



Relationship between smartphone use and sedentary behavior: a school-based study with adolescents

Relacionamento entre smartphone e comportamento sedentário: estudo de base escolar com adolescentes

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ABSTRACT

The aims of this study were a) to describe the smartphone use and sedentary behavior (SB) on typical weekdays and weekends, and b) to verify the association between smartphone use and SB among adolescents. This is a cross-sectional population school-based, which surveyed 984 students from Uberaba, Minas Gerais, in 2015. Gender-stratified analysis were performed using t-tests, Pearson's correlation (r) and multiple linear regression (β). Girls used more smartphones than boys (weekdays: 6.58 hrs vs. 5.29 hrs, $p < 0.001$; weekend: 7.81 hrs vs. 6.18 hrs, $p < 0.001$). Both genders used more smartphones in the weekend ($p < 0.001$) than weekdays. SB was higher in girls than boys (weekdays: 5.34 hrs vs. 4.48 hrs, $p < 0.001$, weekend: 5.22 hrs vs. 4.38 hrs, $p < 0.001$). SB was higher for both genders at weekend ($p < 0.001$) than on weekdays. Correlation between SB and smartphone use ranged from weak to moderate in both genders (weekdays: boys, $r = 0.30$; girls, $r = 0.17$, $p < 0.001$; weekend: boys, $r = 0.39$; girls, $r = 0.17$, $p < 0.001$). Smartphone use was positively associated with SB during the weekdays (boys: $\beta = 0.25$, girls: $\beta = 0.19$, $p < 0.001$) and weekend (boys: $\beta = 0.31$; girls: $\beta = 0.14$, $p < 0.001$). Girls showed greater SB and smartphone use than boys, regardless if compared on weekdays or weekend. SB and smartphone were positively associated in both genders.

Keywords: Sedentary lifestyle; Computers; Handheld; Cell phones; Health surveys.

RESUMO

Os objetivos deste estudo foram a) descrever o uso de smartphone e o comportamento sedentário (CS) em dias típicos de semana e final de semana (FDS) e, b) verificar a associação entre o uso de smartphone e o CS em adolescentes. Trata-se de um estudo transversal, com 984 escolares de Uberaba, Minas Gerais, conduzido em 2015. Para análises estratificadas por sexo, utilizou-se testes-t, correlação de Pearson (r) e regressão linear múltipla (β). Moças usavam mais o smartphone que os rapazes (semana: 6,58 vs. 5,29 horas, $p < 0,001$; FDS: 7,81 vs. 6,18 horas, $p < 0,001$). Ambos os sexos usaram mais smartphone no FDS ($p < 0,001$). O CS foi maior nas moças que nos rapazes (semana: 5,34 vs. 4,48 horas, $p < 0,001$; FDS: 5,22 vs. 4,38 horas, $p < 0,001$). O CS foi maior no FDS, em ambos os sexos ($p < 0,001$). A correlação entre CS e smartphone foi de fraca a moderada em ambos os sexos (semana: rapazes, $r = 0,30$; moças, $r = 0,17$, $p < 0,001$; e FDS: rapazes, $r = 0,39$; moças, $r = 0,17$, $p < 0,001$). Uso de smartphone foi positivamente associado com CS durante a semana (rapazes: $\beta = 0,25$; moças: $\beta = 0,19$, $p < 0,001$) e FDS (rapazes: $\beta = 0,31$; moças: $\beta = 0,14$, $p < 0,001$). Moças apresentaram maior CS e uso de smartphone do que rapazes, independentemente se comparados na semana ou FDS. CS e uso de smartphones foram positivamente associados em ambos os sexos.

Palavras-chave: Estilo de vida sedentário; Computadores de mão; Telefone celular; Inquéritos epidemiológicos.

