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Active Commuting and Physical Activity in Adolescents From Europe: Results From the HELENA Study

Palma Chillón
University of Granada

Francisco B. Ortega
Karolinska Institutet

Jonatan R. Ruiz
University of Granada

Ilse De Bourdeaudhuij
Ghent University

David Martínez-Gómez
Spanish National Research Council (CSIC)

Germán Vicente-Rodriguez
Universidad de Zaragoza

Kurt Widhalm
Medical University of Vienna

Dénes Molnar
University of Pécs

Frédéric Gottrand
University Lille2

Marcela González-Gross
Universidad Politécnica de Madrid

Dianne S. Ward
University of North Carolina Chapel Hill

Luis A. Moreno
Universidad de Zaragoza

Manuel J. Castillo
University of Granada

Michael Sjöström
Karolinska Instituteton
on behalf of the HELENA study group

Chillón and Ruiz are with the Department of Physical Education and Sport, University of Granada, Spain. Chillón and Ward are with the Center for Health Promotion and Disease Prevention, University of North Carolina at Chapel Hill, NC, USA. Ortega, Ruiz and Sjöström are with the Unit for Preventive Nutrition, Department of Biosciences and Nutrition, Karolinska Institutet, Sweden. Ortega and Castillo are with the Department of Medical Physiology, University of Granada, Spain. De Bourdeaudhuij is with the Department of Movement and Sport Sciences, Ghent University, Belgium. Martínez-Gómez is with the Immunonutrition Research Group, Department of Metabolism and Nutrition, ICTAN, Spanish National Research Council (CSIC), Spain. Vicente-Rodríguez and Moreno are with Growth, Exercise, Nutrition and Development (GENUD) Research Group, Universidad de Zaragoza, Spain. Widhalm is with the Department of Paediatrics, Division of Clinical Nutrition, Medical University of Vienna, Austria. Molnar is with the Deprtment of Paediatrics, Clinical Center, University of Pécs, Hungary. Gottrand is with Inserm U995, University Lille2 and CIC-9301-CH&U-Inserm, University Hospital of Lille, France. González-Gross is with the Department of Health and Human Performance, Universidad Politécnica de Madrid, Spain.

We assessed commuting patterns in adolescents from 10 European cities and examined associations with physical activity (PA). A total of 3112 adolescents were included. PA was objectively measured with accelerometry. Commuting patterns and overall PA were self-reported using questions from the International Physical Activity Questionnaire modified for adolescents (IPAQ-A). Adolescents reported to spend 30 min (15,60) [expressed as median (25th, 75th percentiles)] walking. In boys, associations between active commuting (walking and biking) and PA levels were observed for moderate, moderate-to-vigorous and overall PA. In girls, these associations were observed for moderate and moderate-to-vigorous PA (walking). Similar results were found with the IPAQ-A. We observed positive associations between overall commuting and PA levels in European adolescents, yet due to the cross-sectional study design we cannot state the direction of these. Future studies should address the causation between active commuting and PA levels.

Daily routine activities, such as active commuting, may contribute to overall physical activity (PA) levels, which in turn may have important health implications in adolescents. Results indicate that young people who walk or bike to school report higher daily levels of PA than those who travel to school by vehicle in Denmark (5,7), England (6) and U.S (25–27). Similar results have been observed in adults for commuting to work (14,17). Little is known, however, about the specific association of overall active commuting accumulated across the day (e.g., to school, cinema, shopping, etc.) and daily PA levels in adolescents.

Accelerometry is a useful methodology to measure free-living PA, and its use in large scale population-based studies is increasing. It provides a good opportunity to explore the relationships between overall active commuting and daily PA levels, as has been done in several studies for commuting to school (5,6,27). However, one of the limitations of this methodology is that it underestimates activities that involve minimal vertical displacement such as cycling and does not capture well load-bearing activities (16). Self-report methods are valuable for the assessment of activity setting and mode of activity behaviors, which may be more difficult than assessing objectively (8). Studies that include both accelerometry and self-report measures may provide a more accurate assessment of commuting behavior in adolescents.

Therefore, the current study aimed to: 1) describe active commuting patterns in European adolescents comparing gender and age differences; and 2) examine the associations between time spent in active commuting and daily PA assessed by accelerometry and questionnaires.

