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Original Article

The effect of co-stabilizer muscle activation on knee joint position sense: a single group pre-post test

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Abstract. [Purpose] The purpose of this study was to investigate the effect of co-stabilizer muscle activation on knee joint position sense. [Subjects and Methods] This study was a pre-post, single-blinded randomly controlled trial (angle sequence randomly selected) design. Seven healthy adults with no orthopaedic or neurological problems participated in this study. Knee joint position sense was measured by a target matching test at target angles of 30°, 45° and 80° of knee flexion a using digital inclinometer under two conditions: erect sitting, which is known to highly activate co-stabilizer muscle and slump sitting, which is known to little activate the co-stabilizer muscle. [Results] A significant difference in joint position matching error at the knee flexion angle of 45° was founded between two conditions erect sitting: (3.83 ± 1.47) and slump sitting: (1.00 ± 0.63). There were no significant differences in joint position matching error at the other target angles. [Conclusion] Knee joint position sense at 45° is likely to be affected by activation of co-stabilizer muscle, and this value is suitable for facilitation of joint position sense with skilled movement.

Key words: Knee joint position sense, Co-stabilizer muscle, Sitting position

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INTRODUCTION

The activity of trunk muscles, including the abdominal muscles and back muscles precedes lower extremity muscle activity in the temporal sequence of many general tasks[1)]. Hodges and Richardson demonstrated that trunk muscle activity often occurs before activity of the lower extremity musculature during moving[2)]. Activity of the trunk muscles is essential for maintaining stability of the lumbar spine and the contraction of muscles associated with skilled movement of a limb[3)]. Trunk stability from co-contraction of the abdominal muscles is a foundation of trunk dynamic control that allows production, transfer, and control of force and motion to distal segments of the kinetic chain[4)].

Co-stabilizer muscle activity is reported to be different between slump sitting and erect sitting. The lumbar multifidus (MF) and transversus abdominis (TrA) are known to be involved in controlling spinal stability as local stabilizers[5, 6)]. Recent studies has shown that electromyographic activities of the lumbar multifidus, internal oblique abdominis, and thoracic erector spinae muscles are significantly lower in slump sitting than in erect sitting[7)]. The electromyographic activities of the external oblique abdominis and rectus abdominis do not differ significantly between these two sitting postures, demonstrating the

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limited role that these muscles play in lumbopelvic stability under low load conditions such as sitting[7)].

One method of estimating skilled movement is proprioception. It is determined by measuring the accuracy of joint position matching[8)]. Proprioceptive information from skin, muscle and joint receptors plays an important role in the control of limb segment timing[9, 10)] and skilled movement[11)].

Sensory feedback plays an important role in all aspects of movement including updating motor plans based on previous movement experience and monitoring movement execution[12)], and proprioception provides primary sources of sensory information during joint position matching[9)]. Proprioceptive performance can be tested with joint position matching accuracy from the data of matching error[13)].

Many studies have been conducted of the effects of trunk stability on skilled movement of the extremities. Previous studies have shown that the speed of lower limb movement[1, 14)] and component part of movement depend on the stability of the trunk[15, 16)]. Information from proprioception and visual feedback provides accuracy of purposeful movement[17)]. Although research about the effect of trunk stability on limb movement has been performed, research on details such as joint position matching accuracy in movement of the lower limb joints is comparatively rare. The purpose of the study was to investigate the effect of co-stabilizer muscle activity on knee joint position sense in different sitting positions.

SUBJECTS AND METHODS

Seven healthy adults with no orthopaedic or neurological problems participated in this study. The inclusion criteria were no orthopaedic or neurological problems and consent to participation in the study. The subjects gave their informed consent and this study was approved by the Institutional Review Board at the University of Sun-moon in Korea (SM-201508-022-2). This study had a pre-post, single-blinded randomly controlled trial (angle sequence randomly selected) design.

Joint position sense was determined by the accuracy with which the subjects could reposition to a target angle. The difference between the target angle and the reposition angle is known as the joint position matching error.

