27. Cesari M, Kritchevsky SB, Newman AB *et al* Added value of physical performance measures in predicting adverse health-related events: results from the health, aging and body composition study. J Am Geriatr Soc 2009; 57: 251–9.

28. Greenlund LJS, Nair KS. Sarcopenia: consequences, mechanisms, and potential therapies. Mech Ageing Develop 2003; 124: 287–99.

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Association of physical activity with sarcopenia and sarcopenic obesity in community-dwelling older adults: the Fourth Korea National Health and Nutrition Examination Survey

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Abstract

Objective: this study examined the association of physical activity with sarcopenia and sarcopenic obesity among the community-dwelling Korean elderly.
Methods: subjects consisted of 2,264 aged 65 years or older in the 2008–09 Korea National Health and Nutrition Examination Survey. Sarcopenia was defined as 2 SD below the mean of the appendicular skeletal muscle/weight for healthy young adults. Obesity was defined as waist circumference ≥90 cm for men and ≥85 cm for women. Levels of physical activity were classified using the metabolic equivalent task method.
Results: the prevalence of sarcopenia was 12.1% in men and 11.9% in women. Among those with sarcopenia, obesity was prevalent in 68.3% of men and 65.0% of women. Adjusting for all covariates, compared with those with low physical activity, men who engaged in moderate and high activity were 38% and 74%, respectively, less likely to have sarcopenia ($P_{trend} < 0.001$). In women, the relationship between physical activity and sarcopenia was not significant. For sarcopenic obesity, men participating in moderate [odds ratio (OR) = 0.47; 95% confidence interval (CI) 0.26–0.87] and high (OR = 0.27; 95% CI: 0.12–0.60) physical activity, compared with low activity, had significantly lower risk ($P_{trend} = 0.001$). In women, high physical activity was associated with a lower risk of sarcopenic obesity (OR = 0.43; 95% CI: 0.22–0.86).
Conclusion: physical activity is associated with a reduced risk of sarcopenia and sarcopenic obesity in older Korean adults. There were gender differences in the relationship, with stronger associations observed in men than in women.

Keywords: *sarcopenia, sarcopenic obesity, physical activity, aged, older people*

Introduction

Sarcopenia is an age-related condition characterized by the loss of the muscle mass, often accompanied by a decline in voluntary muscle strength and increase in the fat mass [1, 2]. The prevalence of sarcopenia increases with age [3], which places older individuals at risk for frailty, falls and disability [4]. Moreover, ageing-associated changes in body composition, with an increase in body fat mass, raise cardio-metabolic risks and may induce obesity, increasing the risk of developing functional limitations [5, 6]. With the rise in the prevalence of obesity in the older population, obesity co-occurring among those with sarcopenia, defined as sarcopenic obesity, may further increase the risk of disability and mortality [7].

Accumulating evidence suggests that sarcopenia and sarcopenic obesity are potentially modifiable [4]. Among the risk factors physical inactivity has gained wide attention as a possible target for intervention to slow down the progression of age-dependent muscle loss [8]. A number of cross-sectional and longitudinal studies have shown low levels of physical inactivity to be associated with sarcopenia [9–12]. Intervention studies also have found exercise to increase muscle mass and strength in old age [13]. Identifying levels of physical activity that would be beneficial in delaying progression of muscle loss in the general older population would be important.

Currently, the majority of studies on the association between sarcopenia and physical activity are from Western countries. Korea is rapidly ageing, with people aged 65 years and older comprising 11.0% of the population in 2010, but projected to increase to 24.3% in 2030 and reach 37.4% in 2050 [14]. In a nationwide survey of people aged 65 years and older, the prevalence of sarcopenia was estimated to be 9.7% for men and 11.8% for women [3]. The prevalence of sarcopenic obesity was 7.6% of men and 9.1% in women. Despite the high prevalence, there have been few epidemiological studies investigating sarcopenia or sarcopenic obesity among older Koreans [15–17], and their association with physical activity is largely unknown.

This study examined the association of sarcopenia and sarcopenic obesity with physical activity among people aged 65 years and older living in the community, using a nationwide survey conducted in South Korea. Because of the prevalence of sarcopenia and participation rates in physical activity differ between older men and women, gender differences in the association of sarcopenia and sarcopenic obesity with physical activity were investigated.

