apunts EDUCACIÓN FÍSICA Y DEPORTES

ISSUE 153

Published July 1, 2023
https://doi.org/10.5672/apunts.2014-0983.es.(2023/3).153.10

OPEN ACCESS

Physical Activity in Schoolchildren: Effect on Executive Functions, Academic Performance and Quality of Life

Elena Escolano-Pérez[1*] & Fernando Martín-Bozas[1]

[1] University of Zaragoza (Spain).

Cite this article
Escolano-Pérez, E. & Martín-Bozas, F. (2023). Physical Activity in Schoolchildren: Effect on Executive Functions, Academic Performance and Quality of Life. *Apunts Educación Física y Deportes, 153*, 114-123. https://doi.org/10.5672/apunts.2014-0983.es.(2023/3).153.10

Editor:
© Generalitat de Catalunya
Departament de la Presidència
Institut Nacional d'Educació Física de Catalunya (INEFC)

ISSN: 2014-0983

***Corresponding author:**
Elena Escolano-Pérez
eescola@unizar.es

Section:
Human and Social Sciences

Original language:
Spanish

Received:
October 17, 2022
Accepted:
January 30, 2023
Published:
July 1, 2023

Front cover:
Two surfers practicing freestyle kitesurfing. Adobestock ©MandicJovan. Mediteraneo

Abstract

Although the literature on the effect of physical activity on different areas of human development is extensive, there are still insufficiently conclusive results on some questions concerning its potential cognitive and psychological benefits. The aim of this study was to analyse whether there were differences in the executive functions, academic performance and quality of life of primary school students according to the level of physical activity performed. The sample consisted of 333 students from Year 3 to 6 of primary school at two public schools. The PAQ-C, SENA and KIDSCREEN-27 questionnaires were administered to assess, respectively, physical activity, executive functions (attention, inhibition and emotional regulation) and quality of life. Academic performance was measured according to the grades obtained by the students. The results revealed statistically significant differences according to the level of physical activity performed by students in terms of quality of life (specifically, in the five dimensions comprising it: physical well-being, psychological well-being, autonomy and relationship with parents, relationship with friends and social support, relationship and support in the school environment). No significant differences were found in any of the three executive functions studied (attention, inhibition, emotional regulation) or in academic performance. It is important to promote socio-educational policies aimed at increasing the practice of quality physical activity among schoolchildren (i.e. ones that have the quantitative and qualitative characteristics associated with a higher quality of life in the literature). Intervening at this age is of great importance since this is when habits that will last throughout life are established.

Keywords: academic performance, cognition, executive functions, physical activity, primary school, quality of life.

Introduction

There is a large body of literature that demonstrates that the practice of physical activity (which nowadays should be considered not only from a biological perspective —"all bodily movement produced by the locomotor apparatus involving energy expenditure" (World Health Organization, 2020, p. 6)—, but from a more holistic and human perspective in which emotional facets, perceptual-motor and socio-motor capacities are included (Anguera et al., 2017; Buscà, 2022; Camerino et al., 2012; Devís, 2000), has numerous benefits on a physical level. Although its potential benefits have also been extensively studied at the cognitive and psychological level, the results on some issues have not yet been sufficiently conclusive (Chacón-Cuberos et al., 2020; Padial-Ruz et al., 2022), which explains the need for this study.

Thus, with regard to the benefits of physical activity in the cognitive domain, a topic of great interest in recent years has been determining whether the practice of physical activity is associated with an adequate level of executive functioning and academic performance in students. Executive functions are higher-level cognitive (attention, inhibition...) and affective (such as emotional regulation) processes that allow for the resolution of new or complex situations that arise in everyday life (Zelazo & Carlson, 2012). Often, studies that have analysed the effects of physical activity on executive functions have done so by adopting a limited —and therefore outdated— conception of executive functions, considering only their cognitive components and overlooking the affective ones (Pesce et al., 2021). Some of these studies indicate that children's cognitive executive functions improve after participating in a physical activity programme (Berrios-Aguayo et al., 2022). However, there are also studies that found no positive relationships between physical activity and cognitive executive functions (Padial-Ruz et al., 2022) and even those that found negative relationships (Tarp et al., 2016). Regarding affective executive functions, there are no known studies focused on their relationship with physical activity in children. All this explains the need to address this issue, assuming a contemporary conception of executive functions which also considers their affective dimension.

Academic performance, understood as the degree to which students acquire the skills and competences of an education system (Romero Sánchez & Hernández Pedreño, 2019), is a matter of political and social interest, as the progress of a country is associated with the academic level achieved by its citizens (García Prieto et al., 2021). In view of the high levels of school dropouts (Mullis et al., 2016, 2019), analysing the possible variables that affect school dropouts is of interest in order to intervene in this area. In this regard, there are certain assumptions about the positive effects of physical activity on academic performance (Berrios-Aguayo et al., 2022; De Greeff et al., 2018), although the literature shows that this is not always the case (Donnelly et al., 2017; Tarp et al., 2016). These heterogeneous results explain the need for further research.

