

Associations of pattern-recognition-measured daily activities with sarcopenia and sarcopenic obesity in old age: The IMPACT65+ study

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ABSTRACT

Background: Physical activity has shown beneficial effects for a good state of muscles in aging, but the specific activities of daily living that could be protective remains unclear. This study aimed to analyse the associations of different pattern-recognition-measured daily activities with sarcopenia and sarcopenic obesity in a sample of older adults.

Methods: 200 community-dwelling older adults wore the Intelligent Device for Energy Expenditure and Activity for two consecutive days. Twelve major daily activities recorded were merged in to three common intensity categories: sedentary behaviour (SB), light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA). For physical performance measurements included, hand grip dynamometer and chair-stand tests were used. Skeletal muscle mass and fat mass were estimated by bioelectrical impedance analysis. Associations of daily activities with the study variables were examined using linear regression models.

Results: There were no significant associations between total time spent in SB, LPA, or MVPA and sarcopenia. Sarcopenic obesity showed a negative association with total time spent in MVPA [β (95%CI): -0.29 (-0.41 , -0.17)]. Walk at a brisk pace was significantly associated with lower limb physical performance, muscle mass and fat mass % [β (95%CI): 1.15 (0.40 , 1.91); 1.45 (0.68 , 2.22) and -2.63 (-4.12 , -1.14) respectively]. Other MVPA activities were also significantly associated with the same sarcopenic obesity components [β (95%CI): 4.65 (0.55 , 8.75); 8.59 (4.51 , 12.67) and -13.98 (-21.96 , -5.99) respectively].

Conclusion: Time spent in daily activities of moderate-to-vigorous intensity is negatively associated with sarcopenic obesity but not with sarcopenia.

1. Introduction

With aging, muscular quality changes occur, mainly due to the muscle fibers' reduced size, number, contractibility, and fat tissue infiltration into them (do Nascimento et al., 2018; Cruz-Jentoft et al., 2019; Pratt et al., 2020). These changes lead to a skeletal muscle condition called sarcopenia, characterized by muscle strength and muscle mass loss (Dos Santos et al., 2021). Prevalence of sarcopenia increases with age, placing this condition as a worldwide public health issue (do Nascimento et al., 2018; Pratt et al., 2020; Komici et al., 2021). Along with sarcopenia, obesity has increased within the aging population due

to long-term unhealthy diets and sedentary lifestyles (Koliaki et al., 2019; Bilski et al., 2022). When increased adipose tissue accompanies sarcopenia, the condition is called sarcopenic obesity (Verma et al., 2022) and its prevalence also increases significantly with age (Koliaki et al., 2019; Batsis et al., 2017). Albeit sarcopenia is associated to frailty, diverse comorbidities, and mortality (Fielding et al., 2011; Liu et al., 2020; Makizako et al., 2019; Ishida et al., 2020; Sosowska et al., 2022; Chen et al., 2019), sarcopenic obesity is also an independent geriatric condition related to harmful health outcomes (Donini et al., 2022; Moreno-Franco et al., 2018).

The United Nations has declared that 2021–2030 is the Decade of

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healthy Aging (World Health Organization, 2022a), which is defined as the process of developing and maintaining the functional ability that enables well-being in older age (World Health Organization, 2015; Huiguera-Fresnillo et al., 2020). One of the domains that contributes to this functional ability is the locomotor capacity (World Health Organization, 2022a; World Health Organization, 2022b) and it requires, indeed, a good state of musculoskeletal system that encompasses muscle strength and muscle power, among others (World Health Organization, 2022a). Randomized controlled trials with old age participants have shown beneficial effects of exercise on muscle strength and muscle mass, as well as on obesity markers (Bernabei et al., 2022; Piastra et al., 2018; Chan et al., 2018). However, these studies are limited to supervised exercise, and therefore, the specific physical activities of daily living that could be protective against sarcopenia and sarcopenic obesity in a population, which spend most of the time in sedentary activities (Wirth et al., 2017), remains unclear.

The use of activity monitors to measure daily physical activity characteristics in old age is widely preferred, because it provides data without the self-reported limitations (Gomes et al., 2021; Giné-Garriga et al., 2020; Migueles et al., 2021; Nelson et al., 2019). These monitors are positioned in specific body locations to capture movements (e.g., wrist, hip, thigh) (Johansson et al., 2021; Scott et al., 2021; Westbury et al., 2018; Shibata et al., 2022; Sánchez-Sánchez et al., 2019), but all locations have both strength and limitations to accurately measure daily activities. Multisensor pattern-recognition devices provides information about movement and posture to measure daily activities without the limitations of monitors with only one body location (Cabanás-Sánchez et al., 2019a). Thus, this study aimed to analyse the associations of different pattern-recognition-measured daily activities with sarcopenia and sarcopenic obesity in a sample of older adults.

