Association between cycling to school and body composition, physical fitness and cardiometabolic risk factors in children and adolescents from Colombia: The FUPRECOL study

Running title: Cycling to school and cardiovascular health in Colombian youth

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Abbreviations

20mSRT: 20 m shuttle run test

AST: Active school transport

BMI: Body mass index

CCI: Intraclass correlation coefficient

CMRI: Cardiometabolic risk index

CRF: Cardiorespiratory fitness

HBSC: Health Behaviour in School-Aged Children

MF: Muscular fitness

R: Reproducibility

SLJ: Standing long jump

WC: Waist circumference

Abstract

Objective: To analyse the association between cycling to/from school and body composition, physical fitness, and metabolic syndrome among a sample of Colombian children and adolescents.

Study design: During the 2014–2015 school years, we examined a cross-sectional component of the FUPRECOL study. Participants included 2,877 youths (54.5% girls) from Bogota (Colombia). A self-reported questionnaire was used to measure frequency and mode of commuting to school. Four components of physical fitness were measured: (1) anthropometric parameter (height, weight, body mass index, and waist circumference); (2) musculoskeletal parameters (handgrip and standing long jump test); (3) motor parameter (speed-agility test; 4 × 10 m shuttle run); and (4) cardiorespiratory parameter (20mSRT: 20 m shuttle run test). The prevalence of metabolic syndrome was determined by the definitions provided by the International Diabetes Federation.

Results: Twenty-three percent of the sample reported commuting by cycle. Active commuting boys showed lower likelihood (OR) of having unhealthy 4 x 10 m levels (OR = 0.72; 95% CI 0.53 to 0.98, $p = 0.038$) compared to the reference group (passive commuters). Active commuting girls showed a lower likelihood of having unhealthy 20mSRT levels (OR = 0.81; 95% CI 0.56 to 0.99, $p = 0.047$) and metabolic syndrome (OR = 0.61; 95%CI 0.35 to 0.99, $p = 0.048$) compared to passive commuters.

Conclusion: Our results provide some evidence that regular cycling to school may to be associated to greater physical fitness and lower metabolic syndrome than passive transport, especially in girls.

Introduction

A decrease in habitual physical activity is suggested to be a contributor to rising levels of childhood overweight and obesity (1). Indirect evidence for a decline in overall physical activity comes from transportation surveys that have recorded both a reduction in the proportion of journeys taken by foot and an increase in car travel (2). These trends are reflected in the decline of active school transport (AST) reported in many countries. Active commuting (walking, cycling, and even public transport) is one component of an active lifestyle that can be incorporated into routine daily activities (3). There is emerging and consistent evidence that AST increases physical activity levels in children and adolescents (4, 5).

Physical activity has many benefits in young people, however the evidence linking AST directly to health outcomes has not been extensively examined and remains unclear. The vast majority of studies have shown a positive relationship between AST and physical activity levels (6). In addition, there is a consistent evidence that cycling to/from school is associated with greater cardiorespiratory fitness; however, the association between AST and indicators of body composition as well as other physical fitness components remains equivocal (6).

Active commuting has been associated with cardiovascular risk factors in adults, and is apparently more robust among women (7). To the best of our knowledge only three studies have examined the association between AST and cardiovascular risk factors in youth (8-10), which shows that studies in this area require further depth. Several studies have addressed AST to promote physical activity in general (5, 11), but few have examined the effects of promotion of cycling to school as a specific behaviour (9, 10). Cycling as a mode of transportation appears to be more energy intensive per unit of time, also seems to benefit health outcomes better than walking. For example, Shephard (12) has calculated that sedentary adults would need to walk for 22 minutes twice a day for 5 days a week in order to expend an additional amount of energy sufficient to reduce all-cause and cardiovascular mortality. However, corresponding benefits could be achieved with just 11 minutes per trip.

In youth, several factors have been described as more or less influential determinants regarding the decision to commute actively, such as: the students' socioeconomic status, the characteristics of the natural environment, the educational level of parents, social support for active commuting, the distance between school and home, and the perceptions of parents and children regarding neighbourhood characteristics (13, 14).

