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# Tracking of physical activity and sedentary behavior of adolescents in different domains

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**ABSTRACT.** This study aimed to verify the tracking of physical activity and sedentary behavior in different domains during adolescence. This longitudinal study involved 265 subjects (boys: 52.8%) with an initial mean age of 13.9 ( $\pm$  1.2) years. Physical activity and sedentary behavior were verified using a questionnaire. The achievement of  $\geq$  150 min. week<sup>-1</sup> of moderate-to-vigorous intensity sport and/or physical exercise for  $\geq$  1 month was adopted as sufficiently active. The data were collected on 2 occasions, with an average interval of 3 years. The description of the results used the relative frequency and Binary Logistic Regression was used to estimate the crude and adjusted odds ratios (95% confidence intervals). Current physical activity (adjusted odds ratios = 3.05; 95% confidence intervals: 1.77 - 5.26) and sedentary behavior (adjusted odds ratios = 1.81; 95% confidence intervals: 1.03 - 3.19) appear to be significantly influenced by previous behavior, except for light-intensity physical activity. Only 12.8% of the participants remained sufficiently active for sport and/or physical exercise. Practice for at least one month of sport and/or physical exercise at baseline was a predictor of practice in the follow-up, both considering participation for at least one month (adjusted odds ratios = 2.81; 95% confidence intervals: 1.37 - 5.79) and for four months (adjusted odds ratios = 2.47; 95% confidence intervals: 1.17 - 5.24) in the follow-up. Being sufficiently active at baseline increased the chance of being sufficiently active in the follow-up during adolescence. Interventions providing sufficient sport and/or physical exercise could positively influence the chances of practice in the future. For light-intensity physical activity interventions, strategies targeting adherence seem especially relevant.

**Keywords:** adolescent behavior; exercise; sports; health behavior; leisure activities.

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## Introduction

Insufficient physical activity and high sedentary behavior have been linked to many health outcomes across life-span and a lower life expectancy (Bull et al., 2020). Even though there are benefits of these behaviors for health, physical activity seems to decline with age, and sedentary behavior tends to increase (Hayes, Dowd, MacDonncha, & Donnelly, 2019). The movement behaviors adopted in childhood and adolescence appear to increase the chance of these behaviors occurring later in life (Telama et al., 2014; Hayes et al., 2019). Therefore, these phases have been recognized as important for stimulating the adoption of a physically active lifestyle (Dearth-Wesley, Howard, Wang, Zhang, & Popkin, 2017; Hayes et al., 2019; Bull et al., 2020).

Physical activity and sedentary behavior are distinct constructs (Baecke, Burema, & Frijters, 1982; Pate, O'Neill, & Lobelo, 2008), which can occur in different contexts, and might have independent effects on health (Pearson, Braithwaite, Biddle, Sluijs, & Atkin, 2014; Dearth-Wesley et al., 2017; Hayes et al., 2019; Bull et al., 2020). Cut-off points for both have been developed based on health-related outcomes. However, there is insufficient evidence to set thresholds or determine if specific health benefits vary by types and domains for these behaviors (Council on Communications and Media, 2016; 2018 Physical Activity Guidelines Advisory Committee, 2018; Bull et al., 2020;). When dealing with physical activity performed systematically in young people, considering the same intensity parameters, a smaller volume seems to be necessary to obtain the same benefits (Strong et al., 2005). Despite the relevance of these behaviors to health, little is known about tracking during adolescence, especially when considering their different domains and the use of different cut-

off points. There is a low number of longitudinal studies on this topic, particularly in developing countries (Hayes et al., 2019; Kemp, Cliff, Chong, & Parrish, 2019; Guthold, Stevens, Riley & Bull, 2020).

High prevalences of both high sedentary behavior (Khan, Mandic, & Uddin, 2021) and insufficient physical activity (Barbosa Filho et al., 2018) are reported among young people. Although previous studies sought to analyze changes in physical activity and sedentary behavior, they did not report tracking by domains (Dearth-Wesley et al., 2017; Kemp et al., 2019), leading to a lack of longitudinal studies about participation in physical activities by domains (Dearth-Wesley et al., 2017). A recent systematic review about tracking of physical activity and sedentary behavior from adolescence to young adulthood found a low-to-moderate level for this transition period. Additionally, the results indicated that few studies have investigated both behaviors simultaneously, that sedentary behavior were less frequently examined, and that only some indicators in specific domains have been investigated (Hayes et al., 2019).