2. Methods

2.1. Design and participants

A cross-sectional study was conducted with 200 high-functioning community-dwelling older adults, who participated of sport activities developed by their community center. Participants were aged 65 to 88 years and participating in the IMPACT65+ study, which aims to examine the association of objectively measured physical activity with frailty, health-related quality of life and other health indicators in Spanish people aged 65 and older (Huiguera-Fresnillo et al., 2020; Cabanás-Sánchez et al., 2019a; Cabanás-Sánchez et al., 2018; Cabanás-Sánchez et al., 2019b). Data collection was carried out from April 2015 to June 2017. After excluding the first 303 participants since bioelectrical impedance analysis was not performed at the study beginning, we included 79 men and 121 women with valid accelerometer data from an initial study cohort of 607 screened subjects (Supplementary fig. 1). The Ethics Committee of the Autonomous University of Madrid (Madrid, Spain) approved the study (May 12, 2015). Moreover, all participants were informed of the nature of the study and provided written informed consent before data collection.

2.2. Daily activities

The multisensor pattern-recognition Intelligent Device for Energy Expenditure and Activity (IDEEA, Minisun, Fresno, CA), that has been previously tested to assess its accuracy and validity (Zhang et al., 2003; Maffiuletti et al., 2008), was used in this study to assess postures, sedentary and active behaviours. The IDEEA consists of a small and lightweight data recorder device (70x44x18mm, 59 g) that can be worn on the belt and connected by wires and wirelessly to five sensors, which are biaxial accelerometers detecting angular acceleration and displacement in two orthogonal planes. Acceleration and position information obtained from the sensors is integrated into the microprocessor within the recorder device. Participants were asked to wear the IDEEA for two

consecutive days (Zhang et al., 2003) without removing the device. Since the device is not waterproof, participants were instructed to not perform water activities nor take showers while carrying the monitor. The sensors were adhered with medical tape to the anterior sternum (i.e., just below the sternal angle), the anterior side of each thigh (i.e., the midpoint between the anterior superior iliac spine and knee joint), and the plantar surface under each foot (i.e., under the foot arch). Devices were located and removed by trained personnel and were initialized and individually calibrated following the IDEEA software instructions (Cabanás-Sánchez et al., 2019a). For this study, all activity types (Huiguera-Fresnillo et al., 2020; Tremblay et al., 2017; Ainsworth et al., 2011) were merged into major daily activities, which, in turn, were classified into three common intensity categories: (i) sedentary behaviour (SB): lie, recline, and passive sit; (ii) light physical activity (LPA): active sit, stand, walk at a slow pace (<2 miles per hour, mph) and walk at an average pace (2–2.49 mph); and (iii) moderate-to-vigorous physical activity (MVPA): walk at a brisk pace (≥2.5 mph) and other activities (step up, step down, run, and jump). Sleep and awake periods were identified using a validated automated algorithm (Cabanás-Sánchez et al., 2018). Valid data for analysis was considered when participants wore the IDEEA ≥1 day for at least 10 waking hours (Troiano et al., 2008). Then, the time spent on each daily activity was calculated as the mean time during the valid days.

2.3. Physical performance

The handgrip strength (HGS) was measured with a TKK 5101 grip dynamometer (Takey, Tokyo, Japan) using the non-dominant hand. The handgrip was adjusted for every subject size (i.e., with the index finger's middle phalanx positioned at 90°). For the test, the subjects were instructed to remove rings from the evaluated hand and to keep the elbow extended, avoiding any contact between their body and the dynamometer. Subjects pressed the handgrip strongly as possible for 3 s. The test was performed two non-consecutive times with a few seconds of rest between them, and the highest value in kilograms was considered for the analysis (Sun et al., n.d.). For lower extremities, the Chair-Stand test was used, and subjects were instructed to stand up from a chair and sit down repeatedly for 30 s. The test started with the subject seated with the back straight, feet on the ground, and arms crossed on the chest. During the performance, the subjects had to achieve a complete knee extension to stand up and then return to seated. The use of the hands to achieve the stand position was not allowed. The total number of movements made in 30 s was recorded for the data analysis (Rikli and Jones, 2013a).