Despite the importance of AST as a strategy to promote physical activity in achieving the international physical activity guidelines of the World Health Organisation and the high rates of physical inactivity and sedentary lifestyles among students in Bogotá, Colombia (15, 16), few studies have analysed correlates and health-related associations in this population (14, 17). Thus, the aim of the current study was to analyse the association between cycling to/from school and adiposity, physical fitness, and cardiometabolic risk factors among a sample of Colombian children and adolescents.

Methods

Study Design and Sample Population

We performed cross-sectional analyses of baseline data from participants of the FUPRECOL study, which focussed on the associations between fitness, health, and non-communicable diseases. We recently published a complete description of the FUPRECOL study design, methods, and primary outcomes for our current cohort (18). In this study, we included a sub-sample (*n* = 2,858) of 9- to 17.9-year-old healthy Colombian children and adolescents. Data were collected from 2013 to 2016 and the analysis was done in 2016. (19). Individuals with endocrine disorders, psychiatric disorders, pregnancy, cardiovascular disease, obesity, systemic infections, asthma, or other physical impairments that made them unable to participate in this study, as well as individuals using any prescribed drugs or actively using illegal or illicit drugs, were excluded from this investigation.

Active Commuting to School by Cycle Assessment

Self-perceived commuting to school as well as cut-off point were assessed by the methodology of the Health Behaviour in School-Aged Children (HBSC) questionnaire (20). The method of commuting to school was elicited by asking the question: 'Have you used a bicycle to get to school and get back home?' Youths were asked to quantify their commuting to school in the previous week, recording the data from Monday to Friday. Responses were categorised as active ('cycle' if they commuted by bicycle) and passive ('non-cycle' if they commuted in a motor vehicle).

Anthropometric Assessment

All data were collected at the same time in the morning, between 7:00 a.m. and 10:00 a.m. Body weight and height were measured following standard procedures using an electronic scale (Tanita® BC544, Tokyo, Japan) and a mechanical stadiometer platform (Seca® 274, Hamburg, Germany), respectively. Body Mass Index (BMI) was calculated as body weight in kilograms divided by the square of height in meters. BMI was classified as underweight, normal weight, overweight, or obese using the International Obesity Task Force criteria (21). Waist circumference (WC) was measured at the midpoint between the last rib and the iliac crest using a tape measure (Ohaus® 8004-MA, Parsippany, NJ, USA). In all measures, we found almost excellent test-retest reliability (body weight [ICC = 0.983], height [ICC = 0.973], BMI [ICC = 0.897], and WC [Intraclass correlation coefficient, ICC = 0.967]). To classify WC, we used criterion-referenced health-related cut-points derived from de Ferranti et al. (22) because of their large sample size, age-specificity, and relatively generalizable ethnicity.

Physical Fitness Assessment

The musculoskeletal component used is appropriate for this age group and has shown acceptable validity and reliability (23, 24). We used standing long jump (SLJ) and isometric handgrip dynamometry as indicators of lower- and upper-body muscular fitness (MF), respectively. To assess lower-body MF, subjects were instructed to jump as far as possible using a two-footed take-off and landing technique. They were encouraged to flex then extend their knees, ankles, and hips, and to swing their arms to maximise performance. SLJ performance was calculated as the distance between the toes at take-off to the heels at the landing point. The best scores from two correctly performed jumps were used. Handgrip strength was assessed as an indicator of upper-body MF using an adjustable analogue handgrip dynamometer, T-18 TKK SMEDLY III® (Takei Scientific Instruments Co. Ltd., Niigata, Japan). Students watched a brief demonstration of technique, and were given verbal instructions on how to perform the test. The dynamometer was adjusted according to the child's hand size per predetermined protocols. SLJ and handgrip measurements in a subsample (n = 229, similar in demographics and biological characteristics to the whole sample) were recorded to ensure reproducibility on the day of the study. The reproducibility of our data were R = 98% to SLJ and R = 96% to the handgrip test.

