Effect of standing postural deviations on trunk and hip muscle activity

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Abstract. [Purpose] It is very important to consider effects that postural deviations has on muscle activity when treating low back pain. Therefore, activities of trunk and hip joint muscles in healthy adults while they attempted three postural conditions of neutral, sway-back, and lordosis was compared and evaluated in this study. [Subjects and Methods] The subjects comprised 17 healthy adult male volunteers. The muscle activity and spinal curve were measured while the subjects attempted different postural conditions (neutral, sway-back, and lordosis) as defined in the text. [Results] Activity of trunk and hip inner muscles was decreased in sway-back posture, and only activity of the trunk back muscles was increased in lordosis. [Conclusion] This results were suggested that postural deviations affected muscle control in the lumbo-pelvic area.

Key words: Standing posture, Low back pain, Muscle activity

INTRODUCTION

Low back pain is common in humans, and approximately 80% of people experience low back pain at least once in their lifetime1). According to clinical observations, the majority of people suffering from low back pain have postural deviations and, therefore, it has been considered that postural deviations and low back pain are associated. In particular, sway-back and lordosis postures, which are noted prior to the growth period, are typical postural deviations associated with low back pain2).

It has been reported in previous research that activity of inner muscles of the trunk, which is involved in spinal stabilization, is decreased when the posture changes from standing to sway-back3, 4). This indicates that a change in the spinopelvic position leads to stress generation of a different kind in the skeletal system. However, previous research has only investigated trunk muscles, and investigation that includes muscles of the hip joint that has yet to be conducted. Additionally, postural deviations that was previously subjected to research only included sway-back posture, while lordosis was not investigated.

There has been a number of reports by researchers stating that increased lumbar lordosis is a cause of the onset of low back pain5, 6). Additionally, Snijders et al.7) have reported that changes in muscles of the hip joint affect the activity of inner muscles of the trunk. Therefore, the association between postural deviations and low back pain cannot be elucidated without investigating effects of lordosis and muscles of the hip joint.

The purpose of this study is to elucidate the association between posture and low back pain by assessing, on the basis of previous research, muscle activity of the trunk and hip joint in healthy adults with no postural problems while they attempt three different postural conditions—neutral and sway-back and lordosis—and to obtain basic insights into postural improvement by clarifying the association between spinal posture and muscle control.
SUBJECTS AND METHODS

The subjects comprised 17 healthy adult men (21.2 ± 3.6 years old, 174 ± 5.5 cm, 67.6 ± 8.8 kg) with no history of low back pain in the past one year. They experienced no pain in bad condition postures. The subjects were given an explanation about the purpose of this research, details about the experiment and handling of data, and other relevant information prior to the experiment; they agreed to cooperate and provided their signatures. This study received approval [Aino2015-022] with regard to its purpose and experiment details prior to the experiment in accordance with the provisions of the “research ethics involving human subjects” as set forth by the ethics committee of Aino University.

Each subject was asked to attempt one of the three postural conditions (Fig. 1) of (1) neutral, (2) sway-back, and (3) lordosis in a random order with the upper limbs hanging down while gazing at the mark placed at the subject’s eye level two meters ahead of each subject at the time of the measurement. Items that were measured included muscle activity and spino-pelvic curvature. Prior to measurement, the subjects were instructed by the same examiner on each postural condition and practiced postural conditions so that they could immediately attempt them on our instruction. The definition of each posture was defined based on previous research. Sway-back posture was defined, in comparison to neutral, as an increase in the thoracic kyphosis angle, the retroversion of pelvis and the backward lean of the trunk. Lordosis was defined as an increase in the lumbar lordosis angle, the anteversion of pelvis and the forward lean of the trunk. During the experiment, we checked whether the subjects were assuming the postures according to the posture definition by measuring the spino-pelvic curvature.