Introduction

Considering both the volume of sales¹ and its technological resources², smartphones are the technology most used every day³⁻⁶. Approximately 122 million smartphones had been sold worldwide in 2007, and that number increased from 1.4 billion in 2015 to 1.56 billion in 2018². The growth of users is a global phenomenon. However, such growth is more expressive in economically emerging countries as Malaysia, China, and Brazil¹. Smartphones, also known as all-in-one devices, are equipped with high-tech operating systems

(e.g., Apple iOS, Google Android, Windows Phone) and advanced features (touch screen, camera, mobile phone, applications, digital assistants, task managers, and mobile internet). Their set of features makes them attractive and multitasking.

Teenagers stand out as the largest group of smartphone users. Approximately three-quarters of US adolescents have a cell phone, and almost half of these are smartphone-type mobile devices³. Among Asian adolescents, the prevalence of smartphone ownership was 40.6% in China, 55.7% in Hong Kong, 56.7% in

Malaysia, 63.8% in Japan, 67.2% in the Philippines and 84.4% in South Korea⁴. A national survey showed that 54%, 81% and 87% of Brazilian adolescents, aged 10 to 14, 15 to 17 and 18 or 19 years old, respectively, had a mobile phone for personal use in 2015. The proportion of ownership varied among students from private (94%), and public schools (67%)⁵. This age group also spends more time using smartphones. Hungarian teenagers were reported to spend an average of 4.48 hours per day using smartphones, and boys use less (3.4 hours) than girls (5.3 hours)⁶.

As a part of sedentary lifestyle, the sedentary behavior (SB), that is, any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting, reclining or lying position⁷ is considered a risk factor for the adolescents' health. SB has been associated with poor eating habits⁸, overweight and obesity⁹, increased cardiovascular and cardiometabolic risks in adolescents¹⁰, and risk of mortality in adulthood¹¹. TV viewing, videogame and computer use, also known as screen time, is the most common way of SB assessment^{12,13}. However, this operational definition can represent only part of the daily sedentary time¹⁴. Moreover, this usual parameter neglects the possibility of sedentary time in other screen activities. To illustrate this, a systematic review update¹⁵ of SB and health indicators in children and youth included search terms related to portable devices. In the review, Carson et al.¹⁵ assumed that young people use the technologies while they remain seated as when they say "[...] the present review included search terms to capture newer technologies, such as tablets and smartphones. [...] Portable devices, including cell phones, were included in the review under the assumption that children and youth primarily used these devices while seated". However, few studies included in the review used mobile devices as a measure of SB, perhaps because it is believed that youth may not be primarily seated when using these devices. In contrast, this relationship has already been explored among adults¹⁶. The authors¹⁶ showed that cell phone use was associated with SB and that 81% of people use the cell phone while sitting or lying down.

As shown, smartphones are available, fashionable and highly used, especially among youth¹⁻⁶. Also, studies on SB almost exclusively consider TV viewing and computer and/or video game use as measures of sedentarism^{12,13}. Up to the moment, no study investigated the association between smartphone use and SB among Brazilian adolescents. Thus, following these gaps, this

cross-sectional population-based study with school students had the aims: a) describe the smartphone use and SB and b) to verify the association between smartphone use and SB among adolescents.

Methods

The Assessment of Health Behavior and Lifestyle of Adolescents in Uberaba (ACtVU Study) was a cross-sectional school population-based study, including private and public schools to evaluate SB and associated factors in adolescents. The study was carried out between May and October of 2015. The city of Uberaba, Minas Gerais, Brazil, has 4,533.81 km² and a population density of 65.29 inhabitants/km². The city has a high human development index (0.772 – 14th in the state and 240th in the country), a Gini index of 0.50, per capita income of R\$ 978.01 and life expectancy of 75.7 years at birth¹⁷. We follow the STROBE Statement¹⁸ to report this paper ([see supplementary material A](#)).

