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Physical activity and sedentary behavior as screening tools for dynapenic abdominal obesity and dynapenic obesity in older adults: A cross-sectional investigation

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ABSTRACT

Objective: To investigate the discriminatory capacity of habitual physical activity (HPA) and sedentary behavior (SB) when screening for dynapenic abdominal obesity (DAO) and dynapenic obesity (DO) in older adults.
Methods: A cross-sectional population epidemiological investigation was conducted with 207 older adults. Obesity was diagnosed by high waist circumference and body mass index. Dynapenia was identified through low handgrip-strength.
Results: In men, the best HPA cutoff points to discriminate DAO and DO were, respectively, 80 minutes/week (sensitivity: 100%; specificity: 71.95%) and 145 minutes/week (sensitivity: 100%; specificity: 54.88%). The best SB value for DAO was 351.43 minutes/day (sensitivity: 100%; specificity: 65.85%) and 400 minutes/day (sensitivity: 100%; specificity: 79.27%) for DO. In women, 150 minutes/week was the best HPA value for both DAO (sensitivity: 75%; specificity: 57.84%) and DO (sensitivity: 90.91%; specificity: 56.76%). The best SB cutoff points for DAO and DO were 381.43 minutes/day (sensitivity: 60%; specificity: 82.35%) and 337.14 minutes/day (sensitivity: 72.73%; specificity: 65.80%), respectively.
Conclusion: Both HPA and SB demonstrated discriminatory capacity for screening DAO and DO in the study population.

Introduction

Among the primary changes associated with aging, the decline in muscular fitness stands out. Older adults may consequently experience a state of weakness known as dynapenia.[1,2] Another significant natural consequence of aging is an excessive accumulation of fat in adipose tissue.[3] The combination of muscle weakness and high intra-abdominal fat distribution is referred to as dynapenic abdominal obesity (DAO),[4,5] while muscle weakness with a concomitant high fat distribution throughout the body constitutes dynapenic obesity (DO).[6,7]

These conditions are prevalent morbidities in older adults, with reported prevalence ranging from 6.10%[4] to 10.76%[5] for DAO and

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from 6.16%[6] to 24.10%[7] for DO. This epidemiological scenario represents a significant public health concern, as the presence of both dynapenia and obesity concurrently leads to a greater risk of falls,[7] functional disability,[4,8] low mobility, reduced walking speed,[5,6] cardiometabolic diseases,[9] and mortality[10] compared to low strength or excess fat alone.

It is important to note that the diagnosis of DAO and DO within the healthcare framework may present limitations. This is because outpatient clinics and health units, particularly in developing countries like Brazil, often lack handheld hydraulic dynamometers,[2,11] a gold standard instrument used to identify dynapenia.[1,12] Given this, it is crucial to propose accessible indicators that can be utilized in these settings to identify older adults with DAO and DO at an early stage.

Systematic reviews with meta-analyses have demonstrated that limited engagement in habitual physical activity (HPA) and prolonged exposure to sedentary behavior (SB) are predictors of both dynapenia[13] and obesity.[14] Therefore, the hypothesis that these risk behaviors are accurate for screening older adults with DAO and DO appears plausible. However, after a thorough literature search, no epidemiological research investigating this perspective was found.

In light of these findings, there is a need to conduct health surveys to support these investigations. The evidence obtained from such surveys can support health surveillance initiatives aimed at optimizing the screening of older adults who are more likely to have and DAO and DO. This can be achieved by utilizing low-cost and easily applicable indicators. With this purpose in mind, the present study aimed to investigate the discriminatory capacity of HPA and SB when screening for DAO and DO in older adults.

