School time is associated with cardiorespiratory fitness in adolescents: The HELENA study.

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ABSTRACT

We assessed the association between school time and physical fitness in adolescents. The study included 2,024 adolescents, aged 12.5–17.5 years, who participated in the Healthy Lifestyle in Europe by Nutrition in Adolescence study. Health-related physical fitness components were assessed using the physical fitness tests battery. Cardiovascular risk was categorized using the sex-specific cutoffs for a healthy cardiorespiratory fitness level in adolescents proposed by FitnessGram®. School time was classified as short or long. Multivariate analysis accounted for confounding factors such age, sex, body mass index, time spent in moderate to vigorous physical activity, pubertal status, and parents' educational level. Cardiorespiratory fitness was higher in adolescents with a long school time than in those with a short school time (42.0 ± 7.6 vs 40.7 ± 7.2 $mL.kg^{-1}.min^{-1}$, respectively; $p < 0.05$). The percentage of adolescents at cardiovascular risk in adulthood was higher in the short than in the long time group (45.2% vs 31.7%, respectively) ($p < 0.05$). These findings suggest that a long school day is associated with higher cardiorespiratory fitness in adolescents and that school time should be considered in interventions and health promotion strategies.

Introduction

Cardiovascular diseases in adulthood have their genesis in childhood, even if the clinical symptoms may not become apparent until later in life. Physical fitness plays an important role in adolescent cardiometabolic health (Högström, Nordström, & Nordström, 2016; Ortega, Ruiz, Castillo, & Sjöström, M, 2008). Health-related physical fitness includes muscular strength and endurance, flexibility, speed/agility, and cardiorespiratory fitness (Caspersen, Powell, & Christenson, 1985; Ortega et al., 2008). Two prospective cohort studies of Swedish male adolescents showed that low cardiorespiratory fitness and muscular strength were strongly associated with risk factors for major causes of death in young adulthood (more widely for cardiovascular diseases) and were equivalent to other risk factors such as elevated body mass index (BMI) or blood pressure (Högström et al., 2016; Ortega et al., 2012). In addition, good physical fitness is associated with numerous health benefits in adolescents, such as a healthier body composition and fewer cardiovascular disease risk factors (García-Hermoso, Ramírez-Campillo, & Izquierdo, 2019; Ortega et al., 2008; Smith et al., 2014). However, physical fitness levels during childhood and adolescence have decreased markedly in the four past decades, especially for cardiorespiratory fitness, which is recognized as the main physiological marker of cardiovascular health (Fühner, Kliegl, Arntz, Kriemler, & Granacher, 2020; Tomkinson et al., 2017). Identifying the factors that influence physical fitness has become an important research issue in the field of public health, and attention has focused on effective methods for improving the physical fitness levels of children and adolescents.

School-aged children spend a significant proportion of their waking hours either in transit to and from or in the school setting. However, school time may vary widely between several European countries, and this difference may affect physical fitness in European adolescents. School time was defined as a specific organization of time spend in the school environment. Several parameters have to be taken into account in a school rhythm such as beginning and finishing hours of the class, number and duration of recesses, the time for the lunch break, number of school days per week and total time spent at school. Each European country has his proper policies concerning the school times leading to differences throughout these parameters mentioned above (especially on finishing hours of the class and by consequent time spent in the school environment, daily time spent in recess and time for the lunch break). In short school time, adolescents finished earlier (before 3:00 PM) have less time in recess and lunch break (in average 50 min per day less time). In addition, adolescents spent 9 h per week less time in the school environment compared with those in the long time group (Vanhelst et al., 2017). We hypothesized that these differences of policies may have an impact on lifestyle behaviors of adolescents and consequently on their physical fitness. We therefore hypothesized that adolescents having a long school time had a lower physical fitness compared to those more physically active in short school time. Therefore, the aim of this study was to assess the associations between school time and physical fitness in a large sample of European adolescents.

Materials and Methods

Study design

The present study was performed under the framework of 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. The HELENA study was performed from 2006 to 2008 in 10 European cities. Details of the recruitment, sampling, standardization, and harmonization processes were published elsewhere (Béghin et al., 2012; Moreno 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.

From the total population of 3,528 adolescents, a subsample of 2,024 (57.4%) was included in the present analysis because the database had complete and valid data about their school schedules.

