistance and strength to negative effects (Janssen and Leblanc, 2010; Smith et al., 2014; Trudeau and Shephard, 2008).

In addition to these physical and mental health benefits, it has been shown that cardiorespiratory fitness (CRF) has positive effects on cognition (Sardinha et al., 2014) but the magnitude of this association remains unknown (Haapala, 2009). Improvements in CRF may contribute to increased academic achievement not only through a direct mechanism also through improvements in executive functions (Visier-Alfonso et al., 2020). Systematic reviews suggest that high levels of CRF and motor skills may be beneficial for cognitive development and academic performance, but the evidence is mainly based on cross-sectional studies (Haapala, 2009). Some longitudinal studies support the positive association between aerobic fitness and academic performance (Álvarez-Bueno et al., 2020). Findings like these add to the growing evidence suggesting that aerobic fitness is positively related to school performance.

It is known that physical fitness is positively associated with academic performance (Van Dusen et al., 2011; Castelli et al., 2007; Antunes et al., 2018) and that children with higher levels of ACR perform better academically than their less fit peers (Donnelly et al., 2016; Chomitz et al., 2009; Castelli et al., 2007; Scott, et al., 2017). Moreover, it appears that higher levels of CRF are associated with a positive effect on children's cognitive functioning (Donnelly et al., 2016; Chaddock, et al., 2011). However, the extent to which executive functions can modify, mediate or diminish the association between CRF and academic performance in children is unclear.

Although it seems clear that there exists a positive associations between CRA, physical fitness, cognition and academic performance, many of the studies are inconsistent and the effects of numerous elements of CRA on cognition, such as type, amount, frequency and timing, remain to be explored (Donnelly et al., 2016). Not all research results are unequivocal,

which may be due to differences in methodology. Some studies have used school grades to measure academic performance and others used language and mathematics tests to measure school performance (Górska et al., 2018).

Regarding specific areas of learning, Moore et al. (2014) demonstrated that the benefits of ACR extend to arithmetic cognition, which has important implications for the educational environment and learning context. In relation to language learning, a positive association has been found between aerobic fitness and specific domains of academic performance (language/reading-related skills, mathematics-related skills and composite scores) (Álvarez-Bueno et al., 2020).

ACR is independently and combined related to academic achievement in seventh grade students regardless of different cohorts, providing further support that students with ACR are more likely to perform better in school, regardless of the year they were in (Donnelly et al., 2016). However, while CRF is positively related to academic performance, in high school students in Taiwan, the relationship depends on the academic subject, as well as the duration and length of time the aerobic fitness was maintained (Hsieh et al., 2019). In these students, no relationship was observed between CRA and text comprehension and expression. Although executive functions were correlated with school grades, cognitive flexibility drove the indirect effect when all executive function domains were considered simultaneously. It is important to note that not all executive function domains contributed equally because cognitive flexibility played a major role in this broad age range. Furthermore, the relationship between CRA and school performance was strongest for mathematics and low-level language subjects, but not significant for higher-level language subjects, which provides a more modulated view of the effect of CRA on language.

Finally, it can be stated that CRF is generally associated with better performances in working memory and inhibitory control aspects of executive function in pre-teens (Zhan et al., 2020).

Many questions remain regarding how to incorporate Physical Activity in schools to develop CRF, such as activity breaks versus active lessons in relation to improving academic performance and learning foreign languages, such as English. Regardless, the literature does not suggest any indication that increases in physical activity negatively affect cognition or academic performance and that CRF is important for growth and development and overall health.

Based on the available evidence, previous studies conclude that CRF has a positive influence on cognition as well as brain structure and function; however, more research is needed to determine the mechanisms and long-term effect, as well as strategies for translating laboratory findings to the school setting. The literature suggests that physical activity and physical education have a neutral effect on academic performance. Therefore, due to limitations in the literature and the current information available, the category rating of evidence for academic performance is C in systematic reviews and meta-analyses (Donnelly et al., 2016).

The purpose of this study is to systematise the existing evidence on the relationship between CRF and the performance of language-related cognitive domains, such as performance English as a foreign language (EFL). In this sense, the hypothesis of the present study will be obtaining a relationship between better values in CRF reflexed in $VO_{2\max}$ and better scores in english performance.

2. METHOD

2.1. Experimental approach to the problem

The present study used an experimental approach to evaluate the relationship between $VO_{2\max}$ and English as foreign language' final score among primary and secondary education students. To assess physical fitness, 6-minute walking test (6MWT) was administered to all participants. The English score was collected using the final academic report card. Dataset was analysed using Pearson's correlation coefficient to determine the strength and direction of the relationship between cardiorespiratory fitness, reflected in $VO_{2\max}$, and English score.

