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Association of dietary intake, nutritional status and physical activity on sarcopenia in pre-elderly and elderly

Hubungan asupan makan, status gizi dan aktivitas fisik terhadap sarkopenia pada pralansia dan lansia

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Abstract

Sarcopenia is a decrease in muscle mass, strength, and function, which has an impact on reducing physical performance and quality of life and is influenced by dietary intake and physical activity. This study aimed to analyze the relationship between diet, nutritional status, physical activity, and the incidence of sarcopenia. A cross-sectional study was conducted in Simpati District, West Sumatra, from October to November 2024. The sample consisted of 167 pre-elderly individuals, and the elderly were selected through simple random sampling. Measurements included muscle and fat mass using a digital body composition scale, muscle strength using a handgrip dynamometer, dietary intake using the SQ-FFQ, physical activity using the GPAQ, waist circumference using a waist ruler, and physical performance assessed through the sit-to-stand test. Chi-square test and logistic regression were used for the analysis. Results: The prevalence rate of sarcopenia was 9,6%. After adjusting for age and sex, waist circumference (p= 0,019; OR= 4,2) was associated with sarcopenia, while after adjusting for age, physical activity (p= 0,016; OR= 4,5), and waist circumference (p= 0,042; OR= 3,3) were associated with sarcopenia. After adjusting for sex, energy intake (p= 0,050; OR= 3,1), physical activity (p= 0,006; OR= 5,7), and waist circumference (p= 0,007; OR= 4,8) were associated with sarcopenia. Conclusion: Energy intake, physical activity, and waist circumference were associated with sarcopenia in elderly and pre-elderly individuals. Appropriate nutritional intervention, increased physical activity, and waist circumference monitoring are essential for sarcopenia management.

Keywords: Elderly, energy intake, physical activity, sarcopenia, waist circumference

Abstrak

Sarkopenia merupakan penurunan massa otot, kekuatan dan fungsi otot yang berdampak pada penurunan peforma fisik serta kualitas hidup, yang dipengaruhi oleh asupan makan dan aktivitas fisik. Tujuan penelitian untuk menganalisis hubungan pola makan, status gizi dan aktivitas fisik dengan kejadian sarkopenia. Penelitian *cross-sectional* dilakukan di Kecamatan Simpati, Sumatera Barat dari Oktober hingga November 2024. Sampel berjumlah 167 pralansia dan lansia diambil melalui *simple random sampling*. Pengukuran meliputi massa otot dan lemak menggunakan timbangan digital komposisi tubuh, kekuatan otot menggunakan handgrip dinamometer, asupan makan menggunakan SQ-FFQ, aktivitas fisik menggunakan GPAQ, lingkar pinggang menggunakan waist ruler, serta peforma fisik dinilai melalui *sit-to-stand test performed*. Analisis menggunakan uji chi-square dan regresi logistik. Hasil, prevalensi sarkopenia mencapai 9.6%. Setelah *adjusted* usia dan jenis kelamin, lingkar pinggang (p= 0,019; OR=4,2) berhubungan dengan sarkopenia, sedangkan *adjusted* dengan variabel usia, aktivitas fisik (p= 0,016; OR= 4,5) dan lingkar pinggang (p= 0,042; OR= 3,3) berhubungan dengan sarkopenia. Setelah *adjusted* dengan variabel jenis kelamin, asupan energi (p= 0,050; OR= 3,1), aktivitas fisik (p= 0,006; OR= 5,7), dan lingkar pinggang (p= 0,007; OR= 4,8) berhubungan dengan sarkopenia. Kesimpulan, asupan energi, aktivitas fisik dan lingkar pinggang memiliki hubungan dengan sarkopenia pada pra lansia dan lansia. Diperlukan intervensi gizi yang tepat, peningkatan aktivitas fisik, serta pemantauan lingkar pinggang sangat penting dalam pengelolaan sarkopenia

Kata Kunci: Aktivitas fisik, asupan energi, lansia, lingkar pinggang, sarkopenia

Introduction

Sarcopenia, a condition characterized by progressive loss of muscle mass and strength, is a major health concern among the elderly population. This condition increases the risk of physical disability and reduces mobility in the elderly (Dao et al., 2020).