The absolute value of this error was used for measurement of joint position sense. A digital inclinometer (Acumar™ model ACU 360, Lafayette, IN, USA) was used for knee joint angle measurements, Fig. 1. The placement of the digital inclinometer's attachment was the lateral ridge of the femur and tibia, Fig. 2. The target angles of 30°, 45° and 80° were tested in two different sitting positions of erect sitting and slump sitting. Slump sitting induces significantly greater kyphosis in the lower-thoracic and lumbar region indicating a flexion-relaxation response of the back muscles. Subjects sat on a chair with no back support and they were instructed to close their eyes, and to extend the knee of the test side to full extension and then slowly bend the test leg. The starting position was full knee extension in the sitting position. Speed of movement to the criterion angle was not limited to a single speed, and was performed at the subject's preferred speed in response to the instruction to "slowly bend your knee". The examiner commanded "stop" at the target angled of 30°, 45° and 80° of knee flexion. This angle was held for 5 seconds, during which time the subject was instructed to remember the position, and the examiner recorded the angle (target angle). The subject then returned to the start (extended) position, and waited for 5 seconds before being instructed to reposition to the target angle as accurately as possible. The target angle sequence was randomly selected by the investigator. The subjects reported when they believed they had repositioned to the target angle and this second angle was recorded as the reposition angle. The joint position matching error (JPME) was calculated as the difference between the target and reposition angles. The JPME of each target angle was measured three times and the mean value of the three measurements were used in the analysis.

The significance of the differences in the joint position matching error between the two sitting positions was investigated using Wilcoxon's signed rank test, using SPSS Ver.12.0 for Windows (SPSS inc. Chicago, IL, USA) and a significance level of $p=0.05$.

RESULTS

At the target angles of 30° and 80°, the joint position matching error difference mean between the two sitting positions was not significant, Table 1 ($p>0.05$). A significant difference was found in the joint position matching error for the knee flexion angle of 45° between the two sitting positions, Table 2 ($p<0.05$).

DISCUSSION

The purpose of this study was to investigate the effect of co-contraction of co-stabilizer muscles on knee joint position sense in the sitting positions of erect sitting and slump sitting. Recent studies have shown that the regions of co-stabilizer muscle activation may differ in response to postural demand and body position and limb movement[18)]. As these responses occur either before or slightly after the onset of activity in the muscle producing the limb movements and before the earliest reflex responses are initiated, they are considered to be pre-programmed by the central nervous system[19)]. Therefore trunk stability from co-stabilizer muscle activation is an essential requirement for the proprioception demanded by skilled, accurate limb movement. In the present study, a joint position matching error decrease in slump sitting. The reason for the significant difference at knee flexion of 45° is that differences in strength and effort occur due to the length change in the lever of the

Fig. 1. Acumar™ digital inclinometer (model ACU360), Lafayette Instrument Company, Lafayette, IN, USA

Fig. 2. Placement of the digital inclinometer

Table 1. Means and standard deviations of joint position matching error in slump and erect sitting at each target angle (Unit °)

Sitting type	Target angle	Matching Error (Mean ± SD)
Slump	30°	4.50 ± 3.08
	45°	3.83 ± 1.47
	80°	2.67 ± 2.16
Erect	30°	3.50 ± 2.59
	45°	1.00 ± 0.63
	80°	1.50 ± 1.38

Table 2. Means and standard deviations of the difference between slump and erect sitting of joint position matching error at each target angle (Unit °)

Target angle matching error	Differences (Mean ± SD)
Slump30° - Erect30°	1.00 ± 2.10
Slump45° - Erect45°	2.67 ± 2.25*
Slump80° - Erect80°	1.17 ± 2.92

*p<0.05

muscular fiber and bio-mechanical conditions when the knee angle changes[20]. The mid-range of knee joint motion elicits the highest stimulation of the bio-mechanical receptors providing information about the position to the brain and it has better recognition of position. The range of target angles was chosen to simulate knee flexion during stance phase of the gait[21], and is reported to be strongly associated with proprioceptive feedback during normal walking[22]. According to the results of the present study, Knee Joint Position Sense is affected by activation of co-stabilizer muscles at knee flexion of 45°, and this angle is suitable for both nervous system patients and orthopedic patients for the facilitation of joint position sense with skilled movement. A limitation of the present study is that care is needed when generalizing the results since this was a pilot study and the sample size was too small for generalization. Future research should test larger sample sizes and co-stabilizer muscle activation of different physical segments.

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