2.4. Body composition

Skeletal muscle mass (SMM) was estimated using the equation developed by Janssen and colleagues (Janssen et al., 2000): $SMM (kg) = [(height (cm^2) / resistance (ohms) \times 0.401) + (gender (0 for women; 1 for men) \times 3.825) + (age (years) \times -0.071)] + 5.102$. Resistance data and fat mass (percentage of total body weight) were obtained from bioelectrical impedance analysis (Tanita BC418MA). Height and weight were measured by a height meter and a scale Seca 225 and Seca 861, respectively. Skeletal muscle index or SMM_{height} was obtained from absolute skeletal muscle mass normalized for height, i.e., $SMM (kg) / Height (m^2)$ (Castaneda and Janssen, 2005). The absolute skeletal muscle mass normalized for body weight (% of skeletal muscle mass), i.e., $SMM (kg) / body weight (kg) \times 100$ (Janssen et al., 2002) was also obtained as skeletal muscle index or SMM_{weight} .

2.5. Sarcopenia and sarcopenic obesity

According to the European Working Group on Sarcopenia in Older People (EWGSOP2), the diagnosis of sarcopenia considers two components, muscle strength, and muscle mass (Cruz-Jentoft et al., 2019). On

the other hand, according to the consensus published in 2022, the diagnosis of sarcopenic obesity considers three components: muscle strength, muscle mass, and fat mass percentage (16). These components are treated like dichotomous variables using specific cut-off points for men and women (e. g., low muscle strength/mass) (Cruz-Jentoft et al., 2019; Donini et al., 2022; Janssen et al., 2002; Fiatarone Singh et al., 2009; Dodds et al., 2014; Rikli and Jones, 2013b; Gallagher et al., 2000). However, dichotomous variables do not allow to consider “progression” in these conditions (Wu et al., 2018) and due to our study sample size and the characteristics of the participants (e.g., high-functioning older adults), sarcopenia and sarcopenic obesity were considered as continuous measures or scores, standardized in Z values, using HGS, Chair-Stand test, SMM_{height}, SMM_{weight}, and fat mass percentage assessments. The following equation calculated sarcopenia score: $-1 * (Z\text{-HGS} + Z\text{-SMM}_{\text{height}}) / 2$, so that a higher score indicates higher levels of sarcopenia. On the other hand, the sarcopenic obesity score was calculated by this equation: $[-1 * ((Z\text{-HGS} + Z\text{-Chair-Stand test})/2 + Z\text{-SMM}_{\text{weight}}) + Z\text{-fat mass percentage}] / 3$, so that a higher score indicated higher levels of sarcopenic obesity (Huigueras-Fresnillo et al., 2020).

2.6. Covariates

Sex, age, and the highest educational level attained were registered with participants classified as low (i.e., illiterate or primary studies) or high (i.e., secondary studies, medium university studies or vocational training, or higher university studies) education. Tobacco and alcohol consumption were reported as current, former, or never consumed. Information on the following chronic conditions diagnosed by a physician and reported by the participants was also recorded: coronary heart disease, stroke, rheumatism, hip fracture, cancer at any site, Parkinson, and dementia/Alzheimer's. Responses were tabulated into two categories: having one or more than one chronic condition and not having any.

2.7. Statistical analyses

Descriptive characteristics of the study sample are presented as means (standard deviation (SD)) or percentages. Pearson correlations were used to assess the relationships between daily activities. Associations of physical activity intensities and sedentary behaviour with the study variables (sarcopenia and sarcopenic obesity) were examined using linear regression models. Furthermore, the associations between daily activities and the study variables were also examined using linear regression models.

Isotemporal substitution analyses were used to estimate the theoretical effect of replacing time in one daily activity for the same amount of time spent in another activity, while awake time was kept constant. Associations of daily activities with sarcopenia and sarcopenic obesity scores were reported for 30 min reallocated.

A mediation analysis was performed to study whether the associations of physical activity intensities and sedentary behaviour with the sarcopenia and sarcopenic obesity scores were mediated by body composition, that is, SMM and fat mass.

Four partition models were fitted with progressive adjustment for potential confounders. The first model was adjusted for age (years), sex, and wear time (i.e., the summation of the time spent in SB, LPA, MVPA, and sleep; h/day); the second model was further adjusted for educational level (low/high), tobacco and alcohol consumption (current/former/never), and chronic conditions (none/one or more); the third model was adjusted as model 2, plus the time (h/day) spent in MVPA for SB and LPA activities, and the time (h/day) spent in SB for MVPA activities; the final model (model 4) was further adjusted for time (h/day) spent in other activities within the same intensity category (e.g., among the SB category, the model for lying was additionally adjusted for the time spent in reclining and passive sitting). Associations were reported

as unstandardized regression coefficients with 95 % confidence intervals.

