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Original Article

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Contraction Ratio Variation of the Lateral Abdominal Muscles in Elderly Gait

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| Abstract |

Purpose: This study aimed to describe and identify the relationship between gait and contracted ratios of the transverse abdominal (TrA), internal oblique (IO), and external oblique (EO) muscles.
Methods: This study was conducted on 50 elderly people. The contracted ratios of the lateral abdominal muscles (LAM) were measured using the abdominal drawing-in maneuver (ADIM) and ultrasonographic imaging. Gait was measured using the timed up and go test and the 10 m walk test.
Results: The contracted ratios of the TrA and IO muscles significantly increased after ADIM. Those of the TrA muscles showed a significant correlation with gait in the limited community ambulatory group. The contracted ratios of the IO and EO muscles showed a significant correlation with gait in the community ambulatory group.
Conclusion: Our findings suggest a specific training on the relationship between gait speed and the activation of the LAM in elderly people.

Key Words: Abdominal muscle, Ultrasound imaging, Gait

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Ⅰ. Introduction

The increasing elderly population has become a problem for societies worldwide, prompting much effort to manage aging-induced chronic diseases and their effects on quality of life. In the past, maintaining quality of life for the elderly was mainly concerned with basic needs (food, clothing, and shelter) and pain control, but has now expanded to include jobs and mobility.

Unrestricted ambulation is one of the most important determinants of the economic existence and quality of life in the elderly. Unrestricted ambulation enables individuals to move farther and easier depending on the functional status of the trunk and lower limbs. In general, aging undermines normal daily functioning and increases fall risks (Urquhart et al., 2005). This is mainly due to disuse atrophy, which is due to loss of motor function (Janssen, 2006). The severity of disuse atrophy varies in accordance with muscle volume and thickness as well as with the number of muscle fibers, and aging results in greater changes in the volume and thickness of the abdominal muscles than in those of the legs, such as the rectus femoris (Rankin et al., 2006). The lateral abdominal muscles (LAM), comprised of the transverse abdominal (TrA), internal oblique (IO), and external oblique (EO), provide stability by controlling trunk movement and supporting the spine (Hodges & Richardson, 1999). The elderly have weaker superficial and deep LAM (Ikezoe et al., 2012), which limits their capabilities in daily routines and leads to falls (Teyhan et al., 2007).

Much research has examined muscle activity, using electromyography (EMG) during the abdominal drawing-in maneuver (ADIM), in order to identify means of improving ambulatory function and preventing falls and lower back pain in the elderly (Henry & Westervelt, 2005). Studies have also tried to identify factors that enhance mobility and stability by measuring the order of muscle contraction, and tried to find a relationship between EMG and change in thickness of the muscles (McMeeken et al., 2004; O'Sullivan et al., 1997). Recently, various methods for measuring the thickness and volume of LAM with ultrasound have been developed, and are currently used in addition to EMG. Ultrasound has been used to examine differences between left and right LAM thickness (Ota & Kaneoka, 2011), as well as the differences in thicknesses between superficial and deep muscles (Ikezoe et al., 2012; Rankin et al., 2006). However, little has been reported on the specific effects of LAM on dynamic balance, static balance, gait endurance, and gait velocity.

Therefore, the present study aimed to determine the correlations between LAM thickness, contracted ratio, and symmetric ratio, and normal and rapid gait speed. The results were intended to provide basic data for the use and development of assistive devices that improve gait ability and mobility and prevent falls, by selectively strengthening trunk muscles according to gait ability.

Ⅱ. Methods

1. Subjects

Fifty normal elderly subjects were enrolled from the A senior community center. Individuals who provided informed consent after listening to the instructions and explanations regarding the study, and who had no orthopedic, medical, or neurological disorders that could affect trunk function and gait within the prior six months, were included. The 10-meter walk test (10MWT) was performed on those who agreed to participate; based on the results, 24 participants were assigned to the limited community ambulatory (LCA) group (<0.8m/s) and 26 to the community ambulatory (CA) group (>0.8m/s). The study was performed in accordance with the principles of the Declaration of Helsinki.

2. Tools and Methods

To examine the correlation between balance and trunk muscle activity, the functional reach test (FRT) and timed up and go (TUG) were performed. Gait ability was measured with the 10MWT-fast and 10MWT-general.

Thickness of LAM was measured with ultrasound (MySono U5, Samsung Medison Co., Korea), using a 7.5MHz linear transducer. The participants were in a supine position with hip and knee bent, and measurements were taken three times each for the left and right sides during normal respiration and during the ADIM. The thickness of the TrA, IO, and EO was measured (Mannion et al., 2008).

During normal respiration, thickness was measured at the medial abdomen, 25mm from the lateral abdomen, between the 12th rib and iliac crest. The thickness of the TrA, IO, and EO was measured at a point vertical to the horizontal line 15mm from the muscle-fascia junction (Hodges et al., 2003). During the ADIM, the participants were instructed to draw in the lower abdomen as much as possible, and measurements were taken with sustained maximum contraction for 10s at the end of expiration (Stetts et al., 2009). All measurements were taken in a random order, and the participants rested for three minutes between measurements on each side to minimize fatigue (Teyhen et al., 2005). Two tailed paired t-test were used to compare the thickness in groups and the Level of significance was set a priori to be 0.05. All data were analyzed using SPSS Version 18.1 (SPSS, Inc, Chicago, IL).

Ⅲ. Results

LCA group consists of 11 men and 13 women, and CA group consists of 12 men and 14 women. The average age of LCA group was 69.48±4.59 years old, and CA group was 70.92±5.98 years old. The average weight of LCA group was 64.22±8.81kg, and healthy people group was 65.42±6.50kg. For the average height of LCA group was 158.83±7.75cm, and CA group was 160.19±9.51cm. Contracted ratios of the TrA and IO muscles were significantly increased after ADIM in all groups (Table 1). Contracted ratio of the TrA muscles showed a significant correlation with FRT and TUG in the LCA group. Contracted ratios of the EO muscles showed a significant correlation with FRT in the CA group (Table 2).