2.2. Participants

A total of 223 students in grades K5 (fifth grade of primary education in Spain -9 years old- 111 students) to K10 (fourth year of secondary school in Spain -16 years old- 112 students) (primary school: 10.11 ± 0.82 ; secondary school: 13.66 ± 0.97 , in years) participated in this study. The participants were from two schools in the region of Balears and had to meet the following inclusion criteria: (i) normal vision and no history of neuropsychological impairments that could affect the results of the experiment; (ii) no health problems that could bias the results or prevent them from taking the study's tests; and (iii) participation in an extracurricular sports activity. The students were recruited from the city of Palma de Mallorca. A written and signed consent had to be obtained from the parent/guardian of each adolescent who wished to participate. The study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of the university's research institute (2021/89).

2.3. Measures and instruments

The research assistants were familiarised with the anthropometric and 6MWT protocols through previous meetings. However, the principal investigator was always present at the data recording.

2.3.1. Anthropometrical measure

Anthropometric data for height and body mass were collected using a standardized protocol (Marfell-Jones et al., 2012). Participants were asked to remove their shoes and heavy clothing and stand on a flat surface with their head in the Frankfurt plane. Height was measured to the nearest 0.1 cm using a stadiometer, and weight was measured to the nearest 0.1 kg using a digital scale. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. All measurements were taken by trained research assistants and were completed in triplicate to ensure accuracy. Data were analyzed using statistical software to calculate means and standard deviations.

2.3.2. *Physical Fitness*

Aerobic capacity and endurance were measured through the 6-minute walking test (6MWT) in a 30-meter corridor with markers every 3 meters, developed by the American Thoracic Society. Cones were used to mark the return points and a brightly colored tape was used to indicate the starting point. Participants were instructed to walk back and forth in a straight line as quickly as possible at their own pace for a 6-minute period. Subjects were informed every minute during the 6MWT, and the total distance covered by each student was recorded as the result of the 6MWT test Reproducibility: We follow the protocol of González-Fernández et al., 2022 performed with 187 young students. In addition, to confirm the reproducibility of the 6MWT, 80 boys were randomly selected to repeat the 6MWT with a 1-week interval (Ulrich et al., 2013; Jalili et al., 2018).

2.3.3. *English score*

English scores were collected from students' report card. The scores were provided by the school and included the final grades for the previous academic year, which ended in June. To ensure the accuracy and confidentiality of the data, only trained research assistants were allowed to access the transcripts. The English grades were recorded and entered a secure database for analysis. All data were handled in accordance with the appropriate ethical guidelines and protocols.

2.4. Procedure

The 6-minute walking test was used to assess physical fitness on the first day during a physical education class. Data collection followed established protocols and obtained informed consent from participating families. Ensuring ethical treatment of study participants is crucial, and appropriate measures were taken to protect the rights and well-being of the individuals involved. This included obtaining written consent from families prior to collecting any data and informing participants about the nature and purpose of the study. All data were collected in accordance with relevant ethical guidelines and regulations, and efforts were made to minimize any potential risks or discomfort for the participants. The evaluations were conducted with a 24–72-hour interval between them and took place between 9 a.m. and 1:30 p.m. in the morning.

The score of the participants was collected by the advisors using the academic report card, with the permission of the responsible parties. In order to ensure the accuracy and reliability of the data, the advisors were trained on the proper procedures for collecting and recording the grades. The grades were collected for all subjects, including language score, and were converted to a standardized scale to allow for comparison across subjects and schools. The data were entered into a secure database and only the research team had access to the raw data. Any discrepancies or missing data were addressed with the advisors to ensure the completeness and accuracy of the data. The inclusion criteria were: i) students that were registered in school and had $VO_{2\max}$ values and final English scores. The exclusion criteria for participants in this study were (i) have a health problem that could bias any result or prevent you from taking a 6MWT of the study, and (c) not have parental authorization.

To further validate the score data, we also conducted a thorough review of the participants' attendance records and teacher evaluations. This allowed us to identify any potential

issues that may have affected the students' grades and to ensure that the data accurately reflected their achievement. Overall, the data collection process was thorough and carefully controlled to ensure the reliability and validity of the results.

