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Influence of active commuting on cardiorespiratory fitness in schoolchildren
Influencia de los desplazamientos activos sobre la aptitud cardiorrespiratoria en escolares

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Abstract. Active commuting (walking or cycling) is associated with health benefits and cardiorespiratory fitness (CRF) improvements. The aim was to analyze the influence of active commuting on CRF in schoolchildren and, secondarily, to characterize the type and mode of active commuting used by the participants in this research. Study quantitative, descriptive-correlational design. 81 adolescents between 11 and 14 years from two municipal schools in Talca, Chile, were evaluated. The active commuting was evaluated with the PACO questionnaire (from its acronym in Spanish, *Pedalea y anda al Cole*) while the CRF was obtained through the Course Navette test, which allows indirect estimation of the oxygen consumption (VO2max) of the participants. The Statistical Package for the Social Sciences (SPSS) version 25 software was used for the statistical analysis, and a multiple linear regression analysis was conducted. Schoolchildren who engage in active commuting have a significantly higher VO2max compared to those with passive commuting ($p<0.001$; β=2.267). Among the adjustment variables, age was found to have a significant influence on the model, with younger schoolchildren exhibiting a higher VO2max ($p=0.043$; β=-1.118). Sex and body mass index did not affect the VO2max outcome. This study showed that active commuting to and from school, as well as the age of the participants, influence CRF, which could contribute to improved physical fitness.
Keywords: Transportation, Walking, Aerobic capacity, Adolescents, Active Commuting

Resumen. Los desplazamientos activos (caminar o andar en bicicleta) se asocian con beneficios para la salud y con mejoras en el fitness cardiorrespiratorio (FCR). El objetivo fue analizar la influencia del desplazamiento activo sobre el FCR en escolares y secundariamente, caracterizar el tipo y modo de desplazamiento activo de los participantes de esta investigación. Estudio de diseño cuantitativo, descriptivo-correlacional. Se evaluaron 81 adolescentes entre 11 y 14 años de dos colegios municipales de la ciudad de Talca, Chile. El desplazamiento activo se evaluó con el cuestionario PACO (Pedalea y anda al Cole), mientras que el FCR se obtuvo a través de la prueba *Course Navette*, que permite estimar el consumo de oxígeno (VO2max) de los participantes. Se utilizó el software *Statistical Package for the Social Sciences* (SPSS) y se realizó un análisis de regresión lineal múltiple. Escolares con desplazamiento activo presentan un VO_2max significativamente mayor en comparación a que quienes tienen un desplazamiento pasivo ($p<0,001$; β= 2,267). Dentro de las variables de ajuste se pudo observar que la edad influye significativamente en el modelo, en donde los escolares de menor edad presentaron un mayor VO_2max ($p=0,043$; β=-1,118). El sexo y el índice de masa corporal no influyeron en el resultado del VO_2max. Este estudio mostró que los desplazamientos activos hacia y desde la escuela y la edad de los participantes influyen sobre el FCR, lo que podría contribuir a mejorar la condición física.
Palabras clave: Transporte, caminar, Capacidad aeróbica, Adolescentes, Transporte activo.

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Introduction

The World Health Organization (WHO) recommends that children and adolescents do at least 60 minutes a day of moderate to vigorous intensity physical activity (OMS, 2020). This practice has shown significant benefits for cardiovascular and metabolic health (Elagizi et al., 2020), in addition to reducing the risk of overweight and obesity (Sun et al., 2021). However, despite extensive evidence supporting the benefits of physical activity, a significant increase in physical inactivity and sedentary behavior has been observed across all ages, particularly in children and adolescents (Gonzalez-Torres et al., 2023; Patiño et al., 2022). Research revealed that more than 81% of adolescents in school between 11 and 17 years old fail to meet the minimum daily recommendations for physical activity established by the WHO (Chaput et al., 2020) and that the prevalence of physical inactivity in children and adolescents reaches 80.7% (Aguilar-Farias et al., 2016). In Chile, one study revealed that 8 out of 10 adolescents are physically inactive (Aguilar-Farias et al., 2016), while Guthold et al. (2020) revealed that the prevalence of physical inactivity reached 84.2% in preadolescents and 91.2% in adolescents (Guthold et al., 2020). It has been observed that among the various causes that contribute to the increase in physical inactivity and sedentary behavior is spending long hours using screens and electronic devices (Nguyen et al., 2020). Likewise, physical inactivity has experienced notable growth due to the phenomenon of globalization and increased access to different means of transportation (Rodriguez-Rodriguez et al., 2022; Te Velde et al., 2017). Thus, commuting passive such as car use or public transportation, has been associated with a reduction in participation in physical activities, which could have a negative impact on cardiovascular health and cardiorespiratory fitness (CRF) of teenagers (Reimers et al., 2021). The CRF is a physiological indicator of the health of body systems and an important marker of physical activity (Vásquez-Gómez et al., 2020). It is capable of estimating the body's respiratory capacity in the face of a maximum or submaximal stress test (Garber et al., 2011). Likewise, it is considered an essential component of physical condition, positioning itself as one of the most significant health indicators and a predictor of morbidity, mortality and non-communicable diseases (Gómez-Cabello et al., 2018; Imboden et al., 2018). A study revealed an inverse relationship between physical inactivity and a decrease in CRF (Smith et al., 2014), while López-Bueno et al. (2021) estimated a 7.3% reduction in maximum oxygen consumption (VO2max) in physically inactive adolescents compared to their physically active peers (López-Bueno et al., 2021). Finally, Ruiz et al. (2019) showed that adolescents who do not meet the minimum physical activity recommendations have a significant reduction in their aerobic capacity.

