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Exploring the relationship between daily sedentary time and occurrence of multimorbidity in middle-aged and older adults: results from ELSI-Brazil

Jéssica Fernanda Corrêa Cordeiro[1*], André Pereira dos Santos[1,2,3,4,5,6], Lucimere Bohn[7,8], Emerson Sebastião[9], Gianna Fiori Marchiori[10], Euripedes Barsanulfo Gonçalves Gomide[4,11], Jose Castro-Piñero[12], Alex Antonio Florindo[13], Jorge Mota[7] and Dalmo Roberto Lopes Machado[1,2,3,4,7,14]

Abstract

Aim To explore the relationship between varying durations of sedentary time (ST) in hours per day and multimorbidity, while considering covariates such as non-compliance to moderate to vigorous physical activity (MVPA) recommendations, age, sex, and smoking in middle-aged and older adults.

Methods Data from the first wave (2015–2016) of the nationally-representative Brazilian Longitudinal Study of Aging (ELSI-Brazil) were analyzed. Ordinary regression analysis was utilized to assess the odds ratio for individuals with varying daily ST durations concerning the escalation in the number of diseases while accounting for covariates such as failure to meet MVPA recommendations, age, sex, and smoking status.

Results A cohort of 7,314 individuals aged 50–105 years (56,3% females) participated in the study. The most prevalent occurrence of multimorbidity was having 2 conditions (1521/19.3%). A clear trend emerges, showing a rise in the number of multimorbidities as ST increase. Notably, individuals engaging in less than 4 h of daily ST exhibited a significantly lower likelihood of experiencing an increase in the total number of multimorbidity cases, with an odds ratio of 0.842 and a confidence interval of 0.764 to 0.928, even after adjusting for potential covariables.

Conclusions Our findings indicate a progressive increase in multimorbidity with longer durations of ST. Moreover, limiting ST to less than 4 h daily was associated with a lower chance of multimorbidity.

Keywords Midlife and older populace, Physical activity, Physical inactivity, Number of illnesses, Smoking

*Correspondence:
Jéssica Fernanda Corrêa Cordeiro
jessica.cordeiro@alumni.usp.br
Full list of author information is available at the end of the article

Textbox 1. Contributions to the literature

- This study highlights the association between prolonged sedentary time and increased multimorbidity in older adults, emphasizing the importance of limiting sedentary time.
- It adds to public health literature by providing data from a middle-income country, addressing a gap often overlooked in global studies.
- An association between daily sedentary time and the number of multimorbidities in older adults was identified, providing insights into the impact of sedentary behavior on multimorbidity and guiding future research and public health strategies.

Introduction

The aging process, inevitable at a physiological level, encompasses a cascade of cellular and molecular dysfunctions leading to various chronic diseases [1, 2]. These diseases often stem from prolonged exposure to unhealthy lifestyle habits, particularly inactivity and/or low levels of physical activity (PA) [1, 2]. While the literature extols the benefits of PA, scant attention has been paid to the measure PA intensity and sedentary time (ST). Nonetheless, evidence that meeting moderate to vigorous physical activity (MVPA) recommendations can confer significant health advantages, including increased longevity and reduced mortality rates [3]. Yet, for older adults and those with physical disabilities, adhering to these recommendations can be particularly challenging, if not possible. Thus, it becomes imperative to scrutinize ST, an oft-overlooked facet of physical inactivity, which is the lack of physical activity sufficient to maintain health and well-being.

ST entails activities performed during waking hours characterized by low energy expenditure, typically involving prolonged sitting, reclining, or lying down for extended periods. ST, consequently, denotes the duration dedicated to such low-intensity activities throughout the day [4]. Engaging in MVPA recommendations and curtailing ST are linked to an array of health benefits, including diminished risk of cardiovascular diseases, cancer, and all-cause mortality [3, 5–7]. These illnesses rank among the primary causes of premature mortality in numerous countries, Brazil included. Notably, cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases significantly impact public health and carry substantial economic burdens [3, 5, 6, 8]. While infectious diseases held sway overpopulation mortality in the early twentieth century [9], socioeconomic and cultural shifts have markedly influenced mortality patterns in Brazil [10].

Despite the well-documented benefits of PA for health, its sole practice may not suffice to fully mitigate the risk of diseases and ailments. A considerable portion of an average individual's waking hours is devoted to sedentary activities, such as watching television and using the computer, leading to prolonged periods of sitting [11]. This prevalent lifestyle trend is particularly worrisome, giving evidence indicating that extended periods of inactivity can have adverse health effects, even when adults meet recommended PA guidelines [12, 13]. Moreover, it's crucial to recognize the complex coexistence of PA and ST. For instance, some individuals who meet PA goals may still predominantly engage in ST throughout the day, while others who don't regularly participate in PA may avoid ST due to their leisure activities, work settings, or both [11, 14, 15].

A recent systematic review evidenced that the persistence of ST is correlated with a significant increase in the risks of various noncommunicable chronic diseases and overall mortality. Individuals, especially those who do not meet MVPA recommendations, are encouraged to interrupt sedentary periods every 30 to 60 min and limit the total time dedicated to ST throughout the day, whenever possible [12]. However, despite these findings, it is essential to emphasize the need for additional studies to validate and better understand the association between ST and multimorbidity [16, 17]. Multimorbidity, defined as the presence of two or more chronic conditions in an individual, is an increasing public health concern, particularly in aging populations, leading to challenges in healthcare management and worse clinical outcomes [18, 19].