Measurements

Physical fitness

The health-related physical fitness components were assessed using a battery of physical fitness tests, which assessed cardiorespiratory fitness, muscular strength (upper and lower limbs), flexibility, and speed/agility (Ortega et al., 2011). All tests were performed twice, and the best score was recorded, except for the cardiorespiratory fitness and the bent arm hang tests, which were performed only once each. Good reliability in young people has been reported for all tests used in the study (Ortega et al., 2008).

Cardiorespiratory fitness was assessed with a 20-m shuttle run test (Leger, Mercier, Gadoury, & Lambert, 1988). Participants were required to run between two lines 20 m apart while keeping pace with audio signals. The initial speed of 8.5 km/h, was increased by 0.5 km/h for each stage, which lasted 1 min. The participants were instructed to run in a straight line, to pivot on completing each shuttle run, and to pace themselves in accordance with the audio signals. The test was finished when the participant failed to reach the end lines concurrent with the audio signals on two consecutive occasions or stopped because of fatigue. Participants were encouraged to keep running throughout the test. The last completed stage or half-stage was recorded and used to estimate VO_{2max} (Leger et al., 1988).

Muscular strength of the lower limbs was assessed using the standing broad jump test. From a starting position immediately behind a line and standing with the feet approximately shoulder-width apart, the adolescents were instructed to jump as far as possible with the feet together. The hand grip test was used to assess upper limb muscular strength. The digital Takei TKK 5101 dynamometer (range, 5–100 kg) was used to measure the maximum grip strength for both hands.

Flexibility was assessed by the back-saver sit-and-reach test. A standard box with a small bar, which the participant must push, was used to perform the test. The adolescents were instructed to bend the trunk and reach forward as far as possible from a seated position. In the first test, one leg was straight and the other bent at the knee, and the test was then performed a second time with the opposite leg pattern. The farthest position of the bar reached for each leg was scored in centimeters, and the average of the distances reached by both legs was used in the analysis.

Speed/agility was assessed using the 4 × 10-m shuttle run test. The participant performed four shuttle runs as fast as possible between two lines spaced 10 m apart. Every time the participants crossed a line, they were instructed to pick up (the first time) or exchange (second and third times) a sponge that had earlier been placed behind the lines. The time taken to complete the test was recorded to the nearest tenth of a second.

School time

A detailed description of school time definitions has been published elsewhere (Vanhelst et al., 2017). Briefly, school time was divided into two groups (short school time and long school time) using the information contained in the school schedule. A short school rhythm was defined as finishing school at 3:00 p.m. or earlier and with shorter recess(es) during the school day. A long school time was defined as finishing school after 3:00 p.m. with long recess(es) during the day. The characteristics of school diaries for these two categories are shown in Table 1.

Participants' characteristics

Each participant underwent a detailed medical examination. Pubertal status was assessed by direct observation according to method of Tanner and Whitehouse (Tanner & Whitehouse, 1976). Body weight was measured to the nearest 0.1 kg using an electronic scale (SECA 871; SECA, Hamburg, Germany) with the participant wearing shorts and a T-shirt without shoes. Height was measured without shoes to the nearest 0.1 cm using a standard physician's scale (SECA 225; SECA, Hamburg, Germany). BMI was calculated as weight/height squared (kg/m^2). Weight status was classified according to the International Obesity Task Force cutoff (Cole & Lobstein, 2012).

Parental educational level (PEL) 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). PEL was scored as 1, primary and lower education (levels 0, 1, and 2 in the ISCED classification); 2, higher secondary (levels 3 and 4 in the ISCED classification); and 3, tertiary (levels 5 and 6 in the ISCED classification).

Physical activity

PA patterns were assessed using a uniaxial accelerometer (ActiGraph® MTI GT1M model, Pensacola, FL, USA). Participants were instructed to attach the accelerometer device on their lower back with an elastic band and adjustable buckle, and to wear it for 1 week (7 consecutive days). They were also asked to follow their normal daily routine and to remove the device only during water-based activities (such as swimming, showering, and bathing) and at night. The sampling interval (epoch) was set at 15 seconds and the output was expressed as counts per min. The GT1M sampling frequency was set to 30 Hertz, and the monitor measures 0.05-2.5 *g* in dynamic range in the vertical axis. Adolescents who did not record at least 3 days (including at least one weekend day) of recording with a minimum of 10 h of activity per day were excluded from the analyses (Mâsse et al., 2005; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). We excluded from the analysis bouts of 20 continuous minutes of activity with intensity counts of 0, considering these periods to be nonwearing time. The times engaged in sedentary, light, moderate, vigorous, and moderate to vigorous PA (MVPA) throughout the day were calculated using previously validated thresholds (Vanhelst et al., 2011).

