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Original Article

Health Indicators Related to Urban Mobility: A Cross-Sectional Study of Employees of a Company in Anápolis.

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Abstract

Background: Physical inactivity among adolescents is a major public health concern and is associated with increased risk of obesity, cardiometabolic disorders, and poorer psychological health. Active commuting to school, such as walking or cycling, may represent an accessible strategy to increase daily movement and promote broader health benefits. However, the relationship between active commuting, body composition, physical activity level, and subjective well-being remains insufficiently explored, particularly in adolescent populations. **Objective:** To investigate the association between active commuting to school and indicators of physical health, physical activity level, and subjective well-being in adolescents. **Methods:** This prospective analytical observational pilot study included 20 adolescents aged 14 to 17 years from a school in Anápolis, Goiás, Brazil. Participants were classified into two groups according to their home–school commuting mode: Active Commuting Group (ACG; n = 10) and Non-Active Commuting Group (NACG; n = 10). The groups were balanced by sex, with five girls and five boys in each group. Active commuting was assessed based on commuting mode, travel time, and home–school distance, which was estimated using Google Maps. Physical activity level was assessed using the Physical Activity Questionnaire for Adolescents (PAQ-A), and body composition was evaluated by multifrequency bioelectrical impedance analysis. Subjective well-being was assessed through positive affect, negative affect, life satisfaction, and global subjective well-being. Descriptive statistics were presented as mean and standard deviation. Between-group comparisons and association analyses were performed adopting a significance level of $p < 0.05$. **Results:** No statistically significant differences were observed between the ACG and NACG for age, body mass index, body fat percentage, PAQ-A score, or commuting distance. The ACG presented slightly lower mean body mass index and body fat percentage than the NACG, although these differences were not statistically significant. Walking was the only active commuting mode reported, with a mean home–school distance of approximately 2 km. Adolescents in the ACG showed higher positive affect (3.9 ± 0.5 vs. 3.3 ± 0.6), higher life satisfaction (3.8 ± 0.6 vs. 3.2 ± 0.7), and lower negative affect (2.1 ± 0.6 vs. 2.7 ± 0.7) compared with the NACG. Global subjective well-being was significantly higher in the ACG than in the NACG (3.53 ± 0.42 vs. 3.07 ± 0.48; $t = 2.37$; $p = 0.029$; $d = 0.84$). **Conclusion:** Active commuting to school was associated with higher subjective well-being in adolescents, particularly through higher positive affect, greater life satisfaction, and lower negative affect. Although no significant differences were observed for body composition or physical activity level, the findings suggest that active school commuting may contribute to psychological well-being.

Keywords: Active commuting; Adolescents; Physical activity; Body composition; Subjective well-being; School transportation

1. Introduction

The decline in physical activity levels among children and adolescents has been recognized as a major global public health concern. It is estimated that more than 80% of adolescents worldwide do not meet the minimum physical activity recommendations proposed by the World Health Organization, substantially increasing the risk of early development of noncommunicable chronic diseases, including obesity, type 2 diabetes, and cardiovascular diseases (Guthold et al., 2020; World Health Organization, 2020). This scenario has contributed to the growing prevalence of overweight and obesity among young people in different regions of the world, representing an important challenge for public health systems (Abarca-Gómez et al., 2017).

Among the strategies proposed to promote more active lifestyles in children and adolescents, active commuting stands out as a promising approach. Active commuting is defined as any form of non-motorized transportation that requires energy expenditure through bodily movement, such as walking or cycling as a means of transportation (Andrade et al., 2016). In the school context, active commuting between home and school represents an important opportunity to

increase daily physical activity levels, contributing to the accumulation of moderate-to-vigorous physical activity throughout the day (Chillón et al., 2010; Peralta et al., 2020).

The adoption of active commuting has been associated with multiple health benefits, including greater daily energy expenditure, better cardiorespiratory fitness, and lower risk of overweight among children and adolescents when compared with those who use motorized transportation (Ikeda et al., 2021; Larouche et al., 2022). In addition, this form of mobility may contribute to reducing sedentary behavior and fostering healthy habits from childhood and adolescence onward (Peralta et al., 2020).

