
Volume 55, Issue 2, August 2012
ISSN 0091-7435
ELSEVIER
PM
Preventive Medicine
This Month in
Preventive Medicine
Could Chinese herbal medicine be nephrotoxic?
Review Articles
Participation in immunochemical & guaiac faecal occult blood tests
Overweight/Obesity
Weight change misperceptions of US adults
Invited Commentary
Physical Activity (PA)
Bicycling to school & cardiorespiratory fitness in children
PA & neighborhood environments/transportation modes in older adults
Ecological momentary assessment of children's PA environment perceptions
Smoking
Money as motivation to quit among socially disadvantaged smokers
Breast Cancer Screening
Effectiveness of mailed reminders on compliance
Colorectal Cancer Screening
Identifying unmet needs of vulnerable populations
Liver Cancer Risk
Predicting 10-year risk in middle-aged Japanese
Invited Commentary
Skin Cancer/Sun Safety
Sun protection & vitamin D status in a subtropical community
Multiple Health Behaviors/Risk Factors
Reminders for cancer prevention: automated voice reminders or text messages?
Kidney Disease
Increased risk among users of non-prescribed Chinese herbal medicine
Available online at www.sciencedirect.com
SciVerse ScienceDirect

Preventive Medicine 55 (2012) 108–112

Contents lists available at SciVerse ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Bicycling to school is associated with improvements in physical fitness over a 6-year follow-up period in Swedish children

Palma Chillón [a,*], Francisco B. Ortega [a,b,c], Jonatan R. Ruiz [a,b], Kelly R. Evenson [d,e], Idoia Labayen [b,f], Vicente Martínez-Vizcaino [g], Anita Hurtig-Wennlöf [h], Toomas Veidebaum [i], Michael Sjöström [b]

[a] Department of Physical Education and Sport, School of Sport Sciences, University of Granada, Granada, Spain
[b] Department of Biosciences and Nutrition, Unit for Preventive Nutrition, Karolinska Institutet, Sweden
[c] Department of Physiology, School of Medicine, University of Granada, Granada, Spain
[d] Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, NC, USA
[e] Center for Health Promotion and Disease Prevention, University of North Carolina at Chapel Hill, NC, USA
[f] Department of Nutrition and Food Sciences, University of the Basque Country, UPV/EHU Vitoria, Spain
[g] Social and Health Care Research Center, University of Castilla-La Mancha, Cuenca, Spain
[h] School of Health and Medical Sciences / Clinical Medicine, Örebro University, Örebro, Sweden
[i] National Institute for Heath Development, Centre of Behavioral and Health Sciences, Tallinn, Estonia

ARTICLE INFO

Available online 7 June 2012

Keywords:
Bicycling
Walking
Fitness

ABSTRACT

Objective. To examine whether modes of commuting to school at baseline and changes in commuting were related to 6-year changes in cardiorespiratory fitness in youth.

Methods. A total of 262 (142 girls) Swedish children (9 years at entry) were measured at baseline (1998/9) and follow-up (2004/5). Mode of commuting to school was assessed by questionnaire and fitness by a maximal bicycle test.

Results. At baseline, 34% of children used passive modes of commuting (e.g., car, motorcycle, bus, train), 54% walked, and 12% bicycled to school. Six years later the percentage of bicyclists increased 19% and the percentage of walkers decreased 19%. On average, children who bicycled to school increased their fitness 13% ($p = 0.03$) more than those who used passive modes and 20% ($p = 0.002$) more than those who walked. Children who used passive modes or walked at baseline and bicycled to school at 6 years later increased their fitness 14% ($p = 0.001$) more than those who remained using passive modes or walking at follow-up.

Conclusions. Implementing initiatives that encourage bicycling to school may be a useful strategy to increase cardiorespiratory fitness of children.

Introduction

Cardiorespiratory fitness (henceforth referred to as fitness) during childhood and adolescence is an important health indicator (Ortega, et al., 2008). Low fitness has been associated with clustering of cardiometabolic risk factors (i.e., insulin resistance, lipid profile, blood pressure) in young people that may persist into adulthood (Andersen, et al., 2003). Physical activity is a major determinant of fitness (Ruiz and Ortega, 2009). Active transportation to/from school provides an opportunity for increasing levels of physical activity (Chillón et al., 2010; Davison, et al., 2008) and fitness (Aires, et al., 2011; Andersen, et al., 2009; Chillón et al., 2010) mainly when active commuting is by bicycle (Bere et al., 2011a,b; Ostergaard, et al., 2012).

