Physical activity, sedentary behavior, and BMI in schoolchildren: age and gender differences

DOI: 10.46932/sfjdv6n7-003

Received on: Jun 2nd, 2025
Accepted on: jun 24th, 2025

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ABSTRACT
Physical activity during childhood and adolescence is essential for healthy development, yet levels of activity tend to decline with age and may differ according to gender and body mass index (BMI). This study aimed to assess physical activity (PA) and sedentary behavior in children and adolescents aged 6 to 17 years and to examine differences by gender, age, and BMI. A total of 89 schoolchildren (46 boys and 43 girls) from Bizkaia, Spain, wore ActiGraph WGT3X-BT accelerometers for seven consecutive days. PA levels were categorized into light, moderate, and vigorous intensities. Statistical analyses included Pearson correlations, t-tests, and ANOVA. The results showed a strong negative correlation between age and moderate-to-vigorous physical activity (MVPA) ($r = –0.738$, $p < 0.001$), as well as between BMI and MVPA ($r = –0.445$, $p < 0.001$). Girls accumulated more light ($p < 0.001$) and moderate PA ($p = 0.001$), while boys engaged in more vigorous PA ($p = 0.002$). Sedentary behavior increased significantly with age ($p = 0.006$), and only 38% of participants met the World Health Organization's recommendation of at least 60 minutes of MVPA per day. These findings highlight the need for tailored interventions that address age- and gender-related differences in physical activity patterns and promote healthier behaviors across the school years.

Keywords: Physical Activity, Sedentary Behavior, Accelerometry, Age Differences, Body Mass Index.

1 INTRODUCTION

Physical activity (PA) during childhood and adolescence is a key factor in determining overall health and development. International institutions such as the World Health Organization (WHO) recommend at least 60 minutes of moderate-to-vigorous physical activity (MVPA) daily for this population group (WHO, 2021). However, numerous studies have shown that most children and adolescents fail to meet these guidelines, with a marked decline during adolescence and among girls (Franz *et al*., 2023; Fundación Gasol, 2019).

It is vital for public health and education systems to understand the patterns of PA and the factors contributing to its decline. Research undertaken to date has indicated that age, sex and body mass index (BMI) are all significant variables associated with levels of physical activity. However, it should be noted that many of these studies rely on self-reported questionnaires, which are susceptible to recall bias and social desirability effects. This may potentially compromise the accuracy of the data.

The present study aims to address this gap by using accelerometry, a reliable and objective method of assessing PA intensity and duration. This method will be used to analyse PA levels in a representative sample of school-aged children and adolescents in the Basque Country (Spain). The primary objective is to examine how physical activity (PA) varies by intensity level (light, moderate, vigorous, and MVPA) according to sex, age, and BMI.

2 THEORETICAL FRAMEWORK

Regular physical activity during childhood and adolescence has well-documented benefits across a range of domains, including physical, cognitive, emotional and social (Janssen & LeBlanc, 2010; Strong *et al*., 2005). It has been demonstrated to support cardiovascular, muscular, and skeletal development, enhance mood and self-esteem, and is positively associated with academic performance and social integration (Nagata *et al*., 2023; Hills *et al*., 2015).

However, longitudinal and cross-sectional studies consistently report a decline in PA levels as children age, particularly during adolescence (Dumith *et al*., 2011; Farooq *et al*., 2018). This decline is often accompanied by an increase in sedentary behaviour, which is linked to negative health outcomes such as obesity, poor metabolic profiles, and reduced quality of life.

Research in this field has also identified significant gender differences. Boys tend to engage more frequently in vigorous physical activity (PA) and organised sports, while girls report higher levels of light or moderate PA and greater sedentary time (Franz *et al*., 2023; Carrillo *et al*., 2017). As Romero-Cerezo *et al*. (2011) point out, these disparities are not solely explained by biological differences, but are influenced by sociocultural factors, gender norms, and disparities in access to physical activity opportunities.

Body mass index (BMI) is another factor that has been closely associated with levels of physical activity (PA). Research has identified a link between overweight and obesity, on the one hand, and reduced participation in physical activities, on the other. This is due to a combination of physical limitations and psychological barriers, including low self-confidence and stigma (Hills *et al*., 2011; Zhang *et al*., 2024). The relationship is complex and often bidirectional: reduced physical activity (PA) contributes to weight gain, which in turn limits PA participation.