Faced with this, the practice of physical activity and strategies that allow achieving the recommendations proposed by the WHO, such as commuting to and from school have been positioned as efficient alternatives to reverse the harmful effects that physical inactivity and sedentary behavior affects the CRF and cardiovascular health of adolescents (Chang et al., 2023). Active commuting to school is the action of going to the educational center utilizing transport that involves energy expenditure such as walking or cycling (Nieuwenhuijsen & Khreis, 2020; Gálvez-Fernándezet et al., 2021; Rodriguez-Rodriguez et al., 2022). This practice not only offers a way to incorporate physical activity into the daily routine but can also have a significant impact on CRF of the students (Chillón et al., 2010). In schoolchildren, active commuting to and from school by walking or cycling has been recognized as a good strategy to improve health and, at the same time, physical fitness (Campos-Garzón et al., 2023). Previous studies in rural and urban children and adolescents from Denmark, the United Kingdom, Estonia, and Sweden (Chillón et al., 2010; Voss & Sandercock, 2010) suggest an association between traveling by bicycle to and from school with a higher FCR. In contrast, other authors have not found such associations, which suggests the need to create new studies (Henriques-Neto et al., 2020; Villa-González et al., 2015).

Given that physical inactivity leads to a decline in crucial health components like CRF and considering that this decline could be mitigated or improved through active commuting to and from school, it's worth noting that the literature presents divergent perspectives on this matter. Hence, this study aimed to explore the relationship between active commuting and CRF among schoolchildren, and secondarily, to characterize the type and mode of active commuting used by the participants in this research.

Materials and Methods

Design and Participants

Descriptive - correlational study developed in June to November 2023. A non-probabilistic sample was selected for convenience, consisting of 81 schoolchildren of both sexes (44 males and 37 females) from two schools in the city of Talca, Chile. The inclusion criteria used were: a) adolescents of both sexes between 11 and 14 years old who had the authorization of their parents and/or legal guardians by signing an informed consent; b) they agreed to participate and signed an informed consent.

Exclusion criteria: a) had a musculoskeletal injury that made it impossible to perform the physical tests were excluded; b) had decompensated or uncontrolled neuromuscular, respiratory and/or cardiovascular disease; c) presence of pain, edema and/or inflammation at the time of evaluation; d) those who had ≥ 160 heartbeats per minute once the Cafra test was completed.

Instruments

Anthropometric measures

The Anthropometric measurements of weight and height were performed according to a standardized protocol based on the WHO guidelines (WHO, 2004). To determine weight, a calibrated digital scale (SECA® 813) and portable stadiometer (SECA® 217) were used. Students' weight was measured in kilograms, while height was measured in meters (m). Body mass index (BMI) was calculated using the formula weight (kg)/(height (m)^2).

Cardiorespiratory fitness

The CRF was estimated using the Course Navette test, which allows indirect estimation of VO2max (Ayán et al., 2015). The test consists of traveling a demarcated distance of 20 meters at an incremental speed of 0.5 km/h using an audible signal (Ayán et al., 2015). The test ends when the subject stops due to fatigue or when he or she places himself behind the line twice in a row when the acoustic signal sounds (Raghuveer et al., 2020).

The estimation of VO2max in the Course Navette test was carried out through the equation proposed by Léger and Lambert (1988):

$VO2max=31.025 + (3.238 \times VFA) - (3.248 \times E) + (0.1536 \times VFA \times E)$; where VFA= final speed reached and E=age.

Considering that the Course Navette test is maximal and

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indirect, the protocol was strictly adhered to achieve maximum values from the participants. In response to this, participants were instructed to run at an increasingly standardized pace. Additionally, the staff administering the test provided continuous support and encouragement to motivate participants to reach their maximum performance (Cazorla, 2003).

Before the execution of the Course Navette test, the Cafra test was applied, which has the function of determining the cardiovascular adaptive capacity of schoolchildren based on workloads during walking (Ministry of Education [MINEDUC], 2015). The test consisted of the student having to walk maintaining a constant speed of 6 km/h for 3 minutes on a pentagon of 10 meters on each side (a total of 500 meters) to the rhythm of a sound stimulus. At the end of the test, heart rate was monitored using a heart rate monitor (Polar F4, Finland). Schoolchildren who reached heart rates ≥ 160 heartbeats/minute were excluded and did not perform the Course Navette test since they could present cardiovascular risk (MINEDUC, 2015).

