

TITLE: Associations of sleep and depression with obesity and sarcopenia in middle-aged and older adults

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Abbreviations

BIA, Bioelectrical impedance analysis; BMI: Body Mass Index; EWGSOP2: European Working Group on Sarcopenia in Older People-2; HADS: Hospital Anxiety and Depression Scale; PSQI: Pittsburgh Sleep Quality Index; SM: Skeletal Muscle Mass; SMI: Skeletal Muscle Mass Index; SO: Sarcopenic Obesity; WC: Waist Circumference.

Abstract

Objectives: To analyze the association of depression and the quality and duration of sleep with general and abdominal obesity, sarcopenia, and sarcopenic obesity (SO) in Spanish middle-aged and older adults.

Study design and outcome measures: A total of 304 participants (72.04±7.88 years, 83.88% women) participated in this study. Body mass index, waist circumference, skeletal muscle mass index (bioelectrical impedance analysis), and hand-grip strength were used to evaluate sarcopenia, obesity, and SO. The Pittsburgh Sleep quality index was used for sleep quality. Sleep duration (hours) was categorized as either short (<6), normal (6-8), or long (>8). Depression was measured using the Hospital Anxiety and Depression Scale. Fatigue (Fatigue Severity Scale), nutritional status (Mini Nutritional Assessment survey) and physical activity (PA) level (International Physical Activity Questionnaire-Short Form) were also assessed. Independent associations were evaluated by multivariate logistic regressions.

Results: Only depression was associated with sarcopenia (OR=1.10, 95% CI=1.02-1.19). Poorer sleep quality (OR=1.06, 95% CI=1.06-1.11) and short sleep duration (OR=2.63, 95% CI=1.45-4.78) were related to general obesity, as well as fatigue and low PA level. Poor sleep latency (OR=1.43, 95% CI=1.09-1.87) was linked to abdominal obesity, along with fatigue, low PA level, older age, and female sex. Finally, short sleep duration (OR=5.25, 95% CI=1.97-14.00), together with fatigue, low PA level, and male sex were associated with OS.

Conclusion: Among Spanish middle-aged and older adults, after adjusting for potential confounding variables, depression was uniquely associated with sarcopenia, while short sleep duration was related to general and sarcopenic obesity, and poor sleep quality was linked to general and abdominal obesity.

Keywords: Sarcopenia; Obesity; Sarcopenic Obesity; Sleep quality; Sleep duration; Depression

1. Introduction

As the world's population ages, its associated functional changes are the source of considerable costs to health care systems. Sarcopenia is a progressive and generalized skeletal muscle disorder, associated with increased likelihood of adverse outcomes [1]. Sarcopenia is common among older adults and a recent systematic review and meta-analysis reported that, depending on the definition employed, estimates of sarcopenia may vary from 9.9 to 40.4% [2]. The European Working Group on Sarcopenia in Older People-2 (EWGSOP2) recently reported that low levels of measured muscle strength and muscle quantity/quality are, along with poor physical performance, the three parameters considered in the diagnosis of sarcopenia and its severity [3].

In addition, it is known that the prevalence of obesity increases with age. As one study indicates, the highest proportions of obesity were observed in people over 55 years of age (21.58% in men and 33.9% in women) [4]. The coexistence of sarcopenia and obesity is referred to as sarcopenic obesity (SO) [5], and both conditions might synergistically increase their health-related deleterious effects on, among others, cardiovascular diseases, metabolic disorders, and physical disability [6].

Sleep disorders, such as insomnia and poor sleep quality, are very common in older adults. Approximately 50% of older adults often have sleep problems in their daily lives. This not only influences the quality of life of older adults, but also puts them at greater risk of death [7]. Late-life depression is associated with increased risk of morbidity and mortality, and is perhaps the most frequent cause of emotional suffering in later life, as it significantly decreases the quality of life of older adults [8].

The objective of the present study was to analyze if the quality and duration of sleep are, as well as depression, independently associated with sarcopenia, obesity, and SO among community-dwelling Spanish middle-aged and older adults.

