Original Article

Association among the Prevalence of Sarcopenia without Obesity, Nonsarcopenic Obesity, Sarcopenic Obesity, and Metabolic Syndrome in Cancer Survivors: Based on Korea National Health and Nutrition Examination Survey

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ABSTRACT

Objective: In this study, we aimed to investigate the association among the prevalence of sarcopenia without obesity, nonsarcopenic obesity, sarcopenic obesity, and metabolic syndrome in cancer survivors using data from the 4th and 6th Korea National Health and Nutrition Examination Survey (KNHANES), a nationally representative data source. **Methods:** The 4th and 6th KNHANES was conducted in 2008–2011. Data from cancer survivors were obtained including 133 obese patients without sarcopenia, 98 obese patients with sarcopenia, and 87 patients with sarcopenia but without obesity. SPSS 22.0 was used for statistical analysis with complex sample survey modules and commands. **Results:** The prevalence of metabolic syndrome was 25.3% in the sarcopenia without obesity group, 61.7% in the nonsarcopenic obesity group, and 67.3% in the sarcopenic obesity group, showing the highest rate in the sarcopenic obesity group, with a significant difference among the three groups ($P < 0.001$). **Conclusions:** In this study, the prevalence of metabolic syndrome was 25.3%, 61.7%, and 67.3% in the sarcopenia without obesity, nonsarcopenic obesity, and sarcopenic obesity groups, respectively, showing that the sarcopenic obesity group had the highest metabolic syndrome rate. Based on these results, various education programs for the prevention and treatment of metabolic syndrome should be developed for cancer patients.

Key words: Cancer survivor, metabolic syndrome, obesity, sarcopenia

Introduction

Approximately 200,000 people are diagnosed with cancer every year in the Republic of Korea (ROK), and in 2017,

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78,863 people died from cancer, with cancer accounting for approximately 27.6% of all deaths. More than half of the cancer patients (52.7%) survive for 5 years or longer, and the probability of an individual who survives to the life expectancy (82 years) to develop cancer is 36.2% in the ROK.[1] Due to the growing cancer survivor population much attention is being directed to their physical health as well as social and psychological problems and quality of life, for which several studies are being conducted in various disciplines.[2]

Cancer survivors are defined as cancer patients who are alive after completing cancer treatment and refer to patients at all stages of life from the time of diagnosis.[3] The 1986 National Coalition for Cancer Survivorship in the United States stated that a multilateral, individualized approach needs to be taken for all cancer patients in consideration of their survival rate following diagnosis and the physical and psychological changes that occur over time. It stressed the importance of comprehensive health management, including management of relapse of the primary cancer, complications of cancer treatment, and prevention of secondary cancer as well as general health management and lifestyle modification needed for patients' long-term survival.[4]

Therefore, multilateral analysis is crucial to promote the health management of cancer survivors, and the ROK is no exception. In particular, 24% of 5-year cancer survivors died from noncancer causes, and 31.4% of that number died from cardiovascular disease (CVD).[5] Therefore, various CVD assessment methods have been developed to predict the risk of CVD that affects the mortality of cancer survivors, of which metabolic disorder-related assessments have been highlighted in both clinical practice and research. Many cancer patients are older adults aged 60 years or older, and treatments such as androgenic deprivation therapy, an aromatase inhibitor, and steroid therapy exacerbate patients' lipid profiles; further, cancer survivors with abdominal obesity are at a high risk of developing metabolic syndrome.[6]

In addition, cancer survivors engage in less physical activity and are at an increased risk of weight gain due to factors such as pain, postoperative complications, psychological withdrawal, and depression.[7] Weight gain leads to obesity and induces tissue dysfunction, which in turn increases vascular and endocrine diseases, metabolic syndrome,[8] and cancer mortality.[9]

In the ROK, body mass index (BMI) is used as an indicator of obesity. BMI is calculated by dividing body weight (kg) by height squared (m^2), and obesity is defined as having a BMI of 25 kg/m^2 or higher.[10]

