# Relationship between school rhythm and physical activity in adolescents: the HELENA study

Jeremy Vanhelst, Laurent Beghin, Alain Duhamel, Stefaan de Henauw, Dénes Molnar, German Vicente-Rodríguez, Yannis Manios, Kurt Widhalm, Mathilde Kersting, Angela A. Polito, et al.

**Relationship Between School Rhythm and Physical Activity in Adolescents: The HELENA Study**

**Running head:** Physical activity and school rhythm

**Keywords:** Physical Activity; School rhythm; Health; Adolescents

**Authors** : Jérémy Vanhelst, Laurent Béghin, Alain Duhamel, Stefaan De Henauw, Denes Molnar, Germán Vicente-Rodriguez, Yannis Manios, Kurt Widhalm, Mathilde Kersting, Angela Polito, Jonatan R Ruiz, Luis A. Moreno, Frédéric Gottrand

## ABSTRACT

The aim was to assess the relationship between school rhythm and physical activity (PA) in adolescents. The study included 2024 adolescents (12.5–17.4 years). Participants wore an accelerometer for 7 days. A short school rhythm was defined as a short time at school with short recesses and less time in teaching per day (Group 1). A long school rhythm was defined as a longer time at school with more time in teaching and recess (Group 2). Adolescents in group 1 performed less moderate to vigorous PA (MVPA) than those in group 2 per week ($P < .0001$), especially during school days (recess: 3.9 ± 4.0 vs. 9.8 ± 7.9 min.day$^{-1}$; $P$<.0001; teaching hours: 14.5 ± 9.8 vs. 19.1 ± 12.0 min.day$^{-1}$; $P$<.0001). Adolescents in group 1 were less likely to meet the PA recommendations than were adolescents in group 2: 30.7% vs. 34.1% ($P$<.0001). During school days, the percentage of adolescents who spent more than 2 h.day$^{-1}$ in sedentary activities was greater in the group 1 ($P$<.001). Our results suggest that leisure-time out-of-school hours is used mainly for sedentary activities, and that school time provides a good opportunity for promoting PA.

## Introduction

Physical inactivity levels are rising in many countries, and this increase has major implications for the prevalence of obesity throughout the European countries. Physical inactivity is now identified as the fourth leading risk factor for global mortality (WHO, 2009). To face this challenge, in 2006 the European member states adopted the European Charter on Counteracting Obesity as a part of the new European health policy (WHO, 2010). It includes the recommendation of 60 minutes of moderate-to-vigorous physical activity (MVPA) every day (WHO, 2010; Cale & Harris, 2001). However, a large proportion of youth do not achieve this recommended level of MVPA (Riddoch et al., 2004; Ruiz et al., 2011). In 2004, from 2185 adolescents assessed by the accelerometry, 18% of boys and 38% of girls did not achieve the PA recommendations (Riddoch et al., 2004). In a population of 2200 European adolescents, 43% of boys and 73% of girls did not meet the PA recommendations of at least 60 minutes/day of MVPA using a accelerometer device (Ruiz et al., 2011).

Childhood and adolescence are key periods for education about and prevention of adult metabolic diseases. Adolescence is a period marked by a decline in participation in physical activity (PA) mainly because of the reduced time spent in MVPA (Ortega et al., 2013). Many factors are responsible for this decline, including overweight and obesity, social context (e.g., the perceptions and behaviors of siblings, parents or friends), parental educational level, the built environment, and seasonal variation (Ruiz et al., 2011; Valery et al., 2012; Beets, Vogel, Forlaw, Pitetti, & Cardinal, 2006; Salvy et al., 2008; Vanhelst et al., 2013, Gracia-Marco et al., 2013).

Children and adolescents spend a substantial proportion of their time at school, and intervening in the school environment may provide opportunities for children and adolescents to be more physically active. Recess, after-school programs and commuting to school in walking are opportunities to improve PA levels and other health-related aspects in adolescents (Beets, Beighle, Erwin, & Huberty, 2009; Saksvig et al., 2007; Saksvig et al., 2012; Ridgers, Salmon, Parrish, Stanley, & Okely, 2012). While several studies have investigated separately the impact of specific periods (recess, after school, commuting to school) on PA patterns during a school day, no study was performed to assess the relationship the school rhythms and the PA patterns and sedentary behaviours in adolescents. The school rhythm corresponds to the organization of the time during school day and includes beginning and finishing hours of the class, number and duration of recess, lunch break, number of school days per week and total time spent at school (Dobbins, Husson, DeCorby, & LaRocca, 2013). It is of public health interest to study whether the school rhythm is associated with PA patterns and sedentary behaviors in adolescents. If so, adaptation of the school rhythm may be a good strategy for promoting PA.

The aim of this study was to assess the relationships between school rhythm and PA patterns, and sedentary behaviors in a large sample of European adolescents.

## Methods

### Study Design

The current report is based on data from the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. The aim of the HELENA study was to obtain a broad range of standardized, reliable, and comparable nutrition- and health-related data from a random sample of European adolescents aged 12.5–17.5 years.

Data were collected in 10 European cities: Vienna (Austria), Ghent (Belgium), Lille (France), Athens (Greece), Heraklion (Greece), Pecs (Hungary), Rome (Italy), Dortmund (Germany), Zaragoza (Spain), and Stockholm (Sweden). In total, 3528 adolescents (1844 girls and 1684 boys) meeting the inclusion criteria completed all examinations. A detailed description of the HELENA study methodology and sampling has been published elsewhere (Béghin et al., 2012; Moreno et al., 2008). In summary, an extended and detailed manual of operations was designed for and thoroughly read by every researcher involved in fieldwork before the data collection started (Nagy et al., 2008). In addition, a workshop training week was carried before the study began, to standardize and harmonize the methodology of data collection. The instructions given to the participants in every measurement were standardized for all the cities and were translated into the local language. In this way, the same verbal information was given to all participants in the HELENA Study. Pilot studies were conducted in 10 cities and included 202 adolescents and to assess the intraobserver and interobserver technical error of measurements as well as the reliability of measurements were checked. The detailed information has been previously reported (Nagy et al., 2008).

