DR ALBERTO GRAO-CRUCES (Orcid ID : 0000-0003-1425-9745)

DR VÍCTOR SEGURA-JIMÉNEZ (Orcid ID : 0000-0001-8655-9857)

DR VERONICA CABANAS-SANCHEZ (Orcid ID : 0000-0003-1235-3535)

DR JOSÉ CASTRO-PIÑERO (Orcid ID : 0000-0002-7353-0382)

Article type : Original Article

Changes in compliance with school-based physical activity recommendations in Spanish youth: The UP&DOWN longitudinal study

Changes in school-based physical activity

Alberto Grao-Cruces [1], David Sánchez-Oliva [1], Víctor Segura-Jiménez [1], Verónica Cabanas-Sánchez [2], David Martínez-Gómez [2,3], Fernando Rodríguez-Rodríguez [4], Luis A. Moreno [5], José Castro-Piñero [1]

[1] Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Puerto Real, Spain.

[2] Department of Physical Education, Sports and Human Movement, Faculty of Teacher Training and Education, Autonomous University of Madrid, Madrid, Spain.

[3] IMDEA Food Institute, CEI UAM + CSIC, Madrid, Spain.

[4] IRyS Research Group, School of Physical Education, Pontifical Catholic University of Valparaiso, Viña del Mar, Chile.

[5] GENUD (Growth, Exercise, NUtrition and Development) Research Group, Faculty of Health Sciences, University of Zaragoza, Zaragoza, Spain.

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/sms.13355

Correspondence: José Castro-Piñero, Department of Physical Education, Faculty of Education Sciences, University of Cadiz, Avda. República Saharaui s/n, 11519 Puerto Real, Spain. Email: jose.castro@uca.es. Phone: (+34) 956016947. Fax: (+34) 956016253.

ABSTRACT

The study aimed (i) to examine changes in physical activity (PA) during the whole day, school hours, recess, and physical education classes (PEC) during a 2-year period in primary and secondary students; (ii) to identify changes in the proportion of compliance with specific PA recommendations for these periods; and (iii) to examine whether PA levels at baseline are associated with PA levels 2 years later. Eight hundred fourteen (51.8% boys) children and 658 (50.1% boys) adolescents from 41 Spanish schools participated in the study. Hip-worn accelerometers were used to assess PA during different time periods. Light PA (LPA) declined during the whole day, school hours, recess (all $p<0.001$, except child girls for recess) and PEC (all, $p<.05$) in children and adolescents. Moderate-to-vigorous PA (MVPA) during the whole day and recess declined in child boys ($p<.01$ and $p<.001$, respectively) and adolescent boys ($p<.001$ and $p<.05$, respectively). MVPA during PEC declined in adolescent boys ($p<.001$) and adolescent girls (all $p<.05$). The proportion of compliance with the specific PA recommendations for these periods declined ($p<.05$), except for PEC in adolescent girls. PA during the whole day at baseline was moderately associated with PA during the whole day years later (ICCs=0.210-0.544, with one exception), but this association was lower for the school-based PA. In conclusion, time spent in MVPA and LPA during the whole day and recess declined over time in child and adolescent boys and during PEC in adolescents. These findings highlight the need to promote PA interventions in these settings.

KEYWORDS

lifestyle, physical education, recess, primary education, secondary education, tracking

1 INTRODUCTION

Low levels of physical activity (PA) in children and adolescents are recognized as a critical risk factor for suffering chronic diseases later in life [1] and are linked to other health-related risk behaviors, such as substance abuse or unhealthy diets.[2] Children and adolescents are recommended to engage in at least 60 minutes of moderate-to-vigorous PA (MVPA) per day.[3] However, more than half of children and adolescents worldwide do not meet this recommendation.[4,5] Spain also has this problem, and it especially affects Spanish adolescent girls, among which only 26% are physically active.[6]

Schools have great potential to increase the PA levels of students because of their unique access to millions of children and adolescents who spend a large proportion of their waking hours at school.[7,8] The American Heart Association indicated that children and adolescents should perform at least 30 minutes of MVPA during school hours.[7] It was also suggested that youths should spend 50% of recess (i.e., time periods of noncurricular activities in school) and physical education classes (PEC) total time in MVPA.[9,10] In this context, previous studies have reported a compliance rate of less than 25% with the school hour PA recommendation even lower than the percentage of compliance for the MVPA during the whole day,[5,6,11] and showed that less than 15% of students satisfied the MVPA recommendations during recess and PEC.[9,12–14]

Given that inactivity increases with age,[4,15] it is interesting to identify whether or not the school period contributes to the maintenance of MVPA levels in childhood. Several longitudinal studies have examined children and adolescents objectively-measured PA levels during the whole day,[16–19] but few of them have done it with school-based PA.[16,19,20] MVPA during the whole day significantly declined over the following 4-6 years in English and American children aged 9-10 years,[16–18] but MVPA decline was not clear in 12-year-old English children.[19] Likewise, total PA and MVPA during school hours decreased in English children over a 4-year period,[16] although in 12-year-old English children, only light PA (LPA) during school hours declined over 3 years.[19] Research on longitudinal changes in PA during recess is limited

to one study, where Ridgers et al.[20] showed a MVPA decline during recess in 5 to 6- and 10 to 12-year-old Australian students over 3 and 5 years. To our knowledge, no study has examined longitudinal changes in PEC using an objective measure of PA. In addition, previous studies analyzed the association over time (tracking) between objectively measured PA at baseline and PA years later.[21–23] However, all of these studies analyzed PA only during the whole day. Therefore, the current study aimed (i) to provide a comprehensive view of changes of PA in children and adolescents during the whole day, school hours, recess and PEC during a 2-year period, (ii) to identify changes in the rate of compliance with the specific PA recommendations for these periods in primary and secondary schools, and (iii) to examine whether PA at baseline is associated with PA two years later.