Sarcopenia is a condition indicated by a decline in muscle mass and strength. Reduction in skeletal muscle mass, along with decreased muscle strength and physical performance, leads to disabilities that impair mobility. Sarcopenia also affects health by causing physical disabilities, impaired limb function, reduced quality of life, and increased risk of mortality (Li et al., 2022). The global prevalence of sarcopenia in older adults ranges from 10% to 27%. Epidemiological studies in Asia indicate that the prevalence of sarcopenia varies between 5,5% and 27,5% (Yuan & Larsson, 2023). A study conducted in Surabaya, Indonesia, found that 41,8% of the elderly were affected by sarcopenia, while 36,7% suffered from frailty, as assessed using the Asian Working Group for Sarcopenia (AWGS) (Widajanti et al., 2020). Setiati et al. (2019) found that 25,2% of the older adults in Indonesia were frail. The relatively high prevalence of sarcopenia poses a significant economic and social burden.

According to data from the Central Statistics Agency in 2023, Indonesia's population aged 45-70 years reached 81,6 million, an increase from 73,7 million in 2022. This figure is expected to continue to increase annually. Similarly, the elderly population in West Sumatra and Pasaman Regency has also increased (Statistics Indonesia West Sumatra Province, 2024). As aging is a risk factor for sarcopenia, the growing elderly population suggests a potential rise in sarcopenia cases in Indonesia. This highlights the urgent need for research on the factors contributing to sarcopenia, such as dietary intake, nutritional status, and physical activity, to develop effective preventive strategies. Although sarcopenia risk factors have been widely studied, research on the links between dietary intake, nutritional status, and physical activity in pre-elderly and elderly individuals in Indonesia, particularly in West Sumatera, remains limited. This study addresses this gap by identifying modifiable risk factors for sarcopenia.

Sarcopenia affects the quality of life of older adults, leading to physical impairment, limited mobility, and a higher risk of falls and mortality. Individuals with sarcopenia also have an increased risk of developing frailty. Kwon et al. (2023) stated that individuals with sarcopenia have 3,7 times higher risk of mortality than those without sarcopenia. Sarcopenia is influenced by several factors, including inadequate nutritional intake, hormonal status, oxidative stress, fat infiltration into the muscle tissue, physical inactivity, and neuromuscular junction degeneration. Pro-inflammatory cytokines, such as Tumor Necrosis Factor-α) and IL-6 (Interleukin-6) can disrupt muscle protein metabolism and accelerate muscle fiber degradation, contributing to the loss of muscle mass and strength (Tuttle et al., 2020). Additionally, fat infiltration into the skeletal muscle tissue impairs contractile function, leading to a decline in muscle strength (Pagano et al., 2018). Physical inactivity also plays a crucial role in sarcopenia progression. Prolonged bed rest or lack of physical activity accelerates muscle atrophy, reduces muscle protein synthesis, and promotes fat infiltration into muscle tissues, leading to a significant decline in muscle strength (Hamalainen et al., 2024).

Adequate nutrition, particularly protein intake and physical activity, is crucial for reducing the risk of sarcopenia. Proteins support muscle synthesis and maintenance. Stoodley et al. found that women at risk of sarcopenia consumed less than 1 g/kg of body weight of protein daily and engaged only in moderate-intensity exercise, accelerating muscle loss (Stoodley et al., 2024). Protein- and fiber-rich diets are associated with a lower risk of sarcopenia. Consuming foods, such as meat, fish, eggs, legumes, and vegetables, supports body composition and muscle mass maintenance (Stoodley et al., 2024). Wang et al. found that a diet containing dairy, fruits, and legumes has a protective effect against sarcopenia by preserving muscle strength and function (Wang et al., 2022).

In addition, traditional dietary patterns in some countries have been linked to a lower prevalence of sarcopenia. The Japanese diet, rich in fish, soy products, vegetables, mushrooms, seaweed, and fruits, supports muscle health and reduces the risk of sarcopenia (Yokoyama et al., 2021). Meanwhile, a study by Lee et al. in Korea found that a healthy diet rich in vegetables, fish, and fruits is associated with increased muscle mass. In contrast, foods high in carbohydrates and saturated fats, such as fast food, instant noodles, and sugary beverages, provide no benefits to muscle health and may contribute to declining muscle function (Lee & Lee, 2019).