Written, informed consent was obtained from the adolescent and the parents. The HELENA study was approved by the local ethics committee for each country, and all procedures were performed in accordance with the ethical standards of the Helsinki Declaration of 1975 as revised in 2008 (Béghin et al., 2008).

From the total population of 3528 adolescents, 2024 (57.4%) were included in the present study because complete information about their school schedules PA and sedentary behaviors assessment.

## Measurements

Participants' Characteristics

Anthropometric measurements were carried out only once. Body weight was measured with the participant wearing light clothes, without shoes, to the nearest 0.1 kg using an electronic scale (SECA 871; SECA, Hamburg, Germany). Height was measured without shoes to the nearest 0.1 cm using a telescopic height-measuring instrument (SECA 225; SECA). Body mass index (BMI) was calculated as weight in kg/height in $m^2$ ($kg/m^2$). Weight status was assessed using the International Obesity Task Force scale (Cole, Bellizzi, Flegal, & Dietz, 2000). Pubertal status was assessed by a physician through direct observation according to the method of Tanner and Whitehouse (Tanner & Whitehouse, 1976).

Parental education level was classified into one of three categories using a specific questionnaire adapted from the International Standard Classification of Education (ISCED) (http://www.uis.unesco.org/Library/Documents/isced97-en.pdf). Parental education level was scored as I for primary and lower education (levels 0, 1, and 2 in the ISCED classification), II for higher secondary (levels 3 and 4 in the ISCED classification), and III for tertiary (levels 5 and 6 in the ISCED classification).

School Rhythm

Adolescents were recruited through the schools where the entire classes including adolescents aged 13 to 16 years old were asked to participate. Sampling was stratified and random, and was performed in multiple steps (Béghin et al. 2012). Firstly, within the selected cities, schools were randomized taking into account several cluster stratifications: private/public school, location/area (zone or district), socio-economic level and age strata. The second step included randomisation of classes. In this random cluster sampling process, stratification was done at two levels, first at the level of cities and secondly at the level of school strata (as mentioned above). Data concerning public/private school status, number of adolescents per class, and class level or grade, were provided by local school authorities. This procedure was carried out to ensure diversity of the sample in cultural and socioeconomic aspects. The random selection of schools and classes was performed centrally (by the Ghent University). A list of 10 randomly selected schools was provided for each center. At the same time, a replacement list including 20 substitute schools was also provided (replacement schools/classes were for the event of a school/class refusing to participate, and were from the same district and same class level/grade). Ten schools were involved in the survey for each center. A researcher from each center was instructed to obtain the schedule of the different classes that participated in the study. The questionnaire was completed by the school executive and comprised several parts: (*i*) beginning and finishing hours of the class every day; (*ii*) teaching hours (*i.e* time spent in class only) per day and per week for each class; (*iii*) hours of recess defined as time in school out of class (including recess per se, commuting in school and lunch break); (*iv*) number of school days per week; and (*v*) total amount of time spent at school. All of these parameters were reported for each class during 1 week.

Because there are no validated data for defining school rhythm, we applied an a priori definition of school rhythm using the information contained in the school schedule (Figure 1). Using the information in the diary for each class, we decided to classify a priori the adolescents into two groups: a short school rhythm group and a long school rhythm group. A short school rhythm was defined as finishing school at

3:00 PM or earlier (Figure 1). A long school rhythm was defined as finishing school after 3:00 PM (Figure 1). The two groups differed significantly on other criteria: duration of school recess, total time spent at school per day and per week, hours of teaching per day and per week, and the number of classes with <5 days of school per week (Table 1). School recess was defined as noncurricular time between lessons allocated by schools for the students to engage in leisure activities (Ridgers et al. 2006).

PA

The ActiGraph® Monitor (ActiGraph, GT1M® model, Pensacola, FL) was used to assess the PA level in free-living conditions. This device has been validated against oxygen consumption and heart rate to assess PA level (Vanhelst, Béghin, Turck, & Gottrand, 2010; Treuth et al., 2004). The interinstrument reliability of this device is high for both sedentary and vigorous activities (Vanhelst, Baquet, Gottrand, & Béghin, 2012; McClain, Sisson, & Tudor-Locke, 2007). A researcher of each center involved in fieldwork completed a workshop training about the instructions to give to participants. The adolescents were instructed to wear the accelerometer on the lower back with an elastic belt and adjustable buckle the most longtime possible during 7 consecutive days and they were also asked to follow their normal daily routine. In addition, the participants were instructed to remove the accelerometer during swimming, showering, and bathing, and at night. The epoch interval for the accelerometer was set at 1 min, and the output was expressed as mean counts per minute.

Data were uploaded from the monitor to a computer after the completed 7-day registration period. Participants who did not record at least 3 days (week day and weekend day) of recording with a minimum of 10 h of activity per day were excluded from the analyses (Masse et al., 2005; Ward, Evenson, Vaughn, Rodgers & Troiano, 2005). The assessment of time spent in sedentary activities, moderate PA, vigorous PA, and MVPA was based on the cutoff points of 0-400, 1901–3918 and >3918 counts/min, respectively we previously established in laboratory conditions (Vanhelst et al., 2010). MVPA was dichotomized into <60 min/day and ≥60 min/day, according to the current PA recommendations (Cale & Harris, 2001). The PA patterns were analyzed according to school days (Monday to Friday) and school-free days when adolescents did not have lessons (Sunday and Saturday and/or Wednesday for some adolescents who did not have lessons). For this study, only cumulative amounts of MVPA were considered.