Speed-agility test (speed of movement, agility, and coordination assessment) was measured in two parallel lines that were drawn on the floor 10 m apart. The participant ran as fast as possible from the starting line to the other line, and returned to the starting line, crossing each line with both feet every time. This was performed twice, covering a distance of 40 m (4 x 10 m). Every time the adolescent crossed any of the lines, he/she was instructed to pick up (the first time) or exchange (second and third time) a sponge that had earlier been placed behind the lines. The stopwatch was stopped when the adolescent crossed the end line with one foot. The time taken to complete the test was recorded to the nearest tenth of a second. A slip-proof floor, four cones, a stopwatch, and three sponges were used to perform the test. Flexibility component was assessed thought hamstring and lumbar extensibility, and was measured using the sit and reach test. Participants were asked to sit on the floor with legs out straight ahead. Feet with shoes off were placed with the soles flat against the test device and shoulder-width apart. Both knees were held flat against the floor. The measuring stick on the device has the zero mark at 25 cm before the feet. The result was recorded directly from the meter on the device. We used the 20th percentile as a threshold for unhealthy speed-agility and flexibility as reported in school children and adolescents from Europe (25) and Spain (26), respectively. The reproducibility of our data were R = 98% to Speed-agility test and R = 96% to the flexibility test.

Cardiorespiratory fitness (CRF) was assessed with the 20 meter Shuttle Run Test (20mSRT) (27). This test requires participants to run back and forth between two lines set 20 m apart. Running speed started at 8.5 km/h and increased by 0.5 km/h each minute, reaching 18.0 km/h per minute. Each level was announced on a tape player. The participants were instructed to keep up with the pace until exhausted. The test was finished when the participant failed to reach the end lines concurrent with the audio signals on two consecutive occasions.

Otherwise, the test ended when the subject stopped because of fatigue. The participants received verbal encouragement from the investigators to achieve maximum performance to keep running as long as possible. The number of shuttles performed by each participant was recorded. Unhealthy CRF was defined by using either the cut-off by sex and age (shuttle-runs or estimated $\dot{V}O_2$peak) listed in the healthy fitness zone (needs improvement and health risk). The FITNESSGRAM® (28) has been shown to have predictive value for cardio-metabolic health , and $\dot{V}O_2$peak cut-off points were validated against the presence of metabolic syndrome using nationally representative U.S. data (29). The reproducibility of our data was R = 84%. Intra-rater reliability was assessed by determining the intraclass correlation coefficient (ICC = 0.96, CI 95% 0.95 to 0.97).

Blood samples

Blood samples were collected between 6:00 a.m. and 8:00 am by two experienced paediatric phlebotomists after at least 12 hours of fasting. Before the extraction, the child and parents confirmed the fasting condition. Blood samples were obtained from an antecubital vein, and analyses were subsequently completed within 1 day from collection. The levels of triglycerides, total cholesterol, cholesterol linked to high-density lipoproteins, and glucose were measured using colorimetric enzymatic methods with the use of a CardioChek analyser. The fraction of cholesterol linked to low-density lipoproteins was calculated using the Friedewald formula (30). The precision performance of these assays was within the manufacturer's specifications.

Diagnosis of Metabolic Syndrome

The prevalence of metabolic syndrome and its components were evaluated according to definitions provided by IDF (31, 32, 33). For children age 8 or older, metabolic syndrome can be diagnosed with abdominal obesity (using waist circumference percentiles) and the presence of two or more other clinical features (elevated triglycerides, low-density lipoproteins -cholesterol, high blood pressure or increased plasma glucose).

Resting Blood Pressure

After the tests and blood draw, systolic and diastolic blood pressure were determined as the average of two measurements separated by a 5-minute interval in left harm, using an electronic oscillometric device (Riester Ri-Championmodel, Jungingen, Germany), after being seated in a quiet room for 10 minutes with their back supported and feet on the ground. Before blood pressure session monitoring, the accuracy of the device was tested against a standard mercury sphygmomanometer in a random subsample (n = 25) to ensure that there was no consistent difference of >10 mmHg in measured blood pressure; interobserver variability was R = 96%.

