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ASSOCIATION BETWEEN SARCOPENIA AND OVERACTIVE BLADDER IN ELDERLY DIABETIC PATIENTS

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Abstract: *Objectives:* To determine the association between sarcopenia and overactive bladder (OAB) in elderly diabetic patients using the Japanese version of SARC-F called SARC-F-J. *Design:* Cross-sectional study. *Settings and participants:* The study included 329 elderly diabetic patients (aged ≥65 years) who regularly visited the outpatient clinic at Community hospital in Japan. *Measurements:* The condition of OAB was evaluated using the OAM symptom score, which involves a self-administered questionnaire, and sarcopenia was evaluated using the self-administered SARC-F-J questionnaire comprising five items. The odds ratio for OAB due to sarcopenia was calculated using multiple logistic regression analysis, with OAB as the dependent variable and sarcopenia as the explanatory variable. *Results:* A total of 329 patients (186 males, 143 females) were included for analysis in the present study. Of these patients, 22.9% had sarcopenia and 18.7% had OAB. After adjusting the variables, the odds ratio for OAB due to sarcopenia was 4.46 (95% confidence interval [CI], 1.14–17.36, P = 0.031) and 2.09 (95% CI, 0.52–8.26, P = 0.293) for males and females, respectively. *Conclusion:* This study found that sarcopenia was significantly associated with OAB in elderly diabetic male patients based on SARC-F-J. Moreover, the possibility of the development of OAB should be considered during the medical examinations of elderly diabetic male patients with sarcopenia.

Key words: Sarcopenia, overactive bladder, elderly diabetic patients.

Background

Overactive bladder (OAB) is a condition that presents with urinary urgency as the primary symptom and frequent urination during the day or at night. It is critically observed as a serious health problem (1). Previous studies have observed that OAB is associated with decreased activities of daily living (ADL) and quality of life (QOL), cognitive decline, increased medical costs, and death (2-6). The frequency of OAB in middle-aged diabetic patients has been previously reported to be 11.7%–24.2%, which is higher than that of the general population (7, 8). Furthermore, because the frequency of urination reportedly increases with age, OAB in elderly diabetic patients poses a serious health problem (9, 10).

Sarcopenia, characterized by the loss of muscle mass, muscular strength, and physical function, has been observed as a condition associated with aging as well as declined ADL, QOL, and even death (11). Because the prevalence of sarcopenia is higher in diabetic patients, with a reportedly estimated prevalence of 20%–30%, it is important to consider that diabetic patients may have or develop sarcopenia (12). However, confirming sarcopenia is complicated and can be difficult to perform during a regular medical examination. Malmstrom and Morley et al. created a simple screening tool, known as the SARC-F, for detecting sarcopenia in the elderly population, and its validity has been evaluated in various studies (13, 14). In the recent years, the authors of the present study have developed a Japanese version of the SARC-F, known as the SARC-F-J, which targets elderly diabetic patients (15). Using the SARC-F-J, we have demonstrated the possible correlation between sarcopenia and cognitive dysfunction as well as depression (16, 17).

As noted above, the frequency of OAB is high in elderly diabetic patients, and this has been attributed to various factors, including diabetic neuropathy, osmotic diuresis, bladder vascular insufficiency, inflammation, and oxidative stress (18-20). Sarcopenia reportedly causes conditions such as inflammation and oxidative stress and promotes arteriosclerosis (21, 22). Thus, we have hypothesized that sarcopenia is closely associated with OAB. To the best of our knowledge, little or no research has been conducted on the association between sarcopenia and OAB in elderly diabetic patients. Therefore, this cross-sectional study aimed to examine the association between sarcopenia and OAB in elderly diabetic patients using the SARC-F-J.