Materials and methods

Study design, location, and participants

This cross-sectional epidemiological investigation was conducted with older adults residing in the urban area of Aiquara, Bahia, Brazil. All participants were registered in the Family Health Strategy Program (FHS), which covers 100% of the city's population.[15] The investigation was structured and described according to the guidelines of Strengthening the Reporting of Observational Studies in Epidemiology.[16] Aiquara, with a population of 4,447, is located in the central-southern region of Bahia. It ranks 410th out of the state's 417 cities and has a low Human Development Index of 0.583.[15]

Ethical aspects

The study was based on the baseline data from the survey "*Health conditions and lifestyle of older adults living in a small town*",[15] which was conducted in accordance with the principles of the Declaration of Helsinki of the World Medical Association and the guidelines established by Resolution No. 466/2012 of the Brazilian National Health Council. Consequently, it received approval from the Research Ethics Committee of the State University of Southwest Bahia (opinion No. 171.464, CAAE No. 10786212.30000.0055). All participants were informed of the survey objectives and protocols and provided voluntary consent by signing the Free and Informed Consent Form.

Eligibility criteria

Inclusion criteria included being 60 years or older, not institutionalized, and living in a permanent residence in the urban area for at least four days per week.[17] Exclusion criteria included cognitive deficits, as identified by the reduced and validated version of the Mini-Mental State Examination (MMSE)[18] with a cutoff point < 13,[19] bedridden status, and neurological or hearing disorders that could hinder understanding the interview questions.[17]

Data collection

Data collection occurred in two stages: 1) home interviews to obtain socioeconomic, behavioral, and health-related information; and 2) anthropometric and handgrip strength (HGS) measurements. The second stage was scheduled two to three days after the interview and took place in a space provided by the Municipal Health Department of Aiquara, Bahia, Brazil. For more details on the data collection stages and procedures, please refer to the paper by Santos *et al.*[20]

Descriptive variables (population characteristics)

Age (in years), sex (male or female), education (yes or no), skin color (white or non-white), income ($\leq$ 1 minimum wage or $>$ 1 minimum wage), tobacco use (yes or no) alcohol consumption (yes or no), diagnosis of systemic arterial hypertension (yes or no), and diabetes *mellitus* (yes or no).[20]

Independent variables (discriminators)

HPA was assessed using the first four domains of the long version of the International Physical Activity Questionnaire (IPAQ),[21] an instrument validated for Brazilian older adults of both sexes.[22,23] A score was constructed based on the quantification of weekly time spent in moderate to vigorous physical activity at work, commuting, domestic tasks, and during leisure time.[11,22,24]

Exposure to SB was investigated using the fifth domain of the IPAQ, which considers the time spent sitting or reclining on a weekday and a weekend day.[21] The weighted average of SB was calculated using the following formula: (5 x sitting time during a weekday) + (2 x sitting time during a weekend day) / 7.[11,22,24]

Dependent variables (outcomes)

Waist Circumference: measured in an upright position with arms crossed over shoulders and feet together. The narrowest point between the rib cage and the iliac crest was identified, and the measurement was taken immediately after a normal exhalation.[25] A flexible and inelastic anthropometric tape (Sanny®) was used, and the measurement was repeated three times. The average of the three measurements was considered.[3]

Body Mass (BM): quantified using a digital scale (Plena®) while participants were wearing light clothing, barefoot, and in an upright position. Stature (St): measured using a portable stadiometer (Wiso®) installed in a suitable location. Participants stood upright, barefoot, with feet together, heels, buttocks, and shoulder girdle against the wall, looking fixedly at an axis parallel to the floor (Frankfurt Plan).[26] Body Mass Index was calculated as (BMI = BM/St^2).[27]

Throughout the HGS measurement, participants were encouraged to press the dynamometer handle with as much force as possible for five seconds.[28,29] The test was performed twice, one minute apart, and the highest value identified in kilogram-force (kgf)[11,22,24,29] was used for the assessment. DAO diagnosis was based on the concomitant presence of large waist circumference values (women: $\geq$ 88 cm; men: $\geq$ 102 cm)[25] and muscle weakness (women: HGS $\leq$ 18.37 kgf; men: HGS $\leq$ 26 .75 kgf).[30] Finally, DO diagnosis was made based on the simultaneous verification of high BMI ($>$ 27 kg/m^2)[27] and dynapenia (women: HGS $\leq$ 18.37 kgf; men: HGS $\leq$ 26.75 kgf).[30]