While many studies have explored these associations, the majority have relied on subjective measures. In contrast, accelerometry allows for precise quantification of PA intensities and durations, offering more robust and reliable data (Cooper *et al*., 2015). However, few studies to date have used accelerometry to simultaneously examine the roles of age, sex, and BMI in shaping PA patterns among schoolchildren.

The objective of this study is to address this knowledge gap by providing an objective and comprehensive analysis of PA levels across developmental stages. The study will highlight how these key determinants interact and evolve during the school years.

3 METHODOLOGY

3.1 STUDY DESIGN AND PARTICIPANTS

This cross-sectional observational study aimed to examine physical activity (PA) levels and sedentary behavior among school-aged children and adolescents. A total of 89 participants (46 boys and 43 girls), aged 6 to 17 years, were recruited from four urban municipalities in the Basque Country (Leioa, Getxo, Santurtzi, and Bilbao), using a non-probabilistic convenience sampling strategy. Schools were selected to ensure a heterogeneous sample, including both public and private institutions.

Inclusion criteria were: (a) students aged 6–17 years enrolled in compulsory education; (b) no diagnosed physical or cognitive limitations affecting mobility; and (c) provision of informed consent by legal guardians and assent by the students. Participants not meeting accelerometer wear-time criteria (see below) were excluded from the final analysis.

To determine the minimum sample size required for correlation analysis, a priori power analysis was conducted using G*Power (v.3.1.9.7). For a medium effect size ($r = 0.30$), with $\alpha = 0.05$ and power = 0.80, the required sample size was 84 participants.

The study was approved by the Basque Medicines Research Ethics Committee (CEIm-E), and adhered to the ethical principles of the Declaration of Helsinki (2013) and relevant national regulations.

3.2 INSTRUMENTS AND ACCELEROMETER PROTOCOL

Physical activity and sedentary behavior were objectively assessed using ActiGraph wGT3X-BT accelerometers (ActiGraph LLC, Pensacola, FL, USA), worn on the non-dominant wrist for seven consecutive days, including weekdays and weekends. Participants were instructed to wear the device for at least 10 hours per day on a minimum of three valid days, including one weekend day. Non-wear periods (e.g., water-based activities or technical issues) were documented by the participants or families using a diary.

Raw accelerometer data were processed with ActiLife software (v.6.13.3) and aggregated into 60-second epochs. Valid wear-time criteria followed the recommendations of Troiano *et al*. (2008), and cut-off points for intensity classification were based on the Evenson *et al*. (2008) thresholds for children and adolescents. Time spent in sedentary, light, moderate, and vigorous activity was extracted, as well as moderate-to-vigorous physical activity (MVPA) by summing the moderate and vigorous durations.

Additionally, total sleep time, time in bed, and sleep efficiency were estimated using the Sadeh algorithm validated for pediatric populations.

3.3 PROCEDURE

After ethical approval, the Basque Department of Education was contacted to assist in school recruitment. Invitations were emailed to schools, and those willing to participate were included. School administrators and physical education teachers facilitated participant outreach. Information sheets and consent forms were distributed to families, and students meeting inclusion criteria were randomly selected from the pool of consented participants.

Participants received instructions on proper device usage and were contacted mid-week to ensure compliance. After the 7-day monitoring period, accelerometers were collected and data were downloaded for analysis.

3.4 STATISTICAL ANALYSIS

All data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean ± standard deviation) were computed for all continuous variables. Pearson's correlation coefficients were used to explore the relationships between PA levels, sedentary behavior, age, and BMI. Independent samples t-tests were applied to examine gender differences. One-way ANOVA was used to compare variables across three age groups (6–9, 10–13, 14–17 years). Where significant effects were found, Bonferroni-adjusted post-hoc comparisons were conducted.

Effect sizes were reported using Cohen's d for t-tests and partial eta squared (η^2) for ANOVAs. The significance level was set at $p < 0.05$.