Materials and methods

Data source

Data were from the Fourth Korea National Health and Nutrition Examination Survey (KNHANES IV). KNHANES IV is a cross-sectional survey based on a nationally representative sample of non-institutionalized Koreans in 2007–09, conducted by the Korea Centers for Disease Control and Prevention [18]. This study included 11 253 participants aged 10–93 years who underwent medical examinations for the measurement of body composition from July 2008 to December 2009. Of these participants, 8,914 aged < 65 years and 75 with missing data were excluded. The final analytical sample consisted of 2,264 (men: 940, women: 1,324).

Data collection

Anthropometric measurements were taken by trained examiners. Height, body weight and waist circumference of all participants were recorded. The body mass index (BMI) was calculated using measured weight and height values (kg/m^2). Waist circumference (WC) was measured at mid-point between the borders of the lowermost rib and the uppermost lateral border of the ilium to the nearest 0.1 cm at the end of normal expiration.

Participants were asked about their demographic characteristics such as age, gender, education level (≤primary school, middle school and ≥high school), smoking status (never smoker, ex-smoker and current smoker) and alcohol drinking (never-drinker and ever-drinker). The presence of chronic conditions, including diabetes mellitus, hypertension, hyperlipidaemia, heart disease (myocardial infarction and angina) and stroke, was also recorded.

Serum was separated from peripheral venous blood samples obtained after 12 h of fasting. Fasting blood glucose, total cholesterol, triglyceride and high-density lipoprotein (HDL) cholesterol were measured using Hitachi-7600 analyzer (Hitachi Ltd., Tokyo, Japan). Both systolic and diastolic blood pressure was measured after a 15-min rest.

Definitions of sarcopenia, sarcopenic obesity and physical activity

Whole-body composition was estimated using dual-energy X-ray absorptiometry (DISCOVERY-W fan-beam densitometer, Hologic, Inc., USA). Appendicular skeletal muscle (ASM) was calculated as the sum of the muscle mass in arms and legs, assuming that all non-fat and non-bone tissue is skeletal muscle.

To define the status of sarcopenia, we used the body weight-adjusted ASM [3, 16]. To estimate the cut-off value of sarcopenia, the mean and standard deviation (SD) of the ASM/weight × 100 of the young reference group (healthy men and women aged 20–39 years, $n = 3366$) were used [3, 19]. To select the healthy reference, those who had any history of diabetes, stroke, coronary artery disease, thyroid disease, arthritis, tuberculosis, asthma, chronic obstructive lung disease, liver cirrhosis, kidney disease and cancer were excluded ($n = 509$). Sarcopenia was indicated as weight-adjusted ASM below −2 SD [3, 20]. Sarcopenic obesity was defined as having obesity among participants with sarcopenia. Obesity was defined as WC ≥90 cm for men and ≥85 cm for women [21].

The intensity of a physical activity was expressed as metabolic equivalents (METs), according to the International

Physical Activity Questionnaire [22, 23]. MET is defined as the ratio of metabolic rate (the rate of energy consumption) during a specific physical activity to a reference metabolic rate, set by convention to 3.5 ml O_2 kg^{-1} min^{-1} (equivalently 1 kcal kg^{-1} h^{-1} or 4.184 kJ kg^{-1} h^{-1}). One MET was considered as the resting metabolic rate obtained during quiet sitting [24]. METs were calculated as the MET level of each activity × minutes of having activity × times of having activity per week. Walking, moderate-intensity and vigorous-intensity activity were multiplied by 3.3, 4.0 and 8.0, respectively [22, 23].

Three levels of physical activity were used to classify the subjects: high, moderate and low [23]. Participants with either of the following criteria were considered as 'high': (i) vigorous-intensity activity at least 3 days/week accumulating at least 1500 MET-min/week; (ii) ≥7 days of ≥3,000 MET-min/week with any combination of walking, moderate-, or vigorous-intensity activities. For 'moderate', participants with any of following criteria were considered: (i) ≥20 min/day of vigorous-intensity activity for ≥3 days/week; (ii) ≥30 min of moderate-intensity activity and/or walking for ≥5 days/week; (iii) ≥600 MET-min/week of any combination of walking, moderate- or vigorous-intensity activities for ≥5 days/week. Finally, participants who did not meet any of the criteria for either of the previous categories (moderate and high) were considered as in the 'low' level activity.

