Sarcopenic Obesity: Prevalence and Association With Metabolic Syndrome in the Korean Longitudinal Study on Health and Aging (KLoSHA)

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OBJECTIVE — We investigated the prevalence of sarcopenic obesity (SO) and its relationship with metabolic syndrome in a community-based elderly cohort in Korea.

RESEARCH DESIGN AND METHODS — In this study, 287 men and 278 women aged 65 or older were recruited. Sarcopenia was defined as the appendicular skeletal muscle mass (ASM) divided by height squared (Ht^2) (kg/m^2) or by weight (Wt) (%) of <1 SD below the sex-specific mean for young adults. Obesity was defined as a visceral fat area ≥100 cm^2.

RESULTS — The prevalence of SO was 16.7% in men and 5.7% in women with sarcopenia defined by ASM/Ht^2; however, it was 35.1% in men and 48.1% in women by ASM/Wt. Using ASM/Wt, the homeostasis model assessment of insulin resistance of subjects with SO was higher and they were at higher risk for metabolic syndrome (odds ratio [OR] 8.28 [95% CI 4.45–15.40]) than the obese (5.51 [2.81–10.80]) or sarcopenic group (2.64 [1.08–6.44]).

CONCLUSIONS — SO defined by ASM/Wt was more closely associated with metabolic syndrome than either sarcopenia or obesity alone.

Diabetes Care **33:1652–1654, 2010**

The number of obese elderly people is increasing worldwide. Aging is associated with increased fat mass and reduced muscle mass or strength, even in those with stable body weight. This sarcopenic obesity (SO) is associated with deteriorations in physical disability, morbidity, and mortality. Therefore, sarcopenia and obesity might act synergistically on metabolic and functional impairments in the elderly (1–2). However, there have been few reports investigating the association of SO with metabolic syndrome, particularly in Asian ethnic groups. The aim of the present study was to investigate the prevalence of SO and its association with metabolic syndrome in a community-based elderly cohort in Korea.

RESEARCH DESIGN AND METHODS

— This study was a part of the Korean Longitudinal Study on Health and Aging (KLoSHA), which has been described in detail (3). Appendicular skeletal muscle mass (ASM) was measured by dual energy X-ray absorptiometry (DXA; Lunar Corporation, Madison, WI). We used two definitions for sarcopenia: *1*) ASM divided by height squared (ASM/Ht^2) (kg/m^2), as proposed by Baumgartner et al. (4) and *2*) ASM as a percentage of body weight (ASM/Wt), which was modified from the study of Janssen et al. (5). Sarcopenia was defined as <1 SD below the sex-specific mean for a young reference group. The cutoff point for sarcopenia was 7.09 kg/m^2 in men and 5.27 kg/m^2 in women as measured using ASM/Ht^2. For ASM/Wt, the cutoff was 29.9% in men and 25.1% in women. The sex-specific young reference group included 32 men and 38 women. Their mean age ± SD was 28.4 ± 3.1 and 26.3 ± 2.6 years, respectively. Obesity was defined as a visceral fat area exceeding 100 cm^2 on abdominal computed tomography (Somatom Sensation 16; Siemens, Munich, Germany) (6). The subjects were classified into sarcopenic obese, obese, sarcopenic, and normal groups according to the definitions set out above.

Metabolic syndrome was defined according to the National Cholesterol Education Program criteria using the Asia-Pacific abdominal obesity criteria (waist circumference ≥90 cm in men and ≥80 cm in women) (7–8). Differences between the four groups were tested using ANOVA. Pearson's correlation and multiple logistic regression models were used. $P < 0.05$ was considered statistically significant.

RESULTS

— The prevalence of SO was 16.7% in men and 5.7% in women with sarcopenia defined by ASM/Ht^2. However, it was 35.1% in men and 48.1% in women when defined by ASM/Wt. When sarcopenia was defined by ASM/Ht^2, the obese group showed a higher BMI, greater waist circumference, more visceral fat mass, and more insulin resistance than any other group in either sex, although the SO group had poorer profiles than the group with sarcopenia alone. In contrast, the SO group defined by ASM/Wt showed a higher BMI, more visceral fat mass, and more insulin resistance than any other group in either sex (Table 1).

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Received 20 January 2010 and accepted 25 March 2010. Published ahead of print at http://care.diabetesjournals.org on 11 May 2010. DOI: 10.2337/dc10-0107.