Sedentary Behaviors

Sedentary behaviors were assessed using a structured questionnaire that included questions about the amount of time habitually spent in front of the television or a computer, or playing video games during school days and school-free days. The questionnaire used questions such as: “On weekdays, how many hours do you usually spend watching television?”, “On weekdays, how many hours do you usually spend on computers?”, and “On weekdays, how many hours do you usually spend playing video games?” The answers were classified into two categories: 0–2 h/day and >2 h/day (Strong et al., 2005; Dunstan et al., 2010). The questionnaire was administered in the classroom under the supervision of an HELENA fieldworker during the morning before the PA assessment. The complete duration of this test was 10 minutes. This measure has been shown to provide a reliable (intraclass correlation=0.82; 95% CI 0.75 to 0.87) and valid (criterion validity=0.3) (Strong et al., 2005; Dunstan et al., 2010). This questionnaire was used for studying the impact of school rhythm on sedentary behaviors.

*Statistical Analysis*

Data are presented as number (percentage) for qualitative variables and as mean (± standard deviation [SD]) or median (range) for quantitative variables. The normality of the distribution was checked graphically and using the Shapiro–Wilk test. Bivariate comparisons between the two school rhythm groups were made using the Student *t* test or Mann–Whitney *U* test for quantitative variables, chi-square test for nonordinal qualitative variables, and a Mantel–Haenszel trend test for ordinal qualitative variables. Comparisons for PA and sedentary outcomes between the two school rhythm groups were adjusted for prespecified confounding factors such as age, sex, BMI, pubertal status, and mother's and father's educational levels (Ridgers et al., 2012; De Moraes et al., 2013; Rey-Lopéz et al., 2011, Ortega, Ruiz, & Castillo, 2013). Adjustment of the prespecified confounding factors was made using analysis of covariance for quantitative outcomes (for total PA, MVPA, and sedentary PA) and logistic regression analysis for binary outcomes (for ≥60 min/day of MVPA during the week and sedentary behaviors). Odds ratios (ORs) with their 95% confidence intervals (95% CIs) for each binary outcome were calculated using the long rhythm group as the reference. All statistical tests were performed using a two-tailed $\alpha$ level of .05. The data were analyzed using SAS software version 9.4 (SAS Institute Inc., Cary, NC).

## Results

This study included 2024 adolescents (1008 boys and 1015 girls). The mean age, height and body weight were 14.6 ± 1.2 years, 165.7 ± 9.2 cm and 58.4 ± 12.4 kg, respectively. The median [range] time spent at school, in class and in recess were 6.10 [4.00; 9.55] hours per day, 5.40 [3.00; 8.15] hours per day and 60 [15; 150] min per day, respectively.

The short rhythm group comprised those students who finished school earlier in the afternoon (before 3:00 PM) and who had a shorter cumulative school recess and a shorter time spent at school during the week. The long rhythm group comprised those students who finished later in the afternoon (after 3:00 PM) and who had a longer time spent in the school environment and a longer cumulative school recess (Table 2). In average, students in the short rhythm group finished 2.20 hours earlier, had 50 min per day less time in recess and spent 9 hours per week less time in the school environment compared with those in the long rhythm group.

Among the 2024 adolescents with available data about their school schedules, 794 (39.2%) had a long school rhythm. The long rhythm group had a higher percentage of girls, older age, lower adiposity levels, and parental education level compared with the short rhythm group.

**PA**

The distribution of objective PA measurements throughout the week varied significantly between the two rhythm groups (Table 3) before and after adjustment for the prespecified confounding factors.

The short rhythm group had a lower number of counts during the week compared with the long rhythm group. Analysis of the number of counts according to the different daytime activities showed that this difference reflected differences in the number of teaching and recess hours: the short rhythm group had a higher number of counts during hours spent outside school (school-free days or during school days) compared with the long rhythm group.

The amount of MVPA also differed between the two groups, although the difference was not significant on school-free days (Table 3). After adjusting for prespecified confounding factors, students in the short rhythm group spent 9.1% less time in MVPA per week compared with those in the long rhythm group ($P < .0001$). The corresponding differences for MVPA during teaching and recess hours were 25.2% and 62.3%, respectively.

Students in the short rhythm group were less likely to meet the PA recommendation of ≥60 min/day of MVPA per week compared with students in the long rhythm group (30.7% vs. 34.1%; adjusted OR, 0.73; 95% CI, 0.58–0.92; $P = .008$).

Students in the short rhythm group spent more time in sedentary activities per week than did those in the long rhythm group (mean ± SD, 860 ± 52 vs. 848 ± 49 min/day; $P < .0001$). This difference was explained mainly by the hours spent outside school (565 ± 53 vs. 464 ± 53 min/day; $P < .0001$), whereas no such difference was found for other daytime activities. The short rhythm group spent significantly less sedentary time during teaching and recess compared with the long rhythm group. When expressing MVPA in percentage according to teaching and recess duration, we found that the percentage of MVPA of school attendance was higher in the long rhythm group both during recess and teaching hours compared to the short rhythm group. Similarly, the percentage of time spent in sedentary PA during the school attendance was higher in the long rhythm group compared to the short rhythm group (Table 3).

## Sedentary Behaviors

Sedentary behaviors during school days and school-free days differed between the two rhythm groups (Figure 2). During school days, a higher percentage of students in the short rhythm group watched television or played video games for >2 h/day compared with the long rhythm group. The time spent on a computer did not differ significantly between groups. After adjusting for the prespecified confounding factors, the ORs in the short rhythm group were 1.54 (95% CI, 1.22–1.94) for spending ≥2 h/day watching television and 2.08 (95% CI, 1.22–1.94) for spending ≥2 h/day playing video games.

