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Combined physical activity and sitting time and their contribution to body mass index in adults

Atividade física e tempo sentado combinados e sua contribuição no índice de massa corporal em adultos

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Abstract – The aim of this study was to analyze the contribution of physical activity (PA) and sedentary time (ST) to Body Mass Index (BMI) in adults. The study was conducted in 2009, in Curitiba, Parana, Brazil with adults aged 18-65 years (1,411). A multidimensional questionnaire was used in which BMI, weekly minutes of PA and ST were obtained from self-reports. PA and ST were combined to determine the following independent variables: a) "active and not sedentary"; b) "active and sedentary"; c) "not active and not sedentary" and d) "not active and sedentary". Multinomial logistic regressions were used to test the associations between PA, ST and BMI. The adjusted regression model showed that PA, regardless of ST, lowered the likelihood of participants being classified as obese by 34% and 55%, respectively. In addition, PA at recommended levels (≥150 minutes/week), while not being sedentary, lowered by 85% the likelihood of being classified in the underweight category. Finally, ≥10 minutes/week of PA, while reporting higher ST levels, reduced the likelihood of being classified as overweight by 37%. PA is associated with BMI regardless of TS. In addition, PA at recommended levels is inversely related to obesity and overweight.

Key words: Brazil; Motor activity; Nutritional status; Sedentary lifestyle.

Resumo – *O objetivo do estudo foi analisar a contribuição da atividade física (AF) e do tempo sedentário (TS) no Índice de Massa Corporal (IMC). O estudo foi conduzido em 2009, em Curitiba, Paraná, Brasil com adultos de 18 à 65 anos (n=1.411). Foi aplicado um questionário multidimensional em que o IMC, AF e TS foram obtidos de forma autorreportada. AF e TS foram combinados para determinar as variáveis independentes: a) "ativo e não sedentário"; b) "ativo e sedentário"; c) "não ativo e não sedentário" e d) "não ativo e sedentário". A regressão logística multinominal foi empregada para testar as associações entre AF, TS e IMC. As análises ajustadas demonstraram que AF, independente do TS, reduz entre 34% e 55% as chances dos participantes serem classificados como obesos. Além disto, praticar ≥150 minutos/semana de AF e não ser sedentário reduziu em 85% as chances dos participantes serem classificados com baixo peso. Por fim, praticar ≥10 minutos/semana de AF, mesmo apresentando TS elevado, reduziu em 37% a chance de classificação em sobrepeso. A prática de AF está associada com IMC independente do TS. Além disto, AF em níveis recomendados tem relação inversa com a obesidade e sobrepeso.*

Palavras-chave: *Atividade motora; Brasil; Estado nutricional; Estilo de vida sedentário.*

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INTRODUCTION

High Body Mass Index (BMI) values are an important risk factor for chronic noncommunicable diseases (NCDs), such as cardiovascular diseases, renal diseases, diabetes, some cancers and musculoskeletal disorders [1]. Data from more than 19 million people in 186 countries have shown that the mean BMI has increased considerably in recent decades[1]. In Brazil, in 2014, the prevalence of adults in Brazilian capitals with overweight and obesity was 52.5% and 17.9%, respectively[2]. Thus, the identification of factors that may attenuate or reverse this situation has been widely discussed in literature[3].

In this sense, the regular practice of physical activity (PA) and the reduction of sedentary time (ST) have been highlighted throughout the world as they are factors of prevention for the emergence of NCDs[4]. Nevertheless, 23% of the world population[5] and 15.4% of the Brazilian population[2] is considered physically inactive. Regarding sedentary behavior, 25.3% of the adult population of Brazilian capitals has a habit of watching television for more than three hours daily[2]. In addition, women, older adults and people of low socioeconomic status (SES) are more likely to spend longer times in sedentary behavior[6].

There is evidence, especially in high-income countries, that the increase in PA levels and the reduction of ST are associated, independently and together, with lower adiposity[7] and also with favorable lipid profile (HDL cholesterol)[8]. Data from a multicenter study in 10 countries have shown that higher PA levels were associated with reduction in the probability of overweight and obesity in adults, although no significant results were found for ST[9]. In addition, a recent meta-analysis has found that practicing at least 60 minutes of moderate daily PA can eliminate the increased risk of death for a variety of NCDs, such as dyslipidemia, diabetes, hypertension, and cardiovascular disease caused by high ST[10]. In a cohort study conducted in Switzerland with 3,042 adults between 1991 and 2011, vigorous PA was inversely associated with obesity in both cross-sectional and longitudinal data. Participants who remained or became inactive were associated with weight gain and increased body fat, but ST was not associated with increased BMI[11]. In another study conducted in Brazil, active commuting and BMI were inversely associated[12].