However, some recent studies have raised concerns regarding the definition of obesity based on BMI. In fact, an analysis of the Korean National Health and Nutrition Examination Survey (KNHANES) data from 1998 to 2007 showed that the optimal cutoff of BMI for developing hypertension, diabetes mellitus, or hypercholesterolemia is 23.1–24.3 kg/m^2, which was lower than the BMI criterion for obesity (25 $kg/m^{2)}$. Furthermore, this argument has been supported by the finding that the increased prevalence of metabolic syndrome is due to the increased prevalence of dyslipidemia and abdominal obesity, as opposed to increased BMI.[11] In particular, the mortality rate of cancer patients with sarcopenic obesity is higher than that of cancer patients with nonsarcopenic obesity who only have increased BMI.[12]

Sarcopenia is a condition in which the percentage of appendicular skeletal muscle mass (ASM) measured with dual energy X-ray absorptiometry (DXA) from body weight is lower than the standard deviation (SD). Sarcopenic obesity is defined as a waist circumference ≥90 cm in men and 85 cm or higher in women with sarcopenia.[13] Cancer patients are at a higher risk of developing sarcopenia and sarcopenic obesity than their healthy counterparts due to factors such as protein degradation by cancer cells, toxicity of therapeutic agents, inappropriate nutritional intake, and continuous bed rest.[14]

Compared to individuals with sarcopenia and those with general obesity, individuals with sarcopenic obesity had the highest risk for hypertension.[15] Further, a study on menopausal women also reported that the 10-year arteriosclerotic CVD risk, an indicator of CVD risk, increases across the nonsarcopenic group, sarcopenic group, and sarcopenic obesity group.[16] The Korean Longitudinal Study on Health and Aging, a cohort study on the older population, reported a significantly higher insulin resistance, total cholesterol, and triglyceride concentrations, and significantly lower high-density lipoprotein cholesterol (HDL-C) in the sarcopenia group,[17] showing that sarcopenia and sarcopenic obesity have a grave impact on the cardiovascular system. This should be taken more seriously for cancer survivors, who are at a higher risk for sarcopenia.

However, most studies on sarcopenic obesity have been conducted on the general population, focusing on the loss of skeletal muscle mass as a result of aging, with studies on cancer survivors relatively lacking. In addition, comparative studies involving sarcopenic obesity, which is known to be more dangerous than general obesity, are also scarce. Thus, it is necessary to compare the differences in metabolic syndrome components between nonsarcopenic obesity and sarcopenic obesity. Moreover, sarcopenia without obesity must also be compared, as it has been reported to cause metabolic syndrome and have an adverse cardiovascular impact on cancer patients.[6]

In light of previous findings that fat distribution should be taken into consideration in addition to overall muscle mass when assessing metabolic risk factors,[18] identifying the group with greater metabolic risk is important.

Therefore, in this study, we aimed to investigate the prevalence of sarcopenia without obesity, nonsarcopenic obesity and sarcopenic obesity among cancer survivors using the 4th and 6th (2008–2011) KNHANES, a nationally representative data source. Furthermore, we investigate and analyzed the risk factors associated with increased blood pressure, waist circumference, blood sugar, triglyceride, and serum HDL-C, which are the lower factors of metabolic syndrome. In addition, we aimed to present foundational data for developing health promotion programs for cancer survivors.

Methods

Study design and participants

In this cross-sectional descriptive research study, we analyzed data from the 4th and 6th National Health and Nutrition Survey conducted by the Korea Centers for Disease Control and Prevention. Raw data were downloaded from the Korea Disease Control and Prevention Agency KNAHES website (https://knhanes.kdca.go.kr/knhanes/main.do). The study was exempted from IRB review (IRB number 2016-3). The total number of participants in the National Health and Nutrition Survey from 2008 to 2011 was 37,753, of which 28,377 participants were aged 19 years or older. After its introduction on July 1, 2008, DXA measurements were conducted until May 2011. There were 798 participants who answered "yes" to the question "have you ever been diagnosed with cancer by a doctor?" Of them, data from 133 obese patients without sarcopenia, 98 obese patients with sarcopenia, and 87 patients with sarcopenia who did not have obesity, were finally included in the analysis.

Demographic and disease characteristics

The general characteristics of the participants included sex, age, monthly income, education level, physical activity, cancer type, onset period, alcohol consumption, and smoking status. The type of cancer was classified as gastric, liver, colon, breast, lung, and other cancers. Thyroid cancer was included in other cancers because it was classified independently from the 5th KNHANES (2010–2012) but was included in other cancers in earlier KNHANES.

