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PHYSICAL FITNESS ACCORDING TO SEDENTARY BEHAVIOR EXPOSURE IN OLDER ADULTS: A CROSS-SECTIONAL ANALYSIS

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ABSTRACT

Introduction: Aging is associated with physiological changes and increased exposure to sedentary behavior (SB), both of which may compromise functionality and increase the risk of adverse events. Objective: To compare performance in physical fitness tests between older adults with and without high exposure to SB. Materials and methods: A cross-sectional, census-based epidemiological study was conducted with 209 older adults (58.40% women). Physical fitness was assessed using the following tests: handgrip strength (HGS), chair stand (CS), arm curl (AC), timed up and go (TUG), sit-and-reach (SR), and step-in-place (SP). Exposure to SB was measured using the fifth domain of the International Physical Activity Questionnaire, with high exposure defined as ≥ 342.85 minutes/day (75th percentile). Group comparisons were performed using Student's t test or the Mann-Whitney U test, according to normality assessed by the Kolmogorov-Smirnov test ($P \leq 0.05$). Results: The prevalence of high SB exposure was 23% in women and 25.30% in men. Older adults with high SB exposure showed lower performance in the following tests: HGS, CS, AC, TUG, and SP ($p<0.05$). Conclusion: Older adults of both sexes with high SB exposure demonstrated lower performance in tests of mobility, agility, muscular strength and endurance, dynamic balance, and aerobic endurance.

Key words: Functional performance. Aging. Epidemiology. Sedentary lifestyle. Public Health.

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RESUMO

Aptidão física de acordo com a exposição ao comportamento sedentário em idosos: uma análise transversal

Introdução: O envelhecimento está associado a alterações fisiológicas e ao aumento da exposição ao comportamento sedentário (CS), ambos capazes de comprometer a funcionalidade e aumentar o risco de eventos adversos. Objetivo: Comparar o desempenho em testes de aptidão física entre pessoas idosas com e sem alta exposição ao CS. Materiais e métodos: Estudo epidemiológico transversal, censitário, realizado com 209 pessoas idosas (58,40% mulheres). A aptidão física foi avaliada por meio dos seguintes testes: força de preensão manual (FPM), levantar e sentar da cadeira (LSC), flexão do cotovelo (FC), levantar, caminhar e sentar (LCS), sentar e alcançar os pés (SAP) e marcha estacionária (ME). A exposição ao CS foi mensurada com base no quinto domínio do International Physical Activity Questionnaire, considerando-se como alta exposição os valores ≥ 342,85 minutos/dia (percentil 75). As comparações entre os grupos foram realizadas pelo teste t de Student ou pelo teste U de Mann-Whitney, conforme a normalidade verificada pelo teste de Kolmogorov-Smirnov ($p \leq 0,05$). Resultados: A prevalência de alta exposição ao CS foi de 23% entre as mulheres e 25,30% entre os homens. As pessoas idosas com alta exposição ao CS apresentaram pior desempenho nos seguintes testes: FPM, LSC, FC, LCS e ME ($p<0,05$). Conclusão: Identificou-se que as pessoas idosas de ambos os sexos com alta exposição ao CS demonstraram menor desempenho em testes de mobilidade, agilidade, força e resistência muscular, equilíbrio dinâmico e resistência aeróbica.

Palavras-chave: Desempenho funcional. Envelhecimento. Epidemiologia. Estilo de vida sedentário. Saúde Pública.

INTRODUCTION

Sedentary behavior (SB) is characterized by activities performed in lying, reclining, or sitting positions during waking hours, with an energy expenditure of 1.5 metabolic equivalents or less (Tremblay et al., 2017).

Time spent in this risk behavior tends to increase with advancing age, outlining an epidemiological scenario with a high prevalence of elevated SB exposure in older age groups (Santos et al., 2022a; Silva et al., 2023; Galvão et al., 2021).

In Brazil, data from the survey "Surveillance of Risk and Protective Factors for Chronic Diseases Through Telephone Interview (VIGITEL)," conducted by the Ministry of Health, revealed that 30.40% of Brazilians aged 55 to 64 years spend three or more hours daily in sedentary activities. Among those aged 65 and older, the prevalence rises to 39.40% (Brazil, 2023).

