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Original Research

Changes and differences in functional fitness among older adults over a four year period

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Abstract

Background and objective: Functional fitness is an important task in the health of the older adults. The present study investigated the changes and differences in functional fitness of young and middle older adults by a 4 years age increase. **Methods**: We performed a longitudinal and cross-sectional study of 261 male older adults who were working as school guardians at elementary schools in Seoul, Korea and had their yearly functional fitness for four years from 2014 to 2017. Participants were young-older adults (n = 98), early middle-older adults (n = 100), and late middle-older adults (n = 63). Functional fitness was measurement by muscle strength (grip strength), muscle endurance test (30-seconds chair stand up), cardiorespiratory endurance test (2-minutes step), flexibility test (sit & reach), agility test (20-seconds side step), and dynamic balance (3-m Up & Go) over a 4 year period. **Results**: Our study showed that grip strength ($P < 0.001$), 30-seconds chair stand ($P < 0.001$), 2-minutes step ($P < 0.001$), sit & reach ($P < 0.001$), 20-seconds side step ($P < 0.001$) were found to decrease with aging in all groups. By contrast, 3-m Up & Go was found to increase ($P < 0.001$). For each measurement year, middle-older adults on grip strength ($P < 0.001$), 30-seconds chair stand ($P < 0.001$), 2-minutes step ($P < 0.001$), 20-seconds side step ($P < 0.001$) were lower, whereas that on 3-m Up & Go ($P < 0.001$) was higher compared with young-older adults. **Conclusion**: The functional fitness of older adults was found to decrease with aging, and that between young-older adults and middle-older adults was found to be different.

Keywords

Aging; Muscle strength; Cardiorespiratory endurance; Flexibility; Agility; Balance

1. Introduction

Recently the aged society and life expectancy increase phenomenon continues all over the world. In an aged society, a healthy life span without chronic diseases and functional disorders is important. However, as a result of biological aging, the ability to maintain an independent life diminished. This has been suggested as a result of degradation of physiological function due to aging, increased susceptibility to diseases, and decreased antioxidant function against oxidative stress [1, 2]. The biological indicators of aging are directly related to cardiovascular and musculoskeletal hypofunction and physical fitness that determine the prevention of chronic diseases and promote health decreases [3–5]. For older adults, functional fitness, which means the ability to perform daily living independently, is important. Accordingly, muscle strength, cardiopulmonary endurance, flexibility, balance, and agility, which are focused on daily living function, are used to measure the functional fitness of older adults [6]. Higher functional fitness in old age will

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slow the aging, resulting in the extension of lifespan. If functional fitness is low, however, the difference between life expectancy and healthy life expectancy increases, which, in turn, intensifies the risk of chronic diseases and makes independent living difficult [7–9].

Meanwhile recently most countries have enters an aged society. Therefore, research on changes in functional fitness in older adults is important because it will provide basic data that determine the extension of healthy life expectancy of older adults in an aged society. According to previous longitudinal and cross-sectional studies, the functional fitness of older adults decreases with aging, and differences were found in functional fitness between early and late older adults [10, 11]. Research that investigated changes in functional fitness with aging and their differences between early and middle older adults, by measuring functional fitness for consecutive years, is rare. In addition, the level of physical activity needs to be considered because it greatly affects the functional fitness of older adults.

Accordingly, the present study intended to investigate changes in functional fitness based on a 4 year increase in age and differences in functional fitness among young, early middle, and late middle older adults using a measurement year. This study assessed the male older adults who worked as school guardians and whose amount of physical activity is similar because of their work participation. Therefore, the purpose of this study is to investigate the change and difference in functional fitness of the older adults over a 4 years period.

2. Methods

2.1 Participants

The present study was conducted on 261 male older adults who were working as school guardians at national and public elementary schools in Seoul, Korea from 2014 to 2017. This study is a longitudinal and cross-sectional study on the changes and differences in functional physical fitness of over a 4 years period. Participants in this study were retired public officials and male elderly who worked as school guardians after retirement. The school guardians were in charge of the safety of school life of elementary school students. In addition, participants were healthy older adults who were free from medication for cardiovascular, respiratory, and musculoskeletal diseases in the health questionnaire survey. The exclusion criteria for this study were those who retired from school guardians due to health problems or did not perform functional physical fitness tests over a 4 years period.

