Anthropological Review • Vol. 86(1), 51–66 (2023)

ANTHROPOLOGICAL REVIEW

Available online at: https://doi.org/10.18778/1898-6773.86.1.05

Sarcopenia: prevalence and its main risk factors in older women

Aleksandra Bogucka[1], *Anna Kopiczko*[1], *Jadwiga Charzewska*[2]

[1] Department of Human Biology, Faculty of Physical Education, Józef Piłsudski University of Physical Education in Warsaw, Poland

[2] Department of Nutrition and Nutritive Value of Foods, National Institute of Public Health NIH – National Research Institute Warsaw, Poland

ABSTRACT: *Introduction:* Sarcopenia is a major public health concern. It is defined as a progressive and generalized skeletal muscle disorder that is associated with an increased likelihood of falls, fractures, physical disability, and ultimately, premature death.

Objective: The aim of the study was to assess the prevalence and determine the role of physical activity, nutrient intake, and selected risk factors for the development of sarcopenia in older women.

Methods: The study involved 302 women aged ≥65 years (mean age: 72.1± 5.9 years). Bioelectrical impedance analysis of body composition, static muscle strength measurements, Timed Up and Go test, and the assessment of current physical activity using accelerometers were performed. Diets were assessed using the 24-h recall method from two non-consecutive days. The energy and nutrient content of diets was calculated using the computer program DIETA 6.

Results: Sarcopenia was present in 28.8% of the women studied. The most important factor in the decrease in the risk of sarcopenia was protein intake ≥ 0.9 g/kg b.m. (OR=0.08;p<0.001), and physical activity ≥ 4000 steps/day. However, these results were not statistically significant (OR=0.58; p=0.08). Furthermore, the risk of developing sarcopenia increased as BMI (OR=1.36; p<0.001) or percent of body fat (OR=1.29; p<0.001) increased.

Discussion: Implementing sarcopenia risk prevention programs should be a priority in preventing this condition.

KEY WORDS: sarcopenia, muscle disease, muscle failure, protein intake, physical activity, body mass index, body fat.

Original article

Received: 8.12.2022; Revised: 28.02.2023; Accepted: 6.03.2023

Introduction

Sarcopenia is a major public health concern. In 1988, Irwin Rosenberg proposed that the term sarcopenia be used to describe the major changes in body composition and function associated with aging. It is defined as a progressive and generalized skeletal muscle disorder that is associated with an increased likelihood of falls, fractures, physical disability, and ultimately, death (Cruz-Jentoft et al. 2019; Chen et al. 2020). It is characterized by progressive muscle failure (Zanker et al. 2019), increased risk of falls and fractures (Schaap et al. 2018; Yeung et al. 2019), and worse functional capacity in older adults (Malmstrom et al. 2016). Ultimately, it leads to reduced quality and length of life (Anker, Morley and von Haehing 2016; Beaudart et al. 2017; Tanaka et al. 2021).

The term sarcopenia is primarily defined as a low level of muscle mass. However, its definition is often broadened to include the underlying cellular processes involved in skeletal muscle loss as well as their clinical manifestations. In terms of the clinical aspect, sarcopenia is often used to describe both a set of cellular processes (denervation, mitochondrial dysfunction, inflammatory and hormonal changes) and a set of outcomes, such as decreased muscle strength, decreased mobility and function, increased fatigue, increased risk of metabolic disorders, and increased risk of falls and skeletal fractures (Lang et al. 2010).

Numerous studies have shown that sarcopenia is a strong determinant in the development of many other diseases, such as metabolic syndrome, cardiovascular disease, and osteoporosis (Karakelides and Nair 2005; Miyakoshin et al. 2013; Pacifico et al. 2020). For several years, sarcopenia has been recognized as a muscle disease and is numbered in the ICD-10-MC international classification of diseases (Anker, Morley and von Haehing 2016; Cruz-Jentoft et al. 2019).

Sarcopenia is known to be more prevalent in older populations. However, the decline in muscle mass starts from 40 years old. In addition to older-aged adults, underweight people, women, and people with other chronic conditions are more likely to develop sarcopenia and adverse health outcomes associated with this disease. Research has shown that the prevalence of sarcopenia is significantly higher in females than in males (Petermann-Rocha et al. 2022).