Methods

Study design and subjects

This was a cross-sectional study including diabetic patients who regularly attended the outpatient clinic at Ise Red Cross Hospital in Ise City, Mie Prefecture. Informed consent was obtained from all eligible patients, and the study was approved by the Ethics Committee of the hospital. Eligibility was set for diabetic patients aged ≥65 years who visited the outpatient clinic between June and November 2017. Exclusion

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criteria were defined as any patient with secondary diabetes, alcoholism, severe mental disorder, bladder tumors or history of any malignant tumors, and a past history of intrapelvic surgery; those using implanted pacemakers or home oxygen therapy; those who had undergone bilateral knee joint replacement or hip replacement; those diagnosed with heart failure within the past 6 months; or those who could not participate in the study unaided (8, 9).

Measurement of OAB

The OAB symptom score (OABSS) was used to measure OAB, which comprised four items: "urination frequency during the day," "urination frequency during the night," "frequency of urinary urgency," and "frequency of urinary incontinence," on a scale of 0–15 points (23). OAB was diagnosed as having a urinary urgency score of ≥2 points and a total score of ≥3 points.

Evaluation of sarcopenia using SARC-F-J

The self-administered questionnaire SARC-F-J was used to evaluate sarcopenia (15). The questionnaire comprised the following five items: strength, assistance in walking, rising from a chair, climbing stairs, and falls. Answers were categorized into 3 tiers of "no difficulty," "occasional difficulty," and "frequent difficulty" with 0, 1, or 2 points assigned for each answer, respectively. The answers regarding falls were divided into none, 1–3 times, and ≥4 times. The total number of points ranged from 1 to 10, and a total score of ≥4 points indicated sarcopenia.

Measurement of other variables

Age, sex, body mass index (BMI) (weight [kg]/height [m^2]), smoking history, alcohol consumption, type of diabetes (type 1, type 2, or other), duration of diabetes, hemoglobin A1c (HbA1c), hypertension, dyslipidemia, insulin resistance, diabetic retinopathy, diabetic neuropathy, diabetic nephropathy, cardiovascular disease, antidiabetic medication regimen, depression, cognitive function, and sleep disorders were investigated. Diabetes was classified into type 1, type 2, or other according to the Japan Diabetes Society examination standard (24). Serum lipid profile was measured using an enzyme test, and blood plasma glucose concentration was measured using the glucose oxidase test. HbA1c was measured using high pressure liquid chromatography and listed on the National Glycohemoglobin Standardization Program. Hypertension was defined in patients as having either systolic pressure of ≥130 mmHg or diastolic pressure of ≥80 mmHg when their blood pressure was measured in the examination room or taking antihypertensive medications. For lipids, dyslipidemia was defined in patients as having either triglycerides (TG) of ≥150 mg/dl, high-density lipoprotein-cholesterol (HDLC) of <40 mg/dl, or low-density lipoprotein-cholesterol (LDLC) of ≥120 mg/dl (in case of coronary heart disease, LDLC of ≥100 mg/dl) or were taking any lipid-lowering drugs. The indicator of insulin resistance was based on the TG/HDLC ratio (25). Diabetic retinopathy was diagnosed by the ophthalmologist and was defined in patients as having either decreased Achilles reflex or vibratory perception in the lateral malleolus or an abnormality in the nerve conduction medical examination. Cardiovascular disease was defined in patients as currently having or having a history of any ischemic heart disease, such as angina pectoris or myocardial infarction, or cerebrovascular disease, such as cerebral infarction. Depression was measured using the nine-item Japanese version of the Patient Health Questionnaire 9 (J-PHQ-9), developed and validated by Muramatsu et al (26). Symptoms from the previous 2 weeks were measured on a 4-point scale (nearly every day was 3 points, half of the time 2 points, several days 1 point, and not at all 0 point). The total number of points could range from 0 to 27, with a higher score indicating more serious symptoms of depression. In this study, depression was defined in patients as having a J-PHQ-9 score of ≥5 points based on previous studies. Cognitive function was measured using the Japanese version of the self-administered cognitive function evaluation tool Test Your Memory (TYM-J), developed and validated by Hanyu et al (27). Points were distributed according totems, with orientation as 10 points, sentence copying 2 points, knowledge 3 points, arithmetic 4 points, word fluency 4 points, analogies 4 points, pseudonyms 5 points, visual space/structure 7 points for two topics, sentence memory recall 6 points, and assistance 5 points. The total number of possible points ranged from 0 to 50, with a lower score indicating low cognitive function. Based on this point system, cognitive impairment in this study was defined in patients as having a total TYM-J score of ≤44 points. Sleep disorders were measured using the Japanese version of the Pittsburgh Sleep Quality Index, which is a widely used self-administered questionnaire for the evaluation of sleep disorders and comprises seven items: quality of sleep, time to fall asleep, amount of sleep, sleep efficiency, sleep difficulty, use of sleeping medication, and difficulty in staying awake during the day (28). Each item was assigned a score between 0 and 3 points, with the total number of points ranging from 0 to 21. A higher number of points indicated poorer sleep quality. In this study, a total score of ≥5.5 points indicated sleep disorder according to previous studies.