Macronutrients and micronutrients, including magnesium, calcium, selenium, and fiber, also play a role in sarcopenia. Dronkelaar et al. reported that selenium and calcium are associated with muscle mass in the elderly, whereas magnesium, iron, and zinc are related to physical performance (Dronkelaar et al., 2017). Fibers also affect the muscle health. Several studies have demonstrated that fiber consumption can help prevent low muscle strength. Shin demonstrated a positive association between fiber intake and grip strength in Korean adults (Shin, 2024).

Nutritional supplementation combined with physical exercise has been proven to be effective in increasing muscle strength and mass in older adults with sarcopenia (Luo et al., 2017). Muscle protein metabolism relies heavily on adequate nutrient intake, particularly protein intake, which plays a crucial role in muscle synthesis and repair. A well-balanced nutritional strategy that provides sufficient energy and essential nutrients has the potential to prevent or slow sarcopenia progression by supporting muscle regeneration. Adequate protein intake stimulates muscle protein synthesis, reduces the anabolic resistance associated with aging, and helps maintain muscle mass and function when combined with regular physical exercise (Luo et al., 2017).

Based on the research problem regarding the susceptibility of the elderly population to sarcopenia, which is influenced by various contributing factors, this study aimed to determine whether there is a significant association between dietary intake, nutritional status, and physical activity and sarcopenia among the pre-and elderly

Methods

This was an observational cross-sectional study. The study was conducted in Simpati Subdistrict, Pasaman Regency, West Sumatra Province, from October to November 2024. The total number of subjects of the study was 167, selected using the simple random sampling method. Sample size was determined using the Lameshow formula for a finite population.

$$n = \frac{\left(Z_1 - \frac{\alpha}{2}\right)^2 \times P\ (1\text{-}P) \times N}{d^2 (N\text{-}1) + \left(Z_1 - \frac{\alpha}{2}\right)^2 \times P(1\text{-}P)}$$

With a confidence interval of 95% (Z=1,96), margin of error (d) of 5%, and population size (N) of 2860, the proportion from a previous study was 12% (p =0,12). To anticipate potential dropouts, the sample size was increased by 10%, resulting in a total of 167 participants. The inclusion criterion was adults aged 45-70 years. Individuals who were unable to sit, stand, or walk; those with limb deformities (amputation and severe arthritis-related deformities), mobility impairments due to stroke, or spinal cord injuries resulting in immobility were excluded. Individuals with uncontrolled diabetes mellitus (blood glucose >200 mg/dl) and cancer were also excluded from this study.

Subject identity and characteristic data, such as age and gender, were collected through direct interviews using a respondent characteristics questionnaire. Anthropometric data were obtained through direct measurements conducted by the researcher assisted by trained enumerators. Height was measured using a stadiometer (Seca 213. Body weight, fat mass, and muscle mass were measured using the Omron HBF 375 Body Composition Scale. Muscle strength was assessed by using a digital handgrip dynamometer. Physical activity levels were evaluated using a Global Physical Activity Questionnaire (GPAQ).

Body Mass Index (BMI) was calculated by dividing the body weight (kg) by the square of the height (m^2). Height was measured twice and averaged. Nutritional status based on BMI was categorized as underweight (≤18,4 kg/m^2), normal (18,5-25 kg/m^2) and obese (>25 kg/m^2) (Kementerian Kesehatan RI, 2018). Muscle mass and strength were categorized based on the recommendations of the Asian Working Group for Sarcopenia (AWGS) 2019. The AWGS 2019 recommends these cut-off points as standards for the Asian population, including Indonesia. Muscle mass was categorized as low if it was <7,0 kg/m^2 for men and <5,7 kg/m^2 for women. Muscle strength was categorized as low if it was <28 kg for men and <18 kg for women (Chen et al., 2020). Fat mass was categorized as obese if it was ≥25% in men and ≥35% in women (Chen et al., 2021). Waist circumference was measured using a waist ruler and categorized as at risk if it was ≥90 cm in men and ≥80 cm in women (Haam et al., 2023).

According to the AWGS 2019 recommendations, physical performance was assessed using a five-time sit-to-stand test. Subjects who completed five repetitions in ≥12 s were classified as having low physical performance, while those who completed it in <12 s were categorized as normal. According to the AWGS 2019, sarcopenia is diagnosed based on the presence of low muscle mass, low muscle strength, and low physical performance (Chen et al., 2020).