2 METHODS

2.1 Participants

Participants were enrolled in the UP&DOWN study, a longitudinal study designed to assess the impact of PA and sedentary behaviors on health indicators over time, as well as to identify the psychoenvironmental and genetic determinants of PA in a convenience sample of Spanish children and adolescents. The UP&DOWN study established the following selection criteria: (i) 1st and 4th graders (6–7 and 9–10 years old, respectively) for children at baseline and in 7th and 10th graders (12–13 and 15–16 years old, respectively) for adolescents at baseline, and (ii) do not have physical disability or health problems, which might limit levels of PA. Forty-five schools, of the 70 invited, agreed to participate in the study, of which four were excluded for logistical reasons. In total, 1188 children from 23 primary schools in Cadiz and 1037 adolescents from 18 secondary schools in Madrid agreed to participate in the study (without taking into account the specific sample child with Down syndrome). Complete information of the study has been described elsewhere.[24] The present sample comprised 1472 Spanish children and adolescents, including 814 children (mean age at baseline 8.1±1.5 years; 51.8% boys) and 658 adolescents (mean age at baseline 13.8±1.5 years; 50.1% boys), with valid data

on objectively measured PA during the whole day, school hours, recess and PEC at baseline and at the follow-up two years later. The inclusion criteria required having PA data at baseline and follow-up for (i) at least three valid days (≥10 hours of valid wear time) and (ii) at least one complete period of both recess and PEC.

Data collection took place from September 2011 to June 2012 and from September 2013 to June 2014 for baseline and follow-up measurements, respectively. Participants, their families and school supervisors were informed concerning the nature and objectives of the study at a meeting, in which informed consent from parents or legal guardians and participants was obtained. The UP&DOWN study was approved by the Ethics Committee of *Puerta de Hierro* Hospital (Madrid, Spain), the Bioethics Committee of the Spanish National Research Council (Madrid, Spain) and the Ethics Committee for Research Involving Human Subjects at the University of Cádiz (Cadiz, Spain).

2.2 Measurements

PA variables were objectively assessed by the ActiGraph accelerometer models GT1M, GT3X and GT3X+ (ActiGraph TM, LLC, Pensacola, FL, US). The GT1M is a small and lightweight uniaxial accelerometer (3.8 x 3.7 x 1.8 cm, 27 g) designed to detect vertical accelerations ranging in magnitude from 0.05 to 2.00 g with a frequency response of 0.25-2.50 Hz. The GT3X and GT3X+ are triaxial accelerometers (4.6 x 3.3 x 1.5 cm, 19 g) capable of measuring accelerations from -6 to 6 g with a frequency response of 0.25 to 2.50 Hz. The accelerometers have been widely calibrated for children and adolescents in laboratory and free-living conditions.[25] A strong agreement among the three ActiGraph accelerometer models has been reported.[26] The data were downloaded and analyzed using ActiLife software (v.6.6.2). Before any analyses were performed, data were integrated into 10-second epochs as recommended by Cain et al.[27] Nonwear time was defined as a period of 60 minutes of zero counts and an allowance of up to two consecutive minutes<100 counts per minute (cpm) with the

up/downstream 30 minutes consecutive of zero counts (i.e., 60-30-2) for detection of artifactual movements.[27,28]

For both measurement moments, each participant wore the accelerometer at the lower back for seven consecutive days, removing it during sleep and water-based activities. Minutes of PA during school hours, recess and PEC were calculated individually for each participant by extracting these specific periods using schedules provided by each school. In the majority of Spanish schools, school hours amounts to 300 minutes in children and 345 minutes in adolescents. The mean accelerometer wear time during school hours was 292 and 293 minutes in children at baseline and follow-up, respectively, and 339 minutes at baseline and 329 minutes at follow-up in adolescents. In Spain, every school has at least one daily recess ranging from 20 to 45 minutes, typically 30 minutes. The mean accelerometer wear time during recess was 29 minutes in children (both at baseline and follow-up) and 32 minutes at baseline and 30 minutes at follow-up in adolescents. PEC are part of the regular Spanish curricula, which is common for all schools. PEC address various content (i.e., sports, dance, physical fitness-driven activities, etc.) and only qualified physical education teachers can teach this subject. The majority of schools had two PEC per week with a duration ranging from 45 to 120 minutes per class (typically 60 minutes in primary schools and 55 minutes in secondary schools); for those who had one PEC per week, the duration was from 90 to 150 minutes per class. The mean accelerometer wear time during PEC was 63 and 61 minutes in children at baseline and follow-up, respectively, and 51 and 54 minutes in adolescents at baseline and follow-up, respectively.

The following cutoff values were used to define the PA intensity categories to be in agreement with those used in previous studies with European children and adolescents.[29,30] LPA was established as between 100 and 2000 counts/minutes, while MVPA was estimated using cutoff values of >2000 counts/minute and vigorous PA (VPA) used cutoff values of >4000 counts/minute. Total PA was expressed as the mean cpm. The dependent variables included in

this study were average minutes per day of LPA, MVPA, VPA, and total PA during the whole day, school hours, recess and PEC.

