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Association of sagittal spinal alignment with thickness and echo intensity of lumbar back muscles in middle-aged and elderly women

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ABSTRACT

Objective: Quantitative changes, such as a decrease in muscle mass, and qualitative changes, such as an increase in the amount of intramuscular non-contractile tissue, occur with aging. However, it is unclear whether quantitative or qualitative changes in back muscles are associated with spinal alignment in the standing position. We investigated the association of sagittal spinal alignment with muscle thickness as an index of the mass of lumbar back muscles and muscle echo intensity as an index of the amount of non-contractile tissue within these muscles.
Methods: Study participants comprised 36 middle-aged and elderly women. Thickness and echo intensity of erector spinae, psoas major, and lumbar multifidus muscles were measured using an ultrasound imaging device. Standing sagittal spinal alignment, determined from thoracic kyphosis and lumbar lordosis angles, and the sacral anterior inclination angle was measured using the Spinal Mouse.
Results: Stepwise regression analysis performed using muscle thickness, echo intensity, and age as independent variables showed that erector spinae muscle thickness was a significant determinant of the thoracic kyphosis angle. Psoas major muscle thickness and echo intensity of the lumbar multifidus muscle were significant determinants of the sacral anterior inclination angle.
Conclusion: Our results suggest that an increase in thoracic kyphosis is associated with a decrease in the mass of the erector spinae muscle, and that a decrease in pelvic anterior inclination is associated with a decrease in the mass of the psoas major muscle and an increase in the amount of non-contractile tissue within the lumbar multifidus muscle.

1. Introduction

It is well established that age-related changes in spinal alignment in the standing position such as increased kyphosis (Kado, Huang, & Karlamangla, 2013; Takeda, Kobayashi, Atsuta, Matsuno, Shirado, & Minami, 2009) and pelvic posterior inclination (Takeda et al., 2009) occur in middle-aged and elderly women. In fact, 20–40% of elderly people develop hyperkyphosis, which may be caused by deformity of the vertebral body, degeneration of intervertebral disks, and muscle weakness (Kado, Prenovost, & Crandall, 2007a). Hyperkyphosis leads to a decline in mobility, with effects such as decreased walking speed (Miyazaki, Murata, Horie, Uematsu, Hortobágyi, & Suzuki, 2013; Katzman, Vittinghoff, & Kado, 2011) and falls (Kado, Huang, Nguyen, Barrett-Connor, & Greendale, 2007b). Therefore, improvement in spinal alignment and prevention of kyphosis progression are important for middle-aged and elderly people, especially in elderly women who have a higher risk of osteoporotic fracture (Swezey, 2000).

Although muscle weakness may contribute to hyperkyphosis alignment in the standing position, a previous study demonstrated

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no association of trunk flexor strength with lumbar lordosis and sacral anterior inclination angles (Kim, Chung, Kim, Shin, Lee, & Song, 2006). However, it has been revealed that a decrease in trunk extensor strength is associated with thoracic kyphosis and lumbar lordosis angles, and the sacral anterior inclination angle in the standing position (Sinaki, Itoi, Rogers, Bergstralh, & Wahner, 1996). A previous study using computed tomography also indicates that the muscle density of lumbar back muscles including erector spinae and lumbar multifidus muscles is associated with thoracic kyphosis in the elderly individuals (Katzman, Cawthon, & Hicks, 2012). These studies suggest that kyphosis progression with aging may be associated with back muscles rather than abdominal muscles.

It has been verified that muscle thickness (MT) on ultrasound imaging, which is strongly correlated with muscle mass on magnetic resonance imaging (Miyatani, Kanehisa, Ito, Kawakami, & Fukunaga, 2004), influences muscle strength (Fukumoto, Ikezoe, & Yamada, 2012). Muscle strength is influenced by not only muscle quantity, such as muscle mass, but also muscle quality, such as the amount of intramuscular non-contractile tissue (i.e., adipose and fibrous tissue). It has been recently demonstrated that muscle echo intensity (EI) on ultrasound imaging, which is utilized as an objective assessment of muscle quality represents the amount of intramuscular non-contractile tissue (Pillen, Tak, & Zwarts, 2009; Reimers, Reimers, Wagner, Paetzke, & Pongratz, 1993). EI of upper and lower extremity muscles increases with aging (Arts, Pillen, Schelhaas, Overeem, & Zwarts, 2010; Ikezoe, Mori, Nakamura, & Ichihashi, 2012a) and these qualitative changes are associated with muscle strength in middle-aged and elderly women (Fukumoto et al., 2012).