Maturation Status Assessment

Maturation status (self-reported) was assessed by the classification described by Tanner (five stages: I–V) (34). Each participant entered into an isolated room where, using a set of images exemplifying the various stages of sexual maturation, they categorised the development of their own genitalia (for boys), breasts (for girls), armpits (for boys), and pubic hair (for both genders). The reproducibility of our data reached 85%.

Ethics Statement

The study protocol was explained verbally to the participants and their parents/guardians before they gave their written consent. Participation in the study was fully voluntary and anonymous, with no incentives provided to participants. The Review Committee for Research on Human Subjects at the University of Rosario (code No. CEI-ABN026-000262) approved all study procedures. The protocol was in accordance with the latest revision of the Declaration of Helsinki and current Colombian laws governing clinical research on human subjects (Resolution 008430/1993 Ministry of Health).

Statistical Analysis

Anthropometric components, physical fitness, and cardiometabolic risk factors of the study sample were presented as means, *SD*, or relative frequencies *n* (%). The normality of the variables was verified using histograms and Q-Q plots. Since no significant interaction was observed between age group (children or adolescents; e.g., age group x active commuting) to increase statistical power, all the statistical analyses were performed with both age groups together.

Differences by groups (cycling vs not-cycling to school) were analysed using the chi-square test (χ^2). To examine the odds ratios (ORs) and 95% confidence interval of having an unhealthy profile (physical fitness and metabolic syndrome), we used multinomial logistic regression adjusted by age, tanner stage, and the academic level of parents. We used SPSS V. 21.0 software for Windows (SPSS, Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

Results

Of the students surveyed, $n = 668$ (23%) actively commuted to school by bicycle. Boys reported higher values and performance in height, body mass, WC, diastolic blood pressure, SLJ, 4x10 m and 20mSRT than girls ($p < 0.001$ for all). In contrast, girls showed higher values and performance in BMI, cholesterol linked to low-density lipoproteins, triglycerides, and sit and reach tests ($p < 0.05$ for all; Table I).

Table I. Anthropometric components, physical fitness and cardiometabolic risk factors of study cohort

Characteristics	**Overall n=2,877**	**Girls n= 1,568**	**Boys n=1,309**	***p value***
Age (years)	13.2 (2.2)	13.2 (2.2)	13.3 (2.3)	0.067
Anthropometric				
Height (cm)	152.9 (11.9)	150.7 (9.5)	155.6 (13.8)	**<0.001**
Body mass (kg)	46.8 (11.6)	46.2 (10.7)	47.6 (12.5)	**<0.001**
Body mass index (kg/m^2)	19.8 (3.1)	20.1 (3.2)	19.3 (2.9)	**0.002**
Weight status n [%] [a]				
Underweight	446 [15]	243 [15]	203 [16]	
Normal	1,728 [60]	861 [55]	867 [66]	**0.001**
Overweight	522 [18]	362 [23]	160 [12]	
Obesity	181 [7]	102 [7]	79 [6]	
Waist circumference (cm)	64.6 (7.6)	63.8 (7.5)	65.7 (7.6)	0.872
Tanner stage n [%] [a]				
Pre-puberty	163 [6]	78 [5]	85 [6]	
Puberty	1,473 [51]	794 [51]	679 [52]	0.157
Post-puberty	1,241 [43]	696 [44]	545 [42]	
Physical fitness				
Standing long jump (cm)	132.1 (30.2)	118.7 (20.8)	148.2 (31.7)	**<0.001**
Handgrip strength (kg)	22.6 (7.9)	20.4 (5.2)	25.3 (9.5)	**<0.001**
4x10 test (s)	14.5 (2.0)	15.2 (1.8)	13.5 (1.8)	**<0.001**
Sit & Reach test (cm)	21.4 (8.1)	22.8 (8.1)	19.8 (7.9)	**<0.001**
20mSRT (VO_2peak, ml kg min^{-1})[a]	41.4 (5.3)	39.2 (4.3)	44.0 (5.2)	**<0.001**
Cardiometabolic risk factors				
Systolic blood pressure (mmHg)	111.7 (13.3)	110.3 (12.4)	113.3 (14.0)	**<0.001**
Diastolic blood pressure (mmHg)	68.4 (8.9)	68.5 (8.6)	68.1 (9.3)	0.282
Total cholesterol (mg/dl)	145.0 (31.5)	149.4 (30.6)	139.6 (31.6)	0.504
HDL cholesterol (mg/dl)	47.2 (12.3)	47.4 (12.2)	46.8 (12.4)	0.226
LDL cholesterol (mg/dl)	83.3 (31.1)	85.1 (28.3)	81.7 (34.3)	**<0.001**
Triglycerides (mg/dl)	91.3 (48.4)	96.5 (54.1)	85.4 (39.4)	**0.001**
Glucose (mg/dl)	82.4 (15.8)	81.5 (15.7)	83.3 (15.7)	0.806
Metabolic syndrome prevalence n [%]*	276 [9.6]	163 [10.4]	250 [8.7]	0.071