Considering the escalating burden of diseases and multimorbidity, we acknowledge the significant impacts on health, quality of life, and the associated costs to the healthcare system and society. While the beneficial role of MVPA in the prevention and treatment of various diseases is widely recognized, existing literature provides limited insights into "how many – hours/day" ST is associated with the increased number of multimorbidity cases in a large population over 50 years old, particularly in Brazil. There exists a notable gap in comprehending the influence of ST within this age demographic and its contribution to the overall burden of diseases accompanying the aging process.

Therefore, our study aims to explore the relationship between varying durations of ST in hours per day and multimorbidity, while considering covariates such as non-compliance to MVPA recommendations, age, sex, and smoking in middle-aged and older adults. By doing so, we aim to address this knowledge gap and better understand how daily ST correlates with the overall disease burden in a sizable population over 50 years. Our findings will offer valuable insights for designing preventive interventions and enhancing clinical management strategies tailored to this demographic, by contributing to improved health outcomes and quality of life in this population.

Methods

Study design

This cross-sectional analysis utilized data from the first wave of ELSI-Brazil, conducted during 2015–2016. ELSI-Brazil implemented a sophisticated multistage stratified cluster sampling framework to ensure a comprehensive representation of urban and rural areas across small, medium, and large municipalities. The municipalities were categorized into four strata based on their population size. In the initial three strata (municipalities with up to 750,000 inhabitants), the sample was selected through three stages: municipality, census tract, and household. For the fourth stratum, encompassing the largest municipalities, the sample selection occurred in two stages: census tract and household. The selection of households followed a systematic approach, involving a four-house jump after an interview or after three unsuccessful contact attempts. This systematic jump was omitted in instances of refusal or ineligibility [(1) absence of residents aged 50 years and over; (2) vacant household; (3) collective living arrangements (pension, asylum, republic, shelter, or hostel); (4) interviewee with a disability preventing questionnaire response without a substitute informant (proxy)]. In such cases, the interviewer proceeded to the next household, adhering to the right-hand rule. All residents aged 50 years and older in the chosen households, inclusive of those with disabilities, bedridden individuals, and wheelchair users, were eligible for participation. ELSI-Brazil constitutes a nationally representative survey comprising individuals aged 50 years or older, residing in 70 municipalities across the five regions of Brazil. In our study, 438 participants were excluded from the total sample of 8,974 due to missing Body Mass Index (BMI) measurements for obesity calculation, and 1,222 were excluded due to missing ST values. Thus, the sample totaled 7,314 participants. Additional insights into ELSI Brazil's sample and its national representativeness have been previously documented [20]. For further details, the research homepage is accessible at http://elsi.cpqrr.fiocruz.br/en/home-english/.

The ethics board of FIOCRUZ, Minas Gerais, approved ELSI-Brazil (CAAE: 34649814.3.0000.5091). Participants provided separate informed consent for interviews and physical measurements, as well as access to administrative records.

Data collection

Sociodemographic and anthropometric variables

Face-to-face interviews meticulously examined sociodemographic attributes, encompassing age (in years) and sex (categorized as male or female). Additionally, participants were queried about their smoking habits, distinguishing between daily and non-daily smokers. Response options included "yes, daily," "yes, less than daily," and "no." Accordingly, this variable was dichotomized, and categorized as "yes" (regardless of daily frequency) or "no" for the classification of smokers. Moreover, participants were queried about their medical history, including diagnoses for conditions such as hypertension, diabetes, hypercholesterolemia, a history of heart attack, angina, cardiac insufficiency, stroke, asthma, emphysema, bronchitis, lung disease, arthritis, rheumatism, osteoporosis, chronic back problems or back pain, depression, cancer, chronic renal failure, Parkinson's, and Alzheimer's. The total number of multimorbidity cases by each participant was aggregated, resulting in a new variable classified as follows: 0 = no multimorbidity, 1 = one multimorbidity, 2 = two multimorbidities, 3 = three multimorbidities, 4 = four multimorbidities, and 5 = five or more multimorbidities. The classification of multimorbidity in this study was based exclusively on medical diagnoses reported by the participants, provided by doctors or other qualified healthcare professionals. Although ELSI-Brasil also collects information on medication use, these were considered as complementary data and were not used directly to classify the presence of multimorbidity. Medication use provided additional insights into the management of participants' health, but the determination of multiple chronic conditions was made based on the medical diagnoses reported by the participants.

Height measurements, recorded in centimeters (cm), were obtained using a portable vertical stadiometer (NutriVida®, Brazil). Participants stood barefoot with legs and feet parallel, weight evenly distributed on both feet, arms relaxed at the sides, palms facing the body, and heads in the Frankfurt horizontal plane. Weight, measured in kilograms (kg), was assessed using a portable digital scale (SECA®, Germany) with participants in a barefoot stance. BMI was computed as the ratio of weight in kilograms (kg) to the square of height in meters (m^2). BMI categories aligned with World Health Organization recommendations: underweight (< 18.5 kg/m^2), eutrophic (18.5 to < 25.0 kg/m^2), overweight (25.0 to < 30.0 kg/m^2), and obese (≥ 30.0 kg/m^2). Participants' BMIs were dichotomized into < 30.0 kg/m^2 (normal) and (≥ 30.0 kg/m^2) obese [21]. Obesity was also factored into the total count of diseases. All anthropometric variables underwent dual measurements during the home visit by trained interviewers, and the mean of these measurements was employed in subsequent analyses. Further information can be seen in the handbook on the survey homepage (http://elsi.cpqrr.fiocruz.br/en/home-english/questionnaires/).

