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Original Article

The correlation between toe flexor strength and performance-based measures of physical fitness in the elderly

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Abstract: [Purpose] To examine the correlation between toe flexor strength (TFS) and physical fitness performance measurements and their gender differences in the elderly. [Participants and Methods] Japanese males (n=50) and females (n=121), aged 65–88 years, participated in this study. We measured TFS, handgrip strength (HGS), knee extensor strength (KES), sit-and-reach distance (SR), and functional reach (FR). [Results] The female participants had significantly lower TFS, KES, and HGS than the male participants; however, the female participants had a significantly higher SR than that the male participants. FR was not significantly different between males and females. In males, TFS was significantly correlated with HGS, KES, SR, and FR. In females, TFS had correlations with HGS, KES, and FR; however, no correlation with SR was found. We could observe these correlations even after adjustment for age and body weight. [Conclusion] Elderly male had higher TFS than elderly females. In addition, TFS was correlated with all the physical fitness measurements in the male participants and all the measurements except for SR in the female participants. Gender and aging may explain the inconsistent results between SR and other physical fitness performance measurements.

Key words: Toe grip, Aging, Physical fitness

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INTRODUCTION

Toe flexion is a combination of the action of plantar intrinsic and extrinsic muscles[1)]. Toe flexor strength (TFS) is related to physical activity level[2, 3)], locomotive performance[4)], fall[5–7)], diabetes mellitus[8)], and cognitive function[9)]; thus, evaluation of TFS may be useful for screening for health and aging-related problems.

We previously showed the characteristics of TFS such as age-related decline and relationship of diabetes mellitus as well as physical fitness level in males[3, 8, 10)]. TFS is correlated with other physical fitness performance measurements including upper and lower limb strength, body flexibility, and dynamic balance in elderly males[3)]. Although skeletal muscle distribution, total volume, and age-related change of muscle composition such as intramuscular adipose tissue ratio differ between males and females[11, 12)], characteristics of TFS in women were not determined. The purpose of the present study was to investigate the correlation between TFS and physical fitness performance measurements in both elderly males and females.

PARTICIPANTS AND METHODS

A total of 50 elderly males and 121 females (65–88 years) participated in this study. The participants were recruited from among participants at events run by public bodies or the Tohoku Institute of Technology. All anthropometric and physical

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fitness data were measured at the event. All participants provided written informed consent to participate in this study. This study was approved by the Ethical Committee of the Tohoku Institute of Technology (No. 00007).

In this study, we performed five physical performance tests: TFS, knee extensor strength (KES, lower limb muscle strength), handgrip strength (HGS, upper limb muscle strength), sit-and-reach (SR, trunk flexibility), and functional reach (FR, dynamic balance). All estimations were performed by independent experts in exercise testing. The details of measurements were described previously[3].

Values were mean ± SD. An unpaired t-test was used to compare the means of the males and females. Differences were considered significant when $p<0.05$. To determine the correlation between TFS and other fitness performance measurements, Pearson and age- and body weight (BW)-adjusted partial correlation coefficients were calculated. SPSS software (Version 22.0 for Windows, SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

RESULTS

Table 1 shows the mean age, height, BW, and physical fitness levels of the participants. The age, height, and BW of the females were significantly lower than those of the males. There was no significant difference in body mass index. TFS, KES, and HGS in the females were significantly lower than those of the males, whereas SR in the females was higher than that of the males. There was no significant difference in FR between the genders. TFS/BW, KES/BW, and HGS/BW in the females were also significantly lower than those of the males (data not shown).

Table 2 shows the correlation coefficients between TFS and other parameters in the males and the females. In the Pearson correlation tests, TFS was negatively correlated with age in both the males and the females. TFS was positively correlated with KES, HGS, and FR in both genders; however, TFS was also correlated with SR in the men but not in the females. Partial correlation tests (adjusted by age and BW) confirmed these results.

DISCUSSION

The present study examined the correlation of TFS with other physical fitness performance measurements in elderly males and females. TFS was positively correlated with KES, HGS, and FR in both genders. The results suggest that TFS may reflect other physical fitness levels. TFS, KES, and HGS are maximal muscular strength performance measurements. In addition, the recruitment of many muscles was observed by electromyography during FR tests[13]. Therefore, TFS may be used to predict whole body muscle strength and function in the elderly.

One of the purposes of this study was to examine the gender differences of characteristics of TFS. TFS was positively correlated with KES, HGS, and FR in both genders. On the other hand, it was important to note that TFS was correlated with SR in males but not in females. This study also found that the SR of the females was significantly higher than that of the males unlike TFS, KES and HGS. In addition, SR was not correlated with age in either gender (data not shown) while TFS was negatively correlated with age in both genders. The age-related decrease of TFS was faster than KES and HGS[3, 10]. Thus, gender and aging may explain the inconsistent results between SR and other physical fitness performance measurements.

Table 1. Characteristics of the participants

	Age (years)	Height (cm)	BW (kg)	TFS (kg)	KES (kg)	HGS (kg)	SR (cm)	FR (cm)
Males	73.9 ± 5.3	163.5 ± 4.4	62.2 ± 9.1	8.1 ± 3.4	25.1 ± 6.9	35.0 ± 6.1	29.0 ± 10.9	30.9 ± 8.9
Females	72.2 ± 4.9*	151.5 ± 5.4*	52.5 ± 6.8*	5.3 ± 2.2*	19.0 ± 5.6*	21.4 ± 4.4*	34.0 ± 10.2*	33.1 ± 9.0

Data are means ± SD. *The difference was significant ($p<0.05$). BW: body weight; TFS: toe flexor strength; KES: knee extensor strength; HGS: handgrip strength; SR: sit-and-reach; FR: functional reach.

Table 2. Correlation coefficients between TFS and other characteristics

	Age	BW	KES	HGS	SR	FR
			Pearson correlation coefficients			
Males	−0.354*	0.205	0.525*	0.505*	0.329*	0.414*
Females	−0.251*	0.247*	0.574*	0.428*	0.127	0.387*
			Partial correlation coefficients adjusted by age and BW			
Males	—	—	0.444*	0.389*	0.354*	0.400*
Females	—	—	0.520*	0.328*	0.146	0.338*

*Significant correlation with toe flexor strength ($p<0.05$). BW: body weight; TFS: toe flexor strength; KES: knee extensor strength; HGS: handgrip strength; SR: sit-and-reach; FR: functional reach.

Previous studies showed an association between TFS and physical activity[2, 3], prevalence of diabetes mellitus in middle-aged men[8], gait performance[4], fall[5–7], and cognitive function in the elderly[9]. TFS is a simple, safe, and inexpensive way to evaluate lower limb muscle strength. Poor TFS is a potential useful marker for decreased physical activity and performance, prevalence of metabolic abnormalities, and age-related physical and cognitive problems.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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