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Comparison of Muscle Activities Using a Pressure Biofeedback Unit during Abdominal Muscle Training Performed by Normal Adults in the Standing and Supine Positions

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Abstract. [Purpose] The purpose of this study was to assess the effects of draw-in exercise on abdominal muscle activity in the standing and supine positions. [Methods] Twenty healthy women participated in this study. The subjects were required to complete two draw-in exercises (standing and supine positions) using a biofeedback pressure unit. The root mean square (RMS) values of the EMG data were expressed as a percentage of the resting contraction. The data were analyzed using the independent t-test. [Results] According to the changes in the activities of the abdominal muscles, the draw-in exercise in the standing position produced the most significant increase in the activities of the rectus abdominis, the transverse abdominis, the internal oblique, and the external oblique muscles. [Conclusion] The activities of the trunk stability muscles (rectus abdominis, transverse abdominis, internal oblique, and external oblique) increased more in the standing than in the supine position, enabling the subjects to overcome gravity. Therefore, to strengthen the activation of the abdominal muscles, a standing position seems to be more effective than a supine position for draw-in exercises.
Key words: Abdominal muscle activity, Positions, Pressure biofeedback unit

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INTRODUCTION

Back pain is one of the most frequent diseases of the musculoskeletal system, affecting the daily activities of many people. Approximately 50–90% of the whole population experience back pain at least once in their lives[1)]. Muscles involved in trunk stabilization include local muscles, such as the transverse abdominis and the internal oblique abdominis, and global muscles, such as the rectus abdominis and the external oblique abdominis. The local muscles are directly connected to the spine, and they provide fine adjustment of the spine and stability between spinal segments. The global muscles mainly generate torque and gross movements of the trunk and the pelvis, and they are involved in providing overall trunk stability[2)]. There are three general techniques for the activation of abdominal muscles: the drawing-in maneuver, abdominal bracing, and pelvic posterior tilting[3)]. Of these, the drawing-in maneuver is recommended for trunk stabilization training because it increases intra-abdominal pressure by moving the abdominal walls inward[4)]. The use of a pressure biofeedback unit during abdominal exercises is beneficial for the maintenance of constant pressure under external loads. The unit shows when the subject's pressure values have increased abnormally[5)]. Exercises in supine positions are easier to perform than those in standing positions. No study has directly compared the effects of exercises in supine positions with the same exercises in standing positions on the activation of the abdominal muscles.

Therefore, the purpose of this study was to compare abdominal muscle activities between a standing position and a supine position with the subjects' knees flexed at 90°, which is the most commonly used flexion during trunk stabilization training, using a pressure biofeedback unit.

SUBJECTS AND METHODS

The study subjects were 20 adult females who voluntarily agreed to participate in the experiment. All the subjects had appropriate muscle power, range of motion, and balance ability for the performance of the exercises in the experiment. They had no orthopedic or neurological history relating to back pain, the trunk, or the lower extremity musculoskeletal system. The mean age of the subjects was 21.40±1.39 years. Their mean height was 163.75±4.38 cm, and their mean weight was 56.90±7.11 kg. The procedures

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of this study were harmless to the human body. All subjects read and signed a written consent form.

In the experiment, the subjects performed the drawing-in maneuver in a standing position and in a supine position, with their knees flexed at 90°. To perform the drawing-in maneuver, all the subjects were instructed to slowly draw in their lower abdomen as if they were holding their urine and then draw up their pelvic floor muscle so that it could contract, together with their lower abdomen, while continuing normal breathing[6]. The end part of the pressure device (Stabilizer Pressure Biofeedback, USA) was placed on the posterior superior iliac spine (PSIS). The pressure gauge was set to indicate 40 mmHg before the drawing-in maneuver began. The subjects were told to increase the pressure by 10 mmHg using the drawing-in maneuver on the verbal instruction, "Start", and to maintain the state for 5 seconds. The length of time that the pressure was maintained was measured in seconds within a margin of error of ±1–2 mmHg.

A surface EMG (MP150WSW, BiopacSystems, Inc., USA) was used to measure the muscle activities of the abdominal muscles. The electrodes were attached to a point 2 cm lateral to the navel for the rectus abdominis, to a point half-way between the navel line and the anterior superior iliac spine (ASIS) for the internal oblique abdominis, to a point 15 cm lateral to the navel for the external oblique abdominis, and to a point lateral to the center of the pelvisternum and parallel to the superior pubic ramus for the transverse abdominis[7]. The electromyographic signal sampling rate was set to 1,000 Hz. Amplified waveforms were filtered using a band pass filter of 200 Hz and a notch filter of 60 Hz, and their root mean square (RMS) values were calculated. The measured data were analyzed using SPSS for Windows (ver. 19.0). The independent t-test was conducted to compare the activities of the abdominal muscles between the two positions, and a significance level of α=0.05. was used.

