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Factors Affecting Sarcopenia in Korean Adults by Age Groups

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Objectives: This study aimed to investigate factors affecting sarcopenia in different age groups among Korean adults aged 20 years or older.
Methods: In this secondary analysis, data were collected from records for 17,968, participants who participated in the Korea National Health and Nutrition Examination Survey during 2008–2011. Data were analyzed using multiple logistic regression to determine the associated factors of sarcopenia by age groups.
Results: The prevalence of sarcopenia increased significantly with age. Physical activity, blood pressure, waist circumference, triglycerides, vitamin D level were found to be factors significantly associated with sarcopenia in all age groups. Total energy intake was found to be a factor that is significantly associated with sarcopenia among the adults aged 20–39 years. Fasting glucose, suicidal ideation, perceived health status, mobility problem, pain/discomfort, total energy intake were found to be factors associated with sarcopenia in the adults aged 40–64 years. Sex, residential area, smoking, drinking, fasting glucose, osteoarthritis, fall experience, usual activity problem, protein intake were factors associated with sarcopenia in the adults over 65 years of age.
Conclusion: The findings show that sarcopenia in adults and the associated factors were different by age groups. Thus, these factors should be considered in the development of intervention programs for the care and prevention of sarcopenia, and such programs should be modified according to different age groups.

Key Words: sarcopenia, age groups, Korea National Health and Nutrition Examination Survey (KNHANES)

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INTRODUCTION

Sarcopenia is an age-related decline in the skeletal muscle mass and muscle strength [1,2]. It results from a disproportionate decrease in skeletal muscle protein synthesis and/or increase in skeletal muscle protein breakdown [3]. The prevalence of sarcopenia in adults over 60 years of age was about 42.0% [4], but the diagnosis of sarcopenia before problems, such as physical functioning or falls occur, is difficult [3]. In addition to changes in the musculoskeletal system due to aging, the imbalance in the nervous system, hormones, and the nutritional status, and the inflammatory state affect the incidence of sarcopenia [5,6]. This results in the impairment of physical function, the risk of falls, and the increased likelihood of admission to long-term care facilities [5–7]. Additionally, a 2-fold increase in the risk of death for every 1 kg/m^2 reduction in muscle mass has been reported [8]. Therefore, sarcopenia has recently been recognized as an important health problem.

Even with a conservative estimate of prevalence, sarcopenia will affect more than 200 million people in the next 40 years [9]; hence, reducing the prevalence of sarcopenia by 10% would result in saving 1.1 billion US dollars per year in United States healthcare costs [10]. Sarcopenia is a serious problem that causes not only health problems and physical disabilities but also high social medical expenditure. Therefore, it is necessary to actively try to prevent the occurrence of sarcopenia, thereby improving the health of the individuals and reducing the burden of medical expenses.

Muscle volume peaks in the third decade of life, gradually decreasing from the fourth decade of life, with a decrease of 8% in the seventh decade of life, and further decreases of 15% every decade thereafter [11]. Sarcopenia is recognized as a problem of aging, and most studies are conducted in the elderly [12,13]. However, the prevalence of sarcopenia is 15%, 25%, 36%, and 38% among the individuals in their 20s, 30s, 40s, and 50s, respectively [14]. This suggests the necessity of research on the prevalence and the influencing factors of sarcopenia among adults in their 20s to 50s.

As individuals get older, it takes longer to grow muscle. This is because the function of hormones and the cellular organelles that promote protein synthesis are impaired. Therefore, it is emphasized that in order to maintain muscle mass and muscle strength in old age, muscles should be exercised as early as possible [2,15]. It is necessary to manage health care for each life cycle to maintain health for a long time by managing muscle mass aggressively, starting from adolescence and middle age.

Most of the previous studies were conducted on elderly people over 60 years of age [12,16], but relatively few studies have focused on differences by age in the general population. Most studies focus on the relationship between sarcopenia and the individual factors [4,17]. There are a few studies that have comprehensively analyzed the influential factors, such as sociodemographics, health behaviors, physical, psychological, and nutritional factors.

The purpose of this study was to explore the prevalence of sarcopenia in different age groups (20–39 years, 40–64 years, and 65 years or older) to compare the prevalence of sarcopenia according to influencing factors, and to examine the age-specific influencing factors for sarcopenia.

MATERIALS AND METHODS

1. Study design

This study is a secondary analysis of data collected in the Fourth and Fifth Korea National Health and Nutrition Examination Survey (KNHANES) conducted during 2008–2011, a nationally representative cross sectional and population-based survey, conducted by the Korea Centers for Disease Control and Prevention (KCDC).

2. Participants

We initially selected those aged 20 years or older, and excluded participants who had any malignancy or were pregnant. Finally, 17,968 participants were included in our analysis.