Surface electromyography was used to measure muscle activity. Disposable electrodes (Ag/AgCl) with a sensor size of 1 cm by 1 cm were used as surface electrodes. After sufficient dermal treatment, the electrodes were placed 2.0 cm apart parallel to the fiber direction of the muscles. Based on previous research, the rectus abdominis muscle, abdominal internal oblique muscle, abdominal external oblique muscle, iliocostalis lumborum muscle, and lumbar multifidus muscle among the trunk muscles and the tensor fasciae latae muscle, sartorius muscle, rectus femoris muscle, iliopsoas, and upper and lower portions of the gluteus maximus muscle among the hip joint muscles were chosen for measurements and as locations for electrode placement. Electrodes were placed on the right side, with the earth electrode placed on the right patella. Telemetry type electromyograph (MQ16, Kissei Comtec Co., Ltd.) and a piece of dedicated software (KineAnalyzer2, Kissei Comtec Co., Ltd.) in a bipolar derivation at a sampling frequency of 1,000 Hz were used to record electromyograms. The electromyography data obtained were subjected to filter processing (Band pass 20 to 500 Hz) and root mean square smoothing processing using motion analysis software (ImageJ Version 1.48, NIH). The maximum muscle integral value of each muscle was calculated from the stable five seconds by normalizing the activity of each muscle at the time of maximum isometric contraction (MVC).

Spino-pelvic curvature were measured using a digital camera (EX-F1, CASIO COMPUTER Co., Ltd.). Based on previous research, we took sagittal plane images after attaching reflective markers with a diameter of 20 mm to the anatomical feature points (C7, Th7, Th12, L3, S2, ASIS, PSIS, acromion, and greater trochanter). Thoracic kyphosis angle (C7-Th7-Th12), lumbar lordosis angle (Th12-L3-S2), pelvic tilt angle (ASIS-PSIS), and trunk inclination angle (acromion-greater trochanter) were calculated from the acquired images using image processing software (ImageJ Version 1.48, NIH).

We performed one-way analysis of variance on the muscle activity and angle data, and a multiple comparison test using the Bonferroni method on items with a significant difference in order to compare the muscle activity and the angles among the different postural conditions. Analysis software (SPSS Statistics Ver21 for Windows) was used for statistical processing and the significance level was set at less than 5% for all tests.

RESULTS

Based on the spino-pelvic curvature (Table 1), sway-back posture showed a significant increase in thoracic kyphosis angle.

| Posture Defined Indicators | Neutral | Sway-back | Lordosis |
|----------------------------|---------|-----------|----------|
| Thoracic kyphosis          | 22.5 ± 5.8 | 30.3 ± 4.7* | 23.5 ± 5.7 |
| Lumber lordosis            | 22.2 ± 5.5 | 24.1 ± 5.8* | 33.2 ± 4.3* |
| Anterior pelvic tilt       | –10.5 ± 4.2 | –2.9 ± 5.5* | –23.6 ± 6.7* |
| Trunk lean                 | –1.8 ± 2.6 | –5.4 ± 3.9* | 3.7 ± 3.6* |

Each value represents the mean ± SD.

*Statistically significant, p<0.05
Subsequently, lordosis showed a significant increase (p<0.05) in the lumbar lordosis as well as in the anteversion of the pelvis and trunk in comparison to neutral posture. Thus, it has been confirmed that each postural condition fit the posture definition. Next, with respect to muscle activity of the trunk (Table 2), sway-back posture showed an increase (p<0.05) in the rectus abdominis muscle and a decrease (p<0.05) in the internal oblique muscle. Additionally, in the hip joint, there was a significant decrease (p<0.05) in the iliopsoas as well as the upper and lower parts of the gluteus maximus muscle. Next, lordosis showed increased activity (p<0.05) of the iliocostalis dorsi, iliocostalis lumborum, and lumbar multifidus muscles in the trunk compared to neutral posture. Furthermore, activity of the lower portion of the gluteus maximus muscle was significantly decreased (p<0.05) in the hip joint.