There is an increasing interest regarding the long-term effects of active commuting to school on health parameters in youth. Two longitudinal studies in Danish (Cooper, et al., 2008) and Canadian children (Pabayo, et al., 2010) observed an association between active commuting to school with fitness and body mass index (BMI), respectively. However, two other longitudinal studies in US children (Heelan, et al., 2005; Rosenberg, et al., 2006) did not find significant associations between active commuting to school (mainly walking) and BMI. Two longitudinal studies conducted in cities where bicycling to school was common found positive associations between bicycling to school and a healthier weight (Bere et al., 2011a) and cardiometabolic risk factors (Andersen, et al., 2011). Longitudinal data on active commuting to school and its relationship with markers of total and central body fat (i.e., sum of 5 skinfolds, waist circumference) are lacking.

Among a sample of Swedish children, we aimed: 1) to describe longitudinal changes over 6-years in commuting to school patterns, 2)

* Corresponding author at: Department of Physical Education and Sport, School of Sport Sciences, University of Granada, Ctra. Alfacar, s/n, Granada 18011, Spain (España). Fax: +34 958 24 43 69.

E-mail addresses: pchillon@ugr.es (P. Chillón), ortegaf@ugr.es (F.B. Ortega), ruizj@ugr.es (J.R. Ruiz), Kelly_evenson@unc.edu (K.R. Evenson), idoia.labayen@ehu.es (I. Labayen), Vicente.Martinez@uclm.es (V. Martínez-Vizcaino), anita.hurtig-wennlof@oru.se (A. Hurtig-Wennlöf), toomas.veidebaum@tai.ee (T. Veidebaum), michael.sjostrom@ki.se (M. Sjöström).

0091-7435/$ – see front matter © 2012 Elsevier Inc. All rights reserved.
doi:10.1016/j.ypmed.2012.05.019

to examine the association between modes of commuting to school at childhood with 6-year changes in fitness, fatness, and cardiometabolic risk factors, and 3) to investigate the association between changes in mode of commuting to school and changes in fitness, fatness, and cardiometabolic risk factors from childhood to adolescence.

Methods

Study sample and design

The European Youth Heart Study (EYHS) addresses cardiovascular risk factors and their determinants in European children and adolescents (Riddoch, et al., 2005). The current study sample belongs to the Swedish part of the EYHS. A cohort study started in 1998/9 (Wennlöf, et al., 2003) and the participants were invited to complete the same examination in 2004/5 (Grjibovski, et al., 2006). The dropout rate was 60% (from 907 9 year old children to 278 15 year old adolescents). A total of 262 Swedish children with complete data on commuting to school at baseline and follow-up were included in the current study. The study protocol was approved by the Örebro County Council and Huddinge University Hospital. Parents or legal guardian provided written informed consent. All measures were performed at both time periods.

Assessment of active commuting to school

Participants completed a computerized questionnaire at both time periods with the following question: "How do you usually travel to school?" Possible answers were: by car or motorcycle, by bus or train, by bicycle, and on foot. Commuting to school was categorized as passive (car, motorcycle, bus, or train), walk, or bicycle. Similar questions have shown evidence for reliability and validity (Evenson, et al., 2008).

Assessment of fitness

Fitness was measured at both time periods by an incremental maximal cycle ergometer test (Hansen, et al., 1989) with evidence for validity (Riddoch, et al., 2005; Strong, et al., 2005). The "Hansen formula" (Hansen, et al., 1989) was used for calculating maximal oxygen consumption (VO_2max) expressed in absolute terms (l/min). Absolute levels of VO_2max are more suitable for comparison purposes and future meta-analyses, since they can be derived from different modes of fitness testing (e.g., treadmill, stair stepping) (Labayen, et al., 2012).

Assessment of fatness

Height (cm), weight (kg), and waist circumference (cm) were measured by standard procedures. Skinfold thicknesses (mm) were measured at the biceps, triceps, subscapular, suprailiac, and medial calf areas on the left side (Lohman, et al., 1991). The sum of 5 skinfolds and waist circumference were used as surrogates of total and central fatness, respectively.