Statistical analysis

Population characteristics were described using relative and absolute frequencies, means, medians, standard deviations, interquartile ranges, and percentiles. The Kolmogorov-Smirnov test was used to identify non-normal distributions of time spent in HPA and exposure to SB. Comparisons of quantitative variables between older adults with and without DAO and DO were performed using the Mann-Whitney U test. The effect size of the differences was calculated using the equation $r = (Z\ score/(\sqrt{n}))$.[31]

The discriminatory capacity of weekly time spent in HPA and daily exposure to SB was verified using Receiver Operating Characteristic (ROC) curve analysis.[32-34] The accuracy values of each risk behavior were assessed by comparing the areas under the ROC curve. The best cutoff points, sensitivity, and specificity values were identified using the Youden index.[33,34] All analyses were conducted with a 95% confidence interval and a significance level of 5% ($P \leq 0.05$). Statistical procedures were performed using the Statistical Package for Social Sciences (SPSS® 21.0, 2013, Inc, Chicago, IL) and MedCalc® (version 19.4.1, 2018).

Results

In a census conducted in partnership with Community Health Agents in Aiquara, Bahia, Brazil, all homes in the urban area were visited, resulting in the identification of 263 older adults.[20,29] Of these, 207 (58.90% women) participated in this study, as shown in Fig. 1.

The average ages of women and men were 71.05 ± 6.76 and 72.24 ± 8.16 years, respectively. The prevalence of DAO was 11.10% (women: 16.40%; men: 3.50%), and the prevalence of DO was approximately 6.80% (women: 9%; men: 3.50%). Additionally, 61.40% of participants had no education, 85.11% were non-white, 87.10% reported income ≤ 1 minimum wage, 9.20% used tobacco, 58.90% were hypertensive, 22.20% consumed alcoholic beverages, and 17.40% were diabetic. For more details on the characteristics of the Aiquara municipality population, please refer to previous studies.[24,35] As shown in Table 1, older adults with DAO and DO spent significantly less time per week in HPA and had longer exposure to SB compared to those without these conditions.

Fig. 2 illustrates the areas under the ROC curve for the weekly time spent on HPA and daily time spent on SB exposure, which were used as discriminators of DAO and DO in the study population. Both variables demonstrated an area under the ROC curve ≥ 0.70, with no difference between accuracy in both sexes ($P > 0.05$).

Regarding the other parameters investigated, the best cutoff point for discriminating DAO in males based on weekly time spent in HPA was 80 minutes/week (sensitivity: 100%; specificity: 71.95%), while for DO it was 145 minutes/week (sensitivity: 100%; specificity: 54.88%). For SB exposure, the best cutoff points to discriminate DAO and DO were 351.43 minutes/day (sensitivity: 100%; specificity: 65.85%) and 400 minutes/day (sensitivity: 100%; specificity: 79.27%), respectively (Table 2).

In females, the best HPA cutoff point for discriminating DAO and DO was 150 minutes/week (sensitivity: 75%; specificity: 57.84% and sensitivity: 90.91%; specificity: 56.76%, respectively). The best SB cutoff points for discriminating DAO and DO were 381.43 minutes/day (sensitivity: 60%; specificity: 82.35%) and 337.14 minutes/day (sensitivity: 72.73%; specificity: 65.80%), respectively (Table 3).

Discussion

This epidemiological study is the first to investigate the discriminatory capacity of HPA and SB for screening DAO and DO in older adults. The primary findings revealed that individuals affected by DAO and DO exhibited significantly less time spent in HPA and greater exposure to SB. Notably, both risk behaviors demonstrated accuracy ≥ 70% in both sexes, with no significant difference between them and a lower confidence interval limit > 50%, highlighting their potential as indicators for discriminating these outcomes.