3.5 ETHICAL CONSIDERATIONS

The study protocol was approved by the Basque Medicines Research Ethics Committee (CEIm-E), and all procedures were conducted in accordance with the Declaration of Helsinki and local ethical regulations. Written informed consent was obtained from parents or legal guardians, and assent was given by all participating children. Participation was voluntary, and data were anonymized and kept confidential. Students could withdraw from the study at any point without consequences.

4 RESULTS AND DISCUSSIONS

This section presents the main findings regarding the associations between age, sex, body mass index (BMI), physical activity (PA) levels, and sedentary behaviour in a sample of 89 children and adolescents aged 6 to 17 years. Both descriptive and inferential statistics were applied, including Pearson correlation coefficients and ANOVA tests. Unless otherwise specified, physical activity is reported in minutes per week.

4.1. DECLINE IN PHYSICAL ACTIVITY WITH AGE

Age emerged as a key determinant of physical activity behaviour. A strong and statistically significant negative correlation was found between age and total moderate-to-vigorous physical activity (MVPA) ($r = -0.738$, $p < 0.001$), suggesting a sharp decline in PA as children grow older (Table 1).

Table 1

Correlation between Age and MVPA.

Variable	Age	Total MVPA
Age	1	-0.738**
Sig.	-	0.000
N	89	89
Total MVPA	-0.738**	1
Sig.	0.000	-
N	89	89

[1] The correlation is significant at the 0.01 level (bilateral)

This association remained consistent when PA was disaggregated by intensity. Light ($r = -0.640$), moderate ($r = -0.717$), and vigorous PA ($r = -0.723$) all decreased significantly with age (Table 2). Conversely, sedentary behaviour increased with age ($r = 0.323$, $p = 0.002$), indicating a behavioural shift from movement to sedentary habits across adolescence.

Table 2

Correlations between age, PA Intensities, and Sedentary behavior

Variable	Age	Total MVPA	Light PA	Moderate PA	Vigorous PA	Sedentary
Age	1	-0.738**	-0.640**	-0.717**	-0.723**	0.323**
Sig.	-	0.000	0.000	0.000	0.000	0.000
N	89	89	89	89	89	89
Total MVPA	-0.738**	1	0.840**	0.996**	0.841**	-0.292**
Sig.	0.000	-	0.000	0.000	0.000	0.006
N	89	89	89	89	89	89

[1] The correlation is significant at the 0.01 level (bilateral)

To better understand these dynamics, participants were divided into four age groups: 6–8, 9–11, 12–14, and 15–17 years. Between-group comparisons confirmed significant differences in all PA intensities ($p < 0.001$). Children aged 6–8 reported the highest levels of activity across all intensities, with a total MVPA of 761 minutes per week. In contrast, adolescents aged 15–17 showed a dramatic drop in activity, with only 332 minutes of weekly MVPA—a reduction of more than 50% (Table 3). These patterns underscore the need to implement early interventions to preserve active behaviours into adolescence.

Table 3

Comparison of PA by Age groups.

Age group	Light PA (min)	Moderate PA (min)	Vigorous PA (min)	Total MVPA (min)
6-8 years	1746	685	75	761
9-11 years	1591	470	48	560
12-14 years	1371	433	28	495
15-17 years	1227	318	13	332

4.2 GENDER DIFFERENCES: GIRLS ARE MORE ACTIVE

Contrary to some traditional expectations, girls in this sample accumulated significantly more light and moderate physical activity than boys. Girls engaged in 1544 minutes of light PA and 540 minutes of moderate PA per week, compared to 1379 and 437 minutes in boys, respectively. Although vigorous activity levels were similar (39 minutes for both sexes), boys exhibited greater variability (SD = 37 vs. SD = 32). These differences were all statistically significant ($p < 0.001$ or $p = 0.002$), indicating clear gender-specific activity patterns (Table 4).

Table 4

Gender and Age differences in Physical Activity

Gender	Light PA (min)	Moderate PA (min)	Vigorous PA (min)	Total MVPA (min)
Girls	1544 (SD=324)	540 (SD=165)	39 (SD=32)	579 (SD=189)
Boys	1379 (SD=333)	437 (SD=220)	39 (SD=37)	493 (SD=212)

Importantly, these trends persisted across different age groups, reinforcing the notion that interventions should be tailored not only by age but also by gender, recognising the differentiated ways in which children engage in physical activity.