With regard to a decrease in back muscle mass, the thickness of psoas major and erector spinae muscles in elderly women who are able to perform activities of daily living independently is lower than that in young women, whereas no difference is observed in the thickness of the lumbar multifidus muscle between the two groups (Ikezoe et al., 2011a; Ikezoe, Mori, Nakamura, & Ichihashi, 2011b; Ikezoe, Mori, Nakamura, & Ichihashi, 2012b). Thus, many studies investigated the effect of age on atrophy of back muscles. However, there have been few studies focusing on age-related qualitative changes in back muscles (McLoughlin, D'Arcy, Brittain, Fitzgerald, & Masterson, 1994). Furthermore, no study has individually evaluated quantitative or qualitative changes in back muscles, and examined whether their changes in each back muscle influence sagittal spinal alignment, i.e. thoracic kyphosis and lumbar lordosis angles, and the sacral anterior inclination angle in the standing position, in middle-aged and elderly women.

This study had two aims. First, we investigated the effect of age on MT as an index of the mass of lumbar back muscles and muscle EI as an index of the amount of non-contractile tissue within these muscles using ultrasound. Second, we examined the association of sagittal spinal alignment in the standing position with the thickness and EI of lumbar back muscles in middle-aged and elderly women.

2. Participants and methods

2.1. Participants

Study participants comprised 36 middle-aged and elderly women who were living independently in Kyoto, Japan. The participants were excluded if they had low back pain; a history of orthopedic, neurological, respiratory, or circulatory disorders; previous spinal surgery; or a history of low back pain lasting 3 months or more.

All participants provided written informed consent, and the protocol was approved by the Ethics Committee of the Kyoto University Graduate School and Faculty of Medicine.

2.2. Ultrasound measurement

MT and EI were measured using a B-mode ultrasound imaging device (LOGIQ Book Xp; GE Healthcare Japan, Tokyo, Japan) with an 8-MHz linear array probe. Longitudinal ultrasound images of erector spinae and psoas major muscles and transverse ultrasound images of the lumbar multifidus muscle were taken bilaterally in the prone position (Fig. 1). Measurement sites were as follows: erector spinae and psoas major muscles (Ikezoe et al., 2011a,b) were assessed 7 cm lateral from the L3 spinous process, and the lumbar multifidus muscle (Ikezoe et al., 2012b) was assessed 2 cm lateral to the L4 spinous process. A 58-dB gain was used for all muscles, and dynamic focus depth was set to the depth of the muscles. Dynamic range (69 Hz) and time gain compensation in the neutral position were set for measurement.

From the obtained images, EI was determined using image processing software (ImageJ; National Institutes of Health, Bethesda, MD, USA). Regions of interest were set at the depth of 2.0–3.5 cm for the erector spinae muscle, 1.5–2.5 cm for the lumbar multifidus muscle, and 3.5–5.0 cm for the psoas major muscle, avoiding the surrounding fascia. The mean EI of the region was assessed by computer-assisted 8-bit gray-scale analysis and was expressed as a value between 0 (black) and 255 (white). Enhanced EI indicates an increase in the amount of intramuscular fibrous and adipose tissue. The mean values of the thickness and EI for the right and left muscles were used for statistical analyses.

Furthermore, to examine the intrarater reliability of the ultrasound technique for measuring the thickness and EI of erector spinae, lumbar multifidus, and psoas major muscles, two images of each muscle were taken on two separate days in eight healthy volunteers (age, 23.5 ± 1.5 years).

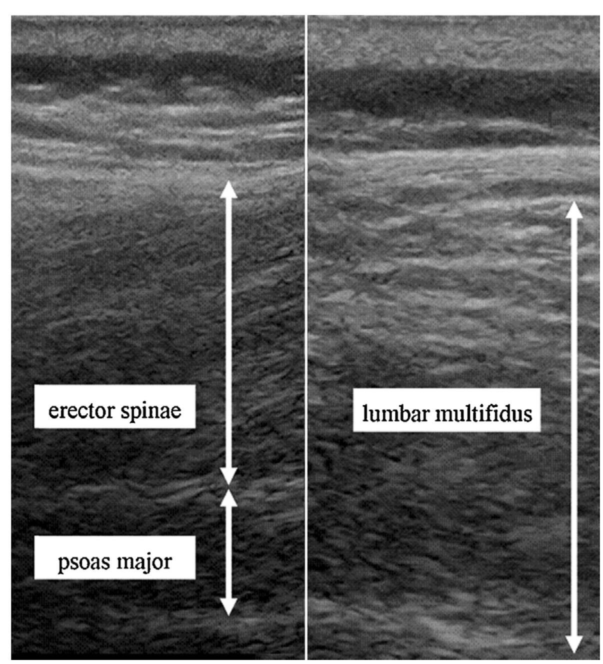

Fig. 1. Representative ultrasound images of lumbar back muscles.