Sample size was calculated considering: survey population (N = 10,903), SB prevalence (P = 50%), 95% confidence level, acceptable sampling error (5%), two-point effects design (deff = 2) and addition of 20% and 10% for losses/refusals and confounding analyses, respectively. The estimated sample size was 979 adolescents – this sample size was calculated for the ACtVU Study project using Epi Info™ 7. A post hoc tests revealed that the sample size achieved for the multiple regression models in this study reached values between 0.99 and 1.00 power (G*Power 3.1.9.2, parameters: F test; R² = 0.084 to 0.162; effect size f² = 0.091 to 0.193; sample size = 440 [boys] and 554 [girls]; n predictors = 5; α = 0.05). The selection process adopted was a two-stage proportional conglomerate. In the first stage, 15 schools (public = 9, private = 6, out of 36 eligible) were drawn. In the second stage, 50 classes were randomly selected (out of 362 eligible). Eligibility criteria for this study included adolescents aged 14 to 18 years with valid data for all interest variables.

We use two previously validated questionnaires^{19,20}. The Portable Technologies and Mobile Internet Questionnaire (Tecno-Q) was used to assess smartphone use. The Tecno-Q reproducibility test-retest showed Kappa values ranging from 0.77 to 1.00 and intraclass correlation coefficient ranging from 0.94 to 0.98¹⁹. The Behavior of Adolescents from Santa Catarina state Questionnaire (COMPAC) was used to assess SB. Test-retest reproducibility for the COMPAC Questionnaire ranged from 0.51 to 0.96²⁰. Body mass index (BMI)

was calculated as weight (kg)/height (m)² and then classified as low weight/eutrophic and overweight/obesity²¹. A stadiometer (WCS®, Wood Portable Compact, capacity 220 cm, graduation 1 mm) and a digital scale (Wiso®, w939, capacity 180 kg) were used in these measurements. A trained team of physical education students and teachers carried out all data collection.

Adolescents were asked about ownership (yes or not) and the type of cell phone (smartphone or other). Smartphone use was ascertained through the question: “How much time per day do you spend accessing the internet through the mobile phone?”. “Access to the internet” was considered as the forms of access via wireless network (e.g. Wi-Fi™, mobile internet - 3G/4G modem etc.) for any use like check email, social networks (e.g. Facebook, Instagram etc.), online chatting, watching videos, listening to music and playing online. The access was considered only by the adolescent himself. SB was estimated by the sitting time, using the following question: “How much time do you spend sitting, talking to friends, playing cards or dominoes, talking on the phone, driving or as a passenger, reading or studying?”. Adolescents were asked to disregard the time watching TV, using a computer and/or video game and playing games on the smartphone when responding to this question. Both questions were answered for a typical weekday (Monday to Friday) and weekend (Saturday or Sunday). The variables were assessed and analyzed in hours per day.

The covariates were age (full years), school type (public or private), school grade (first, second or third grade) and screen time (TV viewing and computer use). We selected these covariates to adjust for possible demographic, school characteristics and other sedentary screen activities that could act as confounding factors in the sample.

Descriptive characteristics including frequencies, means, standard deviations (\pm), and 95% confidence intervals (95%CI) were calculated for the total sample and school type groups. The Kolmogorov-Smirnov test was used to test the normality of the data. Independent and dependent t-tests were used to compare means in continuous variables between gender and between weekdays and weekend days, respectively. Independent t-test was also used to compare time using smartphone and SB throughout the study sample. The Levene's test for equality of variance was used in the independent t-test. The chi-squared test (χ^2) was used to test the differences in the categorical variables.

