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Age- and BMI-related differences in blood pressure and functional fitness in elderly men: a large-scale population-based study

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Abstract

Background: This study examined the impact of age and body mass index (BMI) on blood pressure and functional fitness in elderly men. **Methods**: A total of 56,725 elderly men who participated in the Korean National Fitness Award program between 2015 and 2019 were analyzed. Researchers measured height, weight, and blood pressure indicators, including systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse pressure (PP), and mean arterial pressure (MAP). Functional fitness was assessed through grip strength, the sit-and-reach test (flexibility), the chair stand test (lower limb strength), the 2-minute step test (aerobic endurance), the timed up-and-go test (balance), and the 8-foot up-and-go test (coordination). **Results**: Significant interaction effects between age and BMI groups were observed in SBP, DBP, and MAP, suggesting that both factors jointly influence blood pressure. Additionally, elderly men over 80 had significantly higher SBP and PP than those aged 65–69. Obese individuals also showed significantly higher blood pressure levels compared to underweight participants. For functional fitness, interactions between age and BMI were significant for flexibility, lower limb strength, balance, and coordination. Age had a strong effect on all fitness components, with men over 80 performing significantly worse than those aged 65–69 across all variables. BMI also influenced fitness levels; notably, Class 2 obese individuals had higher grip strength and relative grip strength than underweight peers, although obesity was generally associated with poorer performance in other areas. **Conclusions**: Both age and BMI have a significant influence on blood pressure and functional fitness in elderly men. These findings highlight the need for tailored exercise programs that consider an individual's age and BMI to effectively maintain cardiovascular health and physical function. Future research should incorporate factors such as physical activity levels and dietary intake to better understand and manage health outcomes in elderly men.

Keywords

Elderly men; Age-related; Body mass index; Obesity; Blood pressure; Functional fitness

1. Introduction

Recent research has reported that men have increased health risks due to biological and social factors [1]. As age increases, body mass index (BMI) and body fat percentage rise, while muscle mass decreases, and these changes differ depending on gender [2]. Intramyocellular lipids in men were more strongly associated with cardiometabolic risk markers than in women [2]. Concurrently, physical activity levels decline, resulting in a decrease in basal metabolic rate and an increase in body fat accumulation [3]. Decreased physical activity has been linked to a higher prevalence of obesity, chronic diseases, and musculoskeletal disorders [4]. Muscle mass and strength reduction accelerate from middle to old age [5]. These age-related changes in body composition have a negative impact on the health of elderly individuals [6]. Elderly individuals naturally experience sarcopenia, a progressive loss of muscle mass and strength, which is further exacerbated by decreased physical activity [7]. This reduces cross-sectional muscle area, muscle fiber size, and fiber count [8, 9]. The proportion of individuals aged 65 and older who are underweight ranges from 4.3% to 12.9%, increasing to 14% in those aged 85 and older [10]. Being underweight in old age can weaken muscle function, reduce bone mineral density, and impair immunity, leading to delayed recovery from illness [11]. Furthermore, underweight status is associated with limitations in activities of daily living and an increased risk of falls [12]. Among individuals with severe depression, the proportion of underweight elderly individuals is even higher [13]. Therefore, maintaining an appropriate weight is crucial for preventing various health problems in elderly men [14].

Obesity increases the risk of metabolic diseases such as type 2 diabetes, hypertension, dyslipidemia, coronary artery disease, and stroke [15]. Additionally, obesity is associated with a higher risk of cancers, including breast, colon, and liver cancer [16]. Mortality due to coronary artery disease, cardiovascular disease, and cancer is also linked to obesity [17]. Hypertension is often asymptomatic in its early stages, leading to delayed treatment and increased risk of heart disease and cerebrovascular disease [18]. Early detection and prevention of hypertension are critical for disease management [19]. Systolic blood pressure (SBP) increases by an average of 7 mmHg for every 10% gain in body weight [20]. In contrast, weight loss is associated with reductions in SBP and diastolic blood pressure (DBP) [20]. In elderly individuals, hypertension is often caused by decreased vascular elasticity resulting from structural and functional changes in the cardiovascular system [21]. Unlike younger individuals, elderly individuals usually experience significantly increased SBP due to arterial stiffness, while DBP may decrease due to reduced coronary artery blood flow [22]. This results in a higher pulse pressure (PP), which is the difference between SBP and DBP [23]. Increased PP is associated with myocardial infarction, heart failure, and stroke [24]. Mean arterial pressure (MAP), calculated as DBP plus one-third of PP, is an essential indicator of blood flow speed and cardiovascular health [25]. Since both PP and MAP are predictors of cardiovascular disease risk, they should be carefully monitored in elderly populations [25].