In the epidemiological context, sensitivity is a crucial parameter as it pertains to an indicator's ability to identify individuals most likely to exhibit the outcome of interest (true positives).[2] However, increased sensitivity can lead to a higher likelihood of misclassifying individuals without the morbidity as having the outcome.[3] Therefore, specificity is a complementary parameter that can help identify true negatives and minimize false positive diagnoses.[11]

Considering the results of this study, the specificity values of HPA (71.50%) and SB (65.85%) for DAO screening in older men can mitigate

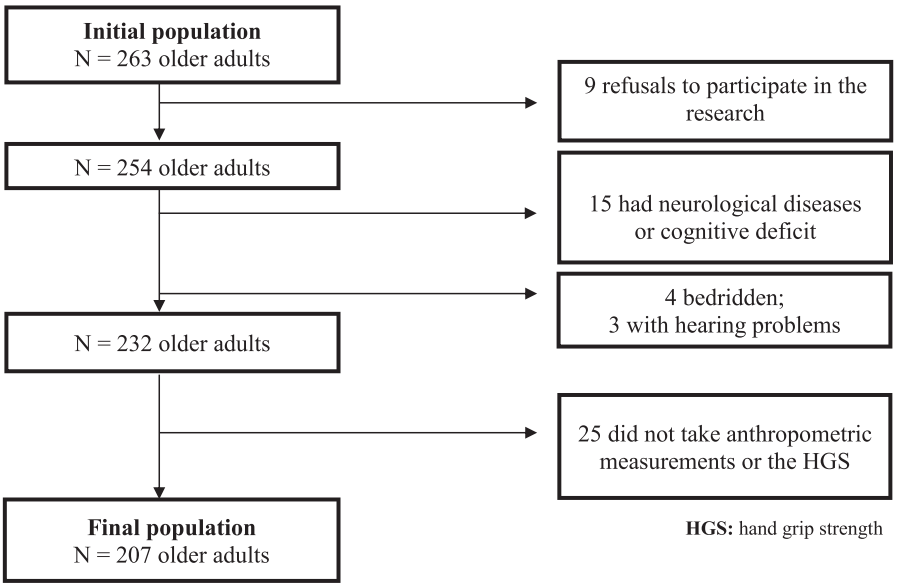

Fig. 1. Flowchart describing the eligibility process for the older adults participating in the study.

Table 1
Comparison of time spent in habitual physical activity and exposure to sedentary behavior among older adults, of both sexes, with and without dynapenic abdominal obesity and dynapenic obesity.

Variables	Dynapenic Abdominal Obesity		Value of U	Z Score	ESD (*r*)	P-value
HPA (min/wk)	No (n = 184)	240.00* (P25: 70.00; P75: 535.50)	1299.000	-3.020	0.21	**0.003**
	Yes (n = 23)	70.00* (P25: 30.00; P75:150,00)				
SB (min/day)	No (n = 184)	300.00* (P25: 222.85; P75: 360.00)	1084.500	-3.811	0.26	<**0.001**
	Yes (n = 23)	420.00* (P25: 300.00; P75: 720.00)				
Variables	**Dynapenic Obesity**		**Value of U**	**Z Score**	**ESD (*r*)**	**P-value**
HPA (min/wk)	No (n = 193)	240.00* (P25: 60.00; P75: 525.00)	811.500	-2.496	0.17	**0.013**
	Yes (n = 14)	70.00* (P25: 40.00; P75:146.25)				
SB (min/day)	No (n = 193)	300.00* (P25: 222.85; P75: 360.00	704.500	-2.990	0.21	**0.003**
	Yes (n = 14)	405.71* (P25: 332.14; P75: 630.00)				

HPA: habitual physical activity. **SB:** sedentary behavior. **min:** minutes. **wk:** week. **ESD:** effect size of differences. **n:** number of people per group. **P:** percentile. *median.

potential false positives arising from their high sensitivity (100%). However, for DO in males, while both HPA and SB showed high sensitivity (100%), only SB demonstrated considerable specificity (71.95%). Therefore, it is recommended that screening for DO in older men begin with HPA and/or SB to initially identify individuals with a higher probability of presenting the outcome, so that the screening is complemented with the specificity of the SB, hence minimizing false positive diagnoses.