Harmonization and standardization of anthropometric data in the UP&DOWN study were strictly controlled.[24] Weight was measured with an electronic scale (Type SECA 861; range, 0.05 to 130 kg; precision, 0.05 kg), and height was measured in the Frankfort plane with a telescopic stature-measuring instrument (Type SECA 225; range, 60 to 200 cm; precision, 1 mm). BMI was calculated using the commonly used formula as follows: weight/height^2 (kg/m^2). Overweight and obesity were established according to the BMI international cutoff values.[31]

A single survey question was used, asking parents, "In which of these categories does the level of education of the participant's mother best fit?" The response scale presented five options as follows: 1=no education, 2=elementary school, 3=middle school, 4=high school, and 5=university.

2.3 Data Analysis

Analyses were performed separately by age groups (children and adolescents) and sex (boys and girls) because we found statistically significant time*group interactions. The participants' characteristics and the PA data are presented as means and standard deviations (for continuous variables) or as percentages (for categorical variables). Differences in the participants' characteristics between age groups and sexes were analyzed by one-way ANOVA. Differences in PA between baseline and follow-up were analyzed by means of linear models for continuous variables and logistic binary regression for dichotomous variables (compliance or not with PA recommendations: at least 60 minutes daily of MVPA, 30 minutes of MVPA in school hours, and 50% of recess and PEC total time in MVPA), generalized linear mixed models (GLMM) were used in both cases[32,33]. To examine the association over time (tracking) between PA at baseline and follow-up, intraclass correlations (ICCs) were calculated for continuous variables by applying a one-way random-effect model through linear mixed models,[34] and odds ratio (OR) were calculated for dichotomous variables (compliance or not with PA

recommendations) using logistic binary regression in GLMM. In all analyses, BMI, maternal education, age at baseline and accelerometer wear time for each period were included as covariates due to their influence on PA.[5,35,36]. In the GLMM, the 4-level structure of the data study, level 1=observations, level 2=students; level 3=classes, and level 4=schools, was taken into account. SPSS Statistics 21.0 software package for MS Windows (IBM Software Group, Armonk, NY, US) was used for analysis, and the level of significance was set at $p<0.05$.

3 RESULTS

Table 1 shows the anthropometric characteristics of the study participants by sex and age groups. Adolescent boys and girls were taller, heavier and had higher BMI values than child boys and girls at baseline and follow-up (all $p<0.001$). Moreover, adolescent boys were also taller and heavier than their peers girls at follow-up (all $p<0.001$).

Tables 2 to 5 show the differences in average PA variables (i.e., PA during the whole day, school hours, recess and PEC) between baseline and 2-year follow-up by sex and age groups. Children and adolescents of both sexes diminished their LPA (Table 3) levels during the 2-year follow-up (all, $p<0.05$), except for child girls during recess ($p>0.05$). In these 2-year follow-ups, child and adolescent boys significantly decreased MVPA levels during the whole day (-4.7%/year, B=-7.140, $p<0.01$ in child boys and -4.1%/year, B=-5.236, $p<0.05$ in adolescent boys) and MVPA levels during recess (-8.8%/year, B=-1.358, $p<0.05$ and -17.1%/year, B=-1.951, $p<0.01$ in child and adolescent boys, respectively), and adolescents of both sexes diminished MVPA levels during PEC (-11.8%/year, B=-5.434, $p<.001$ in adolescent boys and -12.2%/year, B=-3.338, $p<0.05$ in adolescent girls; Table 4). The data also showed a VPA decline during the 2-year follow-up during recess and PEC in adolescents of both sexes (all, $p<0.05$); however, it increased during school hours in adolescent girls ($p<0.05$; Table 5).

Figure 1 presents the differences in the proportion of children and adolescents who met the different PA recommendations at baseline and 2-year follow-up by sex and age groups. The percentage of boys who met the daily PA recommendation decreased from 79.4% at baseline

to 67.9% at the 2-year follow-up (OR=0.570, p<0.01) in child boys and from 66.2% to 48.7% (OR=0.448, p<0.001) in adolescent boys. The percentage of child girls who met the school PA recommendation decreased from 8.3% to 4.3% (OR=0.217, p<0.01); however, in adolescent girls, this percentage increased from 1.5% to 3.4% (OR=8.052, p<0.05). Recess PA recommendations were fulfilled by a higher percentage of child boys and adolescent boys at baseline than after the 2-year follow-up [10.1% vs. 3.4%, OR=0.089, p<0.001 in child boys and 10.6% vs. 4.7%, OR=0.041, p<0.05 in adolescent boys (threshold of 50%)]. A greater percentage of adolescent boys met the PA recommended for PEC at baseline than two years later at the follow-up (10.6% vs. 4.2%, OR=0.126, p<0.01).

Total PA and time spent in LPA, MVPA and VPA during the whole day at baseline were from low to moderately associated with total PA, LPA, MVPA and VPA during the whole day at the follow-up in children and adolescents of both sexes [ICCs=0.210-0.544, except for total PA in adolescent girls (ICC=0.014)]. In general, ICCs from the studied school periods were substantially lower than those from the whole day in both age groups and sexes (Tables 2-5). Likewise, children and adolescents who met with the daily PA recommendations at baseline were more likely to remain active two years later (OR=4.885, p<0.001 for child boys; OR=5.903, p<0.001 for child girls; OR=3.487, p<.001 for adolescent boys; and OR=3.593, p<0.001 for adolescent girls). Child boys who met PA recommendations for school hours and recess at baseline also increased the likelihood of meeting these PA recommendations after 2 years [OR=2.463, p<0.01 for school hours and OR=5.047, p<0.01 for recess (threshold of 50%)]. The results did not change when analyses were repeated by adjusting for the Tanner stage instead of age, by adjusting by the change of BMI instead of the BMI at baseline, and without adjusting for accelerometer wear time (data not shown).