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Table 1—*Anthropometric and biochemical parameters among groups with SO, obesity, or sarcopenia defined by ASM/Ht^2 or ASM/Wt*

		Sarcopenia defined by ASM/Ht^2				Sarcopenia defined by ASM/Wt			
	Sex	SO	Obesity	Sarcopenia	Normal	P*	SO	Obesity	Sarcopenia	Normal	P*
Age (years)	M	75.4 ± 8.2	72.5 ± 7.0	77.7 ± 9.2	71.7 ± 5.6		73.9 ± 7.7	72.5 ± 7.0	79.0 ± 7.9	73.8 ± 7.7	
	F	72.0 ± 6.9	72.8 ± 7.2	74.4 ± 6.3	72.5 ± 7.1		73.1 ± 7.5	71.6 ± 6.0	71.7 ± 5.4	73.9 ± 7.8	
BMI (kg/m^2)	M	23.5 ± 2.0	26.1 ± 2.6	19.9 ± 2.4	23.1 ± 2.1	a,b	26.6 ± 2.9	24.3 ± 1.8	23.1 ± 1.3	21.1 ± 2.8	a,b,c
	F	22.8 ± 3.4	26.2 ± 2.7	21.0 ± 2.2	22.8 ± 2.2	a,b	26.5 ± 2.9	24.0 ± 1.9	23.9 ± 2.0	21.2 ± 1.8	a,b,c
Waist circumference (cm)	M	90.0 ± 8.1	93.3 ± 6.5	79.2 ± 6.5	83.6 ± 5.8	a,b	94.2 ± 7.5	90.8 ± 6.0	84.9 ± 4.3	80.9 ± 6.6	a,b,c
	F	82.3 ± 11.7	88.3 ± 8.1	72.7 ± 6.7	79.7 ± 7.1	a,b	88.6 ± 8.6	85.0 ± 8.5	79.0 ± 7.2	77.1 ± 7.9	b,c
Visceral fat area (cm^2)	M	157.5 ± 44.2	168.3 ± 49.3	52.5 ± 27.0	66.1 ± 22.5	b,c	180.3 ± 52.3	150.1 ± 38.1	70.1 ± 25.8	57.0 ± 25.6	a,b,c
	F	132.3 ± 23.2	148.9 ± 35.5	69.1 ± 21.9	73.9 ± 15.6	b,c	152.0 ± 36.2	132.8 ± 26.0	78.5 ± 15.0	68.4 ± 17.8	a,b,c
Fasting glucose (mg/dl)	M	103.4 ± 18.0	118.1 ± 27.1	107.5 ± 23.4	109.1 ± 29.3	a	115.3 ± 25.3	113.8 ± 26.7	109.7 ± 19.7	108.0 ± 27.0	
	F	119.2 ± 57.6	108.0 ± 19.0	97.9 ± 9.3	98.3 ± 11.3	b,c	110.9 ± 25.5	103.1 ± 21.1	98.6 ± 11.8	97.8 ± 10.1	c
HOMA-IR	M	1.34 ± 0.73	1.81 ± 1.15	0.84 ± 0.31	0.88 ± 0.39	a,b,c	1.95 ± 1.27	1.42 ± 0.76	1.03 ± 0.32	0.83 ± 0.34	a,b,c
	F	1.77 ± 2.01	1.77 ± 1.19	1.03 ± 0.67	0.97 ± 0.34	c	1.88 ± 1.37	1.40 ± 0.79	1.15 ± 0.53	0.86 ± 0.29	a,b,c
Total cholesterol (mg/dl)	M	201.5 ± 41.2	196.0 ± 34.6	183.4 ± 34.9	188.6 ± 33.9	b	199.8 ± 38.1	194.7 ± 34.4	193.1 ± 45.6	184.7 ± 32.8	c
	F	226.2 ± 48.3	209.5 ± 31.6	208.2 ± 40.6	216.9 ± 37.4		211.6 ± 35.5	209.2 ± 26.6	216.1 ± 37.5	213.8 ± 39.0	
Triglyceride (mg/dl)	M	149.7 ± 82.9	142.6 ± 72.3	96.2 ± 51.5	98.3 ± 45.0	b,c	155.3 ± 85.0	132.6 ± 60.6	107.9 ± 34.1	95.6 ± 50.0	a,b,c
	F	159.2 ± 100.5	147.2 ± 83.4	154.9 ± 112.2	137.5 ± 82.4		148.6 ± 74.7	147.3 ± 111.7	133.8 ± 60.2	147.6 ± 107.4	
HDL cholesterol (mg/dl)	M	42.7 ± 10.7	40.8 ± 11.0	48.0 ± 15.1	48.7 ± 11.1		40.6 ± 11.3	42.2 ± 10.5	44.5 ± 11.8	48.8 ± 13.6	c
	F	46.6 ± 17.0	45.4 ± 11.2	46.0 ± 11.6	51.6 ± 15.2		45.9 ± 12.4	44.4 ± 9.5	50.7 ± 14.7	49.9 ± 14.6	
LDL cholesterol (mg/dl)	M	128.9 ± 39.2	124.8 ± 31.8	116.2 ± 33.7	120.2 ± 28.3	b	128.5 ± 34.5	123.0 ± 32.8	127.0 ± 42.6	116.7 ± 29.5	c
	F	147.8 ± 41.8	133.7 ± 31.4	131.3 ± 33.7	137.8 ± 35.7		134.8 ± 35.0	135.3 ± 23.8	138.7 ± 32.9	134.3 ± 37.1	