Assessment of cardiometabolic risk factors

Blood samples were taken by venipuncture after an overnight fast. High-density lipoprotein cholesterol (HDLc), triglycerides (TG), and insulin levels were measured as reported elsewhere (Wennlöf et al., 2005). Systolic and diastolic blood pressures were measured with an automatic oscillometric method (Ruiz, et al., 2007). The mean arterial pressure (MAP) was calculated: diastolic blood pressure + [0.333 × (systolic blood pressure–diastolic blood pressure)]. The cardiometabolic risk score was calculated as the sum of the age-sex standardized scores (insulin, waist circumference, TG/HDLc, and MAP) multiplied by their loadings in a factorial model validated in children and adolescents from Spain, Sweden, and Estonia (Martínez-Vizcaino et al., 2010, 2011).

Assessment of covariates

Sexual maturation status was assessed at both time periods (Tanner and Whitehouse, 1976). Mother's and father's income was used as markers of socioeconomic level; incomes were reported by parents at baseline. Physical activity was objectively measured using an activity monitor (MTI model WAM 7164, Manufacturing Techonolgy Inc., Fort Walton Beach, FL) and expressed in counts/min (Chillón et al., 2010).

Statistical analysis

All statistical analyses were performed using SPSS (version 18.0, Chicago, IL, USA). The level of significance was set at <0.05 for all analyses. To describe longitudinal changes over 6-years in commuting to school patterns (aim 1), data were presented as percentages separately for girls and boys. To examine the association between modes of commuting to school at baseline with 6-year changes in fitness, fatness, and cardiometabolic risk factors (aim 2), interactions between gender with fitness (VO_2max), fatness (BMI, waist circumference, and sum of 5 skinfolds) and cardiometabolic risk factors (insulin, TG/HDLc, MAP, and cardiometabolic risk score) were studied using analysis of covariance (ANCOVA). Because there were only two time points (baseline and follow-up), ANCOVA was chosen, and modes of commuting to school at baseline was included as a fixed factor. Waist circumference, sum of 5 skinfolds, insulin, and TG/HDLc were log transformed. There were no interactions by gender; thus, analyses were conducted with boys and girls combined. The model for fitness was adjusted for gender, change in sexual maturation status, baseline VO_2max, and baseline weight. The models for fatness and cardiometabolic risk factors were adjusted for gender, change in sexual maturation status, and the baseline value of each studied outcome. Pairwise comparisons between baseline modes of commuting to school (passive vs. walk, passive vs. bicycle, and walk vs. bicycle) were adjusted for multiple testing using the Bonferroni correction.

To investigate the association between changes in mode of commuting to school and changes in fitness, fatness, and cardiometabolic risk factors from childhood to adolescence (aim 3), we focused on the participants who were passive or walkers at baseline. We compared changes in fitness, fatness, and cardiometabolic risk factors between those that became bicyclists at follow-up (called the passive/walk to bicycle group) compared to those who did not change the mode (called the persistent passive/walk group). These associations were examined by ANCOVA, and the same covariates as in aim 2 were included in the models. Additional analyses were calculated for changes in fitness, adjusting for baseline height, mother's income, father's income, and baseline physical activity, separately.

Results

(Aim 1) Changes in school commuting patterns

Characteristics of the study sample by gender at baseline and follow-up are shown in Table 1. In the whole sample, the percentage of passive commuting at baseline (34%) was similar at follow-up (34%); the percentage of bicyclists increased from 12% to 31%, and the percentage of walkers decreased from 54% to 35%, both from baseline to follow-up.

(Aim 2) Baseline commuting to school and changes in fitness, fatness, and cardiometabolic risk factors

The change observed in fitness significantly differed by commuting groups at baseline ($p = 0.003$, Table 2). On average, children who bicycled to school increased their fitness 13% ($p = 0.03$) more than those who used passive modes and 20% ($p = 0.002$) more than those who walked during the 6-year period. Changes in fatness and cardiometabolic risk factors did not differ between baseline commuting groups. Unadjusted values at baseline and follow-up for passive mode, walkers, and bicyclists are presented in Supplementary Table 1.