Anthropometric characteristics

The National Health and Nutrition Examination Surveys were conducted through direct observation, measurement, and specimen analysis. In this study, we used physical measurements (height, weight, waist circumference), blood pressure (final systolic and diastolic blood pressures), and blood tests from the examination items of the survey data.

Biochemical measurements

The median cubital vein and cephalic vein were mainly used for drawing blood after at least 8-h of fasting, and blood samples were stored in the refrigerator. The blood samples were transported to a diagnostic medical testing laboratory and analyzed within 24 h. Serum total cholesterol, triglycerides, HDL-C, and fasting glucose were measured by enzymatic methods using a Hitachi automatic analyzer 7600 (Tokyo, Japan).

Sarcopenia

Sarcopenia was diagnosed by measuring bone mineral content (g), fat mass (g), and regional lean mass (g) of each body part using DXA (DISCOVER-W-bean-densitometer, Hologic, Inc., USA). ASM was calculated as the sum of the upper and lower limb muscle mass without bone and fat. Sarcopenia was defined as a weight-adjusted ASM. Therefore, sarcopenia was diagnosed when a value, which is obtained by dividing the ASM by body weight (ASM/total body weight [%], is 1 SD below the mean value of the reference group (adults aged 20–39 years without any underlying disease).[14]

Metabolic syndrome

Metabolic syndrome was identified based on the criteria for the abdominal obesity diagnosis for Koreans published by the Korean Society for the Study of Obesity. The risk factors for metabolic syndrome are systolic blood pressure >130 mmHg or diastolic blood pressure >85 mmHg, waist circumference >90 cm (men) or 85 cm (women), fasting blood sugar over 100 mg/dL, serum triglyceride concentration over 150 mg/dL, serum HDL-C concentration <40 mg/dL (men) or 50 mg/dL (women); and a person with more than three of them was diagnosed with metabolic syndrome, according to the US National Cholesterol Education Program's Adult Treatment Panel III in 2001.[19]

Statistical analysis

The collected data were analyzed using IBM SPSS Statistics software (version 22.0; IBM SPSS Inc., Chicago, IL, USA). Participants' general characteristics, namely sex, age, household income, education, regular exercise, type of cancer, time since diagnosis, and drinking and smoking status, were analyzed using percentages, means, and SDs. The metabolic syndrome factors, namely waist circumference, triglyceride levels, HDL-C, blood pressure, and fasting glucose were analyzed using mean and SD, and the differences among the sarcopenia without obesity,

nonsarcopenic obesity, and sarcopenic obesity groups were analyzed using ANOVA and Chi-square tests. The predictors of metabolic syndrome were identified using binary logistic regression for each variable. Statistical significance was set at $P < 0.05$.

Results

Demographic and disease characteristics

Of the 798 cancer survivors analyzed in this study, there were 87 with sarcopenia without obesity (10.9%), 133 with nonsarcopenic obesity (16.7%), and 98 with sarcopenic obesity (12.3%).

The sarcopenia without obesity, nonsarcopenic obesity, and sarcopenic obesity groups showed statistically significant differences based on sex and type of cancer. There were more female than male survivors in all three groups, and the percentage of female survivors was 54.0% in the sarcopenia without obesity group, 74.4% in the nonsarcopenic obesity group, and 67.3% in the sarcopenic obesity group, with significant differences among the three groups ($P = 0.007$). The types of cancer in order of decreasing prevalence were other cancers (27.6%), cervical cancer (13.8%), breast cancer (12.6%), and colon cancer (12.6%) in the sarcopenia without obesity group; other cancers (45.1%), breast cancer (18.0%), and cervical cancer (17.3%) in the nonsarcopenic obesity group; and other cancers (36.7%), breast cancer (15.3%), and cervical cancer (13.3%) in the sarcopenic obesity group, with significant differences among the three groups ($P = 0.015$). The three groups did not significantly differ in age, income, education, regular exercise, time since diagnosis, and smoking and drinking status [Table 1].