Except for the mediation analysis that was carried out with the PROCESS macro for SPSS (IBM Corporation, SPSS, Inc., Chicago, IL, USA), all analyses were performed using STATA version 15.1, setting the significance level at $p < 0.05$.

3. Results

The main characteristics of the study participants are presented in Table 1. Most individuals had high educational levels (60 %) and no chronic condition (59.50 %). Moreover, most participants never consumed tobacco (51 %) but currently consume alcohol (74 %). The mean wear time was 22.92 h/day, with 8.20 h/day sleep time. The most common daily activity was passive sitting (5.41 h/day), while time spent in other activities (i.e., step up, step down, run, and jump) was the less prevalent (0.07 h/day).

Bivariate correlations between daily activities ranged from -0.48 to 0.54 (Table 2). There is no significant association between total time spent in MVPA, LPA, or SB and sarcopenia. Nevertheless, sarcopenic obesity presents a negative association with total time spent in MVPA [β

Table 1
Descriptive statistics of study sample.

	All
<i>n</i>	200
Age, years (SD)	71.7 (4.96)
Sex, <i>n</i> (%)	
Women	121 (60.50)
Men	79 (39.50)
Educational level ^a , <i>n</i> (%)	
Low	80 (40)
High	120 (60)
Tobacco consumption, <i>n</i> (%)	
Current	9 (4.50)
Former	89 (44.50)
Never	102 (51)
Alcohol consumption, <i>n</i> (%)	
Current	148 (74)
Former	6 (3)
Never	46 (23)
Chronic conditions, <i>n</i> (%)	
None	119 (59.50)
One or more	81 (40.50)
Weight, kg (SD)	71.78 (13.20)
Height, cm (SD)	158.66 (8.97)
Sarcopenia, <i>n</i> (%)	22 (11)
Sarcopenic obesity, <i>n</i> (%)	48 (24)
IDEEA wear time, h/day (SD)	22.92 (2.05)
Sleep time, h/day (SD)	8.20 (1.70)
Sedentary behaviours, h/day (SD)	7.31 (1.81)
Lie	0.77 (0.92)
Recline	1.13 (1.18)
Passive sit	5.41 (1.87)
Light PA, h/day (SD)	6.56 (1.91)
Active sit	0.63 (0.41)
Stand	4.81 (1.65)
Walk at a slow pace ^b	0.74 (0.29)
Walk at an average pace ^c	0.39 (0.18)
MVPA, h/day (SD)	0.86 (0.61)
Walk at a brisk pace ^d	0.79 (0.58)
Other activities ^e	0.07 (0.10)

Values are mean (SD) or percentages.

IDEEA: Intelligent Device for Energy Expenditure and Activity.

PA: physical activity.

MVPA: moderate-to-vigorous PA.

^a Low: illiterate or primary studies; high: secondary studies, medium university studies or vocational training, or higher university studies.

^b Walk at 2 mph.

^c Walk at 2–2.49 mph.

^d Walk at ≥ 2.5 mph.

^e Other activities include step up, step down, run and jump.

Table 2

Bivariate correlations between pattern-recognition-measured daily activities.

Daily activities	1	2	3	4	5	6	7	8	9
1. Lie	1	-0,02	-0,10	-0,09	-0,15*	-0,11	-0,16*	-0,20**	-0,06
2. Recline		1	-0,48***	-0,06	0,04	0,08	-0,01	-0,14*	-0,06
3. Passive sit			1	0,04	-0,35***	-0,21**	-0,16*	0,03	0,05
4. Active sit				1	0,02	0,10	0,04	-0,19**	0,00
5. Stand					1	0,46***	0,19**	-0,10	0,06
6. Walk at slow pace ^a						1	0,54***	0,04	0,1*
7. Walk at average pace ^b							1	0,25***	0,10
8. Walk at brisk pace ^c								1	0,28***
9. Other activities ^d									1

^a Walk at 2 mph.^b Walk at 2–2.49 mph.^c Walk at ≥ 2.5 mph.^d Other activities include step up, step down, run and jump.* $p < 0.05$.** $p < 0.01$.*** $p < 0.001$.