Data are shown as mean (SD) or frequencies relative [%]. Significant between-group differences (student-t test or chi-square test*).

[a]VO_2peak **(**ml kg min^{-1}) predicted using the Leger et al. equation (1988)

Associations between cycling to school, physical fitness, and cardiometabolic risk factors by sex is presented in Table II. For boys, active commuters displayed significantly lower percentages in the unhealthy category compared to passive commuters for the 4x10 m test (p = 0.002) and sit & reach test (p = 0.025). For girls, active commuters showed lower percentages than passive commuters, with significant differences for SLJ (p = 0.012), the 4x10 m test (p = 0.005), and 20mSRT (p = 0.026).

Table II. Association between cycling to school, physical fitness and cardiometabolic risk factors, by sex.

Characteristics	Girls n= 1,568			Boys n=1,309		
	Noncycling n= 1,297	**Cycling n= 271**	***p value for groups***	**Noncycling n= 912**	**Cycling n= 397**	***p value for groups***
Physical fitness n [%]						
Standing long jump (unhealthy)	754 [58.1]	126 [46.5]	**0.012**	434 [47.6]	201 [50.6]	0.481
Handgrip strength (unhealthy)	957 [73.8]	184 [67.9]	0.097	634 [69.5]	285 [71.8]	0.542
4x10 test (unhealthy)	1044 [80.5]	194 [71.6]	**0.005**	678 [74.3]	260 [65.7]	**0.006**
Sit & Reach test (unhealthy)	248 [19.1]	38 [14.0]	0.458	624 [68.5]	240 [60.7]	**0.025**
20mSRT (unhealthy)	708 [54.6]	119 [43.9]	**0.026**	98 [10.7]	40 [10.1]	0.917
Cardiometabolic risk factors n [%]						
Increased waist circumference	362 [27.9]	75 [27.7]	0.977	224 [24.6]	89 [22.4]	0.706
High triglyceride	433 [33.4]	80 [29.5]	0.482	187 [20.5]	97 [24.4]	0.436
Low HDL-C	838 [64.6]	163 [60.1]	0.332	592 [64.9]	259 [65.2]	0.779
High fasting plasma glucose	61 [4.7]	9 [3.3]	0.145	49 [5.4]	18 [4.5]	0.883
High systolic blood pressure	166 [12.8]	37 [13.7]	0.866	139 [15.2]	62 [15.6]	0.999
High diastolic blood pressure	154 [11.9]	19 [7.0]	0.593	97 [10.6]	38 [9.6]	0.863
Metabolic syndrome prevalence	144 [11.1]	18 [6.6]	0.514	81 [8.9]	34 [8.6]	0.997

Significant between-group differences by chi-square test.