2. Methods

2.1 Study design and participants

For this analytical, cross-sectional study, 315 participants from Eastern Andalusia were initially contacted, of which 304 finally took part. Participants were recruited through several day centers for older adults in the Eastern Andalusia region. A flow diagram of the participants is presented in Figure 1. Data collection took place from November 2018 to February 2019. This study was approved by the Research Ethics

Committee of Jaén, Spain (NOV.18/2.TES). All participants provided written informed consent to participate in this study, which was conducted in accordance with the Declaration of Helsinki, good clinical practices, and all applicable laws and regulations.

Inclusion criteria were: age of 50 years and older, being ambulatory, community-dwelling, able to understand and complete the study-related questionnaires, and willing to give written informed consent to participate in the study. Participants were excluded if they had contraindications to bioelectrical impedance analysis (i.e. implanted medical devices), conditions that limit physical activity, and suffered from a chronic and/or severe medical disease or any neuropsychiatric disorder that could influence their responses to the questionnaires.

2.2 Study parameters

All participants were interviewed by experienced interviewers, who collected demographic, anthropometric, and clinical data such as age, marital, and occupational status, education level, and smoking habits.

Weight was assessed by a 100g-130kg precision digital weight scale (Tefal), and a T201-T4 Asimed adult height scale was used for height. Body mass index (BMI) was calculated by dividing the participants' weight (kg) by their height squared (m^2). A $BMI \geq 30 \text{ kg}/m^2$ indicated obesity [9]. A 1.5-meter flexible tape was used to obtain waist circumference (WC), with values $\geq 102\text{cm}$ in men and $\geq 88 \text{ cm}$ in women indicating abdominal obesity [9].

Muscle strength (hand-grip strength) was measured with a hand-grip dynamometer (TKK 5001, Grip-A, Takei, Tokyo, Japan). Participants were asked to apply their maximum grip strength three times with the dominant hand, with 30s resting intervals between measurements. Low muscle strength was defined as grip strength values of $< 16\text{kg}$ (women) and 27kg (men) [10].

Body composition was assessed by bioelectrical impedance analysis (BIA, InBody 720, Biospace Co., Ltd.; Seoul, Korea). Participants stood upright with their arms abducted apart from their trunk and legs slightly spread. Skeletal muscle mass (SM) was calculated using the BIA equation from a previous study: $[SM \text{ (kg)} = [0.401 \times (\text{height}^2 / \text{resistance}) + (3.825 \times \text{sex}) - (0.071 \times \text{age}) + 5.102]$, where height and resistance were assessed in cm and ohms respectively [11]. The sex was assigned a value of zero for women and one for men. The height-adjusted skeletal muscle mass index (SMI) was calculated by dividing height by meters squared (kg/m^2), and a cut-off point

for low muscle mass was set at 6.42 and 8.87 kg/m² for women and men respectively [12].

According to the operational definition recently proposed by the EWGSOP2 [3], a diagnosis of sarcopenia is confirmed by the presence of low muscle strength together with low SMI according to the cut-off points specified earlier. Sarcopenic obesity was defined as the presence of sarcopenia together with a BMI \geq 30 kg/m².

The Hospital Anxiety and Depression Scale (HADS) [13,14], was used to assess depression symptoms. This scale includes 14 items (7 concerning anxiety and 7 depression). The scoring of each item ranges from 0 (no distress) to 3 (most distress). The total HADS depression score ranges from 0 to 21.

The Pittsburgh Sleep Quality Index (PSQI) was employed to evaluate sleep quality [15,16]. It consists of 19 self-rated questions and 5 more to be answered by bedmates or roommates (these last ones are only employed for clinical purposes). This tool provides a total score and seven domains or subscales: 1) subjective sleep quality, 2) sleep latency, 3) sleep duration, 4) habitual sleep efficiency, 5) sleep disturbance, 6) use of sleeping medication, and 7) daytime dysfunction. Higher scores represent poorer subjective sleep quality. The number of hours of sleep was obtained with PSQI item 4 and sleep duration was categorized as <6 h (short sleep duration), 6–8 h (normal sleep duration), and \geq 8 h (long sleep duration) [17].

Fatigue severity during the previous week was assessed by the Fatigue Severity Scale [18]. This questionnaire has 9 items whose responses are graded using a Likert scale (1-7), and produces a total score where higher values imply greater fatigue.

