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Original Article

Comparison of the thicknesses of the transversus abdominis and internal abdominal obliques during plank exercises on different support surfaces

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Abstract. [Purpose] This study applied variable plank exercises on a stable surface consisting of a mat, on an unstable surface consisting of a dynamic cushion placed under the upper extremities and lower extremities. [Subjects] Forty-three healthy male and female subjects in their 20s voluntarily consented to participate in this study. [Methods] The subjects performed the plank exercises on the three support surfaces. Ultrasound imaging was conducted while they carried out plank exercises. [Results] The changes in the thicknesses of both the transversus abdominis and internal abdominal obliques were statistically more significant for LEDCP than for MatP. In addition, the changes in the thickness of the transversus abdominis were statistically more significant for LEDCP than for UEDCP. [Conclusion] Therefore, applying an unstable condition to the lower limbs using a dynamic cushion is considered more effective during plank exercises.
Key words: Plank exercises, Ultrasound imaging, Unstable condition

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INTRODUCTION

Plank exercise is a method used to test core stability muscles and is one of the exercises used for improving core stability[1)]. In particular, the transversus abdominis is the first muscle activated among the abdominal muscles prior to movement of the extremities, and it forms and regulates intra-abdominal pressure and improves core stability together with the internal abdominal obliques, diaphragm, and pelvic floor muscles. It also stimulates the mobility of the distal part and plays a role as the center of the functional movement chain[2–4)]. Exercises for core stabilization are often conducted to maximize muscle strength, improve endurance, and prevent injuries in sports and rehabilitation[5)]. Such core stabilization exercises are applied in diverse ways using different postures, tools, and surfaces. Among others, application of an unstable surface using a tool is advantageous in increasing the muscular actions required to maintain postural stability[5)]. Accordingly, this study applied variable plank exercises on a stable surface consisting of a mat, on an unstable surface consisting of a dynamic cushion placed under the upper extremities, and on an unstable surface consisting of a dynamic cushion placed under the lower extremities. Then, it compared the thicknesses of the transversus abdominis and internal abdominal obliques during plank exercises on the three support surfaces using ultrasound imaging.

SUBJECTS AND METHODS

Forty-three healthy male and female subjects in their 20s voluntarily consented to participate in this study. Approval was obtained from the Clinical Research Review Committee of Inje University Busan Paik Hospital. A written explanation of this study was distributed to the subjects, and their written consent was received. The subjects' average age, height, weight, and body mass index were 22.6±2.19 years, 174.6±7.8 cm, 68.2±11.6 kg, and 21.9±2.6 kg/m^2, respectively. SonoAce X4 (Medison, Seoul, Republic of Korea) ultrasound diagnostic equipment was used to measure the thicknesses of the transversus abdominis and internal abdominal obliques. Ultrasound imaging was performed by placing the center of a 7.5 MHz linear transducer on the upper part of the iliac crest, with the right auxiliary line of the subjects as the center[6)]. All ultrasound measurements were performed three times. The average values of the thickness for the transversus abdominis and internal abdominal obliques were used as statistical data. For plank exercises, the subjects maintained a push-ups posture with their hands placed against the floor and their arms bent 90° at the elbow. While the subjects maintained protraction of the scapulas and the lumbar spine in a neutral posture, they straightened their bodies from the ankles, knees, hips, pelvis and spine

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to the head. The subjects placed their arms shoulder width apart and their feet pelvis width apart to improve support. To provide an unstable surface to the upper extremities, the subjects placed the middle of their forearms at the center of a dynamic cushion in the plank position, and to provide an unstable surface to the lower extremities, the subjects placed the ends of both feed at the center of a dynamic cushion in the plank posture. A dynamic cushion is a tool used to provide an unstable surface, and the diameter and thickness of the cushion used in this study were 30 cm and 6 cm, respectively. Two dynamic cushions were used, on each for the upper and lower extremities. All subjects conducted plank exercises without wearing shoes and socks. Each subject raised their knees to 90° in a supine position, and ultrasound measurements were conducted to identify the thicknesses of the relaxed transversus abdominis and internal abdominal obliques at rest prior to exercise. Ultrasound imaging was performed after the third expiration ended after the initiation of measurement. Ultrasound imaging was also conducted while the subjects carried out plank exercises under the three conditions. Condition 1 was a plank exercise on a mat (MatP), condition 2 was a plank exercise with a dynamic cushion applied to the upper extremities (UEDCP), and condition 3 was a plank exercise with a dynamic cushion applied to the lower extremities (LEDCP). Ultrasound measurement was began when they started the exercises on each type of surface, and ultrasound imaging was performed when the third expiration ended after the initiation of the exercise. The order of plank exercises on the three types of surfaces was randomly determined by each subject to minimize the effect of exercise order. Data processing and analysis were performed using the SPSS program. Repeated measures analysis of variance was employed to compare changes in the thicknesses of the transversus abdominis and internal abdominal obliques during the plank exercises on the three different types of surfaces. The significance level was set at $\alpha = 0.05$.

RESULTS

The changes in the thicknesses of both the transversus abdominis and internal abdominal obliques were statistically more significant for LEDCP than for MatP ($p<0.05$). In addition, the changes in the thickness of the transversus abdominis were statistically more significant for LEDCP than for UEDCP ($p<0.05$). The changes in the thickness of the transversus abdominis were 0.29±0.17 cm for MatP, 0.34±0.15 cm for UEDCP, and 0.38±0.16 cm for LEDCP, and those of the internal abdominal obliques were 0.34±0.21 cm for MatP, 0.39±0.24 cm for UEDCP, and 0.43±0.25 cm for LEDCP.

DISCUSSION

The transversus abdominis and internal abdominal obliques after plank exercises on the different types of surfaces showed changes in thickness that were significantly greater for LEDCP than for MatP. Vera-Garcia et al.[7] and Behm et al.[8] noted that exercise on an unstable surface rather than on a stable surface increased the activity of the core muscles. Mok et al.[9] compared the activity of core muscles during plank exercises, and they observed that the electromyographic activity was greatest in the transversus abdominis and internal abdominal obliques when a suspension device was applied to the lower limbs with the subjects spreading the legs. A suspension device may be utilized to provide an unstable surface in core stabilization exercises[2–4]. In the present study, the changes in the thickness of the transversus abdominis and internal abdominal obliques were greatest in plank exercises when an unstable surface was applied to the lower extremities using a dynamic cushion, which supports the results of prior studies. Also, the transversus abdominis under the LEDCP conditions acted strongly relative to that under the UEDCP conditions to ensure stability of the pelvis due to instability of the lower limbs. The transversus abdominis contributes to stability of the lumbar spine-pelvis and ameliorates the instability of the sacroiliac articulation[2–4]. The transversus abdominis under the LEDCP conditions acted strongly relative to that under the UEDCP conditions to ensure stability of the pelvis due to instability of the lower limbs, and therefore, the changes in the thickness of the muscle were significantly greater in the former than in the latter. Therefore, applying an unstable condition to the lower limbs using a dynamic cushion is considered more effective during plank exercises.

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