On the other hand, and with regard to the psychological field, a construct that is currently the object of great interest is quality of life, defined as "the degree of satisfaction that the person experiences in relation to the fulfilment of their needs and objectives in relation to the living conditions that the environment offers them" (Muntaner Guasp, 2013, p. 38). It is a multidimensional construct and its assessment involves understanding the individual's own perception of his or her physical, psychological and social well-being. This perception, in turn, is affected by the degree of satisfaction of three basic psychological needs (Ryan & Deci, 2007, 2017): autonomy (the origin or source of one's own behaviour), competence (feeling of confidence and effectiveness) and relatedness (feeling connected and integrated with others). The relationship between physical activity and quality of life has been extensively studied in both healthy and unhealthy adults (Helmrich et al., 2022; Pallanch et al., 2022; Peters et al., 2019; Pucci et al., 2012), as well as in children and adolescents with different pathologies and neurological disorders. However, studies in healthy children have been scarcer (Marker et al., 2018). The results of some of these studies suggest a possible relationship between physical activity, provided it is well guided and educational, and quality of life (Jiménez Boraita et al., 2021) or one of its dimensions (Halasi & Lepes, 2022). The relevance of the topic justifies further research in this area in order to increase its understanding.

In relation to all this, the aim of this study was to analyse whether there were differences in the executive functions (attention, inhibition and emotional regulation), academic performance and quality of life of Primary School (PS) students according to the level of physical activity performed. The hypothesis postulated that there would be significant differences in the three variables (executive functions, academic performance and quality of life) depending on the level of physical activity performed, such that students who practised a higher level of physical activity would demonstrate higher levels of these variables.

Methodology

In this study, given its objective, there was no experimental manipulation of the only independent variable studied (physical activity). The absence of such a manipulation allowed participants to be classified according to their level in the independent variable, and participants' values for the dependent variables (executive functions, quality of life and academic performance) were recorded. Moreover, these values were recorded at a single point in time. All this meant that the research was a non-experimental study whose design was ex post facto prospective and simple cross-sectional (León & Montero, 2003).

Participants

The sample consisted of 333 students aged 9-12 (M = 9.90; SD = 0.50). 50.1 % were female and 49.9 % were male. The participants (selected by means of convenience sampling) belonged to two public schools in the province of Huesca, which are mainly attended by students from middle socio-economic backgrounds. All participants belonged to this socio-economic level.

The inclusion criteria were: (1) be in the 3rd, 4th, 5th or 6th year of primary school and (2) have the informed consent of parents/legal guardians. The exclusion criteria were (1) lack of an adequate level of spoken and written Spanish and (2) students with special educational needs (Organic Law for the improvement of the quality of education, 2013).

The study was carried out in compliance with the 1975 Helsinki Declaration —revised in 2013— and the Organic Law 3/2018 of 5 December on the Protection of Personal Data and Guarantee of Digital Rights. This research was approved by the Research Ethics Committee of the Autonomous Community of Aragon (PI22/066).

Materials and resources

To measure the level of physical activity, the Physical Activity Questionnaire for Children (PAQ-C) validated in Spanish by Manchola-González et al. (2017) was administered. It consists of ten items assessing the physical activity of the students in the last week (e.g. item 7: "Last weekend, how many times did you participate in sports, dance or play games in which you were very active?"). Participants have to select (on a Likert-type scale of five options, where 1 = None and 5 = 6 or more times) which response option best suits their level of physical activity. The arithmetic mean of the scores of the first nine items forms the final score, which is higher the more active the child is. The last item is not considered since it collects information on illnesses or situations that have prevented the child from carrying out this type of activity in the last seven days. In the present research, the internal consistency of the questionnaire was α = .797, which was considered an adequate value and similar to that obtained by the authors of the version validated in Spanish (Manchola-González et al., 2017).

The SENA Questionnaire (Fernández-Pinto et al., 2015) was used to assess attention, inhibition and emotional regulation (executive functions), specifically the Attention Problems, Hyperactivity/Impulsivity and Emotional Regulation Problems scales, respectively. The first consists of ten items and measures the existence of symptoms related to distractibility and inattention, focusing on lack of attentional control, which makes it possible to detect problems in directing attention to the task and maintaining it (e.g. item 4: "I get distracted and make mistakes without realising it"). Its internal consistency was α = .867. Using ten items, the Hyperactivity/Impulsivity scale (α = .878) assesses the existence of impulsive and hyperactive behaviours, characterised by motor activities that are inappropriate and excessive for the context, i.e. it assesses impairments of inhibitory control (e.g. item 3: "I find it difficult to wait for my turn"). The Emotional Regulation Problems scale (α = .853) consists of seven items measuring difficulties in understanding, regulating and expressing emotions (e.g., item 2: "Some things bother me and I don't know why"). In all three scales, high scores indicate problems in the corresponding executive functions.

Quality of life was assessed using the KIDSCREEN-27 Questionnaire (Ravens-Sieberer et al., 2014). It consists of 27 items grouped into five dimensions: (1) physical well-being: this assesses, through five items, the child's energy, physical activity and physical fitness (e.g. item 2: "Have you been able to run properly?"). Its internal consistency was α = .776; (2) psychological well-being: this assesses satisfaction with life and emotions. It consists of seven items (e.g. item 2: "Have you been in a good mood?"). An α = .730 was obtained after the removal of item 18, which moderately affected internal consistency; (3) autonomy and relationship with parents: this assesses parent-child relationships and self-perceived autonomy. It consists of seven items (e.g. item 1: "Have you had enough time for yourself?"). The α value was .787; (4) relationship with friends and social support: this assesses the child's relationships with peers including the feeling of support. It consists of four items (e.g. item 4: "Have you been able to trust your friends?"). Its internal consistency was α = .787; and (5) relationship and support in the school environment: this measures the child's perception of his/her emotions towards school through four items (e.g., item 1: "Have you felt happy at school?"). The α value was .817.