The Mini Nutritional Assessment [19,20] survey was used to assess nutritional status. This tool contains 18 questions that covers covering anthropometric measures, health status, dietary patterns, and subjective assessments of nutritional and health status. Higher scores indicate better nutritional status.

Finally, in order to assess physical activity (PA) level, the International Physical Activity Questionnaire-Short Form was used [21,22]. Total moderate to vigorous physical activity (in min/day) was calculated by combining the activity score of both moderate and vigorous intensity activity for each work and recreational activity domain. Responses were converted to Metabolic Equivalent Task minutes per week (MET-min/week) according to the scoring protocol, and participants were thus divided into three categories: high, moderate, and low physical activity level

2.3. Sample size calculation

For sample size calculation at least 10 participants per variable were required in the logistic regression model [23], given that we employed 12 possible predicting variables linked to sleep quality (7 domains and the total score of the PSQI), sleep duration (3 categories), and depression, in addition to 7 covariables (sex, age, 3 categories of physical activity level, nutritional status, and fatigue), over 190 subjects were required for the purposes of our analysis. The final number of participants was 304.

2.4. Statistical analysis

Continuous variables were described using means and standard deviations, whereas categorical variables were described using frequencies and percentages. Variable normality was analyzed using the Kolmogorov-Smirnov test. In order to explore possible differences in sleep quality, anxiety and depression regarding the presence or absence of sarcopenia, both general and abdominal obesity, and SO, Student's t-test and the chi-square test were used. Multivariate logistic regression models were used to analyze independent associations. The presence or absence of sarcopenia, general and abdominal obesity, and SO were individually introduced as dependent variables in separate models. The domains and total score of the PSQI, as well as depression and anxiety HADS scores, were input as independent variables, whereas sex, age, physical activity level, nutritional status, and fatigue were entered as covariables. Those variables with significant individual associations ($p < 0.05$) were selected for the stepwise logistic regression model. The odds ratio (OR) can be considered as significant when the 95% confidence interval (CI) does not include 1.00. Chi-square and Hosmer–Lemeshow tests were conducted to assess the overall goodness-of-fit of each of the steps of the model, as well as the final model. A 95% confidence level was used ($p < 0.05$). Data management and analysis were carried out using the SPSS statistical package for the social sciences for Windows (SPSS Inc., Chicago, IL, USA).

3. Results

Descriptive data of the sample group are presented in Table 1. In all, 304 participants (83.88% women) completed all assessments, of whom 46.38% had primary education or less, 51.64% were married or living as a couple, and 75% were retired. Of all participants, 23.68% had sarcopenia. Percentages for general, abdominal, and sarcopenic obesity were 38.82%, 73.68%, and 5.59% respectively. Data regarding BMI,

WC, hand-grip strength, sleep quality and duration, depression, PA level, nutritional status, and fatigue are also displayed in Table 1.

When analyzing both general and abdominal obesity (Table 2), our results showed individual associations of general obesity with PSQI domain numbers 2, 5, 7, and total score, sleep time, depression, PA level, and fatigue. Abdominal obesity was related to domains 2, 3, 5, and 7 of the PSQI and its total score, as well as to PA level, age, fatigue, and female sex. As for sarcopenia (Table 3), only depression and fatigue were individually related, whereas regarding SO (Table 3), individual associations with sleep duration, depression, fatigue, low level of physical activity, and male sex were observed.

As for independent associations with sarcopenia, the logistic regression model (Table 4) showed that only a higher level of depression symptoms remained as an independent predictor (OR=1.10, 95% CI=1.02-1.19). Adequacy of the multivariate logistic regression model was demonstrated by the Hosmer-Lemeshow goodness-of-fit test (Chi-square of 3.395, $p = 0.907$), and the model as a whole correctly classified 76.32% of all cases of sarcopenia.

With respect to SO (Table 4), short sleep duration (OR=5.25, 95% CI=1.97-14.00), greater fatigue (OR=1.04, 95% CI=1.01-1.07), low PA level (OR=4.039, 95% CI=1.68-11.49), and male sex (OR=0.21, 95% CI=0.07-0.61) were independently associated with this condition. The Hosmer-Lemeshow test showed adequacy (Chi-square=2.138 $p=0.952$), and 92.05% of all cases were accurately classified by this model.