This scenario constitutes a significant public health issue, as senescence triggers physiological changes such as increased adiposity and reduced muscle mass (Santos et al., 2022a; Santos et al., 2022b), a decline in upper and lower limb muscle strength (Cruz-Jentoft et al., 2019; Santos et al., 2022c), and decreases in physical fitness components, including aerobic capacity, balance, mobility (Tieland, Trouwborst, Clark, 2018), and flexibility (Palmenr, Jansen, 2022).

These changes may also result from SB (Ramsey et al., 2021; Pinto et al., 2023; Raffin et al., 2022), which makes the hypothesis of differences in physical fitness between older adults with and without high exposure to this risk behavior plausible.

Despite this, in Brazil, studies with this investigative perspective remain scarce. Literature searches have not revealed findings from population-based health surveys focused on this issue.

Therefore, there is a clear need to monitor the time spent in SB by older adults and to examine the potential impact of this behavioral pattern on physical fitness throughout aging.

This information may support the actions of professionals working in Primary Health Care, aiding in the screening of older adults at risk for adverse outcomes and, consequently, strengthening all levels of prevention, as well as promoting, rehabilitating, and maintaining the best possible living conditions for this population. Thus, this study aimed to compare performance in physical fitness tests among older adults with and without high exposure to SB.

MATERIALS AND METHODS

Study Design, Setting, and Population

This is a cross-sectional epidemiological study, structured according to the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology - STROBE (Cuschieri, 2019), and developed from the baseline of the population-based research "Health conditions and lifestyle of older adults living in a small municipality" (Casotti et al., 2021).

A census was conducted involving all older adults residing in the urban area of Aiquara, Bahia (BA), Brazil, who were registered in the Family Health Strategy (FHS) (Neto et al., 2023).

Ethical Aspects

The research was conducted in accordance with Resolution No. 466/2012 of the National Health Council and approved by the Research Ethics Committee of the State University of Southwest Bahia, under approval number 171.464 and Certificate of Presentation for Ethical Consideration No. 10786212.30000.0055. Initially, participants were informed about the objectives, procedures, and voluntary nature of the study. Subsequently, they signed the Informed Consent Form.

Eligibility Criteria

Included in the study were individuals aged 60 years or older, non-institutionalized, residing in the urban area, and sleeping in their homes four or more days per week (Silva et al., 2023).

Exclusion criteria were: older adults with cognitive impairment, assessed using the shortened and validated version of the Mini-Mental State Examination (MMSE) (Icaza and Albala, 1999), with a cutoff score of ≤ 12 (Bertolucci et al., 1994); those with neurological diseases or hearing problems that hindered understanding of the questions; and bedridden individuals (Santos et al., 2023).

Data Collection

Data collection was carried out in two stages: (1) face-to-face interviews conducted in participants' homes, and (2) anthropometric measurements and administration of physical fitness tests, conducted in a space provided by the Municipal Health Department. Additional information on methodological procedures and the standardization process can be found in a previous publication (Santos et al., 2023).

Anthropometry

Body mass (BM) was measured using a portable digital scale (Plenna®). Participants stood barefoot, wearing light clothing, with arms relaxed at their sides and eyes facing forward (Frisancho, 1984).

Height (Ht) was measured with a portable stadiometer (WiSO®), with participants barefoot, feet together, heels, buttocks, and scapular region touching the wall, standing upright, looking straight ahead (Frankfurt plane), and holding their breath at inspiration (Frisancho, 1984). These measurements were used to calculate Body Mass Index (BMI = BM/Ht^2) (WHO, 1995).

Physical Fitness Tests

Physical fitness was assessed through handgrip strength (HGS) measurement (Figueiredo et al., 2007) and the application of the Senior Fitness Test battery (Rikli and Jones, 1999). HGS was measured using a Saehan hydraulic dynamometer - SH5002 (Saehan Corporation, 973 Yangdeok-Dong, MasanHoewon-Gu, Changwon 630-728, South Korea).

For the measurement, participants were seated with the shoulder close to the trunk, the elbow flexed at 90°, and the forearm in a neutral position (Figueiredo et al., 2007).

During the assessment, verbal encouragement was provided to ensure participants exerted maximum force on the dynamometer handle for five seconds (Silva et al., 2023).

Two measurements were taken with a one-minute interval, and the highest value obtained, expressed in kilogram-force (kgf), was used for analysis (Santos et al., 2023).