Dietary intake data were collected using the SQ-FFQ, which assesses energy, protein, fat, fiber, and calcium intake. The SQ-FFQ used in this study was validated for the Indonesian population based on previous research (Syauqy et al., 2021). Portion size was estimated using food photographs as a reference during data collection in the field. Nutrient requirements were determined based on the Recommended Dietary Allowance (RDA) of 2019 set by the Indonesian Ministry of Health. Dietary intake was calculated by dividing the daily intake by nutrient requirements according to the 2019 RDA and then converting it into a percentage. Intake was considered adequate if it was ≥80% of the requirement, while intake was categorized as low if it was <80% of the requirement (Lembaga Ilmu Pengetahuan Indonesia, 2014).

Physical activity was classified based on the GPAQ. Low physical activity was defined as a MET value <600, whereas sufficient physical activity was defined as a MET value ≥600. The GPAQ collects data on an individual's participation in physical activity across three primary domains: work, travel, and recreation. Work and recreation are further categorized into vigorous and moderate activities, with vigorous activity assigned a value of 8 MET, multiplied by the duration of the activity, and moderate activity assigned a value of 4 MET, multiplied by the duration. Travel was assigned a value of 4 MET. Physical activity data were collected based on a recall period of the past seven days, as specified in the GPAQ guidelines (World Health Organization, 2012).

Bivariate analysis was performed using the chi-square test with a 95% confidence interval to examine the relationship between energy, protein, fat, calcium, and fiber intake, as well as age, sex, physical activity, waist circumference, fat mass, and BMI. A relationship was considered significant if the p-value was <0,05. Multivariate analysis was performed using logistic regression with a backward elimination approach to assess the interaction variables. This approach ensures systematic consideration of key variables and potential confounders. Variables were selected based on theoretical considerations and bivariate analysis results (p-value <0,25) (Dahlan, 2012). Logistic regression was conducted using four analytical models: Model 1 was unadjusted; Model 2 was adjusted for age; Model 3 was adjusted for sex; and Model 4 was adjusted for age and sex. All statistical analyses were performed using IBM SPSS Statistics version 25.0.

Ethical clearance was approved by the ethics committee of Diponegoro University (number 540/EC/KEPK/FK-UNDIP/X/2024). All respondents were provided an explanation of the study's objectives, procedures, and benefits before participating in the study. Informed consent was obtained from all participants prior to data collection.

Result and Discussion

Table 1 shows that 42,5% were elderly (60-70 years), whereas 57,5% were pre-elderly (45-59 years). The prevalence of sarcopenia among the respondents was 9,6%, whereas 90,4% were non-sarcopenic. Among the respondents, 13,8% had low muscle mass, 56,9% had low muscle strength, and 34,1% had low physical performance. The percentages of respondents with inadequate intake of energy, protein, and fat were 40,2%, 68,3%, and 43,7%, respectively, while those with inadequate intake of fiber and calcium were 82,6% and 78,4%, respectively. Furthermore, 35,3% of respondents had low physical activity. The majority of respondents (67,1%) had excessive body fat, and based on the body mass index, 46,7% were classified as obese.

The prevalence of sarcopenia in Indonesia remains limited and has not yet been studied on a national scale. In this study, the prevalence of sarcopenia was 9,6%, which was lower than that reported in Surabaya (41,8%) (Widajanti et al., 2020) and Pedawa Village, Bali (91,3%) (Budiartha et al., 2019). The high prevalence in Surabaya is associated with the risk of malnutrition, whereas in Pedawa Village, it is influenced by factors such as age, nutritional status, education, and sociocultural aspects. Nevertheless, older adults in Pedawa Village maintained a good functional status, suggesting the possible presence of protective factors.