Methods

Study Design

The data were gathered as a part of the multicenter HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study that focused on examining lifestyle and nutrition among adolescents from 10 European cities: Athens (mainland city) and Heraklion (Mediterranean island city) in Greece, Dortmund in Germany, Ghent in Belgium, Lille in France, Pecs in Hungary, Rome in Italy, Stockholm in Sweden, Vienna in Austria, and Zaragoza in Spain. Detailed descriptions of the

HELENA sampling and recruitment approaches, standardization and harmonization processes, data collection, analysis strategies, quality control activities and inclusion criteria were published elsewhere (12,23,24). Data collection took place from 2006 to 2008. The study was approved by the Research Ethics Committees of each city involved. Written informed consent was obtained from both the parents and the adolescents (2).

Study Sample

The sample size was calculated with a confidence level of 95% and ± 0.3 error for the parameter, Body Mass Index (BMI). After regarding the diversity of the sample for gender, age, cultural and socioeconomic aspects, a total number of at least 3000 adolescents (300 for each city) was included. Ten European cities of more than 100,000 inhabitants located in separated geographical points in Europe were selected for the study. The geographical distribution was not random and not represented by the strata, but according to the following criteria: representation of territorial units (counties) of Europe according to geographical location (N/S/E/W), cultural reference and socioeconomic situation; and selection of a territorial unit (city) in the country with a research group available to accomplish the study. The age range considered valid for the HELENA study was 12.5–17.49 y and participants were recruited at schools. Schools were randomly selected after stratification on school zone or district to guarantee diversity in cultural and socioeconomic characteristics. Finally, school classes with at least 20 students, males and females of similar age, were randomly selected after stratification for grade; complete school classes were evaluated. A total of 3528 adolescents, 1683 boys 1845 girls, were considered eligible for the HELENA analyses. To make maximum use of the data in the current study, all participants with completed data on any mode of commuting and accelerometry were included: 2003 adolescents (1080 girls) for vehicle, 2011 (1082 girls) for walking and 2029 (1090 girls) for biking. No significant differences in commuting were noted between adolescents with and without valid data on accelerometry ($p > .4$).

Physical Examination

Weight was measured in underwear and without shoes with an electronic scale (Type SECA 861) to the nearest 0.1 kg and height obtained with a telescopic height measuring instrument (Type SECA 225) to the nearest 0.1 cm. Body mass index was calculated as body weight divided by the square of height in meters. Identification of pubertal status (stages I-V) was assessed by direct observation of a medical doctor according to Tanner and Whitehouse (29).

Commuting Assessment

Active commuting information was assessed by self-report using questions related to transportation from the *International Physical Activity Questionnaire for Adolescents* (IPAQ-A). The validation of this questionnaire can be found elsewhere (11,19). The questionnaire was an adolescent-adapted version of the long version of the IPAQ. The original questionnaire, developed for adults aged 18–65 years, assesses different domains of PA (work, transport, house and garden, leisure time) and is a valid and reliable instrument to measure PA at population level (9). To adapt the questionnaire to our study population, questions about PA at work were replaced by questions about PA at school and items relating to domestic and gardening were reduced to one question. A pilot concurrent validation found modest correlations between the PA reported in the questionnaire and PA measured by accelerometry (19).

Adolescents were asked how they travelled from place to place (including places like school, stores, movies) as follows: (i) "During the last 7 days, on how many days did you travel for at least 10 uninterrupted minutes in a motor vehicle like a train, bus, car or tram?";(ii) "How much time did you usually spend of those days travelling by motor vehicle?__hours, __minutes per day". Both questions were repeated for bicycling and walking. The recall time included the immediate previous 5 weekdays and 2 weekend days. Minutes per day in vehicle (train, bus, car or tram), walking and biking for commuting were computed. Based on previous research (18), scores of walking and biking were truncated for more reasonable and realistic levels: scores higher than 180 min per day were reduced to 180 min, and scores lower than 10 min per day were reduced to 0 min (11). Additionally, minutes per day of noncommuting PA (total PA excluding commuting), were calculated using the other PA domains (school, home, leisure) from the modified IPAQ questionnaire.