Each item should be answered on a five-point Likert-type scale where 1 = Not at all and 5 = A lot. The questionnaire provides a score for each dimension: the higher the score, the higher the quality of life in that domain.

Academic performance was assessed through the grades obtained by the participants in the core subjects in the second term in year 3-6 of primary school: Mathematics, Language, Foreign Language, Social Sciences, Natural Sciences, Physical Education and Art Education. Grades ranged from 0 to 10, with 0 being the worst grade and 10 being the best. A mark of ≥ 5 meant passing the subject.

Procedure

The management teams of the participating schools were informed of the research. Subsequently, the same was done with the parents/legal guardians of the potential participants, and those who so wished signed the informed consent form. Management teams advised on the exclusion criteria.

In order to administer the questionnaires, the researchers went to the schools on the days agreed with the respective management teams. For each class there was a 50-minute session in which a researcher and the class tutor were present. Due to the different IT resources available at each school, and even the different access to these resources among classes in the same school, the administration and completion of the questionnaires was carried out in two different formats/modalities: on paper (all students in one school and 4th year students in the second school; $n_1 = 191$) and online using the school's computers (the remaining classes in the second school; $n_2 = 142$). In all cases, students completed the questionnaires in the same order: PAQ-C, KIDSCREEN-27 and SENA (Scales of Attention Problems, Hyperactivity/Impulsivity and Emotional Regulation Problems).

In order to ascertain the academic performance of the participants, the management teams were asked for the marks obtained by the students in the seven core subjects in the second term from year 3 to 6 of Primary School: Mathematics, Language, Foreign Language, Social Sciences, Natural Sciences, Physical Education and Art Education. From these grades, the average academic performance of each participant was calculated (arithmetic mean of all the above-mentioned subjects).

Statistical Analysis

Before carrying out the corresponding data analyses to address the objective of the study, it was necessary to prepare the data in the following way.

(1) The scores referring to executive functions (attention, inhibition and emotional regulation) were inverted so that they could be interpreted in the same way as the rest of the variables, since the SENA questionnaire assessed executive function problems, meaning that, originally, high scores indicated executive problems. Thus, after this inversion, high values implied high capacity in the corresponding executive function.

(2) A student t test was calculated for each of the variables assessed through the questionnaire (physical activity, executive functions and quality of life) in order to find out whether the questionnaire administration method (paper/online) influenced the results.

(3) Participants were assigned to different groups according to their PAQ-C score, i.e. according to the level of physical activity performed: low, medium or high. Tertiles were used to establish these three levels, following the procedure used in previous studies (García-Perujo & Carrillo López, 2020).

The normality of the data and the homogeneity of variances could then be assessed using the Kolmogorov-Smirnov and Levene tests, respectively. Given the normality of the data and homogeneity of variances, one-factor ANOVAs analyses were carried out to address the research objective (to analyse whether there were differences in executive functions, quality of life and academic performance according to the level of physical activity performed). Additionally, the effect size was calculated using eta squared (η^2). In those cases where the ANOVAs results revealed significant differences, a post hoc analysis using the Scheffé test was conducted in order to determine between which levels of physical activity these differences occurred.

All analyses were performed with SPSS 23.0 (IBM, Chicago, IL, USA), with statistical significance set at $p < .05$.

Results

No significant differences were found in executive functions, quality of life or physical activity performed according to the mode of completion (paper/online) of the assessment instruments (Table 1). Therefore, no variables were excluded from the research.

Table 1
Executive functions, quality of life and physical activity: Comparison of averages according to the mode of completion of the assessment instruments (paper/online).

Variable		*t*	*p*
Executive functions	Attention	1.743	.083
	Inhibition	–1.024	.919
	Emotional regulation	1.15	.249
Quality of life	Physical well-being	1.846	.066
	Psychological well-being	0.364	.716
	Autonomy and relationship with parents	0.579	.569
	Relationship with friends and social support	–1.613	.107
	Relationship and support in the school environment	0.176	.862
Physical activity		1.335	.194

Table 2
Descriptive statistics and analysis of variance. Executive functions, academic performance and quality of life according to the level of physical activity performed (low, medium, high).

Variable		Physical activity									
		Low level		Medium level		High level					
		M	SD	M	SD	M	SD	gl	*F*	*p*	η^2
Executive functions	Attention	1.98	0.82	1.81	0.67	1.91	0.73	332	2.020	.134	.01
	Inhibition	1.90	0.86	1.84	0.76	1.99	0.82	332	0.874	.418	.01
	Emotional regulation	2.02	0.88	2.05	0.83	2.16	0.93	332	0.798	.451	.01
Academic performance		7.67	1.35	7.73	1.14	7.79	1.26	332	0.281	.754	.00
Quality of life	Physical well-being	3.40	0.70	3.86	0.58	4.20	0.56	332	38.911	.000***	.19
	Psychological well-being	3.95	0.91	4.20	0.83	4.22	0.76	332	3.441	.003**	.02
	Autonomy and relationship with parents	3.56	0.80	3.81	0.81	3.91	0.75	332	5.577	.004**	.03
	Relationship with friends and social support	1.74	0.78	1.72	0.75	2.20	0.69	332	22.731	.000***	.08
	Relationship and support in the school environment	4.02	0.80	4.30	0.67	4.38	0.59	332	14.332	.000***	.05

Note. ** = $p < .01$; *** = $p < .001$.