Comparability of data on the prevalence of sarcopenia worldwide is ensured by a widely accepted definition, designated cut-off points, and consensus guidelines for the population (Cruz-Jentoft et al. 2019; Chen et al. 2020). It is estimated that the problem of sarcopenia may affect several to tens of percent of the world's older adult population (Cruz-Jentoft et al. 2019).

A meta-analysis of two international studies, Collaborative Research on Aging in Europe and the SAGE study of the World Health Organization, showed that among 18,363 people over 65 years of age, on average, sarcopenia was diagnosed in 15.2% of participants (Tyrovolas et al. 2016). The highest prevalence of sarcopenia in that study was in India (17.7%) and the lowest was in Poland (12.6%) (Tyrovolas et al. 2016).

A study of 542 randomly selected Singaporeans over 60 years of age showed that sarcopenia was present in 32.2% of participants, with 33.7% of men and 30.9% of women (Pang et al. 2021). In China, the prevalence of sarcopenia in people over 50 years of age is 19.31%

(Liu et al. 2020). Furthermore, in South Korea, the prevalence of this problem in a group of 82,221 individuals over 50 years of age was estimated to be 21.5% (Cho et al. 2020).

A recent systematic review and meta-analysis performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) analyzed studies published between 2019 and 2020. The review included 207 cross-sectional studies and 53 cohort studies, with 3 using both designs. The overall prevalence of sarcopenia ranged from 0.2% to 86.5% according to the classification used (0.3–91.2% in women and 0.4–87.7% in men). Severe sarcopenia was estimated only in 34 studies, with prevalence ranging from 0.2% to 45.0% in women and from 0.2% to 17.1% in men (overall prevalence range: 0.2–34.4%) (Petermann-Rocha et al. 2022).

A meta-analysis conducted by Pacifico et al. (2020) showed an increased prevalence of sarcopenia among men and women diagnosed with various chronic diseases. Among 17,206 participants aged 65±1.6 years, the prevalence of sarcopenia was 31.4% in those with cardiovascular diseases, 26.4% with dementia, 31.1% with diabetes, and 26.8% with respiratory diseases. The meta-analysis showed highly prevalent sarcopenia in individuals with multiple system diseases (Pacifico et al. 2020). Basing on the prospective cohort study of medical inpatients, not only diseases related to malnutrition but especially sarcopenia was associated with poor quality of life, more readmissions, and higher mortality (Ballesteros-Pomar et al. 2021).

The different prevalence of sarcopenia in the world may be due to the different severity of the main risk factors involved in the development of this condition, such as general physical fitness, the level of habitual daily physical activity, different diets, and different population-specific factors. The factors that contribute to the development of sarcopenia in older populations are chronic inflammation, motoneuron atrophy, reduced protein intake, and immobility (Malafarina et al. 2012). Adequate protein intake is important for maintaining muscle mass during aging, although the amount and source of protein necessary for optimal prevention of sarcopenia remains to be determined. One study showed that increasing the proportion of plant-derived at the expense of animal-derived proteins in diet is beneficially linked to lower sarcopenia risk in a cross-cultural sample of older European adults (Montiel-Rojas et al. 2020).

Previous studies suggested that protein synthesis and degradation, autophagy, impaired satellite cell activation, mitochondrial dysfunction, and other factors associated with muscle weakness and muscle degeneration may be potential molecular pathophysiology of sarcopenia. Dietary strategies and exercise represent the interventions that can also alleviate the progression of sarcopenia (Rong et al. 2020).

An adequate level of knowledge about sarcopenia among adults living in society is very important for the effective prevention and treatment of sarcopenia. Unfortunately, as research indicates (Van Ancum et al. 2020), knowledge about sarcopenia is limited and strategies are needed to increase health education among adults about this problem.

The aim of the present study was to evaluate the prevalence of sarcopenia in women and to analyze the role of selected lifestyle risk factors for its development.

The level of physical activity, intake of selected nutrients, body nutritional status, and total body fat were analyzed.

