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Full Length Research Paper

Relationship between muscle thickness and spinal column alignment in the standing and sitting positions

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ABSTRACT

The trunk muscles play a role in posture maintenance, but whether they are related to spinal alignment in different postures has only been investigated in young adults and not in the elderly who show age-related changes in the spine. This study aimed to determine the relationship between changes in spinal alignment and muscle thickness in three postures in healthy elderly subjects. Spinal mouse measurements of Spinal alignment and ultrasound measurements of the trunk muscles were performed in the standing, upright and slump sitting positions on healthy elderly individuals living in the community. Results showed significant differences in the sacral tilt, lumbar curvature, and overall tilt angles in the slump sitting position for spinal alignment, and significant differences were noted in muscle thickness between standing and upright sitting, standing and slump sitting, and standing and slump sitting, and upright and slump sitting for the spinal proprioceptive muscle (second lumbar level). In conclusion, there was no correlation between the two changes. It was suggested that the spine be viewed as a whole and not in parts, with muscle thickness changes.

Keywords: Spine, postural difference, posture holding muscle.

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INTRODUCTION

Low back pain (LBP) is the most common condition, affecting 70 to 80% of people at least once in their lifetime (Andersson, 1999; Cassidy et al., 1998; Frymoyer and Cats-Baril, 1991). Posture has been confirmed to be correlated with LBP, and it has been reported that sitting places more stress on the lumbar spine than standing (Nachemson, 1981) and that prolonged standing or sitting increases LBP (Søndergaard et al., 2010; Miura et al., 2013). Therefore, it would be beneficial to determine the relationship between posture and LBP. Although many factors, including psychological aspects, are involved in the LBP mechanism (Borenstein, 2001; Chou et al., 2007), the trunk muscles, which maintain posture, are thought to play an important role.

The trunk muscles can be divided into two groups: the global and local muscle groups (Bergmark, 1989). The global muscles include the rectus abdominis (RA), external oblique (EO), and erector spinae (ES), which are mainly involved in trunk movements. In contrast, the local muscles involve the lumbar multifidus (LM), internal oblique (IO), and transversusabdominis (TrA), which are responsible for the stabilization of the body. In addition, the TrA and IO are involved in abdominal pressure increase and play a role in stabilizing the trunk (De Troyer et al., 1990; Cresswell et al., 1992) and the LM in fine control of the lumbar spine (Bergmark, 1989). Trunk muscles have complex roles; however, changes in the activity of each muscle in different postures, including standing and sitting, have not been fully investigated. In particular, it is predicted that the trunk muscle changes associated with postural changes in the elderly will differ from those in the young because of the effects of aging on spinal alignment changes (Shin et al., 2015; Gutman et al., 2016) and muscle atrophy (Greenlund et al., 2003). However, there have been only a few studies on postural changes, including spinal alignment in young people (Claus et al., 2009; Waongenngarm et al., 2015), and no previous studies have focused only on the elderly.

There are currently two widely used non-invasive methods for evaluating muscle activity: surface electromyography and ultrasonography. Surface electromyography is performed by attaching an electromyogram to the skin and measuring the muscle potential. It can measure muscle activity during movement; however, it can only be used for superficial muscles. Conversely, a diagnostic ultrasound device emits ultrasonic waves from a probe to a living body and then receives the reflected ultrasound waves from the body again with the probe to image the tissues inside the body. It is not able to measure muscle activity during movement; nonetheless, it can measure deep muscles. In investigating the relationship between posture and trunk muscles, ultrasound evaluation is appropriate (Bunce et al., 2002; Kidd et al., 2002). For the spine evaluation method, radiography is necessary to analyse the spine alignment in detail. However, Spinal Mouse has been increasingly used because of the zero risks of radiation exposure, and it being a non-invasive measurement (Post and Leferink, 2004).

Thus, in this study, we used these devices to determine the changes in spinal alignment and trunk muscle activity in response to postural changes in the elderly and to investigate whether there is a relationship between spinal column alignment and changes in trunk muscle activity. By clarifying these factors, we believe that they can be used as criteria for preventing low back pain and intervening with those who have low back pain, thereby enabling more effective physical therapy.