Pearson correlation (r) was used to test the correlation between smartphone use and sitting time (both in hours/day). The r scores were interpreted²² as weak correlation ($r = 0.10-0.29$), moderate ($r = 0.30-0.49$) and substantial ($r = 0.50-1.00$). Simple and multiple linear regression models, adjusted for covariates, were constructed to quantify the angular coefficients (β) between smartphone use and SB (both in hours/day). The β coefficient represents how much the mean of Y (SB) change for an increase of one unit of variable X (smartphone). The adjusted models were tested for multicollinearity using the Variance Inflation Factor (VIF) and the tolerance ($1/VIF$). $VIF < 10$ and $1/VIF > 0.10$ were considered acceptable diagnostic values²³. The normality of the residuals was verified using the single sample Kolmogorov-Smirnov test (D). The cross-validation of the models was verified by the adjusted R^2 (R^2_a).

All analyses used recommended survey procedures and sample weighting to account for the clustered sampling design and to yield school population-based representative findings. We found inconsistent values for smartphone use and SB. Therefore, the data were cleaned and the analyses were adjusted to the average self-reported daily sleep time on weekdays (boys = 429.5 min/day; girls = 429.9 min/day) and weekend (boys = 521.0 min/day; girls = 514.6 min/day) in our sample²⁴. The inferential analyzes are shown separated by gender and weekdays (weekdays and weekend). Results were considered statistically significant if $p < 0.05$. The Epidata Entry (<http://www.epidata.dk/>) was used for double typing and data validation. The SPSS software version 21 (IBM® SPSS® Inc., Chicago, USA) was used to carry out the analyses.

The Secretariat of Education of the State of Minas Gerais and the Regional Superintendence of Education of Uberaba authorized this study. The local research ethics committee approved the protocol (number 994,772), and informed consent was obtained from all participants. The ACtVU Study was conducted following the Declaration of Helsinki.

Results

A total of 1,363 adolescents were invited to participate, 295 do not consent/assent to participate, and 84 were outside the age group or were missing data (BMI, $n = 67$ - for descriptive analysis). The final sample consisted of 984 participants, for the main analyses. The mean age was 15.93 ± 1.13 and 15.87 ± 1.06 years for boys and girls, respectively. Girls corresponded to

55.6% of the sample. The characteristics of the participants (gender, age group and BMI) are reported for the total sample and for school types (Table 1).

Nine out of ten adolescents (95.8%) responded by owning a cell phone and almost all were smartphone (95,3%). Overall and gender-stratified smartphone use and SB are shown in Table 2. The independent t-test showed significant differences between boys and girls in smartphone use for both weekdays ($p < 0.001$) and weekends ($p < 0.001$). There were significant differences between weekdays and weekends among boys ($p < 0.001$) and girls ($p < 0.001$). As for SB, there was a significant difference between boys and girls during both weekdays ($p < 0.001$) and weekends ($p < 0.001$). Both genders showed differences in SB between weekdays and weekends ($p < 0.001$). Time using smartphone was superior to the sitting time both on weekdays and weekend days ($p < 0.001$) - Table 2.

The overall correlation between SB and smart-

phone use was weak and positive (weekdays: $r = 0.24$, $p < 0.001$; weekend: $r = 0.28$, $p < 0.001$). In boys, there was a weak positive correlation between smartphone use and SB in weekdays ($r = 0.30$, $p < 0.001$) and a moderate positive correlation in weekends ($r = 0.39$, $p < 0.001$). In girls, weak positive correlations were identified in both weekdays ($r = 0.17$, $p < 0.001$) and weekends ($r = 0.17$, $p < 0.001$).

Table 3 shows simple and multiple linear regression models. All adjusted linear regression models were significant ($p < 0.001$). In all models, a change of one unit in the time of smartphone use was positively associated with the change in SB. All adjusted regression models presented acceptable values for diagnostic statistics. Cross-validation values were low for all models (Table 3).

Discussion

This study described the use of smartphone and SB among adolescents and verified the relationship bet-

Table 1 – Sample characteristics, overall and stratified by school type. ACtVU Study 2015. Uberaba, Minas Gerais.