Active commuting to school

It was assessed through the application of the PACO questionnaire short version (from its acronym in Spanish, *Pedalea y anda al Cole*). This instrument contains questions about the mode of travel to the educational center and has been subjected to a validation procedure with children and young people between 7 and 19 years old (Chillón et al., 2017). The instrument consists of four questions through which it measures the mode of travel to and from school, as well as the weekly frequency of the students' mode of commuting (Chillón et al., 2010). Any student who made ≥ 8 active trips (round trip) per week, whether walking or cycling, was categorized as active commuting (Vaquero-Solís et al., 2021; Vaquero-Solís et al., 2022).

Procedures and Ethical Considerations

In the first instance, permissions were requested from the school directors and teachers. After that, for two weeks the dissemination and invitation to participate in the study was carried out. The volunteers who agreed to participate in the research signed an informed consent form, while their parents also provided authorization by signing a separate informed consent form. These documents established that their data would be utilized for scientific research purposes. The confidentiality of their background, methodology, and objective of the study were explained before data recording. The participants were included voluntarily.

This research was developed following the ethical standards outlined in the Declaration of Helsinki, which regulates work with human beings (General Assembly of the World Medical Association, 2014).

Statistical analysis

The statistical analysis was performed using SPSS software, version 25.0. The results were described using measures of central tendency, such as the mean, and dispersion, using the standard deviation (SD). Before conducting the inferential analysis, the presence of outliers was checked using Cook's Distance, normality was assessed with the Kolmogorov-Smirnov test, and independence was evaluated using the Durbin-Watson test.

For the inferential analysis, a multiple linear regression (95% confidence interval [95% IC]) was used with VO2max as the dependent variable. The collinearity of the variables was verified using tolerance values less than 0.10 and variance inflation factor (VIF) values greater than 10.0 to confirm the absence of multicollinearity. The type I error rate was set at 5%, and the statistical power at 0.8.

Results

Table 1 shows the mean and standard deviation of age, weight, height, and BMI of the participants in this study divided by sex.

Table 1.
Characteristics of the sample

	All		Men		Women	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	12.7	0.88	12.9	0.78	12.4	0.93
Weight (kg)	60.0	15.9	58.9	16.6	61.3	15.3
Height (m)	1.59	0.08	1.60	0.09	1.57	0.06
BMI (kg/m²)	23.6	5.27	22.7	4.91	24.6	5.56

BMI: body mass index; SD: Standard deviation.

Table 2 shows the results obtained in VO2max and active commuting of the men and women in this study. In general, the average VO2max obtained by the participants was 38.2 ml kg^{-1} min^{-1} and they obtained an average of 5.66 active commuting. No differences were observed in maximum VO2 between men and women (*p=0.51*) in the number of total commuting (*p=0.80*), commuting to school (*p=0.49*), or in the number of commuting from school (*p=0.15*).

Table 2.
Results of commuting active and CRF measured through VO2 max based on sex

	All		Men		Women		
	Mean	SD	Mean	SD	Mean	SD	p value
VO2max (ml kg-^{1} min-^{1})	38.2	4.42	38.7	3.55	37.7	4.55	0.51
Active commuting							
N° commuting to school	2.77	2.30	3.00	2.26	2.57	2.35	0.49
N° commuting from school	2.85	2.29	3.14	2.20	2.61	2.35	0.15
N° total commuting	5.62	4.32	6.14	4.26	5.18	4.38	0.80

N°= number

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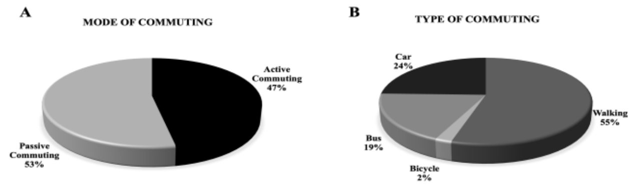

Figure 1. Mode and type of commuting of participants

Figure 1A shows that of the total participants, 53% used passive commuting to get to and from school, while 47% used active commuting. The different types of commuting used are shown in Figure 1B where it is observed that within active commuting the main methodology was walking (55%) and only 2% used a bicycle.

The linear regression model obtained was significant ($p<0.001$) after adjusting for the variables age, sex, BMI, and mode of commuting. Overall, it was observed that schoolchildren with active commuting had a significantly higher VO2max compared to those with passive commuting ($p < 0.001$; $\beta=2.267$). Among the adjustment variables, age significantly influenced the model, with younger schoolchildren showing a higher VO2max ($p = 0.043$; $\beta = -1.118$). Sex and BMI did not affect the VO2max outcome (Table 3).