The Senior Fitness Test battery assessed upper (arm curl - AC) and lower (chair stand - CS) limb strength and endurance, aerobic endurance (two-minute step-in-place - SP), dynamic balance and agility (timed up and go - TUG - 2.44 m), and flexibility (sit-and-reach - SR) (Rikli and Jones, 1999).

Additional details about the instruments and procedures have been previously published (Santos et al., 2023).

Before test administration, each older adult received an individual demonstration of the Senior Fitness Test battery from a team of evaluators composed of one Physical Education professional, two undergraduate students in the field, and one undergraduate student in Physical Therapy.

To reduce measurement bias, participants were asked to perform some repetitions of the tests beforehand to become familiar with the movement patterns. Each test was then performed individually, in duplicate, with a two-minute interval between attempts, and the best performance was considered for analysis (Santos et al., 2023; Silva et al., 2023).

Sedentary Behavior

SB was assessed based on the fifth domain of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003), a tool validated for Brazilian older adults (Benedetti et al., 2007; Benedetti, Mazo, and Barros, 2004), which considers time spent sitting on both weekdays and weekends (Craig et al., 2003). The weighted average was calculated as follows: (5 x min/day on weekdays) + (2 x min/day on weekends) ÷ 7 (Santos et al., 2024).

The cutoff point for high SB exposure was defined based on the 75th percentile of the weighted average, corresponding to 342.85 minutes per day (Santos et al., 2022a; Santos et al., 2023).

Statistical Analysis

Descriptive analysis of the population characteristics was performed using relative and absolute frequencies and response percentages for each analyzed variable. Means, medians, standard deviations, and interquartile ranges were also calculated. For inferential analysis, the normality of the distribution of quantitative variables, stratified by sex, was tested using the Kolmogorov-Smirnov method (Mishra et al., 2019).

For group comparisons, the Student's t test was used for normally distributed variables, and the Mann-Whitney U test was used for non-

normally distributed variables (Hazra, Gogtay, 2016). All analyses were performed with a significance level of 5% (p≤ 0.05) and conducted using the Statistical Package for the Social Sciences (SPSS® 21.0, 2013, Inc., Chicago, IL).

RESULTS

Initially, a census was conducted among older adults residing in the urban area to identify all individuals living in the town center of Aiquara, Bahia, with the support of community health agents linked to the FHS, which covers 100% of the municipality's population (Neto et al., 2023).

All households in the urban area were visited, identifying 263 older adults (Santos et al., 2024), of whom 209 composed the evaluated sample, as presented in Figure 1.

A total of 87 men (72.21 ± 8.06 years) and 122 women (71.28 ± 6.79 years) participated in the study. The prevalence of high exposure to SB was 23% among women and 25.30% among men. The characteristics related to the socioeconomic, behavioral, and health profiles of the population were previously published and can be consulted in Santos et al., (2023).

As shown in Table 1, no differences were observed in height, body mass, or body mass index scores between older adults of both sexes with and without high exposure to SB (p>0.05).