Physical Activity Assessment

Levels of PA were objectively measured using the accelerometer ActiGraph GT1M (ActiGraph, Pensacola, FL, USA), which is a compact, small, lightweight and uniaxial monitor designed to detect vertical acceleration movements. The ActiGraph (previously MTI and CSA) has been widely validated in laboratory setting and free-living conditions with children and adolescents (16). Adolescents were instructed to place the accelerometer at the lower back, to wear it for 7 consecutive days, and to remove it only during water-based activities and sleeping. The interval of time (epoch) was set at 15 s in concordance with consensus recommendations for assessing PA for this age group (30). Data were downloaded onto a computer using the manufacturer software and later analyzed by software based on Visual Basic. Bouts of 20 continuous min of zeros were excluded from the analysis as an indication of periods as nonwear time. At least 3 days of valid recording and a minimum of 8 hr of wear per day were necessary for the adolescents' data to be included in the study. The time spent (min/d) in moderate PA and vigorous PA were calculated based upon cut points of 2000–3999 and ^{3}4000 counts per minute (cpm), respectively. Time spent in moderate and vigorous PA (MVPA) was determined using the cut-off point of ^{3}2000 cpm which is equivalent to walking at 3 kph (3). These cut-offs points are similar to those used in previous studies with European children and adolescents (1,15).

On day one, a researcher visited the adolescents in the classroom during school hours, where they were instructed how to handle the accelerometers. The students were asked to wear the device during waking hours for 7 consecutive days, starting on day 2. They were advised not to wear the monitor during aquatic activities (e.g., bathing, swimming). On day 8 the adolescents returned the accelerometers to the researcher. At the end of the accelerometer testing period, the adolescents also completed the IPAQ-A. The total self-reported PA was obtained from the IPAQ-A based on all the domains previously described: work, transport, house and garden, leisure time (11).

Statistical Analysis

Study sample characteristics are presented as means and standard deviations (*SD*) or median (25th, 75th percentiles), unless otherwise stated. Gender and age differences in the normally distributed variables were analyzed by one-way analysis of covariance (ANCOVA). For gender differences, gender was entered as a fixed factor, city as a random factor and age as covariate. To assess age differences, age group was entered as a fixed factor, city as a random factor and gender as covariate. Age was categorized in 4 groups (12.5–13.99, 14–14.99, 15–15.99 and 16–17.49 y). We studied the residuals pattern and performed a square root transformation for vigorous PA and log transformation for average PA. Nominal data (pubertal status) were analyzed using Chi-square tests. Nonnormally distributed variables (vehicle, walk and bike) were analyzed using Mann-Whitney test. Linear regression analyses were conducted to examine the relationships between commuting mode (exposures: vehicle, walk and bike) and objective PA (outcomes). In addition, we studied the associations between biking and walking (exposure) and the noncommuting PA obtained from questionnaire (outcome). Analyses were stratified for boys and girls and controlled for city (entered as dummy variables) and age. Analyses were examined separately for each exposure. All analyses were performed using the SPSS v.16.0 software for Windows. For all analyses, the level of significance was set at an alpha of 0.05.

Results

Adolescents reported to spend [expressed as median in min (25th, 75th percentiles)] 30 min (15,60) walking for transportation. There were no significant differences in the time spent in commuting by walking for either gender ($p = .9$) or age ($p = .6$). However, time spent commuting by biking was higher in boys and younger adolescents than in girls and older adolescents, respectively ($p < .001$ and $p = .016$ respectively). The 75th percentile for commuting by biking was 30 min in boys and 10 min in girls (Table 1). Biking for transportation decreased over time; the 75th percentile for commuting by biking was 30 min in adolescents aged 12.5–13.9 years, 25 min in adolescents aged 14–14.9 years and 20 min in adolescents aged 15–15.9 years and 16–17.4 years (data not shown). Time spent in commuting by bike was 0 min (0,0) in adolescents from Athens, Zaragoza, Heraklion and Rome; 0 min (0,8) in adolescents from Pecs; 0 min (0,30) in adolescents from Dortmund, Lille and Vienna; 15 min (0,30) in adolescents from Stockholm and 15(0,38) in adolescents from Gent.

In boys, we observed a positive and significant association between active commuting (walk and bike) and objectively measured PA; walking was associated with moderate, vigorous, MVPA and overall PA ($p \leq .013$), while biking was associated with moderate, MVPA and overall PA (*p* £ .032) but not vigorous PA (Table 2). In girls, walking was associated with moderate PA and MVPA (*p* £ .01), while biking was associated only with moderate PA ($p = .03$; Table 2).