4 DISCUSSION

This study reports 2-year changes in objectively measured PA (i.e., PA during the whole day, school hours, recess and PEC) in children and adolescents. The results showed that LPA declined during the 2-year follow-up during the whole day, school hours, recess and PEC. Moreover, MVPA and the rate of compliance with the specific PA recommendations during different time periods on a daily basis diminished significantly for the whole day and recess in child boys and adolescent boys and for PEC in adolescents of both sexes. Moreover, PA (i.e., total PA, LPA, MVPA, and VPA) during the whole day was moderately associated with PA during whole day two years later. These findings suggest that it is important to promote PA at early ages and prevent its subsequent decline.

The longitudinal decline in LPA during the whole day found in our study is consistent with previous research that also revealed a significant age-related decline in overall objectively measured PA at these ages.[16–18] However, the decline in both total PA and MVPA during the whole day and in compliance with the recommendations of 60 minutes of MVPA per day observed in the studied child boys and adolescent boys was not statistically significant among girls. Brooke et al.[17] noted a MVPA decline in youths from ages 10 to 14 years, which was also notably higher among boys than girls. Several studies also showed a significant MVPA decrease among girls,[16,18] however, other studies did not find a decrease in MVPA either for boys or for girls.[19] This discrepancy between studies could be explained by their different follow-up time and age of participants at baseline. We and Harding et al.[19] did not study the transition from childhood to adolescence. Regardless, the largest percentage of inactive females at baseline could hinder large MVPA declines.

Regarding school-based PA, the decreases in total PA and LPA, statistically significant for school hours and recess in almost all subgroups studied, are consistent with studies reporting significant declines of PA during school hours[16,19] and during recess.[20] However, we did not observe significant declines in MVPA or VPA during school hours. This result contrasts with studies by Harding et al.[19] and Brooke et al.[16] performing 3- and 4-year longitudinal studies

with English children and adolescents, and they found a significant decrease in MVPA during school hours. These longitudinal studies had larger durations than ours, and their MVPA changes, still statistically significant, were not meaningful.[19]

Concerning recess time, we found a decline in MVPA, VPA (nonsignificant in children) and percentage of child boys and adolescent boys meeting the PA recommendations of engaging in at least 50% of recess time in MVPA. These findings are consistent with the decrease in moderate PA and VPA found by Ridgers et al.[20] in 5 to 6- and 10 to 12-year-old Australian boys after 3 and 5 years of follow-up. It is noteworthy that larger decreases occurred in the older cohort.[20] In contrast, they found moderate PA and VPA declines also in child girls, which in our study, was not statistically significant. This difference could be due to the different follow-up periods since some changes observed in child girls after a 5-year period were not significant after a 3-year period.[20] Moreover, the limited minutes of MVPA at baseline in child girls and adolescent girls hinder a sharp and widespread decline.

This is the first longitudinal study to examine objectively measured PA changes in PEC. LPA during PEC declined in all subgroups, whereas MVPA and VPA declined in adolescents of both sexes. Furthermore, there was a decrease in the percentage of adolescent boys meeting the PEC PA recommendation (10.7% vs. 4.5%). These results are consistent with the decline of VPA found in 51 Australian adolescents by Dudley et al.[37] along a 1-year follow-up, although they did not report significant changes for MVPA and used direct observation.[37] These results suggest that special surveillance aiming to reduce the age-associated changes in PA during PEC along secondary school is needed.

In relation to PA tracking, total PA, LPA, MVPA, and VPA during the whole day at the baseline were moderately associated with total PA, LPA, MVPA, and VPA during the whole day 2 years later in the majority of subgroups studied. This is consistent with previous studies[21–23] and with the fact that meeting the daily PA recommendations at baseline predicted children and adolescents to remain physically active at follow-up. It is known that PA levels decrease during primary and secondary school and the fact that PA at baseline is associated with PA 2 years

later, which indicates the importance of promoting PA at an early age. However, the PA tracking was substantially lower for the school periods studied than for the whole day. Indeed, only in child boys, compliance with school-based recommendations at baseline predicted the rate of compliance with these recommendations at follow-up. Moreover, very low tracking coefficients for PA are probably due to measurement error[34]. Our study is pioneering in studying whether objectively measured school-based PA is associated with time spent in school-based PA years later; more future research on the topic is needed.

The study has some limitations linked to the use of accelerometry, such as the lack of sensitivity to capture upper body movements, water-based activities, cycling or other complex movements.[38] Another limitation is that the sample was of convenience. One of the main strengths of this work was the analysis of PA changes in different settings, such as recess and PEC, which had been requested by previous research.[38] Another innovation of this study was the inclusion of an objective measure of PA in a large sample of children and adolescents. Moreover, these measurements were assessed without interrupting the normal development of school activities and during a complete week in each of the two measurements instead of a single day.[35]

In conclusion, our findings revealed that LPA declined both in the whole day and during school hours in children and adolescents, while MVPA and the rate of compliance with the specific PA recommendations declined for the whole day and recess in child boys and adolescent boys and for PEC in adolescents of both sexes. Moreover, greater levels of PA (i.e., total PA, LPA, MVPA, and VPA) in childhood were associated with greater levels of PA over time.