Finally, regarding the different types of obesity (Table 4), the multivariate logistic regression analysis revealed several significant results. General obesity was independently associated with poorer sleep quality as assessed by PSQI total score (OR=1.06, 95% CI=1.06-1.11), short sleep duration (OR=2.63, 95% CI=1.45-4.78), as well as with greater fatigue (OR=1.03, 95% CI=1.01- 1.04) and low PA level (OR=2.25, 95% CI=1.29-3.79). The Hosmer-Lemeshow test showed the good fitness of the model (Chi-square = 6.703, $p = 0.569$). On the other hand, poorer sleep quality assessed by sleep latency domain of the PSQI (OR=1.43, 95% CI=1.09-1.87), fatigue (OR=1.03, 95% CI=1.01-1.05), low PA level (OR=2.48, 95% CI=1.30-4.71), older age (OR=1.05, 95% CI=1.01-1.09), and female sex (OR=0.310, 95% CI=1.52-6.29) were independent predictors of abdominal obesity. The Hosmer-Lemeshow test revealed that this model is appropriate (Chi-square=3.650, $p = 0.887$). These two models correctly classified 67.44% and 76.08% of all cases of general obesity and abdominal obesity respectively.

4. Discussion

The aim of the present study was to determine if sleep quality, depression, and anxiety could be independently associated with sarcopenia, obesity, and SO in a population of community-dwelling Spanish middle-aged and older adults. Our results showed that, after adjusting for potential confounding variables, depression was only associated with sarcopenia, while short sleep duration was related to general and sarcopenic obesity, and sleep quality was linked to general and abdominal obesity.

A bidirectional relationship between sleep duration and body composition has been proposed, as sleep interruptions or disordered sleep appear to contribute to the increase of body adiposity or vice versa [24]. Compared to younger age groups there is a relative scarcity of research on sleep and obesity in older adults, and most of these studies have focused on sleep duration. Chaput et al. [25] described that short sleep duration does not predict an increased risk of being overweight or obese in older women, and Grandner et al. [26] reported that more sleep is associated with lower BMI in young adults, although such association weakens in older people. On the other hand, it has been shown that both short and long sleep durations are associated with obesity or higher BMI [17], which is partly in accordance with our results, given that only short but not long sleep duration was significantly associated with general obesity. As for sleep quality, the number of studies analyzing the associations with anthropometric measurements is limited, and as with sleep duration, previous studies have shown different results. Öztürk et al. [27] did not find any relationship between sleep quality and BMI and WC in women aged 20-55 years, whereas poor sleep quality was found to be an independent risk factor for obesity in community-dwelling Japanese older adults (>80 years) [28]. Our findings are consistent with these latter findings and indicate that poor global sleep quality is independently associated with general obesity. Among the potential mechanisms underlying this association the endocrine and metabolic consequences associated with restricted sleep should be considered, of which increases in insulin resistance and night cortisol and ghrelin levels are an example. Similarly, leptin levels decrease, and these are known to influence food intake regulation [29, 30].

With respect to abdominal obesity, López-García et al. [31] did not observe any association between sleep duration and abdominal obesity in Spanish older adults (≥ 60 years) while Patel et al. [32] reported that short sleep was also associated with central body fat distribution. A recent study showed negative associations between sleep duration and WC, whereas sleep quality was negatively related to both BMI and WC in women

but not in men (≥ 65 years) [33]. Our results revealed an independent association between abdominal obesity and poor sleep quality (sleep latency), but not with sleep duration. This is in accordance to the findings of Rahe et al. [34], who reported that sleep quality assessed with PSQI was associated with abdominal obesity in an age and sex-adjusted model. Several potential factors may explain the inconsistent results found throughout the literature regarding the association between sleep and obesity, among which we may cite the choice of measurement methods and a variety of adjustments made for confounding variables. In this study, general obesity was related to both fatigue and low physical activity level, which were also found to be associated with abdominal obesity along with female sex and older age.