Sedentary time

The Brazilian version of the International Physical Activity Questionnaire—Short Version (IPAQ-SV) was used to assess the level of PA. ST was expressed as total sitting time. The question about sedentary time in the IPAQ-SV is formulated as follows: "During the last 7 days, how much time did you spend sitting, whether at work, at home, during leisure activities, or while using transportation?" Data from the responses were used to calculate the total sitting time, considering this time on weekdays and weekends. A weighted average calculation was performed as follows: the weekday time was multiplied by 5, added to the weekend time multiplied by 2, and divided by 7 to obtain the average number of hours per day spent in the sitting position. For analyses and graphics, ST was divided into groups by hours per day ($0 > ST \leq 1$; $1 > ST \leq 2$; $2 > ST \leq 3$; $3 > ST \leq 4$; $4 > ST \leq 5$; $5 > ST \leq 6$; $6 > ST \leq 7$; $7 > ST \leq 8$; and $ST > 8$).

Moderate to vigorous physical activity (MVPA)

Regarding MVPA, the IPAQ-SV was also used, this instrument assesses the domains and intensity of PA, including walking and sitting time, that people perform as part of their everyday lives. The IPAQ-SV conceptualizes the categories as follows: (a) sedentary: does not perform any PA for a minimum of 10 continuous minutes during the week; (b) insufficiently active: practices PA for a minimum of 10 continuous minutes per week, but not enough to be classified as active. (c) Active: meets the following recommendations: (i) VPA: ≥ 3 days/week and ≥ 20 min/session; (ii) MPA or walking: ≥ 5 days/week and ≥ 30 min/session; (iii) any added activity: ≥ 5 days/week and ≥ 150 min/week. (d) Very active: meets the following recommendations: (i) vigorous activity: ≥ 5 days/week and ≥ 30 min/session; (ii) vigorous activity: ≥ 3 days/week and ≥ 20 min/session + moderate activity and/or walking ≥ 5 days/week and ≥ 30 min/session. Classification of daily MVPA complied with the American College of Sports Medicine recommendations (American College of Sports Medicine, 2021), as sedentary (< 30 min/day); moderately active (30–60 min/day); active (460 min/day). When combined, the duration of vigorous activities is doubled and then added to the time spent in moderate activities. PA categories were defined according to the duration of time spent in MVPA, distinguishing between those not meeting MVPA recommendations (< 150 min/week) and those meeting MVPA recommendations (≥ 150 min/week).

Statistical analysis

After downloading ELSI's Brazil data we uploaded the dataset in the STATA software, version 16.0 (Stata Corporation, College Station, Texas, USA), then downloaded it in a Microsoft Excel® spreadsheet format. Two researchers independently coded the data, and the validation was performed by double checking in Microsoft Excel® to minimize the risk of bias in data tabulation. The variables, including age group (50 to 54; 55 to 59; 60 to 64; 65 to 69; 70 to 74; 75 to 79; 80 to 84; and ≥ 85 years), sex (male [code = 0]; female [code = 1]), MVPA (≥ 150 min/week) [code = 0] or (< 150 min/week) [code = 1], smokers (no) [code = 1]; (yes) [code = 0], and diagnostic for each diseases were presented as absolute (n) and relative (%) frequency. To address the study's objectives, the dependent variable was defined as the "total number of multimorbidity cases," categorized into 0 = no multimorbidity, 1 = one multimorbidity, 2 = two illnesses, 3 = three multimorbidities, 4 = four multimorbidities, and 5 = five or more multimorbidities. It was classified this way because studies have shown differences in outcomes for those with five or more multimorbidities [22, 23]. Ordinary regression analysis was employed to determine the odds ratio (OR) for individuals in different groups of hours per day of ST in relation to the proportional escalation in the number of illnesses, taking into account the presence of covariates (MVPA achievement, age group, sex, and smoking). Assumptions for conducting ordinal regression were confirmed (VIF < 10) [24] to avoid multicollinearity between the factor and covariates, and the proportional odds assumption was satisfied ($p > 0.05$) [25]. For better comprehension, the OR was transformed in percentage according to the equation: $[\% = (OR - 1) \times 100\%]$. Statistical analysis was performed using the SPSS® version 20.0 program with a significance level of $\alpha = 5\%$.

Results

Figure 1 describes the flowchart of the participants throughout the study. A total of 1660 were excluded according to the reasons below.

Our analytical sample consisted of 7,314 participants aged 50 to 105 years. Table 1 presents the absolute and relative frequencies of the study population, grouped by age in five-year increments. The majority were female, engaged in MVPA, and non-smokers. Regarding self-reported illnesses, the most common were systemic arterial hypertension (52.7%), chronic spine issues (back pain, neck pain, lumbago, sciatic pain, vertebral or disc problems) (40.8%), hypercholesterolemia (31.0%), obesity (29.6%), followed by arthritis or rheumatism (21.5%).

Figure 2 demonstrates the frequency distribution of the total number of multimorbidity cases per participant, revealing that the most common occurrence is having 2 multimorbidity (1521/19.3%). Notably, 883 individuals (12.1%) exhibit no multimorbidity, while 1293 (17.7%) have more than 5 illnesses, surpassing the count of those with 4 illnesses (887/12,1%).

