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Original Article

The Changes of Muscle Strength and Functional Activities During Aging in Male and Female Populations☆

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SUMMARY

Background: Aging is associated with the loss of muscle strength and difficulties in functional activities. The aim of this study was to investigate the changes of muscle strength and functional activities during aging in male and female individuals.
Methods: This study was a cross-sectional study recruiting healthy individuals aged 40–89 years. The muscle strength of bilateral hip flexors, knee extensors, and ankle plantar flexors were measured. Activities including functional reach test, timed up and go test, and alternating stair stepping were also measured.
Results: A total of 373 male and 371 female individuals participated in this study. The muscle strength of hip flexors and knee extensors were all significantly decreased after age 80 years as compared with the age group of 40–49 years in both male and female groups. The abilities of functional reach and timed up and go task were significantly decreased after age 70 years in the male group and decreased after age 60 years in the female group as compared with the age group of 40–49 years.
Conclusion: We noted that the muscle strength and functional activities were decreased earlier in female than male individuals. The decrease of functional activities during the aging process seems to be earlier than the decrease of muscle strength. It is important to implement functional activities training in addition to strengthening exercise to maintain functional levels of the geriatric population.

1. Introduction

Muscle strength and functional activity have been shown to decline during the aging process[1]. The degeneration of muscle strength with aging is due to the overall decrease in muscle mass, especially the type II muscle fibers[2]. A previous study indicated that muscle weakness of the lower extremity is a statistically significant and clinically important risk factor of falls[3]. Furthermore, the muscle strengths of the lower extremity are more affected by aging than the upper extremity due to less use of lower limbs than upper limbs in daily activity in the elderly population[4]. However, it is noted that the muscles of the lower limb are necessary to perform functional activities in the elderly population to maintain independent living and to participate in community activities[5]. Therefore, greater attention should be directed to the effect of aging on the muscle strength, especially the lower extremity, and functional activities to improve the quality of life.

The loss of isometric muscle strength starts earlier in females than in males when comparing the same muscle group[6]. Furthermore, according the demographic statistics, women have a longer life expectancy but a higher rate of disability than men[7]. However, the effect of gender on functional activities is not immediately known. Therefore, for the female population, early evaluation of the musculoskeletal system and functional abilities should be administered for possible rehabilitation to maintain quality of life.

Although muscle strength and functional performance both decline with aging, which deteriorates earlier? Many other factors, in addition to muscle strength, may influence functional activities such as balance ability. The aim of this study was to investigate the changes of muscle strength and functional activities during aging in male and female individuals.

☆ Conflicts of interest: All contributing authors declare that they have no conflicts of interest.

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2. Materials and methods

Participants were recruited in Taiwan; all met the following inclusion criteria: (1) age > 40 years; and (2) ability to walk independently with or without a device. The exclusion criteria were: (1) unstable medical conditions interfering with participation in the study; and (2) a score of < 24 on the mini-mental state examination. Finally, a total of 373 male and 371 female individuals were recruited and participated in the study.

The assessments included muscle strength and functional activities. Each test was evaluated three times and the average was used for data analysis. Information about age, gender, height, weight, and medical status were obtained from patient interviews.

2.1. Muscle strength assessment

A handheld dynamometer (PowerTrack II; JTech Medical, Midvale, UT, USA) was used to evaluate the muscle strength of the dominant side. All tests done were "make" tests in which the dynamometer was held stationary by the examiner while the participant exerted a maximum force against it[8]. Three trials were recorded with a 1-minute rest between trials and the average was used for data analysis. The muscle groups measured were hip flexors, knee extensors, and ankle plantar flexors.

The testing position for hip flexors was lying with hips and knees put on the cabinet and flexed at 90° with a strap around the pelvic region for stabilization. The dynamometer was placed over the distal part of the anterior thigh to test the hip flexors. The testing position for knee extensors was sitting with hips and knees flexed at 90° with a strap around the pelvic region for stabilization. The dynamometer was placed over the distal part of the lower leg to test the knee extensors. For ankle plantar flexors, the testing position was supine with hips and knees extended. Stabilization was provided by a strap around the distal leg region. The dynamometer was placed over the sole of foot. Prior to the study, the intrarater reliability of these muscles was established with intraclass correlation coefficients ranging from 0.93 to 0.98.