Statistical analysis

Simple frequencies of demographics, health behaviour variables and physical activity intensity by gender were calculated. Differences between groups according to the presence of sarcopenia and sarcopenic obesity were assessed by *t* and Chi-square tests. Logistic regression analyses were used to examine the association of levels of physical activity with sarcopenia, adjusting for covariates. All analyses were conducted with SAS version 9.2 (SAS Institute, Inc., Cary, NC, USA), applying weights for the complex sampling design.

Results

Of the 2,264 older Koreans, 12.1% of men and 11.9% of women were classified as having sarcopenia. Among those with sarcopenia 68.3% of men and 65.0% of women were obese. In men, compared with those without sarcopenia, those with sarcopenia were older, and had higher weight, BMI, WC, fasting blood glucose levels, prevalence of diabetes and hypertension, and a higher percentage of alcohol consumption (Table 1). For women, those with sarcopenia, compared with those without sarcopenia, showed higher weight, BMI, WC and triglyceride, but lower height and percentage consuming alcohol. Similar patterns were observed among those with sarcopenic obesity. In addition, compared with those with no sarcopenia, men with sarcopenic obesity had lower levels of HDL-cholesterol and lower percentage of current smokers, whereas women showed higher percentages of diabetes and hypertension.

The prevalence of sarcopenia and sarcopenic obesity tended to decline with increasing levels of physical activity (Figure 1), being more pronounced in men than in women. In men, whereas 17.9% of the low-activity group had sarcopenia, this rate was 12.4 and 5.7%, respectively, among the moderate- and high-activity groups. In women, the prevalence of sarcopenic obesity was significantly lower among those engaging in high versus low activity.

In the logistic regression analyses (Table 2), adjusting for age (model 1), men who participated in higher levels of activities were less likely to have sarcopenia ($P_{trend} < 0.001$). Adjusting for other demographics, health behaviours and chronic conditions (model 2) further strengthened the association, with those engaging in moderate and high levels of activity being 38 and 75%, respectively, less likely to have sarcopenia ($P_{trend} < 0.001$). Even with further adjustment for total cholesterol, fasting blood glucose and triglyceride (model 3), the associations remained statistically significant. However, for women the relationship between levels of physical activity and sarcopenia was not significant.

For sarcopenic obesity, men participating in moderate and high levels of physical activity, compared with low activity, had significantly lower risk, controlling for all covariates ($P_{trend} = 0.001$). In women, high physical activity was associated with a lower risk of sarcopenic obesity (OR = 0.43; 95% CI: 0.22–0.86), adjusting for numerous covariates ($P_{trend} = 0.08$) (model 2). No significant trend, however, was observed when additionally adjusted for blood test profiles.

Discussion

This study demonstrated that higher levels of physical activity were associated with a reduced risk of sarcopenia and sarcopenic obesity among the older Korean population. Our study is unique in that the study population comes from a nationally representative sample of older Koreans living in the community. The majority of previous studies on these associations have been limited to Caucasians, not Asians. Considering that body compositions differ by ethnicity, with Asians comparatively having low muscle mass but high body fat [25], sarcopenia and sarcopenic obesity pose as serious problems.

These findings agree with a number of epidemiological studies from diverse ethnic groups. The New Mexico Aging Process Study [10] and French MINOS study [9] reported negative correlations between muscle mass and leisure-time physical activity. A study of older Chinese in Hong Kong showed physical inactivity to be associated with low muscle mass [11]. Among older Japanese daily walking and moderate intensity exercises were associated with a decreased sarcopenia risk [12]. Among older Swiss volunteers higher levels of leisure-time physical activity were correlated with a higher muscle mass but less total and truncal fat [26]. The loss of lean tissue with age and baseline fat mass was also found to be reduced with increasing daily energy expenditure through physical activity [27].