Understanding the changes in these behaviors is relevant as these behaviors are associated with favorable conditions regarding biological, psychological, social, and cognitive indicators related to health. In addition, physical activity and sedentary behavior habits in adulthood seem to be developed during childhood and adolescence (Grøntved et al., 2014; Telama et al., 2014; Metcalf, Hosking, Jeffery, Henley, & Wilkin, 2015). Information about the tracking of these behaviors according to their different contexts could assist in planning strategies to reduce sedentary behavior and increase physical activity (Hayes et al., 2019). This study aimed to verify the tracking of physical activity and sedentary behavior in different domains during adolescence.

## Material and methods

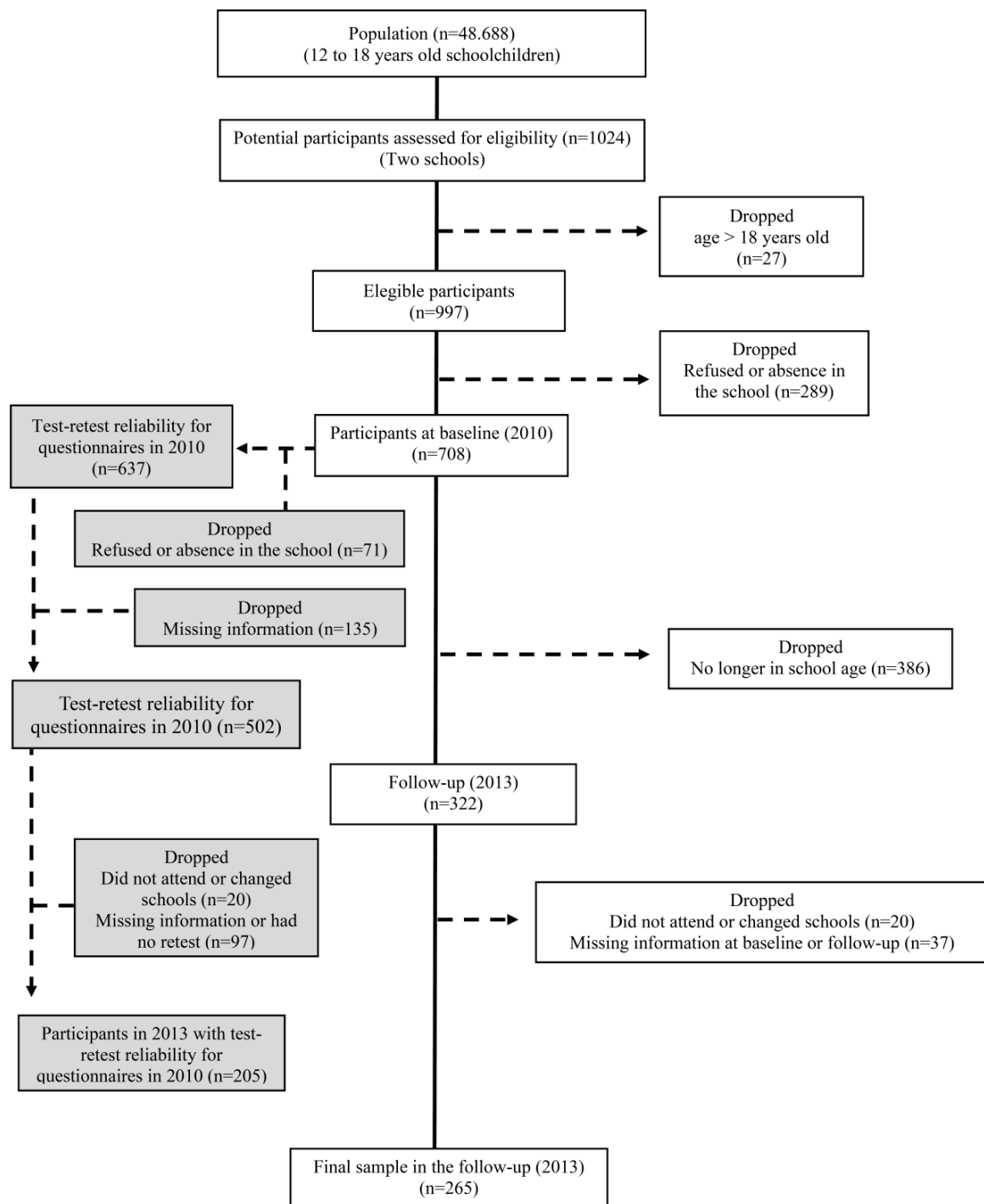
This is a longitudinal study involving adolescents from Londrina, Paraná, Brazil. The methods description, variables collected, and sample characterization are available elsewhere (Arruda et al., 2020). Between the baseline and follow-up there was a mean interval of 3 ( $\pm 0.17$ ) years (Figure 1). Study protocols were approved by the Ethics in Research Committee from the university where the study took place (Protocol no. 234/10).