Table 1 Descriptive Characteristics of the Study Sample by Gender

	n	Boys	n	Girls	P *
Age (y)	1472	14.8 ± 0.0	1640	14.8 ± 0.0	0.526
Pubertal status (%): stages I/II/III/IV/V	1472	1/7/21/41/30	1640	0/3/19/45/33	<0.001
Weight (kg)	1472	62.1 ± 0.4	1640	56.1 ± 0.4	<0.001
Height (cm)	1472	169.9 ± 0.2	1640	161.9 ± 0.2	<0.001
Body mass index (kg/m^2)	1472	21.3 ± 0.1	1640	21.3± 0.1	0.892
Commuting					
Vehicle (min/day): Md (25th, 75th percentiles)	1430	30 (15,60)	1589	30 (15,60)	0.066
Walk (min/day): Md (25th, 75th percentiles)	1454	30 (15,60)	1612	30 (15,60)	0.888
Bike (min/day): Md (25th, 75th percentiles)	1440	0 (0,30)	1592	0 (0,10)	<0.001
Physical activity					
Moderate (min/day)	960	41.9 ± 0.5	1110	35.7 ± 0.5	<0.001
Vigorous (min/day) †	960	23.2 ± 0.5	1110	13.4 ± 0.4	<0.001
Moderate-vigorous (min/day)	960	65.1 ± 0.8	1110	49.1 ± 0.7	<0.001
Average (counts/min) ‡	960	480.6 ± 5.5	1110	377.1 ± 5.1	<0.001

Data are shown as means ± *SE*, except for pubertal status (which is percentages), vehicle, bike and walk which are median (Md)

*Analysis adjusted by city and age, except for age, sexual maturation status, vehicle, bike and walk. †Squared-root and ‡log transformed data were used in the analysis, but raw data are presented.

Results from the IPAQ-A confirmed our findings from the accelerometer. Using self-report data from the IPAQ-A, a positive association was observed between both biking walking and noncommuting PA for both boys and girls ($p < .001$; Table 3). When the analyses were controlled for pubertal status instead of age, the results remained unchanged.

Discussion

Our results show that adolescents who report to spend more time in active commuting across the week have higher levels of daily PA than those who report less active commuting. These results were consistent for both boys and girls, although commuting PA seemed to have a greater impact on vigorous PA in boys than in girls.

To our knowledge, there are no studies in adolescents that assessed the association of commuting patterns on daily PA. However, associations between commuting to school and PA have been well-studied (10) among young population, and similar findings have been observed. One study examined active commuting (school/work or shops) in a wide-range of Chinese individuals aged 15–60 years

Table 2 Associations (Linear Regression) Between Commuting (Vehicle, Bike and Walk) and Objectively Measured Physical Activity Levels in Boys and Girls

		Moderate (min/day)			Vigorous PA* (min/day)			MVPA (min/day)			Overall PA† (count/min)		
Commuting	n	β	P	R^2	β	P	R^2	β	P	R^2	β	P	R^2
Boys													
Vehicle	923	0.035	0.279	0.089	-0.012	0.707	0.050	0.014	0.662	0.056	0.012	0.707	0.056
Walk	929	0.173	<0.001	0.108	0.082	0.013	0.052	0.157	<0.001	0.078	0.130	<0.001	0.070
Bike	939	0.101	0.002	0.088	0.014	0.664	0.045	0.070	0.032	0.058	0.082	0.011	0.060
Girls													
Vehicle	1080	-0.022	0.464	0.085	0.050	0.086	0.118	0.015	0.514	0.119	0.029	0.317	0.127
Walk	1082	0.090	0.003	0.096	0.026	0.373	0.119	0.075	0.011	0.128	0.041	0.167	0.134
Bike	1090	0.065	0.032	0.086	-0.014	0.630	0.115	0.037	0.212	0.118	0.029	0.323	0.126

Analyses were controlled for city and age. City was entered as dummy variables. Vehicle, bike and walk were one by one added to the basic model (city and age).
*Squared-root and †log transformed data were used in the analysis. b Standardized linear regression coefficients.

