International Journal of Gerontology 13 (2019) 278–282
https://doi.org/10.6890/IJGE.201912_13(4).0003

International Journal of Gerontology

journal homepage: http://www.sgecm.org.tw/ijge/

Original Article

# Association between Body Mass Index and Frailty Factors in Korean Elderly

Jun Woo Kim [a], Yoon Jeong Cho [a*], Kwang-Hee Shin [b], Geon Ho Lee [a], Sung Hi Kim [a], Hae Jin Ko [c]

[a] *Department of Family Medicine, Daegu Catholic University School of Medicine, Daegu, Republic of Korea,* [b] *College of Pharmacy, Research Institute of Pharmaceutical Sciences, Kyungpook National University, Daegu, Republic of Korea,* [c] *Department of Family Medicine, Kyungpook National University School of Medicine, Daegu, Republic of Korea*

ARTICLE INFO

Accepted 28 January 2019

*Keywords:*
body mass index,
elderly,
frailty,
life transit period examination

SUMMARY

*Background:* This study aimed to evaluate the frailty risk according to body mass index (BMI) using National Health Insurance Service (NHIS) data.
*Methods:* Data from a total of 60,704 subjects of 66-year-old subjects who had taken the Life Transition Period Health Examination from 1 January 2007 to 31 December 2013 were included in the final analysis. The subjects were classified into five groups according to their BMI, as follows: low weight, normal, overweight, obese and morbidly obese. The associations between the BMI groups and risk of frailty factors such as gait speed, balance, history of falls, cognitive function, and incontinence were evaluated.
*Results:* The frailty risk in terms of gait speed and balance, and the prevalence of a history of falls were increased in the obese and morbidly obese groups compared to in the normal weight group.
*Conclusion:* Differential risks of frailty factors according to BMI groups were evaluated in the current large-scale data analysis.



## 1. Introduction

In many countries belonging to the Organization for Economic Co-operation and Development, including Korea, the population aged over 65 years is classified as the elderly population and is used as an index of population aging.[1] Currently, the elderly population aged over 65 years accounts for more than 12% of the total population in South Korea, and the population aging is rapidly progressing to a level not experienced in other developed countries,[1] which is associated with serious clinical issues.

Frailty refers to a condition in the elderly that associates with a poor prognosis due to poor physical condition, diminished mental function, and increased vulnerability. Frailty is also related with health associated quality of life.[2] However, this concept is controversial, owing to the fact that the evaluations of frailty use different definitions or measurement tools.[3–7] Fried et al. defined frailty when three or more of the five criteria of weight loss, extreme fatigue, weakness, reduction in walking speed, and physical activity decrease are met.[4] Jones et al. assessed frailty using the Frailty Index based on the Comprehensive Geriatrics Assessment.[5] In South Korea, the Korean version of the tool for measuring frailty, developed by the Geriatric Function Evaluation Committee,[6] is used. Weight loss or nutritional status is used in most methods of assessing frailty, and the World Health Organization (WHO) has proposed the use of body mass index (BMI; kg/m$^2$) to monitor nutritional status and obesity or low weight in adults worldwide.[7] Yusuke Adachi et al. showed frail people have low plasma essential amino acids with low a BMI and insufficient nutritional intake.[8] In the Asia-Pacific population, overweight is classified as a BMI of 23–24.99 kg/m$^2$ and obesity as BMI over 25 kg/m$^2$, taking into account the local population characteristics.[9]

In 2005, a study of the relationship between obesity and frailty in 599 elderly women in the US reported that the obesity group had a 3.52-fold increased risk of frailty and that weight loss, weakness (grip strength), and walking speed were significantly associated with frailty.[10] Hubbard et al. reported a U-shaped correlation between BMI and the Frailty index in elderly people over 65 years of age, with the lowest Frailty index score reported in the overweight group (BMI 25–29.99 kg/m$^2$).[11] Moreover, a study with participants aged 41–81 showed that both underweight and obesity were associated with participants' physical frailty.[12]

In Korea, one study on this issue was published in 2015. In this study, among a total of 131 subjects aged 65 years and older, it was estimated that overweight status could reduce frailty more than normal weight.[13] However, the small sample size was an important limitation. In the current study, the relationship between BMI and various clinical factors used in the assessment of frailty were examined in 60704 patients who received a health examination at the age of 66 years from 2007 to 2013.