Comparison of metabolic syndrome factors among the sarcopenia without obesity, nonsarcopenic and sarcopenic obesity groups

Metabolic syndrome factors were compared between the sarcopenia without obesity group, nonsarcopenic obesity group, and sarcopenic obesity group. The three groups showed a significant difference in waist circumference and prevalence of metabolic syndrome. The mean waist circumference was 80.93 ± 5.22 cm in the sarcopenia without obesity group, 91.07 ± 4.73 cm in the nonsarcopenic obesity group, and 92.97 ± 6.00 cm in the sarcopenic obesity group. The sarcopenic obesity group had the largest waist circumference, with a significant difference among the three groups ($P < 0.001$). The mean triglyceride concentration was 152.42 ± 87.87 mg/dL in the sarcopenia without obesity group, 163.79 ± 106.74 mg/dL in the nonsarcopenic obesity group, and 161.79 ± 84.18 mg/dL in the sarcopenic obesity group. The nonsarcopenic obesity group had the highest triglyceride concentration, but there was no significant difference among the three groups. The mean HDL-C concentration was 47.8 ± 11.96 mg/dL in the sarcopenia without obesity group, 47.28 ± 12.20 mg/dL in the nonsarcopenic obesity group, and 48.25 ± 11.39 mg/dL in the sarcopenic obesity group. The nonsarcopenic obesity group had the lowest HDL-C level, but there was no significant difference among the three groups. The mean systolic blood pressure was 127.11 ± 18.84 mmHg in the sarcopenia without obesity group, 126.17 ± 17.12 mmHg in the nonsarcopenic obesity group, and 127.47 ± 16.67 mmHg in the sarcopenic obesity group, showing that the sarcopenic obesity group had the highest systolic blood pressure. The mean diastolic blood pressure was 77.03 ± 9.42 mmHg in the sarcopenia without obesity group, 78.10 ± 9.94 mmHg in the nonsarcopenic obesity group, and 78.77 ± 10.23 mmHg sarcopenic obesity group. The nonsarcopenic obesity group had the highest diastolic blood pressure, but there was no significant difference among the three groups. In the sarcopenic obesity group, fasting glucose levels were 103.77 ± 24.58 in the sarcopenia without obesity group, 110.01 ± 34.68 in the nonsarcopenic obesity group, and 112.78 ± 31.71 in the sarcopenic obesity group. The sarcopenic obesity group had the highest fasting glucose level, but there was no significant difference among the three groups.

The prevalence of metabolic syndrome was 25.3% in the sarcopenia without obesity group, 61.7% in the nonsarcopenic obesity group, and 67.3% in the sarcopenic obesity group, showing the highest rate in the sarcopenic obesity group, with a significant difference among the three groups ($P < 0.001$) [Table 2].

Odds ratio for metabolic syndrome factors among the sarcopenia without obesity, non-sarcopenic obesity and sarcopenic obesity groups using binary logistic regression analysis in cancer survivors

Logistic regression was performed based on the results of the Chi-square test and ANOVA with metabolic syndrome factors as the independent variables to identify the predictors of metabolic syndrome in the sarcopenia without obesity, nonsarcopenic obesity, and sarcopenic obesity groups. The odds ratios (ORs) with 95% confidence intervals (CIs) are: In the sarcopenia without obesity group, the patients with metabolic syndrome had an OR of 1.011 for triglyceride (95% CI, 1.002–1.020, $P = 0.017$), 0.859 for HDL (95% CI, 0.759–0.972, $P = 0.016$), 1.053 for systolic blood pressure (95% CI, 1.001–1.077, $P = 0.046$), and 1.048 for fasting glucose (95% CI, 1.004–1.093, $P = 0.032$) with reference to the patients without metabolic syndrome. In the nonsarcopenic obesity group, patients with metabolic

Table 1: Baseline characteristics of participants according to sarcopenia without obesity, nonsarcopenic obesity and sarcopenic obesity status in cancer survivors (n=318)