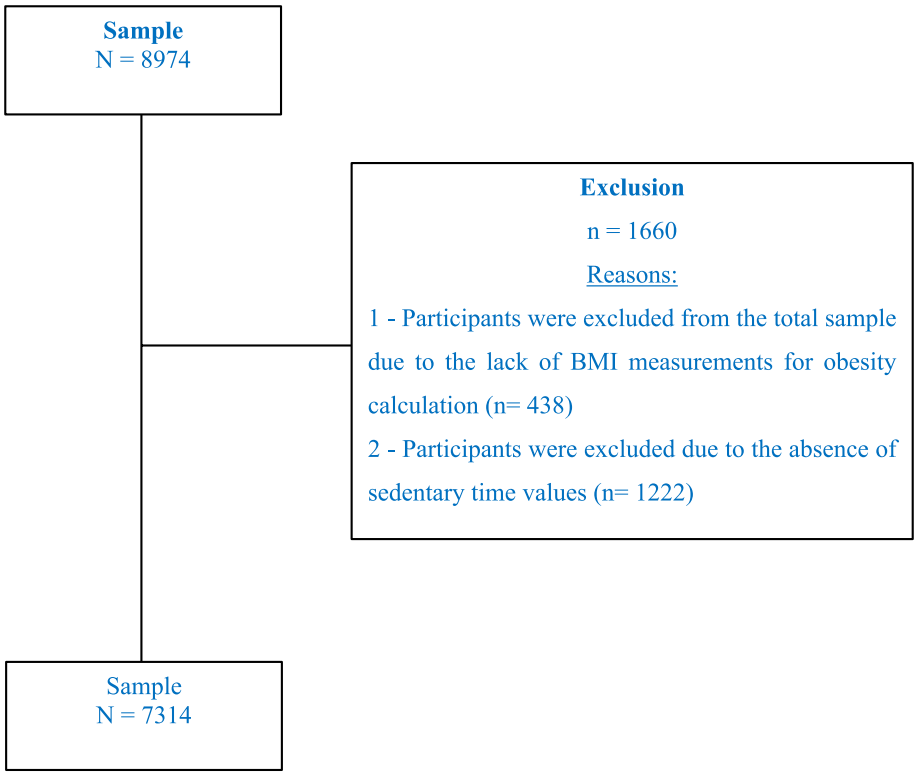

Fig. 1 Study flowchart

The Fig. 3 depicts the frequency distribution of the total number of hours per day of ST per participant, revealing that the most common occurrence is having 1 to 3 h per day of ST (3,375/46.1%). Notably, 690 individuals (9.4%) exhibit more than 7 h per day of ST.

Figure 4 presents graphs for the different categories of multimorbidity (no, one, two, three, four, and five or more), about the hours of ST per day. A trend of increasing time of ST is observe as the number of multimorbidity increases.

In Table 2, it is observed that in the regression, ST became statistically significant from 4 h. It is important to note that not having a ST above 4 h reduced the OR of incremental multimorbidity cases. Not having ST > 4, > 5, > 6, > 7, and > 8 showed reductions in multimorbidity risk by 15.8%, 16.4%, 20.3%, 22.0%, and 29.5%, respectively. It is noteworthy that, in the logistic regression, MVPA did not show significance in the analysis. It is worth mentioning that not being a smoker significantly decreased the proportional odds of experiencing an escalation in the total number of multimorbidity cases already considering just one disease. These associations persist even after considering age and sex as potential confounding variables. A trend of increasing multimorbidity was observed as ST increased. It became evident that limiting ST to less than 4 h is significantly associated with a lower likelihood of experiencing an increase in the total number of multimorbidity cases. These associations, consistent and persistent, remained even after a thorough examination of potential confounding variables such as age, sex, non-compliance with MVPA recommendations, and smoking status.

Discussion

The results of this study provide valuable insights into the relationship between daily time spent in ST and the escalation of diseases, considering variables such as non-compliance with recommendations for MVPA, age, sex, and smoking status. Among the most commonly self-reported conditions were systemic arterial hypertension, chronic spine problems, and hypercholesterolemia. The analysis revealed that most participants spend between 1 and 3 h per day in sedentary time. In terms of multimorbidity, the most common occurrence was having 2 conditions. A trend of increasing multimorbidity was observed as ST increased. It became evident that not engaging in ST for more than 4 h is significantly associated with a lower likelihood of experiencing an increase in the total number of multimorbidity cases. These associations, robust in their persistence, remained even after careful consideration of age, sex, non-compliance with MVPA recommendations, and smoking as potential

Table 1 Characteristics of the study population: age distribution, sex, health indicators, and self-reported illnesses. ELSI-Brazil, 2015–2016

Variable	Category	Frequency	
		N	%
Age group (years)	50 – 54	1743	23.8
	55 – 59	1403	19.2
	60 – 64	1244	17.0
	65 – 69	1002	13.7
	70 – 74	783	10.7
	75 – 79	590	8.1
	80 – 84	324	4.4
	≥ 85	225	3.1
Sex	Male	3194	43.7
	Female	4120	56.3
Moderate to vigorous physical activity achievement	Yes	5037	68.9
	No	2277	31.1
Smoker	Yes	1217	16.6
	No	6097	83.4
Systemic Arterial Hypertension	Yes	3857	52.7
	No	3447	47.1
	Don't know/ didn't respond	10	0.1
Diabetes	Yes	1157	15.8
	No	6119	83.7
	Don't know/ didn't respond	38	0.5
Hypercholesterolemia	Yes	2268	31.0
	No	4984	68.1
	Don't know/ didn't respond	62	0.8
Heart attack	Yes	437	6.0
	No	6865	93.9
	Don't know/ didn't respond	12	0.2
Angina	Yes	244	3.3
	No	7021	96.0
	Don't know/ didn't respond	49	0.7
Heart failure	Yes	544	7.4
	No	6745	92.2
	Don't know/ didn't respond	25	0.3
Stroke	Yes	371	5.1
	No	6937	94.8
	Don't know/ didn't respond	6	0.1
Ashma	Yes	369	5.0
	No	6934	94.8
	Don't know/ didn't respond	11	0.2
Emphysema. Chronic Bronchitis. or Chronic Obstructive pulmonary disease	Yes	420	5.7
	No	6880	94.1
	Don't know/ didn't respond	14	0.2
Arthritis or Rheumatism	Yes	1572	21.5
	No	5694	77.9
	Don't know/ didn't respond	48	0.7
Osteoporosis	Yes	1174	16.1
	No	6076	83.1
	Don't know/ didn't respond	64	0.9