Functional fitness in elderly individuals refers to their ability to independently perform daily activities such as household chores, walking, and carrying objects [26]. It encompasses muscle strength, cardiovascular endurance, flexibility, and balance, which are fundamental to daily functioning [27]. Adverse changes in physical function increase the risk of falls and musculoskeletal injuries, ultimately limiting an elderly individual's independence [28]. Physical activity and functional fitness are key indicators of health in older adults [29]. Modern society is increasingly recognizing the importance of maintaining and improving the health and physical fitness of the elderly [30]. Additionally, various exercise programs tailored to elderly individuals are designed to reduce health risks and improve functional fitness [30].

As the elderly population grows, health concerns among older people have become a national issue. Systematic evaluation and management of fitness levels among elderly individuals could lead to economic benefits, such as reduced medical and elder care costs [31]. Therefore, this study utilizes data from the National Fitness Award (NFA) program conducted by the Korea Sports Promotion Foundation from 2015 to 2019 to analyze differences in blood pressure (BP) and functional fitness by BMI among older men. The findings will provide foundational data for developing health policies and exercise programs to enhance the health of the elderly.

2. Materials and methods

2.1 Participants

NFA datasets from the Republic of Korea were used in this analysis. The NFA is a nationwide test conducted at 75 sites that assesses the physical fitness of the general population in the Republic of Korea. In the NFA dataset, data on BP and functional fitness variables for older adults were provided; however, physical activity, nutrition, chronic disease status, and hemodynamic data were not included. The study participants were older men aged 65 and above who participated in the NFA program (n = 56,725), conducted by the Korea Institute of Sport Science, from 2015 to 2019. The data were obtained from the Big Data Market operated by the Korea Culture & Information Service (https://www.bigdata-culture.kr/bigdata/user/main.do). According to the obesity treatment guidelines of the Korean Society for the Study of Obesity, the classification criteria for obesity in the Republic of Korea are as follows: underweight is defined as a BMI of ≤18.4 kg/m^2, normal weight as 18.5–22.9 kg/m^2, pre-obesity as 23–24.9 kg/m^2, class 1 obesity as 25–29.9 kg/m^2, and class 2 obesity as 30–34.9 kg/m^2 [32]. Hypertension in the elderly is defined as a SBP of 140 mmHg or higher or a DBP of 90 mmHg or higher [33]. The Institutional Review Board of Konkuk University waived the requirement for informed consent. The study was conducted in accordance with the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board of Konkuk University (IRB No. 7001355-202101-E-132). The physical characteristics of the study participants are presented in Table 1.

TABLE 1. Participants' characteristics.

	Elderly men (n = 56,725)
Age (yr)	73.30 ± 5.43
Height (cm)	165.14 ± 5.84
Weight (kg)	66.44 ± 8.85
Body fat (%)	26.03 ± 6.39
BMI (kg/m^2)	24.34 ± 2.79

Values are expressed as Mean ± SD. BMI, body mass index.

2.2 Body composition

Participants stood barefoot on a height scale (Seca 213, Seca, Hamburg, HH, Germany) with their backs straight and in a natural stance, facing forward. Height was measured to the nearest 0.1 cm. Body weight and body fat percentage were measured using a bioelectrical impedance analyzer (Inbody 720, Biospace, Seoul, Korea) while participants wore light clothing and were barefoot. Weight was recorded to the nearest 0.1 kg, and body fat percentage was recorded to the nearest 0.1%. BMI was calculated using the measured height and weight values according to the formula: weight (kg)/height (m^2).