Table 3 Associations (Linear Regression) Between Bike and Walk and Self-Reported Noncommuting Physical Activity in Boys and Girls

		Noncommuting PA		
Commuting	**n**	β	**P**	R^2
Boys				
Walk	1225	0.420	< 0.001	0.280
Bike	1226	0.328	< 0.001	0.213
Girls				
Walk	1429	0.385	< 0.001	0.328
Bike	1431	0.209	<0.001	0.229

Analyses were controlled for city and age. City was entered as dummy variables. Walk and bike were one by one added to the basic model (city and age). b Standardized linear regression coefficients.

and found no gender differences in commuting behavior (20). For this population, the mean commuting time on foot or by bike was 31 min/day for men and 30 min/day for women. In younger populations, Davison showed that boys are more likely to actively commute to school than girls (10), which concur with our findings. These results may reflect the social tendency of less independent mobility in girls. However, we observed in a sample of Spanish adolescents that girls reported to be more active commuters to school than boys (4).

Our results also suggest that younger adolescents spend more time in active commuting than older adolescents. A different tendency was observed in Chinese adults for overall commuting: older adults (34–69 y) spent more time in active commuting to work, school and shops than younger adults (15–34; 20). A similar trend to our results was found for commuting to school in Spanish adolescents of similar age (13–18.5 y; 4). However, Danish children (9 y) showed lower levels of active commuting to school than Danish adolescents (15 y), mainly due to the increased use of biking in adolescents (7).

The time spent in biking was rather low among adolescents in this study. However, for a better understanding of this result, differences among cities in Europe must be considered. Although the HELENA study was not powered to examine differences among countries, substantial variations in the percentages of bike use among countries were observed; e.g., 61.8% of the adolescents from Stockholm vs. 5.1% of the adolescents from Rome commuted by bike at least 10 min in the reported week. Sweden, Norway, Denmark, Belgium and the Netherlands have long tradition and effective policies for biking, which is a usual mode of commuting not only for adolescents, but for the general population (Cooper et al., 2006; Bere et al., 2008; Rietveld and Daniel 2004).

We observed a positive association between active commuting and PA levels in adolescents and these associations were stronger in boys than in girls. Other studies that examined commuting to school and objectively measured PA found similar results (5,26). In a recent review, 9 out of 11 studies found a significant association between commuting to school and PA levels (10). These associations could be explained in two ways: active commuters may choose to be more active during the rest of the day through doing sports or other active physical activities, but also physically active adolescents may choose to walk or bike for travel. Other cross-sectional studies did not find differences in PA levels among walkers and nonwalkers, and suggested that walkers decreased their PA during the rest of the day (22,31). Caution must be paid when interpreting the results from cross-sectional studies. We cannot state that increasing active commuting will increase daily PA levels in adolescents, since a compensation effect could take place. Intervention studies are needed to confirm or contrast these hypotheses.

We observed that the association between active commuting and objective PA was stronger for walking compared with biking, which was expected owing to the fact that accelerometers underestimate activities that involve minimal vertical displacement such as cycling. The extent of this underestimation is difficult to assess due to lack of specific information on types of PA across the day. Bear in mind, however, that commuting by bike was reported less frequently than commuting by walking. Additional analysis using PA measured through questionnaire confirmed these results. Using the self-report data, we observed a positive association between commuting by biking and PA and, even a lightly stronger association between walking and PA. Of the total PA measured by questionnaire, 5.1% corresponded to commuting by biking and 12.5% to commuting by walking.

Since there is evidence that active commuting offers health benefits (28), public efforts are required among health professionals, local planners and community members to promote this behavior among adolescents (10). Both educational and environmental strategies are necessary to encourage adolescents to walk or bike and to provide safety and pleasant physical environments for adolescents and the general population.

This study has a number of strengths, including its relatively large sample of adolescents, data collected from 10 European cities using a consistent protocol and the use of accelerometry to assess PA. A limitation of the current study is our inability to separate overall commuting from school commuting. Commuting results might reflect predominantly commuting to school during weekdays since adolescents spend most of their day at schools. However, we used a question designed to capture broadly active commuting that has been used previously to measure the total commuting behavior (9,21). Future research should address the specific contribution of commuting to school to overall commuting behavior. From a study of South Australian students, those who actively commuted to school were approximately 30% more likely to actively commute to other neighborhood destinations compared with passive commuters (13). From the current study, however, we are unable to determine how much of the objectively measured PA was done while participants were actively commuting.

In conclusion, our data demonstrate important associations between overall active commuting and PA levels in adolescents; these associations were slightly stronger for boys than for girls. Future interventional studies should be developed to examine the change in youth´s PA levels which result from incorporating active modes of commuting.

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