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Original Article

Relationship between gait speed and trunk muscles in frail elderly individuals

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Abstract. [Purpose] The external and internal abdominal muscles may be related to gait speed; however, this has not yet been elucidated. In this study, we aimed to clarify the relationship between gait speed and trunk muscle thickness in elderly individuals. [Participants and Methods] The participants were 12 elderly individuals (4 males and 8 females, mean age 83.4 years old, SD ± 0.5) that attend a day service center. We measured the 5 m free gait speed, the 5 m fastest gait speed, and the thickness of five trunk muscles (the rectus abdominis [divided into three parts: upper, central, and lower], external oblique, internal oblique, transverse abdominis, and iliopsoas muscles). [Results] There were positive correlations between the free gait speed and the thickness of the lower rectus abdominis, internal oblique, and transverse abdominis muscles. There were also positive correlations between the fastest gait speed and the thickness of the lower rectus abdominis, internal oblique, and transverse abdominis muscles. [Conclusion] Incorporating muscle strength training of the lower rectus abdominis, internal oblique, and transverse abdominis muscles into existing lower limb muscle training protocols is important to effectively maintain the gait speed of elderly individuals.

Key words: Gait speed, Trunk muscles, Frail elderly individuals

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INTRODUCTION

According to the Annual Report on the Ageing Society 2019[1)], the number of elderly individuals aged over 65 years in Japan was 35.58 million in 2018, which constituted 28.1% of the total Japanese population. This is the world's largest percentage of elderly population and therefore, health expectancy is an important issue in Japan.

Gait speed strongly correlates with health status[2)]. A reduced gait speed, accompanied by ageing, triggers falls[3)] and hinders the activities of daily living[4)]. This, in turn, affects the daily activities required for independent living. A reduced gait speed is a useful parameter[5, 6)] to predict the deterioration of cognitive functions.

It has been reported that gait speed is a good indicator of the overall physical fitness[7, 8)]. Gait speed is related to health expectancy and survival rate; elderly individuals who can walk fast have a higher survival rate than those who walk slowly[9)]. This suggests that gait speed is a predictor of life expectancy in elderly individuals. Therefore, maintaining a good gait speed is important for this population.

Through an experimental simulation, Song and Geyer[10)] illustrated that reduced muscle strength and muscle mass contribute to reduced energy efficiency, and these factors mainly influence the gait speed.

The lower limb muscles show ageing-related alterations more than the upper limb muscles[11)]. Anti-gravity muscles con-

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taining more type 2 fibres are affected more[12, 13]. Previous studies have shown that ageing-induced reduced lower limb muscle strength was a cause of a slower gait speed[14–16]. Furthermore, in recent years, it has been shown that not only lower limb muscle strength, but also trunk muscle strength plays a significant role for gait stabilisation and efficiency[17]. Through the complex movement of walking, trunk muscles contribute to maintaining stability and mobility of the whole vertebral column[18].

However, few studies have reported the relationship between gait speed and trunk muscles in elderly individuals. Granacher et al.[19] reported that trunk muscle strength training could improve gait speed. Ota et al.[20] compared the trunk muscle thickness (MT) of females who could walk independently categorised by age (20−85 years). There was no significant difference in the thickness of transverse abdominis muscles between the groups. However, the thickness of the external and internal abdominal muscles in females over 75 years of age was smaller than that in younger females. Samson et al.[21] have shown that the gait speed of elderly individuals decreases with age. The external and internal abdominal muscles may be related to the gait speed; however, the relationship has been unclear. Therefore, the aim of the present study was to elucidate the relationship between gait speed and trunk MT in elderly individuals.

PARTICIPANTS AND METHODS

The participants were 12 elderly individuals (4 males and 8 females) attending a day service centre for the elderly, who could walk independently or with a walking aid. The participants were certified to receive long-term care service from the needed support level one to the nursing care level four[22]. The mean (± SD) age was 83.4 ± 0.5 years, the mean weight (± SD) was 49.8 ± 7.5 kg, and the mean height (± SD) was 150.8 ± 10.8 cm.

The 5 m free gait speed, the 5 m fastest gait speed, and five trunk MTs were measured. The following five muscles were evaluated: rectus abdominis (divided into three parts; upper [URA], central [CRA], and lower [LRA]), external oblique (EO), internal oblique (IO), transverse abdominis (TrA), and iliopsoas (ILIO). For the measurement of gait speed, the participants walked 7 m each, including 1 m runways at the starting and finishing points. The runways were excluded, and the 5 m walking time was used to calculate the free and the fastest walking speed in m/s.

The MTs were assessed using a B-mode ultrasonographic apparatus (SSD-3500SV; Aloka, Japan) with a 7.5 MHz linear scanner. The definition of the three parts of the rectus abdominis (URA, CRA, and LRA) was derived from Balius et al[23]. The MT of URA and CRA was measured at the second and third layers of the tendinous intersection, respectively. The MT of LRA was measured at the fourth layer, which is the lower part of the tendinous intersection until the pubic symphysis.

Each MT was assessed at the point of maximum distance between the upper and lower edges of each tendinous intersection. The first tendinous intersection was excluded due to the presence of other fibres and the variation in the rib shapes. The MTs of EO, IO, and TrA were measured according to the method of Sugaya et al.[24]: at the 15 mm upper point of the TrA muscle-tendon junction, which is located at the midpoint between the lower edge of the ribcage at the anterior axillary line and the anterior superior iliac spine. The ILIO was assessed just under the inguinal ligament. The participants were lying relaxed on the bed in the supine position while measuring the MTs.