Table 1. Characteristics of study participants by sarcopenia and sarcopenic obesity: mean ± standard deviation, *n* (%)

	Men (*n* = 940)			Women (*n* = 1,324)		
	No sarcopenia (*n* = 837)	Sarcopenia (*n* = 103)	Sarcopenic obesity (*n* = 70)	No sarcopenia (*n* = 1,165)	Sarcopenia (*n* = 159)	Sarcopenic obesity (*n* = 99)
Age, year	71.8 ± 5.4	74.3 ± 6.1**	73.5 ± 6.0	73.0 ± 5.7	73.4 ± 5.2	73.2 ± 5.2
Height, cm	164.7 ± 5.9	164.0 ± 6.2	165.6 ± 6.2	150.6 ± 5.8	149.1 ± 5.9*	149.6 ± 5.5
Weight, kg	61.5 ± 9.5	69.1 ± 11.1**	74.4 ± 9.0**	54.0 ± 8.5	57.5 ± 9.9**	62.1 ± 7.7**
BMI, kg/m²	22.6 ± 2.9	25.6 ± 3.1**	27.1 ± 2.3**	23.8 ± 3.1	25.8 ± 3.9**	27.7 ± 2.6**
Waist circumference, cm	82.9 ± 8.8	93.5 ± 8.8**	98.4 ± 5.8**	82.3 ± 9.1	87.8 ± 11.6**	94.5 ± 6.7**
ASM, kg	19.4 ± 2.9	18.1 ± 3.0**	19.5 ± 2.5	13.5 ± 1.8	12.5 ± 1.9**	12.7 ± 1.8**
ASM/height^2, kg/m^2	7.14 ± 0.83	6.71 ± 0.85**	7.09 ± 0.64	5.94 ± 0.64	5.61 ± 0.67**	5.68 ± 0.63**
ASM/weight	31.7 ± 2.4	26.3 ± 1.3**	26.2 ± 1.0**	25.1 ± 2.2	22.2 ± 4.4**	20.5 ± 1.5**
Total fat mass, kg	13.0 ± 4.2	20.7 ± 4.8**	22.7 ± 4.3**	18.0 ± 4.8	22.2 ± 7.0**	25.6 ± 4.2**
SBP, mmHg	129.5 ± 18.2	132.6 ± 16.8	131.5 ± 15.0	131.3 ± 18.0	132.0 ± 19.9	132.5 ± 18.4
DBP, mmHg	77.4 ± 10.1	78.0 ± 10.2	77.7 ± 9.4	76.9 ± 10.0	77.4 ± 10.3	78.7 ± 10.5
Fasting blood glucose, mg/dl	104.0 ± 24.6	113.7 ± 34.9**	114.0 ± 27.9*	104.7 ± 26.9	105.9 ± 19.8	108.9 ± 20.8
Total cholesterol, mg/dl	179.6 ± 34.3	186.5 ± 34.5	183.6 ± 30.5	199.4 ± 33.4	205.8 ± 36.2	208.7 ± 36.1
Triglyceride, mg/dl	140.4 ± 85.1	157.6 ± 93.6	165.6 ± 108.5	148.2 ± 84.1	167.0 ± 74.6*	180.5 ± 75.2**
HDL-cholesterol, mg/dl	48.6 ± 11.9	45.8 ± 11.4	43.3 ± 10.1**	49.2 ± 11.2	50.2 ± 10.8	50.6 ± 10.9
Education level						
≤Primary school	451 (51.1)	55 (49.6)	34 (40.9)	1,025 (86.3)	148 (91.1)	93 (92.3)
Middle school	142 (18.7)	21 (23.2)	18 (27.8)	65 (5.9)	3 (3.1)	2 (2.0)
≥High school	244 (30.2)	27 (27.2)	18 (31.2)	75 (7.8)	8 (5.7)	4 (5.7)
Smoking						
Never smoker	141 (15.4)	25 (22.1)	18 (25.4)*	1,019 (86.5)	144 (88.2)	87 (85.6)
Ex-smoker	461 (56.0)	58 (61.4)	40 (60.4)	72 (6.8)	9 (7.2)	7 (7.9)
Current smoker	233 (28.6)	19 (16.5)	11 (14.1)	68 (6.7)	6 (4.6)	5 (6.6)
Alcohol drinker	722 (87.0)	95 (94.2)*	65 (95.3)*	617 (53.5)	66 (39.9)**	37 (37.5)**
Diabetes mellitus	121 (13.5)	33 (31.6)**	22 (31.2)**	192 (16.7)	35 (24.7)	27 (29.2)*
Hypertension	346 (40.7)	61 (58.7)**	45 (61.9)**	586 (51.9)	90 (57.2)	71 (74.8)**
Hyperlipidaemia	62 (9.0)	9 (8.5)	4 (7.8)	145 (11.9)	15 (11.3)	12 (13.3)
Heart disease	48 (5.5)	10 (9.0)	7 (9.9)	52 (4.1)	5 (3.7)	4 (4.6)
Stroke	59 (6.7)	14 (12.3)	9 (11.5)	52 (4.6)	11 (6.3)	8 (7.2)