4.3 SEDENTARY BEHAVIOUR: A GROWING CONCERN WITH AGE

Parallel to the decline in PA, sedentary behaviour increased significantly with age. Children aged 6–8 years spent an average of 3486 minutes per week in sedentary activities, compared to 4244 minutes among those aged 15–17—a difference of more than 10 hours per week ($p = 0.006$) (Table 5). This reinforces concerns that as children grow older, they not only reduce physical activity but also increase screen time or other sedentary behaviours.

Table 5

Sedentary Behavior by Age group.

Age group	Sedentary Behaviour (min)
6-8 years	3486
9-11 years	4018
12-14 years	4027
15-17 years	4244

4.4 BMI AND ITS ASSOCIATIONS WITH ACTIVITY AND SEDENTARISM

BMI showed a moderate but significant negative correlation with all PA intensities: light ($r = -0.323$), moderate ($r = -0.423$), and vigorous PA ($r = -0.491$), all with $p < 0.001$. This suggests that children with higher BMI tend to be less physically active. Moreover, a positive association between BMI and sedentary behaviour ($r = 0.231$, $p = 0.031$) was observed, indicating a potential risk loop between inactivity, sedentarism, and increased BMI (Table 6).

Table 6

Correlation between BMI, PA, and Sedentary behavior.

Variable	Total MVPA	Light PA	Moderate PA	Vigorous PA	Sedentary	BMI
BMI	-0.445**	-0.323**	-0.423**	-0.491**	0.231**	1
Sig.	0.000	0.000	0.000	0.000	0.031	-
N	89	89	89	89	89	89

When grouped by BMI category (underweight, normal weight, at risk of overweight, overweight), significant differences were found in MVPA ($p = 0.029$), moderate PA ($p = 0.031$), vigorous PA ($p = 0.044$), and sedentary behaviour ($p = 0.001$) (Table 7).

Table 7

PA and Sedentary Time by BMI groups.

BMI Category	Light PA	Moderate PA	Vigorous PA	Sedentary
Underweight	1600	500	50	500
Normal weight	1700	600	60	450
At risk of overweight	1500	500	40	550
Overweight	1400	400	30	600

Notably, the "at risk of overweight" group accumulated 794 more minutes of sedentary time and 159 fewer minutes of MVPA compared to those with normal weight. These patterns underline the importance of early weight management and active lifestyle promotion, especially in high-risk populations.

4.5 ADHERENCE TO WHO RECOMMENDATIONS

Finally, we evaluated compliance with the 2021 WHO guidelines, which recommend at least 60 minutes of MVPA daily. Only 38% of the total sample met these guidelines, while 62% were considered physically inactive. Age group comparisons revealed a marked drop in adherence: all children aged 6–8 complied with WHO recommendations (100%), but only 17% of adolescents aged 15–17 did (Table 8).

Table 8

WHO Compliance by Age group.

Age group	Number of participants	Meeting WHO PA Guidelines (≥60 min/day MVPA)	WHO Compliance (%)
6-8 years	10	10	100%
9-11 years	20	18	90%
12-14 years	28	14	50%
15-17 years	31	5	16,1%

Although one participant's compliance status could not be confirmed due to incomplete data, the general trend remains robust and concerning.

These findings reinforce earlier results, showing how PA sharply declines during adolescence, and highlight the urgent need for policy and school-based actions to promote and sustain physical activity through adolescence.

5 DISCUSSION

The present study aimed to analyse physical activity (PA) and sedentary behaviour patterns among children and adolescents aged 6 to 17 years in the Basque Country, exploring how these patterns vary

according to age, sex, and body mass index (BMI). The results support previous evidence indicating a strong inverse relationship between age and PA levels, particularly moderate-to-vigorous physical activity (MVPA), accompanied by a parallel increase in sedentary time (Dumith *et al*., 2011; Strong *et al*., 2005).