The ANOVAs results (Table 2) indicated the absence of statistically significant differences in the three executive functions studied (attention, inhibition and emotional regulation) and in academic performance according to the level of physical activity performed (low, medium, high). Significant differences were found according to the level of physical activity performed in all the dimensions comprising quality of life, the effect size being significant (high) in the dimension physical well-being ($F_{(2, 330)} = 38.911$; $p = .000$, $\eta^2 = 19$); medium in the dimensions relationship with friends and social support ($F_{(2, 330)} = 22.731$; $p = .000$, $\eta^2 = .08$) and relationship and support in the school environment ($F_{(2, 330)} = 14.332$; $p = .000$, $\eta^2 = .05$); and small (low) on the other two remaining dimensions: psychological well-being ($F_{(2, 330)} = 3.441$; $p = .003$, $\eta^2 = .02$) and autonomy and relationship with parents ($F_{(2, 330)} = 5.577$; $p = .004$, $\eta^2 = .03$).

Table 3
Post hoc analysis of differences in quality of life according to the level of physical activity performed.

Variable		Physical activity level		
		Low vs. Medium	Medium vs. High	Low vs. High
Quality of life	Physical well-being	.000***	.005**	.000***
	Psychological well-being	.093	.991	.049*
	Autonomy and relationship with parents	.074	.637	.005**
	Relationship with friends and social support	.985	.000***	.000***
	Relationship and support in the school environment	.011*	.752	.001**

Note. * = $p < .05$; ** = $p < .01$; *** = $p < .001$.

Table 3 presents the results of the post hoc tests, indicating between which levels of physical activity the significant differences in quality of life were found.

The results of the post hoc comparisons revealed statistically significant differences between low and high levels of physical activity in all dimensions of quality of life. In addition, in three dimensions, significant differences were also found between other levels of physical activity. Specifically: in the physical well-being dimension, significant differences were also found between the low and medium level, and between the medium and high level, meaning that in this dimension of quality of life, significant differences were detected between the three levels of physical activity; in the relationship with friends and social support dimension, significant differences were also found between the medium and high level of physical activity; and in the relationship and support in the school environment dimension, between the low and medium level of physical activity.

Discussion

The aim of this research was to analyse whether there were differences in the executive functions, academic performance and quality of life of students from Year 3 to Year 6 of primary school according to their level of physical activity. The hypothesis postulated the existence of significant differences across all variables, such that higher levels of physical activity would be associated with higher levels of executive functions, academic performance and quality of life.

The results obtained only partially corroborated this hypothesis, given that significant differences were only found in quality of life (in its five dimensions) but not in executive functions or academic performance. Therefore, it can be concluded that, in this research, a high level of physical activity was positively associated with a higher quality of life level. This result is in line with previous works (Halasi & Lepes, 2022; Jiménez Boraita et al., 2021). Lubans et al. (2016) proposed a model attempting to explain how physical activity affects quality of life by operating through neurological, psychosocial and behavioural mechanisms. These authors argue that being physically active releases neurotransmitters, improves mood, increases social connectedness and enhances sleep quality (in addition to other mechanical processes), all of which interact and have an effect on subjective perceptions of well-being and quality of life.

On the other hand, the fact that no significant differences were found in the three executive functions analysed or in academic performance contrasts with much of the existing literature (Berrios-Aguayo et al., 2022; De Greeff et al., 2018; Escolano-Pérez & Bestué, 2021). However, there are also studies which, like this one, reported no effect on executive functions or academic performance depending on the level of physical activity performed (Donnelly et al., 2017; Tarp et al., 2016). These discrepancies between results may be due to the different procedures and instruments used to assess the variables of interest, as well as differences in the characteristics of the samples studied in each case. Other variables that may help explain the differences in results between studies include the following. According to various authors (Berrios-Aguayo et al., 2022), different features of physical activity (such as duration, frequency, intensity and specific type of physical activity performed) have been found to be significant moderators of the association between physical activity and cognitive functions. Thus, a minimum of 150 minutes per week of moderate-intensity, cognitively demanding physical activity (i.e. requiring attention and cognitive effort/commitment as is the case, for example, in

team and competitive sports where numerous and rapidly changing stimuli are involved) is considered to be the most cognitively beneficial (Chacón-Cuberos et al., 2020). However, in the present study, despite establishing 3 groups/levels of physical activity practice (low, medium and high), the instrument used does not allow for ensuring that the group of participants which corresponds to a high level of physical activity practice performed said physical activity with sufficient intensity, frequency and/or duration to produce benefits at a cognitive level (Contreras-Osorio et al., 2021). The instrument also does not reveal what kind of physical activity they performed. It could be that even with regular moderate-vigorous physical activity, there is no effect on cognitive processes as the activity in question is not cognitively demanding but rather involves automated movements, for example, running (Van der Niet et al., 2015). Thus, in the future it would be interesting to look at the qualitative information provided by participants in item 1 of the PAQ-C, requiring them to indicate which specific type/s of physical activity were performed during the last week.

There is also research indicating that physical activity affects some executive functions, but not others, with discrepancies between studies as to which executive functions are affected and which are not (Contreras-Osorio et al., 2022; Van Der Niet et al., 2015). Moreover, there are studies that indicate that, even when considering the same executive function, its relationship with physical activity will depend on the task used for its assessment or even on the parameters considered in that task. In this respect, Van Der Niet et al. (2015) found that, based on global assessment parameters, only the executive function of planning (considered highly complex and late-developing) was affected by physical activity performed, but not other less complex and earlier-developing executive functions, such as working memory, flexibility, attention or inhibition (the latter two addressed in this research). However, when looking at different assessment parameters of the executive planning function individually, it was found that only total task execution time was affected by physical activity, not reaction time. This evidences the complexity of the physical activity-cognition relationship and the need for further research on this topic.