Two state schools (publicly administered institutions) from Londrina, Paraná, Brazil, were randomly selected for the composition of the sample: a medium and a large-sized school. Classrooms were randomly selected in each school. The sample involved approximately 50% of the participants of each school.

The baseline sample involved 708 participants, consisting of boys and girls, aged between 12 and 18 years. For the follow-up, 322 individuals were considered, as they were still of school age. After collecting data from the follow-up, there was a 17.7% sample loss (6.2% did not attend or had changed schools and 11.5% presented incomplete information at baseline or follow-up). Thus, 265 individuals with a mean age of 13.9 years ( $\pm 1.2$ ) were part of the present study.

Physical activity and sedentary behavior data were obtained through the Baecke Questionnaire of Habitual Physical Activity (BQHPA). The BQHPA is structured in 3 sections; the first considers physical activities at school, the second, sports during leisure time, and the third, physical activity during leisure time. Habitual physical activity was calculated by adding the scores (Baecke et al., 1982). Based on the BQHPA scores, participants were classified as insufficiently active or sufficiently active. From dimension 2, questions 9 through 9.6 were used to obtain information about sport and/or physical exercise (SPE). As a dependent variable, the moderate-to-vigorous SPE (follow-up) was dichotomized from 2 perspectives. In the first, SPE of moderate-to-vigorous intensity for  $\geq 150$  min. week<sup>-1</sup> and  $\geq 1$  month was classified as sufficiently active. The second considered practice  $\geq 4$  months. Moderate-to-vigorous SPE as an independent variable (baseline) was categorized ordinally into sufficiently active ( $\geq 150$  min. week<sup>-1</sup> and  $\geq 1$  month), insufficiently active ( $< 150$  min. week<sup>-1</sup> and/or  $< 1$  month), and non-practitioners. Light-intensity SPE was dichotomized between those who reported practicing and not practicing. The BQHPA questions were also dichotomized. To produce additional information regarding sedentary behavior a score was calculated using the average score of questions 2 and 13. Individuals who achieved a score  $\geq 4$  were classified as having high sedentary behavior and those  $< 4$  as reduced sedentary behavior (Table 1). Acceptable indices of test-retest reliability in adolescents have been previously reported for all strategies used for the classifications in the present study (Arruda et al., 2019).

The household education was obtained through a questionnaire (Arruda et al., 2020) and Education was dichotomized between:  $<$  Complete high school and  $\geq$  Complete high school.



**Figure 1.** Sample flowchart.

Descriptive statistics were used to characterize the sample, using absolute and relative frequency measurements (%). The Chi-square or Fisher's exact test verified attrition. The association between losses (remained, baseline, or follow-up losses) and sociodemographic variables, school size, physical activity, and sedentary behavior was verified. Binary Logistic Regression was used to verify the magnitude of the association between baseline and follow-up for physical activity and sedentary behavior indicators. Crude Odds Ratios (OR) and adjusted Odds Ratios (AOR) by sex, age group ( $< 13.5$  or  $\geq 13.5$  years), and household education were calculated, as well as their respective 95% confidence intervals (95% CI). The Hosmer-Lemeshow test was used to determine the goodness-of-fit of each model. The analyses were performed with IBM/SPSS Statistics for Windows, version 20 (IBM Corp., Armonk, N.Y., USA). The sample size ( $n = 265$ ) was sufficient to analyze the multivariate models in the present study according to procedures suggested by Peduzzi, Concato, Kemper, Holford & Feinstein (1996).

**Table 1.** Cut-off points used in the present study. BQHPA: Baecke Questionnaire of Habitual Physical Activity; SPE: Sport and/or physical exercise.