The present study classified the participants into young-older adults (n = 98, 61~64 years old), early middle-older adults (n = 100, 65-69 years old), and late middle-older adults (n = 63, 70~74 years old), with reference to the classification of Brody, [12] that is young (61~65 years old) and middle (66~75 years old) older adults. Participants' physical characteristics at the time of the first functional fitness test, and functional fitness measurement data are presented shown in Table 1.

Participants undertook functional fitness measurements for 4 years from the first year (aged 61, 66, and 71 years, with respect to the age groups, in 2014), to the second year (aged 62, 67, and 72 years, respectively, in 2015), to the third year (aged 63, 68, and 73 years, respectively, in 2016), and the fourth year (aged 64, 69, and 74 years, respectively, in 2017).

Functional fitness measurements were conducted at the National Fitness Center, which is a fitness certification organization located in Seoul. For the validity of the functional measurement, fitness measurement methods and matters that require attention were explained in advance. The present study was performed in accordance with the Declaration of Helsinki and approved by the Institutional Ethical Committees of Changwon National University (Institutional Review Board: 040271-201806-HR-012), and all subjects received approval for data approval.

2.2 Physical measurement

An automatic extensometer (BSM 330, Korea) was used to measure height and weight. The body mass index was calculated by [body weight (kg)/height (m)^2]. Body fat percentage was measured using a body composition analyzer (X-scan, Jawon Medical, Korea), which uses a bioelectrical impedance analysis.

2.3 Functional fitness measurements

For functional fitness, muscle strength (grip strength), muscle endurance test (30-seconds chair stand up), cardiorespiratory endurance test (2-minutes step), flexibility test (sit & reach), agility test (20-seconds side step), and dynamic balance (3-m Up & Go) were measured. Among functional fitness test, grip strength, sit & reach were measured twice, and the maximum value from the two measurements was recorded. In this study, functional fitness is measured based on the items presented in the senior fitness test manual [6].

Grip strength was measured twice with participants' feet shoulder-width apart and arms hanging naturally at the sides, using a hand dynamometer (GRIP-D 5101, TAKEI, Co, Japan). Participants were cautioned not to touch their body with the instrument.

The 30-seconds chair stand test was conducted where participants sat on a chair with their arms crossed in front of their chest, hands placed on their shoulders. With the start signal of the tester, participants repeatedly sat and stood as fast as possible for 30 seconds. Participants must fully sit on the chair and their legs must be extended fully when standing.

For the 2-minutes step test, the examiner marked the height to which participants had to lift their knees. They were asked to lift their legs to the marked height. When participants lifted and lowered their legs during the test, only the number of times when their heel touched the floor fully was counted.

Sit & reach test was performed by bending the upper body forward. After sufficient stretching prior to the flexibility test, the subjects sat on the examination table and bent the upper body forward as much as possible with the legs fully extended.

TABLE 1. Participants' physical characteristics and functional fitness measurement data (Mean ± SD).

	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)	Functional fitness measurement data	
Young-older adult(n = 98)	60.53 ± 0.50	167.37 ± 5.23	70.94 ± 9.26	25.29 ± 2.80	First	20, Oct, 2014 ~ 07, Dec, 2014
Early middle-older adults(n = 100)	65.43 ± 0.50	166.65 ± 4.58	68.72 ± 8.62	25.74 ± 2.91	Second	19, Oct, 2015 ~ 13, Dec, 2015
Late middle-older adults(n = 63)	70.52 ± 0.54	165.47 ± 6.17	67.24 ± 9.07	24.52 ± 2.50	Third	17, Oct, 2016 ~ 09, Dec, 2016
P-valve	0.001	0.075	0.003	0.186	Fourth	18, Oct, 2017 ~ 16, Dec, 2017

BMI: body mass index

For the 20-seconds side step test, participants were asked to stand with their feet shoulder-width apart and the measuring line going through the center of the stance. With the start signal, participants were asked to sidestep to the right and cross one foot over a line drawn 120 cm away from the center line, come back to the center line, and then sidestep to the left and cross one foot over a line drawn 120 cm away from the center line. The total number of repetitions in 20 seconds was counted.