Material and methods

Material

This cross-sectional study involved 302 randomly selected women aged ≥65 years (average age 72.1± 5.9 years) from the Electronic System for Registration of the Population of City Councils living in towns with about 10.000 inhabitants in the eastern part of Poland. The sample size was calculated using the formula proposed by Lwanga (Lwanga et al. 1991). The study was conducted in the summer and early fall of 2018. The response rate was 40.6%. The exclusion criteria were hormone replacement therapy, contraindications to bioelectrical impedance body composition measurement, severe physical or intellectual disabilities, and diseases affecting muscle tissue metabolism such as cancer, anorexia, rheumatoid arthritis, and osteoporosis (Jochum et al. 2019; Tsutsumimoto et al. 2020).

Methods

The face-to-face interview was used to collect data on metric age, age at menopause, level of education, type of past work, and others. Basic body measurements (body height and mass, waist circumference, hip circumference) were performed using standard anthropometric methods (Lohman, Roche and Martorell 1988; Hall et al. 2007). Body height was measured using the GPM anthropometer (Siber Hegner, Zurich, Switzerland) in anthropometric landmarks with a measurement accuracy of 0.1 cm. Waist circumference and hip circumference were measured using the Holtain anthropometric tape (Crymych, UK) with a measurement accuracy of 0.1 cm. All measurements were performed by one person with appropriate qualifications and extensive experience in anthropometric measurements in optimal climatic conditions. The mean of two measurements was used in the analyses. Protein-energy nutritional status disorders were assessed based on body mass index (BMI) whereas the type of body fat was identified based on the waist-to-hip ratio (WHR) using the classification recommended by WHO (WHO 2008). Bioelectrical impedance analysis (BIA) using the Tanita BC-418 four-leg body composition analyzer was used to measure percentage body fat (PBF), lean body mass (LBM), and total body water (TBW).

Methods to assess sarcopenia

Sarcopenia was diagnosed according to the accepted methodology recommended by the European Working Group on Sarcopenia in Older People (EWGSOP) (Cruz-Jentoft et al. 2010) and EWGSOP2 in 2018 (Cruz-Jentoft et al. 2019). However, in a recent publication, more attention has been paid to the assessment of muscle strength as a measure enabling a quick diagnosis (Cruz-Jentoft et al. 2019). Muscle mass was assessed using bioelectrical impedance analysis (BIA) on the Tanita BC-418 four-leg body composition analyzer. Total skeletal muscle mass (SMM) was calculated according to the methodology proposed by Kim et al. (2002). Muscle mass for the diagnosis of sarcopenia was assessed based on the skeletal muscle index (SMI) recommended for the European population (Cruz-Jentoft et al. 2010). An SMI value <28.94% calculated for the Polish population was used as the cut-off point (Krzymińska-Siemaszko 2014).

Assessment of static muscle strength

Static muscle force was measured using the Jamar® Hydraulic Hand dynamometer (Warrenville, IL, USA). The hand grip force of both hands was measured alternately and twice. The mean of the two measurements was used in the assessment of muscle strength. The criteria for assessment of muscle strength were adopted according to the EWSGOP recommendations for women relative to BMI (Cruz-Jentoft et al. 2010).

Assessment of physical fitness and the level of physical activity

Physical fitness was assessed using the standardized Timed Up and Go test. The time of ≥14 s recommended by EWGSOP was used as a cut-off point (Shumway-Cook, Brauer and Woollacotta 2000) for low fitness and risk of sarcopenia. Criteria for the diagnosis of sarcopenia were adopted as recommended by EWGSOP (Cruz-Jentoft et al. 2010). The current level of physical activity was measured over 48 h (2x24h) using the Tanita AM-180 three-axis accelerometer. European Union guidelines for older adults (2008) were used to assess the level of physical activity (high physical activity: >4,000 steps a day, moderate physical activity: 3,500–3,999 steps a day, low physical activity: 2,500–3,499 steps a day, very low physical activity: <2,500 steps a day.

Dietary Assessment

Face-to-face 24-hour dietary recalls for two non-consecutive days preceding the interview were administered in the study. The album of Photographs of Food Products and Dishes (2018/2019) was used to estimate the portion sizes of products and foods consumed. The energy and nutrient content of the women's diets was calculated using the computer program DIETA 6.0. Protein intake, expressed in g/day and g/kg body mass/day, and vitamin D intake in μg/day were included in the analyses. Consumption of proteins was categorized as low <0.73 g/kg/body mass, medium 0.73–0.89 g/kg/body mass, and high ≥0.9 g/kg body mass. Energy consumed from protein was categorized as <15% E, 15%–20% E, and >20% E. In the case of vitamin D, the categorization was: <1.5 μg/day, 1.5–2.2 μg/day, and ≥2.2 μg/day.