Table 1. The respondent characteristic (n=167)

Variables	n	%
Gender		
Female	98	58,7
Male	69	41,3
Education		
Elementary School	19	11,4
SMP/equivalent	48	28,7
SMA/equivalent	81	48,5
College	19	11,4
Age		
Elderly	71	42,5
Pre-elderly	96	57,5
Sarcopenia		
Sarcopenia	16	9,6
Non sarcopenic	151	90,4
Muscle Mass		
Low	23	13,8
Normal	144	86,2
Muscle Strength		
Low	95	56,9
Nomal	72	43,1
Physical Performance		
Low	57	34,1
Normal	110	65,9
Energy Intake		
Low	67	40,2
Adequate	100	59,9
Protein Intake		
Low	114	68,3
Adequate	53	31,7
Fat Intake		
Low	73	43,7
Adequate	94	65,3
Fiber Intake		
Low	138	82,6
Adequate	29	17,2
Calcium Intake		
Low	131	78,4
Adequate	36	21,6
Physical Activity		
Low	69	35,3
Adequate	108	64,7
Waist Circumference		
Normal	67	40,1
Risk	100	59,9
Fat Mass		
Obesity	112	67,1
Normal	55	32,9
BMI		
Underweight	10	6
Normal	79	47,3
Obesity	78	46,7

Table 2 shows that there was an association between energy intake, protein intake, age, physical activity, waist circumference, and body mass index with sarcopenia. Energy, protein, fat, and calcium levels tended to be lower in individuals with sarcopenia. This can be interpreted as sarcopenia caused by inadequate nutrient intake, particularly protein intake.

Nutrition plays a crucial role in maintaining muscle mass and function, and nutrient deficiency can contribute to the development of sarcopenia through various mechanisms. A deficiency in proteins and amino acids, particularly leucine, disrupts the activation of the IGF-1/PI3K/Akt/mTOR pathway, which is essential for muscle protein synthesis.

Table 2. Association dietary intake, nutritional status and physical activity on sarcopenia: bivariate analysis

Variable	Incident of Sarcopenia						p-value
	Sarcopenia		Non Sarcopenia		Total		
	n	%	n	%	n	%	
Energy Intake							0,029
Low	11	16,4	56	83,6	67	100	
Adequate	5	5	95	95	100	100	
Protein Intake							0,043
Low	15	13,2	99	86,8	114	100	
Adequate	1	1,9	52	98,1	53	100	
Fat Intake							0,789
Low	8	11	65	89	73	100	
Adequate	8	8,5	86	91,5	94	100	
Fiber Intake							0,484
Low	12	8,7	126	91,3	138	100	
Adequate	4	13,8	25	86,2	29	100	
Calcium Intake							1,000
Low	13	9,9	118	90,1	131	100	
Adequate	3	8,3	33	91,7	36	100	
Age							0,000
Elderly	14	19,7	57	80,3	71	100	
Pre-elderly	2	2,1	94	97,9	96	100	
Gender							0,097
Female	13	13,3	85	86,7	69	100	
Male	3	4,3	66	95,7	98	100	
Physical Activity							0,001
Low	12	20,7	46	79,3	58	100	
Adequate	4	3,7	105	96,3	109	100	
Waist Circumference							0,029
Normal	11	16,4	56	83,6	67	100	
Risk	5	5	95	95	100	100	
Fat Mass							0,322
Obesity	13	11,6	99	88,4	112	100	
Normal	3	5,5	52	94,5	55	100	
BMI							0,001
Underweight	3	30	7	70	10	100	
Normal	12	15,2	67	84,8	79	100	
Obesity	1	1,3	77	98,7	78	100	

Reduced mTOR activity inhibits protein synthesis and accelerates muscle degradation, which leads to a decline in muscle mass. Additionally, nutrient deficiencies can lower the levels of growth hormone (GH) and IGF-1, which are essential for muscle growth repair. A decrease in these hormones promotes catabolic processes, further accelerating muscle loss. Energy imbalance due to inadequate calorie intake also contributes to reduced energy reserves in muscles, thereby accelerating the atrophic process (Tezze et al., 2023).

Table 2 shows that fiber and calcium intakes had no relationship with sarcopenia. Although fiber and calcium are essential for overall health, they do not have a direct significant relationship with muscle mass synthesis and maintenance. The role of fiber depends on the gut microbiota conditions, which can indirectly influence metabolism and health (Calatayud et al., 2021). Calcium plays a role in muscle contraction but does not directly determine muscle mass maintenance (Terrell et al., 2023).