Category	Sarcopenia without obesity (n=87), n (%)	Nonsarcopenic obesity (n=133), n (%)	Sarcopenic obesity (n=98), n (%)	F or χ^2	P
Group**	87 (10.9)	133 (16.7)	98 (12.3)		
Gender					
Male	40 (46.0)	34 (25.6)	32 (32.7)	9.892	0.007*
Female	47 (54.0)	99 (74.4)	66 (67.3)		
Age, years, mean±SD	62.55±11.38	62.70±10.83	64.28±11.15	0.932	0.395
Household income***					
Lowest	30 (35.3)	50 (38.8)	31 (32.6)	6.775	0.342
Lower middle	20 (23.5)	37 (28.7)	21 (22.1)		
Upper middle	20 (23.5)	16 (12.4)	20 (21.1)		
Highest	15 (20.2)	26 (20.2)	23 (24.2)		
Educational (years) ***					
0-6	42 (48.3)	67 (50.8)	52 (53.1)	5.550	0.475
7-9	14 (16.1)	20 (15.2)	13 (13.3)		
10-12	16 (18.4)	34 (25.8)	23 (23.5)	5.550	0.475
13 or more	15 (17.2)	11 (8.3)	10 (10.2)		
Regular exercise					
Yes	43 (49.4)	72 (54.1)	42 (42.9)	0.287	0.024
No	44 (50.6)	61 (45.9)	56 (57.1)		
Type of cancer					
Stomach	12 (13.8)	6 (4.5)	17 (17.3)	27.809	0.015*
Liver	7 (8.0)	5 (3.8)	4 (4.1)		
Colon	11 (12.6)	13 (9.8)	10 (1.2)		
Cervical	12 (13.8)	23 (17.3)	13 (13.3)		
Breast	11 (12.6)	24 (18.0)	15 (15.3)		
Lung	10 (11.5)	2 (1.5)	3 (3.1)		
Others	24 (27.6)	60 (45.1)	36 (36.7)		
Time since diagnosis (years)					
1-5	50 (57.5)	67 (50.4)	52 (53.1)	1.067	0.588
6 or more	37 (42.5)	66 (49.6)	46 (46.9)		
Smoking status					
Nonsmoker	51 (58.6)	91 (68.4)	69 (70.4)	6.434	0.169
Ex-smoker	12 (13.8)	10 (7.5)	13 (13.3)		
Current	24 (27.6)	32 (24.1)	16 (16.3)		
Drinking habit ***					
Yes	20 (23.5)	31 (23.5)	27 (27.6)	0.594	0.743
No	65 (76.5)	101 (76.5)	71 (72.4)		

*P<0.05; **Percentage in parentheses is a percentage of the total cancer patients (n=798). SD: Standard deviation, . ***Missing value is excluded.

syndrome had an OR of 0.980 for triglycerides (95% CI, 0.967–0.993, P = 0.002), 1.165 for HDL-C (95% CI, 1.068–1.272, P = 0.001), and 0.899 for systolic blood pressure (95% CI, 0.841–0.961, P = 0.002) with reference to the patients without metabolic syndrome. In the sarcopenic obesity group, the patients with metabolic syndrome had an OR of 0.989 for triglycerides (95% CI, 0.980–0.998, P = 0.017), 1.164 for HDL-C (95% CI, 1.029–1.318, P = 0.016), and 0.955 for fasting glucose (95% CI, 0.915–0.996, P = 0.032) [Table 3].

Discussion

In this study, we analyzed data from the National Health and Nutrition Survey. The participants included 798 cancer survivors from the data, comprising 87 participants with sarcopenia without obesity, 133 with obesity without sarcopenia, and 98 with sarcopenia and obesity.

Based on a previous study,[18] if we were to predict the metabolic risk of cancer survivors in consideration of their muscle mass and fat distribution, 318 out of 789 cancer survivors (38.84%) who belonged to one of the three groups above can be deemed to be at risk for metabolic syndrome. Identifying the group with a higher metabolic risk, that is, higher CVD risk, among the sarcopenia without obesity group, nonsarcopenic obesity group, and sarcopenic obesity group would be worthwhile.

The average age of the participants in this study was 62–64 years. Aging is the main cause of skeletal muscle

Table 2: The comparisons of metabolic syndrome factors among participants with sarcopenia without obesity, nonsarcopenic obesity and sarcopenic obesity (n=318)