2.3 Blood pressure

BP was measured using a central aortic BP measurement device (HEM-9000AI, Omron, Kyoto, Japan) after participants had rested in a seated position for 15 minutes. Pulse pressure (PP) increases along with BP because it is determined by arterial elasticity and wave reflection. PP was calculated using the formula: SBP − DBP. After the age of 60, PP increases significantly due to the rise in SBP and the decline in DBP [24]. Therefore, PP is suggested as a predictive factor for increased morbidity and mortality due to cardiovascular diseases, particularly in individuals aged 60 and older [24]. Arterial pressure continuously changes from systole to diastole, and the MAP represents the average BP throughout this cycle [25]. MAP represents the central value of BP and is considered a critical factor, along with SBP and DBP, in assessing cardiovascular disease risk [25]. Mean arterial pressure was calculated using the formula: DBP + (PP/3).

2.4 Functional fitness

Grip strength (GS) was measured using a dynamometer (GRIP-D 5101, Takei, Tokyo, Japan) while participants stood with their feet shoulder-width apart [34]. The highest value from two trials per hand was recorded to the nearest 0.1 kg. Relative GS was calculated using the formula: GS (kg)/body weight (kg) × 100.

Flexibility was measured using the "sit-and-reach test". Participants sat with their legs extended and feet flat against a measuring device, then reached forward as far as possible [34]. The best score from the two trials was recorded to the nearest 0.1 cm.

Lower limb strength was assessed using the "chair stand test", where participants repeatedly stood up and sat down on a chair for 30 seconds while keeping their arms crossed over their chest [34]. The total number of complete stands was recorded.

Aerobic endurance was measured using the "two-minute step test", where participants marched in place for two minutes, lifting their knees to a designated height [34]. The total number of correct steps was recorded.

Balance was assessed using the "timed up and go test", where participants stood up from a chair, walked around a marker 3 meters away, and returned to sit down [34]. The fastest time from two trials was recorded to the nearest 0.001 seconds.

Coordination was assessed using the "figure-8 walk test". Participants walked around two cones in a figure-eight pattern and returned to their starting position [34]. The total time for two complete laps was recorded to the nearest 0.001 seconds.

2.5 Statistical analysis

All collected data were analyzed using SPSS PC+ for Windows (version 28.0, IBM, Chicago, IL, USA). The mean and standard deviation were calculated for each variable. Normality and homogeneity of variance assumptions were verified using the Shapiro-Wilk test before conducting parametric statistical analyses. A two-way analysis of variance (ANOVA) was applied to examine the differences in dependent variables based on BMI categories and age groups. *Post-hoc* analysis was performed using Scheffe's test for one-way ANOVA. Effect sizes were calculated using partial eta squared (η^2) values (with cutoffs of small: ≥0.01, medium: ≥0.06, large: ≥0.14). The significance level (α) for all statistical tests was set at 0.05.

3. Results

3.1 Comparison of blood pressure by age and BMI in elderly men

The results of the comparison of BP by age and BMI in elderly men are presented in **Supplementary Table 1**. Statistically significant interaction effects were observed for DBP ($p < 0.001$), SBP ($p < 0.001$), and MAP ($p < 0.001$), whereas no interaction effect was found for pulse pressure. However, significant main effects were observed for all variables according to age ($p < 0.001$) and BMI ($p < 0.001$).

DBP was found to be significantly lower with increasing age: 65–69 years (77.69 ± 9.82 mmHg), 70–74 years (75.90 ± 9.93 mmHg), 75–79 years (74.34 ± 10.33 mmHg), and 80 years and older (73.12 ± 10.69 mmHg) ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Additionally, BMI was associated with significantly higher DBP in the following order: underweight (73.63 ± 10.69 mmHg), normal weight (74.28 ± 10.24 mmHg), pre-obese (75.60 ± 10.03 mmHg), obesity class 1 (76.62 ± 10.22 mmHg), and obesity class 2 (77.75 ± 10.25 mmHg) ($p < 0.001$). Significant differences were found between all groups except for the underweight and normal weight groups ($p < 0.05$).

SBP increased significantly with age: 65–69 years (132.33 ± 14.79 mmHg), 70–74 years (133.44 ± 14.80 mmHg), 75–79 years (134.46 ± 15.22 mmHg), and 80 years and older (134.55 ± 15.00 mmHg) ($p < 0.001$). Significant differences were observed among all groups except between the 75–79 years and 80 years and older groups ($p < 0.05$). BMI was also positively correlated with SBP: underweight (125.98 ± 16.81 mmHg), normal weight (131.44 ± 15.39 mmHg), pre-obese (133.44 ± 14.61 mmHg), obesity class 1 (135.33 ± 14.52 mmHg), and obesity class 2 (136.89 ± 14.40 mmHg) ($p < 0.001$), with significant differences among all groups ($p < 0.05$).