During school-free days, a higher percentage of students in the short rhythm group also watched TV or played video games for >2 h/day compared with the long rhythm group. However, after adjusting for the prespecified confounding factors, only the difference in the percentage of students who played video games for >2 h/day remained significant (OR, 1.60; 95% CI, 1.15–2.24). By contrast, a lower percentage of students in the short rhythm group spent >2 h/day on a computer (65.3% vs. 73.1%; adjusted OR, 0.71; 95% CI, 0.56–0.89).

## Discussion

School rhythms correspond to alternating lessons and noncurricular periods including recess, break lunch and extracurricular activities. Although each country defined its own directives for organizing school time, many school rhythms vary among different schools of the same country as shown in our study (Figure 1). To our knowledge, this is the first study to assess whether the school rhythm is associated with PA patterns and sedentary behaviors in European adolescents from 7 countries. The main finding was that a long school rhythm was associated with higher PA levels, mainly during school recess, and less time spent in sedentary activities. Another important result is that adolescents who had a long school rhythm also had a higher PA level over the entire week and were more likely to meet the PA recommendations. These results show the importance of both the school recess and after-school time in promoting PA to adolescents.

In our study, students in the schools with the shorter rhythm spent half the time in recess during a school day compared with those in the schools with a long rhythm. In addition, we showed that the time spent in MVPA during recess was lower in the short rhythm group than the long rhythm group reinforcing the effect of recess duration on PA. In a recent systematic review, Ridgers et al. showed that recess in schools contributes strongly to fulfilling the daily recommended amount of MVPA for adolescents (Ridgers, Stratton, & Fairclough, 2006). Despite the identified decline in PA and the increase in sedentary time during recess, recess time contributes to about 20% of the recommended daily MVPA level when no interventions are used (Martinez-Gomez et al., 2014). Intervention studies of sedentary and active behaviors have shown positive effects of an intervention program during recess (Kriemler et al., 2011; Toftager et al., 2014). Our results indicate that providing recess time and encouraging PA in schools with a shorter school rhythm may increase MVPA. In addition to physical education classes, the school recess is one of the main opportunities for children and adolescents to be physically active in the school environment. As more MVPA was performed during teaching hours, we cannot excluded that long rhythm group had more physical education lessons compared to short rhythm group. This hypothesis could not be confirmed since we had no precise information regarding sport participation (out and at school) in our population.

Another outcome from our study is that adolescents in the short rhythm group who finished school earlier in the day were more likely to perform sedentary activities (watching TV, playing video games or computer). A possible explanation is that the highly condensed teaching hours (with short breaks between lessons) leads to tiredness at the end of the school day, which increases sedentary behaviors after school hours. This hypothesis remains to be tested in an appropriate intervention study. Previous studies showed that after-school programs contribute to increase the time spent in MVPA during school days (Lubans & Morgan, 2008; Weintraub et al., 2008; Kelder et al., 2005). Lubans & Morgan (2008) demonstrated that extra-curricular school sport program permits to increase of 34% the PA level at the end of program. In a meta-analysis, Beets et al. showed also that interventional after-school programs have a positive impact on different health outcomes (reduce sedentary behaviors and BMI, increase MVPA and physical fitness) (Beets et al., 2009). Our results are consistent with previous studies and suggest that the after-school setting holds considerable promise for increasing the PA levels of youth. (Lubans & Morgan, 2008; Weintraub et al., 2008; Kelder et al., 2005).

Our results also show that the school rhythm influences PA both on school days and over the entire week. Moreover, our finding shows that PA (both MVPA and sedentary) did not differ during school free days between the two groups, suggesting that the number of day in class (< or ≥ 5 days of school per week) did not influence the results we observed. This is inconsistent with the hypothesis of an “activity stat,” which says that increasing PA during school hours will not increase the overall PA level because of the actions of a biological PA regulator through which the body uses a range of biological responses to changes in PA to maintain a constant daily energy expenditure (Metcalf, Voss, Jeffery, Perkins, & Wilkin, 2004; Wilkin, 2011). Several studies have found no evidence for same-day or next-days in the amount of PA performed (Long et al., 2013; Goodman, Mckett, & Paskins, 2011, Baggett et al., 2010).

In our study, the difference in MVPA we found between the 2 groups 7% that rise the question of clinical significance of such quite low difference. There no clear answer to this important question (Wen et al., 2011; Hupin et al., 2015) although recent studies clearly show a progressive continuous positive effect of MVPA on mortality rate, suggesting that even small difference at a population could have a positive effect on global health indicators.

Our study has strengths and limitations. One strength is that it included a large sample size of adolescents and used a panel of standardized and harmonized tests to assess nutrition and PA level (i.e., accelerometry is a robust objective method for evaluating PA patterns) (Moreno et al., 2008). One limitation is the subjectivity of the assessment of the sedentary behaviors, which were evaluated and reported by the adolescents themselves. Another limitation is the cross-sectional design of the study, which rules out the ability to draw causal conclusions. In that, setting the two groups differed by several characteristics. However, we were able to control for several confounding factors (age, sex, BMI, pubertal status, and mother's and father's educational levels) in the statistical analysis. Nevertheless, since the number of physical education lessons and after-school activities were not available, we could not introduced them in the statistical analysis although they could have an influence on our results. Regarding the multiple comparisons issues, we could not also exclude false significant association and the present results should be interpreted with caution. The study is also limited by the use of only a single week of measurement of PA and school schedules. However, in European countries, the school schedule is the same throughout the school year. Variations in weather (wind, rain and sunshine) during the PA assessment were not recorded in our study and might also have affected our results. Finally, since short and long rhythm group differs also by center/country, we cannot exclude the effect of different schools culture of spending the recess.

## Conclusions

Our results suggest that school time provides a good opportunity for adolescents to be physically active. Sedentary behavior was observed mainly during school-free periods, which suggests that after-school programs may be complementary and beneficial for promoting PA. The data obtained from this study contribute to a better understanding of the PA patterns in adolescents and may help caregivers and health and school authorities adapt school rhythms for the promotion of PA.

## Conflict of interest

The authors do not have any competing interests.