Table 3.
Linear Regression Model for VO2max

Outcome	R^2	β	95% IC	p value
Intercept		53.5	38.6 to 68.5	<0.001***
Active commuting	0.306	2.26	0.17 to 4.30	0.034*
Male		1.53	-0.21 to 3.29	0.085
Age		-1.11	-2.20 to -0.03	0.043*
BMI		-0.12	-0.28 to 0.03	0.125

*p<0,05; ***p<0,001; BMI: body mass index.

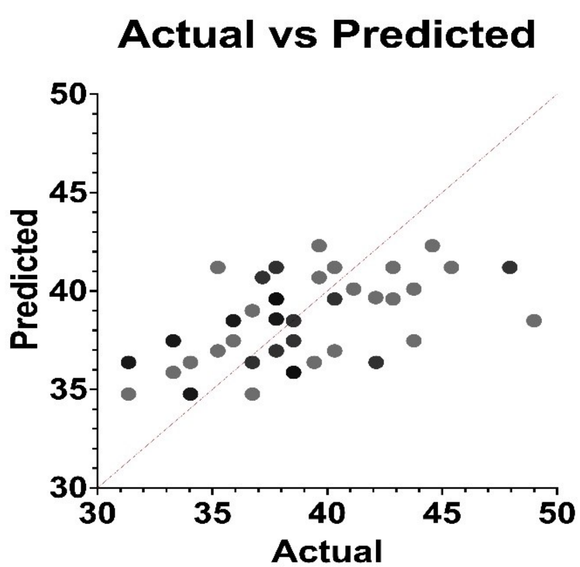

Figure 2. Graph of Actual vs. Predicted Values by Linear Regression Model for VO2max

Figure 2 shows a graph comparing the actual values of the dependent variable (VO2max) with the values predicted by our model. Each point on the graph represents an observation from the obtained data. The dispersion of the points relative to the ideal line reflects how well the model is performing. The closer the points are to the line, the better the model's predictions. Therefore, as observed in Figure 2, the model obtained in this analysis shows a tendency to predict the actual VO2max values accurately.

Discussion

The main objective of this research was to analyze the influence of active commuting on CRF in schoolchildren and secondarily, to characterize the type and mode of active commuting used by the participants in this research. Based on this, the main results revealed that schoolchildren with active commuting have a significantly higher VO2max compared to those with passive commuting. Additionally, younger schoolchildren exhibited a higher VO2max. Sex and BMI did not influence the VO2max outcome.

Similar results were previously reported in Swedish adolescents, where it was found that increased cycling activity to and from school significantly influenced ($p < 0.001$) a higher VO2max and thus greater CRF (Chillón et al., 2010). Similarly, in 9.7-year-old Danish children, cycling to school was significantly associated with greater CRF in children of both sexes (Cooper et al., 2006). The same result was found in 9-year-old Norwegian children (Østergaard et al., 2013). A possible explanation for our findings is that physical activity such as walking or cycling to school increases myocardial contractility, allowing for an increase in stroke volume and a reduction in heart rate both at rest and during exercise, reflecting greater cardiovascular efficiency (Mihaileanu, 2016). Additionally, muscle perfusion and oxygen transport are optimized, facilitated by higher capillary density and improved endothelial function. In the pulmonary domain, physical activity enhances vital capacity and the efficiency of gas exchange, increasing the VO2max that the lungs can absorb and transfer to the blood (Sagiv & Sagiv, 2012). At the cellular level, exercise stimulates mitochondrial biogenesis and the activity of oxidative enzymes, boosting the aerobic capacity of muscle fibers (Thomas & Dunn, 2019).

In contrast, Villa González et al. (2015) and Henriques-Neto (2020) did not report significant associations, suggesting the need to create new studies (Henriques-Neto et al., 2020; Villa-González et al., 2015). Among the possible factors that could explain the lack of association found by the authors between CRF and active commuting are the ages of the participants, the mode of active commuting (for example, walking or cycling), the shortest distance of active commuting, neighborhoods with high deprivation and frequency of commuting (Henriques-Neto et al., 2020; Noonan et al., 2017). For example, the age of the participants can affect their level of physical fitness, as well as the mode of active commuting and the distance traveled. Similarly, neighborhood characteristics, such as the level of deprivation, can influence the ease and safety of active commuting. The frequency and total amount of time dedicated to active commuting can also play a significant role in the relationship with aerobic capacity. Together, these factors can influence the presence or absence of an association between active commuting and aerobic capacity observed in the study. Another finding of this study was that younger adolescents showed a higher VO2max, a result that contrasts with previous literature indicating an increase in VO2max as individuals age (Harrison et al., 2015; Marinho et al., 2020). One possible explanation for our results is that VO2max is influenced by biological maturation and physical development. During childhood and adolescence, VO2max increases with age, but this increase slows down in late adolescence. Younger children are in a stage of rapid growth, which may lead to a higher VO2max compared to children aged 13 or 14, who are in a stage of slower growth (Sánchez, 2020).