Despite the consistent relationship between influence of PA on BMI and the benefits of regular practice of PA, to date, there is no evidence of the combined association of PA and ST with population BMI in samples of the Brazilian population. Available studies have analyzed these behaviors and factors in isolation[13]. Understanding this relationship will serve as a subsidy for public health decision makers, especially because in the last 10 years, in the Brazilian population, there was a 10% increase in the prevalence of overweight and obesity, 16% of physical inactivity and 23% in daily time watching television (≥3 hours / day). Thus, the aim of this study was to analyze the contribution of PA and ST, analyzed together, on BMI levels in an adult sample.

METHODOLOGICAL PROCEDURES

Place of study

This study was carried out in the city of Curitiba, capital of the State of Paraná, which is located in the southern region of Brazil. At the time of data collection, the city had 1,897,997 inhabitants (≈1,130,139 adults) in an area of 435,036 Km^2. The city has high Municipal Human Development Index (0.823), when compared to other Brazilian municipalities, and with an extensive green area (65m^2 per inhabitant), which includes 21 parks and 454 squares[14].

Design, study characteristics and ethical aspects

This is an observational epidemiological study of cross-sectional design, part of a broader project called "*Caminhos para o Parque*", which aimed to examine the role of urban parks in PA levels of adults in Curitiba, Paraná, Brazil. The details of the methodology of this study are described in literature[14].

Selection of parks and squares

For the present study, eight public leisure spaces (four parks and four squares) were selected. Initially, neighborhoods in which there were public spaces with characteristics of the physical environment were selected (e.g., parks, squares, animation axes) suitable for the practice of PA (75 neighborhoods). Then, with the aim of covering different characteristics of neighborhoods and the population of Curitiba, neighborhoods were stratified according to income and characteristics of the "social and built environment" (AMB) aimed at the practice of PA[16]. Coordinators of the Municipal Secretariat of Sports Leisure and Youth (SMELJ) and Municipal Health Secretariat (SMS), indicated in which public spaces there were PA interventions or programs. After three consultations, consensus was obtained among coordinators and four parks and four squares were selected, being distributed in different income strata and AMB (high income and high AMB, high income and low AMB, low income and high AMB; low income and low AMB)[14].

Selection of households and participants

For the selection of households, an area of 500 meters radius was determined from the central point of each public space included in the study. All segments of streets within this area were listed in order to identify places with domiciles. In each street segment, a household was randomly selected, and all residents of the household considered eligible (≥18 years, apparently healthy and residing at the place selected for at least one year) were identified. Among these, a resident was randomly selected. More detailed information on the sampling process is available in literature[14].

Data collection

Face-to-face interviews were conducted between April and July 2009,

totaling 86 days. Twenty-five female interviewers with experience in data collection were selected and trained by specialists from the Research Group on Physical Activity and Quality of Life. The theoretical course lasted 24 hours and the practical one lasted four hours. The research was approved by the Ethics Research Committee (No. 005/2008) and participants signed the Free and Informed Consent Form.

Dependent variable

BMI was calculated from self-reported measures of height and body mass[17] and participants were classified as "low weight" (≤18.5 kg / m^2), "normal weight" (18.6-24.9 kg / m^2), "overweight" (25-29.9 kg / m^2) and "obese" (≥30 kg / m^2), as recommended by the World Health Organization[18].

Independent variables

Total leisure PA was subjectively measured using the long version of the International Physical Activity Questionnaire (IPAQ), validated for the Brazilian population, using the following equation: [walk + moderate activity + (vigorous activity * 2)][19]. ST was measured by the sum of the time spent seated during weekdays and weekends, except time spent sitting in a passive commuting (bus and / or car)[4]. Subsequently, the daily mean of the total time spent in ST was calculated.