(Aims 3) Changes in commuting to school and changes in fitness, fatness, and cardiometabolic risk factors

The change (follow-up — baseline) observed in fitness significantly differed among passive/walker participants at baseline that kept with the same mode of commuting at follow-up and those who changed their mode of commuting to school as bicyclists at follow-up (Table 3). Children who were passive or walked at baseline and bicycled to school at follow-up increased their fitness 14% ($p = 0.001$) more than those who kept passive or walking 6-years later. When these analyses were

Table 1
Baseline (1998/9) and follow-up (2004/5) characteristics of the Swedish cohort (n = 262).

	Baseline (1998/9)						Follow-up (2004/5)					
	Girls			Boys			Girls			Boys		
	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)	n	Mean	(SD)
Age (years)	142	9.5	(0.4)	120	9.5	(0.3)	142	15.5	(0.4)	120	15.5	(0.3)
Tanner stage (% at I/II/III/IV/V)	140	65/33/3/0/0		113	99/1/0/0/0		140	0/5/24/49/22		111	1/3/6/22/69	
Weight (kg)	141	32.7	(6.6)	119	33.5	(6.5)	142	56.9	(8.9)	120	64.0	(10.9)
Height (cm)	141	137.8	(6.6)	119	139.2	(5.6)	142	164.7	(5.4)	120	176.5	(7.1)
Commuting (% Passive/Walk/Bicycle)	142	38/49/13		120	28/60/12		142	35/37/28		120	33/32/35	
VO_2max (l/min)	137	1.2	(0.2)	115	1.4	(0.2)	131	2.2	(0.4)	116	3.1	(0.5)
Body mass index (kg/m^2)	141	17.1	(2.3)	119	17.2	(2.5)	142	20.9	(2.7)	120	20.5	(2.9)
Waist circumference (cm)	141	59.2	(6.0)	119	60.6	(6.3)	142	68.4	(6.6)	120	71.7	(6.6)
Sum of 5 skinfolds (mm)	132	45.5	(17.4)	117	40.8	(18.0)	142	69.8	(24.8)	117	45.2	(19.6)
Insulin (pmol/L)	89	33.1	(14.5)	96	28.4	(12.4)	128	52.1	(22.9)	116	45.0	(22.1)
Triglyceride (mmol/L)	106	0.8	(0.3)	103	0.6	(0.2)	129	0.8	(0.3)	116	0.9	(0.4)
HDL cholesterol (mmol/L)	106	1.4	(0.2)	103	1.5	(0.3)	129	1.5	(0.3)	116	1.4	(0.3)
Systolic blood pressure (mm Hg)	141	104.1	(7.3)	120	103.6	(6.9)	140	106.1	(8.8)	119	111.0	(10.8)
Diastolic blood pressure (mm Hg)	141	62.8	(5.9)	120	61.1	(5.3)	141	62.1	(6.5)	119	60.2	(6.3)
Cardiomebatolic risk score	87	0.1	(1.2)	94	−0.1	(1.2)	126	−0.2	(1.3)	116	−0.4	(1.4)

SD, standard deviation. VO_2max, maximal oxygen consumption.

further adjusted for baseline height, mother's income, and father´s income separately, the results persisted. However, when these analyses were adjusted for baseline physical activity the association was attenuated ($p = 0.03$). There were no significant differences for fatness and cardiometabolic risk factors among the persistent passive/walk group and the passive/walk to bicycle group. Unadjusted values at baseline and follow-up for persistent passive/walkers and passive/walkers that changed to bicycling are presented in Supplementary Table 2.

Discussion

The results suggest that in this cohort of Swedish children: 1) bicycling to school increased while walking to school decreased from childhood to adolescence, both in girls and boys; 2) bicycling to school in childhood was related to improvements in fitness 6 years later; 3) passive/walker children who became bicyclists at adolescence improved their fitness levels compared to those who kept commuting by passive/walking; and 4) the two previous findings were not observed for changes in fatness and cardiometabolic risk factors.

Patterns of active commuting to school changed similarly in boys and girls from childhood to adolescence; the prevalence of bicycling increased and the prevalence of walking decreased. A similar change in active commuting patterns was found among Danish youth (Cooper, et al., 2008) from childhood to adolescence, with bicycling increasing and walking declining. This might be related with age-related independent mobility (Davison, et al., 2006; Page, et al., 2010). Both participants and parents might perceive that it is safer to bicycle rather than walk during adolescence. Another reason might be that distance to school increased (e.g., secondary school was farther than primary school), making it more feasible to bicycle rather than walk.