### DISCUSSION

The experiment in this study was conducted with the purpose of clarifying the relationship between the muscles of the trunk/hip joint and spino-pelvic curvature by comparing and evaluating muscle activity of healthy adult men while they attempted the basic standing posture (neutral) and two postural deviations (sway-back and lordosis). The results of this study revealed that postural changes affect activity of the muscles in the hip joint and trunk that are involved in maintaining posture. Changes in muscle control caused by postural changes suggest that a different kind of stress is generated in the lumbar area while attempting a postural deviations.

Sway-back posture showed an increase in retroversion of the trunk and pelvis and thoracic kyphosis in comparison to neutral posture. Additionally, this postural change was associated with increased activity of the rectus abdominis muscle and decreased activity of the abdominal internal oblique muscle, as was confirmed by previous research\(^{12, 13}\), while it decreased activity of the iliopsoas and gluteus maximus muscles in the hip joint. Little research has been done so far to investigate the relationship between postural changes and the muscles of the hip joint. Previous studies have reported that retroversion of the trunk increases the internal moment for flexion of the trunk as well as the hip joint\(^{12, 13}\). However, it is interesting to note that, in this study, sway-back posture increased activity of the rectus abdominis muscle while decreasing activity of the iliopsoas and created no change in other hip flexor muscles. This suggests that sway-back posture maintenance is dependent on factors not related to contraction, such as the skeletal structure. Moreover, this finding provides scientific basis to therapists’ understanding of sway-back posture that they consider a passive posture dependent on factors not related to contraction. The iliopsoas is an inner muscle involved in supporting the spine and a decrease in its activity is associated with low back pain\(^{14, 15}\). Also, the gluteus maximus is a muscle important for posture maintenance\(^{16}\) that decreases the stress applied to the sacrotiae joint. Therefore, we believe that a decrease in activity of these hip joint muscles leads to generation of a different kind of stress in the lumbar area.

Next, lordosis showed an increase in anteversion of the trunk and pelvis and in lumbar lordosis compared to neutral posture. This postural change was associated with increased activity of the extensor muscles of the trunk and decreased activity of the extensor muscles of the hip joint. Although there are previous studies that reported association between lordosis and low back pain, no study has reported association between lordosis and muscle activity so far. However, as shown in this study, there have been reports that activity of erector spinae muscles is increased in those suffering from chronic low back pain\(^{17}\). In addition, activity of fibers of the lower part of gluteus maximus was low in response to increased demand for the trunk extension torque. It has been reported that the gluteus maximus contributes to stability of the pelvis by compressing...
the sacroiliac joint and that its activity is decreased in those suffering from low back pain\(^{16}\). We, therefore, believe that a different kind of stress is generated not only in the muscles of the back but also in the lumbar area in response to changes in muscle activity of the hip joint caused by lordosis as well as by sway-back posture.

The subjects of this study comprised healthy adult men with no low back pain or postural abnormalities. Therefore, further investigation is required to ascertain whether similar changes in muscle activity can be observed in low back pain patients when they change posture. However, as previous research shows, we believe that knowledge on postural changes and changes in muscle activity in healthy adults is of great significance that is required for clarifying the association between posture and muscle control. The results of this study suggest that sway-back posture reduces contraction of the skeletal muscles, thereby applying stress to the skeletal system, which is a factor not related to contraction, and leads to an increase in stress applied to the lumbar area. Further, it has been suggested that lordosis increases stress in the lumbar area due to increased activity of the flexor muscles of the trunk and decreased activity of the flexor muscles of the hip joint. The results of this study demonstrated that postural deviations affects muscle control of the muscles around the trunk and hip joint. On the basis of the findings of this study, we believe that posture coaching, which takes functions of the muscles of the hip joint into account, is important in promoting transition from a postural deviations to a good posture.

Muscle activity of the trunk and hip joint was compared and evaluated while healthy adults attempted three different standing postures (neutral, sway-back, and lordosis). The results confirmed changes in muscle activity associated with spinal alignment in both sway-back and lordosis postures. These findings are fundamental for clarifying the association between postural deviations and low back pain, and in postural reeducation.

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