Several factors have been identified as determinants of physical activity and active commuting among young people. Individual, social, and environmental aspects, including characteristics of the urban environment, traffic safety, pedestrian and cycling infrastructure, family support, and socioeconomic conditions, may directly influence students' choice of transportation mode (Bauman et al., 2012; Loureiro et al., 2022; Wangzom et al., 2023). In Brazil, previous studies have also identified important socioeconomic and regional inequalities in active transportation, highlighting the influence of structural and environmental factors on this behavior (Sá et al., 2016).

Among the factors associated with active commuting, the distance between home and school has been consistently described as one of the main predictors of active mobility. International studies have shown that the probability of active commuting decreases substantially when the distance exceeds approximately three kilometers, favoring the use of motorized transportation (Rodrigues et al., 2022; Sandretto et al., 2024). Therefore, understanding the characteristics of school mobility is essential for developing strategies aimed at encouraging more active lifestyles among adolescents.

Beyond physiological benefits, recent evidence suggests that physical activity also plays an important role in promoting mental health and psychological well-being among young people. Studies indicate that higher levels of physical activity are associated with improved mood, greater self-esteem, and reduced symptoms of anxiety and depression in children and adolescents (Rodriguez-Ayllon et al., 2019; Biddle et al., 2019). In this context, active commuting may contribute to these positive effects by promoting greater exposure to outdoor environments, social interaction, and a stronger sense of autonomy during the journey between home and school (Smith et al., 2021).

Despite the growing body of research on active mobility, important gaps remain in the scientific literature. Most studies have focused primarily on physical indicators, such as total physical activity levels, cardiorespiratory fitness, and body composition. In contrast, the relationship between active mobility and psychological health indicators, such as subjective well-being, remains less explored, particularly among adolescents and in Latin American contexts (Larouche et al., 2022; Smith et al., 2021). Furthermore, studies simultaneously examining mobility-related factors, physical activity, body composition, and psychological well-being in school-aged populations are still relatively scarce.

Given this context, further research is needed to clarify the role of active mobility as a strategy for promoting comprehensive health among adolescents. Therefore, the present study aimed to investigate the association between the use of active commuting modes for home–school travel and indicators of physical health, physical activity level, and subjective well-being in adolescents.

2. Methods

2.1 Study Design

This was a prospective analytical observational pilot study. Participants were classified according to their mode of commuting between home and school. Students who reported walking or cycling to school were allocated to the Active Commuting Group (ACG), whereas those who used motorized or non-active transportation were allocated to the Non-Active Commuting Group (NACG).

2.2 Sample

A convenience sample of 20 schoolchildren was recruited, with equal distribution by sex: 50% girls and 50% boys. As this was a pilot study, the groups were intentionally balanced according to sex and commuting mode. Thus, the sample included five girls in the ACG and five girls in the NACG, as well as five boys in the ACG and five boys in the NACG. Students from a single school located in Anápolis, Goiás, Brazil, were included. All participants were between 14 and 17 years of age. Participation was authorized by parents or legal guardians, and all students provided individual assent, in accordance with Resolution 466/2012 of the Brazilian National Health Council.

2.3 Procedures

Selected students completed an electronic questionnaire in the school setting. The questionnaire included information on active commuting indicators and habitual physical activity level, which was assessed using the Physical Activity Questionnaire for Adolescents (PAQ-A) (Guedes & Guedes, 2015). Based on the reported mode of commuting between home and school, participants were stratified into two groups: the Active Commuting Group (ACG) and the Non-Active Commuting Group (NACG).

Subsequently, body composition was assessed using multifrequency bioelectrical impedance analysis (TeraScience). This method was selected because it is non-invasive, practical, rapid, and has shown good accuracy and strong correlation with dual-energy X-ray absorptiometry (DXA) for estimating fat-free mass in adolescents (Castillo-Martínez et al., 2018).