The current study showed that children who bicycle to school at baseline improved their VO_2max more than those who were passive or walked to school over the 6-year period. This relationship was further supported when examining the relationship of longitudinal changes in mode of commuting with changes in fitness from childhood to adolescence. Passive/walker children who became bicyclists at adolescence improved their fitness levels more than those who kept commuting by passive/walking. The changes in fitness were mainly due to the change of commuting mode, because statistical analyses were adjusted for baseline weight and change in sexual maturation status. When these analyses were additionally adjusted for baseline height and mother or father's incomes separately, the results persisted. However, when these analyses were adjusted for baseline physical activity assessed by accelerometry the association was attenuated. However, this adjustment is of concern because the measure includes counts taken from active commuting. Whether the differences in the improved fitness between those who bicycled to school and those who walked or used passive modes to school was due solely to active commuting or to a higher overall physical activity remains to be established.

We did not find significant associations between mode of commuting to school and fatness levels or cardiometabolic risk factors. It might be that bicycling is not enough stimulus to improve the levels of fatness and cardiometabolic risk factors. However, fatness might be improved in bicyclists followed for a longer period, since there were small

Table 2
Mean and 95% confidence intervals (CI) of changes (follow up-baseline) in fitness, fatness, and cardiometabolic risk factors by mode of commuting to school at baseline (1998/9) in the Swedish cohort (n = 262).

Modes of commuting to school at baseline										
Change in:	Passive			Walk			Bicycle			P[a]
	n	Mean	95% CI	n	Mean	95% CI	n	Mean	95% CI	
VO_2max (l/min)	75	1.289	1.210 to 1.367	118	1.235	1.172 to 1.298	28	1.488	1.360 to 1.617	0.003
Body mass index (kg/m^2)	82	3.601	3.188 to 4.014	131	3.555	3.227 to 3.882	29	3.642	2.945 to 4.339	0.97
Waist circumference[b] (cm)	82	10.157	9.084 to 11.231	131	9.879	9.028 to 10.730	29	9.940	8.131 to 11.749	0.88
Sum of 5 skinfolds[b] (mm)	78	14.501	10.865 to 18.137	125	13.564	10.693 to 16.436	26	14.836	8.574 to 21.098	0.99
Insulin[b] (pmol/L)	53	13.501	8.209 to 18.793	86	14.473	10.349 to 18.597	20	20.322	11.693 to 28.951	0.59
Triglycerides/HDLc[b] (mmol/L)	61	0.108	0.030 to 0.187	100	0.100	0.039 to 0.161	22	0.068	−0.062 to 0.198	0.73
Mean arterial pressure (mm Hg)	81	0.942	−0.387 to 2.271	129	0.459	−0.593 to 1.511	29	2.205	−0.011 to 4.420	0.37
Cardiometabolic risk score	52	−0.398	−0.704 to −0.091	85	−0.493	−0.731 to −0.255	20	0.019	−0.471 to 0.509	0.18

All analyses were adjusted for gender, change in sexual maturation status, and the baseline value of each studied outcome. In addition, fitness was adjusted for baseline weight.
[a] P overall from ANCOVA analyses within the passive, walk, and bicycle groups; each row is a separate analysis.
[b] Log-transformed data were used in the analysis, but raw data are shown in the table.

Table 3
Mean and 95% confidence intervals (CI) of changes (follow up-baseline) in fitness, fatness and cardiometabolic risk factors for persistent passive/walkers and those who changed from passive/walk to bicycle from baseline (1998/9) to follow-up (2004/5) in the Swedish cohort (n = 262).