The association between sleep problems and sarcopenia has been studied, although the exact mechanisms that explain this association still remain unclear. The role of several factors such as insulin resistance or hormones (such as insulin-like growth factors-1, growth hormone, or cortisol) have been proposed [35]. Previous studies have shown inconsistent results regarding sleep duration. Some authors described that long sleep duration (9 hours or longer) [36] or short and long sleep time were linked with sarcopenia [17]. On the other hand, Lucassen et al. [37] failed to find any relationship with sleep duration in middle aged and older adults, but reported an association regarding sleep quality, and this relationship was strongest in women. In this study, we could not find an association between sleep duration or quality and sarcopenia, but our results indicated that a sleep time <6 hours was independently related to SO. With regards to this, a recent study [38] reported that SO was associated with sleep conditions such as obstructive sleep apnea and nocturnal hypoxia (which was also related to obesity alone), but no exclusive association between poor sleep/sleep disorders and sarcopenia was reported. Such discrepancies may be due to the use of disparate criteria for the definition of sarcopenia and to the varying instruments used to measure muscle mass (i.e. BIA or Dual X-ray Absorptiometry).

Depression is perhaps the most frequent mental disorder in later life [39]. When studying its association with obesity, a possible bidirectional relation has been suggested, although Mannan et al. [40] described that depression and obesity were associated, that depression seemed to have a larger influence on obesity when the causal direction was considered. In the present study we failed to find any association between depression and obesity, although this may be explained by the fact that our HADS values are all in the normal range [13]. The evidence available regarding the relationship between sarcopenia

and depression shows that there is an association between both variables [41, 42]. Our results are in agreement with these observations, as a higher HADS-depression score was associated with sarcopenia (the only factor). On the other hand, Patino-Hernandez et al [43] reported that sarcopenia was not related to depression or fatigue. However, in their study muscle mass was assessed by calf circumference and EWGSOP1 criteria [44] were used to define sarcopenia. This may explain the differences, given that the EWGSOP2 algorithm and thresholds may decrease the prevalence of sarcopenia compared with EWGSOP1 criteria [45].

Some limitations of this study should be acknowledged. First, the cross-sectional design of this study did not allow us to evaluate causal relations. Secondly, sleep quality and duration were assessed by self-reported methods, so recall bias is a concern. Thirdly, this study was conducted on people from a specific geographical area, and any generalization of its results should be limited to individuals with similar characteristics to those of our sample population. Lastly, we did not screen for the presence of sleep conditions such as obstructive sleep apnea or the use of menopause hormone therapy or diabetes medication, which have been shown to have effects on sleep. Future studies should explore research designs that account for conditions and medications known to affect sleep, employ objective methods of sleep quality assessment (polysomnography or actigraphy), and apply them to a general population of older adults.

In conclusion, our results reveal that, after adjusting for potential confounding variables, poor sleep quality was associated with general and abdominal obesity, short sleep duration was related to both sarcopenic and general obesity, and depression was only linked to the presence of sarcopenia in community-dwelling middle-aged and older adults. These results allow us to suggest that strategies aimed at improving sleep duration and quality, as well as addressing depression, may contribute to preventing sarcopenia, obesity, and sarcopenic obesity.

Contributors

Raquel Fábrega-Cuadros participated in the study concept and design, data acquisition, interpretation of analyses, and preparation of the manuscript. David Cruz-Díaz participated in the study design, preparation of the manuscript and critical revision of its content. Antonio Martínez-Amat participated in the study concept, interpretation of analyses, and critical revision of the paper. Agustín Aibar-Almazán participated in data

acquisition, interpretation of analyses, and critical revision of the paper. María Teresa Redecillas-Peiró participated in data analysis and critical revision of the paper. Fidel Hita-Contreras participated in the study design and concept, interpretation of analyses, preparation of the manuscript and critical revision of the paper. All authors approved the final manuscript.

Conflict of Interest

The authors have no conflicts of interest to declare.

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Data statement

The data that has been used is confidential. Due to the sensitive nature of the questions asked in this study, survey respondents were assured raw data would remain confidential and would not be shared.

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Figure 1. Flow diagram of the study participants.