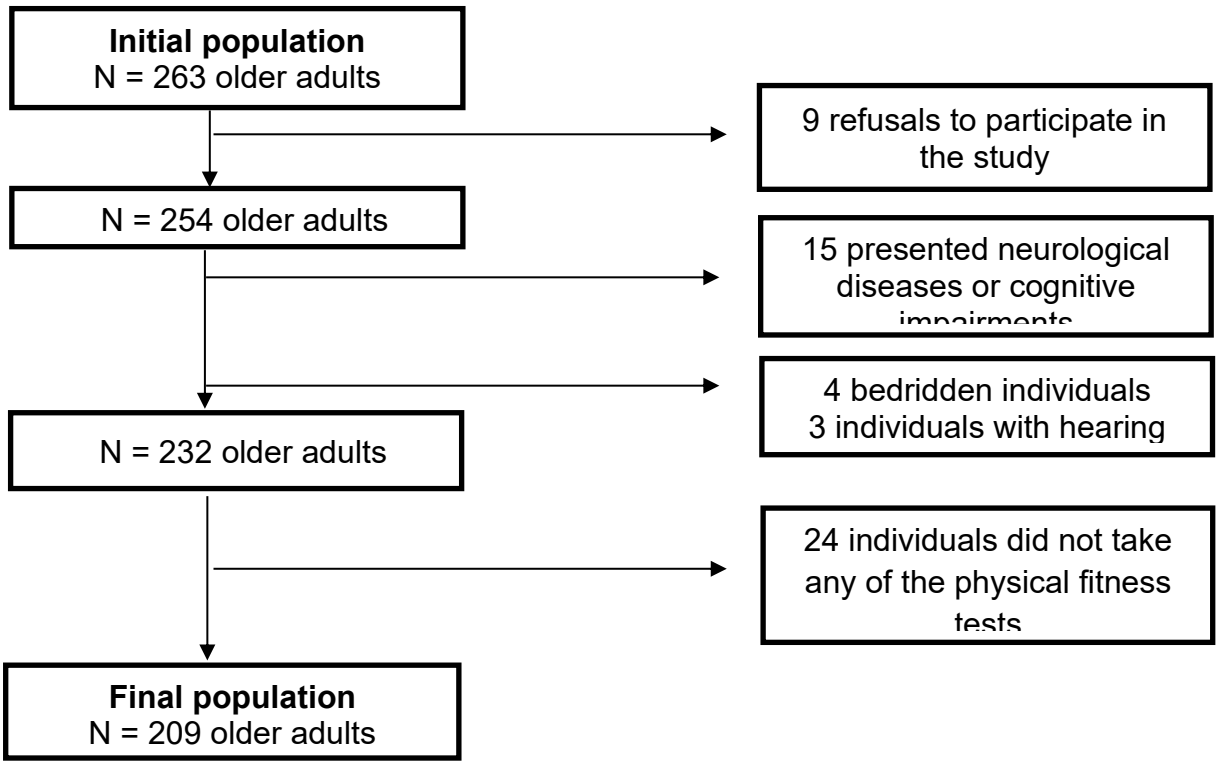

Figure 1 - Flowchart describing the eligibility process of older adult participants in the study.

Table 1 - Measures of central tendency and dispersion for height, body mass, and body mass index among older adults, by sex, with and without high exposure to sedentary behavior.

	OLDER MEN			
Variables	% response	Normal SB (n = 65)	High SB (n = 22)	p-value
Ht (m)@	100.00	1.63 (0.06)	1.61 (0.06)	0.221[a]
BM (kg)@	100.00	66.46 (9.94)	62.76 (10.94)	0.144[a]
BMI (kg/m^2)@	100.00	24.82 (3.52)	24.01 (3.52)	0.422[a]

OLDER WOMEN				
Variables	% response	Normal SB (n = 94)	High SB (n = 28)	p-value
Ht (m)@	100.00	1.51 (0.06)	1.49 (0.06)	0.136 [a]
BM (kg)#	100.00	58.85 (17.80)	58.20 (21.00)	0.270[b]
BMI (kg/m^2)@	100.00	26.51 (5.07)	26.16 (6.69)	0.800[a]

SB: sedentary behavior. **Ht:** height. **BM:** body mass. **BMI:** body mass index. **kg:** kilograms. **m:** meters. **kg/m^2:** kilograms per square meter. n: absolute frequency· @mean and standard deviation. #median and interquartile range. [a]p-value obtained by Student t test. [b]p-value obtained by Mann-Whitney U test.

In Tables 2 and 3, analysis of physical fitness test performance revealed that, in both sexes, older adults with high exposure to SB showed lower scores in the following tests: handgrip strength, chair stand, arm curl, timed up and go, and step in place (p<0.05).

Table 2 - Measures of central tendency and dispersion for physical fitness test performance in older men, with and without high exposure to sedentary behavior.

Variables	% response	Normal SB (N = 65)	High SB (N = 22)	p-value
HGS (kgf)@	98.80	34.67 (6.34)	28.81 (7.34)	0.001[a]
CS (repetitions)#	92.50	12.00 (3.00)	11.00 (5.00)	0.013[b]
AC (repetitions)#	86.30	13.00 (5.00)	10.00 (5.00)	0.014[b]
TUG (s)#	96.55	5.93 (1.80)	6.93 (3.79)	0.025[b]
SR (cm)@	96.25	-3.63 (12.40)	-8.39 (11.65)	0.130[a]
SP (steps)#	85.00	89.00 (22.00)	73.00 (52.00)	0.016[b]

SB: sedentary behavior. HGS: handgrip strength. CS: chair stand. AC: arm curl. TUG: timed up and go. SR: sit-and-reach. SP: step in place. kgf: kilogram force. s: seconds. cm: centimeters. n: absolute frequency. %: percentage. @Mean and standard deviation. # Median and interquartile range. [a]p-value obtained by Student t-test. [b]p-value obtained by Mann-Whitney U test. Bold values indicate p-value < 0.05.