Changes in modes of commuting to school							
Change in:	Persistent Passive/Walk			Passsive/Walk to Bicycle			P[a]
	n	Mean	95% CI	n	Mean	95% CI	
VO_2max (l/min)	136	1.205	1.146 to 1.263	57	1.383	1.292 to 1.473	0.001
Body mass index (kg/m^2)	153	3.676	3.379 to 3.973	60	3.376	2.900 to 3.853	0.29
Waist circumference[b] (cm)	153	9.955	9.161 to 10.749	60	10.373	9.098 to 11.647	0.68
Sum of 5 skinfolds[b] (mm)	146	14.992	12.414 to 17.571	57	12.097	7.953 to 16.241	0.19
Insulin[b] (pmol/L)	97	14.048	10.377 to 17.707	42	12.464	6.849 to 18.079	0.79
Triglycerides/HDLc[b] (mmol/L)	112	0.124	0.066 to 0.181	49	0.062	−0.025 to 0.150	0.39
Mean arterial pressure (mm Hg)	151	0.701	−0.292 to 1.695	59	0.688	−0.909 to 2.284	0.99
Cardiometabolic risk score	95	−0.458	−0.676 to −0.239	42	−0.516	−0.846 to −0.186	0.77

All analyses were adjusted for gender, change in sexual maturation status, and the baseline value of each studied outcome. In addition, fitness was adjusted for baseline weight.
[a] P overall from ANCOVA analyses within the persistent passive/walk and the passive/walk to bicycle groups; each row is a separate analysis.
[b] Log-transformed data were used in the analysis, but raw data are shown in the table.

improvements in the sum of 5 skinfolds. Participants reported short bicycling trips; 90% of the trips lasted less than 15 min. Similar results were observed in a cohort of 7th grade US children; active commuting to school over 2 years was not associated with changes in BMI or weight status (Rosenberg, et al., 2006). Pabayo, et al. (2010) found improvements in BMI of early adolescent Canadian children with sustained active transportation in 3 years. Also, in a longitudinal study among Norwegian and Dutch adolescents, those who continued bicycling had a lower odds of being overweight than those that did not bicycle, those that stopped bicycling, and those that started bicycling (Bere et al., 2011a). A longitudinal study has recently shown a consistent pattern of better cardiovascular risk factor profile in commuter bicyclists compared with children using other means of transport in Denmark (Andersen, et al., 2011). The two previous studies occurred in cities with a long-standing tradition of bicycling and rates of bicycling were more than 30% among participants.

Limitations

The current study presented some limitations. The sample size was low to test all possible combinations regarding passive, walkers, and bicyclists at baseline and follow-up. A larger sample size is needed to confirm the results. The question used for assessing commuting to school did not account for frequency or multi-modes and it only reported the trip to school. Moreover, we categorized all motorized modes of transportations (car, motorcycle, bus, or train) as passive; however, previous studies found differences in energy expenditure between mass transit transportation and transportation by car (Morabia, et al., 2010). There might be other covariates not measured that would account for changes in fitness, such as distance to school. There were only two time points (baseline and follow-up) for analyzing the longitudinal changes.

Fitness was measured using a cycle ergometer and frequent bicyclists might perform the test better than walkers and passive commuters. This limitation has also been showed in previous studies (Andersen, et al., 2009; Chillón et al., 2010; Cooper, et al., 2008). A cross-sectional study carried out in English children assessed fitness using the 20 m shuttle-run test (Voss and Sandercock, 2010) and showed that those who bicycled to school were fitter than passive travelers (car and public transportation). In this study, fitness was assessed by a running test, which suggests that associations between bicycling to school and fitness may only be observed in studies using either bicycling or running tests to assess fitness.

Conclusion

Bicycling to school in childhood was associated with fitness improvements over a 6-year period and becoming a bicyclist to school was also associated with fitness improvements. Implementing initiatives that encourage bicycling to school for young people might be a useful public health strategy. To date, interventions promoting active commuting to school have been implemented and assessed, but with limited effectiveness (Chillón et al., 2011). Our data support that more efforts focused on long-term outcomes and sustainability of active transportation to school, particularly bicycling, might be beneficial for youth health.

Supplementary materials related to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2012.05.019.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

Acknowledgments

We are grateful to the Swedish participants and families, as well as the European Youth Heart Study field teams. This study was supported by grants from the Stockholm County Council and by the Spanish Ministry of Science and Innovation (RYC-2010-05957, RYC-2011-09011).