Sarcopenic obesity is defined as having obesity (waist circumference ≥90 cm for men, ≥85 cm for women) among those with sarcopenia. BMI, body mass index; ASM, appendicular skeletal mass; SBP, systolic blood pressure; DBP, diastolic blood pressure; HDL, high-density lipoprotein.
*$P < 0.05$.
**$P < 0.01$; *t* and Chi-square tests, compared with no sarcopenia for each sex.

In this study, moderate or higher levels of physical activity were associated with lower odds of sarcopenia and sarcopenic obesity. Moderate levels of physical activity were defined as 20–30 min/day of moderate to vigorous intensity activity for 3–5 days/week or 600 MET-min/week (85 MET-min/day) of combined activities of walking, moderate and vigorous intensity. It is difficult to directly compare our findings to other studies because of few studies using METs to measure physical activity. A recent Japanese study found those engaging in physical activity at moderate intensity (>3 METs) for >15–20 min/day maintained muscle mass exceeding the sarcopenia threshold [12]. In a study of healthy older people in Geneva, those who increased daily physical activity by more than or equal to three METs showed slower decline in the lean muscle mass [27].

Low physical activity is thought to lead to a decrease in the number and size of muscle fibres due to muscle cell apoptosis and reduced mechanical stimuli [28]. However, studies from life-long athletes indicate that regular, intense exercise may prevent or reverse age-related loss of the muscle mass by causing hypertrophy of the surviving muscle cells. Further, resistance training has been shown to induce muscle hypertrophy.

In this study, gender differences in the relationship between physical activity and sarcopenia were observed, with significant associations found in men but not in women. Previous studies have reported conflicting findings. A study that followed older subjects over 9 years reported that physical activity slowed the loss of lean tissue in men but not in women [27]. Others, in contrast, have found no such gender difference [10–12]. The observed gender differentials might be due to different physical activity patterns. It has been reported that older men tend to engage in more sporting activities, whereas women perform more domestic activities [29]. Thus, the intensity of physical activity performed is likely to be higher in men than women. More men than women also tend to participate in resistance exercise [17], which helps to enhance muscle mass and strength. Moreover, age-related hormonal changes that induce sarcopenia may affect men more than women, while women may be protected partly from trophic effects of weight bearing on muscles [10].

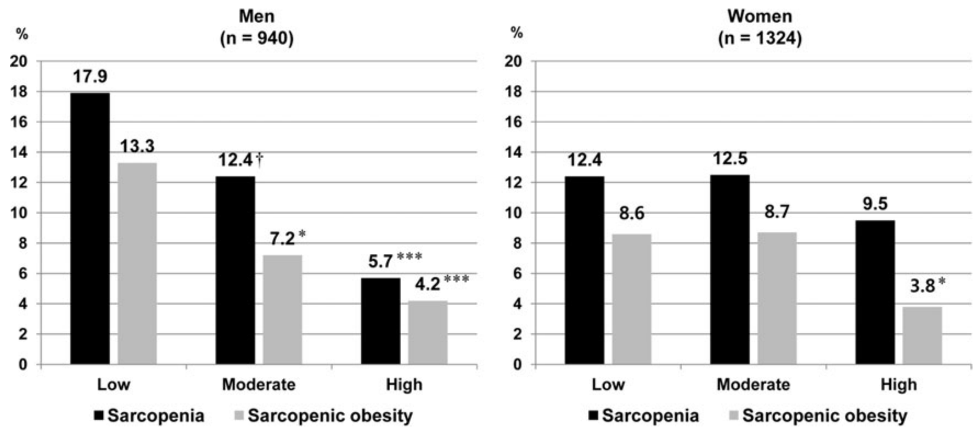

Figure 1. Prevalence of sarcopenia and sarcopenic obesity by levels of physical activity among respondents aged 65 years and older (weighted %). †$P < 0.1$, *$P < 0.05$, ***$P < 0.001$ (low activity as reference).