On the other hand, this study showed that passive commuting (53%) predominated among the participants active commuting (47%), a precedent that is aligned with previous literature. International studies have shown that only 33% of schoolchildren actively traveled to and from school (Jiménez Boraita et al., 2022), while in Spanish adolescents active commuting only reached 40% (Gálvez-Fernández et al., 2021). In recent years, a clear trend has been observed towards a decrease in active movement in schoolchildren, a worrying history because it reflects a loss of physical activity, which can have a negative impact on the physical fitness levels of children and adolescents.

Another finding of this research is that a predominance of the active commuting of the participants from school to home was observed, over the commuting from home to school, which could be explained given the cultural context of the region in which the adolescents reside (Jurak et al., 2021). In general, for the age group included in this study, school starts between 8:00 a.m. and 8:30 a.m., which corresponds to the parents leaving for work and therefore increases the probability of traveling by bus or car. Once the school day is over, adolescents must return home independently, preferring to walk or by bicycle. A similar predilection was reported in adolescents from Canada, the United States, and Iran, which showed that 4.6% to 8% more children and adolescents walked more from school than to school (Larsen et al., 2012; McDonald et al., 2014; Samimi & Ermagun, 2013).

On the other hand, when analyzing the type of commuting, the most frequent among the participants of this research was walking (55%), followed by the car (24%) and public transportation (bus) (19%). These results align with what was reported in a study of Mexican adolescents, where it was found that the most frequent modes of transportation were walking (66.2%), followed by the car (16.2%) and public transportation (15.3%) (Ortiz-Hernández et al., 2019). In both cases (2% and 1.6%, respectively), bicycle use is very reduced, so it should be promoted. Regarding the Colombian adolescent population, a recent study also reported that walking was the most used modality (40.3%) (Patiño et al., 2022).

Finally, when analyzing the VO2max obtained by the participants of this research (women = 37.7 ml kg^{-1} min^{-1} and men = 38.7 ml kg^{-1} min^{-1}), it is below that reported in different age populations. Similar. Villa-González et al (2020) using a 20-m shuttle run test reported an oxygen consumption of 42.6 ml kg^{-1} min^{-1} in men and 40.2 ml kg^{-1} min^{-1} in Spanish women aged 8 to 11 years (Villa-González et al., 2015), similar values were exhibited by Cardenas-Sanchez et al. (2017) with the same test in Slovenian adolescents. This suggests, therefore, that Chilean adolescents may have lower oxygen consumption levels compared to their international counterparts. This is concerning, given that CRF is considered a marker of cardiovascular health in youth (Villa-González et al., 2015). A recent meta-analysis suggested that a CRF less than 35 ml/kg/min in boys and girls aged 8 to 19 years could predict the risk of cardiovascular disease in young people, which further emphasizes the need for its assessment in this population (Ruiz et al., 2016).

Limitations and strengths

Among the strengths of this research is the use of validated methods to obtain the study variables. To assess CRF, the Course Navette test was applied, a test that is widely used to estimate the aerobic fitness of children and adolescents. Furthermore, it is a valid field test that is easy to apply in the school context. Even so, if possible, for future studies it is suggested to use direct methods such as ergospirometry or calorimetry. Among the limitations of this study is the descriptive-cross-sectional design of this study, which does not allow for establishing temporal relationships between the variables or cause-effect. In addition to this, we highlight the small size of the sample and the non-probabilistic sampling for convenience, which does not allow the generalization of the results to the population, and therefore, the findings obtained should be handled with caution. In addition to the above, for future studies on the topic, it is suggested to include individual and family characteristics of the participants, in addition to the distance between home and school, since this variable can have a mediating and moderating effect.

Finally, it is important to highlight that the inclusion of the Borg Scale to register the perceived effort of the participants would have significantly enhanced the study. The Borg Scale, a well-established tool for quantifying perceived exertion, offers valuable data on the subjective effort experienced during physical activity. Integrating this scale would have allowed for a more precise measurement of the participants' exertion levels, contributing to a more comprehensive evaluation of their cardiorespiratory response. This addition would have been instrumental in confirming that the performed tests achieved maximum exertion values, thereby bolstering the validity and reliability of the results. Future research should incorporate the Borg Scale to improve the accuracy and depth of data related to physical exertion and cardiorespiratory fitness.

Conclusions

This study shows that active commuting to and from school positively influences the CRF of adolescents. The health benefits observed in schoolchildren who engage in active commuting highlight the necessity of increasing efforts to promote this mode of transportation among the school population. To achieve this, public entities, schools, and local communities should be encouraged to provide support by ensuring safe routes to schools, creating bike lanes, reducing traffic speeds in school districts, and offering storage facilities for bicycles and other wheeled equipment at schools.

Conflict of interest

There is no conflict of interest in this study.