Following the perspective of using specificity concomitantly with sensitivity, to optimize DAO screening in females, it is suggested that the first screening be carried out using the time spent in HPA (sensitivity: 75%) and complemented by the exposure time to SB (specificity: 82.35%). While for DO screening, as it has proven to be more sensitive, the time spent in HPA (90.91%) can be adopted, initially, and complemented by the specificity of the SB exposure time (75.80%).

In general, the optimal cutoff points for discriminating DAO and DO, based on HPA, identified in this study are close to the minimum recommended by the World Health Organization (WHO). The WHO suggests that less than 150 minutes per week of HPA is insufficient physical activity.[36] This has been established as a significant risk factor for dynapenia[13] and obesity.[14]

Regarding SB, there is a lack of consensus in the literature concerning normative values for determining high SB exposure in older adults. However, in this study, the best cutoff points for discriminating DAO and DO ranged from 337.14 to 400 minutes/day, which equates to 5.6 to 6.6 hours of a risky behavior that, the higher it is, the greater the risk of developing both dynapenia[13] and obesity.[14]

Therefore, adopting an active aging approach is crucial for improving or maintaining muscle strength[13] and preventing or treating obesity.[14] To achieve this, the WHO recommends 150 to 300 minutes/week of moderate-intensity HPA or 75 to 150 minutes/week of vigorous-intensity HPA. These activities can be quantified by summing the time spent in HPA during leisure time, domestic tasks, commuting, and at work. The WHO also emphasizes that a sufficient level of HPA can be achieved by combining the two types of workout intensities mentioned above.[36]

Furthermore, the WHO recommends resistance training as a specific exercise modality for increasing or maintaining muscular fitness.[36] The National Strength and Conditioning Association suggests two to three days of resistance training for older adults, consisting of 8 to 10 exercises, particularly multi-joint exercises. Training should begin at a level appropriate to the older adult's physical capacity. This means that training periodization should be individualized to accommodate improvements in physical fitness until reaching an intensity of 70 to 85% of the maximum repetition of each exercise.[37] To reduce the adverse effects of SB on the strength and body composition of older adults, the literature suggests taking "breaks" to interrupt prolonged sedentary activities.[11,20,24] This is because standing up for a few minutes can increase energy expenditure beyond rest and mitigate the harmful effects of prolonged sedentary behavior on health.[38,39]

The discriminatory capacity of time spent in HPA and SB in screening for DAO and DO, identified in this study, likely stems from the physiological repercussions that hypokinetics have on metabolism.[38,39,40] Among the primary effects, we highlight a decline in the activity of proteins involved in glucose transport, phosphorylation, and storage. This leads to a significant decrease in insulin sensitivity and reduces the ability of skeletal muscles to utilize glucose as an energy substrate for muscular contractions.[38,39] Consequently, this potential energy is transferred to the liver, where it is converted into fatty acids and subsequently redirected for rapid storage in adipose tissue, both throughout and in the central region of the body. This contributes to the development of obesity and/or abdominal obesity.[39,40]

Additionally, prolonged SB and insufficient HPA can have significant implications for the muscular system. These include increased anabolic resistance, characterized by a decline in synthesis capacity and increased protein degradation,[11,38,40] leading to atrophy and a reduction in the number of muscle fibers, particularly type IIA and IIX fibers.[11,40] Furthermore, evidence suggests that a high amount of time spent in sedentary activities can result in a reduction of genes involved in mitochondrial function, volume, and oxidative capacity. This impairs the process of phosphorylation and energy acquisition for muscle contraction, thereby promoting dynapenia.[11,38,39]

It is also important to emphasize that our investigation suggests etiological hypotheses related to HPA and SB as behaviors that may contribute to the development of DAO and DO in older adults. In this context, there is a need for longitudinal epidemiological studies, such as prospective cohorts, to investigate the potential risk that these indicators may pose to the incidence of these outcomes in older populations.