For sarcopenic obesity, significant associations with physical activity were found in both men and women. Muscle mass loss and weight gain are closely connected, with physical activity playing a key role. Aging-related muscle wasting may lead to reduced physical activity that could, in turn, induce accumulation of visceral fat. Increases in abdominal fat may release pro-inflammatory cytokines, tumour necrosis factor α, and leptin, increasing fatty infiltration and inflammation in muscles, further contributing to muscle loss [5]. In a community-based elderly Korean cohort, the sarcopenic obese exhibited a higher BMI, more visceral fat mass, insulin resistance and higher risk of metabolic syndrome than other groups with normal body composition [16].

A major limitation of our study is its cross-sectional design, thus determining causality between physical activity and sarcopenia is not feasible. Physical activity may have protective benefits against the loss of the muscle mass. Alternatively, the results may indicate that those with the low muscle mass, due to reduced strength, were less likely to participate in physical activity. Selection bias may also exist as participants included in the study were limited to those living in the community and undergoing medical examinations for the measurement of body composition. Exclusion of the institutionalized might have underestimated the strength of the association as the non-participants may be disproportionately affected by functional limitations. Further, only muscle mass, not strength, was assessed in this study. Although there is no uniform definition of sarcopenia, muscle mass itself may not adequately reflect muscle power enhanced by exercise. In this study, we used the weight-adjusted definition of sarcopenia. Using the height-adjusted (ASM/ht^2) definition, the prevalence tended to be underestimated in women, with sarcopenia identified in 14.2% of men, but in only 2.4% of women (sarcopenic obesity was present in only 0.2% in each gender). The weight-adjusted definition, however, resulted in higher BMI values among those classified as sarcopenia and sarcopenic obesity, compared with those without sarcopenia. Physical activity, moreover, was based on self-reports and may not accurately reflect energy expenditure levels. Seasonal variations in physical activity participation may have also influenced the observed associations. A recent prospective study using pedometer-determined ambulatory activity was found to be associated with a reduced loss of the leg muscle mass [30]. The use of objective measurements of physical activity with longitudinal design may help shed more light on the association.

Table 2. Age-adjusted and multivariate-adjusted odds ratio (OR) and 95% confidence intervals (95% CI) of sarcopenia and sarcopenic obesity according to physical activity levels in older Korean men and women

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Sarcopenia			
Men			
Low activity	1.0	1.0	1.0
Moderate activity	0.65 (0.41–1.04)	0.62 (0.39–1.00)	0.62 (0.37–1.04)
High activity	0.29 (0.15–0.56)	0.25 (0.12–0.49)	0.26 (0.13–0.54)
P for trend	<0.001	<0.001	<0.001
Women			
Low activity	1.0	1.0	1.0
Moderate activity	1.01 (0.65–1.57)	1.01 (0.65–1.58)	1.15 (0.71–1.85)
High activity	0.76 (0.45–1.29)	0.76 (0.44–1.32)	0.87 (0.48–1.57)
P for trend	0.30	0.33	0.66
Sarcopenic obesity			
Men			
Low activity	1.0	1.0	1.0
Moderate activity	0.50 (0.28–0.91)	0.49 (0.27–0.86)	0.47 (0.26–0.87)
High activity	0.29 (0.14–0.60)	0.25 (0.12–0.55)	0.27 (0.12–0.60)
P for trend	<0.001	<0.001	0.001
Women			
Low activity	1.0	1.0	1.0
Moderate activity	1.02 (0.62–1.67)	1.05 (0.64–1.73)	1.24 (0.71–2.16)
High activity	0.42 (0.22–0.81)	0.43 (0.22–0.86)	0.60 (0.30–1.20)
P for trend	0.04	0.08	0.32

Model 1: adjusted for age; Model 2: additionally adjusted for education level, alcohol intake, smoking, diabetes, hypertension, hyperlipidaemia, heart disease and stroke; Model 3: additionally adjusted for total cholesterol, fasting glucose and triglyceride.