Finally, multiple logistic regressions predicting an unhealthy profile according to active commuting-to-school categories (cycling or non-cycling) by sex is show in Table III. In boys, active commuters showed lower likelihood (OR) to have unhealthy 4x10 m levels, OR = 0.72, 95% CI (0.53 to 0.98), p = 0.038, compared passive commuters. In girls, active commuters showed a lower likelihood of having unhealthy 20mSRT levels, OR = 0.81, 95%

CI (0.56 to 0.99), p = 0.047, and metabolic syndrome, OR= 0.61, 95% CI (0.35 to 0.99), p = 0.048, compared to passive commuters.

Table III. Multiple logistic regressions predicting unhealthy profile according to active commuting to school categories (cycling or nonclyling) using bivariate analysis, by sex.

Characteristics	**Girls**			**Boys**		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***
Physical fitness n (%)						
Standing long jump (unhealthy)	1.29	0.99-1.78	0.069	0.88	0.68-1.15	0.373
Handgrip strength (unhealthy)	0.82	0.58-1.19	0.300	1.02	0.76-1.32	0.873
4x10 test (unhealthy)	1.44	0.99-2.21	0.051	**0.72**	**0.53-0.98**	**0.038**
Sit & Reach test (unhealthy)	1.06	0.68-1.68	0.778	0.99	0.66-1.50	0.993
20mSRT (unhealthy)	**0.81**	**0.56-0.99**	**0.047**	0.77	0.57-1.04	0.096
Cardiometabolic risk factors n (%)						
Increased waist circumference	4.67	1.10-19.6	0.036	0.78	0.41-1.48	0.548
High triglyceride	1.10	0.78-1.55	0.578	0.84	0.68-1.14	0.287
Low HDL-C	1.11	0.83-1.60	0.317	1.10	0.84-1.64	0.460
High fasting plasma glucose	1.02	0.48-2.12	0.958	1.51	0.81-2.78	0.185
High systolic blood pressure	0.90	0.59-1.39	0.652	0.97	0.69-1.38	0.978
High diastolic blood pressure	1.54	0.91-2.63	0.106	1.26	0.82-1.93	0.277
Metabolic syndrome	**0.61**	**0.35-0.99**	**0.048**	0.89	0.56-1.40	0.620

Reference: Non-cycling (OR=1.0); 20mSRT, 20 meter Shuttle Run Test.
Analysis adjusted for age, tanner stage, and fathers and mothers academic level.

Discussion

The main findings of the current study show that active commuters who cycled to/from school showed higher speed-agility, lower-body muscle strength, flexibility, and cardiorespiratory fitness (only in girls), as well as lower prevalence risk of metabolic syndrome (only in girls) compared to boys passive commuters who did not cycle.

Most of the studies that have reported associations between AST and health-related physical fitness were mainly focussed on cardiorespiratory fitness outcomes. In the review of Lubans et al. (35), the majority of studies indicated that active travellers had greater cardiorespiratory fitness, especially those who cycled to/from school. All studies that assessed walking and cycling separately found that cyclists had greater cardiorespiratory fitness than passive travellers Shephard (12). However, in these studies cardiorespiratory fitness was assessed with different methods, such as cycle ergometer, 20mSRT, 1-mile run time, or even VO_2max by expired gases, which may preclude direct comparisons between studies. In the current study, active female commuters presented on average a better cardiorespiratory fitness and were less frequently to be classified as having a low cardiorespiratory fitness than passive commuters when cardiorespiratory fitness was measured with the 20mSRT. Similar findings were shown in previous studies, where active travellers were more likely to be classified as 'fit' based on their performance on this test (36, 37). The difference found between sexes in our study could be due to the fact that girls ussully show lower physical activity levels, as reported in the last results from Colombia's 2016 Report Card on Physical Activity for Children and Youth (38); and for this reason, AST could be sufficient for promote improvements in girls' physical fitness.