Statistical Methods

Statistical analysis was performed using the STATISTICA 13.0 software. The normality of distribution was assessed using the Shapiro-Wilk test. Multivariate logistic regression models were used to identify the determinants of sarcopenia in women. Wald's chi2 was calculated. Odds ratio (OR) with 95% confidence interval (CI) was calculated for independent variables (Hosmer and Lemeshow 1989). The level of statistical significance was set at *p ≤ 0.05, **p ≤ 0.01, and ***p ≤ 0.001.

Ethical Considerations

The study was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The project received a positive opinion from the Senate Ethics Committee for Scientific Research of the Józef Piłsudski University of Physical Education in Warsaw (protocol No. SKE 01-14/2017). All study participants gave their informed consent to participate in a research project and were informed about the protocol and test methods.

Results

Selected characteristics of the women studied are shown in Table 1. The mean age of the women was 72.1± 5.9 years, with ages ranging from 65 to 87 years. In general, women had a high mean BMI, indicating excessive body mass (83.4% were overweight or obese). One in two women was obese (49.7%). Based on the WHR index, central body fatness was found in 96.7%. The average intake was 0.75 g/kg/body mass/day for protein and 1.8 μg/day for vitamin D, which can be considered as low (Table 1).

Table 1. Baseline selected characteristics of the studied women

Variables	Females (n=302)
	Mean ± SD
Age [years]	72.1±5.9
Body height [cm]	157.1±5.9
Body mass [kg]	73.9±13.4
BMI [kg/m^2]	30.0±5.3
Waist Circumference [cm]	102.7±13.0
Hip Circumference [cm]	109.0±10.0
WHR	0.94±0.07
PBF [%]	39.3±8.1
LBM [kg]	44.2±5.6
TBW [kg/m2]	33.2±3.9
Total protein intake [g/day]	54.1±14.2
Protein intake [g/kg bm/day]	0.75±0.2
Vitamin D [**μg/da**y]	1.8±1.9
Number of steps/day	4416.1±2618
	Percent
BMI <24.99 [kg/m^2]	16.5
BMI 25.0-29.9 [kg/m^2]	33.8
BMI ≥ 30 [kg/m^2]	49.7
WHR ≥0.8	96.7

BMI – body mass index; WHR – waist-to-hip ratio; PBF – percentage body fat; LBM – lean body mass; TBW – total body water.

Table 2 shows that the incidence of sarcopenia of all types (I, II, and III) was present in 28.8% of all women studied. The state of pre-sarcopenia, characterized by a low muscle mass based on SMI, was found in more than 13% of women, while the severe state, manifested by fulfilling three criteria, i.e., low muscle mass, low muscle strength, and impaired physical fitness, was reported in 4.3% of women (Table 2).

Table 2. The incidence rate of sarcopenia in agreement with diagnostic criteria recommended by EWGSOP (Cruz-Jentoft et al. 2010, 2018) *

Diagnostic criteria	Grades of sarcopenia	Females (n=302)	
		n	%
Low muscle mass (SMI < 28.94%)	Pre-sarcopenia I^0	41	13.6
Low muscle mass (SMI < 28.94%) + low muscle strength (17kg to 21 kg) or low physical fitness (> 14 s)	Sarcopenia II^0	33	10.9
Low muscle mass (SMI < 28.94%) + low muscle strength (17kg to 21 kg) + low physical fitness (> 14 s)	Severe sarcopenia III^0	13	4.3
Sarcopenia I^{o}II^o III^o		87	28.8

*with using the cut-off point for the SMI for the Polish female population (Krzymińska--Siemaszko 2014)

Logistic regression analysis (see Table 3) revealed the most important factors affecting sarcopenia in the group studied. Of the variables analyzed, the most importan factor affecting sarcopenia was high protein intake per kilogram of body mass per day, which significantly reduced the risk of developing sarcopenia by 60%

and 92 %. For intake levels ranging from 0.73 g/kg body mass/day to 0.89 g/kg body mass/day, the odds ratio was OR=0.40 (p=0.003). However, at an intake of ≥0.9 g/body mass/day, the ratio was OR=0.08 (p<0.001). In the case of physical activity (PA), this effect was not significant, but a trend for the decreasing risk of developing sarcopenia with an increase in the level of physical activity was found: OR=0.71 for low-level PA, OR=0.45 for moderate PA, and OR=0,58; p = 0.08 for high levels of PA (≥ 4000 steps/day in our study) (Table 3).