| Constructs or questions                                   | Moment                 | Cut-off                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Habitual physical activity                                | baseline and follow-up | Sufficiently active: $\geq 60$ th percentile.<br>Insufficiently active: $< 60$ th percentile.                                                                                                                                                                                                                       |
| Physical activities at school (questions 1 to 8)          | baseline and follow-up | Sufficiently active: $\geq 60$ th percentile.<br>Insufficiently active: $< 60$ th percentile.                                                                                                                                                                                                                       |
| Sports during leisure time (questions 9 to 12)            | baseline and follow-up | Sufficiently active: $\geq 60$ th percentile.<br>Insufficiently active: $< 60$ th percentile.                                                                                                                                                                                                                       |
| Physical activity during leisure time (question 10 to 14) | baseline and follow-up | Sufficiently active: $\geq 60$ th percentile.<br>Insufficiently active: $< 60$ th percentile.                                                                                                                                                                                                                       |
| Moderate-to-vigorous intensity SPE (questions 9.1 to 9.6) | follow-up              | Sufficiently active: moderate-to-vigorous intensity; $\geq 150$ min. week <sup>-1</sup> and $\geq 1$ month.<br>Insufficiently active: moderate-to-vigorous intensity; $< 150$ min. week <sup>-1</sup> and/or $< 1$ month.                                                                                           |
| Moderate-to-vigorous intensity SPE (questions 9.1 to 9.6) | follow-up              | Sufficiently active: moderate-to-vigorous intensity; $\geq 150$ min. week <sup>-1</sup> and $\geq 4$ month.<br>Insufficiently active: moderate-to-vigorous intensity; $< 150$ min. week <sup>-1</sup> and/or $< 4$ month.                                                                                           |
| Moderate-to-vigorous intensity SPE (questions 9.1 to 9.6) | baseline               | Sufficiently active: moderate-to-vigorous intensity; $\geq 150$ min. week <sup>-1</sup> and $\geq 1$ month.<br>Insufficiently active: moderate-to-vigorous intensity; $< 150$ min. week <sup>-1</sup> and/or $< 1$ month.<br>Non-practitioners: does not practice moderate-to-vigorous intensity sport or exercise. |
| Light-intensity SPE (questions 9.1 to 9.6)                | baseline and follow-up | Practicing: practices light-intensity sport or exercise.<br>Non-practitioners: does not practice light-intensity sport or exercise.                                                                                                                                                                                 |
| BQHPA questions 3, 8, 10 to 12, and 14 to 16              | baseline and follow-up | Insufficiently active: alternatives 1 and 2.<br>Sufficiently active: alternatives 3 to 5.                                                                                                                                                                                                                           |
| BQHPA question 9                                          | baseline and follow-up | Yes.<br>No.                                                                                                                                                                                                                                                                                                         |
| BQHPA questions 2 and 13                                  | baseline and follow-up | Reduced sedentary behavior: alternatives 1 to 3.<br>High sedentary behavior: alternatives 4 and 5.                                                                                                                                                                                                                  |
| Average score of questions 2 and 13                       | baseline and follow-up | Reduced sedentary behavior: $< 4$ .<br>High sedentary behavior: $\geq 4$ .                                                                                                                                                                                                                                          |

## Results

Among the study participants, 52.8% were boys and 52.5% were older than 13.5 years. Regarding the household education, 37.4% completed high school and 32.8% had a higher education degree. The attrition analysis did not indicate a significant association between losses with sex, age group, household education, school size, physical activity, and sedentary behavior ( $p > 0.05$ ). For moderate-to-vigorous SPE at baseline, 30.2% of participants were classified as sufficiently physically active using a period  $\geq 1$  month (moderate-to-vigorous,  $\geq 150$  min. week<sup>-1</sup>), which decreased to 26.4% in the follow-up. When considering a period  $\geq 4$  months, this was 22.6% in the follow-up. Only 12.8% of participants remained sufficiently active in the follow-up using the one-month criterion, and 11.3%, using 4 months. For light SPE, the frequency was 8.3% of practitioners at baseline and 4.5% in the follow-up.

The overall reduced sedentary behavior in the follow-up was 71.7%. Considering issues related to sedentary behavior separately, the frequency of reduced sedentary behavior at school was 44.5%, and in leisure time, 57.4%. The analysis of questions related to physical activity indicated frequencies that range from 41.5% to 74.0% of participants considered sufficiently active, for sport (Question 9) and at school I stand (Question 3), respectively. The only exception was the use of a bicycle in leisure time (Question 15), which presented only 25.3% of sufficiently active in the follow-up.

Table 2 shows the levels of sufficiently physically active and reduced sedentary behavior, obtained at the follow-up according to the results at baseline. In general, sufficiently active (AOR = 2.47; 95%CI: 1.17 - 5.24 to 3.05; 95%CI: 1.78 - 5.26) individuals and with reduced sedentary behavior (AOR = 1.81; 95%CI: 1.03 - 3.19) at baseline were more likely to be active in the follow-up. The only exception was physical activity during leisure time, which, after adjusting for sex, age group, and household education, was no longer significant.