Data are means ± SD. *Post hoc analysis using the least significant difference t test (mean difference between two groups): a, SO vs. obesity; b, SO vs. sarcopenia; c, SO vs. normal; all $P < 0.05$. M, male; F, female; HOMA-IR, homeostasis model assessment of insulin resistance.

In the metabolic profiles, the triglyceride level in the men of the SO group defined by ASM/Wt was significantly higher than that of other groups. Fasting glucose concentration of the SO group seems to be higher than that of other groups although it was not statistically significant.

We calculated the odds ratios from logistic regression models predicting metabolic syndrome controlled for age, sex, smoking status, alcohol consumption, and exercise habits. In the case of sarcopenia defined by ASM/Wt, the SO group had an 8.2 times (95% CI 4.45–15.40) and the obese group had a 5.5 times (2.81–10.80) higher risk of metabolic syndrome than the normal group. In contrast, using ASM/Ht^2, the odds ratio for metabolic syndrome was 2.90 (1.28–6.57) in the obese group and 4.80 (2.63–8.75) in the SO group.

CONCLUSIONS — We found that the SO group defined by ASM/Wt had a higher risk of having metabolic syndrome than the obese or sarcopenic groups. Intuitively, having a high fat mass with low muscle mass seems likely to lead to more functional limitations and metabolic disorders. Adipocytes actively secrete leptin and proinflammatory cytokines, which stimulate muscle catabolism. These factors activate a vicious cycle leading to accelerated sarcopenia, additional weight gain largely in the form of fat, and ultimately to physical disability (1,9–12). Therefore, it is appropriate to consider obesity together with sarcopenia in the elderly population.

However, there has been some debate as to whether SO leads to metabolic syndrome. Baumgartner et al. (1) showed that the prevalence of metabolic syndrome was highest in the group of nonsarcopenic obese subjects. In contrast, Stephen and Janssen (13) reported that SO was associated with a 23% increased risk of cardiovascular disease in a large sample of community-dwelling elderly adults during 10 years of follow-up. These discrepancies might have arisen from different definitions of SO and different subjects.

When ASM/Wt was used as a definer, the SO group was more insulin resistant and at a higher risk for metabolic syndrome than the obese or sarcopenic groups in both sexes. Furthermore, ASM/Ht^2 was positively correlated with BMI, visceral fat area, and the homeostasis model assessment of insulin resistance measure in

our study. In contrast, ASM/Wt was negatively correlated with these factors. Therefore, we suggest that ASM/Wt is the more appropriate index for SO.

This study had several advantages over previous studies. First, subjects were recruited from a community-based elderly population, represented a single ethnic group, and were all aged 65 years or older. Second, previous studies used BMI or the percentage of fat mass for the definition of obesity to obtain a sufficient number of subjects within the group for statistical analysis (14). In contrast, we used the criterion of visceral fat area for defining abdominal obesity, which is known to be highly associated with metabolic impairment (6). In this study, people with a visceral fat area $\geq$ 100 cm^2 showed relatively low BMI or waist circumference compared with Caucasians.

There were several limitations of this study. First, the cross-sectional nature of this study makes it impossible to interpret any cause-effect relationship. Second, we did not consider muscle quality or the infiltration of fat into muscle, which has been shown to be associated with reduced strength, the incidence of mobility disability, and insulin resistance (13,15).

In conclusion, subjects with SO defined by ASM/Wt were more insulin resistant and had a higher risk for metabolic syndrome than simply obese or sarcopenic subjects.

Acknowledgments— This study was supported by a grant from the Korea Healthcare Technology R&D Project of the Ministry for Health, Welfare and Family Affairs (A084430).

No potential conflicts of interest relevant to this article were reported.

Parts of this study were presented in abstract form at the 70th Scientific Sessions of the American Diabetes Association, Orlando, Florida, 25–29 June 2010.

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