MATERIALS AND METHODS

Sample

The participants were 30 healthy elderly men (age, 70.7±5.1 years; height, 163.0±5.9 cm; weight, 62.4±7.8 kg) living in the community with independent activities of daily living and instrumental activities of daily living. Because of gender differences in skeletal structure, only males were included in this study (Shin et al., 2015). Those with pre-existing spinal diseases were excluded. This study was conducted in accordance with the Declaration of Helsinki, in which the participants were given a written explanation of the purpose, methods, and expected results of the study and the benefits and disadvantages of research cooperation for the participants, followed by the signature of their consent. The study was approved by the Pathology Review Committee of the International University of Health and Welfare (approval number 20-Io-18).

Measures

This study was a cross-sectional observational study. The positions were measured in three conditions: standing, upright sitting, and slump sitting (Figure 1). In the standing position, both feet were placed with 10 cm between the medial phalanx, the ankle joint was rotated at 0°, the knee joint was extended, both upper limbs were placed in a spontaneous drooping position, and the head was placed at eye level, with eyes focused forward. In each sitting position, the hip and knee joints were set at 90°; in the upright sitting position, the participant was instructed to straighten the back muscles, whereas, in the slump sitting position, the participant was directed to sit with weakness. Muscle thicknesses of the ES, LM (L2, L5), EO, IO, and TrA were measured using the Sonosite 180PLUS ultrasound system (FUJIFILM Sonosite Inc., WA, USA). The LM (L2) and LM (L5) were measured with a probe perpendicular to the spine at 2 cm outside the spinous process at the second and fifth lumbar vertebrae (Urquhart et al., 2005), and ES thickness was measured with a probe perpendicular to the spine at 5 cm outside the spinous process at the third lumbar vertebrae, based on a previous study (Stokes et al., 2007). Nevertheless, TrA, IO, and EO muscle thickness were measured with a probe perpendicular to the spine at the midline of the rib limb and iliac crest on the anterior axillary line, based on a previous study.

For spinal alignment, Spinal Mouse (Idiag, Fehraltorf, Switzerland) was used to measure the sacral tilt angle (positive lordosis, negative kyphosis), lumbar bending angle (negative lordosis, positive kyphosis), thoracic bending angle (negative lordosis, positive kyphosis), and the total tilt angle of the spine (positive lordosis, negative kyphosis). The definitions of each are as follows: the sacral tilt angle is the angle formed by the vertical line between the posterior surface of the sacrum and the floor; the lumbar curvature angle represents the entire spine column from the 12th thoracic vertebrae to the 1st sacral vertebrae, the sum of the angles between the 12th thoracic vertebrae and the 1st lumbar vertebrae to the 4th and 5th lumbar vertebrae; the thoracic curvature angle represents the entire spine column from the 1st thoracic vertebrae to the 12th thoracic vertebrae, the sum of the angles between the 11th thoracic vertebrae and the 12th thoracic vertebrae; and the total tilt angle is the angle formed by the tilt angle between the 1st thoracic vertebrae and the 1st sacral vertebrae and the vertical line from the floor. The measurement method is to take the shape of the spinal column by placing a measuring instrument along the paravertebral line of the spinal column, which is the longitudinal line connecting the transverse process of the vertebrae from the 7th cervical vertebra to the 3rd sacral vertebrae, from the head side to the caudal side.

Data analysis

Statistical analysis was conducted using the one-way allocation analysis of variance and Pearson’s reserve correlation coefficient, and SPSS version 25 (SPSS Inc., Chicago, IL, USA) was used as the statistical software for this study. Significance was inferred for $p < 0.05$.