The adjusted analysis for habitual physical activity indicated that the physically active individuals at baseline presented approximately 3 times more chance of being active when compared to insufficiently

active, and this was the highest AOR obtained from the BQHPA scores. For physical activity at school the AOR was 2.90 (95%CI: 1.73 - 4.86), and a similar magnitude was found in the analysis of the score for sports. Individuals with reduced sedentary behavior at baseline had a higher AOR of being in this same category in the follow-up compared to high sedentary behavior, obtaining an AOR = 1.81 (95%CI: 1.03 - 3.19). Among the analyses performed from the BQHPA scores that remained significant, this was the one with the lowest magnitude.

Using both the period  $\geq 4$  and  $\geq 1$  month as cut-off points for moderate-to-vigorous SPE at follow-up, only the group that practiced 150 min. week<sup>-1</sup> or more at baseline had significantly higher AOR of being sufficiently active in the follow-up, when compared to non-practitioners at baseline. Individuals who practiced more than 150 min/week for at least one month at baseline had an AOR of 2.81 (95%CI: 1.37 - 5.79) to be sufficiently active when considering the period  $\geq 1$  month in the follow-up. When considering the period  $\geq 4$  months in the follow-up, the AOR was 2.47 (95%CI: 1.17 - 5.24). For low-intensity SPE, no participants who reported practicing at baseline practiced in the follow-up, so it was not possible to calculate the OR.

**Table 2.** Odds Ratios for adolescents being sufficiently active or presenting reduced sedentary behavior at follow-up according to baseline status, based on BQHPA scores (n = 265).

| Baseline (n)                                | Follow-up (%) | OR (95%CI)         | AOR (95%CI)*       |
|---------------------------------------------|---------------|--------------------|--------------------|
| <b>Habitual physical activity index</b>     |               |                    |                    |
| Insufficient (153)                          | 28.8          | Reference          | Reference          |
| Active (112)                                | 60.7          | 3.83 (2.29 - 6.42) | 3.05 (1.78 - 5.26) |
| <b>School index</b>                         |               |                    |                    |
| Insufficient (134)                          | 34.3          | Reference          | Reference          |
| Active (131)                                | 59.5          | 2.82 (1.71 - 4.64) | 2.90 (1.73 - 4.86) |
| <b>Sport index</b>                          |               |                    |                    |
| Insufficient (129)                          | 32.6          | Reference          | Reference          |
| Active (136)                                | 65.4          | 3.92 (2.35 - 6.54) | 2.92 (1.69 - 5.05) |
| <b>Leisure-time index</b>                   |               |                    |                    |
| Insufficient (136)                          | 34.6          | Reference          | Reference          |
| Active (129)                                | 49.6          | 1.86 (1.14 - 3.06) | 1.67 (0.99 - 2.80) |
| <b>Sedentary behavior</b>                   |               |                    |                    |
| High (129)                                  | 64.3          | Reference          | Reference          |
| Reduced (136)                               | 78.7          | 2.05 (1.18 - 3.53) | 1.81 (1.03 - 3.19) |
| <b>SPE - Moderate-to-vigorous†</b>          |               |                    |                    |
| No (122)                                    | 14.8          | Reference          | Reference          |
| <150min/week and/or <1month (63)            | 28.6          | 2.31 (1.10 - 4.85) | 2.11 (0.96 - 4.65) |
| $\geq 150$ min/week and $\geq 1$ month (80) | 42.5          | 4.27 (2.19 - 8.33) | 2.81 (1.37 - 5.79) |
| <b>SPE - Moderate-to-vigorous‡</b>          |               |                    |                    |
| No (122)                                    | 13.1          | Reference          | Reference          |
| <150min/week and/or <1month (63)            | 22.2          | 1.89 (0.86 - 4.18) | 1.68 (0.72 - 3.90) |
| $\geq 150$ min/week and $\geq 1$ month (80) | 37.5          | 3.98 (1.99 - 7.95) | 2.47 (1.17 - 5.24) |
| <b>SPE - Light</b>                          |               |                    |                    |
| No (243)                                    | 4.9           | -                  | -                  |
| Yes (22)                                    | 0.0           | -                  | -                  |

Active: Sufficiently physically active; BQHPA: Baecke Questionnaire of Habitual Physical Activity; Insufficient: insufficiently physically active; SPE: Sport and/or physical exercise; OR: Odds Ratio; AOR: Adjusted Odds Ratio. \*Adjusted by sex, age group, and household education at baseline; †Active in follow-up:  $\geq 1$  month;  $\geq 150$  min/week; ‡Active in follow-up:  $\geq 4$  months;  $\geq 150$  min/week.