2.5. Statistical analysis

Descriptive statistics were calculated for each variable. Tests for normal distribution and homogeneity (Kolmogorov-Smirnov and Levene's, respectively) were conducted on all metrics and the data were found to have a normal distribution. Pearson's correlation coefficient (r) was then used to examine the relationship between $VO_{2\max}$ and the final score for each group of subjects in the foreign language (English). To interpret the magnitude of these correlations, the following criteria were used: $r \leq 0.1$, trivial; $0.1 < r \leq 0.3$, small; $0.3 < r \leq 0.5$, moderate; $0.5 < r \leq 0.7$, large; $0.7 < r \leq 0.9$, very large; and $r > 0.9$, almost perfect. A regression analysis was used to examine which group of subjects in the foreign language (English) could be used to better explain the values of $VO_{2\max}$ measures with significant correlations. Pearson's correlation coefficient (r) was then used to examine the relationship between $VO_{2\max}$ and the final score for each group of subjects in the foreign language (English).

3. RESULTS

Descriptive statistics were calculated for each variable (Table 1). x

Table 1. Anthropometrical measures, physical fitness parameters and subjects score (mean \pm SD).

Students [$n=223$ (111 PS and 112 SS)]								
	MEAN (SD)		RANGE		MINIMUM		MAXIMUM	
	PS	SS	PS	SS	PS	SS	PS	SS
ANTHROPOMETRICAL MEASURES								
Age (years)	10.11 \pm 0.82	13.66 \pm 0.97	3.00	3.00	9.00	12.00	12.00	15.00
Height (cm)	145.73 \pm 8.97	163.08 \pm 7.21	40.00	31.00	127.00	150.00	167.00	181.00
Body mass (kg)	41.05 \pm 11.08	53.38 \pm 11.49	46.00	67.70	23.00	30.00	69.00	97.70
BMI (%)	19.01 \pm 3.68	21.08 \pm 3.34	18.95	19.69	8.00	13.33	26.95	33.02
PHYSICAL FITNESS PARAMETERS								
6MWT (m)	640.52 \pm 56.05	699.41 \pm 23.14	359.00	379.00	435.00	341.00	794.00	720.00
6MWT. $VO_{2\max}$ (mL/min/kg)	37.22 \pm 4.98	33.52 \pm 5.54	29.56	28.56	20.62	15.77	50.18	44.33
ENGLISH SCORE								
Score	8.07 \pm 1.78	7.35 \pm 1.41	8.00	1.00	2.00	1.00	10.00	10.00

Note: PS: Primary School; SS: Secondary School, BMI: Body Mass Index

First, a correlation analysis was performed between $VO2_{max}$ and the EFL grades of the subjects which did not reveal any correlation in elementary school, $r=.04$, $p=.65$. However, we found a positive small correlation between $VO2_{max}$ in secondary school ($r=.26$, $p=.01^*$) and English performance. See figure 1, for more information. A multilinear regression analysis was performed to verify which which group of subjects in the foreign language (English) could be used to better explain the values of $VO2_{max}$ measures with significant correlations. Finally, regression analysis showed values of $F=8.06$, $p= 0.01$ and $r^2= 0.07$, adjusted $r= 0.06$.

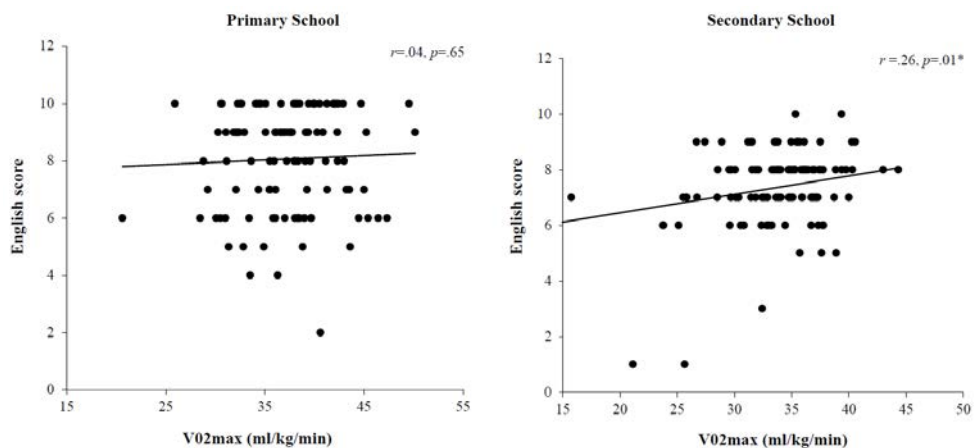


Figure 1. Correlation analysis between foreign language English score and $VO2_{max}$ (ml/kg/min) in elementary and secondary school.