Statistical analysis

Patient backgrounds were listed according toes and if the subject had sarcopenia or not according to SARC-F-J. The groups were compared using the t-test for continuous variables and the chi-square test for binary variables. The odds ratio for OAB due to sarcopenia was calculated after adjustment using logistic regression, with OAB as the dependent variable and sarcopenia as the explanatory variable. Using previous studies and clinical judgments, variables that were adjusted for the analysis were age, BMI, HbA1c, smoking history, alcohol consumption, comorbidity (hypertension, dyslipidemia, diabetic retinopathy, diabetic neuropathy, diabetic nephropathy,

Table 1
Baseline characteristics of the analysis set according to the SARC-F-J definition of sarcopenia

	Males			Females		
	No sarcopenia n = 152 (81.8%)	**Sarcopenia n = 34 (18.2%)**	**P**	**No sarcopenia n = 103 (72.1%)**	**Sarcopenia n = 40 (27.9%)**	**P**
Age (years), mean (SD)	71.1 (5.7)	72.5 (6.4)	0.192	71.5 (5.4)	74.1 (6.5)	0.015*
BMI (kg/m^2), mean (SD)	24 (4.4)	24.6 (4.1)	0.458	23.7 (4.3)	25.2 (4.2)	0.072
T1DM/T2DM/other, %	6.0/91.9/2.1	6.0/94.0/0	0.713	8.0/90.9/1.1	10.2/87.2/2.6	0.718
HbA1c (%), mean (SD)	7.3 (1.1)	7 (0.9)	0.280	7.4 (0.9)	7.6 (1.4)	0.312
Duration of diabetes (years), mean (SD)	17.9 (11.3)	20.1 (11)	0.318	15.9 (9.7)	20.1 (10.2)	0.029*
Alcohol consumption, %	25.5	23.5	0.811	7.9	10.2	0.658
Smoking, %	30.2	32.3	0.811	2.9	10	0.078
Hypertension, %	77.7	91.1	0.075	76.7	79.4	0.730
Dyslipidemia, %	70.4	61.7	0.323	73.1	76.3	0.710
LDLC (mg/dL), mean (SD)	100 (28)	88 (25.7)	0.033*	109.4 (30.3)	93.3 (24)	0.010*
HDLC (mg/dL), mean (SD)	52.3 (13.5)	49.2 (11.1)	0.240	58.6 (14.1)	60.5 (15.4)	0.490
TG (mg/dL), mean (SD)	136.5 (80)	125.5 (69.5)	0.470	132.2 (62)	134.7 (65)	0.832
TG/HDLC ratio, mean (SD)	2.8 (1.9)	2.7 (1.7)	0.573	2.4 (1.4)	2.6 (1.6)	0.546
Retinopathy, %	37.5	32.3	0.132	40.7	40	0.932
Neuropathy, %	62.5	70.5	0.374	64	77.5	0.123
Nephropathy, %	56.5	76.4	0.032*	48.5	55	0.488
Cardiovascular diseases, %	25.6	38.2	0.143	6.1	34.2	<0.001*
Oral hypoglycemic agents, %	79.1	67.6	0.149	79.7	74.3	0.485
Numbers of oral hypoglycemic agents, mean (SD)	1.6 (1)	1.3 (1.1)	0.144	1.5 (0.9)	1.5 (1.1)	0.802
GLP-1 analog, %	9.3	6	0.540	17.1	10.2	0.309
Insulin, %	66.4	75.7	0.299	60.6	79.4	0.035*
Depression, %	58.5	70.5	0.194	56.3	80	0.008*
Sleep disorder, %	46.7	64.7	0.058	50.4	87.5	<0.001*
Cognitive impairment, %	12.5	32.3	0.004*	19.4	37.5	0.024*
OAB, %	16.4	35.2	0.013*	12.6	30	0.014*