Statistical analysis

The data are presented as percentage for qualitative variables and mean ± standard deviation (SD) for quantitative variables. Normality of distribution was checked graphically and by using the Shapiro–Wilk test. To assess the potential bias related to missing or incomplete data on the school schedules, the main characteristics of included and excluded adolescents were compared using Student's *t* test for quantitative variables, the chi-squared test for categorical variables, and the

Cochran–Armitage trend test for ordered categorical variables. To evaluate the magnitude of differences between the included and not included participants, we calculated the absolute standardized differences; a standardized difference >20% denotes a meaningful imbalance. To assess the potential bias related to missing or incomplete data for physical fitness, the main adolescent characteristics were compared between adolescents with and without physical fitness data using Student's *t* test for quantitative variables, the chi-squared test for categorical variables, and the Mantel–Haenszel trend test for ordered categorical variables.

Associations between physical fitness with school time were identified using analysis of covariance models adjusted for prespecified confounding factors, including age, sex, BMI, pubertal status, total time in MVPA during the week, and PEL. To avoid case deletion in the analyses, missing data were imputed by multiple imputations using the regression-switching approach (chained equations with m = 10) (Buren & Groothuis-Oudshoom, 2011). The imputation procedure was performed under the missing-at-random assumption using all adolescents' characteristics, school rhythm and physical fitness using the predictive mean-matching method for quantitative variables, logistic regression model for binary variables, and ordinal logistic regression for ordered categorical variables. Rubin's rules were used to combine the estimates derived from multiple imputed data sets (Rubin, 1990). All statistical tests were performed at the two-tailed α level of 0.05. Data were analyzed using SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA).

Results

The physical characteristics of the adolescents are presented in Table 2. We found some differences between the included and not included adolescents but no meaningful differences regarding the absolute standardized differences expected for age and pubertal status (see supplemental table).

Table 3 shows the physical fitness levels according to school time group before and after adjustment for the prespecified confounding factors. Cardiorespiratory fitness was higher in the long school time group than in the short school time group in both model 1 and 2. The other components of physical fitness, including flexibility, upper and lower muscular strength, and speed/agility, did not differ between groups (Table 3).

Discussion

To our knowledge, this study is the first to assess whether school time is associated with physical fitness in European countries. The main finding from our study is that a long school time was associated with better cardiorespiratory fitness.

Our main finding showing that school time is associated with cardiorespiratory fitness independently of the time spent in MVPA suggests that other factors, such as sedentary behavior or sleep parameters, might explain the low physical fitness level in adolescents with a short school time (Baiden, Tadeo, & Peters, 2019; Chang & Chen, 2015; Santos et al., 2014). Since we did not assessed these parameters in the present study, we cannot speculate more about their roles in explaining a better cardiorespiratory fitness in the adolescents spending less time at school and should deserve further studies.

Our results suggest that the development of prevention strategies for improving cardiorespiratory fitness should consider the school environment. A meta-analysis has shown that interventional after-school programs have a positive impact on various health outcomes, such as reduced sedentary behaviors and BMI, and increased MVPA and physical fitness (Beets, Beighle, Erwin, & Huberty, 2009). In the shorter school rhythm, in which adolescents finish earlier, after-school programs should be devoted to promoting healthy habits, including decreasing sedentary behaviors. The results from our study suggest that a longer school time and its environment can provide a good opportunity for reducing the time spent in sedentary activities, which may help to lower fat mass and improve fitness and cardiovascular health. In addition, considering MVPA as a potential factor of cardiorespiratory fitness (Armstrong, Tomkinson, & Ekelund, 2011) and since that we previously shown that time spent in MVPA increased in long school time (Vanhelst et al., 2017), long school hours and their environment could be also an opportunity to increase MVPA. We suggest that European countries with school policies with short school time and recesses, and less time in teaching per day should focus their policies on reducing sedentary behaviors during school free time and promoting PA and healthy habits.