PP increased significantly with age: 65–69 years (54.64 ± 12.57 mmHg), 70–74 years (57.54 ± 13.37 mmHg), 75–79 years (60.12 ± 14.21 mmHg), and 80 years and older (61.43 ± 14.63 mmHg) ($p < 0.001$). Significant differences were observed among all groups ($p < 0.05$). BMI also showed a statistically significant association: underweight (52.35 ± 13.78 mmHg), normal weight (57.16 ± 14.00 mmHg), pre-obese (57.85 ± 13.69 mmHg), obesity class 1 (58.71 ± 13.57 mmHg), and obesity class 2 (59.14 ± 13.68 mmHg) ($p < 0.001$). However, no significant differences were found between the normal weight and pre-obese groups, pre-obese and obesity class 1 groups, and obesity class 1 and obesity class 2 groups.

MAP decreased significantly with increasing age: 65–69 years (95.90 ± 10.11 mmHg), 70–74 years (95.08 ± 9.95 mmHg), 75–79 years (94.38 ± 10.17 mmHg), and 80 years and older (93.59 ± 10.18 mmHg) ($p < 0.001$). Significant differences were found among all groups ($p < 0.05$). BMI was also significantly associated with MAP: underweight (91.08 ± 11.32 mmHg), normal weight (93.34 ± 10.26 mmHg), pre-obese (94.88 ± 9.83 mmHg), obesity class 1 (96.20 ± 9.95 mmHg), and obesity class 2 (97.46 ± 9.95 mmHg) ($p < 0.001$), with significant differences observed among all groups ($p <$

0.05).

3.2 Comparison of functional fitness by age and BMI in elderly men

The results of comparing functional fitness according to age and BMI in elderly men are presented in **Supplementary Tables 2,3**. Statistically significant interaction effects were observed in the sit-and-reach test ($p < 0.01$), chair stand test ($p < 0.05$), timed up-and-go test ($p < 0.001$), and figure-8 walking test ($p < 0.001$). However, no interaction effects were found in GS, relative grip strength, or the two-minute step test. Meanwhile, significant main effects were observed for all variables by age group ($p < 0.001$) and for all variables by BMI category ($p < 0.001$).

GS was significantly lower with increasing age, with values of 33.17 ± 6.39 kg for ages 65–69, 31.54 ± 6.15 kg for ages 70–74, 29.36 ± 6.09 kg for ages 75–79, and 26.18 ± 6.33 kg for ages 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Furthermore, BMI showed a statistically significant increase in GS across the underweight (25.91 ± 6.32 kg), normal weight (29.47 ± 6.34 kg), pre-obese (31.00 ± 6.49 kg), obesity class 1 (31.57 ± 6.71 kg), and obesity class 2 (31.65 ± 7.12 kg) groups ($p < 0.001$), with significant differences between all groups except for between the obesity class 1 and obesity class 2 groups ($p < 0.05$).

Relative GS also declined significantly with age, recorded at 34.74 ± 6.59 kg for ages 65–69, 32.95 ± 6.32 kg for ages 70–74, 30.83 ± 6.21 kg for ages 75–79, and 27.52 ± 6.52 kg for ages 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Similarly, BMI-related differences were statistically significant, with relative GS values of 27.52 ± 6.46 kg for the underweight group, 30.90 ± 6.52 kg for the normal weight group, 32.48 ± 6.67 kg for the pre-obese group, 33.04 ± 6.89 kg for the obesity class 1 group, and 33.16 ± 7.26 kg for the obesity class 2 group ($p < 0.001$). Significant differences were observed between all groups except between the obesity class 1 and obesity class 2 groups ($p < 0.05$).