Finally, it is important to acknowledge that this study indirectly quantified exposure to HPA and SB, which can be considered a potential limitation. However, it should be noted that cross-validation studies using accelerometers have demonstrated that the IPAQ has highly acceptable validity and reliability criteria in the Brazilian older population.[22,23] Moreover, the use of the MMSE[18,19] as an exclusion criterion for older adults with cognitive impairment to mitigate potential memory bias in obtaining this information.

This finding, coupled with the census-based nature of this study, supports the proposition of using weekly time spent in HPA and daily exposure to SB to screen older adults at higher probability of DAO

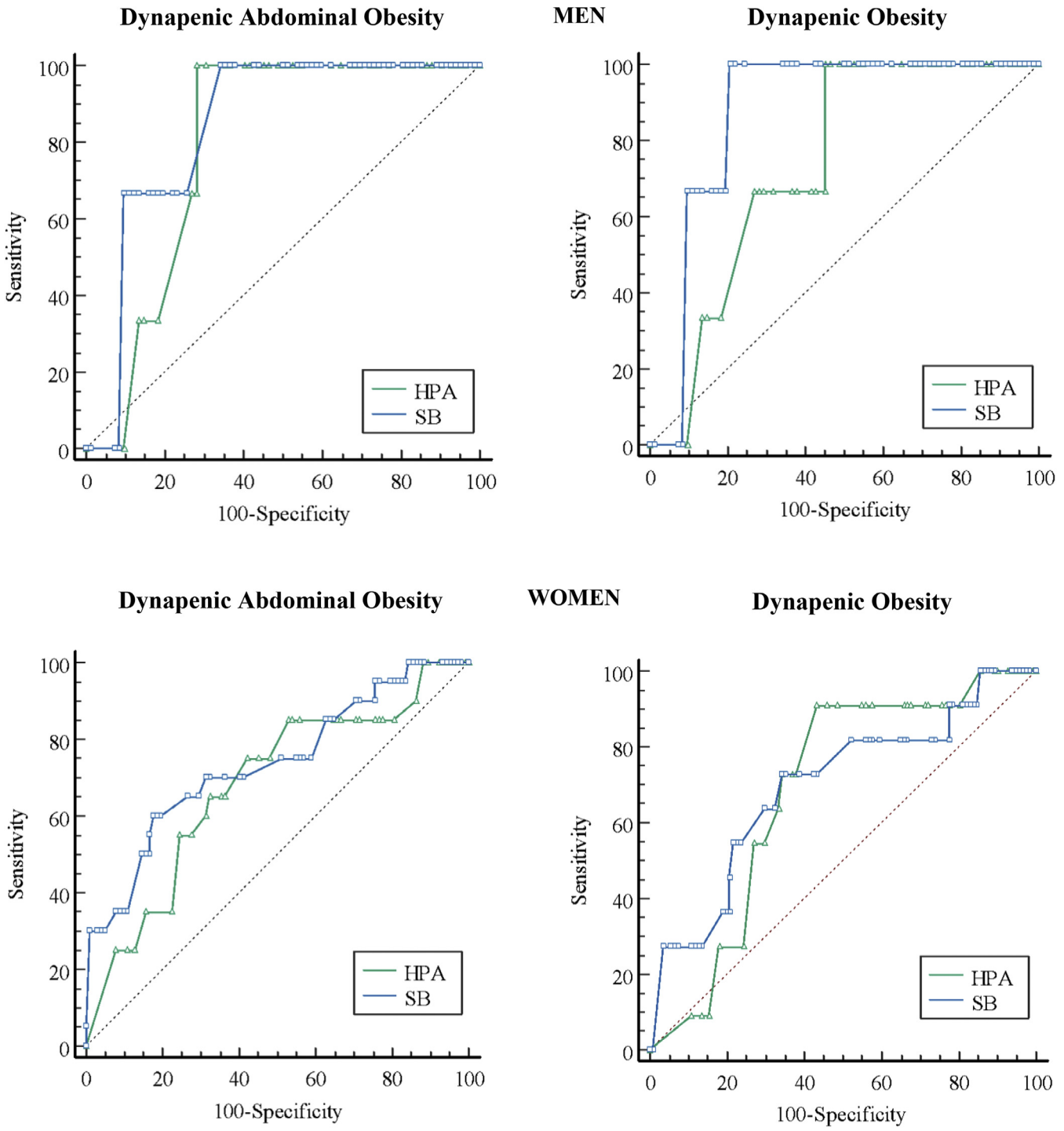

Fig. 2. Receiver Operating Characteristic Curves of weekly time spent in habitual physical activity and daily exposure to sedentary behavior for the discrimination of dynapenic abdominal obesity and dynapenic obesity in older adults of both sexes.

and DO. This constitutes a cost-effective and easily implementable epidemiological strategy that can be adopted in primary healthcare by any health professional familiar with the IPAQ, especially in settings similar to Aiquara, Bahia, Brazil, which have low socioeconomic indicators and limited health resources,[11,15,29] such as the scarcity of hydraulic dynamometers for measuring muscle strength.

Conclusion

The findings of this study support the stated hypothesis, as the weekly time spent in HPA and daily exposure to SB accurately discriminated between prevalent cases of DAO and DO in the study population. Therefore, it is recommended that both behaviors be used

Table 2
Parameters of the receiver operating characteristic curve for discriminating dynapenic abdominal obesity and dynapenic obesity in older men.

Variables	Dynapenic Abdominal Obesity			
	Cutoff point	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**AUC (95% CI)**
HPA (minutes/week)	80.00	100.00 (29.50-100.00)	71.95 (60.90-81.30)	0.80 (0.69-0.87)
SB (minutes/day)	351.43	100.00 (29.20-100.00)	65.85 (54.60-76.60)	0,84 (0.74-0.91)
Variables	**Dynapenic Obesity**			
	Cutoff point	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**AUC (95% CI)**