5 PERSPECTIVE

The present study indicates that PA declines both during the whole day and during specific school settings (i.e., school hours, recess and PEC) during childhood and adolescence. This suggests that interventions targeting PA should be developed in all the periods studied because PA decreases could detrimentally impact the health of the young people, even if only

LPA is decreased.[39] Likewise, in school time, the greatest opportunity for PA interventions may be at recess and PEC because a very low proportion of students meet their specific PA recommendations at baseline and even decrease in some subgroups during the follow-up. Moreover, the current study seems to suggest the convenience of starting the PA promotion at an early age given that greater levels of PA (i.e., total PA, LPA, MVPA, and VPA) in childhood was associated with greater levels of PA over time. Further research should focus on developing specific interventions aimed at avoiding PA decline in both sex and age groups.

ACKNOWLEDGEMENTS

This study was supported by the DEP 2010-21662-C04-00 (DEP 2010-21662-C04-01: DEP 2010-21662-C04-02: DEP 2010-21662-C04-03: DEP 2010-21662-C04-04) grant from the Spanish National Plan for Research, Development and Innovation (R+D+i), MICINN. The Spanish Ministry of Economy, Industry and Competitiveness awarded a "Juan de la Cierva" postdoctoral grant to the author DSO (FJCI-2015-25867) and a “Ramón y Cajal” postdoctoral grant to the author DMG (RYC-2016-20546). VCS was supported by an FPI grant from the Autonomous University of Madrid. AGC is grateful to the "Program to promote and boost research activity" of the University of Cádiz for the granting of a mobility aid.

REFERENCES

1. Rowlands A V. Physical activity, inactivity, and health during youth. *Pediatr Exerc Sci*. 2016;28(1):19-22. doi:10.1123/pes.2016-0007.
2. Grao-Cruces A, Nuviala A, Fernández-Martínez A, Martínez-López EJ. Relationship of physical activity and sedentarism with tobacco and alcohol consumption, and Mediterranean diet in Spanish teenagers. *Nutr Hosp*. 2015;31(4):1693-1700. doi:10.3305/nh.2015.31.4.8256.
3. United States Department of Health and Human Services. *Physical Activity Guidelines*

for Americans. Washington: World Health Organization; 2008. http://www.health.gov/paguidelines. Accessed November 18, 2016.

4. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*. 2012;380(9838):247-257. doi:10.1016/S0140-6736(12)60646-1.
5. Hubbard K, Economos CD, Bakun P, et al. Disparities in moderate-to-vigorous physical activity among girls and overweight and obese schoolchildren during school- and out-of-school time. *Int J Behav Nutr Phys Act*. 2016;13(1):39. doi:10.1186/s12966-016-0358-x.
6. Grao-Cruces A, Segura-Jiménez V, Conde-Caveda J, et al. The role of school in helping children and adolescents reach the physical activity recommendations: The UP&DOWN study. *J Sch Health*. 2018:in press.
7. Pate RR, O'Neill JR. Summary of the American Heart Association scientific statement: promoting physical activity in children and youth: a leadership role for schools. *J Cardiovasc Nurs*. 2008;23(1):44-49. doi:10.1097/01.JCN.0000305056.96247.bb.
8. Institute of Medicine. *Educating the Student Body: Taking Physical Activity and Physical Education to School*. Washington, D.C.: National Academies Press; 2013. doi:10.17226/18314.
9. Stratton G, Mullan E. The effect of multicolor playground markings on children's physical activity level during recess. *Prev Med (Baltim)*. 2005;41:828-833. doi:10.1016/j.ypmed.2005.07.009.
10. United States Department of Health and Human Services. *Strategies to Improve the Quality of Physical Education*. Washington: Centers for Disease Control and Prevention; 2010. http://www.cdc.gov/healthyyouth/physicalactivity/pdf/quality_pe.pdf. Accessed April 26, 2016.
11. van Stralen MM, Yıldırım M, Wulp A, et al. Measured sedentary time and physical activity during the school day of European 10- to 12-year-old children: the ENERGY

project. *J Sci Med Sport*. 2014;17(2):201-206. doi:10.1016/j.jsams.2013.04.019.

12. Nettlefold L, McKay HA, Warburton DER, McGuire KA, Bredin SSD, Naylor PJ. The challenge of low physical activity during the school day: at recess, lunch and in physical education. *Br J Sports Med*. 2011;45(10):813-819. doi:10.1136/bjsm.2009.068072.
13. Viciana J, Martínez-Baena A, Mayorga-Vega D. Contribución de la educación física a las recomendaciones diarias de actividad física en adolescentes según el género; un estudio con acelerometría. *Nutr Hosp*. 2015;32(3):1246-1251. doi:10.3305/nh.2015.32.3.9363.
14. Meyer U, Roth R, Zahner L, et al. Contribution of physical education to overall physical activity. *Scand J Med Sci Sports*. 2013;23(5):600-606. doi:10.1111/j.1600-0838.2011.01425.x.
15. Whitt-Glover MC, Taylor WC, Floyd MF, Yore MM, Yancey AK, Matthews CE. Disparities in physical activity and sedentary behaviors among US children and adolescents: Prevalence, correlates, and intervention implications. *J Public Health Policy*. 2009;30(S1):S309-S334. doi:10.1057/jphp.2008.46.
16. Brooke HL, Atkin AJ, Corder K, Ekelund U, van Sluijs EMF. Changes in time-segment specific physical activity between ages 10 and 14 years: A longitudinal observational study. *J Sci Med Sport*. 2016;19(1):29-34. doi:10.1016/j.jsams.2014.10.003.
17. Brooke HL, Corder K, Griffin SJ, van Sluijs EMF. Physical activity maintenance in the transition to adolescence: A longitudinal study of the roles of sport and lifestyle activities in British youth. *PLoS One*. 2014;9(2):e89028. doi:10.1371/journal.pone.0089028.
18. Nader PR, Bradley RH, Houts RM, McRitchie SL, O'Brien M. Moderate-to-vigorous physical activity from ages 9 to 15 years. *JAMA*. 2008;300(3):295. doi:10.1001/jama.300.3.295.
19. Harding SK, Page AS, Falconer C, Cooper AR. Longitudinal changes in sedentary time and physical activity during adolescence. *Int J Behav Nutr Phys Act*. 2015;12:44.

doi:10.1186/s12966-015-0204-6.