For the 3-m Up & Go test, participants were asked to stand up from their seats at the start signal, walk to a line 3 m away, and come back to their seats and sit down. The total time was measured.

2.4 Data analysis

Means (M) and standard deviations (SD) were calculated for all data of each item. Data were analyzed using a two-way ANOVA with repeated-measures to test the significance of differences in the functional fitness of young-older adults, early-middle older adults, and late-middle older adults by age and measurement year. The significance level (α) in the present study was set at $P < 0.05$. For data analysis, SAS (version 9.1) statistical package was used.

3. Results

3.1 Changes and differences in muscle strength

Grip strength significantly decreased (F = 77.69, $P < 0.001$) with aging in young-older (-1.6%), early middle-older (-7.4%), and late middle-older adults (-10.8%). Significant differences (F = 23.95, $P < 0.001$) were found in young-older, early middle-older, and late middle-older adults by measurement year (Table 2), (Fig. 1-A).

3.2 Changes and differences in muscle endurance

The 30-seconds chair stand test also showed that leg strength significantly decreased (F = 7.44, $P < 0.001$) with aging in young-older (-4.58%), early middle-older (-4.59%), and late middle-older adults (-1.34%). Significant differences (F = 33.85, $P < 0.001$) were found among young-older, early middle-older, and late middle-older adults by measurement year (Table 2), (Fig. 1-B).

3.3 Changes and differences in cardiorespiratory endurance

The 2-minutes step test showed a significant decrease (F = 56.83, $P < 0.001$) with aging in young-older (-4.68%), early middle-older (-5.19%), and late middle-older adults (-3.65%). Significant differences (F = 201.01, $P < 0.001$) were found among young-older, early middle-older, and late middle-older adults by measurement year (Table 2), (Fig. 1-C).

3.4 Changes and differences in flexibility

The sit & reach test was significantly decreased (F = 16.74, $P < 0.001$) with aging in young-older (-8.12%), early middle-older (-16.49%), and late middle-older adults (-16.49%). But no significant difference was found among young-older, early middle-older, and late middle-older adults by measurement year (Table 2), (Fig. 1-D).

3.5 Changes and differences in agility

20-seconds side step was significantly decreased (F = 43.39, $P < 0.001$) with aging in young-older (-6.74%), early middle-older (-10.74%), and late middle-older adults (-4.15%). Significant differences (F = 89.78, $P < 0.001$) were found among young-older, early middle-older, and late middle-older adults by measurement year (Table 2), (Fig. 1-E).

3.6 Changes and differences in dynamic balance

The 3-m Up & Go was significantly decreased (F = 694.51, $P < 0.001$) with aging in young-older (35.5%), early middle-older (19.02%), and late middle-older adults (20.26%). Significant differences (F = 2310.43, $P < 0.001$) were found among young-older, early middle-older, and late middle-older adults by measurement year (Table 2), (Fig. 1-F).

3.7 Changes and difference in body fat percentage

The body fat percentage was significantly decreased (F = 55.97, $P < 0.001$) with aging in young-older (5.67%), early middle-older (7.07%), and late middle-older adults (7.63%). But no significant difference was found among young-older, early middle-older, and late middle-older adults by measurement year (Table 2).

4. Discussion

The purpose of this study is to investigate the changes and differences in the functional fitness of the older adults over 4 years period. Changes in functional fitness measured for 4

TABLE 2. Changes and differences in functional fitness among young-older, early middle-older, late middle-older adults for 4 years (Mean ± SD).