2.4 Study Variables

The main study variables were active commuting, physical activity level, and body composition. For logistical feasibility, active commuting was assessed through the reported mode of transportation, commuting time, and distance traveled between home and school. Physical activity level was assessed using the PAQ-A. Body composition was assessed using bioelectrical impedance analysis (Castillo-Martínez et al., 2018).

2.4.1 Active Commuting

Active commuting was assessed using a questionnaire in which participants reported the mode of transportation used for commuting between home and school, the average commuting time, and the distance traveled. Participants also provided their address and neighborhood to allow confirmation of the commuting distance.

Google Maps was used to georeference the home and school locations and to estimate the distance between both points in meters.

2.4.2 Physical Activity Level

Habitual physical activity level was assessed using the Physical Activity Questionnaire for Adolescents (PAQ-A) (Bervoets et al., 2014). This self-report instrument recalls activities performed during the previous seven days and includes items related to leisure-time activities, sports participation, physical education classes, and activities performed during different periods of the day, including morning, afternoon, evening, and weekends.

Each item is scored on a scale from 1 to 5, where 1 indicates a low level of physical activity and 5 indicates a high level of physical activity. The final score is calculated as the arithmetic mean of the scored items, allowing classification of the participants according to their overall physical activity level. The PAQ-A has been validated for use in the Brazilian population (Guedes & Guedes, 2015). Participants with scores <3 were classified as sedentary/inactive, whereas those with scores ≥3 were classified as active (Guedes & Guedes, 2015).

2.4.3 Body Composition

Body composition was assessed using bioelectrical impedance analysis, a non-invasive, rapid, practical, and painless method based on the passage of a low-intensity electrical current through the body. The impedance (Z), defined as the opposition to current flow, was measured using a tetrapolar BIA analyzer.

Four electrodes were placed on the hand, wrist, foot, and ankle. An electrical current was applied through the distal source electrodes, and the voltage drop caused by body impedance was detected by the proximal electrodes. This procedure allowed the estimation of body composition parameters, including indicators related to fat mass and fat-free mass.

2.5 Statistical Analysis

Statistical analyses were performed using SPSS software, version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive data were expressed as mean and standard deviation for continuous variables, and as absolute and relative frequencies for categorical variables. The Shapiro–Wilk test was used to assess data normality.

The Mann–Whitney U test was applied to compare continuous variables between the Active Commuting Group and the Non-Active Commuting Group. The chi-square test was used to examine associations between categorical variables and to compare frequencies across groups.

Multiple linear regression was performed to examine the association between commuting distance and health-related parameters, including body composition, physical activity level, and commuting mode. Models were adjusted for age and overweight status. Logistic regression was also performed for binary dichotomous outcomes. Spearman's correlation coefficients were used to assess associations between non-normally distributed variables. The significance level was set at $p < 0.05$.

3. Results

As shown in Table 1, no statistically significant differences were observed between the Active Commuting Group (ACG) and the Non-Active Commuting Group (NACG) for age, BMI, body fat percentage, PAQ-A score, or commuting distance. Although adolescents in the NACG showed a higher mean commuting distance than those in the ACG, this difference did not reach statistical significance. Overall, these findings indicate that both groups presented comparable baseline characteristics, allowing subsequent comparisons between commuting mode and health-related outcomes.

As shown in Table 2, walking was the only active commuting mode reported by the adolescents, representing the Active Commuting Group (ACG; n = 10), with a mean home–school distance of 2.04 ± 1.41 km. Among the non-active commuting modes, bus transportation was the most frequent (n = 6), followed by car transportation (n = 4). The bus group presented the longest mean commuting distance (9.94 ± 11.54 km), whereas adolescents who traveled by car covered a mean distance of 3.42 ± 2.40 km. These findings indicate that longer home–school distances were more commonly associated with passive transportation modes.