20. Ridgers ND, Timperio A, Crawford D, Salmon J. Five-year changes in school recess and lunchtime and the contribution to children's daily physical activity. *Br J Sports Med*. 2012;46(10):741-746. doi:10.1136/bjsm.2011.084921.

21. Rääsk T, Konstabel K, Mäestu J, Lätt E, Jürimäe T, Jürimäe J. Tracking of physical activity in pubertal boys with different BMI over two-year period. *J Sports Sci*. 2015;33(16):1649-1657. doi:10.1080/02640414.2015.1012097.

22. Francis SL, Morrissey JL, Letuchy EM, Levy SM, Janz KF. Ten-year objective physical activity tracking: Iowa Bone Development Study. *Med Sci Sports Exerc*. 2013;45(8):1508-1514. doi:10.1249/MSS.0b013e31828b2f3a.

23. Dencker M, Tanha T, Wollmer P, Karlsson MK, Andersen LB, Thorsson O. Tracking of physical activity with accelerometers over a 2-year time period. *J Phys Act Health*. 2013;10(2):241-248. http://www.ncbi.nlm.nih.gov/pubmed/22396324. Accessed April 26, 2017.

24. Castro-Piñero J, Carbonell-Baeza A, Martinez-Gomez D, et al. Follow-up in healthy schoolchildren and in adolescents with Down syndrome: psycho-environmental and genetic determinants of physical activity and its impact on fitness, cardiovascular diseases, inflammatory biomarkers and mental health; the UP&DOWN study. *BMC Public Health*. 2014;14:400. doi:10.1186/1471-2458-14-400.

25. Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. *Med Sci Sports Exerc*. 2005;37(11 Suppl):S523-S530.

26. Robusto KM, Trost SG. Comparison of three generations of ActiGraph™ activity monitors in children and adolescents. *J Sports Sci*. 2012;30(13):1429-1435. doi:10.1080/02640414.2012.710761.

27. Cain KL, Sallis JF, Conway TL, Van Dyck D, Calhoon L. Using accelerometers in youth physical activity studies: a review of methods. *J Phys Act Health*. 2013;10(3):437-450.

28. Choi L, Liu Z, Matthews CE, Buchowski MS. Validation of accelerometer wear and

nonwear time classification algorithm. *Med Sci Sports Exerc*. 2011;43(2):357-364. doi:10.1249/MSS.0b013e3181ed61a3.

29. Ruiz JR, Ortega FB, Martínez-Gómez D, et al. Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. *Am J Epidemiol*. 2011;174(2):173-184. doi:10.1093/aje/kwr068.

30. Fairclough SJ, Beighle A, Erwin H, Ridgers ND. School day segmented physical activity patterns of high and low active children. *BMC Public Health*. 2012;12:406. doi:10.1186/1471-2458-12-406.

31. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes*. 2012;7(4):284-294. doi:10.1111/j.2047-6310.2012.00064.x.

32. Heck RH, Thomas SL, Tabata LN. *Multilevel Modeling of Categorical Outcomes Using IBM SPSS*. New York, NY: Routledge; 2012.

33. Casals M, Girabent-Farrés M, Carrasco JL. Methodological quality and reporting of generalized linear mixed models in clinical medicine (2000-2012): a systematic review. *PLoS One*. 2014;9(11):e112653. doi:10.1371/journal.pone.0112653.

34. Aadland E, Andersen LB, Skrede T, Ekelund U, Anderssen SA, Resaland GK. Reproducibility of objectively measured physical activity and sedentary time over two seasons in children; Comparing a day-by-day and a week-by-week approach. *PLoS One*. 2017;12(12):e0189304. doi:10.1371/JOURNAL.PONE.0189304.

35. Mayorga-Vega D, Viciana J. Differences in physical activity levels in school-based contexts – Influence of gender, age, and body weight status. *Kinesiology*. 2015;47(2):151-158.

36. Sherar LB, Griffin TP, Ekelund U, et al. Association between maternal education and objectively measured physical activity and sedentary time in adolescents. *J Epidemiol Community Health*. 2016;70(6):541-548. doi:10.1136/jech-2015-205763.

37. Dudley DA, Okely AD, Pearson P, Cotton WG, Caputi P. Changes in physical activity

levels, lesson context, and teacher interaction during physical education in culturally and linguistically diverse Australian schools. *Int J Behav Nutr Phys Act*. 2012;9(1):114. doi:10.1186/1479-5868-9-114.

38. Aibar A, Bois JE, Zaragoza Casterad J, Generelo E, Paillard T, Fairclough S. Weekday and weekend physical activity patterns of French and Spanish adolescents. *Eur J Sport Sci*. 2014;14(5):500-509. doi:10.1080/17461391.2013.829127.

39. Hatfield DP, Chomitz VR, Chui K, Sacheck JM, Economo CD. Exploring new relationships between physical activity volume and intensity and cardiometabolic risk in U.S. adolescents. *J Phys Act Health*. 2015;12(9):1312-1319. doi:10.1123/jpah.2014-0418.