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References

Aguilar-Farias, N., Cortinez-O'Ryan, A., Sadarangani, K. P., Von Oetinger, A., Leppe, J., Valladares, M., . . . Walbaum, M. (2016). Results from Chile's 2016 report card on physical activity for children and youth. *Journal of physical activity and health*, 13(s2), S117-S123. https://doi.org/10.1123/jpah.2016-0314

Ayán, C., Cancela, J. M., Romero, S., & Alonso, S. (2015). Reliability of two field-based tests for measuring cardiorespiratory fitness in preschool children. *The Journal of Strength & Conditioning Research,* 29(10), 2874-2880. *DOI:* 10.1519/JSC.0000000000000934

Cadenas-Sanchez, C., Ruiz, J. R., Labayen, I., Huybrechts, I., Manios, Y., Gonzalez-Gross, M., . . . Vanhelst, J. (2017). Prevalence of metabolically healthy but overweight/obese phenotype and its association with sedentary time, physical activity, and fitness. *Journal of Adolescent Health*, 61(1), 107-114. https://doi.org/10.1016/j.jadohealth.2017.01.018

Campos-Garzón, P., Sevil-Serrano, J., García-Hermoso, A., Chillón, P., & Barranco-Ruiz, Y. (2023). Contribution of active commuting to and from school to device-measured physical activity levels in young people: A systematic review and meta-analysis. *Scandinavian Journal of Medicine & Science in Sports,* 33(11), 2110-2124. https://doi.org/10.1111/sms.14450

Chang, X., Wang, Z., Guo, H., Xu, Y., & Ogihara, A. (2023). Effect of physical activity/exercise on cardiorespiratory fitness in children and adolescents with type 1 diabetes: a scoping review. *International journal of environmental research and public health*, 20(2), 1407. https://doi.org/10.3390/ijerph20021407

Chaput, J.-P., Willumsen, J., Bull, F., Chou, R., Ekelund, U., Firth, J., . . . Katzmarzyk, P. T. (2020). 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: summary of the evidence. *International Journal of Behavioral Nutrition and Physical Activity,* 17, 1-9.

Chillón, P., Ortega, F. B., Ruiz, J. R., Veidebaum, T., Oja, L., Mäestu, J., & Sjöström, M. (2010). Active commuting to school in children and adolescents: an opportunity to increase physical activity and fitness. *Scandinavian journal of public health*, 38(8), 873-879. https://doi.org/10.1177/140349481038

Chillón, P., Herrador-Colmenero, M., Migueles, J. H., Cabanas-Sánchez, V., Fernández-Santos, J. R., Veiga, Ó. L., & Castro-Piñero, J. (2017). Convergent validation of a questionnaire to assess the mode and frequency of commuting to and from school. *Scandinavian Journal of Public Health*, 45(6), 612-620. https://doi.org/10.1177/1403494817718

Cooper, A. R., Wedderkopp, N., Wang, H., Andersen, L. B., Froberg, K., & Page, A. S. (2006). Active travel to school and cardiovascular fitness in Danish children and adolescents. *Medicine and science in sports and exercise,* 38(10), 1724-1731. https://doi.org/10.1249/01.mss.0000229570.02037.1d

Elagizi, A., Kachur, S., Carbone, S., Lavie, C. J., & Blair, S. N. (2020). A review of obesity, physical activity, and cardiovascular disease. *Current obesity reports,* 9, 571-581.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., . . . Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Medicine and science in sports and exercise, 43(7), 1334-1359. https://doi.org/10.1249/mss.0b013e318213fefb

Gálvez-Fernández, P., Herrador-Colmenero, M., Esteban-Cornejo, I., Castro-Piñero, J., Molina-García, J., Queralt, A., . . . Vidal-Conti, J. (2021). Active commuting to school among 36,781 Spanish children and adolescents: A temporal trend study. *Scandinavian journal of medicine & science in sports*, 31(4), 914-924. https://doi.org/10.1111/sms.13917

Cazorla G. (2003). Secular trends in the performance of children and adolescents (1980-2000): an analysis of 55 studies of the 20m shuttle run test in 11 countries. *Sports Medicine,* 33:285–300. doi: 10.2165/00007256-200333040-00003

General Assembly of the World Medical Association. (2014). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *The Journal of the American College of Dentists*, 81(3), 14-18.

Gonzalez-Torres, C., Yuing, T., Berral-de la Rosa, F., & Lizana, P. A. (2023). Physical Inactivity, Sedentary Behavior and Quality of Life in the Chilean Population: ENCAVI Results, 2015–2016. Healthcare, *11*(7), 1020; https://doi.org/10.3390/healthcare11071020

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents:

a pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet Child & Adolescent Health*, 4(1), 23-35. https://doi.org/10.1016/S2352-4642(19)30323-2

Gómez-Cabello, A., Vila-Maldonado, S., Pedrero-Chamizo, R., Villa-Vicente, J., Gusi, N., Espino, L., . . . Ara, I. (2018). La actividad física organizada en las personas mayores, una herramienta para mejorar la condición física en la senectud. *Revista Española de Salud Pública*, 92(1), e1-e10.

Harrison, C. B., Gill, N. D., Kinugasa, T., & Kilding, A. E. (2015). Development of aerobic fitness in young team sport athletes. *Sports Medicine*, 45, 969-983.