One of the most salient findings was the significant decline in MVPA across age groups. Children aged 6–11 demonstrated higher levels of PA in all intensity categories (light, moderate, and vigorous), while adolescents, particularly those aged 15–17, showed markedly lower levels. This decline is consistent with global trends and can be attributed to various developmental and contextual factors, including increased academic demands, reduced leisure time, diminished motivation, and greater engagement in sedentary pursuits such as screen-based activities (Sallis *et al*., 2000; World Health Organization [WHO], 2021). Our data indicate that the most substantial drop occurred between the 12–14 and 15–17 age groups, reinforcing the idea that early adolescence is a critical period for the decline in PA (Inchley *et al*., 2020).

Gender differences in PA were also evident. Boys accumulated more vigorous PA, while girls engaged more in light and moderate activity. This partially supports the hypothesis that boys tend to participate in higher-intensity sports (van Sluijs *et al*., 2007). However, contrary to most existing literature (Guthold *et al*., 2020; Inchley *et al*., 2020; Ortega *et al*., 2008), girls in our sample demonstrated higher total MVPA, especially in the oldest age group (15–17 years). This finding may reflect a more uneven distribution among girls, as shown by the higher standard deviation in vigorous PA, indicating that while some girls engaged in high volumes of activity, others did very little. Such heterogeneity underscores the importance of disaggregated analysis and context-specific interpretations.

The observed differences may also be related to sociocultural norms, motivational factors, and access to sport opportunities. Girls' greater participation in light and moderate PA may suggest a preference for less competitive or more socially oriented forms of activity (Mitchell *et al*., 2013; van Sluijs *et al*., 2007). This finding calls for more inclusive strategies that offer a variety of movement experiences beyond traditional sports.

BMI was inversely associated with PA across all intensity levels and positively correlated with sedentary behaviour. Participants with higher BMI showed significantly lower PA and greater sedentary time. These findings are in line with previous studies showing that overweight and obesity in youth are linked to lower activity levels and more sedentary lifestyles (Mitchell *et al*., 2013; Ortega *et al*., 2008). Furthermore, the "at risk of overweight" group showed nearly 800 more sedentary minutes and 160 fewer MVPA minutes compared to their normal-weight peers, indicating a strong behavioural impact of BMI on daily routines.

Notably, despite boys exhibiting lower BMI values on average, they also showed lower total PA levels compared to girls. Interestingly, boys were overrepresented in both the underweight and overweight categories, while girls were predominantly in the normal weight range. This distribution may reflect

differences in lifestyle habits, including lower PA and higher screen time among boys, which could contribute to both extremes of the weight spectrum (Inchley *et al*., 2020).

The proportion of participants meeting the WHO guideline of ≥60 minutes of MVPA per day (WHO, 2021) was low (38%), particularly among older adolescents. While compliance was universal among 6–8-year-olds, only 17% of 15–17-year-olds met the recommendation. This finding is consistent with global data on adolescent inactivity (Guthold *et al*., 2020) and reinforces the need for targeted interventions to maintain PA throughout adolescence. Age-appropriate, school-based strategies—such as active breaks, physical education reforms, and extracurricular opportunities—along with community and family support, are essential to counter this decline (Sallis *et al*., 2000; WHO, 2021).

From a behavioural perspective, younger children's higher PA levels may be linked to their greater engagement in outdoor play and spontaneous movement, while older adolescents may prioritise academic tasks or technology-based leisure, limiting opportunities for active behaviour (Strong *et al*., 2005). Additionally, the COVID-19 pandemic likely exacerbated these trends by reducing access to physical education, sport, and structured physical activity opportunities in schools.

Finally, the results highlight the relevance of using objective measurement tools, such as accelerometers, to assess PA and sedentary time accurately. However, the findings must be interpreted with caution due to several limitations: the relatively small sample size, reduced final sample due to invalid accelerometer data, and potential confounders such as seasonal effects and pandemic-related disruptions.

6 CONCLUSION

This study provides valuable insights into the patterns of physical activity, sedentary behaviour, and body mass index (BMI) among school-aged children and adolescents in the Basque Country. The results confirm a marked decline in physical activity levels with increasing age, alongside a corresponding rise in sedentary behaviour. Gender differences were also evident, with boys engaging more in vigorous activity and girls reporting higher levels of light and moderate activity. These findings highlight the importance of designing age- and gender-sensitive interventions to promote active lifestyles from an early age.