The results obtained in this study may be of interest to researchers, policy makers and practitioners in the field of physical activity, education and health. However, they should be considered with caution in view of the following limitations. Firstly, in the present study, self-reporting was used as the main instrument for collecting information. Its use entails two well-known limitations: social desirability and the fact that it assesses not the behaviours under study but the informant's perception or recollection of them (Hildebrand & Ekelund, 2017). For this reason, it would be interesting in the future to combine the information collected through this type of instrument with that collected through other procedures and instruments, since all instruments have advantages and limitations (Van Der Veer et al., 2020). Thus, accelerometers could be used as a complementary instrument for the assessment of physical activity, although the PAQ-C questionnaire has already been validated since its creation by Kowalski & Crocker (1997), and good correlations have been obtained compaired to accelerometry. For the assessment of executive functions, information collected through self-reporting could be complemented with information obtained through the administration of performance tests, information from third party informants (teachers and/or parents/guardians) and information obtained through systematic observation. The literature evidences that each of these procedures focuses on the assessment of different aspects of executive functions (Escolano-Pérez et al., 2022), so their complementary use would facilitate a more holistic understanding of these cognitive processes and the effect that the practice of physical activity can have on them. In relation to the assessment of quality of life, given that by its very definition quality of life implies a subjective component and its assessment arises from lived experiences (Muntaner Guasp, 2013), the use of self-reporting would be a study strength rather than a limitation in this case. Understanding the key aspects of quality of life from the perspective of its protagonists is a topic of recent interest in research and among the various educational, social and political agents (Requejo et al., 2022). On the other hand, although students' academic performance was not assessed through self-reporting but through the grades provided by teachers, this could also be a limitation. Although this method is widely used in the literature, and it is the legal procedure that determines whether or not a student progresses to a higher grade in Spain, it may constitute another limitation, since the level of demand each teacher places on their students may be different (Escolano-Pérez & Bestué, 2021). To overcome this limitation, standardised assessment instruments for academic performance and academic competences could be applied, although this requires greater investment in terms of human and material resources. Other limitations of the study are the size of the sample, its non-random selection and the fact that it was only drawn from public schools located in one province. Consequently, it would be appropriate to increase the sample size, such that it

could also be randomly selected from all the schools in the province, autonomous community, or even in Spain, with the aim of generalising the results. Finally, the fact that this is a one-off study, and therefore causal inferences cannot be drawn, is another limitation. In this respect, it would be desirable to be able to carry out longitudinal studies.

Future research would need to overcome the above limitations and explore other relevant questions such as whether the type and level of physical activity performed affects academic performance in each of the subjects considered individually, or whether it affects executive functions other than those addressed in this study (e.g., planning or problem solving, which are considered to be more complex functions). It would also be interesting to analyse the effect that other variables (gender, grade, socio-economic level, etc.) may have on the variables studied, as these all depend on a multitude of factors that are impossible to address in a single study. In this sense, it would be of particular interest to identify which factors influence the type and levels of physical activity among students. Intervening in these areas would contribute to improving the quality of life of students, which is an international goal. This is stated in the 2030 Agenda for Sustainable Development adopted by the member states of the United Nations, and specifically in Sustainable Development Goal (SDG) 3: health and well-being, which aims to ensure healthy lives and promote well-being for all people at all ages, especially the most vulnerable —including children—. Intervening during the school years is of great importance since this is when habits that will last throughout life are established (Pastor-Vicedo et al., 2021). In this sense, a socio-educational policy and educational organisational structure is needed to enable professionals to implement innovative strategies based on neurocognitive contributions such as, for example, planning activities that require students to be physically active through different games (especially open games in which the rules and objective are explained, but not instructions on how to play the game) and varied sports activities that can be chosen by the students themselves according to their preferences; that these are carried out with peers who provide social support and positive interactions; that these are cognitively challenging as well as enjoyable and interesting; that these are carried out regularly and continuously (the longer the intervention, the greater the benefits) and during the early hours of the day (before the start of formal lessons, so that their benefits on neurotransmitters that improve concentration and attention can be exploited). Moreover, the benefits are maximised if these physical activities are carried out in nature (e.g. parks) and are supervised by a professional who, guided by the Self-Determination Theory, develops an autonomy-supportive style (since building autonomy support not only increases the perception of this basic psychological competence but also that of the other two: competence and relationship) (Alesi et al., 2016; Campos et al., 2018; De Greeff et al., 2018; Egger et al., 2019; Ellinger et al., 2022; Kolovelonis et al., 2022; Lamoneda & Huertas-Delgado, 2019; Vella et al., 2023).

Conclusions

The findings of this study indicate that students' self-perceived quality of life, but not their executive functions or academic performance, varied according to their level of physical activity, with those who reported a higher level of physical activity experiencing a higher quality of life.