Adolescents who used active commuting for school transportation presented higher levels of subjective well-being when compared with those who used passive transportation. The active commuting group showed higher positive affect (3.9 ± 0.5 vs. 3.3 ± 0.6) and greater life satisfaction (3.8 ± 0.6 vs. 3.2 ± 0.7), as well as lower negative affect (2.1 ± 0.6 vs. 2.7 ± 0.7). Consequently, global subjective well-being was significantly higher in the active commuting group (3.53

± 0.42) than in the non-active commuting group (3.07 ± 0.48), with a large effect size (t = 2.37; p = 0.029; d = 0.84) (Table 3).

These findings suggest that active commuting may be positively associated with psychological well-being in adolescents, possibly reflecting the beneficial role of active mobility in promoting positive emotional experiences, life satisfaction, and overall mental health.

Table 1. Descriptive Characteristics of Adolescents According to School Commuting Mode

Variable	ACG Mean ± SD	Min–Max	NACG Mean ± SD	Min–Max	p
Age (years)	15.80 ± 0.79	15–17	16.20 ± 0.79	15–17	0.272
BMI (kg/m²)	22.90 ± 2.71	19.53–26.78	23.85 ± 2.05	19.22–26.40	0.388
Body fat (%)	22.10 ± 6.98	8–30	24.20 ± 7.48	14–35	0.525
PAQ-A	1.01 ± 0.20	0.78–1.17	1.05 ± 0.26	0.39–1.17	0.714
Distance (km)	2.04 ± 1.42	0.5–5.0	7.34 ± 9.27	1.5–33	0.106

Data are presented as mean ± standard deviation and minimum–maximum values. The p-values refer to between-group comparisons between the Active Commuting Group and the Non-Active Commuting Group. No statistically significant differences were observed between groups for age, body mass index, body fat percentage, PAQ-A score, or commuting distance. ACG = Active Commuting Group; NACG = Non-Active Commuting Group; SD = standard deviation; BMI = body mass index; PAQ-A = Physical Activity Questionnaire for Adolescents; Min–Max = minimum and maximum values.

Table 2. Distribution of Commuting Modes and Mean Distance.

Commuting Mode	n	Distance (km)	Classification
Walking	10	2.04 ± 1.41	ACG
Bus	6	9.94 ± 11.5	NACG
Car	4	3.42 ± 2.40	NACG

Note: Data are presented as mean ± standard deviation. ACG = Active Commuting Group; NACG = Non-Active Commuting Group; n = number of participants.

Table 3. Subjective Well-Being Results Between Groups

Group	PA	NA	LS	GSWB
ACG	3.9 ± 0.5*	2.1 ± 0.6*	3.8 ± 0.6*	3.5 ± 0.4
NACG	3.3 ± 0.6	2.7 ± 0.7	3.2 ± 0.7	3.0 ± 0.4

Note: Data are presented as mean ± standard deviation. PA = Positive Affect; NA = Negative Affect; LS = Life Satisfaction; GSWB = Global Subjective Well-Being; ACG = Active Commuting Group; NACG = Non-Active Commuting Group. *Indicates statistically significant difference between groups.

4. Discussion

The main finding of the present pilot study was that adolescents who used active commuting for home–school transportation showed significantly higher subjective well-being than those who used passive commuting modes. Specifically, the active commuting group presented higher positive affect and life satisfaction, lower negative affect, and a higher global subjective well-being score. In contrast, no statistically significant differences were observed between groups for age, BMI, body fat percentage, physical activity level, or commuting distance. Therefore, although the active commuting group showed a tendency toward better body composition indicators, the most consistent difference observed in this pilot sample was related to psychological well-being.

At baseline, both groups presented similar demographic and health-related characteristics, including age, BMI, body fat percentage, PAQ-A score, and home–school distance. This initial comparability is important because it suggests that the differences observed in subjective well-being were less likely to be explained by major anthropometric or demographic imbalances between groups. Although this does not allow causal inference due to the observational design, it strengthens the interpretation that commuting mode may be associated with psychological indicators in adolescents.