4. DISCUSSION

The present study aimed to examine the relationship between $VO2_{max}$ and performance in foreign language, specifically English, among primary and secondary education students, indicating that physical activity may be related to improved language learning, especially among young learners (Hillman et al., 2008). The results of the 6-minute walk test (6MWT) showed a weak correlation between $VO2_{max}$ and English performance in primary education ($r=.04$, $p=.65$), and a positive small significant correlation in secondary education ($r=.26$, $p=.01^*$). Ranges of respiratory capacity were 29.56 for primary school students and 28.56 for secondary school students. These values fall within the normal range for respiratory capacity in children of this age group. This suggests that the respiratory function of the students in this study was within normal limits.

These findings are in line with previous research suggesting that while physical activity may have some positive effect on learning (Davies et al., 2010; Tremblay et al., 2011, Marqués et al., 2018; Erickson et al., 2019), the relationship is complex and may be influenced by various other factors (Kwak et al., 2009; Sibley & Eitner, 2003; Vazou et

al., 2019, Barbosa et al., 2020). For example, it has been suggested that the type, intensity, and duration of physical activity (Teferi, 2020), as well as the timing and context in which it occurs, may all play a role in its impact on learning (Kwak et al., 2009; Lubans et al., 2012; Benes, Sullivan & Yan, 2016, Daly-Smith et al., 2018). Furthermore, the relationship between physical activity and academic achievement may vary depending on other factors such as the age and developmental stage of the individual (Shephard, 1997; Sibley & Eitner, 2003; Wahlstrom et al., 2014; Donnelly et al., 2016), or socio-economic status (Romeo et al., 2022; Qi, 2022).

In our view, the weak correlation between $VO2_{max}$ and English performance in primary education may not be statistically significant because this association is complex and may be affected by the academic year, the volume and intensity of physical activity and the school grade. From a practical point of view, in order to enhance this small connection between $VO2_{max}$ and English performance, more extensive interventions, compared to the one carried out in this study, should be carried out, taking into account various academic factors, school level and type and intensity of physical activity.

There are several potential mechanisms by which physical activity may influence language learning (Petruzzello et al., 1997, Bidzan-Bluma & Lipowska, 2018; Shadiev & Yang, 2020). For example, physical activity may improve executive function, which is a set of cognitive skills that are important for language learning, such as working memory and attention (Hillman et al., 2008). Physical activity may also increase blood flow to the brain, which may enhance neural functioning and support the learning process (Blair et al., 1989; Saéz et al., 2021). In addition, physical activity may reduce stress and improve mood (Dishman, Sallis & Orenstein, 1985; Sallis et al., 1997) which may facilitate language learning by creating a more positive and supportive learning environment.

Additionally, it is worth noting that the relationship between physical activity and learning may differ depending on the subject or task at hand (Muntaner-Mas et al., 2018; Vazou et al., 2019). For example, some studies have found stronger relationships between physical activity and performance in subjects such as math and science (Davies et al., 2010), while others have found weaker or no relationship in language-based subjects (Kwak et al., 2009, Mullender-Wijnsma et al., 2016, Hiver et al., 2021). This may be because language learning requires different cognitive skills and processes than those involved in physical activity (Kwak et al., 2009; Biddle & Asare, 2011; Biddle et al., 2019). To improve foreign language learning, it may be beneficial to consider strategies that incorporate both physical activity and language learning. For example, incorporating physical activity breaks into language lessons or using physical activity to reinforce language learning (e.g., through sports-themed vocabulary lessons) may be effective in enhancing both physical and cognitive skills (Kwak et al., 2009).

Also, providing students with access to physical activity opportunities outside the classroom may also have a positive impact on their overall learning performance, including EFL learning. Other studies have also found that physical activity may have a greater impact on certain subjects, such as mathematics (Singh et al., 2019; Egger et al. 2019), compared to others (Davies et al., 2010).

It is also important to consider other factors that may influence both $VO2_{max}$ and academic performance, such as genetics, socio-economic status, and access to resources (Sibley

& Eitner, 2003; Kwak et al., 2009; Schwab et al., 2016, Pace et al., 2017). For example, students from disadvantaged backgrounds may have lower $VO_{2\max}$ due to limited access to physical activity opportunities, as well as lower learning outcomes/results due to limited access to educational resources (Vazou et al., 2019; Chen et al., 2018; Qi, 2022). Addressing these broader determinants of health and education may be necessary for optimizing both physical and academic outcomes in students.