References

Aires, L., Pratt, M., Lobelo, F., Santos, R.M., Santos, M.P., Mota, J., 2011. Associations of cardiorespiratory fitness in children and adolescents with physical activity, active commuting to school, and screen time. J. Phys. Act. Health 8 (Suppl. 2), S198–S205.
Andersen, L.B., Wedderkopp, N., Hansen, H.S., Cooper, A.R., Froberg, K., 2003. Biological cardiovascular risk factors cluster in Danish children and adolescents: the European Youth Heart Study. Prev. Med. 37, 363–367.
Andersen, L.B., Lawlor, D.A., Cooper, A.R., Froberg, K., Andersen, S.A., 2009. Physical fitness in relation to transport to school in adolescents: the Danish youth and sports study. Scand. J. Med. Sci. Sports 19, 406–411.
Andersen, L.B., Wedderkopp, N., Kristensen, P., Moller, N.C., Froberg, K., Cooper, A.R., 2011. Cycling to school and cardiovascular risk factors: a longitudinal study. J. Phys. Act. Health 8, 1025–1033.
Bere, E., Oenema, A., Prins, R.G., Seiler, S., Brug, J., 2011a. Longitudinal associations between cycling to school and weight status. Int. J. Pediatr. Obes. 6, 182–187.
Bere, E., Seiler, S., Eikemo, T.A., Oenema, A., Brug, J., 2011b. The association between cycling to school and being overweight in Rotterdam (The Netherlands) and Kristiansand (Norway). Scand. J. Med. Sci. Sports 21, 48–53.
Chillón, P., Ortega, F.B., Ruiz, J.R., Veidebaum, T., Oja, L., Maestu, J., Sjöström, M., 2010. Active commuting to school in children and adolescents: an opportunity to increase physical activity and fitness. Scand. J. Public Health 38, 873–879.
Chillón, P., Evenson, K.R., Vaughn, A., Ward, D.S., 2011. A systematic review of interventions for promoting active transportation to school. Int. J. Behav. Nutr. Phys. Act. 8, 10.
Cooper, A.R., Wedderkopp, N., Jago, R., Kristensen, P.L., Moller, N.C., Froberg, K., Page, A.S., Andersen, L.B., 2008. Longitudinal associations of cycling to school with adolescent fitness. Prev. Med. 47, 324–328.
Davison, K.K., Marshall, S.J., Birch, L.L., 2006. Cross-sectional and longitudinal associations between TV viewing and girls' body mass index, overweight status, and percentage of body fat. J. Pediatr. 149, 32–37.
Davison, K.K., Werder, J.L., Lawson, C.T., 2008. Children's active commuting to school: current knowledge and future directions. Prev. Chronic Dis. 5 (3), A100.
Evenson, K.R., Neelon, B., Ball, S.C., Vaughn, A., Ward, D.S., 2008. Validity and reliability of a school travel survey. J. Phys. Act. Health 5 (Suppl. 1), S1–S15.
Grjibovski, A.M., Bergman, P., Hagströmer, M., Wennlöf, A.H., Meusel, D., Ortega, F.B., Patterson, E., Poortvliet, E., Rizzo, N., Ruiz, J.R., Wärnberg, J., Sjöström, M., 2006. A dropout analysis of the second phase of the Swedish part of the European Youth Heart Study. J. Public Health 14, 261–268.

Hansen, H.S., Froberg, K., Nielsen, J.R., Hyldebrandt, N., 1989. A new approach to assessing maximal aerobic power in children: the Odense School Child Study. Eur. J. Appl. Physiol. Occup. Physiol. 58, 618–624.

Heelan, K.A., Donnelly, J.E., Jacobsen, D.J., Mayo, M.S., Washburn, R., Greene, L., 2005. Active commuting to and from school and BMI in elementary school children-preliminary data. Child Care Health Dev. 31, 341–349.

Labayen, I., Ruiz, J.R., Ortega, F.B., Loit, H.M., Harro, J., Villa, I., Veidebaum, T., Sjostrom, M., 2012. Exclusive breastfeeding duration and cardiorespiratory fitness in children and adolescents. Am. J. Clin. Nutr. 95, 498–505.

Lohman, T.G., Roche, A.F., Martorell, R., 1991. Anthropometric standardization reference manual, 55–70. Human Kinetics, Champaign, IL.