RESULTS

In this study, the activities of the abdominal muscles were measured both in a standing position and in a supine position. Only the right-side values were measured for convenience. The muscle activities of the rectus abdominis in the supine position and the standing position were 278.01±147.83 and 438.90±245.99, respectively, and the muscle activity in the standing position was significantly higher. In the supine and standing positions, the muscle activities of the external oblique abdominis were 409.68±173.16 and 597.87±203.19, respectively; those of the internal oblique abdominis were 584.01±273.06 and 2,161.06±1,422.74, respectively; and those of the transverse abdominis were 650.46±644.57 and 1351.55±667.11, respectively. The muscle activities were significantly higher in the standing position than in the supine position for all of the four muscles ($p<0.05$) (Table 1).

DISCUSSION

Spinal instability in chronic back pain patients can affect their movements and their ability to maintain specific postures during their daily lives. If the imbalance between the abdominal muscles and the trunk extensor muscles, which cause the back pain, is relieved through trunk stabilization, these muscles will be in harmony with each other. These muscles will then play the role of a corset, relieving and preventing the recurrence of the back pain. Thus, trunk stabilization can be used not only for muscle strengthening, but also for treating and preventing musculoskeletal system diseases and improving motor ability[8,9].

To identify effective methods of training the abdominal muscles for trunk stabilization, the muscle activities of the abdominal muscles of 20 subjects were measured using a pressure biofeedback unit while they performed the drawing-in maneuver in supine and standing positions. The results show the muscle activities were significantly higher in the standing position for all of the four muscles: the rectus abdominis, the external oblique abdominis, the internal oblique abdominis, and the transverse abdominis. The standing position adopted in this study was similar to the position adopted in squat exercises. During squat exercises, the muscle activities of the lower extremity muscles and the erector spinal muscles are higher than those of other muscles. In the current study, the activities of the abdominal muscles may have increased in the standing position to maintain symmetric balance, making them higher than those in the supine positions. When selecting positions to strengthen muscles for lumbar stabilization in the acute phase of low back pain, a supine position is selected first to implement active spinal control training, followed by a prone position, a crawling position, a sitting position, and a standing position in order of precedence[4]. Patients with weak muscles can perform exercises in supine positions. However, supine positions are not suitable for patients who need more intensive training or resistance training. Therefore, for patients with lower extremity muscle strength who require more intensive training and who are able to stand up, we consider training in standing positions would be more effective than training in supine positions.

The results of this study suggest that exercises in supine positions using the abdominal drawing-in maneuver should be recommended for patients with insufficient muscle strength during the acute phase of low back pain. In contrast, exercises in standing positions using the abdominal drawing-in maneuver appear to be more suitable for the chronic phase of low back pain subjects who are able

Table 1. Comparison of the muscle activities of the abdominal muscles between the supine and standing positions (unit: %RVC)

Muscle (Rt)	supine	standing
R.A	278.01±147.83	438.90±245.99†
E.O	409.68±173.16	597.87±203.19†
I.O	584.01±273.06	2,161.06±1,422.74†
T.A	650.46±644.57	1,351.55±667.11†

*$p<0.05$, Mean±SD
R.A: rectus abdominis, E.O: external oblique, I.O: internal oblique, T.A: transversus abdominis
†significant difference between supine and standing positions ($p<0.05$).

to maintain muscle strength to some extent and need resistance training.

REFERENCES

1) Christie HJ, Kumar S, Warren SA: Postural aberrations in low back pain. Arch Phys Med Rehabil, 1995, 76: 218–224. [Medline] [CrossRef]
2) Bergmark A: Stability of the lumbar spine. A study in mechanical engineering. 1989, 230: 1–54.
3) Richardson CA, Jull GA: Muscle control-pain control. What exercises would you prescribe? Man Ther, 1995, 1: 2–10. [Medline] [CrossRef]
4) Kisner C, Colby L: Therapeutic Exercise: Foundations and Techniques, 5th ed. F.A. Davis Company, 2007, pp 525–531.
5) Cynn HS, Oh JS, Kwon OY, et al.: Effects of lumbar stabilization using a pressure biofeedback unit on muscle activity and lateral pelvic tilt during hip abduction in sidelying. Arch Phys Med Rehabil, 2006, 87: 1454–1458. [Medline] [CrossRef]
6) Critchley D: Instructing pelvic floor contraction facilitates transvers abdominis thickness increase during low-abdominal hollowing. Physiother Res Int, 2002, 7: 65–75.
7) Neumann P, Gill V: Pelvic floor and abdominal muscle interaction: EMG activity and intra-abdominal pressure. Int Urogynecol J Pelvic Floor Dysfunct, 2002, 13: 125–132. [Medline] [CrossRef]
8) Stuge B, Laerum E, Kirkesola G, et al.: The efficacy of a treatment program focusing on specific stabilizing exercises for pelvic girdle pain after pregnancy: a randomized controlled trial. Spine, 2004, 29: 351–359. [Medline] [CrossRef]
9) Akuthota V, Nadler SF: Core strengthening. Arch Phys Med Rehabil, 2004, 85: S86–S92. [Medline] [CrossRef]