Table 1 (continued)

Variable	Category	Frequency	
		N	%
Chronic spine issues (back pain. neck pain. lumbago. sciatic pain. vertebral or disc problems)	Yes	2986	40.8
	No	4301	58.8
	Don't know/ didn't respond	27	0.4
Depression	Yes	1315	18.0
	No	5977	81.7
	Don't know/ didn't respond	22	0.3
Has or had Cancer	Yes	412	5.6
	No	6890	94.2
	Don't know/ didn't respond	12	0.2
Chronic kidney failure	Yes	311	4.3
	No	6983	95.5
	Don't know/ didn't respond	20	0.3
Parkinson	Yes	51	0.7
	No	7253	99.2
	Don't know/ didn't respond	10	0.1
Alzheimer	Yes	49	.7
	No	7257	99.2
	Don't know/ didn't respond	8	0.1
Obesity	Yes	2166	29.6
	No	5148	70.4

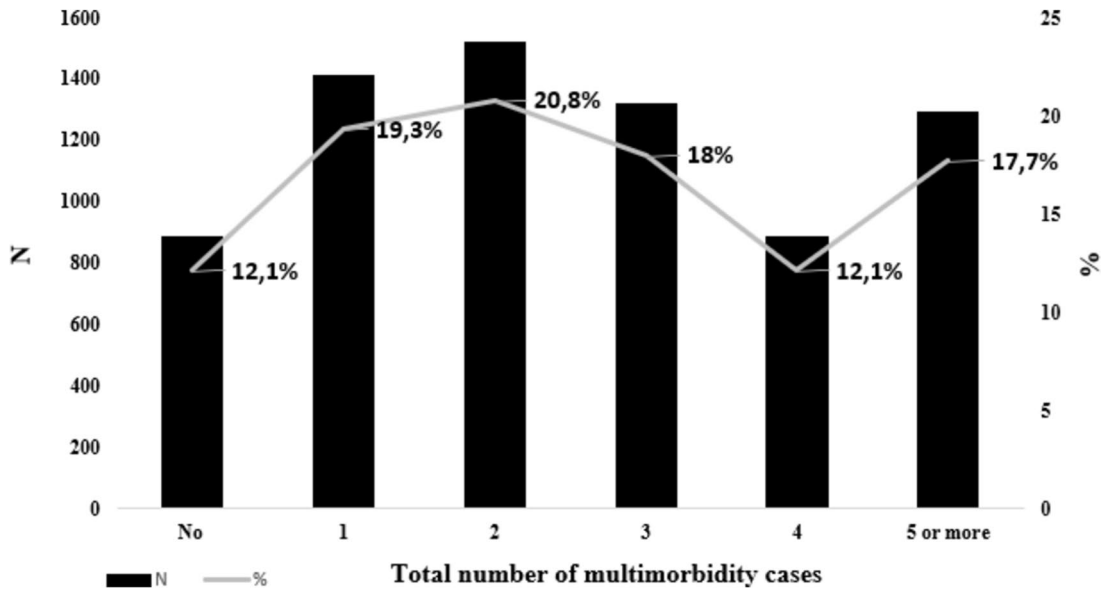

Fig. 2 Frequency distribution of the total number of multimorbidity cases. ELSI-Brazil, 2015–2016

confounders. These findings support the growing awareness of the importance of PA, but more than that, considering ST as an important health variable, is often overlooked in reducing the incidence of the total number of multimorbidity cases.

We investigated the complex relationship between ST in hours per day and the escalation of chronic health conditions in a representative sample of Brazilian adults (aged over 50). As much of the evidence on the effects of PA and ST on health comes from high-income countries,