3. Measurements

1) Sarcopenia

The DXA was used to measure the appendicular skeletal muscle mass (ASM, kg), defined as the sum of the lean soft tissue mass of the arms and legs. Sarcopenia was defined as an ASM/Wt (%) that was less than 1 standard deviation below the mean of a sample of healthy adults aged 20 to 39 years. The reference group of this study included 4,987 healthy adults without any history of chronic diseases, such as diabetes, stroke, coronary artery disease, thyroid disease, arthritis, tuberculosis, asthma, chronic obstructive lung disease, liver cirrhosis, and cancers [18]. The cutoff value for sarcopenia was 30.3% for men and 23.8% for women in this study.

2) Influencing factors

The sociodemographic factors examined include sex (male, female), family structure (with family members, single), residential area (rural, city), socioeconomic status level (high, more than high school and more than household income average; low, below middle school and below household income average, middle; other than that). As health behavior factors, data on current smoking and drinking (< 1 times/month, 1–4 times/month, or ≥ 2 times/week) were analyzed. Physical activity was assessed using the international physical activity questionnaire [19]. The participants were divided into low, medium, and high levels of physical activity based on their total physical activity and the frequency of these activities. The metabolic risk factors were based on the national cholesterol education program adult treatment panel III guidelines, with high blood pressure defined as levels more than 130 mmHg of systolic blood pressure or 85 mmHg diastolic blood pressure, or taking anti-hypertensive medication; abdominal obesity as more than 90 cm for men and 80 cm for women; high fasting glucose levels as more than 100 mg/dL or taking hypoglycemic agent or insulin therapy; high triglyceride levels as more than 150 mg/dL or taking medication for dyslipidemia treatment; low level of high density lipoprotein (HDL)-cholesterol as less than 40 mg/dL for men and 50 mg/dL for women or taking medication for dyslipidemia treatment [20]. Osteoarthritis

Table 1. Differences in characteristics by age groups (n = 17,968)

Characteristic		20–39 y (n = 5,802)	40–64 y (n = 8,265)	Over 65 y (n = 3,901)	χ^{2*}
Sex	Female	3,306 (47.6)	4,657 (49.4)	2,259 (59.7)	108.50
	Male	2,496 (52.4)	3,608 (50.6)	1,642 (40.3)	
Family structure	With family members	5,561 (94.9)	7,902 (96.5)	3,200 (84.1)	527.60
	Single	238 (5.1)	349 (3.5)	693 (15.9)	
Residential area	Rural	773 (12.0)	2,002 (22.0)	1,566 (36.1)	707.23
	City	5,029 (88.0)	6,263 (78.0)	2,335 (63.9)	
SES level	High	3,711 (62.9)	3,457 (43.5)	265 (6.2)	5,210.64
	Medium	1,899 (35.1)	2,798 (35.9)	935 (26.2)	
	Low	106 (2.0)	1,869 (20.6)	2,562 (67.6)	
Current smoking	Yes	1,623 (33.1)	1,786 (25.7)	548 (14.8)	316.87
Drinking (time)	< 1/mo	2,012 (31.7)	3,637 (40.6)	2,521 (66.8)	1,154.29
	1–4/mo	2,536 (46.0)	2,563 (32.0)	583 (14.8)	
	≥ 2/wk	1,206 (22.3)	1,998 (27.4)	723 (18.4)	
Physical activity	High	1,541 (28.9)	2,584 (31.7)	861 (20.6)	126.60
	Medium	1,985 (34.8)	2,577 (31.0)	1,340 (35.2)	
	Low	2,254 (36.3)	3,053 (37.3)	1,630 (44.2)	
Metabolic syndrome					
Blood pressure	Low	4,946 (83.5)	4,591 (56.2)	1,103 (27.6)	2,798.59
	High	856 (16.5)	3,673 (43.8)	2,796 (72.4)	
Waist circumference	Not AO	4,574 (79.9)	4,942 (62.1)	1,997 (49.5)	981.74
	AO	1,205 (20.1)	3,299 (37.9)	1,889 (50.5)	
Fasting glucose	Low	5,060 (89.2)	5,429 (66.9)	1,954 (53.2)	1,584.35
	High	621 (10.8)	2,654 (33.1)	1,635 (46.8)	
Triglyceride	Low	4,583 (79.3)	5,186 (63.2)	2,110 (58.1)	607.96
	High	1,104 (20.7)	2,905 (36.8)	1,467 (41.9)	
HDL cholesterol	High	4,395 (78.7)	5,362 (68.2)	1,907 (52.9)	576.36
	Low	1,292 (21.3)	2,729 (31.8)	1,670 (47.1)	
Osteoarthritis	Yes	110 (1.9)	1,176 (12.2)	1,344 (35.3)	2,039.79
Fall experience	Yes	58 (1.1)	116 (1.5)	109 (2.5)	23.80
Depression	Yes	678 (11.5)	1,184 (13.9)	674 (17.8)	62.39
Stress	Many	1,993 (34.0)	2,199 (26.6)	855 (22.9)	152.28
Suicidal ideation	Yes	785 (13.1)	1,233 (14.6)	938 (25.7)	222.28
Perceived health status	Good	2,520 (44.3)	3,196 (38.1)	1,225 (32.8)	718.73
	Fair	2,508 (42.9)	3,286 (42.1)	1,140 (29.7)	
	Poor	750 (12.8)	1,735 (19.8)	1,473 (37.5)	
Quality of life	Mobility problem	151 (2.6)	1,006 (10.8)	1,733 (46.4)	3,211.35
	Self-care problem	26 (0.4)	194 (2.2)	525 (13.7)	1,118.47
	Usual activity problem	94 (1.7)	578 (6.3)	1,138 (30.4)	2,135.31
	Pain/discomfort	758 (12.7)	1,868 (21.1)	1,690 (43.7)	1,038.20
	Anxiety/depression	450 (7.8)	894 (10.1)	618 (15.7)	124.68
Total energy (kcal/day)	≥ 3,000	656 (15.6)	715 (11.7)	111 (2.9)	624.26
	2,000–3,000	1,525 (32.0)	2,233 (31.2)	698 (18.7)	
	1,000–2,000	2,316 (44.2)	3,834 (50.5)	2,324 (62.0)	
	< 1,000	407 (8.2)	502 (6.6)	517 (15.9)	
Protein (g/kg/day)	≥ 1.2	2,086 (42.8)	2,561 (36.6)	726 (19.0)	606.37
	0.8–1.2	1,524 (30.3)	2,545 (34.7)	1,143 (30.5)	
	< 0.8	1,294 (26.9)	2,178 (28.7)	1,781 (50.5)	
Vitamin D (ng/mL)	≥ 20	1,574 (26.5)	3,314 (40.2)	1,736 (46.4)	443.73
	< 20	4,113 (73.5)	4,764 (59.8)	1,813 (53.6)	
Sarcopenia		1,080 (19.2)	2,484 (29.1)	1,619 (42.3)	532.72