Henriques-Neto, D., Peralta, M., Garradas, S., Pelegrini, A., Pinto, A. A., Sánchez-Miguel, P. A., & Marques, A. (2020). Active commuting and physical fitness: A systematic review. *International Journal of Environmental Research and Public Health*, 17(8), 2721. https://doi.org/10.3390/ijerph17082721

Imboden, M. T., Harber, M. P., Whaley, M. H., Finch, W. H., Bishop, D. L., & Kaminsky, L. A. (2018). Cardiorespiratory fitness and mortality in healthy men and women. *Journal of the American College of Cardiology*, 72(19), 2283-2292.

Jiménez Boraita, R., Arriscado Alsina, D., Dalmau Torres, J. M., & Gargallo Ibort, E. (2022). Factors associated with active commuting to school in adolescents. *Cultura_Ciencia_Deporte* [CCD], 52(17). URI: http://hdl.handle.net/10952/5730

Jurak, G., Soric, M., Sember, V., Djuric, S., Starc, G., Kovac, M., & Leskosek, B. (2021). Associations of mode and distance of commuting to school with cardiorespiratory fitness in Slovenian schoolchildren: a nationwide cross-sectional study. *BMC Public Health*, 21(1), 1-10.

Larsen, K., Gilliland, J., & Hess, P. M. (2012). Route-based analysis to capture the environmental influences on a child's mode of travel between home and school. *Annals of the Association of American Geographers*, 102(6), 1348-1365. https://doi.org/10.1080/00045608.2011.627059

Leger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of sports sciences*, 6(2), 93-101. https://doi.org/10.1080/02640418808729800

López-Bueno, R., Calatayud, J., Andersen, L. L., Casaña, J., Ezzatvar, Y., Casajús, J. A., . . . Smith, L. (2021). Cardiorespiratory fitness in adolescents before and after the COVID-19 confinement: A prospective cohort study. *European Journal of Pediatrics*, 180, 2287-2293.

Mihaileanu, S. (2016). Left ventricular contactile reserve. *Current Approach to Heart Failure*, 127-148.

Marinho, J. L., Martins, A. O., Rey, E., & González-Víllora, S. (2020). Influence of biological maturation on speed, jump, and endurance in high-level youth soccer players. *Revista Brasileira de Ciências do Esporte*, 42, e2052.

Ministerio de Educación (MINEDUC), (2015). Informe Estudio Nacional de Educación Física. 8° básico. https://bibliotecadigital.mineduc.cl/handle/20.500.12365/4525

McDonald, N. C., Steiner, R. L., Lee, C., Rhoulac Smith, T., Zhu, X., & Yang, Y. (2014). Impact of the safe routes to school program on walking and bicycling. *Journal of the American planning Association*, 80(2), 153-167.

Nguyen, P., Le, L. K.-D., Nguyen, D., Gao, L., Dunstan, D. W., & Moodie, M. (2020). The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: an umbrella review of systematic reviews. *International Journal of Behavioral Nutrition and Physical Activity,* 17(1), 1-11.

Nieuwenhuijsen, M., & Khreis, H. (2020). Advances in transportation and health: Tools, technologies, policies, and developments. Elsevier.

Noonan, R. J., Boddy, L. M., Knowles, Z. R., & Fairclough, S. J. (2017). Fitness, fatness and active school commuting among Liverpool schoolchildren. *International journal of environmental research and public health*, 14(9), 995. https://doi.org/10.3390/ijerph14090995

Ortiz-Hernández, L., Vega-López, A. V., & Ayala-Hilario, C. (2019). Factores sociodemográficos asociados con los modos de transporte en escolares y adolescentes mexicanos. Boletín Médico del Hospital Infantil de México, 76(5), 225-236. https://www.medigraphic.com/cgi-bin/new/resumen.cgi?IDARTICULO=89233

Organización Mundial de la Salud (OMS), (2020). Directrices de la OMS sobre actividad Física y hábitos sedentarios. Ginebra. https://www.who.int/es/publications/i/item/9789240014886

Patiño, Y. P., Beltrán, Y. H., Andrade, R. T., Mejía, J. A., Montero, Y. B., Armenta, J. V., & Córdoba, R. B. (2022). Transporte activo: distancia entre el hogar y la escuela. *Retos: nuevas tendencias en educación física, deporte y recreación*, (44), 364-369.