Considering the questions individually (Table 3) in section 1 (school) of the BQHPA, at school I stand (question 3) was not significant in the adjusted analysis. Walking at school (question 4) and being physical active in comparison with peers at school (question 8) did not present significant ORs. The highest AOR was lifting heavy loads at school (question 5) with 3.02 (95%CI: 1.78 - 5.11) and the lowest was that after school I am tired (question 6) with 2.25 (95%CI: 1.34 - 3.77). In section 2 (sport), all AORs were significant. The highest value was obtained for during leisure time I play sport (question 12), with AOR = 3.75 (95%CI: 2.10 - 6.70) and the lowest for physical activity in comparison with peers in leisure-time (question 10), with AOR = 2.46 (95%CI: 1.33 - 4.54). In section 3 (leisure-time), all AORs were significant and the values ranged from 1.94 (95%CI: 1.17 - 3.22) for during leisure time I walk (question 14) to 5.13 (95%CI: 2.67 - 9.86) for during leisure time I cycle (question 15).

**Table 3.** Odds Ratio for adolescents being sufficiently active and having reduced sedentary behavior in the follow-up according to baseline status, based on BQHPA questions (n = 265).

| Baseline (n)                                                                                                     | Follow-up (%) | OR (95%CI)       | AOR (95%CI)*       |
|------------------------------------------------------------------------------------------------------------------|---------------|------------------|--------------------|
| <b>Question 2 - At school I sit</b>                                                                              |               |                  |                    |
| never/seldom/sometimes (127)                                                                                     | 55.9          | 2.46 (1.49-4.03) | 2.49 (1.48 - 4.17) |
| often/always (138)                                                                                               | 34.1          | Reference        | Reference          |
| <b>Question 3 - At school I stand</b>                                                                            |               |                  |                    |
| never/seldom (74)                                                                                                | 64.9          | Reference        | Reference          |
| sometimes/often/always (191)                                                                                     | 77.5          | 1.86 (1.04-3.35) | 1.82 (1.00 - 3.33) |
| <b>Question 4 - At school I walk</b>                                                                             |               |                  |                    |
| never/seldom (83)                                                                                                | 62.7          | Reference        | -                  |
| sometimes/often/always (182)                                                                                     | 67.0          | 1.21 (0.71-2.08) | -                  |
| <b>Question 5 - At school I lift heavy loads</b>                                                                 |               |                  |                    |
| never/seldom (97)                                                                                                | 42.3          | Reference        | Reference          |
| sometimes/often/very often (168)                                                                                 | 68.5          | 2.96 (1.77-4.97) | 3.02 (1.78 - 5.11) |
| <b>Question 6 - After school I am tired</b>                                                                      |               |                  |                    |
| very often/often/sometimes (150)                                                                                 | 58.0          | 2.23 (1.36-3.66) | 2.25 (1.34 - 3.77) |
| seldom/never (115)                                                                                               | 38.3          | Reference        | Reference          |
| <b>Question 7 - At school I sweat</b>                                                                            |               |                  |                    |
| very often/often/sometimes (161)                                                                                 | 60.9          | 3.35 (1.99-5.63) | 2.95 (1.71 - 5.07) |
| seldom/never (104)                                                                                               | 31.7          | ref.             | ref.               |
| <b>Question 8 - In comparison with others of my own age I think my school activity is physically</b>             |               |                  |                    |
| much heavier/heavier/as heavy (205)                                                                              | 71.2          | 1.33 (0.72-2.45) | -                  |
| lighter/much lighter (60)                                                                                        | 65.0          | Reference        | -                  |
| <b>Question 9 - Do you play sports or do physical exercises?</b>                                                 |               |                  |                    |
| Yes (151)                                                                                                        | 56.3          | 4.59 (2.65-7.93) | 3.73 (2.07-6.71)   |
| No (114)                                                                                                         | 21.9          | Reference        | Reference          |
| <b>Question 10 - In comparison with others of my own age I think my physical activity during leisure time is</b> |               |                  |                    |
| much more/more/the same (202)                                                                                    | 73.3          | 2.19 (1.22-3.94) | 2.46 (1.33-4.54)   |
| less/much less (63)                                                                                              | 55.6          | Reference        | Reference          |
| <b>Question 11 - During leisure time I sweat</b>                                                                 |               |                  |                    |
| very often/often/sometimes (153)                                                                                 | 66.7          | 4.05 (2.42-6.80) | 3.48 (2.02-6.01)   |
| seldom/never (112)                                                                                               | 33.0          | Reference        | Reference          |
| <b>Question 12 - During leisure time I play sport</b>                                                            |               |                  |                    |
| never/seldom (81)                                                                                                | 34.6          | Reference        | Reference          |
| sometimes/often/very often (184)                                                                                 | 68.5          | 4.11 (2.36-7.15) | 3.75 (2.10-6.70)   |
| <b>Question 13 - During leisure time I watch television</b>                                                      |               |                  |                    |
| never/seldom/sometimes (96)                                                                                      | 72.9          | 2.86 (1.66-4.91) | 2.63 (1.50-4.63)   |
| often/very often (169)                                                                                           | 48.5          | Reference        | Reference          |
| <b>Question 14 - During leisure time I walk</b>                                                                  |               |                  |                    |
| never/seldom (122)                                                                                               | 46.7          | Reference        | Reference          |
| sometimes/often/very often (143)                                                                                 | 63.6          | 2.00 (1.22-3.27) | 1.94 (1.17-3.22)   |
| <b>Question 15 - During leisure time I cycle</b>                                                                 |               |                  |                    |
| never/seldom (148)                                                                                               | 12.8          | Reference        | Reference          |
| sometimes/often/very often (117)                                                                                 | 41.0          | 4.72 (2.58-8.66) | 5.13 (2.67-9.86)   |
| <b>Question 16 - How many minutes do you walk and/or cycle per day to and from work, school and shopping?</b>    |               |                  |                    |
| <5/5-15 (149)                                                                                                    | 38.9          | Reference        | Reference          |
| 15-30/30-45/>45 (116)                                                                                            | 61.2          | 2.48 (1.51-4.07) | 2.20 (1.32-3.68)   |