(95%CI): $-0.29 (-0.41, -0.17)$] (Fig. 1). Independent associations of daily activities with sarcopenia and sarcopenic obesity are presented in Table 3. After adjustment for main covariates (model 2), time in recline was inversely associated with sarcopenia [β (95%CI): $-0.07 (-0.12, -0.02)$], while the time spent walking at an average pace was directly associated with sarcopenia [β (95%CI): $0.53 (0.23, 0.84)$]. On the other hand, the associations between time spent walking at a brisk pace and in other activities of moderate to vigorous intensity with sarcopenic obesity were significant [β (95%CI): $-0.27 (-0.40, -0.14)$ and $-1.48 (-2.16, -0.79)$ respectively].

The associations of physical activity intensities and sedentary behaviour with sarcopenia and sarcopenic obesity components are presented in supplementary table 1. After adjustment for main covariates (model 2), there was no significant association between MVPA, LPA, SB, and HGS or SMMi_{height}. However, total time spent in MVPA was associated to Chair-Stand test results, SMMi_{weight}, and fat mass percentage (Fig. 2). Furthermore, total time spent in LPA and SB was associated with SMMi_{weight}. The associations between daily activities and sarcopenia and sarcopenic obesity components are presented in supplementary table 1. Regarding sarcopenia components, only two isolated associations were significant after adjustment of main covariates (model 2): walk at an average pace/HGS [β (95%CI): $-6.45 (-10.31, -2.60)$] and recline/SMMi_{height} [β (95%CI): $0.17 (0.08, 0.26)$]. On the other hand, all moderate to vigorous activities presented significant associations with sarcopenic obesity components: walking at a brisk pace with Chair-Stand test results [β (95%CI): $1.15 (0.40, 1.91)$], SMMi_{weight} [β (95%CI): $1.45 (0.68, 2.22)$] and fat mass percentage [β (95%CI): $-2.63 (-4.12, -1.14)$]; other activities with Chair-Stand test results [β (95%CI): $4.65 (0.55, 8.75)$], SMMi_{weight} [β (95%CI): $8.59 (4.51, 12.67)$] and fat mass percentage [β (95%CI): $-13.98 (-21.96, -5.99)$].

Supplementary fig. 2 shows the isotemporal substitution models for

30 min time reallocation between main intensities categories. Replacing the time in SB and LPA by 30 min of MVPA results in a significant decrease in sarcopenic obesity score [β (95%CI): $-0.58 (-0.82, -0.33)$ and $-0.56 (-0.81, -0.31)$ respectively]. Specifically, replacing 30 min of lie, recline, passive sit, active sit, stand, walk at slow pace or walk at average pace with walk at brisk pace or others MVPA daily activities results in a decrease in this score (all $p < 0.01$) (Supplementary table 7). There is no significant association after reallocation between main intensities categories and sarcopenia score (Supplementary fig. 2). Furthermore, replacing 30 min of any daily activity with walk at average pace increases this score (all $p < 0.01$) (Supplementary table 6).

Supplementary fig. 3 shows simple mediation models of the associations between total time spent in pattern-recognition-measured moderate-to-vigorous physical activity intensity and sarcopenic obesity score, with body composition as independent mediator. The percentage of total effect mediated by SMMi_{weight} was 73 % and by fat mass was 46 %. The mediation role of body composition was not significant when the analysis was carried out between total time spent in pattern-recognition-measured physical activity intensities and sedentary behaviour with sarcopenia score nor between sedentary behaviour and sarcopenic obesity score.

4. Discussion

This study examined the associations of different pattern-recognition-measured daily activities with sarcopenia and sarcopenic obesity in a sample of older adults. Our results show that total time spent in MVPA is inversely associated with sarcopenic obesity, and specifically, daily activities such as walking at a brisk pace and others of moderate to vigorous intensity such as stepping up, stepping down, running, and jumping, were significantly associated with all sarcopenic obesity components (i.e., lower body physical performance,