Table 3. Comparison of dietary intake, nutritional status and physical activity between pre-elderly and elderly

Variable	Pre-elderly n= 96	Elderly n=71	p-value
Muscle mass (kg/m²)	9,67 ± 2,15	8,07 ± 2,23	0,000[a]
Muscle strength (kg)	19,5 (8,6 - 34,6)	11,4 (2,7 - 32,1)	0,000[b]
Physical performance (s)	10,9 (8,9 - 17,5)	13,6 (10,1 - 24,3)	0,000[b]
Energy intake (kcal)	1881,4 ± 427,9	1492,6 ± 453	0,000[a]
Protein intake (g)	49,3 (23,8 - 111,3)	35,9 (17,4 - 67,9)	0,000[b]
Fat intake (g)	59,3 (17,3 - 113,7)	50,1 (5,92 - 89,3)	0,000[b]
Fiber intake (g)	11,9 (3,8 - 37,9)	9,5 (2,5 - 32,3)	0,000[b]
Calcium intake (g)	712,7 (174,9 - 1161,3)	430,9 (128,9 - 1112,3)	0,000[b]
Physical activity (g)	840 (120 - 2160)	560 (80 - 3660)	0,000[b]
Fat Mass (%)	33,8 (17,9 - 48,2)	34,3 (15,5 - 45,5)	0,877[b]
Waist circumference (cm)	89,05 (71,3 - 111,9)	85,6 (70,8 - 111,4)	0,022[b]
BMI (kg/m²)	26,3 (17,02 - 41,7)	23,33 (16,18 - 34,01)	0,000[b]

[a]Independent t-test, [b]Mann-Whitney U test

Table 3 shows that muscle mass, muscle strength, physical performance, and physical activity were significantly higher in the elderly (p<0,05). In contrast, fat mass was not significantly different between the two groups (p=0,877). In terms of nutritional intake, the pre-elderly had higher energy, protein, fat, fiber, and calcium intakes than the elderly (p<0,05). A decline in dietary intake and physical activity in the elderly may contribute to a reduction in muscle mass and physical performance.

Table 4 shows that, in the unadjusted model, low energy and protein intake, lack of physical activity, and waist circumference, categorized as at-risk, significantly increased the risk of sarcopenia. After adjusting for age and sex in model 4, only waist circumference was 4,214 times more likely to develop sarcopenia (OR, 4,214; 95%CI: 1,26-14,00, p<0,05). Energy intake, protein intake, and physical activity were initially significant in the unadjusted model; however, their associations weakened after accounting for the demographic factors. This indicates that body fat distribution, as reflected by waist circumference, is a key factor contributing to sarcopenia, after accounting for demographic factors.

Although only waist circumference remained significant in the multivariate model, the role of protein and physical activity remains essential in the prevention and management of sarcopenia. Protein and physical activity play key roles in maintaining and increasing the muscle mass. Numerous studies have shown that a combination of optimal protein intake and regular physical activity can prevent or slow sarcopenia.

Korat et al. found that adequate protein intake is associated with healthy aging. Proteins help to maintain bone density and enhance muscle mass. High protein consumption is associated with a reduced rate of muscle mass loss and improved physical performance. The optimal protein intake stimulates muscle protein synthesis (Korat et al. 2024). According to Ouyang et al., consuming three meals per day, each containing 30 g of protein, is essential for optimizing protein synthesis over 24 h. The inability to stimulate protein synthesis for muscle mass formation leads to a gradual loss of muscle mass, particularly type II muscle fibers, which affects muscle strength and physical performance (Ouyang et al., 2022). Shaikh and Rutikashivdikar (2023) found that elderly individuals with sarcopenia tend to exhibit poor physical performance and a lower quality of life.

Loss of muscle mass in older adults is also influenced by anabolic resistance, which refers to the reduced responsiveness of muscle to anabolic signals, such as protein intake and physical exercise, contributing to sarcopenia. Consequently, older adults require higher protein intake because their muscles are less responsive to anabolic stimulation. Additionally, anabolic resistance leads to a delay in activation of the mTORC1 pathway, which plays a crucial role in muscle protein synthesis. Consuming at least 25-30 grams of high-quality protein per serving can help overcome anabolic resistance and enhance the muscle protein synthesis response (Tezze et al., 2023).