## 2. Methods

### 2.1. Database

Data were extracted from the Life Transition Period Health Examination, conducted at 66 years, among the Health Examination

* Corresponding author. 33, Duryugongwon-ro 17-Gil, Namgu, Daegu, Republic of Korea. Zip code 42472.
*E-mail address:* alpha1229@cu.ac.kr (Y. J. Cho)

data of the National Health Insurance Service (NHIS) using a randomized sampling method. The life transition points have been referred to as the ages of 40 and 66 years in South Korea. At age 66, additional examinations such as elderly cognitive function tests, and physical function tests had been added to the national health examinations.[14] The data analyzed in this study included demographics, previous medical histories, and health examination data for 60,704 patients aged 66 years from January 1, 2007 to December 31, 2013. Subjects who met the following criteria were excluded from the study: 1) a history of stroke and 2) a history of cardiovascular disease. The study flow is presented in Fig. 1.

### *2.2. Ethical statement*

This study was approved by the institutional review board of Daegu Catholic University Medical Center and the need for informed consent of the study subjects was waived by the board.

### *2.3. Definition of variables*

The assessments for cognitive function and lower extremity dysfunction, urinary incontinence, other drug history were based on self-questionnaires. The Timed Up and Go test to assess the walking speed defined in the frailty measuring tool is performed by measuring the time from when the patient is sitting comfortably in a chair, walking straight for 3 meters, turning back, and returning to sit in the chair. The results are judged to be normal if less than 10 seconds, and abnormal if 11 seconds or more. The balance test is performed by measuring the duration of time the patient can stand on one leg. When the test is performed with the eyes closed, the result is judged to be normal for durations of more than 15 seconds, alarming if 6 to 14 seconds, and abnormal if less than 5 seconds. When examining with the eyes open, the result is normal for durations of more than 20 seconds, alarming if 10 to 19 seconds, and abnormal if less than 9 seconds. The two latter groups were defined as abnormal in this study.

The subjects were classified into five groups according to their BMI, as follows: underweight (BMI < 18.5 kg/m$^2$), normal (18.5 kg/m$^2$ ≤ BMI < 23.0 kg/m$^2$), overweight (23.0 kg/m$^2$ ≤ BMI < 25.0 kg/m$^2$), obese (25.0 kg/m$^2$ ≤ BMI < 30.0 kg/m$^2$) and morbidly obese (BMI ≥ 30.0 kg/m$^2$). Physical activity was categorized as low, moderate, and high levels of physical activity according to the Korean version of the International Physical Activity Questionnaire.[15] Smoking status was divided into three groups: current smokers, ex-smokers, and never smokers. In the case of hypertension and diabetes, only those who answered that they had either disease in the questionnaire were defined as hypertension and diabetes patients.

### *2.4. Statistical analysis*

Frailty factors including time up & go, lower extremity dysfunction, balance, fall down, cognitive function problem, incontinence were described as frequency (%) and the frailty risks according to the BMI groups were assessed as odds ratios (95% confidence intervals) using the logistic regression. Backward elimination was employed for the logistic regression analysis and several confounding factors such as hypertension history, diabetes mellitus history, WC, smoking and physical activity were evaluated as covariates except for lower extremity dysfunction and incontinence in women, and for fall down, cognitive function problem, and incontinence in men. For those items, only the effect of BMI groups was evaluated as fixed effect. Statistical analysis was performed using SAS® (ver. 9.4; SAS Institute Inc., Cary, NC, USA).

## 3. Results

The demographic characteristics of the study subjects were compared between the BMI groups. In men and women, mean systolic blood pressures (SBP), diastolic blood pressures (DBP) (mean ± standard deviation), the rates of hypertensive morbidity (%) for men increased, respectively, according to the BMI group ($p$ <0.001) (Table 1).