Table 3 - Measures of central tendency and dispersion for physical fitness test performance in older women, with and without high exposure to sedentary behavior.

Variables	% response	Normal SB (N = 94)	High SB (N = 28)	p-value
HGS (kgf)@	100.00	22.62 (4.61)	18.16 (4.44)	<0.001[a]
CS (repetitions)#	92.20	10.00 (3.00)	8.00 (3.00)	<0.001[b]
AC (repetitions)#	89.70	12.00 (5.00)	7.00 (5.00)	<0.001[b]
TUG (s)#	93.10	6.78 (2.21)	9.14 (2.57)	<0.001[b]
SR (cm)@	93.44	-0.04 (12.14)	-4.18 (13.05)	0.127[a]
SP (steps)@	87.06	72.00 (21.00)	53.00 (17.00)	<0.001[a]

SB: sedentary behavior. HGS: handgrip strength. CS: chair stand. AC: arm curl. TUG: timed up and go. SR: sit-and-reach. SP: step in place. kgf: kilogram force. s: seconds. cm: centimeters. N: absolute frequency. %: percentage. @mean and standard deviation. # median and interquartile range. [a]P-value obtained by Student t-test. [b]P-value obtained by Mann-Whitney U test. Bold values indicate P-value < 0.05.

DISCUSSION

In the present study, it was observed that, in both sexes, older adults with high exposure to SB exhibited poorer performance in the following tests: handgrip strength, chair stand, arm curl, timed up and go, and step in place.

Thus, participants who spent more time in SB demonstrated lower muscular strength and endurance in both upper and lower limbs, as well as reduced agility, dynamic balance, and cardiorespiratory fitness, compared to those with lower exposure to this behavior.

Similar findings were reported in a study conducted in Japan involving 281 community-dwelling older adults aged 65 to 84

years, including 174 men and 107 women (Liao et al., 2018).

In that study, a positive association was found in women between total daily sedentary time and the time required to perform the five-meter walk test (β = 0.247; 95% CI: 0.041–0.607) and the timed up and go test (β = 0.210; 95% CI: 0.003–0.511).

Prolonged sedentary bouts (≥ 30 minutes/day) were also associated with longer times in these tests: five-meter walk (β = 0.249; 95% CI: 0.087–0.534) and timed up and go (β = 0.178; 95% CI: 0.003–0.409) (Liao and et al., 2018).

In a prospective cohort study conducted in the United Kingdom with 1,727 older adults from England, Scotland, and Wales (51.5% women; mean age of 63.30 years), greater exposure to SB was associated with lower performance in the handgrip strength test (β = –0.540; 95% CI: –1.013–0.066) (Cooper and et al., 2015).

Similarly, a previous study conducted by our research group with an older adult population in Aiquara, Bahia, Brazil, found that participants with high sedentary exposure had an 88% higher likelihood (PR: 1.88; 95% CI: 1.19–2.98) of presenting muscular weakness, assessed by handgrip strength, compared to those with less sedentary time (Santos and et al., 2022a).

Supporting these findings, research involving 307 older adults living in San Diego, California, demonstrated that SB was associated with longer times to complete the following tests: 400-meter walk (β = 20.72; p<0.001), five chair stands (β = 1.02; p<0.001), and four-meter walk (β = 0.23; p<0.001).

Lower scores were also observed in the balance test (β = – 0.15; p<0.01) and in the total score of the Short Physical Performance Battery – SPPB (β = – 0.55; p<0.001) (Rosenberg et al., 2016).

The physiological mechanisms likely explaining the poorer performance among older adults with high SB exposure have been attributed to musculoskeletal and metabolic changes induced by hypokinesia (Raffin et al., 2022).