For purposes of analysis, two models were created for the combination of variables: a) active: PA ≥150 minutes / week and sedentary: ST ≥240 minutes / day, according to PA[20] and ST recommendations[4,10]; b) active: PA ≥ 10 minutes / week and sedentary: TS ≥240 minutes / day, considering a less rigid criterion for PA and ST recommendations[4,10]. Finally, the independent variable was operationalized for each model, with PA and ST combination: a) "active and not sedentary"; b) "active and sedentary"; c) "not active and not sedentary" and d) "not active and sedentary". The combination of these variables allowed us identifying which behaviors help to obtain a more adequate nutritional profile.

Covariates

Covariates were obtained through a questionnaire. Sex was obtained by the observation of interviewers (male / female). The age group was calculated from the date of birth and classified into five categories (18-29 years, 30-39 years, 40-49 years, 50-59 years and ≥60 years). Finally, SES was evaluated with questions that consider the number of household appliances, presence of maid and schooling of the family head, proposed by the Brazilian Association of Research Companies (ABEP). For purposes of analysis, SES was classified into three categories: low (E, D, C2 and C1), intermediate (B2 and B1) and high (A2 and A1).

Statistical analysis

Absolute and relative frequency distribution was performed to characterize the sample. Subsequently, the chi-square test (x^2) for heterogeneity

was used to test the association between covariates and the PA and ST models. After performing bivariate analyses, covariates that presented p≤0.20 were included in the adjusted model (sex, age group and SES), as possible confounding factors[21]. Finally, gross and adjusted multinomial logistic regression was used to test the association between PA and ST combinations with BMI classifications. The forced input method was used in which all previously tested significant covariates (p≤0.20) were inserted into the regression model. Analyses were performed in SPSS 23.0 and the significance level was maintained at 5%.

RESULTS

Of the total sample, 50 participants were excluded because they did not present complete data of variables used in the present study. Thus, the final sample consisted of 1,411 adults, mostly women (63.1%), aged 50-59 years (22.8%), intermediate SES (49.5%) and BMI classified as normal (49.1%). Overall, 35.2% of participants reported performing ≥150 minutes / week of leisure PA and more than half (54.7%) reported practicing ≥10 minutes / week of leisure PA. In relation to ST, it was observed that in out of 10 participants, four remained ≥240 minutes / day in this behavior (43.2%). When considering the PA and ST categories, a greater proportion was observed in the non-sedentary and non-active groups for both PA classifications, ≥150 minutes / week (37.8%) and ≥10 minutes / week (26.4 %) (Table 1).

The most frequent measures among men were ST (48.4%, p = 0.003), overweight (37.8%, p = 0.016) and PA level considered active for both classifications, ≥150 minutes / week (41.8%, p <0.001) and ≥10 minutes / week (63.3%, p <0.001). On the other hand, low weight (3.3%, p = 0.016) and obesity (15.5%, p = 0.016) were more frequent among women. Regarding age group, higher frequency of adults classified as sedentary (57.6%, p <0.001), with low weight (3.8%, p <0.001) and normal weight (68.0%, p < 0.001) was found among participants aged 18-29 years. Finally, for SES, higher frequency of participants classified as sedentary (54.4%, p <0.001) and active in both classifications, ≥150 minutes / week (55.0%, p <0.001) and ≥10 minutes / week (75.6%, p <0.001) was found in participants with high SES (Table 2).

In the multinomial logistic regression analysis, for the combination of BMI, PA performed at ≥150 minutes / week and ST (Figure 1), there was an inverse association between "low weight" and "active / not sedentary" (OR: 0. 15, 95% CI 0.03-0.67), "obese" and "active / sedentary" (OR: 0.45, 95% CI: 0.26-0.77) and "obese" and "active / not sedentary "(OR: 0.52; 95% CI: 0.32-0.48) when adjusted for sex, age and SES. For the combination of BMI, PA performed at ≥10 minutes / week and ST (Figure 2), there was an inverse association between "low weight" and "active / not sedentary" (OR: 0.35, 95% CI: 0.13-0.93), "overweight" and "active / sedentary" (OR: 0.63, 95% CI: 0.43-0.92), "obese" and "active / sedentary" (OR: 0.56; 95% CI 0.35-0.92), "obese" and "active / sedentary" (OR: 0.52; 95% CI 0.33-0.82) when adjusted for sex, age and SES.