BQHPA: Baecke Questionnaire of Habitual Physical Activity; OR: Odds Ratio; AOR: Adjusted Odds Ratio. \*Adjusted by sex, age group, and household education at baseline.

## Discussion

The main results of the present study were that current sedentary behavior and physical activity of adolescents seem to be significantly influenced by previous behaviors, except for light-intensity physical activity. Previous studies suggest that a decrease in light-intensity physical activity had a relevant contribution towards the reduction in habitual physical activity with increasing age (Cooper et al., 2015; Metcalf et al., 2015). Furthermore, sedentary behavior and activities with moderate-to-vigorous intensity seem to present greater stability between childhood and adolescence. This information may have important implications for Public Health, aiding in the development of intervention strategies (Grøntved et al., 2014; Metcalf et al., 2015), in different contexts of practice in which adolescents are usually engaged, namely at school, home, and in sports practice.

Sociodemographic variables seem to be important confounding factors for tracking of the leisure-time index and for the 'At school I stand' question. Since tracking of these behaviors could be different between classes of sociodemographic factors, interventions in these contexts must consider these characteristics. Changes in habits regarding physical activity seem to be influenced by changes in the network of social relationships and the structure of the school environment (Marks, Barnett, Strugnell, & Allender, 2015a; Marks, de la Haye, Barnett & Allender, 2015b). In addition, previous behavioral aspects appear to influence later behavior. The previous habit of taking sports equipment to school is associated with a higher practice of light physical activity, and previous physical activity or sport practice in the school recess is associated with higher physical activity later, regardless of intensity (Ridgers, Timperio, Crawford, & Salmon, 2013).

Studies with adolescents have commonly indicated that psychological aspects such as self-efficacy and perception of social support can also influence physical activity (Hamilton, Warner, & Schwarzer, 2017). Nevertheless, perceiving oneself as physically active may not be associated with being sufficiently active, and the lack of awareness about physical activity may be one of the factors contributing to the fact that young people do not recognize the need for physical activity (Corder et al., 2010). In the present study, the current perception of physical activity undertaken at school compared to same age peers was not influenced by the adolescents' previous perception. However, the perception of being active during current free time showed a significant association with the previous perception. This also seems to be associated with practice  $\geq 300$  min. week<sup>-1</sup> and  $\geq 420$  min. week<sup>-1</sup> of moderate-to-vigorous physical activity (Coledam et al., 2014).

An analysis of leisure-time showed that, individually, previous physical activity was associated with current physical activity for all sections of questions, although with different magnitudes. This finding suggests that despite the characteristics identified by Baecke et al. (1982) which include questions about occupation during free time and locomotion as part of the same dimension, these can represent different constructs. It can be observed that sedentary behavior is analyzed together with questions related to activities such as walking and cycling, both as a form of leisure and locomotion. The increase in sedentary behavior has a negative impact on the general score in this section. However, there is now a clearer distinction between sedentary behavior and insufficient physical activity, and that these are not mutually exclusive (Pate et al., 2008; Pearson et al., 2014).