2.2. Functional activities

2.2.1. Functional reach test

The functional reach test (FRT) is a quick screening tool for determining the fall risk of elderly people[9]. This test is defined as the maximal distance one can reach forward while standing in a fixed position. The FRT has good test–retest reliability with an intraclass correlation coefficient (ICC) of 0.92[9]. It has also been reported to distinguish fallers from nonfallers with a sensitivity of 0.75 and a specificity of 0.67 in frail elderly populations[10].

2.2.2. Timed up and go test

The timed up and go test (TUG) is used to evaluate the basic functional mobility. During the test, participants got up from a chair, walked 3 m, made a 180° turn, returned, and sat down in the chair. The time needed to accomplish the test was recorded. The TUG has good test–retest reliability, with an ICC of 0.97 in a community-dwelling elderly population[11]. Regarding the validity, the TUG was correlated with gait speed ($r = -0.61$), the Berg Balance Scale ($r = -0.81$), and the Barthel Index scale ($r = -0.78$)[12].

2.2.3. Alternating stair stepping test

The alternating stair stepping test is one of the tasks in the Berg balance test for evaluating the ability of weight shifting. Participants were asked to place each foot alternatively as fast as possible onto a step (height: 19 cm; length: 40 cm). The time needed to accomplish eight steps by alternating feet was recorded. The test has good test–retest reliability, with an ICC of 0.78 in older adults[13].

2.3. Statistical analysis

SPSS version 16.0 (SPSS Inc., Chicago, IL, USA) software was used for data analysis. A Kolmogorov–Smirnov test was used to demonstrate a normal distribution of each variable and parametric test. One-way analysis of variance and *post hoc* Tukey test were used to test the effects of aging on the normal distributed measured variables in male and female groups. Kruskal–Wallis test and Mann–Whitney *U* test were used to test the effects of aging on the measured variables that are not normal distribution. Statistical significance was set at $p < 0.05$.

3. Results

Fig. 1 shows the flow chart of this study. Seven hundred and forty-four individuals (male: 373; female: 371) participated in the study. Table 1 presents the basic information and demographic data of all participants.

3.1. Effects of aging on muscle strength

Fig. 2 shows the maximal isometric hip flexors strength in different age groups. In the male group, the muscle strength decreased significantly after age 70 years as compared with age 40–49 years ($p < 0.05$ for the 70–79 years age group, $p < 0.01$ for the 80–89 years age group). After age 80 years, the muscle strength was significantly less than any other younger group ($p < 0.01$ vs. the 50–59 years age group, $p < 0.05$ vs. the 60–69 years age group, $p < 0.05$ vs. the 70–79 years age group). In the female group, the decrease of muscle strength was significant since age 70 years as compared with the 40–49 years, 50–59 years, and 60–69 years age groups ($p < 0.01$, $p < 0.01$, and $p < 0.05$, respectively).

Fig. 3 shows the maximal isometric knee extensors strength at different age groups. In male group, the muscle strength decreased significantly after age 80 years as compared with the age groups 40–49 years, 50–59 years, and 60–69 years ($p < 0.05$, $p < 0.01$, and $p < 0.05$, respectively).

In the female group, the decrease of muscle strength was significant from age 70 years as compared with the 40–49 years age group ($p < 0.01$ for the 70–79 years age group, $p < 0.01$ for the 80–89 years age group) and the muscle strength was significantly decreased after age 70 years as compared with the 50–59 years age group ($p < 0.01$ vs. 70–79 years, $p < 0.01$ vs. 80–89 years). However, there were no significant differences among each group in ankle plantar flexors strength (Fig. 4).

3.2. Effects of aging on functional activity

Fig. 5 shows the time needed to complete TUG test in different age groups. In the male group, the time increased significantly after age 60 years as compared with age 40–49 years ($p < 0.05$ for the 60–69 years age group, $p < 0.01$ for the 70–79 years age group, $p < 0.01$ for the 80–89 years age group). After age 80 years, the time was significantly increased than any other younger group ($p < 0.01$ vs. the 50–59 years age group, $p < 0.01$ vs. the 60–69 years age group, $p < 0.01$ vs. the 70–79 years age group). In the female group, the increase of time was significant since age 60 years as compared with the 40–49 years age group and the 50–59 years age group ($p < 0.01$).

Fig. 6 shows the results of functional reach test at different age groups. In the male group, the distance decreased significantly after age 70 years as compared with the age 40–49 years age group and