Values are presented number of unweighted sample size (weighted percent) the discrepancy between number and total number is due to missing value.
SES, socioeconomic status; AO, abdominal obesity; HDL, high density lipoprotein.
*Rao-Scott χ^2-test; $p < 0.001$.

and fall experience coded as "yes" or "no". The psychological factors examined included depression for two consecutive weeks in the past year, the degree of stress (less, many), suicidal ideation for the last year, and perceived health status (good, fair, poor). The quality of life was defined based on the answers of "having problems (including some problems)" and "no problems" to mobility, self-care, usual activity, pain/discomfort, and anxiety/depression in the EQ-5D Questionnaire. Nutritional factors, such as total energy and protein were measured by the single 24-hour dietary recall method. Vitamin D levels were measured using serum 25-hydroxyvitamin D concentration.

4. Statistical analysis

Data analysis was performed using IBM SPSS Statistics for Windows, version 20.0 (IBM Co., Armonk, NY, USA). In order to calculate the total population that the sample would represent, we employed the stratification variables and sampling weights designated by the KCDC. All data were described as unweighted frequency, and weighted percentage. Rao-Scott χ^2-test for categorical variables was performed. Multiple logistic regression analyses were used to identify the influencing factors of sarcopenia according to age groups.

RESULTS

1. Differences in characteristics by age groups

A total of 17,968 Korean adults aged 20 years or older were included in this study: 5,802, 8,265, and 3,901 participants, belonged to the 20–39, 40–64, and 65 years or older age groups. The number of men was more than that of women in the 20–39 and 40–64 age groups, while it was the opposite in the over 65 age group. Most participants of all age groups lived with their families and in cities. The rates of low socioeconomic status level and low physical activity increased with age. The rates of high blood pressure, abdominal obesity, high fasting glucose, high triglyceride, and low HDL cholesterol were the highest in the 65 years old or older age group. Additionally, the rates of osteoarthritis, serum vitamin D levels, fall experience, depression, and suicidal ideation increased with age, while the rate of high stress and perceived good health status, daily total energy and protein intake decreased. The percentage of respondents who answered "with a problem" in the five domains of quality of life increased with age (Table 1).

2. Prevalence of sarcopenia based on characteristics by age groups

The rate of sarcopenia increased with age (19.2%, 29.1%, and 42.3% among the 20–39, 40–64, and 65 and older age groups, respectively) (Table 1).