Regarding body composition, adolescents in the active commuting group presented lower mean BMI and body fat percentage than those in the non-active commuting group. However, these differences were not statistically significant. This result should be interpreted cautiously, particularly because of the small sample size and the pilot nature of the study. Even so, the direction of the findings is consistent with previous evidence suggesting that active commuting may contribute to greater daily energy expenditure and lower risk of overweight among children and adolescents, especially when performed regularly throughout the week (Andersen et al., 2011). Active commuting may be understood as a form of incidental physical activity, since it is incorporated into the daily routine and may contribute to a more active lifestyle without requiring structured exercise sessions (Peralta et al., 2020).

The distribution of commuting modes also provides relevant information. In the present study, all adolescents in the active commuting group walked to school, covering a mean distance of approximately 2 km. In contrast, adolescents

in the non-active commuting group used either bus or car transportation and generally covered longer distances. This pattern supports the idea that distance between home and school is one of the main determinants of school commuting behavior. Previous studies have shown that the likelihood of active commuting decreases as distance increases, particularly when the home–school distance exceeds approximately 3 km (Østergaard et al., 2013; Nunes Júnior et al., 2022). Thus, the present findings reinforce that distance may act as an important barrier to walking or cycling to school, especially in urban contexts where safety, infrastructure, and accessibility may also influence transportation choices (Loureiro et al., 2022; Sandretto et al., 2024).

No significant differences were observed between groups for physical activity level assessed by the PAQ-A. This finding may be partially explained by the small sample size, the low variability in PAQ-A scores, and the use of a self-reported instrument. It is also possible that active commuting alone was not sufficient to produce detectable differences in overall physical activity level in this sample, particularly if the walking distance, intensity, or frequency was not high enough to substantially affect the total weekly activity score. Nevertheless, previous studies indicate that adolescents who use active commuting are more likely to accumulate moderate-to-vigorous physical activity throughout the day and may have better cardiorespiratory fitness when active transportation is performed frequently and at sufficient intensity (Ikeda et al., 2021; Huang et al., 2021; Peralta et al., 2020; Rodrigues et al., 2022).

The most relevant result of the present study was the difference in subjective well-being between groups. Adolescents who actively commuted to school showed higher global subjective well-being, with a large effect size. This suggests that active commuting may be related not only to physical health, but also to psychological health. Several mechanisms may help explain this association. Walking to school may increase exposure to outdoor environments, provide opportunities for social interaction, enhance autonomy, and promote a sense of independence during the daily routine. These factors may contribute to higher positive affect and life satisfaction, as observed in the present study. In addition, regular movement, even at light or moderate intensity, may have favorable effects on mood regulation and emotional well-being, which is consistent with evidence linking physical activity to better mental health, higher self-esteem, and lower symptoms of anxiety and depression in young people (Silva et al., 2018; Liu et al., 2025).

From a public health perspective, these findings are relevant because active commuting is a low-cost and accessible behavior that may be encouraged through school-based and community strategies. However, promoting active commuting requires attention to environmental and social conditions. Distance, route safety, traffic exposure, urban infrastructure, availability of sidewalks and bike lanes, family support, and neighborhood characteristics may all influence whether adolescents are able or allowed to walk or cycle to school. Therefore, interventions aimed at increasing active commuting should not focus only on individual behavior, but also on structural conditions that make active mobility safer and more feasible.

This study has limitations that should be considered. First, the sample was small and homogeneous, which limits the generalizability of the findings. Second, the observational design does not allow causal conclusions. Third, physical activity and commuting behavior were assessed through self-report, which may be affected by recall bias or social desirability bias. Finally, although distance was estimated using georeferencing, the study did not include objective monitoring of the actual route, walking intensity, or total daily movement.

Future studies should include larger and more diverse samples, longitudinal designs, and objective methods such as accelerometry and GPS tracking. These approaches may help clarify whether active commuting contributes independently to physical activity level, body composition, and psychological well-being. It would also be relevant to investigate how environmental and social factors, such as traffic safety, urban infrastructure, perceived neighborhood safety, family support, and school policies, influence active commuting among adolescents.

5. Conclusions

The present pilot study suggests that active commuting to school may be positively associated with subjective well-being in adolescents. Although no statistically significant differences were observed between groups for age, body mass index, body fat percentage, PAQ-A score, or commuting distance, adolescents who used active commuting showed higher positive affect, greater life satisfaction, lower negative affect, and higher global subjective well-being than those who used passive transportation.