RESULTS

The changes in each part of the spine between each posture are shown in Table 1. There was a significant difference in the sacral tilt angle between standing (-1.33±6.2°) and slump sitting (-11.60±8.1°), and between upright (-2.83±5.9°) and slump sitting (-11.60±8.1°). For lumbar bending angle, there was a significant difference between standing (-8.87±9.0°) and slump sitting (15.70±9.9°), and between upright (-4.43±6.9°) and slump sitting (15.70±9.9°). In addition, there were significant differences in the total tilt angle of the spine between standing (2.40±3.7°) and slump sitting (13.23±4.4°), and between upright (3.40±4.0°) and slump sitting (13.23±4.4°). The sacrum showed kyphosis, the lumbar spine kyphosis, and the overall slope lordosis in the slump position compared to the standing and upright

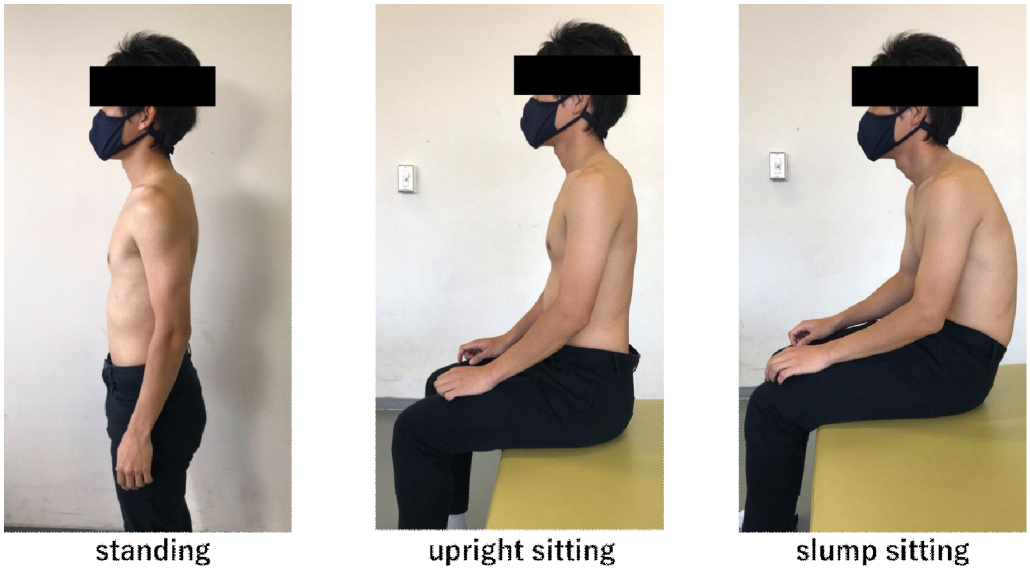

Figure 1. Measurement posture.

Table 1. Results of one-way placement analysis of variance for each posture and spinal alignment.

	Standing	Upright sitting	Slump sitting
Sacral tilt angle (°)	-1.33 (6.2)*	-2.83 (5.9)‡	-11.60 (8.1)*‡
Lumbar bending angle (°)	-8.87 (9.0)*	-4.43 (6.9)‡	15.70 (9.9)*‡
Thoracic bending angle (°)	45.53 (9.6)	40.27 (8.0)	43.93 (11.9)
Total tilt angle of the spine (°)	2.40 (3.7)*	3.40 (4.0)‡	13.23 (4.4)*‡

Note: Data are presented as mean (SD)
Statistical significance indicated by * ‡ p < .05.

positions. There was no significant difference in the thoracic curvature angle between all postures.

The changes in each muscle thickness between each posture are shown in Table 2. There were significant differences in ES between standing (377.3±70.8 mm) and upright sitting (321.6±62.0 mm), and between standing (377.3±70.8 mm) and slump sitting (300.5±59.5 mm). In LM (L2), there were significant differences between standing (356.4±64.0 mm) and slumped sitting (307.9±54.2 mm), and between upright (351.1±57.8 mm) and slumped sitting (307.9±54.2 mm). ES was thicker in the upright position, and LM (L2) was thinner in the slump sitting position. No significant difference was found in EO, IO, TrA, and LM (L5).

Table 3 shows the results of the correlation analysis of the changes in muscle thickness and spinal column depending on the posture. No significant correlation was found for all postures.

Table 2. Results of one-way placement analysis of variance for each posture and muscle thickness.