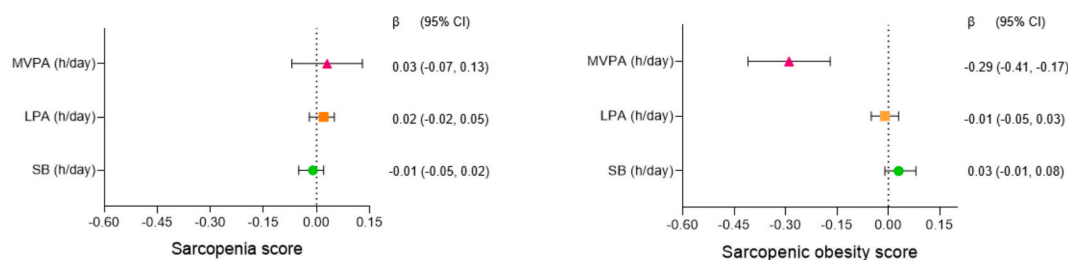


Fig. 1. Association between total time spent in pattern-recognition-measured physical activity intensities and sedentary behaviour with sarcopenia and sarcopenic obesity score. SB: sedentary behaviour; LPA: light physical activity; MVPA: moderate-to-vigorous physical activity. Values are unstandardized regression coefficients (95 % Confidence Interval) and obtained after adjustment for sex, age (years), wear time (hours/day), educational level (low/high), tobacco consume (current/former/never), alcohol consume (current/former/ never) and chronic conditions (none/one or more).

Table 3

Independent associations of pattern-recognition-measured daily activities with the sarcopenia and sarcopenic obesity scores.

	Model 1 (95 % CI)	Model 2 (95 % CI)	Model 3 (95 % CI)	Model 4 (95 % CI)
Sarcopenia (score)				
Lie	0.01 (−0.05, 0.07)	0.01 (−0.05, 0.07)	0.01 (−0.05, 0.08)	0.01 (−0.05, 0.08)
Recline	−0.07 (−0.12, −0.03) **	−0.07 (−0.12, −0.02) **	−0.07 (−0.12, −0.02) **	−0.07 (−0.13, −0.02) *
Passive sit	0.02 (−0.01, 0.05)	0.02 (−0.02, 0.05)	0.02 (−0.01, 0.05)	−0.00 (−0.04, 0.04)
Active sit	−0.11 (−0.24, 0.03)	−0.11 (−0.25, 0.03)	−0.10 (−0.25, 0.04)	−0.13 (−0.27, 0.01)
Stand	0.02 (−0.02, 0.05)	0.02 (−0.02, 0.05)	0.02 (−0.02, 0.06)	0.02 (−0.02, 0.06)
Walk at slow pace ^a	0.12 (−0.09, 0.32)	0.11 (−0.09, 0.32)	0.11 (−0.10, 0.31)	−0.14 (−0.40, 0.12)
Walk at average pace ^b	0.54 (0.23, 0.84) **	0.53 (0.23, 0.84) **	0.55 (0.23, 0.87) **	0.68 (0.30, 1.05) **
Walk at brisk pace ^c	0.02 (−0.08, 0.12)	0.03 (−0.07, 0.14)	0.03 (−0.08, 0.13)	0.03 (−0.08, 0.14)
Other activities ^d	−0.10 (−0.65, 0.45)	−0.06 (−0.61, 0.50)	−0.08 (−0.64, 0.48)	−0.11 (−0.68, 0.46)
Sarcopenic obesity (score)				
Lie	0.04 (−0.04, 0.12)	0.04 (−0.04, 0.12)	−0.01 (−0.09, 0.07)	−0.01 (−0.09, 0.07)
Recline	0.05 (−0.01, 0.12)	0.05 (−0.01, 0.12)	0.04 (−0.02, 0.11)	0.05 (−0.03, 0.12)
Passive sit	−0.00 (−0.05, 0.04)	−0.00 (−0.05, 0.04)	−0.01 (−0.05, 0.03)	0.01 (−0.04, 0.05)
Active sit	0.04 (−0.14, 0.22)	0.05 (−0.13, 0.24)	−0.05 (−0.23, 0.13)	−0.06 (−0.24, 0.12)
Stand	−0.03 (−0.07, 0.02)	−0.03 (−0.07, 0.02)	−0.03 (−0.07, 0.02)	−0.06 (−0.11, −0.01) *
Walk at slow pace ^a	0.16 (−0.11, 0.42)	0.16 (−0.10, 0.43)	0.24 (−0.02, 0.49)	0.36 (0.04, 0.69) *
Walk at average pace ^b	−0.03 (−0.44, 0.37)	−0.01 (−0.42, 0.41)	0.26 (−0.14, 0.67)	0.06 (−0.42, 0.53)
Walk at brisk pace ^c	−0.26 (−0.39, −0.14) ***	−0.27 (−0.40, −0.14) ***	−0.26 (−0.39, −0.13) ***	−0.22 (−0.35, −0.08) **
Other activities ^d	−1.44 (−2.12, −0.75) ***	−1.48 (−2.16, −0.79) ***	−1.43 (−2.13, −0.73) ***	−1.21 (−1.91, −0.52) **