There is little evidence on the association between AST and other physical fitness components (i.e., beyond CRF) (39-41). Regarding muscular fitness, several studies have reported controversial results showing a positive association (39, 41, 42) or no association (40) with cycling to school. In Norwegian children and adolescents aged 9 to 15 years old, there was a positive association found between AST and muscular fitness (higher isometric muscle endurance in the back extensor) (39). Likewise, in Spanish school-aged children, AST was also found to be significantly associated with higher levels of lower body muscular fitness in girls (41); however, only 0.1% of the participants cycled to school, which is not a large enough sample size to study its effects. Confirming our multiple regression results, another study showed no associations between AST and muscular fitness in Danish adolescents aged 15 to 19 years old (40). In the Norwegian and Spanish studies, lower-body muscular fitness was assessed by the standing long jump test, the same test used in the present study, which is considered a general index of both lower-body and upper-body muscular fitness in children and adolescents (42). However, in the Danish study, the functional strength of leg extensors was measured by the Sargent Jump Test, and the functional strength in the dominant arm was measured by the iron ball throw test.

Finally, the positive association between AST and speed-agility was only reported in two studies (40, 41). In Spanish school-aged children, active commuting (mainly walkers) was significantly associated with higher levels of speed-agility in boys; although there is not a clear explanation, it was speculated that boys are often more competitive than girls at this age (41). Contrary to our findings in both sexes, the Danish study did not find associations between AST and speed-agility assessed by the 4 x 10 m shuttle run test, although the age sample differed from the current study (i.e., children vs. adolescents) (40). The review of Lubans et al. (35), concluded that more interventions and longitudinal studies exploring the relationship between changes in health-related fitness and active travel are needed to investigate the causal nature of such relationships. Consequently, a recent quasi-experimental study that focussed on increasing children’s AST did not report increases in health-related fitness for boys or girls (43), requiring more research with a more rigorous design such as randomised clinical trial designs.

Several studies have analysed the relationship between AST and cardiometabolic risk factors in schoolchildren (8, 9). A longitudinal study of Danish young people (9) reported no differences in cardiometabolic risk factors between passive travellers and walkers, but children cycling to school showed consistently better risk factor levels. In the current study, active female commuters showed a lower likelihood of having metabolic syndrome compared to passive commuters. In the study commented above (9), differences between cyclists and non-cyclists were larger in adolescents than in 9-year-old children. Changing from non-cycling as 9-year-olds to cycling at the age of 15 was associated with a better composite risk factor score than remaining a non-cyclist, and the opposite change (stopping cycling) was associated with a worse score. Likewise, a study conducted on Spanish children presenting higher cardiometabolic risk levels lived closer to school than those who did not (8). However, no differences were found in metabolic syndrome index between children who walked/cycled daily to school and those who less frequently commuted actively to school. Unfortunately, we were not able to measure the distance from home to school, although we controlled other important confounders such as socioeconomic status. Similar to findings from a previous randomised controlled trial where researchers investigated whether cycling to school induced improvement of the clustering of cardiometabolic risk factors (10), we concluded that cycling to school contributed to the lower standardised composite score in the intervention group.

The most commonly reported factors, and those that are apparently reliable predictors of active commuting (usually by foot and by bicycle), are the distance between the household and the school, and family-driven factors such as parents' evaluation of public safety, fear of traffic *en route*, and convenience (44). In this study sample, the factor shown to be most determinative for active commuting to school was the level of educational achievement of the parent or parents; it was found that a higher level of educational achievement (university or postgraduate) correlated with a greater probability of children's active commuting to school by cycle (14). Therefore, future studies should take these factors into account when designing interventions to promote and improve cycling to/from school.

The primary limitations of this study are inherent to its cross-sectional nature and the type of sample used. It would be important to increase the population sample studied by including different age groups, or by expanding the survey to private schools (20). The strengths of this study include the fact that the questions in The Health Behaviour in School-Aged Children questionnaire have shown good reliability and validity in children/youth populations as well as the large sample size.

Our results provide some evidence that regular cycling to school compared with passive commuting may relate to greater speed-agility, muscular fitness, cardiorespiratory fitness, and lower metabolic syndrome, particularly in girls. Despite a high proportion of children and adolescents in Bogotá who already cycle to school, our results, together with other studies, should provide an impetus for the necessary social, environmental, and individual changes needed to promote safe bicycling for children and adolescents, and to maintain or improve healthy levels of cycling activity.

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