SD, standard deviation; BMI, body mass index; T1DM/T2DM, type-1/type-2 diabetes mellitus; HbA1c, hemoglobin A1c; LDLC, low-density lipoprotein-cholesterol; HDLC, high-density lipoprotein-cholesterol; TG, triglycerides; GLP-1, glucagon-like peptide-1; OAB, overactive bladder; Cardiovascular diseases included angina pectoris, myocardial infarction, and stroke.
*T-test for continuous variables and chi-square for categorical variables.

or cardiovascular disease), depression, cognitive function, and sleep disorders (9, 29). The level of significance (two-tailed) was set at $P < 0.05$, and STATA version 12.0 (Stata Corporation LP, College Station, TX) was used for the analysis.

Results

A total of 349 patients were eligible for the present study; 19 of them were excluded due to missing information, leaving 329 subjects (186 males and 143 females) for the final analysis. The ratio of sarcopenia was 22.9% (males 18.2% and females 27.9%). The ratio for OAB was 18.7% (males 19.8% and females 17.4%).

Table 1 shows the patient characteristics in the analysis set 1. The frequency of diabetic nephropathy in males was higher in the sarcopenia group than in the non-sarcopenia group. The females in the sarcopenia group were older and had a longer duration of diabetes, used insulin more frequently, and had a higher rate of diabetic neuropathy, cardiovascular diseases, sleep disorders, and depression. The males and females in the sarcopenia group had a higher rate of cognitive impairment and OAB than those in the non-sarcopenia group.

Table 2 shows the results of the logistic regression analysis. After adjusting the variables, the odds ratio for OAB due to sarcopenia was 4.46 (95% confidence interval [CI], 1.14–17.36, $P = 0.031$) in males and 2.09 (95% CI, 0.52–8.26, $P = 0.293$) in females. A statistically significant correlation between sarcopenia and OAB was only observed in elderly diabetic male patients.

Table 2
Factors associated with odds ratios of depression using logistic regression analysis

	Unadjusted OR (95% CI)	P	Adjusted OR (95% CI)	P
Males				
Age, per year increase			0.83 (0.73–0.94)	0.004*
BMI, per 1 kg/m2 increase			0.94 (0.82–1.07)	0.395
Smoking (vs. no)			0.57 (0.31–1.04)	0.070
Alcohol consumption (vs. no)			0.52 (0.14–1.87)	0.321
HbA1c, per 1 % increase			0.33 (0.07–1.38)	0.129
Numbers of comorbidity, per 1 increase			1.35 (0.4–4.58)	0.625
Depression (vs. no)			2.29 (0.52–10.08)	0.271
Sleep disorder (vs. no)			2.26 (0.73–6.99)	0.155
Cognitive impairment (vs. no)			0.79 (0.51–1.23)	0.310
Numbers of oral hypoglycemic agents, per 1 increase			1.11 (0.63–1.95)	0.703
Insulin (vs. no)			0.54 (0.16–1.78)	0.319
Sarcopenia (vs. no)	2.77 (1.21–6.31)	0.015*	4.46 (1.14–17.36)	0.031*
Female				
Age, per year increase			1.08 (0.98–1.2)	0.097
BMI, per 1 kg/m2 increase			0.92 (0.78–1.08)	0.331
Smoking (vs. no)			1.58 (0.92–2.7)	0.093
Alcohol consumption (vs. no)			1.69 (0.18–15.6)	0.640
HbA1c, per 1 % increase			1.94 (0.35–10.63)	0.442
Numbers of comorbidity, per 1 increase			0.56 (0.16–1.99)	0.378
Depression (vs. no)			0.91 (0.24–3.37)	0.888
Sleep disorder (vs. no)			3.12 (0.81–11.92)	0.096
Cognitive impairment (vs. no)			0.71 (0.45–1.11)	0.140
Numbers of oral hypoglycemic agents, per 1 increase			0.71 (0.41–1.22)	0.222
Insulin (vs. no)			0.75 (0.19–2.89)	0.683
Sarcopenia (vs. no)	2.96 (1.21–7.23)	0.017*	2.09 (0.52–8.26)	0.293