One of the strengths of this study is the large sample size, which allows for greater statistical power and the ability to detect trends and associations. One limitation of a study comparing physical activity and language learning is the difficulty in controlling other factors that may impact language learning, such as the amount of time dedicated to language study or innate language ability (Krashen, 1982). However, it would be valuable in future research to expand the sample to include data from other towns and cities in order to more fully understand the generalizability of these findings. This would help to provide a more comprehensive understanding of the factors that may influence the relationship under investigation. Overall, the large sample size and positive trend observed in this study provide valuable insights and suggest the need for further research to explore this relationship in greater depth.

Furthermore, self-report measures of physical activity and language learning may be subject to bias, as participants may not accurately recall or report their behaviors (McAuley & Blissmer, 2000; Chase et al., 2001). Some other limitations of a study comparing physical activity and language learning could include: i) Sample size: A small sample size may not be representative of the larger population, and may not have sufficient power to detect significant relationships between physical activity and language learning. ii) Generalizability: The results of the study may not be generalizable to other populations, such as individuals of different ages, genders, or cultural backgrounds. iii) Interaction effects: It is possible that the relationship between physical activity and language academic achievement may vary based on other factors, such as the type of physical activity or the language being learned. These interaction effects may not be fully captured in a single study. To address these limitations, future studies could include larger sample sizes, more diverse samples, and consider the potential moderating effects of other variables. Additionally, using a multi-method approach, incorporating both quantitative and qualitative data, may provide a more complete understanding of the relationship between physical activity and language learning. Longitudinal or intervention studies, where physical activity is manipulated and language learning is measured over time, may also be useful in further exploring this topic.

There are several areas for future research in relation to the integration of physical activity in language learning. It would be interesting to investigate the relationship between different types of physical activity (e.g. team sports, aerobics, yoga) and how they affect language learning. In addition, one could analyse how the intensity of physical activity influences language learning outcomes by assessing whether there are significant differences between low-intensity physical activities (e.g. gentle stretching) and high-intensity activities (e.g. cardiovascular training).

Similarly, it would be valuable to investigate the ideal duration and frequency of physical activity to maximise language learning benefits. How long and how many times a week should learners engage in physical activity for the best language acquisition outcomes?

In addition to language learning, it would be interesting to investigate how the integration of physical activity into the wider curriculum affects overall academic performance. Does participation in physical activity improve performance in subjects other than language? These hypotheses and areas of research may provide a starting point for future studies to further explore the relationship between physical activity and language learning, as well as its implications in the educational context.

The results of the study therefore support the importance of promoting physical activity as an integral part of the school curriculum. This implies the need for educational policies that prioritise and allocate adequate time and resources for physical activity in schools. In addition, specific programmes and activities should be developed to encourage student participation in physical activity during school hours. These education policies should encourage the integration of physical activity into language classes. This could involve the implementation of strategies such as the use of games, physical exercises related to vocabulary and grammar, or even the organization of outdoor activities that combine language practice with physical movement. Physical activity not only has cognitive benefits, but also improves the general well-being and health of learners. Education policies should recognize the importance of these aspects and promote a holistic approach to education that includes physical activity as an essential part of students' holistic development.

Finally, in order to effectively implement the integration of physical activity into language learning and curricula in general, teachers need to be provided with adequate training and resources. Teachers should be trained on how to incorporate physical activity effectively into their classes and how to adapt existing instructional strategies to include movement. In addition, educational resources should be developed to help teachers implement these practices in appropriate and meaningful ways.

In summary, the study's findings underline the importance of integrating physical activity into language learning and the wider curriculum. To maximize these benefits, educational policies that promote physical activity, teacher training and appropriate educational resources are needed. In doing so, we can improve students' educational experience, foster greater wellbeing and health, and promote a more holistic approach to education.

5. CONCLUSION

The present study found weak to moderate relationship between $VO_{2\max}$ and English performance in primary and secondary education students. While physical activity may have some positive effect on final scores, the relationship is complex and may be influenced by various other factors, including the type and intensity of physical activity, the subject being studied, and individual characteristics such as age and socio-economic status. Incorporating physical activity into language learning and addressing broader determinants of health and education may be effective in enhancing learning in English as a Foreign Language. Further research is needed to better understand the relationship between physical activity and learning, as well as the potential moderating factors involved.

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