Variables	All		Public		Private		χ^2
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	
Genders							0.011
Boys	440	44.4 (39.6;49.2)	373	47.2 (42.1;52.4)	67	34.2 (28.0;40.9)	
Girls	544	55.6 (50.8;60.4)	413	52.8 (47.6;57.9)	131	65.8 (59.1;72.0)	
Age							<0.001
14 to 16 years	697	67.8 (54.4;78.9)	533	65.5 (50.2;78.2)	164	83.0 (62.8;93.4)	
17 to 18 years	287	32.2 (21.1;45.6)	253	34.5 (21.8;49.8)	34	17.0 (6.6;37.2)	
BMI [#]							0.423
Low weight/eutrophic	692	74.5 (69.9;78.6)	553	74.7 (69.7;79.2)	139	72.0 (65.9;77.3)	
Overweight/obesity	225	25.5 (21.4;30.1)	170	25.3 (20.8;30.3)	55	28.0 (22.7;34.1)	

95%CI = 95% confidence interval; BMI = body mass index; [#] = 67 missing data.

Table 2 – Overall and gender-stratified smartphone use and sedentary behavior. ACtVU Study 2015. Uberaba, Minas Gerais.

Variables	Weekdays		Weekend		Dependent t-test	P
	Mean	SD	Mean	SD		
Smartphone use (hours)						
All	6.62 [†]	± 4.41	7.25 [†]	± 4.42		
Boys	5.29	± 3.95	6.18	± 4.25	-32.054	<0.001
Girls	6.58 [§]	± 3.90	7.81 [§]	± 4.31	-45.390	<0.001
Sedentary behavior (hours)						
All	5.11 [†]	± 4.04	4.94 [†]	± 3.95		
Boys	4.48	± 3.64	4.38	± 3.51	3.759	<0.001
Girls	5.34 [§]	± 4.03	5.22 [§]	± 4.11	4.364	<0.001

SD = standard deviation; Symbol (§) indicates significant independent t-test (boys vs. girls, all comparisons $p < 0.001$); Levene's test = smartphone use - weekdays ($F = 20.194$, $p < 0.001$), weekend ($F = 1.137$, $p = 0.242$); sedentary behavior - weekdays ($F = 273.245$, $p < 0.001$) weekend ($F = 694.655$, $p < 0.001$); Symbol (†) indicates significant independent t-test (smartphone use vs. sedentary behavior, for "All sample", all comparisons $p < 0.001$); Levene's test = weekdays ($F = 1,279.3$, $p < 0.001$), weekend ($F = 1,800.0$, $p < 0.001$).

Table 3 – Simple and multiple linear regression models of smartphone use and sedentary behavior. ACtVU Study 2015. Uberaba, Minas Gerais.

Variables	Simple linear regression*				Multiple linear regression ^{†*}			
	Weekdays		Weekend		Weekdays		Weekend	
	β (95CI%)	R ² a	β (95CI%)	R ² a	β (95CI%)	R ² a	β (95CI%)	R ² a
Boys	0.22 (0.21;0.23)	0.06	0.24 (0.23;0.25)	0.08	0.13 (0.12;0.15) ^A	0.08	0.29 (0.28;0.31) ^C	0.16
Girls	0.13 (0.12;0.15)	0.03	0.19 (0.18;0.20)	0.05	0.18 (0.16;0.20) ^B	0.16	0.20 (0.18;0.22) ^D	0.12

B = angular regression coefficient; † = multiple regression model adjusted to age (completed years), school type (public and private), school grade (1st, 2nd and 3rd) and screen time (TV viewing and computer use); R²a = adjusted R²; *All regression models presented p < 0.001 (single and multiple); Upper case letters (^{A,B,C,D}) indicate multiple linear regression models. Model diagnostics (range of values): Age: VIF = 1.0 to 1.8 (models B and D, respectively), 1/FIV = 0.6 to 1.0 (models D and B, respectively); School type: VIF = 1.0 to 1.2 (models A and B, respectively), 1/FIV = 0.9 to 1.0 (models B and A, respectively); School grade: VIF = 1.4 to 1.9 (models A and D, respectively), 1/FIV = 0.5 to 0.9 (models B and A, respectively); Screen time: VIF = 1.0 to 1.1 (models C and A, respectively), 1/FIV = 0.9 to 1.0 (models A and C, respectively); Normality of residuals: D = 5.5 to 10.7 (models D and A, respectively, all models p < 0.001).