Helping students to achieve and maintain a level of physical activity that improves their quality of life and health is one of the main objectives of the physical education curricula (Kolovelonis & Goudas, 2022), and is certainly a foundation for achieving SDG 3 of the 2030 Agenda. All this requires the development and implementation of socio-educational policies that promote the inclusion of educational and innovative physical activities based on neurocognitive contributions, i.e. physical activities that have certain quantitative characteristics (in terms of duration, frequency or intensity) but also qualitative ones (type of activity, variety, novelty, contribution to the satisfaction of students' basic psychological needs, execution in nature, etc.).

References

Alesi, M., Bianco, A., Luppina, G., Palma, A., & Pepi, A. (2016). Improving children's coordinative skills and executive functions: the effects of a football exercise program. *Perceptual and motor skills, 122*(1), 27-46. https://doi.org/10.1177/0031512515627527

Anguera, M. T., Camerino, O., Castañer, M., Sánchez-Algarra, P., & Onwuegbuzie, A. J. (2017). The Specificity of Observational Studies in Physical Activity and Sports Sciences: Moving Forward in Mixed Methods Research and Proposals for Achieving Quantitative and Qualitative Symmetry. *Frontiers in Psychology, 8*:2196. https://doi.org/10.3389/fpsyg.2017.02196

Berrios-Aguayo, B., Latorre-Román, P. A., Salas-Sánchez, J., & Pantoja-Vallejo, A. (2022). Effect of physical activity and fitness on executive functions and academic performance in children of elementary school. A systematic review. *Cultura, Ciencia y Deporte, 17*(51), 85-103. http://dx.doi.org/10.12800/ccd.v17i51.1699

Buscà, F. (2022). Book review: Castañer, M. & Camerino, O. (2023). Enfoque dinámico e integrado de la motricidad (EDIM). De la teoría a la práctica. *Apunts Educación Física y Deportes, 151*, 94-95. https://doi.org/10.5672/apunts.2014-0983.es.(2023/1).151.10

Camerino, O., Castañer, M., & Anguera, M. T. (Ed.) (2012). *Mixed Methods Research in the Movement Sciences: Cases in Sport, Physical Education and Dance*. Abingdon: Routledge.

Campos, R. C., Calvo, T. G., Hernández, J. G., & Bustos, J. G. F. (2018). Necesidades psicológicas básicas, motivación y compromiso en educación física. *Revista de Psicología del Deporte, 27*(1), 97-104. https://dialnet.unirioja.es/servlet/articulo?codigo=6280483

Chacón-Cuberos, R., Zurita-Ortega, F., Ramírez-Granizo, I., & Castro-Sánchez, M. (2020). Physical Activity and Academic Performance in Children and Preadolescents: A Systematic Review. *Apunts Educación Física y Deportes, 139*, 1-9. https://doi.org/10.5672/apunts.2014-0983.es.(2020/1).139.01

Contreras-Osorio, F., Campos-Jara, C., Martínez-Salazar, C., Chirosa-Ríos, L., & Martínez-García, D. (2021). Effects of sport-based interventions on children's executive function: A systematic review and meta-analysis. *Brain Sciences, 11*(6):755. https://doi.org/10.3390/brainsci11060755

Contreras-Osorio, F., Guzmán-Guzmán, I. P., Cerda-Vega, E., Chirosa-Ríos, L., Ramírez-Campillo, R., & Campos-Jara, C. (2022). Anthropometric Parameters, Physical Activity, Physical Fitness, and Executive Functions among Primary School Children. *International Journal Environmental Research and Public Health, 19*(5), 3045. https://doi.org/10.3390/ijerph19053045

De Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2018). Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis. *Journal of Science and Medicine in Sport, 21*(5), 501-507. https://doi.org/10.1016/j.jsams.2017.09.595

Devís, J. (2000). ¿Qué es la actividad física, la salud y el bienestar? In J. Devís (Coord.), *Actividad física, deporte y salud* (pp. 7-18). Cerdanyola del Vallès: Inde.

Donnelly, J. E., Hillman, C. H., Greene, J. L., Hansen, D. M., Gibson, C. A., Sullivan, D. K., Poggio, J., Mayo, M. S., Lambourne, K., Szabo-Reed, A. N., Herrmann, S. D. Honas, J. J., Scudder, M. R., Betts, J. L., Henley, K., Hunt, S. L., & Washburna, R. A. (2017). Physical activity and academic achievement across the curriculum: Results from a 3-year cluster-randomized trial. *Preventive Medicine, 99*, 140-145. https://doi.org/10.1016/j.ypmed.2017.02.006

Egger, F., Benzing, V., Conzelmann, A., & Schmidt, M. (2019). Boost your brain, while having a break! The effects of long-term cognitively engaging physical activity breaks on children's executive functions and academic achievement. *PLoS ONE, 14*(3): e0212482. https://doi.org/10.1371/journal.pone.0212482

Ellinger, J., Mess, F., Blaschke, S., & Mall, C. (2022). Health-related quality of life, motivational regulation and Basic Psychological Need Satisfaction in Education Outside the Classroom: an explorative longitudinal pilot study. *BMC Public Health, 22*(1), 49. https://doi.org/10.1186/s12889-021-12450-9

Escolano-Pérez, E., & Bestué, M. (2021). Academic Achievement in Spanish Secondary School Students: The Inter-Related Role of Executive Functions, Physical Activity and Gender. *International Journal of Environmental Research and Public Health, 18*(4):1816. https://doi.org/10.3390/ijerph18041816

Escolano-Pérez, E., Sánchez-López, C. R., & Herrero-Nivela, M. L. (2022). Teacher-Rated Executive Functions, Gender and Relative Age: Independent and Interactive Effects on Observed Fundamental Motor Skills in Kindergarteners. *Frontiers in Psychology, 13*:848525. https://doi.org/10.3389/fpsyg.2022.848525

Fernández-Pinto, I., Sánchez-Sánchez, F., Carrasco, M. A., & Del Barrio, V. (2015). *SENA. Sistema de Evaluación de Niños y Adolescentes. Manual de aplicación, corrección e interpretación.* Madrid: TEA Ediciones.