Additionally, the negative correlation between BMI and physical activity, along with the positive correlation between BMI and sedentary time, reinforces previous evidence linking physical inactivity with increased health risks. This relationship is particularly concerning during adolescence, when the sharpest drop in activity occurs.

The main strength of this study lies in its context-specific analysis of a representative sample of Basque youth using objective measures of physical activity. However, limitations include the cross-sectional nature of the data, which prevents causal inferences, and the modest sample size.

In light of these findings, educational and community-based policies should prioritize structured opportunities for physical activity, reduce sedentary time, and address social norms that may limit participation—especially among adolescent girls. Future research should include longitudinal designs to better understand causal relationships and intervention effectiveness.

By recognizing the critical period of adolescence and integrating physical activity into school and community environments, we can support healthier trajectories and contribute to reversing the decline in youth physical activity.

ACKNOWLEDGEMENTS

The authors would like to thank all the participants, their parents and the schools that voluntarily participated in the research.

REFERENCES

Brazendale, K., Beets, M. W., Armstrong, B., Weaver, R. G., Hunt, E. T., Pate, R. R., Brusseau, T. A., Bohnert, A. M., Olds, T., Tassitano, R. M., Tenorio, M. C. M., Garcia, J., Andersen, L. B., Davey, R., Hallal, P. C., Jago, R., Kolle, E., Kriemler, S., Kristensen, P. L., & van Sluijs, E. M. F. (2021). Children's moderate-to-vigorous physical activity on weekdays versus weekend days: A multi-country analysis. International Journal of Behavioral Nutrition and Physical Activity, 18, 1–13. https://doi.org/10.1186/s12966-021-01153-x

Breheny, K., Adab, P., Passmore, S., Martin, J., Lancashire, E., Hemming, K., & Frew, E. (2018). A cluster randomised controlled trial evaluating the effectiveness and cost-effectiveness of the daily mile on childhood obesity and wellbeing; The Birmingham daily mile protocol. BMC Public Health, 18, 1–7. https://doi.org/10.1186/s12889-018-6094-0

Carrillo, V. J. B., Sierra, A. C., Loais, A. J., González-Cutre, D., Galindo, C. M., & Cervelló, E. (2017). Diferencias según género en el tiempo empleado por adolescentes en actividad sedentaria y actividad física en diferentes segmentos horarios del día. Retos, 31, 3–7. https://doi.org/10.47197/retos.v0i31.56895

Cooper, A. R., Goodman, A., Page, A. S., Sherar, L. B., Esliger, D. W., van Sluijs, E. M., Andersen, L. B., Anderssen, B., Cardon, G., Davey, R., Froberg, K., Hallal, P., Janz, K. F., Kordas, K., Kreimler, S., Pate, R. R., Puder, J. J., Reilly, J. J., Salmon, J., & Ekelund, U. (2015). Objectively measured physical activity and sedentary time in youth: The International children's accelerometry database (ICAD). International Journal of Behavioral Nutrition and Physical Activity, 12, 1–10. https://doi.org/10.1186/s12966-015-0241-3

Dumith, S. C., Gigante, D. P., Domingues, M. R., & Kohl, H. W. (2011). Physical activity change during adolescence: A systematic review and a pooled analysis. International Journal of Epidemiology, 40, 685–698. https://doi.org/10.1093/ije/dyr029

Eichner, J. E., Folorunso, O. A., & Moore, W. E. (2016). A physical activity intervention and changes in body mass index at a middle school with a large American Indian population, Oklahoma, 2004–2009. American Journal of Public Health, 106, 105–110. https://doi.org/10.2105/AJPH.2015.303034

Farooq, M. A., Parkinson, K. N., Adamson, A. J., Pearce, M. S., Reilly, J. K., Hughes, A. R., Janssen, X., Basterfield, L., & Reilly, J. J. (2018). Timing of the decline in physical activity in childhood and adolescence: Gateshead Millennium Cohort Study. British Journal of Sports Medicine, 52, 1002–1006. https://doi.org/10.1136/bjsports-2018-099429