BMI, body mass index; HbA1c, hemoglobin A1c; comorbidity, chronic condition, including hypertension, dyslipidemia, neuropathy, retinopathy, nephropathy and cardiovascular diseases (angina pectoris, myocardial infarction, and stroke), OR, odds ratio; CI, confidence interval; *P < 0.05.

Discussion

The present study investigated the association between sarcopenia and OAB in elderly diabetic patients using the SARC-F-J. To that effect, a statistically significant correlation between sarcopenia and OAB was observed only in males and not in females.

The frequency of OAB is reportedly higher in elderly diabetic patients than in non-diabetic elderly individuals (7,8). The possible development of OAB has also been associated with diabetic neuropathy, osmotic diuresis, oxidative stress, inflammation, bladder vascular insufficiency (bladder ischemia), and other symptoms caused by diabetes (8,18-20). Factors such as aging, obesity, smoking history, alcohol consumption, cardiovascular diseases, depression, sleep disorders, and cognitive decline are known to be associated with the development of OAB (9). Previous studies have reported that the frequency of OAB measured using the OABSS in middle-aged diabetic patients was 11.7%–24.2% (7,8). The results of the present study for OAB (18.7%; males, 19.8% and females 17.4%) were similar to that of these previous studies. Another study has reported that the prevalence of sarcopenia in elderly diabetic patients was 19% in males and 27% in females (12); Bouchi et al. have also reported a prevalence of 17.6% (30). These previously reported results were similar to those observed in the present study. However, these previous studies had different age ranges, lengths of diabetic disease duration, and comorbidity; therefore, the similarity in the results may not

be directly related.

Several observations must be considered when investigating the mechanisms underlying the association between sarcopenia and OAB. First, sarcopenia reportedly elicits inflammatory cytokines (such as tumor necrosis factor-α) and oxidative stress (21, 22). According to various studies, inflammation and oxidative stress can cause myopathy and neurodegeneration in the bladder, possibly resulting in the development of OAB (18,31). These factors may be responsible for the association between sarcopenia and OAB. Second, recent studies have reported the possible correlation between the development of OAB and bladder vascular insufficiency or bladder ischemia (20). Sarcopenia has also been previously closely associated with arteriosclerosis; indicating that arteriosclerosis is another factor that associates sarcopenia and OAB (21, 22).

The findings of this study are interesting as sarcopenia was significantly associated with OAB only in males. Because arteriosclerotic lesions reportedly develop sooner in males than in females, they may represent a common risk that is closely associated with OAB and sarcopenia in males (32). In this study, the occurrence of retinopathy, neuropathy, and cardiovascular diseases in males was higher in the sarcopenia group than in the non-sarcopenia group, suggesting its strong correlation with arteriosclerosis. However, inflammation, oxidative stress markers, and bladder blood flow were not evaluated in this study. Therefore, future research studies are warranted to understand the mechanism underlying the association between OAB and sarcopenia. Regarding the multivariate analysis results in this study, a significant negative correlation was observed between age and OAB in males. As previously mentioned, the occurrence rate of OAB increases with age (9). However, the high occurrence of underactive bladder (UAB), in addition to aging, has also observed in elderly diabetic patients due to neuropathy from chronic hyperglycemia, urothelial dysfunction, etc (33). The progression pattern from OAB to UAB has been proposed, and the occurrence of OAB may decrease in the elderly patients due to the loss of urinary urgency as an effect of the aging and progression of neuropathy; however, further studies investigating this are warranted in the future (18).