## Funding

The HELENA study is made possible by the financial support of the European Community Sixth RTD Framework Programme (Contract FOOD-CT-20056007034) and the Spanish Ministry of Science and Innovation (RYC-2010-05957 and RYC-2011-09011). The content of this paper reflects only the authors' views, and the European Community is not liable for any use that may be made of the information contained therein.

## REFERENCES

Baggett, C.D., Stevens, J., Catellier, D.J., Evenson, K.R., McMurray, R.G, He, K., & Treuth M.S. (2010). Compensation or displacement of physical activity in middle-school girls: the Trial of Activity for Adolescent Girls. International Journal of Obesity, 34, 1193-9.

Beets, M.W., Beighle, A., Erwin, H.E., & Huberty, J.L. (2009). After-school program impact on physical activity and fitness: a meta-analysis. American Journal of Preventive Medicine, 36, 527-37.

Beets, M.W., Vogel, R., Forlaw, L., Pitetti, K.H, & Cardinal, B.J. (2006). Social support and youth physical activity: the role of provider and type. American Journal of Health Behavior, 30, 278–89.

Béghin, L., Castera, M., Manios, Y., Gilbert, C.C., Kersting, M., De Henauw, S., Kafatos, A., Gottrand, F., Molnar, D., Sjöström, M., Leclercq, C., Widhalm, K., Mesana, M.I., Moreno, L.A., & Libersa, C. (2008). Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the HELENA Cross-Sectional Study. International Journal of Obesity, 32, S12-S12.

Béghin, L., Huybrechts, I., Vicente-Rodríguez, G., De Henauw, S., Gottrand, F., Gonzales-Gross, M., Dallongeville, J., Sjöström, M., Leclercq, C., Dietrich, S., Castillo, M., Plada, M., Molnar, D., Kersting, M., Gilbert, C.C., & Moreno, L.A. (2012). Main characteristics and participation rate of European adolescents included in the HELENA study. *Archives of Public Health* 2012; 70: 14

Cale, L., & Harris, J. (2001). Exercise recommendations for young people: An update. Health Education Journal, 101, 126–138.

Cole, T.J., Bellizzi, M.C., Flegal, K.M., & Dietz W.H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. British Medical Journal, 320, 1240-3.

de Moraes, A.C., Carvalho, H.B., Rey-López, J.P., Gracia-Marco, L., Beghin, L., Kafatos, A., Jiménez-Pavón, D., Molnar, D., De Henauw, S., Manios, Y., Widhalm, K., Ruiz, J.R., Ortega, F.B., Sjöström, M., Polito, A., Pedrero-Chamizo, R., Marcos, A., Gottrand, F., & Moreno, L.A. (2013). Independent and combined effects of physical activity and sedentary behavior on blood pressure in adolescents: gender differences in two cross-sectional studies. PLoS One, 8, e62006.

Dobbins, M., Husson, H., DeCorby, K., & LaRocca, R.L. (2013). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. The Cochrane Database of Systematic Reviews, 28, CD007651.

Dunstan, D.W., Barr, E.L., Healy, G.N., Salmon, J., Shaw, J.E., Balkau, B., Magliano, D.J., Cameron, A.J., Zimmet, P.Z., & Owen, N. (2010). Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Circulation, 121, 384–91.

Goodman, A., Mackett, R.L., & Paskins, J. (2011). Activity compensation and activity synergy in British 8-13 year olds. Preventive Medicine, 53, 293-8.

Gracia-Marco, L., Ortega, F.B., Ruiz, J.R., Williams, C.A., Hagströmer, M., Manios, Y., Kafatos, A., Béghin, L., Polito, A., De Henauw, S., Valtueña, J., Widhalm, K., Molnar, D., Alexy, U., Moreno, L.A., & Sjöström, M. (2013). Seasonal variation in physical activity and sedentary time in different European regions. The HELENA study. Journal of Sports Science, 31, 1831-40.

Hupin, D., Roche, F., Gremeaux, V., Chatard, J.C., Oriol, M., Gaspoz, J.M., Barthélémy, J.C., & Edouard, P. (2015). Even a low-dose of moderate-to-vigorous physical activity reduces mortality by 22% in adults aged ≥60 years: a systematic review and meta-analysis. British Journal of Sports Medicine, 49, 1262-7.

Kelder, S., Hoelscher, D.M., Barroso, C.S., Walker, J.L., Cribb, P., & Hu, S. (2005). The CATCH Kids Club: a pilot after-school study for improving elementary students' nutrition and physical activity. Public Health Nutrition, 8, 133– 40.

Kriemler, S., Meyer, U., Martin, E., van Sluijs, E.M., Andersen, L.B., & Martin, B.W. (2011). Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. British Journal of Sports Medicine, 45, 923–930.

Long, M.W., Sobol, A.M., Cradock, A.L., Subramanian, S.V., Blendon, R.J., & Gortmaker, S.L. (2013). School-day and overall physical activity among youth. American Journal of Preventive Medicine, 45, 150-7.

Lubans, D., & Morgan, P. (2008). Evaluation of an extra-curricular school sport programme promoting lifestyle and lifetime activity for adolescents. Journal of Sports Science, 26, 519 –29.

Martinez-Gomez, D., Veiga, O.L., Zapatera, B., Gomez-Martinez, S., Martínez, D., & Marcos, A. (2014). Physical Activity During High School Recess in Spanish Adolescents: The AFINOS Study. Journal of Physical Activity & Health, 11, 1194-01.

Mâsse, L.C., Fuemmeler, B.F., Anderson, C.B., Matthews, C.E., Trost, S.G., Catellier, D.J., & Treuth, M. (2005) Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. Medicine & Science in Sports & Exercice, 37, S544-54.

McClain, J.J., Sisson, S.B., & Tudor-Locke, C. (2007). Actigraph accelerometer interinstrument reliability during free-living in adults. Medicine & Science in Sports & Exercice, 39, 1509-14.