As a result of confirming the prevalence of sarcopenia in the participants, significant variables were different for each age group (Table 2). In the 20–39 age group, the prevalence of sarcopenia was higher in men and in participants with low socioeconomic status, with current smoking, frequent drinking, low physical activity, high blood pressure, abdominal obesity, diabetes, dyslipidemia, and low HDL cholesterol. In addition, sarcopenia was more prevalent among those with high levels of stress, poor-perceived health status, problems in mobility and usual activity, pain or discomfort. The prevalence of sarcopenia was significantly higher when daily energy and protein intake or serum vitamin D levels were lower. In the 40–64 age group, the prevalence of sarcopenia was higher in women and in participants living alone, with low socioeconomic status, no current smoking, less frequent drinking, low physical activity, high blood pressure, abdominal obesity, diabetes, dyslipidemia, low HDL cholesterol and osteoarthritis than other participants. In addition, sarcopenia was more prevalent among those with depression, suicidal ideation, perceived poor health, having a problem with mobility, self-care and usual activity, and anxiety or depression. The prevalence of sarcopenia was significantly higher when daily energy and protein intake or serum vitamin D levels were lower. Additionally, in the 65 years or older age group, the prevalence of sarcopenia was higher in participants living in the city, with no current smoking, less frequent drinking, low physical activity, high blood pressure, abdominal obesity, diabetes, dyslipidemia, low HDL cholesterol, osteoarthritis and fall experience. The prevalence of sarcopenia was higher in participants having problems with mobility, self-care, usual activity, and pain or discomfort. However, sarcopenia was less prevalent among those with depression and suicidal ideation. The prevalence of sarcopenia was significantly higher when the daily energy and protein intake or the serum vitamin D level was lower.

3. Factors affecting sarcopenia by age groups

As a result of multiple logistic regression analysis, the influencing factors of sarcopenia were different for each age group (Table 3). In the 20–39 age group, significant influencing factors were low physical activity (odds ratio [OR], 1.338; 95% confidence interval [CI], 1.060–1.689), high blood pressure (OR, 1.738; 95% CI, 1.335–2.263), abdominal obesity (OR, 4.236; 95% CI, 3.398–5.281), and high triglycerides (OR, 1.683; 95% CI, 1.322–2.144). Additionally, low energy intake and low serum vitamin D level (OR, 1.290; 95% CI, 1.034–1.609) had a significant effect on sarcopenia. In the 40–64 age group, the risk of sarcopenia in men was 1.329 times (95% CI, 1.112–1.590)

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Table 2. Prevalence of sarcopenia based on characteristics by age groups (n = 17,968)

Characteristic	Category	20–39 y (n = 5,802)			40–64 y (n = 8,265)			Over 65 y (n = 3,901)		
		n (%)	W %	χ^{2*} (p)	n (%)	W %	χ^{2*} (p)	n (%)	W %	χ^{2*} (p)
Sex	Female	565 (43.9)	17.7	7.42 (0.020)	1,441 (52.2)	30.8	10.94 (0.006)	920 (59.1)	41.8	0.45 (0.566)
	Male	515 (56.1)	20.5		1,043 (47.8)	27.5		699 (40.9)	42.9	
Family structure	With family members	1,038 (95.1)	19.2	0.15 (0.747)	2,354 (95.7)	28.9	5.60 (0.039)	1,340 (84.3)	42.4	0.13 (0.746)
	Single	41 (4.9)	18.3		127 (4.3)	35.3		275 (15.7)	41.6	
Residential area	Rural	118 (10.2)	16.2	4.39 (0.128)	568 (21.5)	28.5	0.46 (0.717)	529 (29.5)	34.5	54.72 (< 0.001)
	City	962 (89.8)	19.6		1,916 (78.5)	29.3		1,090 (70.5)	46.7	
SES level	High	667 (59.1)	18.0	13.96 (0.012)	945 (39.6)	26.5	31.09 (< 0.001)	125 (6.6)	45.0	7.15 (0.126)
	Medium	372 (37.9)	20.7		843 (36.3)	29.5		427 (28.2)	45.5	
	Low	26 (3.1)	29.5		651 (24.0)	34.0		1,008 (65.2)	40.8	
Current smoking	No	729 (63.5)	18.2	7.07 (0.029)	1,974 (76.6)	30.1	9.26 (0.015)	1,420 (89.3)	44.4	36.88 (< 0.001)
	Yes	347 (36.5)	21.1		495 (23.4)	26.6		172 (10.7)	30.7	
Drinking (time)	< 1/mo	361 (30.7)	18.5	8.81 (0.031)	1,154 (43.9)	31.5	16.75 (0.002)	1,089 (69.7)	44.1	15.85 (0.006)
	1–4/mo	457 (43.6)	18.1		726 (29.4)	26.8		246 (14.7)	42.1	
	≥ 2/week	249 (25.6)	21.9		580 (26.6)	28.3		252 (15.6)	35.8	
Physical activity	High	251 (24.8)	16.5	15.87 (0.006)	641 (26.1)	24.0	53.20 (< 0.001)	265 (15.4)	31.6	49.73 (< 0.001)
	Medium	369 (34.3)	18.9		808 (32.3)	30.4		582 (36.3)	43.6	
	Low	456 (40.9)	21.6		1,020 (41.6)	32.6		745 (48.4)	46.4	
Metabolic syndrome										
Blood pressure	Low	813 (73.3)	16.8	105.13 (<0.001)	1,123 (45.3)	23.5	161.52 (< 0.001)	340 (20.1)	30.9	79.69 (< 0.001)
	High	267 (26.7)	31.1		1,361 (54.7)	36.3		1,279 (79.9)	46.7	
Waist circumference	Not AO	589 (54.1)	13.0	568.38 (< 0.001)	967 (40.2)	18.8	689.44 (< 0.001)	520 (29.7)	25.4	446.20 (< 0.001)
	AO	486 (45.9)	43.8		1,507 (59.8)	45.9		1,095 (70.3)	58.9	
Fasting glucose	Low	884 (84.0)	18.1	39.02 (< 0.001)	1,432 (58.5)	25.3	103.69 (< 0.001)	676 (44.7)	35.5	74.84 (< 0.001)
	High	174 (16.0)	28.6		980 (41.5)	36.2		803 (55.3)	49.8	
Triglyceride	Low	716 (65.3)	15.8	162.86 (< 0.001)	1,319 (53.1)	24.3	142.91 (< 0.001)	740 (49.9)	36.0	72.49 (< 0.001)
	High	343 (34.7)	32.2		1,098 (46.9)	36.8		731 (50.1)	50.2	
HDL cholesterol	High	761 (73.2)	17.8	25.09 (< 0.001)	1,418 (60.8)	25.8	83.37 (< 0.001)	695 (48.0)	38.1	24.67 (< 0.001)
	Low	298 (26.8)	24.2		999 (39.2)	35.6		776 (52.0)	46.3	
Osteoarthritis	No	1,053 (97.8)	19.0	0.70 (0.476)	2,047 (84.7)	28.2	29.84 (< 0.001)	954 (59.5)	38.9	34.44 (< 0.001)
	Yes	22 (2.2)	22.2		427 (15.3)	36.5		647 (40.5)	48.6	
Fall experience	No	1,067 (98.8)	19.2	0.03 (0.871)	2,443 (98.5)	29.1	0.06 (0.833)	1,553 (96.5)	41.8	12.68 (0.002)
	Yes	13 (1.2)	20.0		41 (1.5)	30.1		66 (3.5)	59.8	