Based on the literature review and to the best of our knowledge, this is the first study to explore the possible association between sarcopenia and OAB. The clinically relevant finding of the present study is that screening elderly diabetic male patients for sarcopenia using SARC-F-J is helpful to identify and warn those at risk for OAB and to facilitate the early diagnosis of OAB. Because a decline in QOL and ADL in elderly diabetic patients could be possibly associated with undiagnosed OAB, early intervention in OAB diagnosis and treatment is considered crucial (34). Previous studies have reported that muscle mass and muscular strength increased with exercise and nutritional intervention in patients with sarcopenia (35, 36). Furthermore, some studies have also reported that the symptoms improved due to kinesitherapy in patients with OAB (37, 38). Further research focusing on the correlation between therapeutic intervention for patients with sarcopenia and the improvement or prevention of OAB as well as longitudinal studies on the development of OAB and the prevalence of sarcopenia in elderly diabetic patients are warranted in the future.

This study had some limitations. First was the self-administered nature of the questionnaire format of the SARC-F-J and OABSS. The subjects were elderly people, indicating that the validity of results is affected by the fact that a number of subjects had cognitive difficulties. Second, all possible confounding factors may not be adjusted during the analysis. Although physical activity and nutritional status were not evaluated in this study, these variables may possibly affect the statistical analysis of the results. Third, the study results may also have been affected by the omission of information on the presence of spinal disease and on drugs (such as anticholinergic drugs) that can affect bladder function. Lastly, because this was a cross-sectional study, the causal association cannot be confirmed. Therefore, future longitudinal research should evaluate this causal relationship between sarcopenia and OAB in elderly diabetic patients using SARC-F-J.

Conclusions and Implications

With consideration of the above limitations, a statistically significant association between sarcopenia and OAB was observed in elderly diabetic male patients in this study. When examining elderly diabetic male patients who also have sarcopenia, it will be necessary to be aware of the possibility of the development of OAB. Further research must take the limitations of the present study into account.

Conflicts of Interest: Satoshi Ida, Ryutaro Kaneko, Kanako Imataka, and Kazuya Murata report other financial relations from sanofi-aventis, outside the submitted work..

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Ethical standards: This study was approved by the Ethical Review Board of the Ise Red Cross Hospital and conducted in accordance with the Helsinki Declaration. Written informed consents were obtained from all participants before enrolment.

References

1. Haylen BT, de Ridder D, Freeman RM, Swift SE, Berghmans B, Lee J, Monga A, Petri E, Rizk DE, Sand PK, Schaer GN. An international Urogynecological association (IUGA)/international continence society (ICS) joint report on the terminology for female pelvic floor dysfunction. Int Urogynecol J 2010;29:4-20.
2. Bartoli S, Aguzzi G, Tarricone R. Impact on quality of life of urinary incontinence and overactive bladder: a systematic literature review. Urology 2010;75:491-500.
3. Coyne KS, Sexton CC, Kopp Z, Chapple CR, Kaplan SA, Aiyer LP, Symonds T. Assessing patients' descriptions of lower urinary tract symptoms (LUTS) and