Raghuveer, G., Hartz, J., Lubans, D. R., Takken, T., Wiltz, J. L., Mietus-Snyder, M., . . . Edwards, N. M. (2020). Cardiorespiratory fitness in youth: an important marker of health: a scientific statement from the *American Heart Association. Circulation,* 142(7), e101-e118. https://doi.org/10.1161/CIR.0000000000000866

Reimers, A. K., Marzi, I., Schmidt, S. C., Niessner, C., Oriwol, D., Worth, A., & Woll, A. (2021). Trends in active commuting to school from 2003 to 2017 among children and adolescents from Germany: the MoMo Study. *European Journal of Public Health*, 31(2), 373-378. https://doi.org/10.1093/eurpub/ckaa141

Rodriguez-Rodriguez, F., Solis-Urra, P., Mota, J., Aranda-Balboa, M. J., Barranco-Ruiz, Y., & Chillón, P. (2022). Role of Sociodemographic Variables and the Mother's Active Behavior on Active Commuting to School in Children and Adolescents. *Frontiers in Pediatrics*, 10, 812673. https://doi.org/10.3389/fped.2022.812673

Ruiz, J. R., Cavero-Redondo, I., Ortega, F. B., Welk, G. J., Andersen, L. B., & Martinez-Vizcaino, V. (2016). Cardiorespiratory fitness cut points to avoid cardiovascular disease risk in children and adolescents; what level of fitness should raise a red flag? A systematic review and meta-analysis. *British journal of sports medicine*, 50(23), 1451-1458. https://doi.org/10.1136/bjsports-2015-095903

Sagiv, M. S., & Sagiv, M. S. (2012). Cardiac output. *Exercise Cardiopulmonary Function in Cardiac Patients*, 59-84.

Sánchez Serna, J. D. (2020). Consumo máximo de oxígeno en niños y adolescentes entrenados y no entrenados. Disponible en: https://repository.urosario.edu.co/server/api/core/bitstreams/22f698ab-2925-4299-8de1-4ba78decc80f/content

Samimi, A., & Ermagun, A. (2013). Students' tendency to walk to school: case study of Tehran. *Journal of urban planning and development*, 139(2), 144-152. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000141

Smith, J. J., Eather, N., Morgan, P. J., Plotnikoff, R. C., Faigenbaum, A. D., & Lubans, D. R. (2014). The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. *Sports medicine,* 44, 1209-1223.

Sun, X., Li, Y., Cai, L., & Wang, Y. (2021). Effects of physical activity interventions on cognitive performance of overweight or obese children and adolescents: a systematic review and meta-analysis. *Pediatric research,* 89(1), 46-53.

Te Velde, S. J., Haraldsen, E., Vik, F. N., De Bourdeaudhuij, I., Jan, N., Kovacs, E., . . . Brug, J. (2017). Associations of commuting to school and work with demographic variables and with weight status in eight European countries: The ENERGY-cross sectional study. *Preventive medicine*, 99, 305-312. https://doi.org/10.1016/j.ypmed.2017.03.005

Thomas, J. S., & Dunn, J. M. (2019). Contractility. *Cardiovascular Hemodynamics: An Introductory Guide*, 41-50.

Vaquero-Solís, M., Tapia-Serrano, M., Prieto, J. P., Cerro-Herrero, D., & Sánchez-Miguel, P. (2022). Desplazamiento activo en adolescentes: importancia de las barreras percibidas y el acompañamiento. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte*, 22(88), 985-999. htps://doi.org/10.15366/rimcafd2022.88.016

Vásuez-Gómez, J. A., Garrido-Méndez, A., Matus-Castillo, C., Poblete-Valderrama, F., Díaz-Martínez, X., Concha-Cisternas, Y., . . . Leiva-Ordoñez, A. M. (2020). Fitness cardiorrespiratorio estimado mediante ecuación y su caracterización sociodemográfica en población chilena: Resultados de la Encuesta Nacional de Salud 2016-2017. *Revista médica de Chile*, 148(12), 1750-1758. http://dx.doi.org/10.4067/S0034-98872020001201750

Vaquero-Solís, M., Serrano, M. A. T., Cerro-Herrero, D., Marques, A., Sarmento, H., Prieto-Prieto, J., & Sánchez-Miguel, P. A. (2021). Importance of the perceived barriers about psychosocial variables in the active commuters: a cross-sectional study in youths. *Journal of Transport & Health*, 22, 101076. https://doi.org/10.1016/j.jth.2021.101076

Villa-González, E., Ruiz, J. R., & Chillón, P. (2015). Associations between active commuting to school and health-related physical fitness in spanish school-aged children: A cross-sectional study. I*nternational journal of environmental research and public health*, 12(9), 10362-10373. https://doi.org/10.3390/ijerph120910362

Voss, C., & Sandercock, G. (2010). Aerobic fitness and mode of travel to school in English schoolchildren. Medicine and science in sports and exercise, 42(2), 281-287. https://doi.org/10.1249/mss.0b013e3181b11bdc

Word Health Organization (WHO). (2004). Global Database on Body Mass Index. Copenhagen: Regional Office for Europe. https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index

Østergaard, L., Kolle, E., Steene-Johannessen, J., Anderssen, S. A., & Andersen, L. B. (2013). Cross sectional analysis of the association between mode of school transportation and physical fitness in children and adolescents. *International journal of behavioral nutrition and physical activity,* 10, 1-7. http://www.ijbnpa.org/content/10/1/91

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