HPA (minutes/week)	145.00	100.00 (29.20-100.00)	54.88 (43.50-65.90)	0.73 (0,63-0.93)
SB (minutes/day)	400.00	100.00 (29.20-100.00)	79.27 (68.90-87.70)	0.87 (0.78.0.92)

HPA: habitual physical activity. **SB:** sedentary behavior. **95% CI:** confidence interval of 95%. **AUC:** area under the receiver operating characteristic curve.

Table 3
Parameters of the receiver operating characteristic curve for discriminating dynapenic abdominal obesity and dynapenic obesity in older women.

Variables	Dynapenic Abdominal Obesity			
	Cutoff point	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**AUC (95% CI)**
HPA (minutes/week)	150.00	75.00 (50.90-91.30)	57.84 (47.70-67.60)	0.70 (0.60-0.76)
SB (minutes/day)	381.43	60.00 (36.10-80.90)	82,35 (73.60-89.20)	0,73 (0.64-0.81)
Variables	**Dynapenic Obesity**			
	Cutoff point	**Sensitivity (95% CI)**	**Specificity (95% CI)**	**AUC (95% CI)**
HPA (minutes/week)	150.00	90.91 (58.70-99.80)	56.76 (47.00-66.10)	0.70 (0.60-0.76)
SB (minutes/day)	337.14	72.73 (39.00-94.00)	75.80 (56.20-76.50)	0.71 (0.60-0.77)

HPA: habitual physical activity. **SB:** sedentary behavior. **95% CI:** confidence interval of 95%. **AUC:** area under the receiver operating characteristic curve.

concurrently to combine the sensitivity and specificity of each indicator. This can optimize the screening of older adults who actually present these outcomes, especially when it is impossible to measure HGS.

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Declaration of competing interest

None.

CRediT authorship contribution statement

Lucas dos Santos: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Paulo da Fonseca Valença Neto:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Claudio Bispo de Almeida:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Débora Jesus da Silva:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Raquel dos Santos Barbosa:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Isaac Costa Santos:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Gabriel Alves Godinho:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Carlos Daniel Dutra Lopes:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Cezar Augusto Casotti:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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