perspectives on treatment outcomes: results of qualitative research. Int J Clin Pract 2010;64:1260-1278.
4. Zarowitz BJ, Allen C, O'Shea T, Tangalos E, Berner T, Ouslander JG. Clinical burden and nonpharmacologic management of nursing facility residents with overactive bladder and/or urinary incontinence. Consult Pharm 2015;30:533-542.
5. Ganz ML, Smalarz AM, Krupski TL, Anger JT, Hu JC, Wittrup-Jensen KU, Pashos CL. Economic costs of overactive bladder in the United States. Urology 2010;75:526-532.
6. Nuotio M, Tammela TL, Luukkaala T, Jylha M. Urgency and urge incontinence in an older population: ten-year changes and their association with mortality. Aging Clin Exp Res 2002;14:412-419.
7. Liu RT, Chung MS, Lee WC, Chang SW, Huang ST, Yang KD, Chancellor MB, Chuang YC. Prevalence of overactive bladder and associated risk factors in 1359 patients with type 2 diabetes. Urology 2011;78:1040-1045.
8. Ikeda M, Nozawa K. Prevalence of overactive bladder and its related factors in Japanese patients with diabetes mellitus. Endocr J 2015;62:847-854.
9. Xu D, Cheng R, Ma A, Zhao M, Wang K. Toileting behaviors and overactive bladder in patients with type 2 diabetes: a cross-sectional study in China. BMC Urol 2017;17:42.
10. Wen JG, Li JS, Wang ZM, Huang CX, Shang XP, Su ZQ, Lu YT, Suo ZH, Wang Y, Qin GJ, Zhang WX, Heesakkers JP. The prevalence and risk factors of OAB in middle-aged and old people in China. Neurourol Urodyn 2014;33:387-391.
11. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, Martin FC, Michel JP, Rolland Y, Schneider SM, Topinková E, Vandewoude M, Zamboni M; European Working Group on Sarcopenia in Older People. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412-423.
12. Kim TN, Park MS, Yang SJ, Yoo HJ, Kang HJ, Song W, Seo JA, Kim SG, Kim NH, Baik SH, Choi DS, Choi KM. Prevalence and determinant factors of sarcopenia in patients with type 2 diabetes: the Korean Sarcopenic Obesity Study (KSOS). Diabetes Care 2010;33:1497-1499.
13. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc 2013;14:531-532.
14. Malmstrom TK, Miller DK, Simonsick EM, Ferrucci L, Morley JE. SARC-F: a symptom score to predict persons with sarcopenia at risk for poor functional outcomes. J Cachexia Sarcopenia Muscle 2016;7:28-36.
15. Ida S, Murata K, Nakadachi D, Ishihara Y, Imataka K, Uchida A, Monguchi K, Kaneko R, Fujiwara R, Takahashi H. Development of a Japanese version of the SARC-F for diabetic patients: an examination of reliability and validity. Aging Clin Exp Res 2016;29:935-942.
16. Ida S, Nakai M, Ito S, Ishihara Y, Imataka K, Uchida A, Monguchi K, Kaneko R, Fujiwara R, Takahashi H, Murata K. Association Between Sarcopenia and Mild Cognitive Impairment Using the Japanese Version of the SARC-F in Elderly Patients With Diabetes. J Am Med Dir Assoc 2017;18:809.e9-809.e13.
17. Ida S, Murata K, Nakai M, Ito S, Malmstrom TK, Ishihara Y, Imataka K, Uchida A, Monguchi K, Kaneko R, Fujiwara R, Takahashi H. Relationship between sarcopenia and depression in older patients with diabetes: An investigation using the Japanese version of SARC-F. Geriatr Gerontol Int 2018;18:1318-1322.
18. Tyagi P, Tyagi V, Qu X, Lin HT, Kuo HC, Chuang YC, Chancellor M. Association of inflammaging (inflammation + aging) with higher prevalence of OAB in elderly population. Int Urol Nephrol 2014;46:871-877.
19. Yamaguchi O, Nomiya M, Andersson KE. Functional consequences of chronic bladder ischemia. Neurourol Urodyn 2014;33:54-58.
20. Azadzoi KM, Tarcan T, Kozlowski R, Krane RJ, Siroky MB. Overactivity and structural changes in the chronically ischemic bladder. J Urol 1999;162:1768-1778.
21. Kinugasa Y, Yamamoto K. The challenge of frailty and sarcopenia in heart failure with preserved ejection fraction. Heart 2017;103:184-189.