For example, it has been shown that SB favors the transition of muscle fibers from type I (oxidative) to type II (glycolytic), as well as reducing mitochondrial volume and the oxidative capacity of muscle (Bergouignan et al., 2011).

Such adaptations impair lipid metabolism efficiency, increase reliance on glycolysis as an energy source, and reduce muscular endurance, negatively affecting performance in strength and endurance tests for upper and lower limbs.

Studies using bed rest models have demonstrated that hypokinesia leads to rapid skeletal muscle fiber atrophy and cytoskeletal disorganization, resulting in functional loss even after short periods of inactivity (Le Roux et al., 2022).

It has also been shown that SB affects central regulatory mechanisms of biological aging. Several cellular markers associated with the hallmarks of aging, such as genomic instability, telomere shortening, mitochondrial dysfunction, and altered anabolic signaling (mTOR, IGF-1, SIRT), are compromised by high sedentary exposure (Raffin and et al.,, 2022).

These changes reduce tissue regenerative capacity and impair neuromuscular and cardiorespiratory functions, leading to declines in mobility, agility, and dynamic balance.

Finally, neuromotor control loss is accelerated under conditions of disuse, and light daily activities are essential to preserve these functions in older adults (Le Roux et al., 2022).

High exposure to SB also appears to be related to hormonal and inflammatory imbalances, including increased serum lipids, low-grade inflammation, and greater secretion of pro-inflammatory adipokines (Pinto et al., 2023).

Therefore, the combination of these factors seems to weaken neuromuscular connections and impair oxygen diffusion in tissues, compromising cardiorespiratory fitness.

During prolonged rest, reductions in fatty acid oxidation and redistribution of blood flow have also been identified, intensifying the decline in aerobic capacity even in the absence of evident clinical comorbidities (Le Roux et al., 2022).

To reduce the adverse impacts of SB) on physical fitness during aging, the World Health Organization has recommended that older adults reduce their sedentary time and, whenever possible, replace it with physical activity of any intensity (Bull et al., 2020).

The adoption of “breaks” has also been suggested (Raffin et al., 2022; Santos et al.,

2022a; Santos et al., 2023), meaning the interruption of prolonged sitting periods.

This is because transitioning to a standing position, even for a few minutes, appears to help mitigate the harmful effects of SB on physiological systems, thereby reducing its adverse health repercussions (Pinto et al., 2023; Santos et al., 2024).

This study presents some limitations, the most notable being the potential underestimation or overestimation of time spent in SB, since exposure was quantified using the fifth domain of the IPAQ (Craig et al., 2003).

Although this instrument is validated for older populations (Benedetti et al., 2004; Benedetti et al., 2007), it relies on self-report, which may introduce recall bias. However, efforts were made to mitigate this bias through the screening and exclusion of individuals with cognitive impairment, using the shortened version of the MMSE (Bertolucci et al., 1994; Icaza, Albala, 1999).

A major strength of this study is the assessment of a population-based sample, ensured by its census design. Furthermore, the originality of the investigation is noteworthy, as this is the first study to analyze the physical fitness of older adults, stratified by sex and level of SB exposure, in a small municipality in the Brazilian Northeast characterized by low socioeconomic indicators and limited healthcare service availability (Casotti et al., 2021; Silva et al., 2023).

It is believed that the findings presented here may support public health surveillance actions aimed at screening older adults with low functional performance due to high SB exposure.

In this context, considering that poorer physical fitness test performance was observed among individuals with greater SB exposure, the hypothesis is raised that such behavior may serve as a discriminator of impaired physical fitness.

Therefore, future studies are recommended to investigate the accuracy, sensitivity, and specificity of SB in identifying conditions such as low muscular strength and endurance, impaired walking capacity, compromised dynamic balance, and reduced cardiorespiratory fitness.

Proposing SB cutoff points for functional screening may represent a useful strategy for identifying older adults with low functional performance, with potential applicability in monitoring and intervention programs in Primary Health Care.

CONCLUSION

The comparisons conducted showed that older adults of both sexes with high exposure to SB presented lower performance in tests of mobility, agility, muscular strength and endurance, dynamic balance, and aerobic endurance.

Therefore, the implementation of public policies is essential to enable, within the scope of Primary Health Care, educational actions aimed at reducing sedentary time and promoting physical activities that replace prolonged periods of sedentary behavior, as a strategy to maintain functionality in older adults.

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