Table 1. Sociodemographic characteristics, physical activity and sedentary time in adults enrolled in the "Caminhos para o Parque" project. Curitiba, Paraná, Brazil (n = 1.411).

Variables	Categories	n	%
Sex	Male	521	36.9
	Female	890	63.1
Age	18-29	316	22.4
	30-39	276	19.6
	40-49	317	22.5
	50-59	322	22.8
	≥60	180	12.8
Socioeconomic status	Low	532	37.7
	Intermediate	699	49.5
	High	180	12.8
Body mass index	Low weight (≤18.5)	37	2.6
	Normal weight (18.6–24.9)	693	49.1
	Overweight (25.0–29.9)	470	33.3
	Obese (≥30.0)	211	15.0
Physical activity *	Inactive (0-149 min/week)	914	64.8
	Active (≥150 min/week)	497	35.2
Physical activity **	Inactive (0-9 min/week)	639	45.3
	Active (≥10 min/week)	772	54.7
Sedentary time	Not sedentary (0-239 min/week)	801	56.8
	Sedentary (≥240 min/day)	610	43.2
Categories sedentary time with physical activity *	Not active and sedentary	381	27.0
	Not active and not sedentary	533	37.8
	Active and sedentary	229	16.2
	Active and not sedentary	268	19.0
Categories sedentary time with physical activity **	Not active and sedentary	267	18.9
	Not active and not sedentary	372	26.4
	Active and sedentary	343	24.3
	Active and not sedentary	429	30.4

Min=minutes; Week=week; ≥150 minutes/week*; ≥10 minutes/week **.

Table 2. Association between individual characteristics and physical activity, sedentary time and body mass index of adults enrolled in the "Caminhos para o parque" project. Curitiba, Paraná, Brazil. (n = 1411).

Variables/ Categories	Sedentary time			Physical activity						Body mass index				
	Not sedentary	Sedentary*		Not active	Active**		Not active	Active**		Low weight	Normal weight	Over-weight	Obese	
	n(%)	n(%)	p	n(%)	n(%)	p	n(%)	n(%)	p	n(%)	n(%)	n(%)	n(%)	p
Sex														
Male	262(51.6)	252(48.4)	0.003[a]	303(58.2)	218(41.8)	<0.001[a]	191(36.7)	330(63.3)	<0.001[a]	8(1.5)	243(46.6)	197(37.8)	73(14.0)	0.016[a]
Female	532(59.8)	358 (40.2)		611(68.7)	279(31.3)		448(50.3)	442(49.7)		29(3.3)	450(50.6)	273(30.7)	138(15.5)	
Age														
18-29	134(42.4)	182(57.6)	<0.001[a]	197(62.3)	119(37.7)	0.409[a]	145(45.9)	171(54.1)	0.220[a]	12(3.8)	215(68.0)	69(21.8)	20(6.3)	<0.001[a]
30-39	161(58.3)	115(41.7)		184(66.7)	92(33.3)		112(46.6)	164(59.4)		3(1.1)	144(52.2)	86(31.2)	43(15.6)	
40-49	182(57.4)	135(42.6)		207(68.5)	100(31.5)		159(50.2)	158(49.8)		10(3.2)	130(41.0)	129(40.7)	48(15.1)	
50-59	203(63.0)	119(37.0)		201(62.4)	121(37.6)		144(44.7)	178(55.3)		10(3.1)	130(40.4)	114(35.4)	68(21.1)	
≥60	121(67.2)	59(32.8)		115(63.9)	65(36.1)		79(43.9)	101(56.1)		2(1.1)	74(41.1)	72(40.0)	32(17.8)	
Socioeconomic status														
Low	353(66.4)	179(33.6)	<0.001[a]	396(74.4)	136(25.6)	<0.001[a]	298(56.0)	234(44.0)	<0.001[a]	16 (3.0)	238(44.7)	188(35.3)	90(16.9)	0.167[a]
Intermediate	366(52.4)	333(47.6)		437(62.5)	262(37.5)		297(42.5)	402(57.5)		15 (2.1)	358(51.2)	225(32.2)	101(14.4)	
High	82(45.6)	98(54.4)		81(45.0)	99(55.0)		44(24.4)	136(75.6)		6 (3.3)	97(53.9)	57(31.7)	20(11.1)	