Table 3. Odds ratios (ORs) and 95% confidence interval (95%CI) of sarcopenia by the physical activity, protein, vitamin D intake and the other selected variables

Variable		OR (95%CI)	Wald chi-square	p
Physical activity (PA)	Very low PA (<2500 steps per day)	1	4.22	
	Low PA (2500-3499 steps per day)	0.71 (0.34 – 1.52)	0.77	0.38
	Moderate PA (3500-3999 steps per day)	0.45 (0.13– 1.51)	1.69	0.19
	High PA (≥4000 steps per day)	0.58 (0.31 – 1.07)	3.00	0.08
Intake of total protein (g/day)	< 50g/day	1	20.70	
	50-64 g/day	0.97 (0.55– 1.71)	0.01	0.92
	≥64g/day	0.97 (0.49– 1.90)	0.01	0.93
Intake of protein (g/kg body mass/day)	(< 0.73g/kg bm)	1	3.71	
	(0.73-0.89 g/kg bm)	0.40 (0.21 – 0.74)	8.65	0.003
	(≥0.9 g/kg bm)	0.08 (0.03– 0.24)	20.58	<0.001
Percentage of energy from protein	< 15%	1	13.73	
	15-20%	0.74 (0.43 – 1.26)	1.23	0.26
	>20%	0.79 (0.35 – 1.75)	0.34	0.56
Vitamin D	<1.5 μg/day	1	28.45	
	1.5-2.2 μg/day	1.20 (0.64– 2.23)	0.33	0.56
	≥2.2 μg/day	0.90 (0.48 – 1.68)	0.11	0.74
Age	65-70 years	1	30.00	
	71-75 years	1.65 (0.90– 3.02)	2.67	0.10
	≥76 years	0.99 (0.54 – 1.85)	0.00	0.99

Table 3 (cont.)

Variable		OR (95%CI)	Wald chi-square	p
Education level	Higher/secondary	1	36.31	
	primary	1.14 (0.63 – 2.06)	0.20	0.65
	vocational	1.69 (0.85 – 3.37)	2.24	0.13
Type of work performed in the past	50% sedentary work, 50% standing or moving work	1	18.64	
	>80% sedentary work	0.96 (0.49 – 1.91)	0.008	0.92
	>80% of standing or moving work	1.49 (0.81 – 2.75)	1.64	0.20
Number of births	0	1	4.19	
	1-2	1.03 (0.37 – 2.87)	0.005	0.94
	3-4	1.03 (0.37 – 2.86)	0.003	0.95
	>4	1.52 (0.46 – 4.96)	0.49	0.48
Age of menopause	< 50 years	1	15.0	
	50-55 years	0.98 (0.57 – 1.70)	0.001	0.96
	>55 years	0.70 (0.23 – 2.10)	0.40	0.52

Complementary factors significantly increasing the risk of sarcopenia were BMI and body fat, expressed as % of body weight. A one-unit increase in BMI was associated with the risk of sarcopenia by 36% (OR=1.36; p<0.001). A similar tendency was found for the increase in body fat by 1%. An increase in this variable led to an increase in the prevalence of sarcopenia by 29% (OR=1.29; p<0.001) (Table 4).

Table 4. Odds ratios (ORs) and 95% confidence interval (95%CI) of sarcopenia by the BMI and total fat expressed as % of body mass

Variable	OR (95%CI)	Wald chi-square	p
BMI	1.36 (1.25-1.48)	51.37	<0.001
FAT [%]	1.29 (1.21-1.40)	52.38	<0.001

Discussion

A female group was chosen for the analysis of the sarcopenia because the latter is more commonly diagnosed among women compared to men (Wang et al. 2015; Bianchi et al. 2016; Dodds et al. 2016; Fozouni, Shafiee et al. 2017; Wang and Lai 2019; Kitamura et al. 2020). Differences in the prevalence of sarcopenia between men and women are influenced by hormonal changes that promote the loss of muscle mass with age (Juul and Skakkebeal 2002), serum homocysteine and C-reactive protein (hsCRP) levels (Lee et al. 2020), as well as the fact that women in all countries live longer than men. Differences in life expectancy between females and males in 2019 were 7.9 years in Poland, 6.2 years in Japan, and 3.8 years in Switzerland (Human Development Rep. 2019).