The sit-and-reach test scores decreased significantly with age, with values of 5.90 ± 9.21 cm for ages 65–69, 4.50 ± 9.40 cm for ages 70–74, 2.69 ± 9.52 cm for ages 75–79, and −0.04 ± 9.63 cm for ages 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Regarding BMI, results showed a statistically significant increase across the underweight (1.03 ± 9.24 cm), obesity class 2 (1.25 ± 9.75 cm), obesity class 1 (3.30 ± 9.55 cm), normal weight (4.21 ± 9.68 cm), and pre-obese (4.45 ± 9.51 cm) groups ($p < 0.001$). However, no significant differences were found between the underweight and obesity class 2 groups or between the normal weight and pre-obese groups.

The chair stand test results decreased significantly with age, with scores of 22.38 ± 5.88 repetitions for ages 65–69, 21.09 ± 5.90 repetitions for ages 70–74, 19.30 ± 5.71 repetitions for ages 75–79, and 16.66 ± 5.50 repetitions for ages 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Regarding BMI, results showed a statistically significant increase across the obesity class 2 (18.54 ± 6.08 repetitions), underweight (18.84 ± 6.04 repetitions), obesity class 1 (20.13 ± 6.00 repetitions), normal weight (20.58 ± 6.19 repetitions), and pre-obese (20.80 ± 6.04 repetitions) groups ($p < 0.001$). However, no significant differences were found between the underweight and obesity class 2 groups, the normal weight and obesity class 1 groups, or the normal weight and pre-obese groups.

The two-minute step test results decreased significantly with age, with values of 114.56 ± 20.52 repetitions for ages 65–69, 109.96 ± 21.01 repetitions for ages 70–74, 104.40 ± 22.13 repetitions for ages 75–79, and 95.00 ± 25.95 repetitions for ages 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Regarding BMI, results showed a statistically significant increase across the underweight (99.07 ± 24.00 repetitions), obesity class 2 (102.07 ± 24.91 repetitions), pre-obese (107.44 ± 22.66 repetitions), normal weight (107.63 ± 22.97 repetitions), and obesity class 1 (109.41 ± 22.27 repetitions) groups ($p < 0.001$). However, no significant differences were found between the normal weight and obesity class 1 groups or between the normal weight and pre-obese groups.

The timed up-and-go test results increased significantly with age, with values of 5.66 ± 1.41 seconds for individuals aged 65–69, 5.97 ± 1.47 seconds for those aged 70–74, 6.47 ± 1.72 seconds for those aged 75–79, and 7.45 ± 2.25 seconds for those aged 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Regarding BMI, results showed a statistically significant increase across the pre-obese (6.12 ± 1.63 seconds), normal weight (6.15 ± 1.70 seconds), obesity class 1 (6.28 ± 1.69 seconds), underweight (6.65 ± 3.27 seconds), and obesity class 2 (6.74 ± 2.45 seconds) groups ($p < 0.001$). However, no significant differences were found between the pre-obese and normal weight groups, the normal weight and obesity class 1 groups, or the underweight and obesity class 2 groups.

The figure-8 walking test results increased significantly with age, with times of 23.26 ± 5.28 seconds for individuals aged 65–69, 24.78 ± 5.43 seconds for those aged 70–74, 27.06 ± 6.35 seconds for those aged 75–79, and 31.20 ± 8.21 seconds for those aged 80 and above ($p < 0.001$). Significant differences were observed between all groups ($p < 0.05$). Furthermore, based on BMI, the pre-obese group (25.38 ± 6.31 seconds), normal group (25.55 ± 6.56 seconds), obesity class 1 group (26.14 ± 6.64 seconds), underweight group (27.22 ± 7.84 seconds), and obesity class 2 group (27.85 ± 7.59 seconds) showed a statistically significant increase ($p < 0.001$). However, no statistically significant difference was observed between the obesity class 1 and normal groups.

4. Discussion

In future aging societies, greater attention should be paid to the importance of men's health, given the imminent decline in quality of life and increased social burden, unless appropriate measures are taken to slow the onset and progression of disease through preventive strategies [1]. This study analyzed BP and functional fitness according to age-specific BMI in elderly men. In this study, elderly men exhibited higher SBP and PP with increasing age, whereas DBP and MAP were statistically significantly lower ($p < 0.001$). Additionally, individuals with higher BMI had statistically significantly higher SBP, DBP, PP, and MAP ($p < 0.001$).