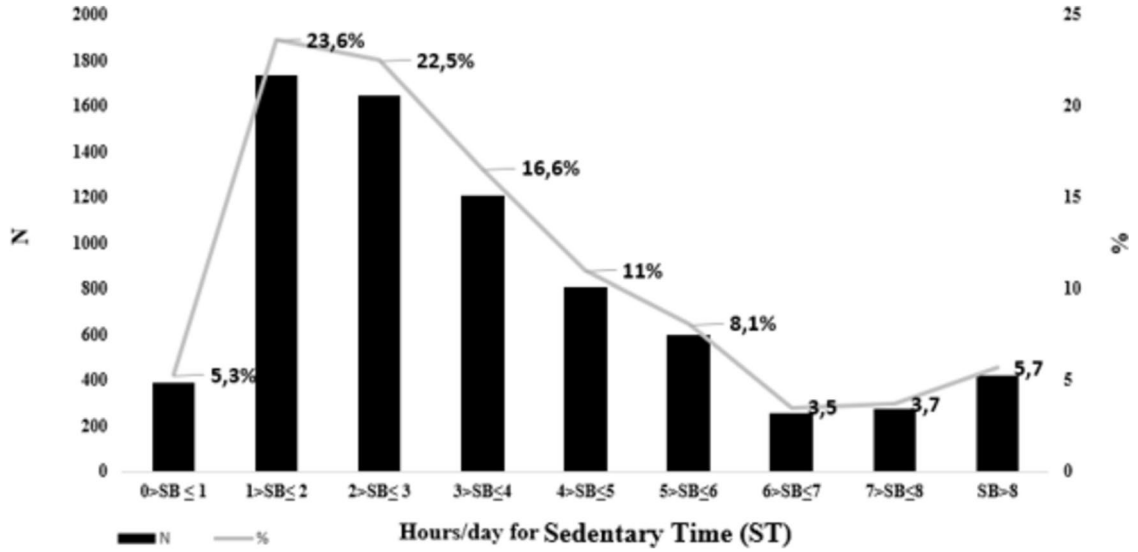

Fig. 3 Frequency distribution of the total number of hours per day of sedentary time per participant. ELSI-Brazil, 2015–2016

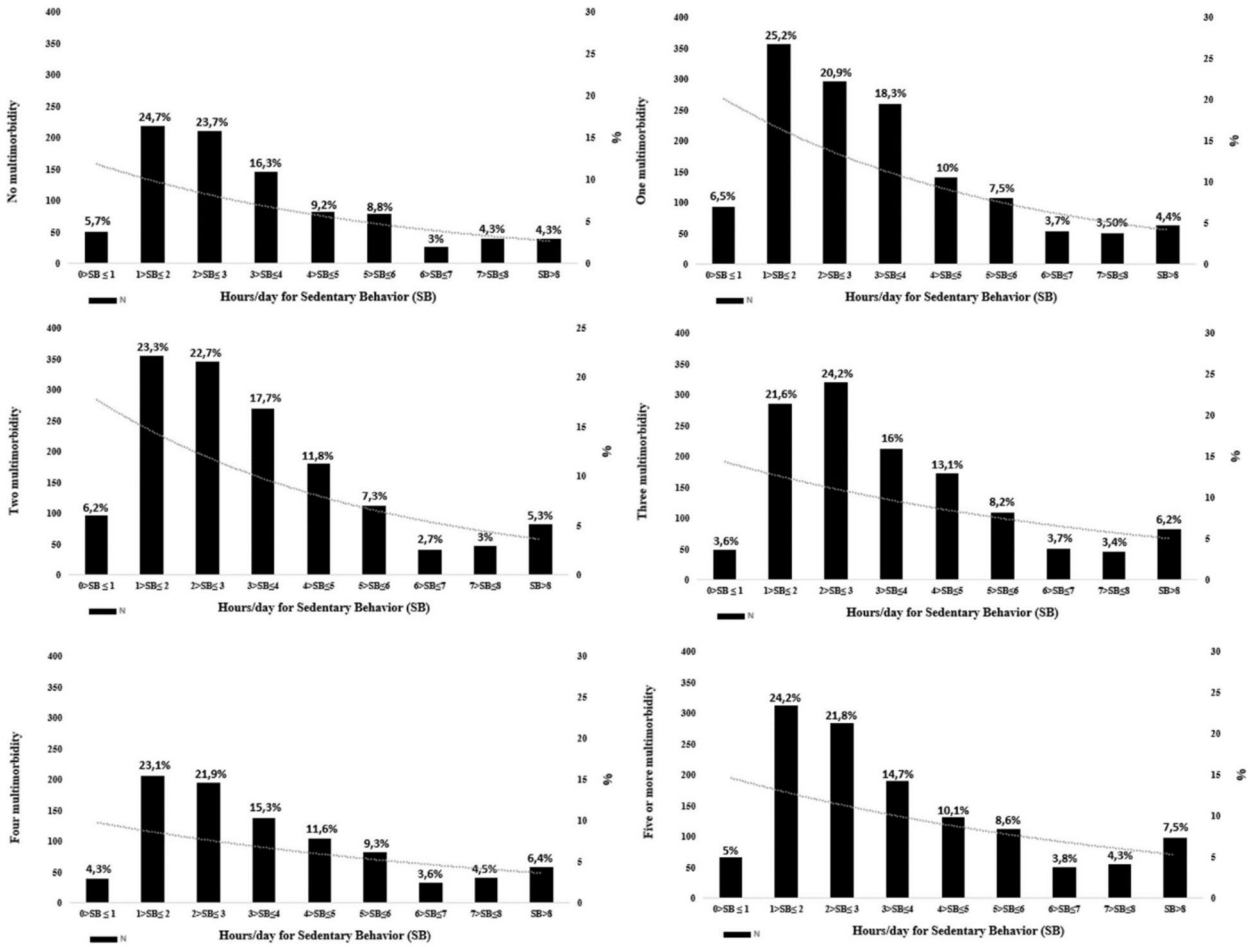

Fig. 4 Frequency distribution of the number of multimorbidity and the hours per day of sedentary time per participant. ELSI-Brazil, 2015–2016

Table 2 The odds ratio for the proportional escalation in the total number of multimorbidity cases in individuals, concerning ST time in hours per day, considering non-compliance with MVPA recommendations, age, sex, and smoking conditions as covariates. ELSI-Brazil. 2015–2016