Frailty factors were evaluated according to the BMI group in both sexes and in men and women separately. In women, the risks of walking speed decrease (odds ratio [95% confidence interval]) were decreased to 0.84 (0.75–0.94) and 0.80 (0.64–0.99) in the obese and morbidly obese groups, respectively. There were significantly higher odds ratios of lower extremity dysfunction in the underweight (1.85 [1.08–3.17]), and morbidly obese (2.44 [1.75–3.41]) groups com-

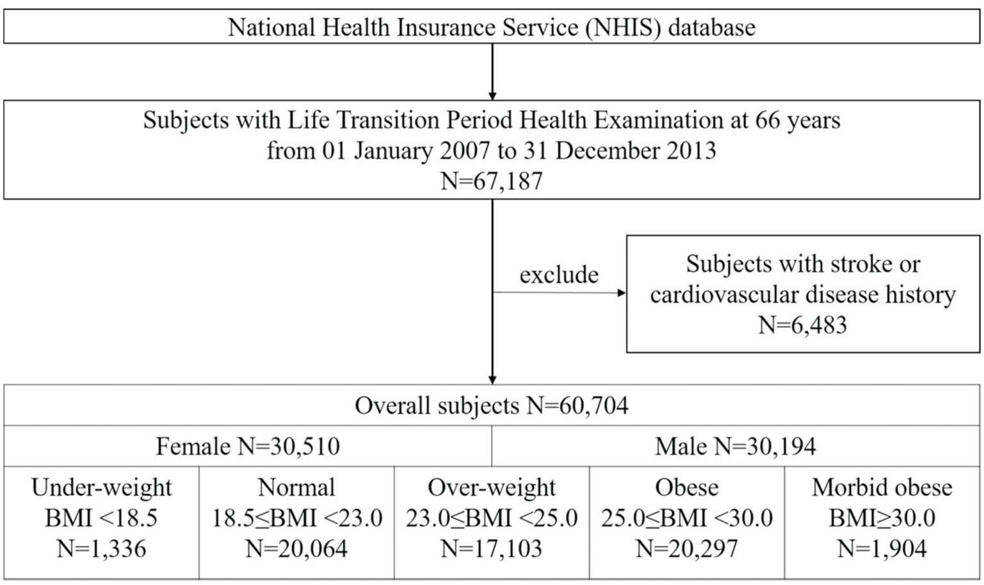


**Fig. 1.** Disposition of subjects.

**Table 1**
General characteristics of study population.

| | Under-weight BMI < 18.5 | Normal 18.5 ≤ BMI < 23.0 | Over-weight 23.0 ≤ BMI < 25.0 | Obese 25.0 ≤ BMI < 30.0 | Morbid obese 30.0 ≤ BMI | *p*-value |
|---|---|---|---|---|---|---|
| ***Women, n (%)*** | 561 (42.0) | 9,526 (47.5) | 8,244 (48.2) | 10,834 (53.4) | 1,345 (70.6) | |
| BMI | 17.5 ± 0.9 | 21.5 ± 1.1 | 24.0 ± 0.6 | 26.8 ± 1.3 | 32.0 ± 2.7 | < .0001 |
| WC | 67.6 ± 6.1 | 75.4 ± 5.6 | 80.8 ± 5.2 | 86.3 ± 5.9 | 95.8 ± 7.1 | < .0001 |
| SBP | 122 ± 16.3 | 125 ± 15.4 | 128 ± 15.1 | 130 ± 15.2 | 134 ± 15.7 | < .0001 |
| DBP | 74.3 ± 10.4 | 75.9 ± 9.7 | 77.3 ± 9.6 | 78.8 ± 9.6 | 80.8 ± 9.7 | < .0001 |
| Smoking status, n (%) | | | | | | |
| Current smoker | 15 (2.72) | 148 (1.57) | 106 (1.30) | 109 (1.02) | 18 (1.37) | |
| Ex-smoker | 6 (1.09) | 54 (0.57) | 43 (0.53) | 49 (0.46) | 11 (0.83) | 0.001 |
| Never smoker | 531 (96.2) | 9,210 (97.9) | 7,975 (98.2) | 10,501 (98.5) | 1,289 (97.8) | |
| Alcohol, n (%) | | | | | | |
| Yes | 40 (8.95) | 718 (9.36) | 626 (9.54) | 861 (10.1) | 118 (10.9) | 0.339 |
| No | 407 (91.1) | 6,957 (90.6) | 5,933 (90.5) | 7,691 (89.9) | 967 (89.1) | |
| Physical activity, n (%) | | | | | | |
| Low | 349 (62.2) | 5,289 (55.5) | 4,566 (55.4) | 6,214 (57.4) | 865 (64.3) | |
| Moderate | 168 (30.0) | 3,338 (35.0) | 2,846 (34.5) | 3,658 (33.8) | 397 (29.5) | < .0001 |
| High | 44 (7.84) | 899 (9.44) | 832 (10.1) | 962 (8.88) | 83 (6.17) | |
| Comorbid disease, n (%) | | | | | | |