Guidelines suggest that adolescents spend less than 2 hours a day using a screen (Council on Communications and Media, 2016) and at least an average of 60 minutes performing moderate-to-vigorous physical activity (Bull et al., 2020). However, a systematic review identified that similar beneficial effects on health and behavioral outcomes could be obtained with supervised programs with moderate-to-vigorous intensity, with durations of 30 to 45 minutes, and a frequency of 3 to 5 days a week (Strong et al., 2005). The cut-off points used in the present study for SPE are in accordance with these recommendations for supervised programs.

The fact that the practice of at least one month at baseline had a significant association with the practice in the follow-up considering both a period  $\geq 1$  month and  $\geq 4$  months is noteworthy. The results suggest that meeting the SPE criteria used in the present study at baseline significantly increased the chance of meeting the criteria again later. It is worth noting that the parameters used were similar to those suggested as the minimum recommended physical activity for adults (Bull et al., 2020), although guidelines for adolescents establish higher cut-off points for habitual physical activity.

Given the tracking of physical activity between childhood and adulthood, the expansion of SPE from moderate-to-vigorous intensity among adolescents could be an interesting strategy to increase the number of adults in the future who achieve the recommendations for physical activity (Telama et al., 2014; Metcalf et al., 2015). Indeed, considering only SPE, without establishing months of practice, it was found that the prevalences of achievement for the cut-off points of 300 min/week and 420 min/week among children and adolescents were 22.1 and 12.6%, respectively (Coledam et al., 2014). Using the cut-off point  $\geq 240$  min. week<sup>-1</sup> for  $\geq 4$  months, the prevalences were 21.7% for boys and 9.4% for girls (Fernandes et al., 2011). These studies were unable to state the total number of participants who met the criteria for habitual physical activity, as other domains of physical activity were not investigated. However, it appears that SPE can contribute in a relevant way to complying with these guidelines.

There is wide variation in the literature regarding the prevalence of sufficient physical activity in adolescents. For instance, using a cut-off point of 300 min. week<sup>-1</sup> among Brazilian adolescents, prevalences ranging between 18.4 and 92.3% were found. However, using the 60 min. day<sup>-1</sup> cut-off point, values from 12.6 to 68.2% were obtained (Barbosa Filho et al., 2018). Moreover, disregarding the criteria used, studies showed

prevalences ranging from 19 to 42% (Guthold et al., 2020; Marques et al., 2020; Freitas et al., 2021). It is essential to consider that part of the prevalence variation might be related to the different instruments and criteria used to analyze physical activity. However, evidence indicates that physical activity is a complex behavior and possibly influenced by a range of factors.

Furthermore, most of this information was obtained from cross-sectional studies, without considering changes over time, and tracking the behavior over time seems to be relevant to better design strategies. For instance, the prevalence of sufficiently active children between 5 and 15 years of age varied from 6 to 27% among girls, and from 32 to 43% among boys (Metcalf et al., 2015).

In our study, only 12.8% of the participants remained sufficiently active. At baseline, 30.2% were classified as sufficiently active and of these 42.5% were classified as sufficiently active for a period  $\geq 1$  month in the follow-up, while among practitioners with  $< 150$  min. week<sup>-1</sup> and/or  $< 1$  month, this figure was 28.6%, and among those who did not practice, 14.8%. This evidence corroborates studies suggesting that habits regarding physical activity developed in childhood might have an influence on further practice in adolescence and adulthood (Telama et al., 2014; Metcalf et al., 2015). Thus, it appears that SPE interventions are necessary to achieve adherence in this age group.

When interpreting the information in the present study, some limitations must be recognized. First, the lack of defined cut-off points for different dimensions of the BQHPA must be considered. Therefore, the 60th percentile was used for the classification of sections. In addition, the questions were dichotomized for carrying out the analyses, and although these strategies are widely used (Corder et al., 2010; Coledam et al., 2014; Guthold et al., 2020), they can influence the magnitude of the obtained associations. Physical activity was assessed by a questionnaire; however, its reliability was verified. Even though the present study was carried out in a non-representative sample, it brings information obtained prospectively, enabling understanding of changes in the behaviors analyzed in the different domains. The positive aspects of the current study should be highlighted, such as the longitudinal design and evaluation of potential confounding variables.

## Conclusion

Physical activity and sedentary behavior during adolescence were significantly influenced by previous practices. This behavior occurred in different domains, except for light physical activity.

Programs to reduce sedentary behavior should consider the possibility of intervention in specific contexts, while for physical activity should consider both the context and the intensity of efforts.

Strategies to encourage adolescents to remain active are required. SPE with moderate-to-vigorous intensities during at least 150 min/week for periods longer than one month, seem to positively influence the chances of this practice in the future. For interventions regarding light physical activity, it seems relevant that strategies aim at adherence.

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