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Table 2. Continued

Characteristic	Category	20–39 y (n = 5,802)			40–64 y (n = 8,265)			Over 65 y (n = 3,901)		
		n (%)	W %	χ^{2*} (*p*)	n (%)	W %	χ^{2*} (*p*)	n (%)	W %	χ^{2*} (*p*)
Depression	No	949 (87.7)	19.0	0.75 (0.416)	2,067 (83.9)	28.4	14.51 (0.001)	1,344 (84.1)	43.3	6.93 (0.029)
	Yes	127 (12.3)	20.4		404 (16.1)	34.0		248 (15.9)	37.8	
Stress	Less	664 (60.2)	17.5	20.42 (< 0.001)	1,775 (71.6)	28.5	5.59 (0.051)	1,261 (78.9)	43.4	5.27 (0.065)
	Many	412 (39.8)	22.4		697 (28.4)	31.2		331 (21.1)	39.0	
Suicidal ideation	No	922 (85.8)	18.9	1.43 (0.313)	2,029 (81.8)	27.9	35.99 (< 0.001)	1,234 (76.5)	43.6	7.51 (0.038)
	Yes	154 (14.2)	20.7		440 (18.2)	36.5		357 (23.5)	38.6	
Perceived health status	Good	399 (38.2)	16.5	25.82 (< 0.001)	826 (32.4)	24.8	70.25 (< 0.001)	476 (31.4)	40.6	6.80 (0.098)
	Fair	511 (45.7)	20.4		1,009 (43.0)	29.8		467 (28.6)	40.8	
	Poor	165 (16.2)	24.1		636 (24.6)	36.4		651 (39.9)	45.0	
Quality of life										
Mobility problem	No	1,031 (95.5)	18.8	18.74 (0.001)	2,058 (84.7)	27.7	69.48 (< 0.001)	804 (49.3)	38.9	21.15 (< 0.001)
	Yes	44 (4.5)	32.8		413 (15.3)	41.2		788 (50.7)	46.2	
Self-care problem	No	1,068 (99.3)	19.1	1.55 (0.281)	2,393 (97.1)	29.0	8.52 (0.012)	1,348 (84.4)	41.4	8.48 (0.021)
	Yes	7 (0.7)	28.8		78 (2.9)	39.0		244 (15.6)	48.1	
Usual activity problem	No	1,051 (97.5)	19.0	6.36 (0.038)	2,228 (91.2)	28.4	35.61 (< 0.001)	1,062 (66.5)	40.4	12.56 (0.006)
	Yes	24 (2.5)	29.1		242 (8.8)	40.8		530 (33.5)	46.6	
Pain/ discomfort	No	909 (84.0)	18.4	13.12 (0.003)	1,858 (77.3)	28.6	4.80 (0.060)	857 (54.0)	40.6	6.04 (0.035)
	Yes	166 (16.0)	24.0		612 (22.7)	31.3		735 (46.0)	44.5	
Anxiety/ depression	No	987 (91.8)	19.0	0.29 (0.646)	2,145 (87.8)	28.5	16.22 (0.001)	1,340 (84.5)	42.4	0.11 (0.759)
	Yes	88 (8.2)	20.1		325 (12.2)	35.2		252 (15.5)	41.7	
Total energy (kcal/day)	≥ 3,000	102 (12.4)	14.9	22.38 (0.005)	184 (9.9)	24.8	24.6 (0.002)	34 (2.1)	30.4	14.10 (0.025)
	2,000–3,000	263 (29.1)	17.1		631 (29.4)	27.7		263 (16.8)	38.3	
	1,000–2,000	445 (47.9)	20.3		1,204 (52.7)	30.7		1,010 (64.2)	43.7	
	< 1,000	93 (10.6)	24.4		190 (8.0)	35.7		220 (16.9)	45.1	
Protein (g/kg/day)	≥ 1.2	300 (32.5)	14.3	63.70 (< 0.001)	656 (31.4)	25.2	54.07 (< 0.001)	229 (13.9)	31.2	60.60 (< 0.001)
	0.8-1.2	286 (31.5)	19.5		756 (34.4)	29.1		456 (29.1)	40.6	
	< 0.8	317 (36.0)	25.1		797 (34.2)	35.0		842 (57.0)	48.0	
Vitamin D (ng/mL)	≥ 20	252 (21.5)	15.6	17.42 (< 0.001)	874 (35.7)	25.6	28.42 (< 0.001)	568 (38.0)	34.3	71.81 (< 0.001)
	< 20	807 (78.5)	20.5		1,536 (64.3)	31.1		885 (62.0)	48.3	