TABLE 1 Anthropometric characteristics for students participating in the study at baseline and follow-up

	Sex	Baseline		Follow-up	
		Children (*n*=422 boys and 392 girls)	Adolescents (*n*=330 boys and 328 girls)	Children (*n*=422 boys and 392 girls)	Adolescents (*n*=330 boys and 328 girls)
Age (years)	Boys	8.1±1.5[b]	13.8±1.5[b]	10.1±1.5[b]	15.8±1.5[b]
	Girls	8.2±1.5[b]	13.8±1.4[b]	10.3±1.5[b]	15.8±1.4[b]
Weight (kg)	Boys	30.7±9.3[b]	55.6±13.2[b]	38.9±11.8[b]	64.3±11.9[a,b]
	Girls	31.3±10.0[b]	52.0±9.7[b]	40.4±12.8[b]	56.4±9.7[a,b]
Height (cm)	Boys	129.4±10.7[b]	161.7±11.1[b]	140.9±10.7[b]	171.6±7.7[a,b]
	Girls	129.7±11.1[b]	157.8±6.6[b]	142.6±11.5[b]	161.8±5.7[a,b]
BMI (kg/m^2)	Boys	18.3±3.1[b]	21.3±3.4[b]	19.6±3.8[b]	21.8±3.3[b]
	Girls	18.6±3.4[b]	20.9±3.1[b]	19.9±4.0[b]	21.5±3.3[b]

[a] Denote sex difference by age groups and [b] age groups difference by sex (p<0.001).

TABLE 2. Differences in total physical activity (PA; mean counts per minute) during whole day, school hours, recess and physical education classes (PEC) between baseline and 2-years follow-up, and PA tracking in children and adolescents*

Age group	Period	Sex	Baseline		Follow-up		Time effect		ICC
			Mean	(SD)	Mean	(SD)	B	*p*	
Children (*n*=422 boys and 392 girls)	Whole day	Boys	557.1	(140.5)	495.2	(144.7)	**-51.624**	**<0.001**	0.375
		Girls	477.3	(128.2)	423.3	(129.6)	-24.891	0.066	0.544
	School hours	Boys	483.2	(148.3)	440.1	(147.2)	-29.921	0.111	0.087
		Girls	392.6	(128.2)	341.7	(120.5)	**-46.587**	**0.004**	0.158
	Recess	Boys	1447.0	(710.0)	1212.7	(657.1)	**-193.193**	**0.049**	0.061
		Girls	973.4	(483.3)	732.9	(462.0)	-122.158	0.104	0.122
	PEC	Boys	963.0	(637.3)	1055.1	(566.5)	146.588	0.097	0.016
		Girls	757.2	(500.0)	852.5	(489.0)	**155.120**	**0.044**	<.001
Adolescents (*n*=330 boys and 328 girls)	Whole day	Boys	454.0	(139.7)	421.3	(184.2)	**-35.731**	**0.005**	0.351
		Girls	349.1	(276.5)	311.1	(114.7)	-32.350	0.113	0.014
	School hours	Boys	368.7	(135.3)	338.5	(159.4)	**-37.573**	**0.023**	0.044
		Girls	240.3	(91.4)	236.9	(123.7)	6.429	0.647	0.193
	Recess	Boys	1166.6	(803.3)	808.8	(633.3)	**-414.160**	**<0.001**	0.045
		Girls	597.8	(339.5)	485.9	(300.7)	**-121.263**	**0.011**	0.104
	PEC	Boys	1525.6	(898.3)	1286.9	(926.9)	**-426.124**	**0.004**	<0.001
		Girls	1083.8	(614.1)	894.9	(700.4)	-278.582	0.064	<0.001

* Analyses were adjusted by BMI, maternal education, and age at baseline, and accelerometer wear time for each period. ICC=intraclass correlation.

TABLE 3 Differences in time (min/day) spent in light physical activity (LPA) during whole day, school hours, recess and physical education classes (PEC) between baseline and 2-years follow-up, and LPA tracking in children and adolescents*

Age group	Period	Sex	Baseline		Follow-up		Time effect		ICC
			Mean	(SD)	Mean	(SD)	B	*p*	
Children (*n*=422 boys and 392 girls)	Whole day	Boys	224.1	(37.5)	196.0	(39.5)	**-29.953**	**<0.001**	0.474
		Girls	221.5	(36.7)	191.5	(38.4)	**-27.998**	**<0.001**	0.440
	School hours	Boys	76.0	(21.1)	63.6	(17.1)	**-12.291**	**<0.001**	0.277
		Girls	71.2	(20.5)	58.56	(16.1)	**-12.357**	**<0.001**	0.183
	Recess	Boys	11.4	(2.8)	10.5	(3.3)	**-1.634**	**<0.001**	0.013
		Girls	11.4	(3.2)	9.6	(3.3)	-0.766	0.132	0.021
	PEC	Boys	19.6	(9.3)	17.0	(8.1)	**-2.655**	**0.005**	0.099
		Girls	19.6	(9.7)	15.9	(7.2)	**-2.375**	**0.014**	0.022
Adolescents (*n*=330 boys and 328 girls)	Whole day	Boys	168.4	(40.8)	135.8	(36.3)	**-32.394**	**<0.001**	0.354
		Girls	156.8	(36.7)	128.9	(31.6)	**-27.546**	**<0.001**	0.440
	School hours	Boys	61.9	(20.5)	48.8	(18.9)	**-11.508**	**<0.001**	0.245
		Girls	51.8	(17.0)	41.4	(15.2)	**-8.631**	**<0.001**	0.335
	Recess	Boys	11.2	(4.2)	8.1	(4.3)	**-2.459**	**<0.001**	0.052
		Girls	10.5	(4.3)	7.5	(4.1)	**-3.072**	**<0.001**	0.130
	PEC	Boys	16.2	(6.0)	11.7	(6.8)	**-6.246**	**<0.001**	<0.001
		Girls	16.1	(6.7)	11.9	(6.3)	**-5.575**	**<0.001**	<0.001

* Analyses were adjusted by BMI, maternal education, and age at baseline, and accelerometer wear time for each period. ICC=intraclass correlation.