In conclusion, an increased amount of physical activity was associated with a lower risk of sarcopenia and sarcopenic obesity in older Korean adults. The relationship between physical activity and sarcopenia was statistically significant in men, but not in women. Further studies are needed to investigate gender differences in the relationship among different ethnic populations.

Key points

- Physical activity was associated with a reduced risk of sarcopenia and sarcopenic obesity in older Koreans.
- There were gender differences in the relationship, with stronger associations observed in men than in women.
- High levels of activity were associated with a 75 and 67% reduced risk of sarcopenic obesity in men and women, respectively.

Conflicts of interest

None declared.

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References

1. Evans WJ. What is sarcopenia? J Gerontol A Biol Sci Med Sci 1995; 50: 5–8.
2. Morley JE, Baumgartner RN, Roubenoff R, Mayer J, Nair KS. Sarcopenia. J Lab Clin Med 2001; 137: 231–43.
3. Kim YS, Lee Y, Chung YS *et al* Prevalence of sarcopenia and sarcopenic obesity in the Korean population based on the Fourth Korean National Health and Nutritional Examination Surveys. J Gerontol A Biol Sci Med Sci 2012; 67: 1107–13.
4. Waters DL, Baumgartner RN, Garry PJ, Vellas B. Advantages of dietary, exercise-related, and therapeutic interventions to prevent and treat sarcopenia in adult patients: an update. Clin Interv Aging 2010; 7: 259–70.
5. Zamboni M, Mazzali G, Fantin F, Rossi A, Di Francesco V. Sarcopenic obesity: a new category of obesity in the elderly. Nutr Metab Cardiovasc Dis 2008; 18: 388–95.
6. Zoico E, Di Francesco V, Guralnik JM *et al* Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. Int J Obes 2004; 28: 234–41.
7. Prado CM, Wells JCK, Smith SR, Stephan BCM, Siervo M. Sarcopenic obesity: a critical appraisal of the current evidence. Clinical Nutrition 2012; 31: 583–601.
8. Freiberger E, Sieber C, Pfeifer K. Physical activity, exercise, and sarcopenia: future challenges. Wien Med Wochenschr 2011; 161: 416–25.
9. Szulc P, Duboeuf F, Marchand F, Delmas PD. Hormonal and lifestyle determinants of appendicular skeletal muscle mass in men: the MINOS study. Am J Clin Nutr 2004; 80: 496–503.
10. Baumgartner RN, Waters DL, Gallagher D, Morley JE, Garry PJ. Predictors of skeletal muscle mass in elderly men and women. Mech Ageing Dev 1999; 107: 123–36.
11. Lee JSW, Auyeung TW, Kwok T, Lau EMC, Leung PC, Woo J. Associated factors and health impact of sarcopenia in older Chinese men and women: a cross-sectional study. Gerontology 2007; 53: 404–10.
12. Park H, Park S, Shephard RJ, Aoyagi Y. Yearlong physical activity and sarcopenia in older adults: the Nakanojo study. Eur J Appl Physiol 2010; 109: 953–61.
13. Snyder PJ, Peachey H, Hannoush P *et al* Effect of testosterone treatment on body composition and muscle strength in men over 65 years of age. J Clin Endocrinol Metab 1999; 84: 2647–53.
14. National Statistical Office of Korea. Population Projections of Korea: 2010–2060 (based on the 2010 census). Daejeon: Korean National Statistical Office, 2012.
15. Kim TN, Yang SJ, Yoo HJ *et al* Prevalence of sarcopenia and sarcopenic obesity in Korean adults: the Korean Sarcopenic Obesity Study. Int J Obes 2009; 33: 885–92.
16. Lim S, Kim JH, Yoon JW *et al* Sarcopenic obesity: prevalence and association with metabolic syndrome in the Korean Longitudinal Study on Health and Aging (KLoSHA). Diabetes Care 2010; 33: 1652–4.
17. Hwang B, Lim JY, Lee J, Choi NK, Ahn YO, Park BJ. Prevalence rate and associated factors of sarcopenic obesity in Korean elderly population. J Korean Med Sci 2012; 27: 748–55.
18. Paek KW, Chun KH. Moderating effects of interactions between dietary intake and socioeconomic status on the prevalence of metabolic syndrome. Ann Epidemiol 2011; 21: 877–83.
19. Baumgartner RN, Koehler KM, Gallagher D *et al* Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 1998; 147: 755–63.
20. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc 2002; 50: 889–96.
21. Lee SY, Park HS, Kim DJ *et al* Appropriate waist circumference cutoff points for central obesity in Korean adults. Diabetes Res Clin Pract 2007; 75: 72–80.
22. Oh JY, Yang YJ, Kim BS, Kang JH. Validity and reliability of the Korean version of International Physical Activity Questionnaire (IPAQ) short form. J Korean Acad Fam Med 2007; 28: 532–41.
23. The IPAQ Core Group. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ): Short and Long Forms. 2005 (cited 5 May 2012). Available from: http://www.ipaq.ki.se/ipaq.htm.
24. Ainsworth BE, Haskell WL, Whitt MC *et al* Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000; 32: S498–516.
25. Rush EC, Goedecke JH, Jennings C *et al* BMI, fat and muscle differences in urban women of five ethnicities from two countries. Int J Obes 2007; 31: 1232–9.
26. Raguso CA, Kyle U, Kossovsky MP *et al* A 3-year longitudinal study on body composition changes in the elderly: role of physical exercise. Clin Nutr 2006; 25: 573–80.

