Research Report

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Effects of the Abdominal Hollowing and Abdominal Bracing Maneuvers on the Pelvic Rotation Angle during Leg Movement

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Background Abdominal hollowing (AH) and abdominal bracing (AB) are well-known stabilization maneuvers used in rehabilitation and training programs. However, few studies have examined how these two techniques affected the lumbopelvic stability during leg movements.

Purpose This study aims to compare pelvic rotation angles during leg movements with AH or AB maneuver.

Study design Comparative, repeated-measures design

Methods This study included 20 male healthy participants. After attaching motion sensor, we asked the participants to perform the two leg movements, straight leg raise (SLR), and bent knee fallout, in three conditions, including abdominal resting (AR), AH, and AB maneuvers, and collected and compared the pelvic rotation angles during each condition.

Results The difference between the three conditions for pelvic rotation angles of both leg movements was significant (p<0.05). When performing SLR or bent knee fallout with AB maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR or AH maneuver (p<0.05). When performing SLR or bent knee fallout with AH maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR maneuver (p<0.05).

Conclusions This study indicated that the AB maneuver is more effective in SLR, and bent knee fallout with lumbopelvic stabilization exercise than the AH maneuver.

Key words Abdominal bracing; Abdominal hollowing; Leg movement; Lumbopelvic stabilization; Motion analysis

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INTRODUCTION

Low back pain (LBP) is one of the most widespread musculoskeletal disorders in many developed countries, frequently affecting people under the age of 45 years.[1] Approximately, acute LBP in 10%–40% of patients becomes chronic and in most of the cases, it is classified as nonspecific. Patients who develop chronic nonspecific LBP are responsible for more than 80% of healthcare costs spent on spinal problems.[3] Chronic LBP patients frequently present with impaired lumbar movements, including limited movement range and velocity, atypical lumbar movement variability, and abnormal trunk muscle contraction.[4] During trunk and limb movements, increased and early lumbopelvic motion is thought to contribute to LBP[5]. Therefore, reducing lumbopelvic motion during upper or lower limb movements could be an important component of LBP physical therapy treatment.[5]

Although it is difficult to define the most effective treatment for LBP, many studies have declared that lumbar stabilization exercise may effectively improve functional mobility and reduce the impairments in LBP patients.[6] Abdominal hollowing (AH) and abdominal bracing (AB) are well-known stabilization maneuvers used in rehabilitation and training programs.[7,8] AH and AB maneuvers could be expected to provide the preferred neutral lumbar spine position with contraction of the abdominal muscles, which are transverse abdominis (TrA), internal oblique, external oblique, or rectus abdominis, contribute to spinal stability.[9] The AH maneuver is a method of selectively contracting the

TrA and internal oblique abdominis muscles by pulling the navel toward the vertebra while minimizing global muscles, including the rectus abdominis muscle.[10,11] On the other hand, the AB maneuver is a method of isometric anterolateral abdominal muscles' contraction to fix the lumbar spine.[12,13]

In many previous studies, the effects of stabilization exercise have been suggested by comparing AH and AB maneuvers. [7,13-16] However, they examined the effects of the two maneuvers through the thickness and activity of the abdominal muscles or lumbopelvic stability in any position or external perturbation. On the other hand, few studies examined how the two techniques affected the stability of lumbopelvic during leg movements. Minimizing lumbopelvic motion during limb movements may be an important component of physical therapy treatment for many LBP patients.[5] In this study, we try to measure the pelvic rotation angle during the two leg movements, which are active straight leg raise (SLR) and bent knee fallout, with abdominal resting (AR), AH, and AB maneuvers. Thus, this study investigated the effect of AH and AB maneuvers on the pelvic rotation angle during leg movement. The hypothesis of this study was that the pelvic rotation angle would differ between AH and AB maneuvers.