Values are unstandardized regression coefficients (95 % Confidence Interval) model 1 was adjusted for sex, age (years), and wear time (hours/day); model 2 was adjusted as model 1, plus educational level (low/high), tobacco consume (current/former/never), alcohol consume (current/former/ never) and chronic conditions (none/one or more); model 3 was adjusted as model 2, plus time (hours/day) in moderate-to-vigorous physical activity for sedentary behaviours and light physical activities, and plus time (hours/day) in sedentary behaviours for moderate-to-vigorous physical activities; model 4 was adjusted as model 2, plus time in other activities within category.

^a Walk at 2 mph.

^b Walk at 2–2.49 mph.

^c Walk at ≥2.5 mph.

^d Other activities include step up, step down, run and jump.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

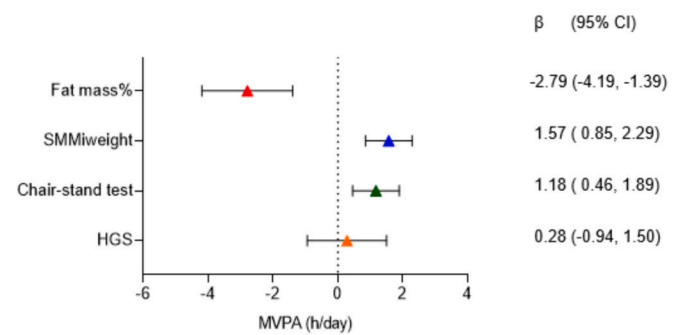


Fig. 2. Associations between sarcopenic obesity components and total time spent in pattern-recognition-measured moderate-to-vigorous physical activity intensity. Sarcopenic obesity components: Handgrip strength (HGS, in kg) and Chair-Stand test (number of movements in 30 s) for physical performance; Skeletal muscle index (SMMi_{weight} obtained from absolute skeletal muscle mass normalized for body weight) for muscle mass; percentage of total body weight for fat mass (Fat mass%). MVPA: moderate-to-vigorous physical activity (hours/day). Values are unstandardized regression coefficients (95 % Confidence Interval) and obtained after adjustment for sex, age (years), wear time (hours/day), educational level (low/high), tobacco consume (current/former/never), alcohol consume (current/former/ never) and chronic conditions (none/one or more).

SMMi_{weight}, and fat mass percentage), emphasizing the mediator role of SMMi_{weight} in this outcome. Total time spent in LPA did not influence sarcopenic obesity and only presented a direct, albeit weak, association with SMMi_{weight}. Total time spent in SB only showed one inverse association with SMMi_{weight}. No physical activity intensity or sedentary behaviour was related to sarcopenia or its components (i.e., HGS and SMMi_{weight}).

Foong et al. found that light, moderate, and vigorous physical activity is positively associated with lean mass percentage (stronger association with vigorous physical activity) and lower limb muscle strength, with also stronger associations with higher physical activity intensities (Foong et al., 2016). Besides, Westbury et al. showed that higher levels of physical activity were associated with less fat mass, body mass index, and weight (Westbury et al., 2018). Our data supports these previous cross-sectional studies with accelerometer-determined physical activity assessments, highlighting the effect of daily activities of moderate-to-vigorous intensity in sarcopenic obesity.

Growing evidence suggests that sarcopenic obesity is associated with a higher risk of disability, morbidity, and mortality than sarcopenia or obesity by itself (Koliaki et al., 2019; Verma et al., 2022). Sarcopenic obesity increases the anti-myogenic adipokines expression and pro-inflammatory agents that inhibit the anabolic actions of insulin-like growth factor IGF-1 (Zhuang et al., 2022) with a direct impact in muscle strength and endurance (Schoufour et al., 2021). However, improves in IGF-1 expression and in all sarcopenic obesity components have been shown with physical activity, according to a recent systematic review and meta-analysis focused on the effect of aerobic training (e.g., walking, dance, among others), resistance training (e.g., weight training equipment, elastic band, among others) and aerobic/resistance training combined in older people with sarcopenic obesity (Zhuang et al., 2022). In consequence, our data could have a clinical application. The promotion of daily physical activities of moderate-to-vigorous intensity, such as walk at brisk pace and go up and down stairs, could be an effective strategy to prevent negative outcomes of sarcopenic obesity. In a population who spent most of the time in SB, specifically around 65 to 80 % of their waking time (Wirth et al., 2017), to replace part of this behaviour for MVPA daily activities could have a positive impact in health maintenance. However, like older people require a comprehensive medical examination before engaging in new activities, is necessary to count with more randomized controlled trials and longitudinal studies to strength these recommendations, specially to those who do

not perform these types of activities.