The association between each MT, the free gait speed, and the fastest gait speed was assessed by calculating the Spearman's correlation coefficient. All statistical analyses were performed using SPSS software (version 21.0). The level of significance was set at $p<0.05$.

Ethical approval was granted by the Ethics Committee of Kanazawa Orthopaedic Clinic (Kanazawa-OSMC-2019-001). All participants provided signed informed consent before participating in this study.

RESULTS

The mean (± SD) of the 5 m free gait speed was 1.02 ± 0.4 m/sec, and the mean (± SD) of the fastest gait speed was 1.24 ± 0.5 m/sec. The MT values were as follows: 0.62 ± 0.2 cm (URA), 0.69 ± 0.2 cm (CRA), 0.70 ± 0.2 cm (LRA), 0.34 ± 0.1 (EO), 0.67 ± 0.2 cm (IO), 0.23 ± 0.1 cm (TrA), and 1.30 ± 0.4 cm (ILO) (Table 1). There were positive correlations between the free gait speed and the LRA ($r=0.643$, $p<0.05$), IO ($r=0.594$, $p<0.05$) and TrA ($r=0.697$, $p<0.05$). There were positive correlations between the fastest gait speed and the LRA ($r=0.602$, $p<0.05$), IO ($r=0.581$, $p<0.05$) and TrA ($r=0.653$, $p<0.05$) (Table 2).

DISCUSSION

For elderly individuals, maintaining gait speed is vital for leading a healthy life. The gait speed is related to the risk of falling and living an independent life. We focused on the relationship between 5 m free and fastest gait speed and trunk MT. We found positive correlations between LRA, IO, and TrA muscles and the gait speed.

Gait alterations, such as reduced step length, slower gait speed, and decreased trunk rotation are caused by ageing[25]. It is assumed that along with these age-related changes, a reduced core stabilisation and abdominal pressure by TrA, as well as reduced limb muscles strength, lead to imbalance and a high risk of falling. With increased gait speed, trunk perturbation also increases. Accordingly, muscle activity on electromyography should be higher[18] and the pelvic rotation should increase[26].

Table 1. Gait speed and trunk muscle thickness of the participants

	Mean ± SD
5 m free gait speed (m/s)	1.02 ± 0.38
5 m fastest gait speed (m/s)	1.24 ± 0.47
Upper rectus abdominis (cm)	0.62 ± 0.15
Central rectus abdominis (cm)	0.69 ± 0.15
Lower rectus abdominis (cm)	0.70 ± 0.16
External oblique (cm)	0.34 ± 0.07
Internal oblique (cm)	0.67 ± 0.19
Transverse abdominis (cm)	0.23 ± 0.15
Iliopsoas (cm)	1.30 ± 0.39

Table 2. Correlation coefficients between gait speed and muscle thickness

	Correlation coefficient	
	5 m gait speed	5 m fastest gait speed
Upper rectus abdominis	0.252	0.231
Central rectus abdominis	0.462	0.455
Lower rectus abdominis	0.643*	0.602*
External oblique	0.210	0.158
Internal oblique	0.594*	0.581*
Transverse abdominis	0.697*	0.653*
Iliopsoas	0.176	0.113

*$p<0.05$.

Crawford et al.[26] showed that elderly individuals have a larger perturbation of trunk rotation and longitudinal direction with increased gait speed as compared to younger ones. TrA and IO have a lumbar stabilisation function[27], and therefore, these muscles may contribute to maintaining the trunk stability. The IO activity during walking is highest at mid-stance which involves the maximum loading[28]. In line with this concept, we found a positive correlation between TrA, IO, and gait speed.

During lower limb activities, CRA and URA activities are inhibited compared to LRA, and hence, the dependence on LRA activity must be high[29]. The lower limbs are involved in locomotor functions (walking), and therefore, LRA thickness and gait speed showed a positive correlation. ILIO did not show a positive correlation with the gait speed. A previous study reported a correlation between gait speed and the cross-sectional area of the ILIO[18]. In the current study, the measurement point of ILIO thickness was close to the insertion area, and hence, the muscle volume may have been inadequate to show a significant correlation with the gait speed. Furthermore, our results may be different from previous studies secondary to the frailty of the participants.

This study demonstrated a significant correlation between LRA, TrA, IO, and gait speed due to the various physical functions of the participants: long-term care service from the needs support level one to the nursing care level four.

There are some limitations to this study. Our sample size was small, and we focused on the relationship between trunk muscles and gait speed. However, the gait speed is defined by both step length and pitch. Thus, further studies with a larger number of participants are needed to evaluate which factors correlate more with the trunk MT.

We suggest that a weaker LRA, TrA and IO result in a lower gait speed and may contribute to an inactive life and further weakening of the muscle strength. To confirm this, a longitudinal study is needed.

In future studies, the measurement point of ILIO thickness should be taken into consideration. Additionally, to better define the role of trunk muscles, the measurement of echogenicity and electromyogram will be needed. In conclusion, there were positive correlations between gait speed and the MTs of LRA, IO, and TrA muscles in frail elderly Japanese individuals. Therefore, we recommend incorporating LRA, IO and TrA strength training into the existing lower limb muscles training protocols to effectively maintain the gait speed in elderly individuals. A longitudinal study may clarify the effectiveness of this training.

Funding and Conflict of interest

None.

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