| Hypertension | 92 (21.5) | 2,629 (35.2) | 3,062 (45.3) | 4,978 (53.9) | 801 (67.1) | < .0001 |
| Diabetes mellitus | 39 (9.15) | 983 (13.7) | 927 (14.4) | 1,453 (16.7) | 290 (25.7) | < .0001 |
| ***Men, n (%)*** | 775 (58.0) | 10,538 (52.5) | 8,859 (51.8) | 9463 (46.6) | 559 (29.4) | |
| BMI | 17.5 ± 0.8 | 21.4 ± 1.2 | 24.0 ± 0.6 | 26.6 ± 1.2 | 31.4 ± 1.6 | < .0001 |
| WC | 70.7 ± 5.7 | 79.6 ± 5.5 | 85.4 ± 4.7 | 90.9 ± 5.6 | 101 ± 6.8 | < .0001 |
| SBP | 122 ± 16.4 | 126 ± 15.5 | 129 ± 14.8 | 131 ± 14.7 | 134 ± 15.7 | < .0001 |
| DBP | 75.6 ± 10.3 | 77.2 ± 9.8 | 78.5 ± 9.5 | 79.8 ± 9.7 | 81.3 ± 10.2 | < .0001 |
| Smoking status, n (%) | | | | | | |
| Current smoker | 304 (40.9) | 2,926 (28.7) | 1,807 (21.1) | 1,697 (18.5) | 89 (16.4) | < .0001 |
| Ex-smoker | 193 (25.9) | 3,232 (31.7) | 3,118 (36.5) | 3,519 (38.4) | 202 (37.3) | |
| Never smoker | 247 (33.2) | 4,025 (39.5) | 3,625 (42.4) | 3,960 (43.2) | 251 (46.3) | |
| Alcohol, n (%) | | | | | | |
| Yes | 382 (56.3) | 5,551 (59.2) | 4,745 (59.7) | 5,115 (60.4) | 294 (58.5) | 0.193 |
| No | 297 (43.7) | 3,823 (40.8) | 3,206 (40.3) | 3,358 (39.6) | 209 (41.6) | |
| Physical activity, n (%) | | | | | | |
| Low | 435 (56.1) | 4,939 (46.9) | 3,861 (43.6) | 4,237 (44.8) | 273 (44.8) | < .0001 |
| Moderate | 247 (31.9) | 4,112 (39.0) | 3,557 (40.2) | 3,697 (39.1) | 196 (35.1) | |
| High | 93 (12.0) | 1,487 (14.1) | 1,441 (16.3) | 1,529 (16.2) | 90 (16.1) | |
| Comorbid disease, n (%) | | | | | | |
| Hypertension | 100 (16.9) | 2,657 (32.6) | 3,264 (45.4) | 4,366 (54.6) | 323 (66.5) | < .0001 |
| Diabetes mellitus | 60 (10.2) | 1,170 (14.9) | 1,279 (18.8) | 1,528 (20.4) | 120 (26.7) | < .0001 |

Data were presented as mean ± standard deviation for BMI, WC, SBP, and DBP and number for subjects (%) for smoking status, alcohol, physical activity, and comorbid disease; *p-values* were obtained from the Kruskal-Wallis test for BMI, waist, SBP, and DBP and the chi-square test for smoking status, alcohol, physical activity, and comorbid disease.