Participants with sarcopenia engaged in less physical activity than those without sarcopenia. This finding is consistent with that of Kitamura et al. (2021), who identified a significant association between sarcopenia and physical activity. Physical activity helps to reduce muscle-related issues associated with aging, such as decreased muscle function, muscle cell degeneration, and inflammation. Aging causes a decline in the quantity, size, and composition of muscle fibers, resulting in a transition from fast-twitch to slow-twitch fibers (Kitamura et al., 2021). Seo et al. found that 16 weeks of resistance training effectively improved functional fitness and prevented age-related increase in intramuscular fat. Therefore, a 16-week resistance training program is recommended for older adults to enhance muscle function and prevent a decline in muscle quality (Seo et al., 2021). Exercise plays a crucial role in preventing and managing sarcopenia in older adults by enhancing muscle protein synthesis through the mTOR signaling pathway. Following exercise, the availability of amino acids, particularly leucine, increases and serves as a key signal for mTORC1 activation, thereby contributing to increased muscle protein synthesis. Activation subsequently triggers the phosphorylation of effector proteins such as p70S6 kinase (p70S6K) and 4E-binding protein 1.

Table 4. Association dietary intake, nutritional status and physical activity on sarcopenia: multivariate analysis

Variables	Model 1: OR (95% CI)	Model 2: OR (95% CI)	Model 2: OR (95% CI)	Model 4: OR (95% CI)
Energy Intake				
Adequate	1	1	1	1
Low	3,73 (1,23-11,29)	2,75 (0,86-8,71)	3,09 (0,99-9,60)	2,36 (0,72-7,64)
p-value	0,020	0,086	0,050	0,152
Protein Intake				
Adequate	1	1	1	1
Low	7,87 (1,01-61,31)	5,67 (0,70-45,68)	5,92 (0,72-48,35)	4,18 (0,49-35,23)
p-value	0,049	0,103	0,097	0,188
Physical Activity				
Adequate	1	1	1	1
Low	6,84 (2,09-22,36)	4,54 (1,33-15,5)	5,68 (1,62-19,83)	3,55 (0,97-12,97)
p-value	0,001	0,016	0,006	0,054
Waist Circumference				
Normal	1	1	1	1
Risk	3,73 (1,23-11,29)	3,29 (1,04-10,42)	4,77 (1,52-14,95)	4,21 (1,26-14,00)
p-value	0,020	0,042	0,007	0,019
Fat Mass				
Normal	1	1	1	1
Obesity	2,27 (0,62-8,34)	3,10 (0,80-11,92)	2,58 (0,69-9,61)	3,37 (0,85-13,27)
p-value	0,215	0,1	0,157	0,082

Model 1: unadjusted; model 2: adjusted by age; model 3: adjusted by gender; model 4: adjusted by age and gender

Additionally, resistance training accelerates amino acid transport into muscle cells by enhancing blood flow, thereby providing more substrate to support muscle growth (Tezze et al., 2023).

Muscle mass is affected by oxidative stress-induced inflammation, which can reduce inflammation through the release of myokines, such as IL-6, which plays a role in mitigating oxidative stress. During exercise, skeletal muscles produce and release IL-6 into circulation, functioning as an anti-inflammatory signal. Unlike IL-6 produced by adipose tissue, which contributes to chronic inflammation, exercise-induced IL-6 production has protective effects. IL-6 released during exercise stimulates the production of IL-10 and IL-1 receptor antagonists, both of which help suppress inflammatory responses and inhibit the production of pro-inflammatory cytokines, such as TNF-α (Barbalho et al., 2020).

During physical activity and exercise, muscle fibers secrete hormones and inflammatory mediators that stimulate satellite cell activation. Satellite cells contribute to muscle recovery and growth by adding new nuclei to muscle fibers, which in turn increases the muscle size. Satellite cell activity is also influenced by nutritional intake, age, and nutritional status. Adequate protein intake and essential nutrients are crucial for promoting satellite cells activation and muscle repair (Kitamura et al., 2021). A meta-analysis by Tirtadjaja et al. (2021) showed that all types of exercise (strength training, body movement exercises, and balance training) significantly enhance muscle strength and improve physical performance in older adults with sarcopenia. Exercise interventions combined with proper nutrition can help to achieve optimal muscle strength and mass.