Category	Mean±SD			F or χ^2	P
	Sarcopenia without obesity (n=87)	Nonsarcopenic obesity (n=133)	Sarcopenic obesity (n=98)		
Waist circumference (cm)	80.93±5.22	91.07±4.73	92.97±6.00	13.832	0.000*
Triglyceride (mg/dL)	152.42±87.87	163.79±106.74	161.79±84.18	0.320	0.726
HDL cholesterol (mg/dL)	47.80±11.96	47.28±12.20	48.25±11.39	0.171	0.843
Blood pressure (mmHg)					
Systolic	127.11±18.84	126.17±17.12	127.47±16.67	0.171	0.843
Diastolic	77.03±9.42	78.10±9.94	78.77±10.23	0.714	0.491
Fasting glucose (mg/dL)	103.77±24.58	110.01±34.68	112.78±31.71	1.635	0.197
Metabolic syndrome, n (%)					
Yes	22 (25.3)	82 (61.7)	66 (67.3)	38.939	0.000*
No	65 (74.7)	51 (38.3)	32 (32.7)		

*P<0.005. HDL: High-density lipoproteins, SD: Standard deviation

Table 3: Odds ratio for metabolic syndrome factors among the participants with sarcopenia without obesity, nonsarcopenic obesity, and sarcopenic obesity using binary logistic regression analysis in cancer survivors (n=318)

Category	Sarcopenia without obesity (n=87)		Nonsarcopenic obesity (n=133)		Sarcopenic obesity (n=98)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Waist circumference (cm)	1.034 (0.844-1.267)	0.746	0.973 (0.855-1.107)	0.673	0.967 (0.789-1.185)	0.746
Triglyceride (mg/dL)	1.011 (1.002-1.020)	0.017*	0.980 (0.967-0.993)	0.002*	0.989 (0.980-0.998)	0.017*
HDL cholesterol (mg/dL)	0.859 (0.759-0.972)	0.016*	1.165 (1.068-1.272)	0.001*	1.164 (1.029-1.318)	0.016*
Blood pressure (mmHg)						
Systolic	1.053 (1.001-1.077)	0.046*	0.899 (0.841-0.961)	0.002*	0.950 (0.903-0.999)	0.950
Diastolic	1.059 (0.946-1.187)	0.319	1.036 (0.936-1.147)	0.496	0.944 (0.842-1.057)	0.944
Fasting glucose (mg/dL)	1.048 (1.004-1.093)	0.032*	0.898 (0.844-0.956)	0.898	0.955 (0.915-0.996)	0.032*

*P<0.05. All data were weighted to the residential population of Korea. OR: Odds ratio, CI: Confidence interval, n: Unweighted sample size; reference, metabolic syndrome, HDL: High-density lipoproteins

mass loss, and population aging is a direct cause of the increase in the prevalence of obesity.[20] Therefore, it cannot be overlooked that aged cancer survivors are also increasing, and it is necessary to conduct studies on aging cancer survivors.

In this study, 87 cancer survivors were in the sarcopenia without obesity group, which was lower than the number of participants (231) in the nonsarcopenic obesity and sarcopenic obesity groups. More specifically, there were 47 female and 40 male cancer survivors in the sarcopenic obesity group, 99 females and 34 males in the nonsarcopenic obesity group, and 66 females and 32 males in the sarcopenic obesity group. The proportion of women was higher than that of men. A previous study[21] reported that older females have a higher body fat percentage and relatively lower muscle strength than older males, resulting in a high probability of exacerbation due to obesity or muscle loss, similar to the results of our study. Therefore, female cancer survivors especially require rigorous management.

Regarding the metabolic syndrome factors among the three groups, the nonsarcopenic obesity group had a larger waist circumference than the sarcopenia without obesity group, and the sarcopenic obesity group had the largest waist circumference, showing a significant difference among the three groups. These results are similar to those of a previous study that confirmed the prevalence of sarcopenia in cancer survivors,[3] where BMI was higher in the sarcopenia group than in the control group. Body fat accumulation is thought to influence the increase in waist circumference, as basal metabolism decreases when muscle mass is low.[22]

Furthermore, the prevalence of metabolic syndrome was higher in the nonsarcopenic obesity group than in the sarcopenia without obesity group, but it was the highest in the sarcopenic obesity group. We could not directly compare this result with the literature because of the lack of research comparing the rate of metabolic syndrome among the three groups. However, we observed that the rate of metabolic syndrome was 25.3% in the sarcopenia without obesity group, which confirms that sarcopenia is also a risk factor for metabolic syndrome. This is similar to the results of a study that compared an adult nonsarcopenic obesity and sarcopenic obesity group, where the percentages of high-risk metabolic syndrome factors were significantly higher in the sarcopenic obesity group than in the nonsarcopenic obesity group.[23] Moreover, this result supports a previous

report where sarcopenic obesity with fat mass increase caused by muscle loss and obesity in old age, induced more profound metabolic abnormalities by triggering mutual deterioration.[20]

The sarcopenic obesity group was more closely related to metabolic syndrome factors than the nonsarcopenic obesity group.[24] In other words, the sarcopenic obesity group was more susceptible to metabolic syndrome than the nonsarcopenic obesity group, suggesting that more intensive management is needed for cancer survivors with sarcopenic obesity.