Martínez-Vizcaino, V., Martínez, M.S., Aguilar, F.S., Martinez, S.S., Gutiérrez, R.F., López, M.S., Martínez, P.M., Rodriguez-Artalejo, F., 2010. Validity of a single-factor model underlying the metabolic syndrome in children: a confirmatory factor analysis. Diabetes Care 33, 1370–1372.

Martínez-Vizcaino, V., Ortega, F.B., Solera-Martinez, M., Ruiz, J.R., Labayen, I., Eensoo, D., Harro, J., Loit, H.M., Veidebaum, T., Sjostrom, M., 2011. Stability of the factorial structure of metabolic syndrome from childhood to adolescence: a 6-year follow-up study. Cardiovasc. Diabetol. 10, 81.

Morabia, A., Mirer, F.E., Amstislavski, T.M., Eisl, H.M., Werbe-Fuentes, J., Gorczynski, J., Goranson, C., Wolff, M.S., Markowitz, S.B., 2010. Potential health impact of switching from car to public transportation when commuting to work. Am. J. Public Health 100, 2388–2391.

Ortega, F.B., Ruiz, J.R., Castillo, M.J., Sjöström, M., 2008. Physical fitness in childhood and adolescence: a powerful marker of health. Int. J. Obes. (Lond.) 32, 1–11.

Ostergaard, L., Grontved, A., Borrestad, L.A., Froberg, K., Gravesen, M., Andersen, L.B., 2012. Cycling to School Is Associated With Lower BMI and Lower Odds of Being Overweight or Obese in a Large Population-Based Study of Danish Adolescents. J. Phys. Act. Health 9, 617–625.

Pabayo, R., Gauvin, L., Barnett, T.A., Nikiema, B., Seguin, L., 2010. Sustained active transportation is associated with a favorable body mass index trajectory across the early school years: findings from the Quebec Longitudinal Study of Child Development birth cohort. Prev. Med. 50 (Suppl. 1), S59–S64.

Page, A.S., Cooper, A.R., Griew, P., Jago, R., 2010. Independent mobility, perceptions of the built environment and children's participation in play, active travel and structured exercise and sport: the PEACH Project. Int. J. Behav. Nutr. Phys. Act. 7, 17.

Riddoch, C., Edwards, D., Page, A., Froberg, K., Anderssen, S., Wedderkopp, N., Brage, S., Cooper, A.R., Sardinha, L.B., Harro, M., Klasson-Heggebo, L., van Mechelen, W., Boreham, C., Ekelund, U., Andersen, L.B., the European Youth Heart Study team, 2005. European Youth Heart Study-Cardiovascular disease risk factors in children: Rationale, aims, study design, and validation of methods. J. Phys. Act. Health 2, 115–129.

Rosenberg, D.E., Sallis, J.F., Conway, T.L., Cain, K.L., McKenzie, T.L., 2006. Active transportation to school over 2 years in relation to weight status and physical activity. Obesity (Silver Spring) 14, 1771–1776.

Ruiz, J.R., Ortega, F.B., 2009. Physical Activity and Cardiovascular Disease Risk Factors in Children and Adolescents. Curr. Cardiovasc. Risk Rep. 1, 281–287.

Ruiz, J.R., Ortega, F.B., Loit, H.M., Veidebaum, T., Sjöström, M., 2007. Body fat is associated with blood pressure in school-aged girls with low cardiorespiratory fitness: The European Youth Heart Study. J. Hypertens. 25, 2027–2034.

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. J. Pediatr. 146, 732–737.

Tanner, J.M., Whitehouse, R.H., 1976. Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. Arch. Dis. Child. 51, 170–179.

Voss, C., Sandercock, G., 2010. Aerobic fitness and mode of travel to school in English schoolchildren. Med. Sci. Sports Exerc. 42, 281–287.

Wennlöf, A., Yngve, A., Sjöström, M., 2003. Sampling procedure, participation rates and representativeness in the Swedish part of the European Youth Heart Study (EYHS). Public Health Nutr. 6, 291–299.

Wennlöf, A.H., Yngve, A., Nilsson, T.K., Sjöström, M., 2005. Serum lipids, glucose and insulin levels in healthy schoolchildren aged 9 and 15 years from Central Sweden: reference values in relation to biological, social and lifestyle factors. Scand. J. Clin. Lab. Invest. 65, 65–76.