Ⅳ. DISCUSSION

To examine the effects of LAM on gait and balance, this study divided the participants into LCA and CA groups, using a cut-off gait speed of 0.8m/s, and measured abdominal muscle activity with ultrasound at rest and during ADIM (Bohannon, 1997, 2008; Waters et al., 1988). We measured muscle contraction and degree of symmetry using ultrasound and found that both groups showed statistically significant contraction of the TrA and IO muscles, but contraction of the EO was not statistically significant in either group. In a study that surveyed maximum TrA contraction, reported an average of 0.40cm for normal adults and an average of 0.35cm for normal older adults (Stetts et al., 2009; Teyhen et al., 2005). In our study, TrA activity was closer to the mean, with participant gait speed closer to that of normal elderly individuals. We speculate that’s lower gait speed increases dependence on TrA more than on EO and IO, which leads

Table 1. Comparison of symmetry and thickness in groups

	LCA group (n=24)		p	CA group (n=26)		p	Between groups	
	Left	Right		Left	Right		Left (p)	Right (p)
TrA (㎝)								
rest	0.34±0.12[a]	0.32±0.07	0.09	0.30±0.10	0.30±0.10	0.49	0.10	0.31
ADIM	0.57±0.30	0.49±0.12	0.13	0.44±0.10	0.49±0.12	0.01*	0.03*	0.48
p	0.00*	0.00*		0.00*	0.00*			
IO (㎝)								
rest	0.43±0.13	0.45±0.12	0.33	0.45±0.10	0.45±0.10	0.39	0.20	0.47
ADIM	0.67±0.15	0.63±0.20	0.08	0.60±0.12	0.63±0.12	0.23	0.06	0.46
p	0.00*	0.00*		0.00*	0.00*			
EO (㎝)								
rest	0.34±0.06	0.33±0.07	0.42	0.31±0.07	0.32±0.08	0.17	0.10	0.37
ADIM	0.36±0.07	0.35±0.06	0.10	0.32±0.06	0.36±0.11	0.02*	0.00*	0.37
p	0.05	0.06		0.28	0.05			

[a]: values are mean±SD
*p<0.05
LCA: limited community ambulatory group, CA: community ambulatory group, TrA: transverse abdominal muscle, IO: internal oblique muscle, EO: external oblique muscle, ADIM: abdominal draw-in maneuver

Table 2. Correlation analysis of gait and balance ratio in groups

	LCA group (n=24)				CA group (n=26)			
	TUG	FRT	10MWT fast	10MWT general	TUG	FRT	10MWT fast	10MWT general
RTrA	-0.206	0.50**	-0.26	-0.17	-0.40	0.08	0.01	-0.11
LTrA	-0.39*	0.46*	-0.00	-0.18	-0.01	-0.32	-0.23	-0.31
RIO	-0.10	-0.11	0.23	0.21	-0.09	0.20	-0.11	-0.02
LIO	-0.25	0.28	-0.10	-0.05	0.03	-0.11	-0.06	0.18
REO	-0.14	0.17	-0.28	-0.30	-0.00	-0.42*	0.06	-0.25
LEO	-0.15	0.26	-0.19	-0.05	0.21	0.10	0.30	-0.10

[a]: values are mean±SD
*p<0.05 **p<0.01 ***p<0.001.
LCA: limited community ambulatory group, CA: community ambulatory group, TUG: timed up & go, FRT: functional reach test, 10MWT: 10 meter walk test, RTrA: right transverse abdominal muscle, LTrA: left transverse abdominal muscle, RIO: right internal oblique muscle, LIO: left internal oblique muscle, REO: right external oblique muscle, LEO: left external oblique muscle, ADIM: abdominal draw-in maneuver.

to decreased muscle strength and shorter muscle length, ultimately resulting in greater than average muscle thickness at rest. The greater muscle thickness at rest on the left side compared to the thickness on the right side may have been due to this phenomenon.

Previous studies using EMG to examine abdominal muscles reported that the TrA and IO show the greatest contraction, with increases in thicknesses in both muscles similar to the results in our study (McMeeken et al., 2004; Teyhen et al., 2008). Henry and Westervelt (2005) reported that elderly patients with lower back pain show excessive contraction of the EO. However, a different study that measured abdominal muscles in accordance with gait speed suggested that normal adults show muscle contraction patterns that are different from those in individuals with pain. In the same study, the LCA group showed excessive activation of the TrA muscles, which was different from that shown in weakened TrA muscles in stroke patients (Seo & Lee, 2013). Excessive use of the TrA muscle in the elderly may be a typical feature of their posture, in which there is an effort to compensate for anterior displacement of the center of mass caused by weakening of the hip flexors and knee extensors, to provide stability in the sacroiliac articulation (Richardson et al., 2002). In general, the ability to shift body weight forward is impaired in elderly individuals (Cromwell et al., 2002).

Ⅴ. CONCLUSION

Our findings showed that individuals with limited and slower gait in both the CA and LCA group used the TrA more frequently than the IO and EO. Thus, we concluded that individuals with slower gait would attempt to maintain speed and balance more with vertical movement than with horizontal movement of the trunk. This provides meaningful information for gait training and development of assistive devices.

This study had limitations. First, the external environment and subjects were not completely controlled for gait measurement. Second, our analysis of gait speed in the LCA and CA groups showed small intergroup differences and weak correlations. Future studies may provide more accurate and significant correlations by expanding the study population to include street cross ambulatory subjects, using a more systematic and continuous study design.

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