pared to in the normal weight group. The odds ratios of having a balance disorder were 1.27 (1.01–1.59) and 1.39 (1.16–1.66), respectively, in the underweight and morbidly obese groups. Based on the results of the self-administered questionnaire, there were statistically significant increase in the incidences of falls in the underweight, overweight, and morbid obese groups compared to in the normal weight group. The incidences of cognitive function problem were increased to 1.35 (1.06–1.71) in underweight group and decreased to 0.84 (0.76–0.93) and 0.67 (0.55–0.82) in the obese and morbid obese groups. The incidence of urinary incontinence were increased to 1.11 (1.02–1.21) and 1.31 (1.11–1.55) in obese and morbid obese groups, respectively (Table 2).

In men, gait speed were decreased to 0.88 (0.78–0.99) and 0.79 (0.69–1.91) in overweight and obese groups. In the case of lower extremity dysfunction, the odds ratios (95% confidence intervals) were decreased according to the BMI increase. For balance disorders was increased in underweight group, and decreased in overweight group and obese group compared to normal weight group. In terms of a history of falls, the odds ratio was 1.47 (1.06–2.04) in morbid obese group compared to in the normal weight group (Table 2).

## 4. Discussion

It is generally known that overweight and obesity are associated with many chronic diseases, including cardiovascular diseases and cancer, but the relationship between weight and frailty has not yet been fully elucidated, especially in Korean subjects. Strandberg et al. reported that overweight or obesity during middle age was associated with frailty in elderly,[16] Bowen et al. reported that overweight may help reduce functional limitations and disability in elderly with frailty or pre-frailty.[17] Jung et al. showed that the overweight group had superior results in terms of walking speed, sitting, and standing ability than the normal weight group, suggesting that overweight status is more beneficial than normal weight in terms of frailty.[13] In the recent study of Malaysia abdominal obesity, BMI and poor physical function were identified as predictors for frailty and pre-frailty.[18]

In this study, the obese and morbidly obese groups of both men and women showed the risk of gait speed problem was decreased. In men lower extremity dysfunction and balance abnormality was also decreased in obese and morbid obese groups. This finding is