* ≥240 minutes of sedentary time per day; ** ≥150 minutes of physical activity per week (leisure); *** ≥10 minutes of physical activity per week (leisure); a Chi-square test; p≤0.05 (significance)

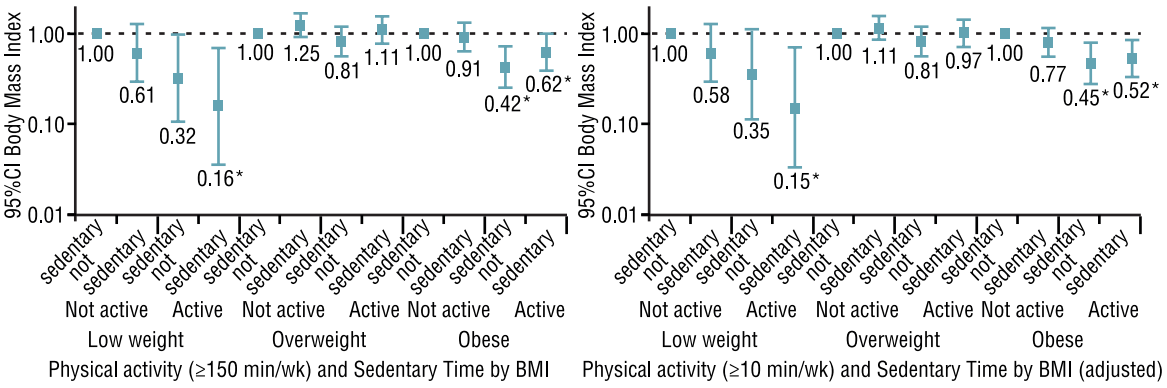

Figure 1. Box-plot for multinomial logistic regression analysis, crude and adjusted, between BMI and combination of physical activity (guidelines) and sedentary time (n=1,411).
BMI: Body Mass Index; Active: ≥150 minutes/week; Sedentary: ≥240 minutes/day; Adjusted by sex, age group and socioeconomic status; *p≤0.05.

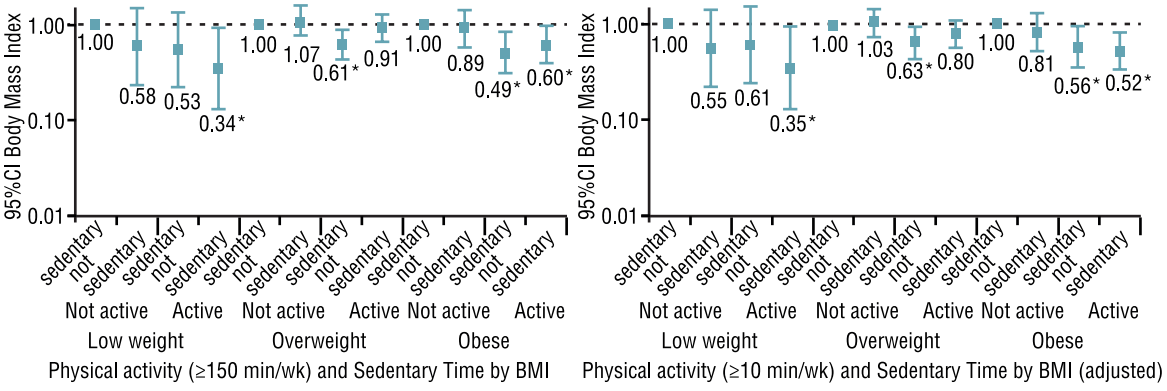

Figure 2. Box-plot for multinomial logistic regression, crude and adjusted, analysis between BMI and combination of physical activity (>10minutes/week) and sedentary time (n=1,411).
BMI: Body Mass Index; Active: ≥10 minutes/week; Sedentary: ≥240 minutes/day; Adjusted by sex, age group and socioeconomic status; *p≤0.05.