It is also well established that adequate protein intake and high levels of physical activity are required to maintain muscle mass and strength in older adults (Chen et al. 2004; Nilsson et al. 2018; Perna et al. 2020; Montiel-Rojas et al. 2020). This conclusion has been confirmed by several studies (Houston et al. 2017; Nilsson et al. 2018; Montiel-Rojas et al. 2020), including a study of 302 Polish women presented in this paper, where the protective and significant role of dietary protein content was also demonstrated. Protein intake of ≥ 0.9g protein/kg body mass /day significantly reduced the risk of developing sarcopenia by 92% (OR=0.08; $p<0.001$). The intake of at least 0.73–0.89g protein/kg BM/day also reduced the risk of developing sarcopenia by 60% (OR=0.40; $p<0.001$). The threshold value of protein intake in the present study that protected against the risk of developing sarcopenia was 0.73 g/kg BM/day or more, i.e. above the Estimated Average Requirement of Polish Dietary Reference Intakes (DRI). Dorhout et al. (2020) also showed that higher protein intake among older adults in Southern Suriname was associated with a lower risk of sarcopenia (OR=0.96, $p<0.001$). Similarly, the results of Papadopoulou (2020) showed an important role of protein in the prevention of sarcopenia as protein intake significantly correlated with reduced muscle strength and thus was associated with an increased incidence of sarcopenia.

The Health ABC study (Houston et al. 2017) conducted among 2,101 individuals with a mean age of 74.5 years found that the risk of sarcopenia in individuals with low protein intake (<0.7g/kg BM/day or 0.7 to <1.0g/kg BM/day) was higher by 3.25 times and 1.78 times, respectively, compared with those consuming ≥1.0 g protein/kg BM/day.

Research by Montiel-Rojsa, et al. 2020, conducted among 986 older Europeans (Italy, Poland, the Netherlands, and the United Kingdom) found that similar to what was observed in our study, protein intake was critical to the prevention of sarcopenia. The participants who consumed ≥1.2 g protein/kg BM/day had the lowest incidence of sarcopenia (Montiel-Rojas et al. 2020).

Polish Dietary Reference Intakes recommend that older adults should consume 0.90 g/kg BM/day protein at the Recommended Dietary Allowances level and that in people aged ≥ 65 years, protein should provide at least 15% to 20% of energy, which, at an average of 18% of energy from protein, corresponds to an intake of about 1.2 g/kg BM/day (Jarosz et al. 2020). In contrast, in individuals with already diagnosed sarcopenia, an increased protein intake of 1 to 1.5 g of protein per kilogram of body mass per day combined with appropriately chosen physical exercise is recommended (Bauer et al. 2019). The results obtained in the present study confirm that the most important factors in the prevention and treatment of sarcopenia in older adults are optimal protein intake (Cruz-Jentoft et al. 2019; Hengeveld et al. 2020; Rondanelli et al. 2020; Rong et al. 2020).

Adequate levels of physical activity are also considered one of the key factors in counteracting the risk of developing sarcopenia (English and Paddon-Jones 2010; Dodds et al. 2016; Bauer et al. 2019; Cui et al. 2020; Kitamura et al. 2020; Marcos-Pardo et al. 2021).

The results of the research discussed in this paper show that a high level of physical activity of ≥4,000 steps/day reduced (although insignificantly) the risk of developing sarcopenia (OR=0.58; p=0.08). The lack of significance was probably due to the generally low average number of steps per day among the women tested (4416/day). Nevertheless, it is worth noting the clear but insignificant trend of reducing the risk of developing sarcopenia with the increase in the number of steps per day in women, which encourages continued research on the role of physical activity in the development of this disease.