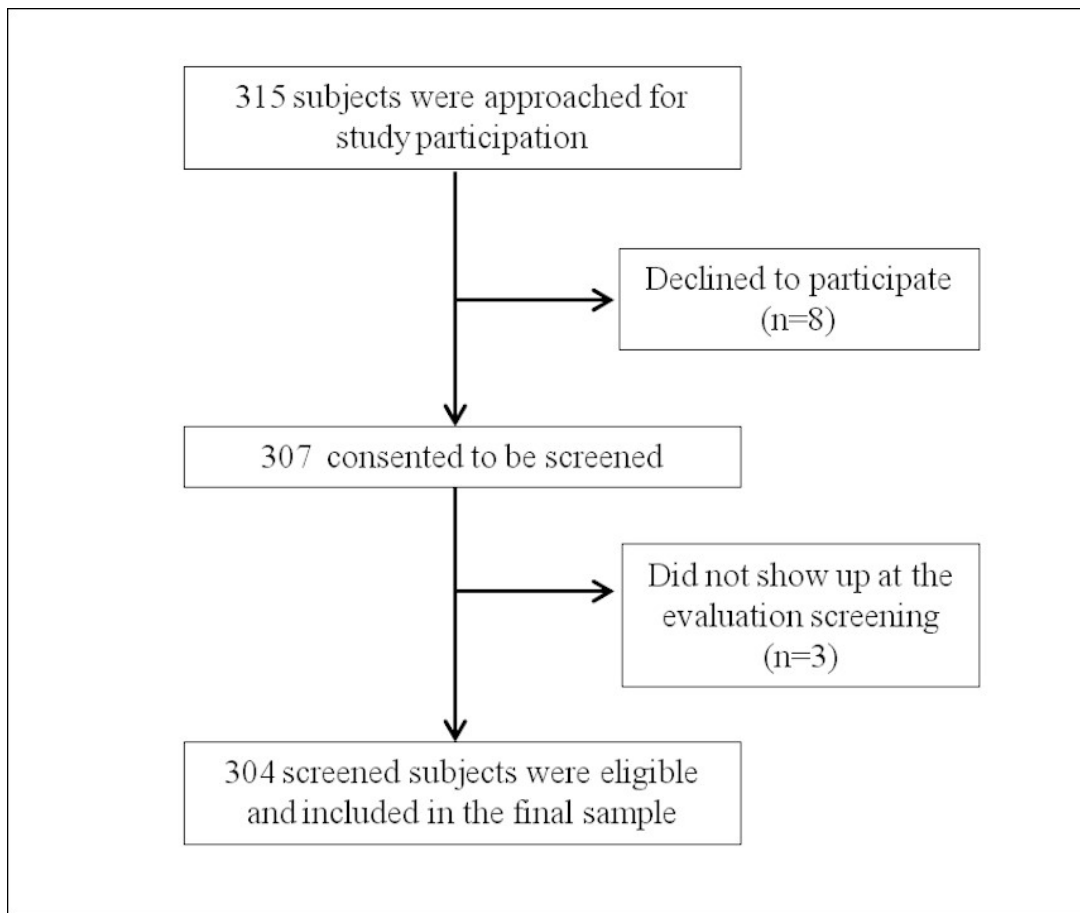


Table 1. Descriptive data of the sample.

Study sample = 304		
Age, mean (SD), y		72.04 ± 7.88
Sex	Male	49 (16.12%)
	Female	255 (83.88%)
Occupational status, n (%)	Retired	228 (75.00%)
	Working	33 (10.86%)
	Unemployed	43 (14.14%)
Marital status, n (%)	Single	21 (6.91%)
	Married/cohabiting	157 (51.64%)
	Separated/divorced/Widowed	126 (41.45%)
Educational status, n (%)	No formal education	42 (13.82%)
	Primary education	146 (48.03%)
	Secondary education	86 (28.29%)
	University	30 (9.87%)
Smoker, n (%)	No	284 (93.42%)
	Yes	20 (6.58%)
Depression, mean (SD)		4.99 ± 3.44
BMI, mean (SD)		29.14± 4.12
WC, mean (SD)		97.25± 10.84
Hand-grip strength, mean (SD)		19.43± 6.42
SMI, mean (SD)		7.81± 3.94
PSQI, mean (SD)	Sleep quality domain	1.01 ± 0.82
	Sleep latency domain	1.18 ± 1.09
	Sleep duration domain	1.00 ± 0.97
	Sleep efficiency domain	0.95 ± 1.10
	Sleep disturbances domain	1.23 ± 0.58
	Use of sleeping medication domain	1.01 ± 1.34
	Daytime dysfunction domain	0.49 ± 0.63
	Total score	6.87 ± 4.70
Sleep duration, mean (SD), hours		6.73 ± 1.41
Sleep duration, n (%)	Short	63 (20.72)
	Normal	208 (68.42)
	Long	33 (10.86)
Physical activity level, n (%)	Low	101 (33.44%)
	Medium	141 (46.69%)
	High	60 (19.87%)
Nutritional status, mean (SD)		26.31 ± 2.08
Fatigue, mean (SD)		21.33 ± 15.25

PSQI: Pittsburgh Sleep Quality index. SD: Standard deviation. BMI: Body Mass Index. WC: Waist Circumference. SMI: skeletal muscle mass index.