According to our results, there is no association between time spent in physical activity and sarcopenia or its components. To generate a muscle mass and strength enhance is necessary to increase protein synthesis and it is possible with an appropriate mechanical stimulus provided for resistance exercises rather than aerobic exercises (Barclay et al., 2019), and daily activities captured with the mutisensor monitor were mostly aerobic based on ambulatory activities. Moreover, the lack of association between physical activity and muscle strength, could be explained considering that the activities recorded involved mainly lower limb muscles and we measured the grip strength to assess this variable, like the EWGSOP2 indicates (Cruz-Jentoft et al., 2019), and this is a task achieved by the forearm muscles. On the other hand, muscle mass was measured by bioelectrical impedance analysis (BIA) instead the gold standard tools for this purpose (Cruz-Jentoft et al., 2019), and that could be the reason why we did not find association between this variable and physical activity. In consequence, it is not possible to dismiss the effect that physical activity could have on sarcopenia components, instead, it could be interesting to study the possible association measuring muscle strength using isometric torque methods in lower limbs and assessing muscle mass with more accurately equipment like magnetic resonance imaging, computed tomography, or dual-energy X-ray absorptiometry (DXA) (Cruz-Jentoft et al., 2019; Scott et al., 2021; Sánchez-Sánchez et al., 2019; Foong et al., 2016).

Our results indicate that SB is not associated with sarcopenia. Mijndarendis et al. showed that sarcopenia diagnosis among older adults who do moderate to high amounts of MVPA, based on questionnaire assessments, is less likely than among those who do MVPA occasionally or never (Mijndarendis et al., 2016). Similar results were found by Scott et al. in 2021, indicating that the average time spent in accelerometer determined MVPA was lower in older adults with sarcopenia (Scott et al., 2021). Taken together, these findings suggest that reducing the time spent in sedentary behaviours in old age population might be not an effective strategy, unless this behaviour could be replaced by MVPA.

Although this study has strengths, some limitations must be acknowledged. Due to storage and battery life restrictions of the IDEEA device, daily activities were monitored only during 48 h, so it is feasible that variability in some behaviours was not completely captured (Zhang et al., 2003; de la Cámara et al., 2019). Even though magnetic resonance imaging and computed tomography are gold standards for non-invasive assessment of muscle quantity (Cruz-Jentoft et al., 2019), and DXA is the first choice for body composition assessments (Donini et al., 2022) in the study of sarcopenia and sarcopenic obesity respectively, we used BIA for this purpose because its equipment is affordable and portable to be used in a large sample of individuals. Despite the value of the appendicular portion of the SMM is important to know because its decrease is associated with disability (Sergi et al., 2015), we couldn't estimate it because the BIA equipment used in this study delivered a unique data about the whole-body resistance and not different data per body segments. It is also necessary to consider that the participants of this study were characterized as high-functioning, which directly influences the variables of body composition and physical performance so the percentage of sarcopenia and sarcopenic obesity differ from those previously reported in the older Spanish population (Diago-Galmés et al., 2023; Gomez-Cabello et al., 2011). Further, although the analyses were adjusted for several confounding variables, some potential confounders were not available (e.g., dietary patterns, recent weight loss, or medications). Finally, the cross-sectional design of our study does not allow establishing for causal relationships, and the sample was not representative, which limits the generalizability of results.

In conclusion, our results suggest that time spent in daily activities of moderate-to-vigorous intensity, such as walk at a brisk pace, step up, step down, run and jump, is negatively associated with sarcopenic obesity but not with sarcopenia. These findings support the promotion of daily activities of moderate-to-vigorous intensity for the sarcopenic obesity prevention in high-functioning community-dwelling older

adults, however, more longitudinal studies and randomized controlled trials are required to strength these postulates.

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CRedit authorship contribution statement

Julia Wiedmaier-Barros: Writing – original draft, Formal analysis. **Sara Higuera-Fresnillo:** Writing – review & editing, Data curation. **Kabir P. Sadarangani:** Writing – review & editing. **David Martínez-Gómez:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no competing interest.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.exger.2024.112511>.

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