Metcalf, B., Voss, L., Jeffery, A., Perkins, J., & Wilkin, T. (2004). Physical activity cost of the school run: impact on schoolchildren of being driven to school (EarlyBird 22). British Medical Journal, 329, 832-3.

Moreno, L.A., De Henauw, S., González-Gross, M., Kersting, M., Molnár, D., Gottrand, F., Barrios, L., Sjöström, M., Manios, Y., Gilbert, C.C., Leclercq, C., Widhalm, K., Kafatos, A., & Marcos, A. (2008). Design and implementation of the

Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study. International Journal of Obesity, 32, S4-11.

Nagy, E., Vicente-Rodriguez, G., Manios, Y., Béghin, L., Iliescu, C., Censi, L., Dietrich, S., Ortega, F.B., De Vriendt, T., Plada, M., Moreno, L.A., & Molnar, D. (2008). Harmonization process and reliability assessment of anthropometric measurements in a multicenter study in adolescents. International Journal of Obesity, 32, S58-65.

Nettlefold, L., McKay, H.A., Warburton, D.E., McGuire, K.A., Bredin, S.S., & Naylor, P.J. (2011). The challenge of low physical activity during the school day: at recess, lunch and in physical education. British Journal of Sports Medicine, 45, 813-9.

Ortega, F.B., Konstabel, K., Pasquali, E., Ruiz, J.R., Hurtig-Wennlöf, A., Mäestu, J., Löf, M., Harro, J., Bellocco, R., Labayen, I., Veidebaum, T., & Sjöström, M. (2013). Objectively measured physical activity and sedentary time during childhood, adolescence and young adulthood: a cohort study. PLoS One, 8: e60871.

Ortega, F.B., Ruiz, J.R., & Castillo, M.J. (2013). Physical activity, physical fitness, and overweight in children and adolescents: evidence from epidemiologic studies. Endocrinology & Nutrition, 60, 458-69.

Rey-López, J.P., Tomas, C., Vicente-Rodriguez, G., Gracia-Marco, L., Jiménez-Pavón, D., Pérez-Llamas, F., Redondo, C., Bourdeaudhuij, I.D., Sjöström, M., Marcos, A., Chillón, P., & Moreno, L.A. (2011). Sedentary behaviours and socioeconomic status in Spanish adolescents: the AVENA study. European Journal of Public Health, 21, 151–7.

Riddoch, C.J., Bo Andersen, L., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L.B., Cooper, A.R., & Ekelund, U. (2004). Physical activity levels and patterns of 9- and 15-yr-old European children. Medicine Science in Sports & Exercise, 36, 86–92.

Ridgers, N.D., Salmon, J., Parrish, A.M., Stanley, R.M., & Okely, A.D. (2012). Physical activity during school recess: a systematic review. American Journal of Preventive Medicine, 43, 320-8.

Ridgers, N.D., Stratton, G., & Fairclough, S.J. (2006). Physical activity levels of children during school playtime. Sports Medicine, 36, 359-71.

Ruiz, J.R., Ortega, F.B., Martínez-Gómez, D., Labayen, I., Moreno, L.A., De Bourdeaudhuij, I., Manios, Y., Gonzalez-Gross, M., Mauro, B., Molnar, D., Widhalm, K., Marcos, A., Beghin, L., Castillo, M.J., & Sjöström M. (2011). Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. American Journal of Epidemiology, 174, 173-84.

Saksvig, B.I., Catellier, D.J., Pfeiffer, K., Schmitz, K.H., Conway, T., Going, S., Ward, D., Strikmiller, P., & Treuth, M.S. (2007). Travel by walking before and after school and physical activity among adolescent girls. Archives of Pediatrics & Adolescence Medicine, 161, 153-8.

Saksvig, B.I., Webber, L.S., Elder, J.P., Ward, D., Evenson, K.R., Dowda, M., Chae, S.E., & Treuth, M.S. (2012). A cross-sectional and longitudinal study of travel by walking before and after school among eighth-grade girls. The Journal of Adolescent Health, 51, 608-14.

Salvy, S.J., Bowker, J.W., Roemmich, J.N., Romero, N., Kieffer, E., Paluch, R., & Epstein, L.H. (2008). Peer influence on children's physical activity: an experience sampling study. Journal of Pediatric Psychology, 33, 39–49.

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. The Journal of Pediatrics, 146, 732–37.

Tanner, J.M., & Whitehouse, R.H. (1976). Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. Archives of Diseases Childhood, 51, 170-9.

Toftager, M., Christiansen, L.B., Ersbøll, A.K., Kristensen, P.L., Due, P., & Troelsen, J. (2014). Intervention effects on adolescent physical activity in the multicomponent SPACE study: a cluster randomized controlled trial. *PLoS One*, 9, e99369.

Treuth, M.S., Schmitz, K., Catellier, D.J., McMurray, R.G., Murray, D.M., Almeida, M.J., Going, S., Norman, J.E., & Pate, R. (2004). Defining accelerometer thresholds for activity intensities in adolescent girls. Medicine & Science in Sports & Exercice, 36, 1259-66.

Valery, P.C., Ibiebele, T., Harris, M., Green, A.C., Cotterill, A., Moloney, A., Sinha, A.K., & Garvey G. (2012). Diet, physical activity, and obesity in school-aged indigenous youths in Northern Australia. Journal of Obesity, 893508.

Vanhelst, J., Baquet, G., Gottrand, F., & Béghin, L. (2012). Comparative interinstrument reliability of uniaxial and triaxial accelerometers in free-living conditions. Perceptual Motors Skills, 114, 584-94.