García-Perujo, M., & Carrillo López, P. J. (2020). Niveles de actividad física y calidad de la dieta en escolares de Educación Primaria. *Revista Iberoamericana de Ciencias de la Actividad Física y del Deporte, 9*(2), 16-31. https://doi.org/10.24310/riccafd.2020.v9i2.7155

García Prieto, F. J., López-Aguilar, D., & Delgado-García, M. (2022). Competencia digital del alumnado universitario y rendimiento académico en tiempos de COVID-19. *Revista de Medios y Educación, 64*, 165-201. https://doi.org/10.12795/pixelbit.91862

Halasi, S., & Lepes, J. (2022). The impact of sport on health-related quality of life at primary school children. *Central European Journal of Educational Research, 4*(1), 80-85. https://doi.org/10.37441/cejer/2022/4/1/10743

Helmrich, I. R. A. R., Van Klaveren, D., Dijkland, S. A., Lingsma, H. F., Polinder, S., Wilson, L., Von Steinbuechel, N., Van Der Naalt, J., Maas, A. I. R., & Steyerberg, E. W. (2022). Development of prognostic models for Health-Related Quality of Life following traumatic brain injury. *Quality of Life Research, 31*(2), 451-471. https://doi.org/10.1007/s11136-021-02932-z

Hildebrand, M., & Ekelund, U. (2017). The assessment of physical activity. In N. Armstrong & W. van Mechelen (Eds.), *Oxford Textbook of Children's Sport and Exercise Medicine* (pp. 303-313). Oxford: Oxford University Press.

Jiménez Boraita, R., Gargallo Ibort, E., Dalmau Torres, J. M., & Arriscado Alsina, D. (2021). Factors associated with a low level of physical activity in adolescents from La Rioja (Spain). *Anales de Pediatría, 96,* 326-333. https://doi.org/10.1016/j.anpedi.2021.02.011

Kolovelonis, A., & Goudas, M. (2022). Exploring the effects of three different types of cognitively challenging physical activity games on students' executive functions and situational interest in physical education. *Cogent Education*, *9*:2148448. https://doi.org/10.1080/2331186X.2022.2148448

Kolovelonis, A., Pesce, C., & Goudas, M. (2022). The Effects of a Cognitively Challenging Physical Activity Intervention on School Children's Executive Functions and Motivational Regulations. *International Journal of Environmental Research and Public Health, 19*(19):12742. https://doi.org/10.3390/ijerph191912742

Kowalski, K., & Crocker, P. (1997). Validation of the physical activity questionnaire for older children. *Pediatric Exercise Science*, *9*(2), 174-186. https://doi.org/10.1123/pes.9.2.174

Lamoneda, J., & Huertas-Delgado, F. J. (2019). Necesidades psicológicas básicas, organización deportiva y niveles de actividad física en escolares. *Revista de Psicología del Deporte, 28*(1), 115-124.

León, O. G., & Montero, I. (2003). *Métodos de investigación en Psicología y Educación* (3rd ed.). Madrid: McGraw-Hill.

Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de derechos digitales. *Boletín Oficial del Estado 294*, de 6 de diciembre de 2018. https://www.boe.es/eli/es/lo/2018/12/05/3/con

Ley Orgánica 8/2013, de 9 de diciembre, para la mejora de la calidad educativa. *Boletín Oficial del Estado 295*, de 10 de diciembre de 2013. http://www.boe.es/boe/dias/2013/12/10/pdfs/BOE-A-2013-12886.pdf

Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., Kelly, P., Smith, J., Raine, L., & Biddle, S. (2016). Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics, 138*(3):e20161642. https://doi.org/10.1542/peds.2016-1642

Manchola-González, J., Bagur-Calafat, C., & Girabent-Farrés, M. (2017). Fiabilidad de la versión española del cuestionario de actividad física PAQ-C / Reliability Spanish Version of Questionnaire of Physical Activity PAQ-C. *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, 17*(65), 139-152. https://doi.org/10.15366/rimcafd2017.65.010

Marker, A. M., Steele, R. G., & Noser, A. E. (2018). Physical activity and health-related quality of life in children and adolescents: A systematic review and meta-analysis. *Health Psychology, 37*(10), 893-903. https://doi.org/10.1037/hea0000653

Mullis, I., Martin, M., Foy, P., & Hooper, M. (2016). *PIRLS 2016. International Results in Reading*. IEA, TIMMS Y PIRLS International Study Center. https://www.educacionyfp.gob.es/inee/dam/jcr:16027373-dfd0-4005-a318-6f6d5d040a81/INFORME%20INTERNACIONAL%20PIRLS%202016.pdf

Mullis, I., Martin, M., Foy, P., Kelly, D., & Fishbein, B. (2019). *TIMMS 2019. International Results in Mathematics and Science.* IEA, TIMMS Y PIRLS International Study Center. https://www.iea.nl/sites/default/files/2020-12/TIMSS%202019-International-Results-in-Mathematics-and-Science.pdf