n, unweighted sample size; W %, weighted percent; SES, socioeconomic status; AO, abdominal obesity; HDL, high density lipoprotein.
The discrepancy between number and total number is due to missing value; *Rao-Scott χ^2-test.

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Table 3. Factors affecting sarcopenia by age groups (n = 17,968)

Characteristic	Category (ref.)	20–39 y (n = 5,802)	40–64 y (n = 8,265)	Over 65 y (n = 3,901)
Sex	Male (Female)	1.100 (0.824–1.467)	1.329* (1.112–1.590)	3.293** (2.551–4.251)
Family structure	Single (With family members)	1.147 (0.789–1.666)	1.222 (0.872–1.712)	1.004 (0.775–1.301)
Residential area	City (Rural)	1.362 (0.962–1.928)	1.109 (0.880–1.396)	1.442* (1.094–1.901)
SES level	Medium (High)	1.148 (0.943–1.399)	1.056 (0.906–1.231)	1.000 (0.665–1.505)
	Low (High)	1.304 (0.676–2.513)	1.002 (0.824–1.219)	0.837 (0.552–1.268)
Current smoking	Yes (No)	1.138 (0.878–1.475)	0.848 (0.707–1.016)	0.613* (0.453–0.831)
Drinking (time)	1–4/mo (< 1/mo)	0.983 (0.792–1.218)	0.875 (0.749–1.021)	0.749* (0.577–0.973)
	≥ 2/wk	0.937 (0.724–1.212)	0.946 (0.791–1.132)	0.811 (0.612–1.075)
Physical activity	Medium (High)	1.275 (0.997–1.630)	1.251* (1.052–1.488)	1.364* (1.039–1.792)
	Low (High)	1.338* (1.060–1.689)	1.327* (1.118–1.576)	1.440* (1.076–1.926)
Metabolic syndrome				
Blood pressure	High (Low)	1.738** (1.335–2.263)	1.476** (1.291–1.688)	1.549** (1.249–1.921)
Waist circumference	AO (Not AO)	4.236** (3.398–5.281)	3.186** (2.731–3.716)	4.705** (3.753–5.898)
Fasting glucose	High (Low)	1.092 (0.806–1.480)	1.174* (1.010–1.364)	1.234* (1.010–1.508)
Triglyceride	High (Low)	1.683** (1.322–2.144)	1.329** (1.138–1.550)	1.375* (1.108–1.704)
HDL cholesterol	Low (High)	0.819 (0.657–1.022)	1.046 (0.896–1.221)	0.929 (0.754–1.145)
Osteoarthritis	Yes (No)	0.933 (0.495–1.757)	1.046 (0.864–1.266)	1.323* (1.066–1.642)
Fall experience	Yes (No)	1.039 (0.511–2.115)	0.871 (0.511–1.485)	2.048* (1.118–3.748)
Depression	Yes (No)	1.013 (0.740–1.387)	0.959 (0.779–1.180)	1.262 (0.955–1.669)
Stress	Many (Less)	1.202 (0.983–1.469)	0.977 (0.832–1.148)	0.952 (0.732–1.238)
Suicidal ideation	Yes (No)	1.015 (0.744–1.385)	1.362* (1.125–1.650)	0.785 (0.591–1.043)
Perceived health status	Fair (Good)	1.043 (0.853–1.275)	1.154 (0.988–1.349)	0.954 (0.754–1.207)
	Poor (Good)	1.073 (0.819–1.405)	1.258* (1.036–1.527)	1.175 (0.911–1.515)
Quality of life				
Mobility problem	Yes (No)	1.373 (0.779–2.418)	1.288* (1.020–1.627)	1.053 (0.815–1.361)
Self-care problem	Yes (No)	1.284 (0.373–4.428)	0.774 (0.497–1.206)	1.282 (0.904–1.819)
Usual activity problem	Yes (No)	0.891 (0.395–2.006)	1.345 (0.996–1.817)	1.330* (1.005–1.759)
Pain/ discomfort	Yes (No)	1.183 (0.901–1.555)	0.782* (0.646–0.948)	0.875 (0.685–1.118)
Anxiety/depression	Yes (No)	1.016 (0.710–1.453)	0.944 (0.749–1.190)	1.028 (0.776–1.363)
Total energy (kcal/day)	2,000–3,000 (≥ 3,000)	1.303 (0.909–1.869)	1.297* (1.002–1.679)	1.050 (0.561–1.966)
	1,000–2,000 (≥ 3,000)	1.761* (1.101–2.819)	1.462* (1.095–1.953)	1.255 (0.666–2.366)
	< 1,000 (≥ 3,000)	2.153* (1.141–4.065)	1.629* (1.079–2.460)	1.310 (0.630–2.722)
Protein (g/day)	0.8–1.2 (≥ 1.2)	1.047 (0.796–1.377)	0.891 (0.738–1.077)	1.371 (0.995–1.888)
	< 0.8 (≥ 1.2)	1.059 (0.744–1.505)	0.920 (0.735–1.153)	1.445* (1.026–2.033)
Vitamin D (ng/mL)	< 20 (≥ 20)	1.290* (1.034–1.609)	1.381** (1.182–1.615)	1.677** (1.375–2.044)