		1^{st} (2014)	2^{nd} (2015)	3^{rd} (2016)	4^{th} (2017)	△%	Time *P*-value	Group *P*-value	Time×Group *P*-value
Grip strength (kg)	a	43.78 ± 5.37	43.69 ± 5.73	43.14 ± 5.57	43.05 ± 5.84	-1.6	0.001	0.001	0.001
	b	42.71 ± 4.56	42.55 ± 4.89	41.10 ± 4.34	39.54 ± 5.08	-7.4			
	c	40.10 ± 5.38	39.44 ± 5.64	37.01 ± 5.58	35.46 ± 5.39	-10.86			
30-seconds chair stand(repetitions)	a	35.09 ± 4.17	34.78 ± 3.02	33.71 ± 3.42	33.48 ± 1.84	-4.58	0.001	0.001	0.309
	b	33.71 ± 4.43	32.88 ± 2.75	32.57 ± 3.49	32.16 ± 1.64	-4.59			
	c	31.27 ± 4.61	31.49 ± 3.84	31.47 ± 3.74	30.85 ± 1.98	-1.34			
2-minutes step (repetitions)	a	143.77 ± 9.52	141.10 ± 4.85	139.13 ± 2.13	137.03 ± 4.12	-4.68	0.001	0.001	0.530
	b	138.51 ± 9.66	135.93 ± 5.66	133.39 ± 3.43	131.31 ± 3.40	-5.19			
	c	130.29 ± 8.49	128.24 ± 7.37	127.14 ± 4.77	125.49 ± 6.15	-3.68			
Sit & reach(cm)	a	14.84 ± 5.90	13.94 ± 4.98	13.18 ± 5.10	12.58 ± 4.33	-15.22	0.001	0.134	0.162
	b	12.67 ± 6.01	12.23 ± 5.26	12.31 ± 5.53	11.64 ± 5.19	-8.12			
	c	13.58 ± 7.41	12.87 ± 6.28	12.90 ± 6.18	11.34 ± 6.67	-16.49			
20-seconds side step (repetitions)	a	40.75 ± 3.78	39.76 ± 4.95	38.80 ± 2.77	38.00 ± 2.83	-6.74	0.001	0.001	0.001
	b	37.33 ± 3.25	37.00 ± 4.44	35.72 ± 3.93	33.32 ± 3.35	-10.74			
	c	33.90 ± 3.91	33.71 ± 4.23	33.58 ± 3.68	32.49 ± 3.25	-4.15			
3-cm Up & Go (sec)	a	3.15 ± 0.33	3.25 ± 0.23	3.68 ± 0.31	4.27 ± 0.33	35.5	0.001	0.001	0.001
	b	4.31 ± 0.31	4.37 ± 0.29	4.77 ± 0.27	5.13 ± 0.33	19.02			
	c	5.33 ± 0.32	5.60 ± 0.31	5.92 ± 0.36	6.41 ± 0.34	20.26			
body fat (%)	a	24.33 ± 4.30	24.44 ± 4.02	24.83 ± 3.87	25.71 ± 3.88	5.67	0.001	0.092	0.726
	b	23.88 ± 4.38	24.37 ± 4.05	24.37 ± 4.15	25.57 ± 4.35	7.07			
	c	23.96 ± 4.71	24.42 ± 4.64	24.78 ± 4.83	25.79 ± 4.81	7.63			

Tested by two-way ANOVA with repeated-measures
a: young-older adults, b: early middle-older adults, c: late middle-older adults
△% = [(first measurement -fourth measurement)/first measurement × 100.]

year period have been showed to decrease muscle strength, cardiorespiratory endurance, flexibility, and agility and increased dynamic balance with aging. In addition, the muscle strength, cardiorespiratory endurance, and agility of middle-older adults in each measurement year were lower than those of young-old adults. In other words, longitudinal analysis of the functional fitness of the older adults for four years shows that it decreases continuously as the aging progresses. In the cross-sectional analysis, it can be seen that there is a difference among older adults.

Older adults' functional fitness is an important factor for managing independent daily living and promoting healthy life expectancy. However, the functional fitness was lowered by aging, and there was a difference among-older adults [11, 13]. Among functional fitness items, muscle strength is drawing attention. Sarcopenia, which is related directly to healthy life expectancy and the recent issue on aging society, is due to the loss of muscle mass and strength [14]. Several studies have reported that muscle strength begins to decrease at the age of about 30 and accelerates after 60 [15, 16]. Especially, a decrease in leg strength impedes daily living and is used as a predictive factor for falls [17]. The present study showed that both grip and leg strength, which are muscle strength assessment items, decrease with aging; moreover, they are weaker in middle than early older adults in each measurement year. Previous studies have also reported that grip strength in older adults is different by age group, and the rate of decrease is higher for late than early older adults [18, 19]. The reasons for the reduction of muscle strength with aging are muscle loss due to decreased ability to synthesize protein and selective loss of type II muscle fibers engaged in muscle contraction [20, 21].