ween these two variables. The main findings of the current study were that SB and smartphone use time differed between boys and girls, during weekdays and weekend days. There were positive correlations, ranging from weak to moderate magnitudes, between smartphone use time and SB in adolescents. Finally, the multiple linear regression models confirmed the contribution of smartphone use time to sitting time in our sample.

In the present study, girls spent more time sitting than boys on weekdays. In a previous study with North-American adolescents, girls also spent more time sitting than boys for most of the comparisons (total time, race/ethnicity [non-Hispanic whites, non-Hispanic blacks, and Mexican-Americans], and body mass status [obese and non-obese])²⁵. Specialists have considered high sitting time as a public health problem, especially among adolescents. High sitting time is associated with poor eating habits⁸, overweight and obesity⁹ and higher cardiovascular and cardiometabolic risk¹⁰. The definition of SB⁷, as known and used today, makes a wide range of daily activities to be classified as SB, even in a single postural position such as the sitting position, as adopted in this study. In the present study, some examples were used to illustrate the “sitting” position (e.g., playing cards or dominoes, talking on the phone, driving or travelling as a passenger, reading or studying). The mention of these activities in a single question is a factor that limits a more detailed identification of the differences in the SB pattern between the genders.

A systematic review of Brazilian studies¹² pointed out that sitting time, apart from screen activities, had not been investigated among the 49 studies included. In the National Health and Nutrition Examination Survey (NHANES)²⁵, conducted with American adolescents (median of 15.5 years old), the average sitting

time was 7.5 hours per day, higher than our results. Also similar to the present study, the NHANES found that girls spent a long time in sitting position compared to boys. However, unlike the present study, the analyses in the NHANES considered sedentary activities in front of screens (TV or computer) as sitting time and did not stratify the results between weekdays and weekend days. Being sedentary is related to other behaviors⁸ and negative outcomes^{9,10} for the health of young people. In adults and the elderly, prolonged sitting time was associated with increased risk of all-cause mortality and cardiometabolic diseases¹¹, thus indicating the need to reduce opportunities to remain seated, especially in discretionary time, in early phases of life (i.e., childhood and adolescence).

Adolescents in the present study reported spending a considerable portion of time using smartphones. Our results were higher than those observed in a study with Hungarian adolescents²⁶, in which girls also spent more time using smartphones than boys. Our results showed that the time using technology was higher on the weekend than on weekdays among boys and girls. Previous research reported that American boys and girls are always online, smartphones are facilitators, and the two groups have distinct profiles as to the purpose of using technology: girls use more social media and boys most often play games²⁶. The present study was limited to investigating only the profile of time spent using smartphones, restricting the analysis and discussion of results regarding the difference between genders in the use of technology.

The positive correlations between sitting and time using smartphones presented in this study reinforce that time spent using smartphones must be taken into account in investigations on SB in adolescents. Furthermore, considering that access and popularity of

screen-based technologies have increased among the pediatric population, as pointed out by Tremblay et al.¹⁴, future research on SB should focus on the use of media. It is necessary to consider the portable devices (e.g., smartphones) that can cause an increasingly common phenomenon: multitasking sedentarism¹⁵. According to these authors, young people can be in front of the TV, use the telephone (smartphone) and the computer at the same time. Thus, considering the expansion of commercialization of new media technologies such as smartphones especially among young people, future research should focus on investigating the impact of the time spent using these devices on SB.