BP increases with aging, and beyond young adulthood, it gradually rises, with hypertension affecting more than half of the population in their 60s and nearly one in four individuals aged 70 and older [35]. Even individuals with normal BP between 55 and 65 years old have a 90% risk of developing hypertension if they live to 80–85 years old [35]. Furthermore, cardiovascular disease risk increases at SBP of 120 mmHg or DBP of 80 mmHg, even if it does not reach the hypertension threshold (SBP $\geq$140 mmHg or DBP $\geq$90 mmHg). This highlights the need for proactive BP management, including the pre-hypertensive stage [36]. The patterns of SBP and DBP change with age. While SBP increases throughout life, DBP gradually rises to approximately age 60, then stabilizes or decreases [37]. Among Western populations, DBP gradually increases from age 20 to 60 before declining, a trend observed regardless of gender, race, or baseline BP levels [38]. The present study similarly found that DBP decreased with age in elderly men, aligning with previous research.

Obesity in elderly individuals is associated with increased body fat, heightened risk of cardiovascular diseases, diabetes, and other chronic conditions [39]. Obesity in older adults is closely linked to changes in body composition, increased disease incidence, and mortality rates [39]. Additionally, studies indicate that obesity in old age negatively affects gait and balance [40]. A higher BMI is associated with the activation of the sympathetic nervous system and the plasma renin-angiotensin system, as well as insulin resistance, inflammation, and increased levels of leptin and neuropeptides, all of which contribute to a greater risk of hypertension and cardiovascular diseases [41]. Therefore, effective weight management and preventive exercise prescriptions should be prioritized to control hypertension. The PP, the difference between SBP and DBP, increases with age [23]. PP is closely related to SBP. As DBP begins to decline, the increase in PP becomes more pronounced due to the loss of vascular elasticity with aging [22]. Furthermore, SBP rises as blood travels from the large to the peripheral arteries [22]. In contrast, DBP decreases, resulting in a significant increase in PP in peripheral blood vessels [22]. The present study's findings align with previous research, which shows that PP increases with age [42]. Additionally, our study found that MAP decreased with increasing age. With aging, the myocardium undergoes atrophy, and some myocardial tissue is replaced with collagen fibers, leading to the thickening of the heart muscle through fibrosis [43]. Consequently, the amount of blood ejected from the left ventricle decreases with age [44]. MAP, which represents the average pressure exerted by cardiac output on the aorta and major arteries, is a vital sign influencing perfusion across all tissues, particularly cerebral and coronary circulation [45]. Aerobic training has been shown to reduce central BP and arterial stiffness in young individuals, healthy older adults, and even those with coronary artery disease [46]. Therefore, proper exercise prescriptions are essential for managing PP and MAP to prevent hypertension in elderly men.

The differences in functional fitness according to age in elderly men indicate that as age increases, GS, relative GS, sit-and-reach (flexibility), chair stand test (lower limb strength), and the 2-minute step test (cardiorespiratory endurance) significantly decrease ($p < 0.001$). Conversely, the time taken for the timed up-and-go (balance) and the 8-foot up-and-go (coordination) significantly increases with age ($p < 0.001$). These findings align with the general expectation that physical fitness declines with aging. In elderly men, functional fitness parameters such as cardiorespiratory endurance, flexibility, and strength sharply decline with aging, necessitating exercise programs to improve overall functional fitness [30]. A study comparing functional fitness between two age groups (60–69 years and 70–79 years) reported that in elderly males, upper body strength decreased by 8%, lower body strength by 12%, upper body flexibility by 29%, agility and dynamic balance by 16%, and overall endurance by 10% [47]. These declines can be attributed to the structural and functional deterioration of the body that occurs with aging and physical decline in elderly men.