Cardiorespiratory endurance is important for assessing cardiovascular system function. Myocardial and vascular hypertrophy, left ventricular diastolic dysfunction, and vascular endothelial dysfunction due to aging cause structural and functional changes in the heart and blood vessels, and decrease aerobic exercise capacity [21–23]. Cardiorespiratory endurance index, VO_2max, has been reported to decrease by 10% every 10 years [24]. The present study showed that cardiorespiratory endurance assessed by 2-minte step decreased with aging. In addition, significant differences were found among older adults by measurement year. Stathokostas *et al.* [25] also reported similar findings in that the VO_2max measured in early (65-72 years), and late older adults (73-90 years) using a treadmill was found to decrease by 14% in male and 7% in female after 10 years. Reduced cardiopulmonary endurance in old age is due to lower cardiac output and arterial-venous oxygen difference compared with adults [26]. Correia *et al.* [27] also found that the maximum cardiac

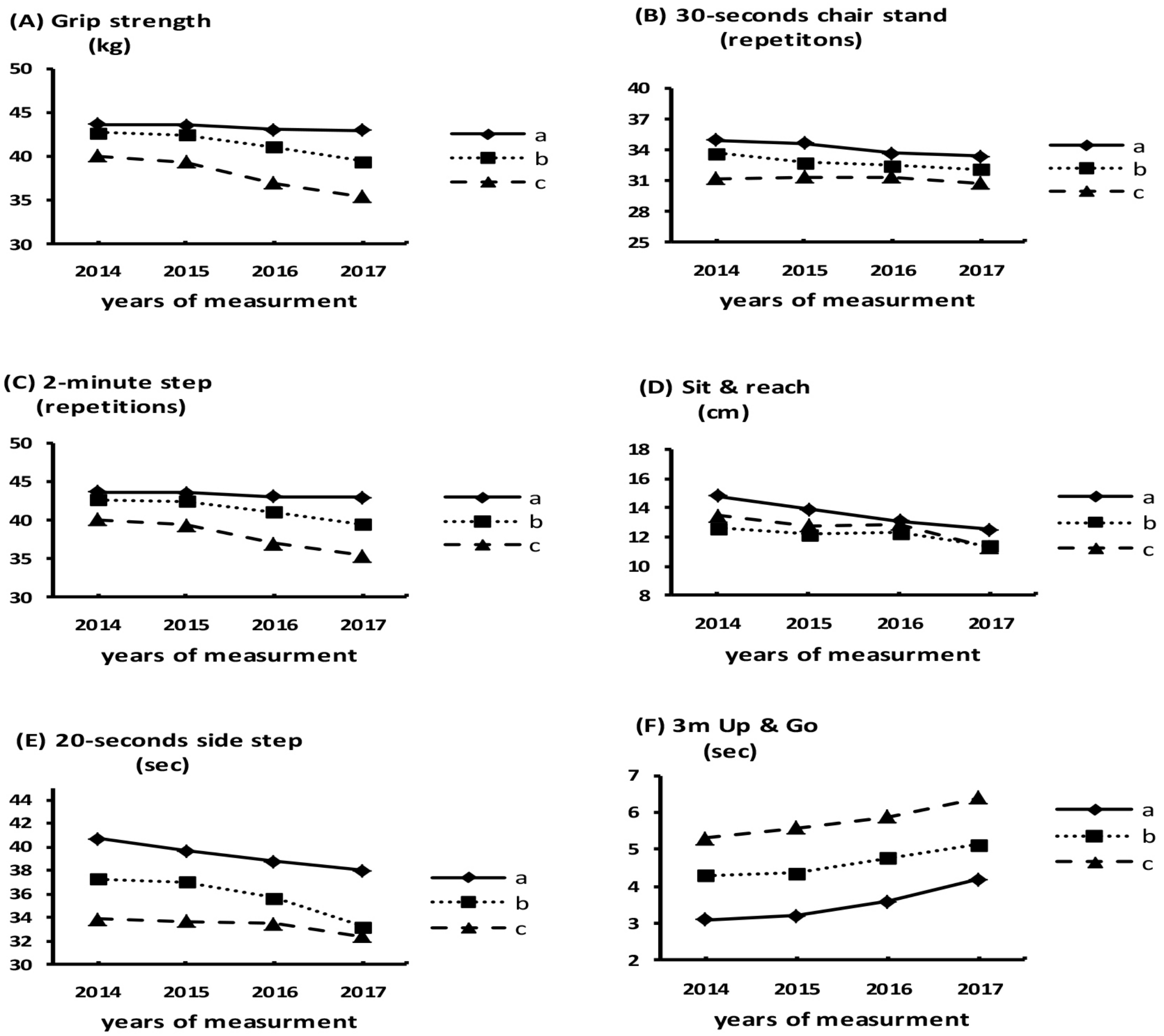

FIG. 1. Changes and differences in functional fitness among young-older, early middle-older, late middle-older adults for 4 years.
a; young-older adults, b; early middle-older adults, c; late middle-older adults.

output of older adults during exercise is lower compared with adults.

Flexibility is the range of motion that is determined by the structure and function of bones, muscles, and connective tissues. It is essential for performing movements necessary for various tasks and for preventing damage to the musculoskeletal system. Especially, the limited mobility of the hip joint, knee, and ankle increases the risk of falls and causes gait dysfunction [28]. Previous studies have also found that flexibility tends to decrease with aging [29, 30]. The present study found that flexibility assessed by a sit & reach test decreased with aging. No difference was found, however, between early-middle older and late-middle older adults in each measurement year. For older adults, flexibility decreases because the extensibility of connective tissues, including fascia, ligaments, and tendons, is reduced [31]. That is, aging can be considered as affecting the range of motion of the joint.

Agility is the ability to change body posture quickly; it is important for tasks that require quick movements [32]. Agility measured by 20-second side step in the present study decreased with aging, and difference in performance between early and middle-older adults was found in each measurement year. Such findings suggest that agility decreases because the ability of effective engagement of nerves, senses, and muscular functions decreases as age increases.