**Table 2**
Association of factors of frailty and body mass index groups.

| | Underweight BMI < 18.5 | Normal 18.5 ≤ BMI < 23.0 | Over-weight 23.0 ≤ BMI < 25.0 | Obese 25.0 ≤ BMI < 30.0 | Morbid obese 30.0 ≤ BMI | Odds ratio (95% confidence interval) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Underweight vs. normal | Over-weight vs. normal | Obese vs. normal | Morbid obese vs. normal |
| ***Women*** | | | | | | | | | |
| Timed up & go | | | | | | | | | |
| Abnormal | 82 (14.6) | 1,229 (12.9) | 1,139 (13.8) | 1,576 (14.6) | 242 (18.0) | 1.35 (1.00–1.82) | 0.93 (0.84–1.03) | 0.84 (0.75–0.94)* | 0.80 (0.64–0.99)* |
| Normal | 479 (85.4) | 8,297 (87.1) | 7,105 (86.2) | 9,258 (85.5) | 1,103 (82.0) | | | | |
| Lower extremity dysfunction | | | | | | | | | |
| Yes | 15 (2.74) | 140 (1.50) | 116 (1.44) | 195 (1.84) | 47 (3.58) | 1.85 (1.08–3.17)* | 0.96 (0.75–1.23) | 1.23 (0.99–1.54) | 2.44 (1.75–3.41)* |
| No | 533 (97.3) | 9,197 (98.5) | 7,944 (98.6) | 10,380 (98.2) | 1,265 (96.4) | | | | |
| Balance | | | | | | | | | |
| Abnormal | 206 (42.1) | 3,417 (41.2) | 3,136 (43.9) | 4,672 (50.0) | 736 (62.5) | 1.27 (1.01–1.59)* | 0.95 (0.87–1.03) | 1.03 (0.94–1.12) | 1.39 (1.16–1.66)* |
| Normal | 283 (57.9) | 4,882 (58.8) | 4,001 (56.1) | 4,677 (50.0) | 441 (37.5) | | | | |
| Fall down | | | | | | | | | |
| Yes | 55 (10.2) | 816 (8.76) | 789 (9.78) | 1,013 (9.59) | 135 (10.4) | 1.41 (1.01–1.97)* | 1.03 (0.91–1.17) | 0.86 (0.75–0.99)* | 0.74 (0.56–0.96)* |
| No | 487 (89.9) | 8,500 (91.2) | 7,282 (90.2) | 9,545 (90.4) | 1,166 (89.6) | | | | |
| Cognitive function problem | | | | | | | | | |
| Yes | 120 (22.2) | 1,766 (19.0) | 1,524 (18.9) | 1,941 (18.4) | 225 (17.2) | 1.35 (1.06–1.71)* | 0.94 (0.86–1.03) | 0.84 (0.76–0.93)* | 0.67 (0.55–0.82)* |
| No | 421 (77.8) | 7,547 (81.0) | 6,530 (81.1) | 8,595 (81.6) | 1,080 (82.8) | | | | |
| Incontinence | | | | | | | | | |
| Yes | 65 (12.0) | 1,086 (11.7) | 1,014 (12.6) | 1,350 (12.8) | 192 (14.8) | 1.03 (0.79–1.35) | 1.09 (1.00–1.19) | 1.11 (1.02–1.21)* | 1.31 (1.11–1.55)* |
| No | 477 (88.0) | 8,228 (88.3) | 7,048 (87.4) | 9,205 (87.2) | 1,108 (85.2) | | | | |
| ***Men*** | | | | | | | | | |
| Timed up & go | | | | | | | | | |
| Abnormal | 91 (11.7) | 1,098 (10.4) | 909 (10.3) | 1,010 (10.7) | 66 (11.8) | 1.26 (0.95–1.65) | 0.88 (0.78–0.99)* | 0.79 (0.69–0.91)* | 0.73 (0.52–1.03) |
| Normal | 684 (88.3) | 9,440 (89.6) | 7,950 (89.7) | 8,453 (89.3) | 493 (88.2) | | | | |
| Lower extremity dysfunction | | | | | | | | | |
| Yes | 11 (1.46) | 142 (1.39) | 95 (1.10) | 123 (1.33) | 5 (0.91) | 1.40 (0.66–2.97) | 0.63 (0.45–0.87)* | 0.64 (0.44–0.93)* | 0.32 (0.11–0.98)* |
| No | 742 (98.5) | 10,103 (98.6) | 8,532 (98.9) | 9,113 (98.7) | 546 (99.1) | | | | |
| Balance | | | | | | | | | |
| Abnormal | 265 (40.2) | 3,042 (33.7) | 2,544 (33.2) | 2,790 (34.1) | 214 (42.7) | 1.60 (1.31–1.95)* | 0.90 (0.83–0.98)* | 0.8 2(0.75–0.91)* | 1.08 (0.84–1.37) |
| Normal | 395 (59.9) | 5,991 (66.3) | 5,111 (66.8) | 5,400 (65.9) | 287 (57.3) | | | | |
| Fall down | | | | | | | | | |
| Yes | 48 (6.39) | 549 (5.36) | 471 (5.46) | 511 (5.55) | 42 (7.69) | 1.21 (0.89–1.64) | 1.02 (0.90–1.16) | 1.04 (0.92–1.18) | 1.47 (1.06–2.04)* |
| No | 703 (93.6) | 9,695 (94.6) | 8,150 (94.5) | 8,694 (94.5) | 504 (92.3) | | | | |
| Cognitive function problem | | | | | | | | | |
| Yes | 126 (16.7) | 1,491 (14.5) | 1,186 (13.8) | 1,232 (13.3) | 67 (12.3) | 1.18 (0.97–1.44) | 0.94 (0.87–1.02) | 0.91 (0.84–0.98)* | 0.83 (0.64-1.08) |
| No | 628 (83.3) | 8,771 (85.5) | 7,418 (86.2) | 8,002 (86.7) | 476 (87.7) | | | | |
| Incontinence | | | | | | | | | |
| Yes | 118 (15.7) | 1,679 (16.4) | 1,385 (16.1) | 1,532 (16.7) | 78 (14.3) | 0.95 (0.78–1.16) | 0.98 (0.90–1.06) | 1.02 (0.94–1.10) | 0.85 (0.66-1.08) |
| No | 633 (84.3) | 8,557 (83.6) | 7,229 (83.9) | 7,668 (83.4) | 469 (85.7) | | | | |