Table 2. Individual differences regarding general and abdominal obesity.

		General obesity			Abdominal obesity		
		No (n=186)	Yes (n=118)	P-value	No (n=80)	Yes (n=224)	p-value
PSQI domains, mean (SD)	1. Sleep quality	0.96 ± 0.80	1.10 ± 0.84	0.132	0.94 ± 0.77	1.04 ± 0.83	0.335
	2. Sleep latency	1.08 ± 1.05	1.35 ± 1.12	0.033	0.93 ± 1.00	1.27 ± 1.10	0.011
	3. Sleep duration	0.88 ± 0.92	1.19 ± 1.01	0.005	0.80 ± 0.83	1.07 ± 1.00	0.019
	4. Sleep efficiency	0.88 ± 1.05	1.08 ± 1.18	0.123	0.76 ± 1.01	1.02 ± 1.13	0.070
	5. Sleep disturbances	1.17 ± 0.55	1.32 ± 0.61	0.032	1.15 ± 0.60	1.26 ± 0.57	0.150
	6. Use of sleeping medication	0.96 ± 1.33	1.08 ± 1.35	0.470	0.81 ± 1.24	1.08 ± 1.37	0.115
	7. Daytime dysfunction	0.42 ± 0.59	0.60 ± 0.68	0.019	0.35 ± 0.51	0.54 ± 0.66	0.008
PSQI total score, mean (SD)		6.34 ± 4.38	7.71 ± 5.08	0.016	5.74 ± 4.13	7.28 ± 4.84	0.012
Sleep duration, n (%)	Short	27 (14.52%)	36 (30.51%)	0.003	15 (18.75%)	48 (21.43%)	0.817
	Normal	139 (74.73%)	69 (58.47%)		57 (71.25%)	151 (67.41%)	
	Long	20 (10.75%)	13 (11.02%)		8 (10.00%)	25 (11.16%)	
Anxiety, mean (SD)		5.46 ± 3.91	6.10 ± 4.22	0.175	5.13 ± 4.15	5.92 ± 3.98	0.133
Depression, mean (SD)		4.56 ± 3.15	5.66 ± 3.77	0.006	4.49 ± 3.16	5.17 ± 3.52	0.131
Physical activity level, n (%)	Low	90 (31.58%)	11 (64.71%)	0.009	17 (21.52%)	84 (37.67%)	0.029
	Medium	135 (47.37%)	6 (35.29%)		42 (53.16%)	99 (44.39%)	
	High	60 (21.05%)	0 (0.00%)		20 (25.32%)	40 (17.94%)	
Nutritional status, mean (SD)		26.45 ± 2.04	26.10 ± 2.12	0.154	26.22 ± 2.21	26.34 ± 2.03	0.645
Fatigue, mean (SD)		19.10 ± 14.22	24.86 ± 16.19	0.002	17.08 ± 13.28	22.85 ± 15.64	0.002
Age, mean (SD), years		71.61 ± 7.69	72.72 ± 8.17	0.233	70.53 ± 7.56	72.58 ± 7.94	0.045
Sex, n (%)	Male	33 (17.74%)	16 (13.56%)	0.424	20 (25.00%)	29 (12.95%)	0.020
	Female	153 (82.26%)	102 (86.44%)		60 (75.00%)	195 (87.05%)	

PSQI: Pittsburgh Sleep Quality index. SD: Standard deviation.

Table 3. Individual differences regarding sarcopenia and sarcopenic obesity.