27. Genton L, Karsegard VL, Chevalley T, Kossovsky MP, Darmon P, Pichard C. Body composition changes over 9 years in healthy elderly subjects and impact of physical activity. Clin Nutr 2011; 30: 436–42.
28. Narici MV, Reeves ND, Morse CI, Maganaris CN. Muscular adaptations to resistance exercise in the elderly. J Musculoskelet Neuronal Interact 2004; 4: 161–4.
29. Moschny A, Platen P, Klaassen-Mielke R, Trampisch U, Hinrichs T. Physical activity patterns in older men and women in Germany: a cross-sectional study. BMC Public Health 2011; 11: 559.
30. Scott D, Blizzard L, Fell J, Jones G. Prospective associations between ambulatory activity, body composition and muscle function in older adults. Scand J Med Sci Sports 2011; 21: e168–75.

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Diagnostic accuracy of three different methods of temperature measurement in acutely ill geriatric patients

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Abstract

Objective: we examined the diagnostic accuracy of different methods of body temperature measurement to diagnose infection in geriatric patients presenting to the emergency department (ED).
Methods: this observational study was done in consecutive patients ≥75 years old presenting to the ED. Body temperature was determined by tympanal thermometry, temporal artery thermometry and rectal temperature measurement. Adjudicated final diagnosis of infection was done by two experts including patient history, clinical and laboratory findings as well as radiographic studies.
Results: a total of 427 patients were included in the data analysis (age: 82.7 ± 5.1 years). Infection was present in 105 patients (24.6%). Respiratory rate, heart rate and body temperature were significantly higher in patients with infection, blood pressure was lower ($P < 0.01$). Body temperature measured by tympanal and temporal artery thermometry was correlated with rectal thermometry. Body temperature was significantly higher in patients with infection compared with those without infection independent of the method of body temperature measurement ($P < 0.001$). The diagnostic accuracy for infection quantified by the area under curve (AUC) was comparable among rectal [AUC: 0.72 (95% CI: 0.65–0.80)] and tympanal thermometry [AUC: 0.73 (95% CI: 0.66–0.81)], but significantly lower in temporal artery thermometry [AUC: 0.65 (95% CI: 0.57–0.73; $P < 0.001$)]. Compared with rectal measurement tympanal thermometry showed a higher bias than temporal artery thermometry (0.54 versus 0.03°C), while its limits of agreement were more narrow (−0.14 to 1.21°C versus −0.94–1.01°C).
Conclusion: diagnostic accuracy for the identification of infection was comparable among tympanal and rectal thermometry and lower for temporal artery thermometry. Different cut-off points should be used to identify infection using