* Statistically significant; WC, hypertension history, diabetes history, physical exercise, and smoking status were included as covariates of logistic regression except for lower extremity dysfunction and incontinence in women, and for fall down, cognitive function problem, and incontinence in men.

considered to be due to the motor power of muscle and fat effects. But in women there was a statistically significant increase in the risk of lower extremity dysfunction and balance abnormality in underweight, obese and morbid obese groups. In women, BMI may have a greater impact on exercise and balance, and this can be understood in relation to the fact that the proportion of fat of the total body weight is higher in females than in men.[19] In other words, it can be inferred that, compared to men, obese women with the same BMI have a lower percentage of muscle mass. The above-mentioned study by Bowen et al.[17] and Jung et al.'s study[13] showing the superiority of exercise capacity in the overweight vs. normal weight group may be related to sarcopenia, which is an important problem in the elderly. In this population, the muscle mass tends to be decreased compared to in younger individuals, and it is thought that overweight status may therefore be advantageous in terms of exercise capacity. However, to support this hypothesis, body composition analysis must be conducted. In a previous report, body composition revealed more effective in evaluating frailty than BMI in elderly.[20] For fall down, the risk was increased in the underweight women, and decreased in obese and morbid obese groups of women. But it was increased in morbidly obese group in men. In a previous study, obesity was revealed to be a protective against fall down.[21] However, the protective effect is controversial. In other studies of the relationship between BMI and fall showed increased BMI lead to higher risk of fall incidences.[22,23] Previous studies have shown that obesity is associated with cognitive impairment. In this study cognitive function problem was decreased in obese groups of men and women. The results might have been caused by the evaluation of cognitive function through self questionnaire in this study. There would be a possibility that it is underestimated by questioning that there was no problem in the cognitive function for oneself.

There are some limitations in the current study. Only persons aged 66 years were included in the study, and these subjects are considered to be relatively young in view of the decrease in exercise capacity due to sarcopenia, and this is likely the reason for why no exercise capacity superiority was seen in the overweight group. For more meaningful research results in the future, subjects aged not only 66 years, but also elderly people over 75 years old should be included in the study. In addition, if the results of body composition analysis can be added, it may be possible to elucidate the exact relationship with sarcopenia. The fact that the only subjects aged 66 years were included and that no additional data such as body composition data were included is considered to be a limitation of this study. Further, in the selection of the study subjects, among the various comorbid diseases that may affect frailty factors, cardiovascular disease and stroke patients were excluded from the study, while only hypertension and diabetes mellitus were used as covariates in the analysis. Moreover, the study is the lack of consideration of arthritis, hematologic diseases including anemia, oncological diseases, eye diseases chronic kidney disease, depression, and other chronic diseases those may affect frailty. Further studies based on a more accurate assessment of each concomitant disease that may affect frailty should be needed. Lastly, the data were retrospectively obtained from the Health Examination database. Examinations and subject management were not strongly controlled compared to clinical trial based studies. And also the assessment for the validity of the test was limited.

Despite these limitations, this study was meaningful in that it was able to examine the characteristics of elderly Koreans by examining the association of physical and cognitive frailty factors with BMI. And we could recognize the proper weight management is important for frailty. Also we would suggest that it would be necessary to gain muscle through exercise from a young age. Further analyses of the associations between various obesity indexes and frailty factors, and a large scale prospective study on elderly people over 75 years old are warranted in the future. These additional studies may provide a basis for determining the appropriate BMI in the elderly. In addition, it is necessary to consider the appropriateness of the timing of the evaluation of exercise ability in the 66-year-old Life Transition Period Health Examination.

## Disclosure statement

The authors declare no conflict of interest.