These findings indicate that the potential benefits of active commuting may extend beyond physical health indicators, also involving psychological and emotional dimensions of adolescent health. Walking to school may contribute to greater autonomy, outdoor exposure, social interaction, and daily movement, which may help explain the better subjective well-being observed among active commuters.

However, given the pilot and observational nature of the study, the findings should be interpreted with caution. Future studies with larger samples, longitudinal designs, and objective measures of physical activity and commuting behavior, such as accelerometry and GPS tracking, are needed to confirm these associations. In addition, environmental and social factors, including route safety, distance, family support, and urban infrastructure, should be further investigated to better understand the determinants and health implications of active school commuting among adolescents.

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References

1. Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., et al. (2017). World-wide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. The Lancet, 390(10113), 2627–2642. https://doi.org/10.1016/S0140-6736(17)32129-3
2. Andersen LB, Riddoch C, Kriemler S, Hills AP. Physical activity and cardiovascular risk factors in children. Br J Sports Med. 2011 Sep;45(11):871-6. doi: 10.1136/bjsports-2011-090333. PMID: 21791456.
3. Andrade V., Rodrigues J., Mariano F., Lobo Z. (2016) (organizadores). Mobilidade por bicicleta no Brasil. Rio de Janeiro: PROURB/UFRJ.
4. Bauman, A. E., Reis, R. S., Sallis, J. F., Wells, J. C., Loos, R. J. F., & Martin, B. W. (2012). Cor-relates of physical activity: Why are some people physically active and others not? The Lancet, 380(9838), 258–271. https://doi.org/10.1016/S0140-6736(12)60735-1
5. Bervoets L, Van Noten C, Van Roosbroeck S, Hansen D, Van Hoorenbeeck K, Verheyen E, Van Hal G, Vankerckhoven V. Reliability and Validity of the Dutch Physical Activity Questionnaires for Children (PAQ-C) and Adolescents (PAQ-A). Arch Public Health. 2014 Dec 24;72(1):47. doi: 10.1186/2049-3258-72-47. PMID: 25671114; PMCID: PMC4323128.
6. Biddle, S. J. H., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. Psychology of Sport and Exercise, 42, 146–155. https://doi.org/10.1016/j.psychsport.2018.08.011
7. CASTILLO-MARTÍNEZ, L. et al. Body composition estimation in children and adolescents by bioelectrical impedance analysis: A systematic review. Journal of Bodywork and Movement Therapies, v. 22, n. 3, p. 717-725, 2018.
8. Chillón, P., Ortega, F. B., Ruiz, J. R., Veidebaum, T., & Oja, L. (2020). Active commuting to school in children and adolescents: An opportunity to increase physical activity. Scandinavian Journal of Public Health, 38(8), 873–879. https://doi.org/10.1177/1403494810384427
9. Giles-Corti, B. et al. (2016) City planning and population health: a global challenge. The lancet, v. 388, n. 10062:2912-2924.
10. GUEDES, D. P.; GUEDES, J. E. R. P. Medida da atividade física em jovens brasileiros: reprodutibilidade e validade do PAQ-C e do PAQ-A. Revista Brasileira de Medicina do Esporte, v. 21, n. 6, p. 425-432, 2015. Disponível em: Scielo.
11. 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
12. Huang C, Memon AR, Yan J, Lin Y, Chen ST. The associations of active travel to school with physical activity and screen time among adolescents. Front Public Health. 2021;9:719742. DOI: 10.3389/fpubh.2021.719742
13. Ikeda E, Hinckson E, Witten K, Smith M. Associations of children's active school travel with health-related fitness: a systematic review. Prev Med. 2021;146:106472. DOI: 10.1016/j.ypmed.2021.106472
14. Liu L, Xin X and Zhang Y (2025) The effects of physical exercise on cognitive function in adolescents: a systematic review and meta-analysis. Front. Psychol. 16:1556721. doi: 10.3389/fpsyg.2025.1556721
15. Loureiro N, Loureiro V, Grao-Cruces A, Martins J, Gaspar de Matos M. Correlates of Active Com-muting to School among Portuguese Adolescents: An Ecological Model Approach. Int J Environ Res Public Health. 2022 Feb 26;19(5):2733. doi: 10.3390/ijerph19052733. PMID: 35270424; PMCID: PMC8910768.
16. Nunes Júnior OF, Teles LAC, Oliveira-Silva I. O uso da mobilidade ativa por crianças e adolescentes: uma revisão integrativa. Rev Interação Interdisciplinar. 2022;1(2):239-251. doi: 10.35685/revintera.v1i2.2344
17. Oliveira-Silva, I., & Billerbeck, N.C. (2020). Trasporte ativo: que ideia é esta? Educação física, infância e saúde em discussão: coletânea de estudos 2, 15.
18. Østergaard, L., Kolle, E., Steene-Johannessen, J. et al. Cross-sectional analysis of the association between mode of school transportation and physical fitness in children and adolescents. Int J Behav Nutr Phys Act 10, 91 (2013). https://doi.org/10.1186/1479-5868-10-91
19. Peralta M, Henriques-Neto D, Bordado J, Loureiro N, Diz S, Marques A. Active Commuting to School and Physical Activity Levels among 11- to 16-Year-Old Adolescents from 63 Low- and Mid-dle-Income Countries. Int J Environ Res Public Health. 2020 Feb 17;17(4):1276. doi: 10.3390/ijerph17041276. PMID: 32079217; PMCID: PMC7068453.
20. Rodrigues, A.; Antunes, H.; Alves, R.; Correia, A.L.; Lopes, H.; Sabino, B.; Marques, A.; Ihle, A.; Gouveia, É.R. Association between the Duration of the Active Commuting to and from School, and Cognitive Performance in Urban Portuguese Adolescents. Int. J. Environ. Res. Public Health 2022, 19, 15692. https://doi.org/10.3390/ijerph192315692