Vanhelst, J., Béghin, L., Salleron, J., Ruiz, J.R., Ortega, F.B., De Bourdeaudhuij, I., Molnar, D., Manios, Y., Widhalm, K., Vicente-Rodriguez, G., Mauro, B., Moreno, L.A., Sjöström, M., Castillo, M.J., & Gottrand, F. (2013). A favorable built environment is associated with better physical fitness in European adolescents. Preventive Medicine, 57, 844-9.

Vanhelst, J., Béghin, L., Turck, D., & Gottrand, F. (2010). New validated thresholds for various intensities of physical activity in adolescents using the Actigraph accelerometer. International Journal of Rehabilitation Research, 34, 175-7.

Ward, D.S., Evenson, K.R., Vaughn, A., Rodgers, A.B., & Troiano, R.P. (2005). Accelerometer use in physical activity: best practices and research recommendations. Medicine & Sciences in Sports & Exercise, 37, S582-S588.

Weintraub, D.L., Tirumalai, E.C., Haydel, K.F., Fujimoto, M., Fulton, J.E., & Robinson, T.N. (2008). Team sports for overweight children: the Stanford Sports to Prevent Obesity Randomized Trial (SPORT). Archives of Pediatric Adolescence & Medicine,162, 232–7.

Wen, C.P., Wai, J.P., Tsai, M.K., Yang, Y.C., Cheng, T.Y., Lee, M.C., Chan, H.T., Tsao, C.K., Tsai, S.P., & Wu, X. (2011). Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet, 378, 1244-53.

WHO. Global health risks: mortality and burden of disease attributable to selected major risks. Genève, Organisation mondiale de la Santé, 2009.

WHO. Global recommendations on physical activity for health. 2010. ISBN : 9789241599979

Wilkin TJ. (2011). Can we modulate physical activity in children? No. *International Journal of Obesity*, 35, 1270-6.

**Legends**

**Table 1.** Characteristics of school diaries for the two school rhythm groups

**Table 2.** Adolescent’s characteristic according to school rhythm group

**Table 3.** Impact of school rhythm on physical activity levels throughout the week

**Figure 1.** Description of school diaries for each class studied

**Figure 2.** Impact of school rhythm on sedentary behavior throughout the week

**Table 1.** Characteristics of school diaries for the two school rhythm groups

| | **Short rhythm group (N school=60)** | **Long rhythm group (N school=44)** | **P** |
|---|---|---|---|
| Start school (*h*, *AM*) | 8.15 [7.15; 8.30] | 8.15 [7.15; 8.30] | - |
| Finish school (*h*, *PM*) | 14.00 [12.00; 15.00] | 16.20 [15.20; 17.40] | - |
| Recess duration (*min/day*) | 40 [15; 105] | 90 [60; 150] | **<0.0001** |
| Time spent at school per day (*h*) | 5.50 [4.00; 7.10] | 7.58 [6.55; 9.55] | **<0.0001** |
| Time spent at school per week (*h*) | 25.25 [20.00; 35.50] | 34.00 [27.40; 49.35] | **<0.0001** |
| Hours of teaching per day (*h*) | 5.15 [3.00; 6.00] | 6.25 [5.45; 8.15] | **<0.0001** |
| Hours of teaching per week (*h*) | 22.00 [15.00; 30.00] | 26.30 [23.00; 41.15] | **<0.0001** |
| Number of classes with < 5 days of school per week, n (%) | 19 (31.7) | 36 (81.8) | **<0.0001** |

Data are median [range] unless indicated.

**Table 2.** Adolescent's characteristic according to school rhythm group

| | **Short rhythm group** | **Long rhythm group** | **P*** |
|---|---|---|---|
| N | 1230 | 794 | |
| Gender (%*M*) | 52.3 | 46.0 | **0.0067** |
| Age (*yr*) | 14.5 ± 1.2 | 14.7 ± 1.2 | **0.0017** |
| Height (*cm*) | 165.3 ± 9.2 | 166.3 ± 9.1 | **0.0229** |
| Body mass (*kg)* | 59.1 ± 12.8 | 57.4 ± 11.6 | **0.0019** |
| BMI ($kg.m^{-2}$) | 21.5 ± 3.8 | 20.6 ± 3.3 | **<0.0001** |
| Weight status (*%UW/%NW/%OW/%O*)[a] | 6.1/67.3/20.2/6.4 | 7.4/77.6/11.7/3.3 | **<0.0001** |
| Pubertal status (*%I/%II/%III/%IV*)[b] | 7.4/24.6/33.9/34.1 | 5.2/18.0/34.5/42.3 | **<0.0001** |
| Father education level (*%I/%II/%III*)[c] | 40.8/30.5/28.7 | 22.8/26.5/50.7 | **<0.0001** |
| Mother education level (*%I/%II/%III*)[c] | 38.1/33.7/28.2 | 25.1/27.2/47.7 | **<0.0001** |

[*] Student *t* test for quantitative variables, Chi-Square test for non-ordinal qualitative variables and a Mantel-Haenszel test for ordinal qualitative variables

[a] Weight status: underweight (UW), normal weight (NW), overweight (OW), obese (O)

[b] Pubertal status staging according to Tanner

[c] PEL: lower education (I); higher secondary education (II); higher education or university degree (III).