In the present study, the multiple linear regressions show that time using smartphones was associated with SB among boys and girls. The substantial amount of time spent by adolescents with smartphone use identified in this study, especially on weekends, represents a worrying finding because the opportunity to remain seated would tend to rise. Fennel et al.¹⁶ also explored the relationship between cell phone use and SB. In an online survey, 81% of the adults (40 ± 16 years old) interviewed responded using their cell phone while sitting or lying down, contrasting with 8% who reported that this typically occurs while standing and 11% reported using their cell phone while walking or moving about. In addition, cell phone use was significantly and positively associated with SB ($\beta = 0.157$, $p = 0.002$). While there has been an increasing effort to reduce the opportunities for younger people to remain seated²⁷, especially in recreational time, smartphones appear to be against to this goal. Most intervention strategies to reduce SB include efforts to restrict the screen - television viewing, computer and/or video game available in rooms used by young people²⁷. Although some success has been found to derive from the adoption of these strategies, future interventions may not be successful if they disregard the influence of portable devices on SB, according to our results. Also, the attraction of young people to smartphones should also be considered, as it has been demonstrated that younger people (15-16 years old) are more likely to exhibit dependence on smartphones than young adults (≥ 19 years old)²⁸.

To clarify some of the issues raised and not answered in this study, some directions are pointed out. Future studies should advance research on smartphone use and sedentary lifestyle, especially to elucidate the differences between genders and content and context of the use of portable devices. The following questions

can be tested in the future studies: what type of media do adolescents consume on their smartphones? Does the media type influence SB? Do students remain in SB and using smartphones during school recess? Finally, as must have occurred with Fennel et al.¹⁶ (since they used a structured question similar to ours), our question about sitting time included “talking on the phone” as an example of sedentary activity, which can lead to misclassification. To deal with this, the question needs to be improved and longitudinal research studies (experimental or observational) can use objective (e.g., Microsoft SenseCam) or mixed methods (e.g., objective + interviews) to answer some that questions and best investigate adolescent behavior to identify and analyze the context of SB and the use of technologies.

This study has some limitations. First, the use of questionnaires to measure the variables of interest – SB and time using smartphones – which may underestimate or overestimate the measures. For instance, a systematic review¹⁴ showed that studies using direct (i.e. accelerometers) measures found that young people spent a large portion of their day (up to 9 hours) being sedentary – higher than shown in our study. However, although the results of SB may be underestimated in our study, we emphasize that the SB that we investigated excluded screen time, that is, we evaluated only part of the sedentary time of adolescents – and the low values may be due to this. Moreover, the instruments used in this study had satisfactory psychometric validation indexes^{19,20}. Second, as this is a observational study, causality can not be confirmed for use of smartphone and SB. Third, the low values of cross-validation of the multiple regression models indicate that caution is needed in what concerns the generalization of the results. Fourth, the situational use of smartphone (e.g., sitting, standing, or moving about)¹⁶ was not evaluated in our study. Thus, we failed to confirm the findings of Fennel et al.¹⁶ and Barkley & Lepp²⁹ when they showed that adults use cell phones primarily while they are sitting (at 81% and 87% of the time, respectively). Additionally, since the time using smartphone was longer than the sedentary time in our sample, using the smartphone can be a sedentary activity but it is not exclusive to that. The strong points of this study were the short intervals of data collection, which minimize the behavioral bias of seasonality; the novelty in revealing that smartphone use is a predictor of SB; the sample that represented well the community of school adolescents according to schools types (public and private) in the municipality studied.

In conclusion, girls showed greater SB and smartphone use than boys, regardless if compared on weekdays or weekend. SB and smartphone were positively associated in both genders.

Conflict of interest

The authors declare no conflict of interest.

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Author's contributions

Lourengo CLM e Mendes EL, participated in the initial design and conduction of the ACtVU Study. All authors equally contributed to the design, analyses and interpretation of results, writing and critical review of this study.

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