21. Rodriguez-Ayllon, M., Cadenas-Sánchez, C., Estévez-López, F., Muñoz, N. E., Mora-Gonzalez, J., Migueles, J. H., Molina-García, P., Henriksson, H., Mena-Molina, A., Martínez-Vizcaíno, V., Catena, A., Erickson, K. I., Lubans, D. R., Ortega, F. B., & Esteban-Cornejo, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. Sports Medicine, 49(10), 1383–1403. https://doi.org/10.1007/s40279-019-01099-7
22. Sá, T. H., Pereira, R. H. M., Duran, A. C., & Monteiro, C. A. (2016). Socioeconomic and regional differences in active transportation in Brazil. Revista de Saúde Pública, 50, 37. https://doi.org/10.1590/S1518-8787.2016050006126
23. Sandretto S, Mandic S, et al. Adolescents' active transport to school and parental perspectives in a school choice policy environment. Active Travel Studies. 2024. DOI: 10.16997/ats.1489
24. Smith, M., Ikeda, E., Hinckson, E., Duncan, S., Maddison, R., Meredith-Jones, K., Walker, C., Mandic, S. (2021). Associations between active school travel and mental well-being among adolescents. Journal of Transport & Health, 20, 101036. https://doi.org/10.1016/j.jth.2020.101036
25. Silva DAS, de Lima TR, Tremblay MS. Association between Resting Heart Rate and Health-Related Physical Fitness in Brazilian Adolescents. Biomed Res Int. 2018 Jun 28;2018:3812197. doi: 10.1155/2018/3812197. PMID: 30050928; PMCID: PMC6046174.
26. Wangzom D, et al. Perceived safety influencing active travel to school: A built environment perspective. Int J Environ Res Public Health. 2023;20(2):1156. DOI: 10.3390/ijerph20021156
27. World Health Organization (2014). Global status report on noncommunicable diseases 2014.
28. World Health Organization. (2020). WHO guidelines on physical activity and sedentary behavior. Geneva: World Health Organization. https://www.who.int/publications/i/item/9789240015128