When comparing functional fitness based on BMI, GS, and relative GS, the latter was highest in the Class 2 obesity group ($p < 0.001$). BMI is the most widely used and straightforward method for assessing obesity based on height and weight, commonly used to estimate obesity prevalence in populations [48]. However, it has limitations, such as misclassification of individuals with high muscle mass as obese, failure to reflect obesity levels in individuals with extreme height variations accurately, and inability to account for racial differences [48]. The pre-obesity group had the highest scores for sit-and-reach, chair stand, and 2-minute step tests ($p < 0.001$). In contrast, the timed up-and-go and 8-foot up-and-go tests yielded the lowest results in the pre-obesity group ($p < 0.001$). Functional fitness in elderly men was highest in the overweight group, followed by the normal weight group. The Asian Working Group for Sarcopenia defines GS as a method for evaluating strength levels, applying a threshold of 26 kg for men [49]. In this study, elderly men in the pre-obesity group aged 75–79 (25.71 $\pm$ 5.99 kg) and those aged 80 and above (22.79 $\pm$ 6.09 kg) fell below this threshold. Among elderly men with low GS, the sit-and-reach, chair stand, and 2-minute step tests were the lowest ($p < 0.001$). The decline in GS can lead to restrictions and reductions in various physical activities, making it an important factor in elderly populations [50]. Sarcopenia has been classified as a distinct disease in the International Classification of Diseases [51]. Low GS in the elderly is closely associated with reduced quality of life and frailty indicators, such as body mass loss and functional limitations [51]. Previous research indicates that higher frailty levels correlate with lower functional fitness levels, including upper and lower body strength, flexibility, agility, dynamic balance, and cardiorespiratory endurance [52]. Studies on functional fitness standards for independent living in elderly Koreans suggest that lower functional fitness is associated with higher risks of frailty [53]. Additionally, studies examining physical fitness based on frailty levels (normal, pre-frail, frail, and disabled) confirm that higher frailty levels are associated with lower physical fitness [54]. These findings highlight the necessity of preventing sarcopenia in the super-aged population (75 years and older). BMI and mortality rates exhibit a U-shaped correlation, with the lowest mortality observed at a BMI of 25–29.9 kg/m^2 in elderly men [55]. These findings support notion that maintaining an overweight body with adequate muscle mass is crucial for elderly men.

Previous studies on BMI and functional fitness in the elderly have yielded mixed findings: (1) some report no relationship between BMI and functional fitness [56], (2) others indicate lower fitness levels with higher BMI [57], and (3) some suggest that both high and low BMI correlate with reduced fitness [58]. The results of the present study align, suggesting the need for weight maintenance efforts as aging progresses. Regular physical activity helps to maintain daily functioning and prevent declines in physical fitness among the elderly [27]. Previous studies have shown that physical activity levels decline with age, with a more significant reduction observed in men compared to women [59]. Regular physical activity and exercise in the elderly enhance cardiovascular function, functional fitness, and coordination while slowing the decline in lean body mass [30]. Given the close relationship between body composition, functional fitness, and physical activity in elderly men, further research incorporating physical activity assessments is necessary for a clearer understanding. To prevent frailty and maintain physical independence, increasing physical activity to sustain functional fitness for daily activities is crucial [27]. Therefore, maintaining a normal (18.5–22.9 kg/m^2) or overweight (23–24.9 kg/m^2) BMI while enhancing functional fitness is essential for preventing frailty in elderly men.

An essential limitation of this study is the time frame of data collection. As such, there is a possibility that the health status, physical activity patterns, and body composition trends among elderly men may have shifted in more recent years due to various socio-environmental factors, including the impact of the COVID-19 pandemic, changes in public health policies, and advancements in preventive health interventions. These developments could potentially influence the generalizability of our findings to the current elderly population. While the large-scale and nationally representative nature of the dataset strengthens the reliability of the results, future studies utilizing more recent data are warranted to validate these findings and assess potential longitudinal changes in blood pressure and functional fitness profiles among elderly men.

5. Conclusions

The study confirms that higher age and BMI correlate with increased BP and decreased functional fitness in elderly men. To mitigate these effects, it is necessary to develop training programs that enhance cardiovascular function and functional fitness in elderly men. Future studies should incorporate additional variables, such as physical activity levels and nutrient intake, to provide a more comprehensive understanding of these relationships.

AVAILABILITY OF DATA AND MATERIALS

The data of this work will be made available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

JH, SWK and KL—designed the research study. JH, YS and JHC—data curation. JH, YS and SWK—analyzed the data. JH, YS, JHC, JK and HYP—conducted the research investigation. JH and SWK—wrote the original draft. SWK and KL—approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Konkuk University (7001355-202101-E-132). The Institutional Review Board of Konkuk University waived the requirement for informed consent.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at `https://oss.jomh.org/files/article/2017115797409677312/attachment/Supplementary%20material.docx`.

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