DISCUSSION

The aim of this study was to test the contribution of PA and ST, analyzed together, in the BMI of Brazilian adults. The main results showed that the likelihood of people being classified as obese and underweight when compared to normal weight was lower in groups that practiced PA, regardless of the weekly volume. In addition, practicing minimum PA (≥10 minutes / week) decreased the participants' likelihood of being classified as overweight. Regarding individual characteristics, only one-third of the interviewees complied with recommendations of practice of leisure PA and approximately half of the sample was classified as overweight or obese. In addition, achieving recommendations of practicing ≥150 minutes of PA per week[20] was associated with males (42%) and with high SES (55%). Similar results were identified in adults living in the Brazilian capitals, where 37.6% of this population performed leisure PA, being more prevalent among men (45.6%) aged 18-24 years (51.4%)[2]. In relation to ST, there was an inverse association with age group, that is, the younger (18-29 years), the higher the ST, corroborating results of a study carried out in 20 countries,

in which adults aged 40-65 years were less likely of showing this behavior when compared to the age group of 18-39 years[22].

In this study, participants classified as low weight, those who practiced some weekly PA and did not remain four hours a day or more in ST, were less likely of being low weight when compared to not active or active groups with ST greater than four hours daily. These findings reinforce the importance of PA, even in small volumes, since low weight is a health condition responsible for an 80% increase in the risk of death from any cause compared to normal weight[23]. In addition, the causes of low weight may be related to excessive alcohol consumption, smoking and inadequate diet[24], but these relationships still remain inconclusive. However, it is known that the practice of PA can influence changes in lifestyle and healthy habits, reducing the risk factors of low weight and increasing the likelihood of participants achieving an ideal weight[3,5].

Participants who had ≥ 10 minutes of leisure PA, even with high ST, were less likely of being overweight compared to those classified as not active and sedentary. Evidence suggests that excess ST is an important risk factor for chronic diseases and premature mortality[25]. Thus, PA can also act as a protective factor, mitigating the detrimental effects of ST. These findings corroborate more recent literature, indicating that performing at least one hour of PA per day may reduce the risk of death associated with high sitting time[10].

More significant results were found for the group of obese participants. Performing some weekly PA regardless of classification used (≥ 10 minutes / week or ≥150 minutes / week), represented approximately 50% less chance of participants being classified as obese, regardless of ST, reinforcing the findings of this study on the importance of the practice of PA and reduction of ST. Literature shows that physical inactivity was responsible for 6% of the causes of death worldwide[3] and 3.8% were attributed to sedentary behavior [26]. In addition, the decrease in physical inactivity and ST can increase life expectancy, on average, 0.68 and 0.23 years, respectively [3,26]. These results indicate that changes in these behaviors, especially in the practice of PA, seem to be the starting point for maintaining healthy body weight.

The results of this study highlight the importance of multifactorial actions to promote healthy habits, such as the inclusion of PA in daily life[3,27], healthy eating[27] and body weight control[1]. In addition, public policies should consider actions in community settings that may benefit, in particular, less active groups with higher prevalence of ST[28]. For example, propose changes in the planning of cities that favor the practice of PA through active commuting [29]. In general, it seems that the inclusion of PA in people's daily lives, even in reduced volume, can improve the chances of adjusting BMI to optimal health levels, thereby improving quality of life and self-esteem, and reducing costs of the public health system[30]. Thus, the findings point to a scenario in which PA is an important factor and acts as a protective effect on body weight maintenance. In addition, the practice of PA, regardless of volume, can bring greater health benefits,

even if people have high ST.

For a better interpretation of results, some limitations should be considered. The cross-sectional design does not allow establishing a causal relationship among variables. Self-reported measures tend to overestimate PA and ST and may contribute to an increase in non-differential error. In the analyses, only leisure PA was considered, not allowing extrapolation of the findings to other domains of PA. Sample selection was conducted in regions intentionally selected based on the social and physical characteristics of the dwelling region of participants. However, the sample distribution was balanced among neighborhoods, reducing the chances of clustering effect. In addition, the main confounding variables were included in the adjusted analyses and the effects were analyzed along different exposure and outcome gradients, assuring greater confidence in the internal validity of the findings.

CONCLUSION

In this study, PA was shown to be a protective factor against overweight and obesity, regardless of ST volume. This evidence strengthens the role of PA in controlling obesity, particularly for people who spend long time performing seated activities, such as in some jobs and during motor transportation. Obesity control actions should prioritize increased opportunities for practicing PA in work environments, as well as increasing access to healthier commuting, such as walking and cycling. In addition, future studies should be conducted on samples from other regions and cities, as well as objective measures should be used to evaluate the PA and ST in order to confirm the findings of this study.

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