Muntaner Guasp, J. J. (2013). Calidad de vida en la escuela inclusiva. *Revista Iberoamericana de Educación, 63,* 35-49. http://dx.doi.org/10.35362/rie630421

Organización Mundial de la Salud. (2020). *Directrices de la OMS sobre actividad física y hábitos sedentarios.*

Padial-Ruz, R., Rejón-Utrabo, M. C., Chacón-Borrego, F., & González-Valero, G. (2022). Review of Interventions in Physical Activity for the Improvement of Executive Functions and Academic Performance in Kindergarten. *Apunts Educación Física y Deportes, 149*, 23-36. https://doi.org/10.5672/apunts.2014-0983.es.(2022/3).149.03

Pallanch, O., Ortalda, A., Pelosi, P., Latronico, N., Sartini, C., Lombardi, G., Marchetti, C., Maimeri, N., Zangrillo, A., & Cabrini, L. (2022). Effects on health-related quality of life of interventions affecting survival in critically ill patients: a systematic review. *Critical Care, 26*(1). https://doi.org/10.1186/s13054-022-03993-3

Pastor-Vicedo, J. C., Prieto-Ayudo, A., López Pérez, S., & Martínez-Martínez, J. (2021). Active Breaks and Cognitive Performance in Pupils: A Systematic Review. *Apunts Educación Física y Deportes, 146,* 11-23. https://doi.org/10.5672/apunts.2014-0983.es.(2021/4).146.02

Pesce, C., Stodden, D. F., & Lakes, K. D. (2021). Editorial: Physical Activity "Enrichment": A Joint Focus on Motor Competence, Hot and Cool Executive Functions. *Frontiers in Psychology, 12*:658667. https://doi.org/10.3389/fpsyg.2021.658667

Peters, M., Potter, C. M., Kelly, L., & Fitzpatrick, R. (2019). Self-efficacy and health-related quality of life: a cross-sectional study of primary care patients with multi-morbidity. *Health and Quality of Life Outcomes, 17*(1), 17-37. https://doi.org/10.1186/s12955-019-1103-3

Pucci, G. C., Rech, C. R., Fermino, R. C., & Reis, R. S. (2012). Association between physical activity and quality of life in adults. *Revista de Saúde Pública, 46*, 166-179. https://doi.org/10.1590/s0034-89102012000100021

Ravens-Sieberer, U., Herdman, M., Devine, J., Otto, C., Bullinger, M., Rose, M., & Klasen, F. (2014). The European KIDSCREEN approach to measure quality of life and well-being in children: development, current application, and future advances. *Quality of Life Research, 23*(3), 791-803. https://doi.org/10.1007/s11136-013-0428-3

Requejo, E., Losada-Puente, L., Rebollo-Quintela, N., & Mendiri, P. (2022). Narrativas del alumnado de Educación Primaria sobre su bienestar escolar: un diagnóstico inicial. *Revista de Investigación en Eudcación, 20*(1), 5-20. https://doi.org/10.35869/reined.v20i1.3964

Romero Sánchez, E., & Hernández Pedreño, M. (2019). Análisis de las causas endógenas y exógenas del abandono escolar temprano: una investigación cualitativa. *Educación XX1, 22*(1), 263-293. https://doi.org/10.5944/educxx1.21351

Ryan, R. M., & Deci, E. L. (2007). Active human nature: Self-determination theory and the promotion and maintenance of sport, exercise, and health. In M. S. Hagger & N. L. D. Chatzisarantis (Eds.), *Intrinsic motivation and self-determination in exercise and sport* (pp. 1-19). Human Kinetics.

Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory. Basic Psychological Needs in Motivation, Development, and Wellness.* New York: The Guilford Press.

Tarp, J., Domazet, S. L., Froberg, K., Hillman, C. H., Andersen, L. B., & Bugge, A. (2016). Effectiveness of a school-based physical activity intervention on cognitive performance in Danish adolescents: LCoMotion—learning, cognition and motion— A cluster randomized controlled trial. *PloS One, 11*(6):e0158087. https://doi.org/10.1371/journal.pone.0158087

Van der Niet, A. G., Smith, J., Scherder, E. J. A., Oosterlaan, J., Hartman, E., & Visscher, C. (2015). Associations between daily physical activity and executive functioning in primary school-aged children. *Journal of Science and Medicine in Sport, 18*(6), 673-677. https://doi.org/10.1016/j.jsams.2014.09.006

Van Der Veer, G., Kamphorst, E., Cantell, M., Minnaert, A., & Houwen, S. (2020). Task-Specific and Latent Relationships Between Motor Skills and Executive Functions in Preschool Children. *Frontiers in Psychology, 11*:2208. https://doi.org/10.3389/fpsyg.2020.02208

Vella, S. A., Aidman, E., Teychenne, M., Smith, J. J., Swann, C., Rosenbaum, S., White, R. L., & Lubans, D. R. (2023). Optimising the effects of physical activity on mental health and wellbeing: a joint consensus statement from sports medicine Australia and the Australian Psychological Society. *Journal of Science and Medicine in Sport*. https://doi.org/10.1016/j.jsams.2023.01.001

Zelazo, P. D., & Carlson, S. M. (2012). Hot and Cool Executive Function in Childhood and Adolescence: Development and Plasticity. *Child Development Perspectives, 6*(4), 354-360. https://doi.org/10.1111/j.1750-8606.2012.00246.x

Conflict of Interests: No conflict of interest was reported by the authors.