Values are presented as odds ratio (95% confidence interval).
n, unweighted sample size; SES, socioeconomic status; AO, abdominal obesity; HDL, high density lipoprotein.
All data were weighted to the residential population of Korea.
*$p < 0.05$, **$p < 0.01$.

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higher than in women. Additionally, medium physical activity (OR, 1.251; 95% CI, 1.052–1.488), low physical activity (OR, 1.327; 95% CI, 1.118–1.576), high blood pressure (OR, 1.476; 95% CI, 1.291–1.688), abdominal obesity (OR, 3.186; 95% CI, 2.731–3.716), diabetes mellitus (OR, 1.174; 95% CI, 1.010–1.364) and dyslipidemia (OR, 1.329; 95% CI, 1.138–1.550) were associated with a high risk of sarcopenia. Suicidal ideation (OR, 1.362; 95% CI, 1.125–1.650), perceived poor health status (OR, 1.258; 95% CI, 1.036–1.527), and mobility problems (OR, 1.288; 95% CI, 1.020–1.627) had a significant effect on sarcopenia. Low energy intake and low serum vitamin D level (OR, 1.381; 95% CI, 1.182–1.615) also had a significant effect on sarcopenia. In the 65 years or older age group, the risk of sarcopenia was 3.293 times (95% CI, 2.551–4.251) higher in men and 1.442 times (95% CI, 1.094–1.901) higher in city dwellers. Additionally, medium physical activity (OR, 1.364; 95% CI, 1.039–1.792), low physical activity (OR, 1.440; 95% CI, 1.076–1.926), high blood pressure (OR, 1.549; 95% CI, 1.249–1.921), abdominal obesity (OR, 4.705; 95% CI, 3.753–5.898), diabetes mellitus (OR, 1.234; 95% CI, 1.010–1.508), and dyslipidemia (OR, 1.375; 95% CI, 1.108–1.704) were associated with high risk of sarcopenia. Osteoarthritis (OR, 1.323; 95% CI, 1.066–1.642), fall experience (OR, 2.048; 95% CI, 1.118–3.748), usual activity problems (OR, 1.330; 95% CI, 1.005–1.759), low protein intake (OR, 1.45; 95% CI, 1.026–2.033), and low serum vitamin D level (OR, 1.677; 95% CI, 1.375–2.044) had significant effects on sarcopenia.

DISCUSSION

This study showed that the prevalence of sarcopenia increased with increasing age, consistent with the findings of domestic and international studies [14,21]. As age increases, muscle mass and muscle strength are known to decrease even when there is no change in body weight [22]. Muscular exercises should be performed as early as possible to maintain muscle mass and muscle strength in old age [2,15], and a preventive approach is needed.

This study found that the factors associated with sarcopenia differ by age. The risk of sarcopenia was significantly higher in men than in women in the 40–64 and 65 or older age groups. Total limb muscle decreases more in men than in women [19], and the decrease in total body potassium, an indicator of the amount of skeletal muscle, is known to be faster in men than in women [23]. Physical activity had significant influence on sarcopenia in all age groups. This is consistent with the findings of other domestic and international studies [24,25]. Limited physical activity reduces the number and size of muscle fibers as muscle cells die and physical stimuli decrease [26], and if the activity of the resting level lasts more than 7 days, it results in the loss of 30% of the muscle mass [27]. It may be necessary to consider the application of a combined exercise program to increase muscle mass and muscle function [28,29]. As sarcopenia is caused by lack of muscle accumulation in young people, health education that increases physical activity needs to be emphasized for them [30].