22. Wannamethee SG, Atkins JL. Muscle loss and obesity: the health implications of sarcopenia and sarcopenic obesity. Proc Nutr Soc 2015;74:405-412.
23. Homma Y, Yoshida M, Seki N, Yokoyama O, Kakizaki H, Gotoh M, Yamanishi T, Yamaguchi O, Takeda M, Nishizawa O. Symptom assessment tool for overactive bladder syndrome--overactive bladder symptom score. Urology 2006;68:318-323.
24. Seino Y, Nanjo K, Tajima N, Kadowaki T, Kashiwagi A, Araki E, Ito C, Inagaki N, Iwamoto Y, Kasuga M, Hanafusa T, Haneda M, Ueki K. Report of the committee on classification and diagnostic criteria of diabetes mellitus. J Diabetes Investig 2010;25:859-866.
25. Fukuda Y, Hashimoto Y, Hamaguchi M, Fukuda T, Nakamura N, Ohbora A, Kato T, Kojima T, Fukui M (2016) Triglycerides to high-density lipoprotein cholesterol ratio is an independent predictor of incident fatty liver; a population-based cohort study. Liver Int 2016;36:713-720.
26. Muramatsu K, Miyaoka H, Kamijima K, Muramatsu Y, Yoshida M, Otsubo T, Gejyo F. The patient health questionnaire, Japanese version: validity according to the mini-international neuropsychiatric interview-plus. Psychol Rep 2007;101:952-960.
27. Hanyu H, Maezono M, Sakurai H, Kume K, Kanetaka H, Iwamoto T. Japanese version of the Test Your Memory as a screening test in a Japanese memory clinic. Psychiatry Res 2011;190:145-148.
28. Doi Y, Minowa M, Uchiyama M, Okawa M, Kim K, Shibui K, Kamei Y. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) in psychiatric disordered and control subjects. Psychiatry Res 2000;97:165-172.
29. Suskind AM, Quanstrom K, Zhao S, Bridge M, Walter LC, Neuhaus J, Finlayson E. Overactive bladder is strongly associated with frailty in older individuals. Urology 2007;106:26-31.
30. Bouchi R, Fukuda T, Takeuchi T, Minami I, Yoshimoto T, Ogawa Y. Sarcopenia is associated with incident albuminuria in patients with type 2 diabetes: A retrospective observational study. J Diabetes Investig 2017;8:783-787.
31. Beshay E, Carrier S. Oxidative stress plays a role in diabetes-induced bladder dysfunction in a rat model. Urology 2004;64:1062-1067.
32. Villablanca AC, Jayachandran M, Banka C. Atherosclerosis and sex hormones: current concepts. Clin Sci (Lond) 2010;119:493-513.
33. Daneshgari F, Liu G, Birder L, Hanna-Mitchell AT, Chacko S. Diabetic bladder dysfunction: current translational knowledge. J Urol 2009;182:S18-26.
34. Sexton CC, Coyne KS, Thompson C, Bavendam T, Chen CI, Markland A. Prevalence and effect on health-related quality of life of overactive bladder in older americans: results from the epidemiology of lower urinary tract symptoms study. J Am Geriatr Soc 2011;59:1465-1470.
35. Singh NA, Quine S, Clemson LM, Williams EJ, Williamson DA, Stavrinos TM, Grady JN, Perry TJ, Lloyd BD, Smith EU, Singh MA. Effects of high-intensity progressive resistance training and targeted multidisciplinary treatment of frailty on mortality and nursing home admissions after hip fracture: a randomized controlled trial. J Am Med Dir Assoc 2012;13:24-30.
36. Tieland M, Dirks ML, van der Zwaluw N, Verdijk LB, van de Rest O, de Groot LC, van Loon LJ. Protein supplementation increases muscle mass gain during prolonged resistance-type exercise training in frail elderly people: a randomized, double-blind, placebo-controlled trial. J Am Med Dir Assoc 2012;13:713-719.
37. Burgio KL, Goode PS, Johnson TM II, Hammontree L, Ouslander JG, Markland AD, Colli J, Vaughan CP, Redden DT. Behavioral versus drug treatment for overactive bladder in men: the male overactive bladder treatment in veterans (MOTIVE) trial. J Am Geriatr Soc 2011;59:2209-2216.
38. Lofgren OE. Overactive bladder: a better understanding of pathophysiology, diagnosis and management. J Urol 2007;178:1553-1553.