Aggio et al. (2016) examined 1,286 men aged 70–92 years and demonstrated that each additional 30 min of daily moderate physical activity significantly reduced the risk of severe sarcopenia (OR=0.53; p<0.001) and sarcopenic obesity (OR=0.47; p<0.001). Furthermore, Marcos-Pardo et al. (2021) found that reduced physical activity due to sedentary lifestyles (>300 min/week) significantly reduced physical fitness and increased the risk of sarcopenia and pre-sarcopenia. Participants older than 65 years were more likely to develop sarcopenia as they showed lower levels of vigorous physical activity (VPA) (OR=0.48; p<0.02) compared to those from the younger age group (Marcos-Pardo et al. 2021). Maintaining adequate levels of appropriately selected physical activity promotes the development of age-appropriate muscle strength and mass (Aggio et al. 2016; Tyrovolas et al. 2016; Houston et al. 2017; Bauer et al. 2019; Cruz-Jentoft et al. 2019; Chen et al. 2020). The results of the analyses in this paper showed a trend that taking more than 4,000 steps per day reduced the risk of developing sarcopenia in older women by 42 % (OR=0.58; p=0.08).

In the study by Omelan et al. (2022) of 774 older residents (above 60 years of age) of rural and urban areas in north-eastern Poland, the level of physical activity of the study participants was at a sufficient level, but in the case of women, it depended on socio-economic characteristics. The authors pointed to the need of finding effective ways to support older adults in maintaining or increasing physical activity, with a particular emphasis on women (Omelan et al. 2022). A study of Polish women also showed that BMI was a strong determinant of developing sarcopenia. A one-unit increase in this index significantly increased the risk of developing sarcopenia by 36% (OR=1.36; p<0.001). Other researchers support these findings, e.g., in a study by Cui et al. (2020), the authors found that BMI in the frame of recommended reference (OR=0.365, 95% CI:0.236–0.661) significantly reduced the risk of developing sarcopenia among patients over 65 years of age diagnosed with type 2 diabetes. A study by Marcos-Pardo et al. (2021) also showed that a BMI less than 30kg/m^2 was a preventive factor for pre-sarcopenia but a nutritional status classified as obesity significantly increased the risk of developing sarcopenia by 65% (OR=1.65; p<0.01) or being overweight compared to reference body mass.

Conclusions

In conclusion, we found that sarcopenia of various degrees is frequent and occurrs in almost every third woman examined. Among the analyzed factors, four showed bi-directional associations with sarcopenia in older women, with optimal protein intake and physical activity measured by the number of steps per day decreased (not significantly), while high BMI indicating excessive body mass and a high percentage of body fat in the body tissue composition increased (significantly) the development of sarcopenia. All these risk factors add some knowledge to the assessment of the promoting role that they could play in the development of sarcopenia. All of these risks factors are fully modifiable and their modification should be a priority in prevention and education or therapeutic programs. Our study may have strong implications for dietary and physical activity recommendations for older women.

The strengths of this cross-sectional study include using standardized methods only, face-to-face interviews using validated questionnaires by highly-trained personnel (first author of the paper), and random selection of women from the studied region.

It should be emphasized that there are also some limitations of the study, such as the absence of participants who did not consent to participate due to the lack of mobility or dementia or other reasons, which represents an important limitation in the final assessment of the severity of sarcopenia in the population. It influenced the response rate, which was 40.6%.

Declaration of interest statement

The authors declare that they have no conflict of interest.

Acknowledgments

We would like to thank Bożena Wajszczyk, PhD, from the National Institute of Public Health NIH – National Research Institute, for her help with nutritional analysis and Mikołaj Rybaczuk, MSc, for his help with the analysis. We would also like to thank all participants in the study.

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors' contribution

A.B. conceptualization, methodology, investigation, all data collection, analysis, writing the manuscript, public relations; A.K. coordinated the project found administration, supervision, review and editing, public relations; J.C. supervision, visualization, review, and editing, revised the final version.

Funding

This work was supported by the Józef Piłsudski University of Physical Education in Warsaw, Poland under science project DM-62. Scientific work was financed by the Ministry of Science and Higher Education in 2020/2022 as part of the Scientific School of the University of Physical Education in Warsaw-SN No. 5 "Biomedical determinants of physical fitness and sports training in adult population".

Supplemental Material

Supplemental material for this article is available in corresponding author.

Corresponding author

Anna Kopiczko, Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education, Department of Human Biology, Section of Anthropology, 34 Marymoncka Street, 00-968 Warsaw, Poland; e-mail: anna.kopiczko@awf.edu.pl

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