		Sarcopenia			Sarcopenic obesity		
		No (n=232)	Yes (n=72)	P-value	No (n=281)	Yes (n=23)	p-value
PSQI domains, mean (SD)	1. Sleep quality	1.02 ± 0.79	1.00 ± 0.89	0.876	1.00 ± 0.81	1.22 ± 0.90	0.213
	2. Sleep latency	1.21 ± 1.06	1.10 ± 1.18	0.455	1.18 ± 1.07	1.22 ± 1.28	0.867
	3. Sleep duration	1.01 ± 0.99	0.97 ± 0.90	0.781	1.00 ± 0.97	1.04 ± 0.93	0.823
	4. Sleep efficiency	0.95 ± 1.11	0.96 ± 1.07	0.969	0.95 ± 1.10	1.00 ± 1.17	0.835
	5. Sleep disturbances	1.24 ± 0.57	1.19 ± 0.62	0.549	1.22 ± 0.58	1.39 ± 0.58	0.166
	6 Use of sleeping medication	1.05 ± 1.35	0.88 ± 1.29	0.340	1.01 ± 1.34	1.00 ± 1.28	0.980
	7. Daytime dysfunction	0.49±0.62	0.51 ± 0.65	0.816	0.48 ± 0.63	0.61 ± 0.58	0.355
PSQI total score		6.96 ±4.61	6.60 ± 5.01	0.572	6.82 ± 4.67	7.48 ± 5.20	0.521
Sleep time, n (%)	Short sleepers	44 (18.97%)	19 (26.39%)	0.395	52 (18.51%)	11 (47.83%)	0.003
	Normal sleepers	162 (69.83%)	46 (63.89%)		197 (70.11%)	11 (47.83%)	
	Long sleepers	26 (11.20%)	7 (9.72%)		32 (11.39%)	1 (4.35%)	
Anxiety, mean (SD)		5.59 ± 3.94	6.24 ± 4.24	0.231	5.73 ± 3.99	5.87 ± 4.41	0.873
Depression, mean (SD)		4.71 ± 3.28	5.89 ± 3.81	0.011	4.85 ± 3.31	6.70 ± 4.49	0.013
Physical activity level, n (%)	Low	70 (30.30%)	31 (43.66%)	0.088	87 (31.18%)	14 (60.87%)	0.004
	Medium	111 (48.05%)	30 (42.25%)		132 (47.31%)	9 (39.13%)	
	High	50 (21.65%)	10 (14.08%)		60 (21.51%)	0 (0.00%)	
Nutritional status, mean (SD)		26.38 ± 2.03	26.10 ± 2.22	0.319	26.32 ± 2.06	26.17 ± 2.29	0.743
Fatigue, mean (SD)		20,60 ± 14,86	24.81 ± 16.06	0.027	20.60 ± 14.90	30.22 ± 16.94	0.004
Age, mean (SD), years		71.59 ± 7.78	73.51 ± 8.08	0.070	71.89 ± 7.94	73.97 ± 7.05	0.248
Sex, n (%)	Male	34 (14.66%)	15 (20.83%)	0.213	41 (14.59%)	8 (34.78%)	0.011
	Female	198 (85.34%)	57 (79.17%)		240 (85.41%)	15 (65.22%)	

PSQI: Pittsburgh Sleep Quality index. SD: Standard deviation.

Table 4. Multivariate logistic regression analyses for factors associated with the different levels of obesity, sarcopenia and sarcopenic obesity.

		OR	95% CI	p-value
General obesity	PSQI total score	1.06	1.06-1.11	0.044
	Short sleep duration	2.63	1.45-4.78	0.001
	Fatigue	1.03	1.01-1.04	0.002
	Low physical activity level	2.25	1.39-3.79	0.002
Abdominal obesity	PSQI Sleep latency	1.43	1.09-1.87	0.010
	Fatigue	1.03	1.01-1.05	0.004
	Low physical activity level	2.48	1.30-4.71	0.006
	Age	1.05	1.01-1.09	0.012
	Sex	3.10	1.52-6.29	0.002
Sarcopenia	Depression	1.10	1.02-1.19	0.012
Sarcopenic obesity	Short sleep duration	5.25	1.97-14.00	0.001
	Fatigue	1.04	1.01-1.07	0.004
	Low physical activity level	4.39	1.68-11.49	0.003
	Sex	0.21	0.07-0.61	0.004

OR: odds ratio. CI: confidence interval.