**Table 3.** Impact of school rhythm on physical activity levels throughout the week

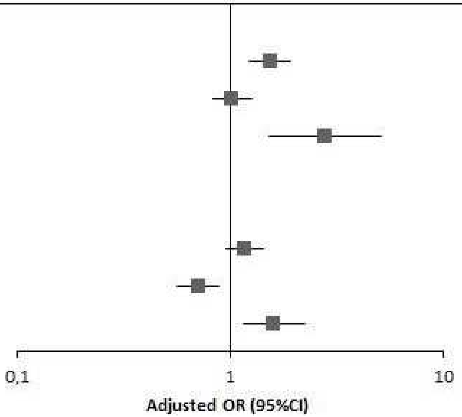
| | Short rhythm group (N=1230) | Long rhythm group (N=794) | P */† |
|---|---|---|---|
| **Total PA** (*counts*) | | | |
| During a week | 1 728 205 ± 920 415 | 1 874 724 ± 819 375 | **0.0002 / <0.0001** |
| During school-free days | 545 849 ± 371 873 | 492 320 ± 325 763 | **0.0020 / 0.0130** |
| During school days | | | |
| *Before-after school* | 854 500 ± 501 119 | 774 793 ± 462 219 | **0.0003 / 0.0480** |
| *During teaching hours* | 344 465 ± 207 842 | 486 106 ± 266 467 | **<0.0001 / <0.0001** |
| *During recess* | 92 083 ± 82 078 | 212 023 ± 142 149 | **<0.0001 / <0.0001** |
| **MVPA** (*min.day*$^{-1}$) | | | |
| During a week | 50.8 ± 25.9 | 54.3 ± 26.0 | **0.0027 / <0.0001** |
| During school-free days | 42.0 ± 34.3 | 39.3 ± 31.5 | 0.10 / 0.18 |
| During school days | 54.2 ± 26.9 | 58.5 ± 27.2 | **<0.0004 / <0.0001** |
| *Before-after school* | 35.8 ± 22.2 (65%) | 29.9 ± 20.6 (49%) | **<0.0001 / <0.0001** |
| *During teaching hours* | 14.5 ± 9.8 (28%) | 19.1 ± 12.0 (34%) | **<0.0001 / <0.0001** |
| *During recess* | 3.9 ± 4.0 (7%) | 9.8 ± 7.9 (17%) | **<0.0001 / <0.0001** |
| **Sedentary activities** (*min.day*$^{-1}$) | | | |
| During a week | 860.3 ± 51.7 | 847.9 ± 49.2 | **<0.0001 / <0.0001** |
| During school-free days | 868.9 ± 67.9 | 867.6 ± 65.5 | 0.69 / 0.051 |
| During school days | 855.3 ± 53.4 | 841.4 ± 50.9 | **<0.0001 / <0.0001** |
| *Before-after school* | 565.1 ± 52.6 (66%) | 463.6 ± 53.3 (55%) | **<0.0001 / <0.0001** |
| *During teaching hours* | 253.8 ± 38.4 (30%) | 316.1 ± 46.6 (38%) | **<0.0001 / <0.0001** |
| *During recess* | 36.4 ± 16.9 (4%) | 63.0 ± 21.7 (7%) | **<0.0001 / <0.0001** |

* Unadjusted P-values / † Adjusted P-values controlled by sex, age, BMI, pubertal status and parental educational levels.


Lessons
Recess
Country
Class
8AM
9AM
10AM
11AM
12PM
1PM
2PM
3PM
4PM
5PM
6PM
LONG SCHOOL RHYTHM
France
Class 1
Class 2
Class 3
Class 4 to 6
Class 7
Class 8
Class 9
Class 10 to 12
Belgium
Class 1 and 2
Class 3 and 4
Class 5 and 7
Class 8 and 9
Class 10 and 11
Class 12 and 13
Class 14 and 15
Class 16 and 17
Class 18 and 19
Class 20 to 22
Spain
Class 13 to 16
Italy
Class 1 and 2
Germany
Class 6
Class 7 and 8
Class 16 and 17
Class 18 and 19
Class 20 and 21
Spain
Class 13 to 16
Hungary
Class 1
Class 2
SHORT SCHOOL RHYTHM
Greece
Class 1 to 11
Spain
Class 1 and 2
Class 3 and 4
Class 5 and 6
Class 7 and 8
Class 9 and 10
Class 11 and 12
Class 17 and 18
Class 19
Class 20 and 21
Class 22
Class 23
Italy
Class 3
Class 4 and 5
Class 6 to 8
Class 9
Class 10 and 11
Class 12 and 13
Class 14 to 16
Class 17 to 19
Class 20 and 21
Germany
Class 1 and 2
Class 3 to 5
Class 9 and 10
Class 11 and 12
Class 12
Class 13 to 15
Hungary
Class 3
Class 4
Class 5
Class 6
Class 7

**Figure 2.** Impact of school rhythm on sedentary behavior throughout the week

| | Short rhythm group (N=1230) | Long rhythm group (N=794) | Unadjusted OR (95%CI) | P | Adjusted OR (95%CI)* | P* |
|---|---|---|---|---|---|---|
| *During school days* | | | | | | |
| TV (% ≥2 h.day$^{-1}$) | 403 (36.3) | 189 (25.3) | 1.68 (1.37-2.00) | **<0.0001** | 1.54 (1.22-1.94) | **0.0002** |
| PC (% ≥2 h.day$^{-1}$) | 557 (51.3) | 355 (48.2) | 1.13 (0.94-1.37) | 0.19 | 1.02 (0.83-1.26) | 0.85 |
| Video games (% ≥2 h.day$^{-1}$) | 70 (6.4) | 22 (3.0) | 2.24 (1.37-3.64) | **0.001** | 2.80 (1.53-5.14) | **0.0009** |
| *During school-free days* | | | | | | |
| TV (% ≥2 h.day$^{-1}$) | 698 (63.6) | 424 (57.0) | 1.32 (1.09-1.60) | **0.004** | 1.17 (0.95-1.44) | 0.15 |
| PC (% ≥2 h.day$^{-1}$) | 699 (65.3) | 530 (73.1) | 0.69 (0.56-0.85) | **0.0005** | 0.71 (0.56-0.89) | **0.003** |
| Video games (% ≥2 h.day$^{-1}$) | 173 (15.8) | 73 (9.9) | 1.71 (1.28-2.29) | **0.0003** | 1.60 (1.15-2.24) | **0.006** |




Odds-ratio (OR) of each sedentary outcomes was calculated for short rhythm group using long rhythm group as reference.
* Adjusted for sex, age, BMI, pubertal status and parental educational levels.