Blood pressure, waist circumference, and triglycerides had significant influence on sarcopenia in all age groups. These results are consistent with those of previous research [12,20]. The relationship between sarcopenia and hypertension in young people had not been studied previously, and a direct comparison with this study was difficult. However, since the prevalence of hypertension in young adults has been increasing steadily, further research on this is needed. In addition, increased visceral fat and chronic inflammation with increased age are suspected to be the cause of sarcopenia, which can explain the correlation between abdominal obesity and sarcopenia according to the redistribution of fat in the elderly [2]. In this study, the risk of sarcopenia was high when fasting blood glucose was high in the middle-aged and elderly groups. Insulin resistance causes sarcopenia by inhibiting the intracellular transport of amino acids that play an important role in protein synthesis [15]. Aerobic exercise has a positive effect on controlling blood glucose by reducing insulin resistance in patients with type 2 diabetes [31]. Therefore, it is necessary to inform individuals that exercise therapy can aid not only maintaining proper blood glucose levels but may also prevent sarcopenia.

In this study, the risk of sarcopenia was higher in patients 65 years or older with a history of osteoarthritis. Not using the painful joints would reduce muscle strength and muscle mass. Fall experience had a significant effect on sarcopenia only among those aged 65 and older. As the age increases, muscle atrophy exacerbates the risk of falls by causing balance disorders. As agility and flexibility are reduced and the reaction rate is slowed, injury related to falls increase [25]. The risk of falls may increase due to sarcopenia. However, fractures due to falls and fear of recurring falls may result in a decreased physical activity, which may then lead to sarcopenia. Therefore, further studies are necessary to confirm the effect of fall experience on sarcopenia.

In the 40–64 years old group, the risk of sarcopenia was significantly higher among participants with suicidal ideation, poor perceived health status, and mobility problems. This was in part consistent with the previous findings that patients with sarcopenic obesity are more likely to perceive stress and increased suicidal ideation, indicating a negative correlation with quality of life [18]. There is a limited, but confirmed, to the causal relationship between psychological health and sarcopenia.

In this study, the lower the serum vitamin D level, the higher

was the risk of sarcopenia, for all age groups. Vitamin D is known to bind to vitamin D receptors in the muscle cells to promote protein synthesis and stimulate calcium mobilization through the cell membrane [32]. Vitamin D deficiency is thought to occur because people spend more time using indoor devices like smart phones and internet, or working indoors in urban areas. This phenomenon is expected to occur in young people, and it is necessary to develop an intervention program that can complement the vitamin D deficiency.

This study showed that the factors influencing sarcopenia differed by age groups. This suggests that it is necessary to provide an intervention program for muscle health based on the life cycle. The 20–39 years old group is not concerned about muscle loss. The social atmosphere favoring a skinny body, excessive diet, caffeinated beverages, and instant food-based diets expose individuals to the risk of muscle loss as well as poor bone health. Therefore, it is necessary to educate people in this age group about the importance of avoiding excessive diets, maintaining appropriate nutrition and exercise, while conducting continuous research on sarcopenia to develop effective intervention programs. During the middle-aged stage, there is lack of time to take the necessary health actions because of the socioeconomic activities. The results of this study showed that psychological health factors as well as physical health factors influenced the occurrence of sarcopenia in the 40–64 years old age group. Therefore, we believe that it is necessary to develop an intervention program to prevent the sarcopenia and to prepare for a healthy old age through proper exercise, blood pressure and diabetes management, and positive mental health. Osteoarthritis and fall experience in the age group of 65 years or older were characteristic factors indicating sarcopenia. As individuals get older, their bone density and muscle mass decreases, and fat increases. However, if the loss of muscle mass is minimized and strength maintained through appropriate physical activity, secondary health problems could be prevented, leading to a healthier and livelier life.

Using the KNHANES, which is representative of Korean adults, we comprehensively identified the prevalence and related factors of sarcopenia by age groups. In addition, it can provide a basis for the development of optimal intervention programs to prevent sarcopenia in each age group. Our study has several limitations. First, sarcopenia should be assessed taking into account both the muscle mass and muscle strength. However, because the KNHANES did not measure muscle strength, it was not possible to select participants for sarcopenia. Furthermore, changes in time should be considered for sarcopenia. However, in this study, because cross-sectional data was analyzed, there was a limit to checking causality between variables. It is recommended that similar studies are conducted in the future using the diagnostic criteria that consider both muscle mass and muscle strength to identify the factors affecting sarcopenia in different age groups. Additionally, we suggest that intervention programs to reduce sarcopenia should be developed by taking into account the influencing factors for each age group and the effects of such interventions should be evaluated.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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