Franz, A., Rieder, P., Sokolov, K., & Lück, A. (2023). Gender differences in physical activity levels among children and adolescents: A systematic review. Journal of Sport and Health Science, 12, 234–247. https://doi.org/10.1016/j.jshs.2023.01.004

Hills, A. P., Andersen, L. B., & Byrne, N. M. (2011). Physical activity and obesity in children. British Journal of Sports Medicine, 45, 866–870. https://doi.org/10.1136/bjsports-2011-090179

Hills, A. P., Dengel, D. R., & Lubans, D. R. (2015). Supporting public health priorities: Recommendations for physical education and physical activity promotion in schools. Progress in Cardiovascular Diseases, 57, 368–374. https://doi.org/10.1016/j.pcad.2015.01.004

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. International Journal of Behavioral Nutrition and Physical Activity, 7, 40. https://doi.org/10.1186/1479-5868-7-40

Jones, R. A., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Tracking physical activity and sedentary behavior in childhood: A systematic review. American Journal of Preventive Medicine, 44, 651–658. https://doi.org/10.1016/j.amepre.2013.03.001

Killough, G., Battram, D., Kurtz, J., Mandich, G., Francis, L., & He, M. (2010). "Pause-2-Play": A pilot school-based obesity prevention program. Revista Brasileira de Saúde Materno Infantil, 10, 303–311. https://doi.org/10.1590/S1519-38292010000300008

Medrano, M., Cadenas, C., Oses, M., Arenaza, L., Amasene, M., & Labayen, I. (2021). Changes in lifestyle behaviors during the COVID-19 confinement in Spanish children: A longitudinal analysis from the MUGI project. Pediatric Obesity, 16, e12731. https://doi.org/10.1111/ijpo.12731

Morano, M., Rutigliano, I., Rago, A., Pettoello-Mantovani, M., & Campanozzi, A. (2016). A multicomponent, school-initiated obesity intervention to promote healthy lifestyles in children. Nutrition, 32, 1075–1080. https://doi.org/10.1016/j.nut.2016.03.017

Nagata, J. M., *et al*. (2023). The association between moderate-to-vigorous physical activity and psychological cognition and mental state in adolescents: A cross-sectional study. Frontiers in Psychology, 15, 1477018. https://doi.org/10.3389/fpsyg.2023.1477018

Pratt, M., Varela, A. R., Salvo, D., Kohl, H. W., & Ding, D. (2020). Attacking the pandemic of physical inactivity: What is holding us back? British Journal of Sports Medicine, 54, 760–762. https://doi.org/10.1136/bjsports-2020-102020

Romero-Cerezo, C., Martínez-Baena, A. C., Ortiz Camacho, M. M., & Jordán, O. R. C. (2011). Percepción de padres y madres respecto a la promoción de actividad físico-deportiva para una escuela activa y saludable. Revista de Psicología del Deporte, 20, 605–620.

Sacher, P. M., Kolotourou, M., Chadwick, P. M., Cole, T. J., Lawson, M. S., Lucas, A., & Singhal, A. (2010). Randomized controlled trial of the MEND program: A family-based community intervention for childhood obesity. Obesity, 18, S62–S68. https://doi.org/10.1038/oby.2010.89

Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., Hergenroeder, A. C., Must, A., Nixon, P. A., Pivarnik, J. M., Rowland, T., Trost, S., & Trudeau, F. (2005). Evidence-based physical activity for school-age youth. Journal of Pediatrics, 146, 732–737. https://doi.org/10.1016/j.jpeds.2005.01.055

Tarro, L., Llauradó, E., Moriña, D., Solà, R., & Giralt, M. (2014). Follow-up of a healthy lifestyle education program (the Educació en Alimentació Study): 2 years after cessation of intervention. Journal of Adolescent Health, 55, 782–789. https://doi.org/10.1016/j.jadohealth.2014.03.006

World Health Organization. (2021). Global Status Report on Physical Activity 2021. World Health Organization. https://www.who.int/publications/i/item/9789240064179

Zhang, Y., Liu, J., Chen, S., & Wang, Z. (2024). Study on the influence of levels of physical activity and socio-economic conditions on body mass index of adolescents. International Health. Advance online publication. https://doi.org/10.1093/inthealth/ihae083