Population (N)	Factor or co-variables	β	Wald	p-value	OR	95% C.I. for OR	
						Lower	Upper
7314	ST > 1 h	-0.168	2.936	0.087	0.845	0.697	1.024
	ST > 2 h	-0.090	0.405	0.525	1.094	0.830	1.442
	ST > 3 h	-0.044	0.662	0.416	0.957	0.860	1.064
	ST > 4 h	-0.172	12.001	**0.001**	0.842	0.764	0.928
	ST > 5 h	-0.179	10.941	**0.001**	0.836	0.752	0.930
	ST > 6 h	-0.226	12.444	**< 0.001**	0.797	0.703	0.904
	ST > 7 h	-0.248	11.596	**0.001**	0.780	0.677	0.900
	ST > 8 h	-0.349	14.996	**< 0.001**	0.705	0.591	0.842

Note: Dependent variable: number of multimorbidity cases. Grouped as 0. 1. 2. 3. 4. and 5 or more; *MVPA* Moderate to vigorous physical activity, *OR* Odds Ratio, *ST* Sedentary time, *ST code* ST > 1,2…hours = 1; ST ≤ 1,2…hours = 0; bold = statistically significant ($p < 0.05$)

the results of this study represent a valuable contribution due to the nature of the sample (i.e., middle-income countries), which are typically underrepresented in epidemiological studies in this field [26]. The WHO reports that approximately 33% of adults worldwide have two or more chronic diseases, with a higher burden in low-income countries compared to high-income countries [27]. Our results are consistent with this, as 19.3% of the sample had 2 or more chronic health conditions. Although we did not provide information on the dose–response relationship between daily ST and the escalation of the number of diseases due to the cross-sectional nature of the study, our regression analysis indicated that not engaging in ST for more than 4 h reduces the risk of developing multimorbidity, with the odds ratio increasing as the amount of ST hours increases. Not engaging in ST may act as a protective factor for multimorbidity, with the magnitude of risk reduction varying significantly depending on the studied population, individual characteristics, and other factors [15, 28]. Additionally, individuals living with chronic diseases are more likely to be sedentary [26]. Our study showed that non-sedentary time aids in the prevention of multimorbidity, and other studies corroborate these findings; however, it is important to note that there is limited evidence in the literature on this topic [15, 28]. Studies show that extended periods (over 3.4 h per day) of sedentary behavior are associated with an increased risk of chronic conditions and metabolic diseases [29]. Additionally, prolonged sedentary time has been linked to higher mortality, especially among those who are less physically active, with physical activity potentially mitigating these risks [30, 31]. While the importance of physical activity in disease prevention is well documented, it is also essential to address sedentary time as a significant risk factor for multimorbidity [29, 31].

Aging has long been recognized as a significant risk factor for conditions and diseases affecting the cardiovascular, muscular, central nervous, immune, pulmonary, and other systems [32, 33]. Consequently, aging increases the risk of chronic diseases such as dementia, heart disease, type 2 diabetes, arthritis, and cancer. Recent data from the Health and Retirement Study in the United States, with 11,820 older adults, demonstrated that hypertension (68.7%), arthritis (68.2%), diabetes (31.2%), heart diseases (30.1%), cancer (19.1%), depression (18.9%), pulmonary diseases (12.7%), stroke (11.5%), and Alzheimer's (2.6%) were among the most prevalent diseases observed in their sample (National Council on Aging). These findings are like those observed in our study, suggesting high rates of chronic diseases in this population segment. Furthermore, our study found that two chronic conditions were the most common among our sample (approximately 21%). Considering two or more conditions, this number increases to almost 70%. According to the National Council on Aging, nearly 95% of adults over 60 have at least one chronic condition, while almost 80% have two or more. In terms of multiple conditions, a meta-analysis of multimorbidity prevalence conducted in developed and developing countries found a pooled global prevalence of 33.1%, although there was a considerable difference in pooled estimates between high-income countries (37.9%) and middle- and low-income countries (29.7%) [34]. This result is somewhat like that observed in the Health and Retirement Study conducted in the United States. In the mentioned study, the prevalence of multiple chronic conditions was 68.6% among study participants. Although multimorbidity is common among the older population, it should be a concern as it has negative consequences for individuals and society. This is because multimorbidity is associated with increased mortality

[35], reduced quality of life and functional status [36–39], increased use of health services [40, 41], and higher healthcare costs. Therefore, the development of strategies and interventions resulting from the connection and dialogue between healthcare professionals involved in the care of older adults and scientists focused on aging research are necessary to improve the management and treatment of older adults diagnosed with multiple chronic conditions.

Our population-based study, conducted in the context of developing Brazil, revealed a concerning trend: as time spent in ST increases, we observe a rise in the number of multimorbidity. Physiologically, prolonged sedentary time can lead to a series of adverse metabolic changes, such as insulin resistance, elevated blood glucose levels, and dyslipidemia, which are risk factors for chronic diseases [42]. Biologically, the lack of physical activity reduces the body's ability to regulate cardiovascular function and lipid metabolism, promoting systemic inflammation and deteriorating metabolic health. These combined effects can contribute to an increase in multimorbidity over time [43]. It is important to emphasize the scarcity of literature addressing this issue, especially in developing countries. A study conducted in a high-income nation sought to fill this gap, focusing on the relationship between time spent in ST and multimorbidity. This study, in line with our findings, evidenced an association between ST and multimorbidity, indicating that the likelihood of multimorbidity increases with ST. Furthermore, the pressing need for further research to deepen understanding of the relationship between ST and multimorbidity is emphasized [28]. A systematic review with meta-analysis independently identified that prolonged ST is associated with adverse health effects, regardless of the level of PA [30]. Another systematic review concluded that high levels of MVPA appear to reduce the increased risk of death associated with prolonged ST. However, although this high level of PA mitigates the increased risk associated with prolonged TV viewing time, it does not eliminate it [44]. These results reinforce the benefits of PA, especially in societies where an increasing number of people spend long hours sitting at work, and may guide future public health recommendations [30, 44].