The binary logistic regression analysis of metabolic syndrome factors revealed that in the sarcopenia without obesity group, those with metabolic syndrome had higher triglycerides, systolic blood pressure, and fasting glucose with reduced HDL-C compared to those without metabolic syndrome, which seems to have had an adverse impact on the onset of metabolic syndrome.

One interesting finding is that the sarcopenia without obesity group showed contradictory results regarding triglycerides and HDL-C concentrations in comparison with the nonsarcopenic obesity group and sarcopenic obesity group, systolic blood pressure in comparison with the nonsarcopenic obesity group, and fasting glucose in comparison with the sarcopenic obesity group. However, despite these results, the prevalence of metabolic syndrome was high, in the sarcopenia without obesity group (25.3%) and higher than 60% in the obese groups (nonsarcopenic obesity group and sarcopenic obesity group). Although metabolic syndrome and obesity are considered as outcomes of metabolic risk factors in the general population, a standard explanation for metabolic syndrome and obesity is lacking for the cancer survivor population, as discussions regarding this population are generally focused on treatment modalities. For example, radiotherapy (i.e. androgen deprivation therapy using a gonadotropin releasing hormone agonist) for prostate cancer is a direct risk factor for coronary artery disease and influences blood glucose concentration due to its close association with arteriosclerosis or insulin resistance. In addition, teriparatide, which is used to supplement the loss of cancer treatment-induced bone loss, induces hypotension. For this reason, prolonged conditions show different manifestations compared with general metabolic syndrome.[25]

Nevertheless, this study is valuable because we found that the potential risk for metabolic syndrome was elevated in patients with sarcopenia, which is a common side effect of cancer treatment. In addition, we observed a significantly higher prevalence of metabolic syndrome in the sarcopenic obesity group. This is a crucial issue, and a previous study also reported that patients with sarcopenia are likely to progress to sarcopenic obesity, and that patients with sarcopenic obesity are at a higher risk of postoperative complications, physical disabilities, and a shorter survival period compared to those without sarcopenic obesity.[26]

In addition, sarcopenia in cancer survivors increases the risk for CVD, including metabolic syndrome,[27] and young adult survivors of leukemia/lymphoma are at a higher risk for metabolic syndrome due to the elevated risk of sarcopenia and obesity following hematopoietic stem cell transplantation and cranial radiotherapy.[28] Further, many studies have pinpointed sarcopenia and sarcopenic obesity as the major causes of CVD and reported that they contribute to metabolic syndrome.[29,30]

We also found that metabolic syndrome risk factors had other negative influences, such as increased triglycerides, raised systolic blood pressure, and fasting glucose with reduced HDL-C in patients with sarcopenia, suggesting that even if these patients are not obese, their progression to obesity in the long term may lead to more serious problems. However, because the KNHNAES does not survey the time of onset of obesity, a time-series analysis should be performed involving the onset of sarcopenia following cancer and the process leading to sarcopenic obesity to assess the specific risks for metabolic syndrome.

The data used in this study spanned 2008–2011, which is not recent. However, the data were appropriate for analysis because the KNHANES conducted a bone mineral density test from 2008 to 2011 and presented data on the area (cm^2), bone mineral content, and bone mineral density of areas needed to diagnose sarcopenia, in addition to including many cancer patients in the sample. However, cohort studies and further investigations are needed in the future.

Conclusions

In this study, the prevalence of metabolic syndrome was 25.3%, 61.7%, and 67.3% in the sarcopenia without obesity, nonsarcopenic obesity, and sarcopenic obesity groups, respectively, showing that the sarcopenic obesity group had the highest metabolic syndrome rate. Based on these results, various education programs for the prevention and treatment of metabolic syndrome should be developed for cancer patients.

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Conflicts of interest

There are no conflicts of interest.

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