Equilibrium or balance is the ability to maintain the body in a certain posture; it is controlled by the function of balance organs and sensory and motor nervous systems [31]. Dynamic balance is required for performing physical activities that involve spatial movements; its decrease due to aging increases the risk of falls among older adults [33]. Dynamic balance assessed by a 3-m Up & Go increased with aging and was higher in middle than young older adults in each measurement year. Previous studies have also found that the measurements of a 3-m Up & Go increased with aging [34, 35]. Because a 3-m Up & Go evaluates walking speed and balance, the ability to maintain balance while walking and moving the body is necessary. As walking speed and the sense of balance decrease with aging, dynamic balance appears to increase.

In addition, the body fat percentage of body composition assessment was found to increase with aging in the present study. However, no difference was found between early and middle older adults in each measurement year. A study that monitored changes in body composition based on age for 10 years also found that body fat increases [36]. Body composition is divided into fat and lean body mass, which is divided into muscle, bone, and other connective tissue. In contrast to the decrease in muscle and bone mass, fat increases with age. Of course, fat mass also stops increasing or even decrease in old age [37].

The present study found that the functional fitness of older adults decreases with age; functional fitness was found to be different between early and middle-older adults. Additional research using a multilateral analysis is necessary to determine if the decreased functional fitness found in the present study was caused by the results of biological aging, degenerative disease, and physical inactivity.

The limitation of the present study is that establishing a pattern of changes in functional fitness is difficult because participants were male older adults who worked as school guardians in one local area. In addition, the amount of their physical activities and exercise during off-duty hours, which can affect functional fitness, were not considered. Despite these limitations, the present study has its significance in analyzing 4 years of annual data on the functional fitness of older adults who had similar occupational physical activities. In future studies, it is necessary to analyze the multifaceted factors that determine whether the change in functional fitness of the elderly occurs as a result of biological aging, degenerative diseases, and physical or occupational activity levels.

5. Conclusions

The clear pattern of decrease in functional fitness of older adults and the difference between early and middle-older adults can be considered as characteristic elements of aging. Accordingly, it is necessary to understand the changes in functional fitness based on aging. Such understanding should guide the development of an exercise program for older adults. In addition, research on measures to delay the decrease in functional fitness of older adults should be carried out continuously.

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Conflict of interest

No potential conflict of interest to this article was reported.

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