When comparing the results of our present study showing an increase of 1.3 $mL.kg.min^{-1}$ of cardiorespiratory fitness to the modest of MVPA (3.5 $min.day^{-1}$) and sedentary behaviors (12.4 $min.day^{-1}$) we found in our previous study (Vanhelst et al., 2017), we are questioned on the type of PA the adolescents performed during school time. Although our study was not designed to answer this question, it has been shown that the type of PA impact differently cardiorespiratory fitness (Ratel et al., 2004). Future interventional study should take this point into account and choose specific PA which impact cardiorespiratory fitness.

The current study has both strengths and limitations. The strengths are the large sample size of adolescents with sex-specific information from several European cities, use of standardized procedures, inclusion of many confounding factors (PA assessed objectively, sex, pubertal status, parental education level, and breastfeeding) in the analyses, and the strong methodology for assessing physical fitness and anthropometric data. The main limitation of the study is the lack of some detailed information about school time. The number of physical education lessons in each class was not available and could not be included in the statistical analysis, which may have influenced our results. However, the accelerometry data obtained for 1 week would have included time spent in physical education classes. Using other VO_2 peak prediction equation rather than those of Léger et al. (1988) or VO_2 peak without performing the allometric scale could have influence our results. Lastly, the HELENA study was performed 14 years ago (2006-2007), we cannot be sure our results represent the present situation. However, school time structures in participating countries did not change from date where data was collected and the date of the present analysis.

Conclusion

A long time spent at school is associated with higher cardiorespiratory fitness in adolescents. This finding suggests that school time should be considered in future interventions and health promotion strategies. As short time school is associated with lower cardiorespiratory fitness, efforts should be focused on after-school programs for promoting MVPA and reducing sedentary behaviors. Future research on intervention programs on school free time for adolescent having a short school time should be performed.

Conflict of interest

The authors do not have any competing interests.

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Table 1. Impact of school time on school rhythm

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

Data are median [range] unless indicated.
"*" means p-value <0.0001.

Table 2. Characteristics of the study population of adolescents.

	Before imputation		
	Without missing data	**With missing data**	**After imputation**
N	1473	551	2024
Gender (%*M*)	49.5	50.8	49.5
Age (*y*)	14.6 ± 1.2	14.7 ± 1.1	14.6 ± 1.2
Height (*cm*)	165.7 ± 9.2	165.9 ± 9.1	165.7 ± 9.2
Body mass (*kg*)	58.2 ± 12.2	59.4 ± 13.0	58.4 ± 12.4
BMI ($kg.m^{-2}$)	21.1 ± 3.5	21.5 ± 3.8	21.2 ± 3.6
Nutritional status (*%UW/%NW/%OW/%O*)[a]	6.6/72.2/16.2/5.0	6.8/68.8/18.7/5.7	6.6/71.4/16.8/5.2
Pubertal status (*%I/%II/%III/%IV*)[b]	6.9/23.0/34.0/36.1	5.2/18.4/34.6/41.8 *	6.5/22.0/34.0/37.5
Father education level (*%I/%II/%III*)[c]	32.8/30.3/36.9	36.7/24.1/39.2	34.3/28.7/37.0
Mother education level (*%I/%II/%III*)[c]	33.1/31.4/35.5	32.5/30.3/37.3	33.2/30.9/35.9
MVPA ($min.day^{-1}$)	52.9 ± 26.1	50.2 ± 25.6 *	52.2 ± 25.9

[*] $P < 0{\cdot}05$ for comparison between the two samples, without and with missing data
[a] Nutritional 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. Physical fitness levels according to school time group

	Short time group	**Long time group**	**Model 1**	**Model 2**
Cardiorespiratory Fitness (*mL.kg.min*$^{-1}$)	40.7 ± 7.2	42.0 ± 7.6	**<0.001**	**0.04**
Flexibility (*cm*)	22.8 ± 8.1	23.1 ± 7.9	0.47	0.52
Upper Muscular Strength (*kg*)	30.3 ± 8.8	30.6 ± 9.0	0.46	0.28
Lower Muscular Strength (*cm*)	164.1 ± 35.2	163.1 ± 35.0	0.56	0.34
Speed/Agility (*sec*)	12.2 ± 1.3	12.2 ± 1.3	0.65	0.64

Mean (± SEM) and P-value were calculated after multiple imputations (m=10) to handle missing data.
Model 1: unadjusted.
Model 2: adjusted for age, gender, pubertal status, BMI, MVPA during whole week, father education level and mother education level