## References


1. OECD. *Health at a Glance 2017: OECD Indicators*. Paris, France: OECD Publishing; 2017. Available at http://dx.doi.org/10.1787/health_ glance-2017-en. Accessed November 11, 2017.
2. Lin YC, Chang JC, Chen YM, et al. Health related quality of life among frail and pre-frail older adults in Taiwan. *Int J Gerontology.* 2017;11:249–252.
3. Fried LP, Ferrucci L, Darer J, et al. Untangling the concepts of disability, frailty, and comorbidity: Implications for improved targeting and care. *J Gerontol A Biol Sci Med Sci.* 2004;59:M255–M263.
4. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: Evidence for a phenotype. *J Gerontol A Biol Sci Med Sci.* 2001;56:M146–M156.
5. Jones DM, Song X, Rockwood K. Operationalizing a frailty index from a standardized comprehensive geriatric assessment. *J Am Geriatr Soc.* 2004;52:1929–1933.
6. Hwang HS, Kwon IS, Park BJ, et al. The validity and reliability of Korean Frailty Index. *J Korean Geriatr Soc.* 2010;14:191–202.
7. World Health Organization. *Obesity and overweight*. Geneva, Switzerland: World Health Organization; 2017. Available at https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed February 16, 2018.
8. Adachi Y, Ono N, Imaizumi A, et al. Plasma amino acid profile in severely frail elderly patients in Japan. *Int J Gerontology.* 2018;12:290–293.
9. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet.* 2004; 363:157–163.
10. Blaum CS, Xue QL, Michelon E, et al. The association between obesity and the frailty syndrome in older women: The Women's Health and Aging Studies. *J Am Geriatr Soc.* 2005;53:927–934.
11. Hubbard RE, Lang IA, Llewellyn DJ, et al. Frailty, body mass index, and abdominal obesity in older people. *J Gerontol A Biol Sci Med Sci.* 2010;65:377–381.
12. Rietman ML, van der A DL, van Oostrom SH, et al. The association between BMI and different frailty domains: A U-shaped curve? *J Nutr Health Aging.* 2018;22:8–15.
13. Jung KH, Kim CH, Sung EJ, et al. The relationship between body mass index and factors of frailty. *Korean J Family Prac.* 2015;5:S563–S568.
14. Kim AS, Ko HJ. Lower limb function in elderly Korean adults is related to cognitive function. *J Clin Med.* 2018;7.
15. Chun MY. Validity and reliability of Korean version of international physical activity questionnaire short form in the elderly. *Korean J Fam Med.* 2012;33:144–151.
16. Strandberg TE, Sirola J, Pitkälä KH, et al. Association of midlife obesity and cardiovascular risk with old age frailty: A 26-year follow-up of initially healthy men. *Int J Obes (Lond).* 2012;36:1153–1157.
17. Bowen ME. The relationship between body weight, frailty, and the disablement process. *J Gerontol B Psychol Sci Soc Sci.* 2012;67:618–626.
18. Badrasawi M, Shahar S, Singh DKA. Risk factors of frailty among multi-ethnic Malaysian older adults. *Int J Gerontology.* 2017;11:154–160.
19. Chun H, Park EJ, Kim IH, et al. Comparisons of obesity indicators for obesity and chronic diseases management among older adults. *Korean J Health Edu Promot.* 2014;31:109–120.
20. Falsarella GR, Gasparotto LPR, Barcelos CC, et al. Body composition as a frailty marker for the elderly community. *Clin Interv Aging.* 2015;10: 1661–1667.
21. Sheehan KJ, O'Connell MDL, Cunningham C, et al. The relationship between increased body mass index and frailty on falls in community dwelling older adults. *Bmc Geriatr.* 2013;13:132.
22. Woods NF, LaCroix AZ, Gray SL, et al. Frailty: Emergence and consequences in women aged 65 and older in the Women's Health Initiative Observational Study. *J Am Geriatr Soc.* 2005;53:1321–1330.
23. Fjeldstad C, Fjeldstad AS, Acree LS, et al. The influence of obesity on falls and quality of life. *Dyn Med.* 2008;7:4.