	Standing	Upright sitting	Slump sitting
ES (mm)	377.3 (70.8)*‡	321.6 (62.0)‡	300.5 (59.5)*
LM(L2) (mm)	356.4 (64.0)*	351.1 (57.8)⁂	307.9 (54.2)*⁂
LM(L5) (mm)	357.6 (49.6)	327.1 (56.0)	275.7 (61.8)
EO (mm)	57.9 (11.9)	62.5 (13.3)	64.5 (16.0)
IO (mm)	95.7 (31.5)	86.1 (27.1)	89.2 (28.5)
TrA (mm)	46.9 (16.5)	42.1 (12.0)	44.9 (19.1)

Note: Data are presented as mean (SD)
Statistical significance indicated by * ‡ ⁂p < .05
EO, external oblique; ES, erector spinae; LM, lumbar multifidus; IO, internal oblique; TrA, transversus abdominis.

Table 3. Correlation analysis of the amount of change in muscle thickness and the amount of change in spinal alignment.

		ES		LM (L2)	
		r	p	r	p
Standing-slump sitting	Sacral tilt angle	-0.209	0.269	0.284	0.128
	Lumbar bending angle	-0.078	0.682	-0.131	0.492
	Total tilt angle of the spine	-0.203	0.283	0.042	0.827
Upright sitting-slump sitting	Sacral tilt angle			-0.030	0.874
	Lumbar bending angle			0.154	0.415
	Total tilt angle of the spine			-0.005	0.981

r: Correlation coefficient.

DISCUSSION

This study aimed to clarify the relationship between each part of the spinal column and the thickness of each postural muscle in standing and upright and slump sitting in the elderly. The results showed no difference in the spinal region between the standing and upright sitting positions. On the other hand, the sacral inclination angle was tilted backward, the lumbar curvature was kyphotic, and the total inclination angle was tilted forward between the standing and upright sitting and slump sitting positions, similar to those defined by O'Sullivan et al. (2006) and Claus et al. (2009).

There was a significant difference in muscle thickness between the standing and upright sitting positions and between the standing and slump sitting positions in the ES. In the LM (L2), there was a significant difference between the standing and slump sitting positions and between the upright and slump sitting positions. The ES was noted to be thicker in the standing position than in the upright or slump sitting position. In this study, there was no difference in the spinal column between standing and upright sitting positions, suggesting that ES activity is enhanced in the elderly by changes in standing and sitting positions, regardless of spinal column alignment. Furthermore, the LM (L2) was thicker in the standing and upright sitting positions than in the slump sitting position. Claus et al. (2009) and Nairn et al. (2013) reported no change in the upright and slump sitting positions in healthy young people. Hence, the previous study and the present results suggest that the activity of LM in the elderly is different from that in the younger age group. In addition, increased muscle activity causes early muscle fatigue and LBP (Waongenngarm et al., 2016), suggesting that the elderly is more likely to develop back muscle fatigue in the standing position than in the sitting position and in the upright position than in the slump position.

This study had limitations. First, only the elderly were included in the study; younger people were not assessed for muscle thickness and spinal alignment under similar conditions. Second, the target population considered was only males, and the results may be different in females. The subject matter should be expanded in the future, and the relationship between balance and equilibrium of each item of spinal alignment should be investigated. We believe that it is significant to investigate how muscle thickness changes when spinal alignment is altered by clinical interventions.

CONCLUSION

The present study investigated the relationship between spinal alignment and muscle thickness by using Spinal Mouse and ultrasound in three different postures in healthy elderly men, assessing detailed spinal alignment and muscle thickness, which are indicators of muscle activity.

As a result, we clarified the differences in spinal alignment and muscle thickness between postures. On the other hand, we investigated whether there was a correlation between the amount of change in each item of spinal alignment and the amount of change in the thickness of each muscle for the sites where significant differences in muscle thickness between postures were observed, but no significant differences were found for all. It was suggested that this could not be explained by the relationship between the individual items of thoracic kyphosis angle, lumbar kyphosis angle, sacral tilt angle, and overall tilt angle and the thickness of the individual muscles because all of the muscles measured in this study had origins that included multiple regions of the spinal column. Therefore, we believe that it is important to evaluate the entire spine rather than focusing on individual parts, such as the thoracic and lumbar vertebrae, when intervening on the activity of the trunk muscles from the spinal column alignment in each posture in clinical situations.

Evaluating the posture and muscle thickness of healthy elderly people is beneficial because it provides basic data for guiding treatment and comparing them with diseased people, leading to the prevention of back pain and bad posture.

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