Waist also been associated with sarcopenia. Participants with sarcopenia typically had a normal waist circumference. However, normal waist circumference in individuals with sarcopenia does not necessarily indicate good health. A reduction in waist circumference in such cases occurs because of loss of muscle mass. Older adults with sarcopenia frequently experience reduced energy and protein intake, resulting in muscle mass loss, and consequently, a decrease in waist circumference. Yoo et al. (2022) found that women in the high waist circumference group had significantly lower appendicular skeletal muscle mass and a higher prevalence of sarcopenia. Yoo also mentioned that high BMI, body fat percentage and waist circumference are independent protective factors against the incidence of sarcopenia, particularly in women. Waist circumference (WC) and body fat percentage (PBF) are closely associated with the amount of visceral fat in women, which contributes to protection against sarcopenia. Adipose tissue, which is the primary site for the storage and metabolism of sex hormones, is also a key source of estrogen. Healthy adipocytes secrete adiponectin, an anti-inflammatory molecule and insulin regulator, which positively affects muscle cells by improving insulin sensitivity and metabolic function (Yoo et al., 2022).

An increase in waist circumference also leads to a reduction in muscle mass. Excess fat, particularly visceral fat, contributes to chronic inflammation, which accelerates muscle loss. Visceral adipose tissue releases pro-inflammatory adipokines such as leptin and resistin, which promote inflammation in the body. Additionally, the accumulation of visceral fat leads to increased levels of pro-inflammatory cytokines, triggering systemic inflammation and oxidative stress. This condition negatively affects muscle metabolism by disrupting protein synthesis and increasing protein degradation. Moreover, chronic inflammation activates catabolic pathways that accelerate muscle tissue breakdown, resulting in the progressive loss of muscle mass. Excess fat, especially visceral fat, plays a role in accelerates muscle loss through inflammatory mechanisms that continuously disrupt the muscle metabolic balance (Mai et al., 2024).

Waist circumference, which is excessively low and exceeds the normal range, can negatively impact muscle health. An excessively low waist circumference in individuals with sarcopenia often reflects muscle mass loss due to inadequate energy and protein intake, rather than an optimal health condition. Conversely, a larger waist circumference, particularly owing to the accumulation of visceral fat, contributes to chronic inflammation, accelerates muscle protein degradation, and exacerbates sarcopenia. Therefore, maintaining a balanced body composition, including an optimal and healthy proportion of muscle and fat, is crucial for supporting overall health in older adults (Mai et al., 2024).

This study employed a cross-sectional design, which can identify associations between variables, but cannot establish causal relationships. Dietary intake was assessed using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), which is susceptible to recall bias, particularly among elderly individuals who may have difficulty remembering their dietary patterns. Although family members assisted in completing the questionnaire, memory limitations could still have affected the accuracy of dietary reporting.

Conclusion

Older adults are more vulnerable to sarcopenia. Those with sarcopenia often have inadequate energy and protein intake along with low levels of physical activity. A significant association was observed between waist circumference and sarcopenia after adjusting for age and sex. Additionally, energy, protein, fat, and calcium intakes were generally lower in individuals with sarcopenia. In the sarcopenia group, the majority were older than the pre-elderly. Factors such as dietary intake, physical activity, and waist circumference are strongly associated with sarcopenia. This study contributes to the field by focusing on the elderly and the pre-elderly in Indonesia, particularly in West Sumatera, an area that has been understudied, while adopting a comprehensive approach to identifying modifiable risk factors for sarcopenia prevention. Given the increasing number of older adults in Indonesia and the high risk of sarcopenia, these findings can serve as a foundation for the development of more effective prevention strategies. Therefore, further research with longitudinal or interventional designs is required to better understand the underlying causal mechanisms.

Healthcare stakeholders can provide nutritional education focusing on adequate calorie intake and high-quality protein consumption to help maintain muscle mass, muscle strength, and optimal physical performance. The daily distribution of protein intake also plays a crucial role in optimizing muscle protein synthesis in older adults. A minimum intake of 25-30 grams of high-quality protein per serving can help overcome anabolic resistance and enhance the muscle protein synthesis response. Additionally, encouraging participation in exercise programs is essential. Resistance training for 16 weeks improves functional fitness. Regular body competition assessments should also be conducted to monitor changes in muscle and fat mass, which are crucial for improving quality of life.

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