TABLE 4 Differences in time (min/day) spent in moderate-to-vigorous physical activity (MVPA) time (min/day) during whole day, school hours, recess and physical education classes (PEC) between baseline and 2-years follow-up, and MVPA tracking in children and adolescents*

Age group	Period	Sex	Baseline		Follow-up		Time effect		ICC
			Mean	(SD)	Mean	(SD)	B	*p*	
Children (*n*=422 boys and 392 girls)	Whole day	Boys	80.8	(23.6)	73.1	(23.6)	**-7.140**	**0.004**	0.297
		Girls	64.7	(21.3)	59.7	(21.1)	-2.827	0.223	0.392
	School hours	Boys	24.2	(8.6)	22.5	(8.4)	-0.879	0.451	0.091
		Girls	18.4	(8.4)	16.7	(6.9)	-1.692	0.088	0.084
	Recess	Boys	8.5	(4.4)	7.0	(4.0)	**-1.358**	**0.028**	0.056
		Girls	5.3	(3.0)	3.8	(2.7)	-0.621	0.183	0.127
	PEC	Boys	11.5	(9.3)	11.5	(8.0)	0.758	0.506	0.056
		Girls	8.9	(7.3)	8.9	(6.7)	1.214	0.169	0.007
Adolescents (*n*=330 boys and 328 girls)	Whole day	Boys	69.8	(22.4)	64.0	(27.4)	**-5.236**	**0.028**	0.276
		Girls	51.0	(17.3)	49.8	(20.5)	-1.122	0.661	0.324
	School hours	Boys	21.5	(10.0)	19.1	(9.8)	-2.222	0.054	0.034
		Girls	13.0	(5.9)	13.3	(7.8)	1.259	0.252	0.102
	Recess	Boys	7.0	(4.8)	4.6	(4.0)	**-1.951**	**0.002**	0.071
		Girls	3.2	(2.1)	2.8	(2.6)	-.332	0.311	0.092
	PEC	Boys	13.9	(8.5)	10.6	(8.7)	**-5.434**	**<0.001**	<0.001
		Girls	9.8	(5.8)	7.4	(6.2)	**-3.388**	**0.011**	<0.001

* Analyses were adjusted by BMI, maternal education, and age at baseline, and accelerometer wear time for each period. ICC=intraclass correlation.

TABLE 5 Differences in time (min/day) spent in vigorous physical activity (VPA) time (min/day) during whole day, school hours, recess and physical education classes (PEC) between baseline and 2-years follow-up, and VPA tracking in children and adolescents*

Age group	Period	Sex	Baseline		Follow-up		Time effect		ICC
			Mean	(SD)	Mean	(SD)	B	*p*	
Children (*n*=422 boys and 392 girls)	Whole day	Boys	23.8	(11.5)	21.9	(11.7)	-0.643	0.536	0.278
		Girls	17.1	(11.8)	15.2	(9.4)	-0.658	0.444	0.210
	School hours	Boys	7.9	(4.4)	7.6	(4.5)	0.268	0.552	0.108
		Girls	5.4	(8.5)	4.8	(3.1)	-0.467	0.185	0.044
	Recess	Boys	3.1	(2.7)	2.5	(2.1)	-0.402	0.173	0.083
		Girls	1.9	(1.6)	1.3	(1.4)	-0.194	0.282	0.240
	PEC	Boys	4.6	(4.9)	5.0	(4.0)	0.636	0.238	0.089
		Girls	3.3	(3.4)	3.5	(3.0)	0.519	0.247	0.002
Adolescents (*n*=330 boys and 328 girls)	Whole day	Boys	26.1	(13.5)	26.1	(17.1)	0.663	0.606	0.287
		Girls	14.9	(10.1)	15.5	(11.5)	1.055	0.292	0.284
	School hours	Boys	7.9	(5.1)	7.3	(5.1)	-0.222	0.693	0.059
		Girls	3.6	(2.8)	4.0	(4.2)	**0.791**	**0.041**	0.113
	Recess	Boys	2.5	(2.6)	1.5	(1.9)	**-0.984**	**0.003**	0.034
		Girls	0.6	(0.7)	0.4	(0.8)	**-0.149**	**0.049**	0.380
	PEC	Boys	6.6	(5.4)	5.8	(5.4)	**-2.507**	**0.005**	<0.001
		Girls	3.9	(3.5)	3.5	(3.8)	**-1.617**	**0.038**	<0.001

* Analyses were adjusted by BMI, maternal education, and age at baseline, and accelerometer wear time for each period. ICC=intra-class correlation.

FIGURE 1 Differences in rate of children and adolescents meeting different physical activity (PA) recommendations during whole day (Figure 1a), school hours (Figure 1b), recess (Figure 1c) and physical education classes (PEC; Figure 1d) between baseline and 2-years follow-up. All analyses were adjusted by BMI, maternal education, and age at baseline, and accelerometer wear time. MVPA = moderate-to-vigorous physical activity, C = children, A = adolescents. *p<.05, **p<.01, ***p<.001