Therefore, it is crucial to direct public policies and guidelines to raise awareness about the impact of ST on health. Studies, such as that of [45], supported our findings, where not having a ST exceeding 4 h is significantly associated with a lower probability of developing multimorbidity. Additionally, each increase of 60 min per day in this time is correlated with a higher multimorbidity index, as concluded by Loprinzi [46]. This underscores the need to minimize prolonged ST, in addition to promoting PA, especially among middle-aged and older adults.

This study has remarkable qualities. The analysis encompassed a representative sample of individuals over 50 years old in Brazil, allowing to demonstration of the impact of ST on the total number of multimorbidity cases. Identifying the influence of ST on the total number of multimorbidity cases represents a significant advancement in bolstering public health policies, particularly given the scarcity of studies on this topic, especially within the Brazilian context. However, despite these strengths, it is imperative to acknowledge the several limitations of our study. The diagnosis of conditions relies on self-assessment, which may underestimate disease occurrence due to limited access to diagnosis, especially among individuals from less privileged socioeconomic backgrounds [47]. Additionally, the utilization of IPAQ as a self-report questionnaire to measure ST presents a limitation; however, given the population-based nature of the study, this instrument is deemed beneficial. Another limitation of this study is its cross-sectional design, which prevents the determination of causality between ST and multimorbidity.

Not having more than 4 h of ST is not associated with an escalation in the total number of multimorbidity cases. These findings have significant practical implications, suggesting that ST should be further investigated, as it may play a crucial role in reducing the total number of multimorbidity cases in the population. Additionally, they highlight the importance of intervention strategies focused on reducing the hours of ST, as preventive measures to improve overall health. Furthermore, these results indicate the need for more longitudinal research to better understand the long-term impact of ST on disease incidence and progression, as well as to explore the effectiveness of interventions targeting these times to improve health outcomes.

Conclusion

While the benefits of PA for health are widely recognized, the relationship between daily hours of ST and the overall disease burden in individuals over 50 years old remains an underexplored area, highlighting a gap in our understanding of its impact within this age group. Our study identified a clear trend: as ST increases, there is a corresponding increase in multimorbidity. Importantly, we found a significant association wherein limiting ST to less than 4 h per day was linked to a decrease in the number of multimorbidity cases. This association persisted even after accounting for potential confounding factors such as age, sex, non-compliance to MVPA recommendations, and smoking.

These findings underscore the importance of implementing integrated strategies that not only promote PA but also address ST to enhance public health outcomes,

reduce healthcare expenditures, improve quality of life, and mitigate the impact of chronic diseases. By bridging this knowledge gap, our study provides valuable insights for informing preventive interventions and optimizing clinical management strategies tailored to the needs of older adults, thereby fostering healthier aging and well-being across populations.

Abbreviations

BMI	Body Mass Index
ELSI-Brazil	Brazilian Longitudinal Study of Aging
IPAQ-SV	International Physical Activity Questionnaire—Short Version
MVPA	Moderate to Vigorous Physical Activity
OR	Odds Ratio
PA	Physical Activity
ST	Sedentary Time
WHO	World Health Organization

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Authors' contributions
JFCC contributed to all stages of the study, including conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, writing – original draft, and writing – review and editing. APS also played roles in conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, writing – original draft, and writing – review and editing. LB, ES, GFM, EBGG, JCP, and AAF contributed to conceptualization, formal analysis, writing – original draft, and writing – review and editing. JM participated in conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, writing – original draft, and writing – review and editing. DRLM also participated in these stages. All authors have read and approved the final version of the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
ELSI-Brazil was approved by the ethics board of FIOCRUZ, Minas Gerais (CAAE: 34649814.3.0000.5091). Participants signed separate informed consent forms for the interviews and physical measurements, and access to administrative records.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Faculty of Sport of the University of Porto, Street Dr. Plácido da Costa 91, 4200-450 Porto, Portugal. [2]College of Nursing of Ribeirão Preto, University of São Paulo, Ribeirão Preto, Brazil. [3]School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Ribeirão Preto, Brazil. [4]Study and Research Group in Anthropometry, Training and Sport, Ribeirão Preto. School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Ribeirão Preto, Brazil. [5]Human Exposome and Infectious Diseases Network (HEID), Ribeirão Preto, Brazil. [6]Department of Child, Family and Population Health Nursing, University of Washington, Seattle, WA, USA. [7]Research Center in Physical Activity, Health and Leisure (CIAFEL)-Faculty of Sports, University of Porto (FADEUP) and Laboratory for Integrative and Translational Research in Population Health (ITR), Porto, Portugal. [8]Research Center in Sport, Physical Education, and Exercise and Health, Lusófona University, Porto, Portugal. [9]Department of Health and Kinesiology, University of Illinois Urbana-Champaign, Illinois, USA. [10]Department of Nursing in Hospital Care, Federal University of Triângulo Mineiro, Uberaba, Brazil. [11]Claretiano University Center of Batatais, São Paulo, Brazil. [12]Department of Kinesiology, University of Cadiz, Cadiz, Spain. [13]School of Arts, Sciences, and Humanities, University of São Paulo, São Paulo, Brazil. [14]School of Education and Communication (ESEC), University of Algarve. Penha Campus, Faro, Portugal.

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