METHODS

Participants

The study included 20 male healthy participants. The anthropometric details of the participants are as follows: mean age, 22.3±2.4 (mean±standard deviation); mean height, 1.72±0.08 m; and mean weight, 74.15±9.38 kg. The study included participants who did not have any neuromuscular or musculoskeletal dysfunction in any limbs. On the other hand, participants with lumbar spine or hip joint pain that would interfere with leg movements were excluded. The experimental protocols were explained in detail to the participants, and all participants provided written informed consent. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Instrumentation

The pelvic rotation angle was measured using Smart KEMA motion sensor (KOREATECH Co., Ltd., Seoul, Korea). The inertial measurement unit, containing a triaxial gyroscope, a magnetometer, and an accelerometer, was used. At a 25 Hz sampling frequency, data were recorded from the motion sensor and transmitted to an Android tablet running Smart KEMA software.[17] The sensor was attached to the anterior superior iliac spine of the pelvis using an adjustable belt.

The pressure biofeedback unit (PBU) (Stabilizer, Chattanooga Group Inc., Hixson, TN, USA), that is, an inflatable air-filled pressure sensor pillow connected to a pressure reading device and placed behind the subject's lumbar spine, was used to measure indirectly the force exerted by the posterior abdominal wall and detect the lumbopelvic motion during leg movement with AH or AB maneuver.

Procedure

After attaching the motion sensor, the participants were asked to perform the two leg movements, SLR and bent knee fallout. We used the movements as a dissociation test that assesses the ability to actively dissociate and control lumbopelvic rotation.[18,19] All of the leg movements were carried out in a hook-lying position. For the SLR, participants were asked to raise their dominant leg, which was determined by asking the subject to kick a soccer ball and the kicking leg was the dominant one, until the heel was 20 cm above the table, without bending the knees.[18, 20, 21] The bent knee fallout movement is to lower the bent knee by moving the hip through abduction/lateral rotation and back while in a hook-lying position. The bent leg should be able to be lowered out through at least 45° of the available range of hip abduction and lateral rotation[19] (Figure 1). The participants were asked to perform leg movements, SLR and bent knee fallout, for 3 s. Furthermore, we used a metronome to control the pace of leg movements.

The two leg movements were performed in three conditions. The first condition was AR, where the participants performed the leg movements without lumbopelvic stabilization. The other conditions were AH or AB, where the participants performed the leg movements with lumbopelvic stabilization using the PBU.

While lying relaxed within a hook-lying position, the PBU was placed between the therapeutic table and the lumbar spine (above the posterior superior iliac spines), with a pressure of 40 mmHg.[22] The method of AH maneuver method was that the participants watch the pressure dial and draws in the abdominal wall without moving the spine or pelvis. The participants were instructed to keep to remain maintain the pressure at 40 mmHg throughout the leg movements.[23]

The participants in the AB maneuver method were instructed to brace (flare out their abdominal muscles laterally) with emphasis on the co-activation of all the abdominal muscles.[24] The participants were also instructed to increase the pressure to 70 mmHg and then maintain the pressure throughout the leg movements.[25]

Figure 1. Leg movements (A. straight leg raise, B. bent knee fallout).

The AB and AH maneuvers were repeated until the participants understood the procedure and were able to carry it out while breathing. Changes in pressure <±5 mmHg were acceptable for data collection.[19] The training session was approximately 15 min in duration.

The participants carried out three trials under each condition, and the order of the three conditions and two movements was determined randomly. We collected the pelvic rotation angles during the three trials of each condition. To minimize muscle fatigue, the participants were allowed to rest for 1 min between the trials, 3 min between the three conditions, and 5 min between the two movements.

Statistical analysis

A repeated one-way analysis of variance was performed to determine the pelvic rotation angle among the three conditions. The Bonferroni procedure was used as a post hoc analysis. The level of significance was set at 0.05. The statistical analyses were performed using the Statistical Package for the Social Sciences for Windows version 19.0 (SPSS, Inc., Chicago, IL, USA).

RESULTS

The difference between the three conditions for pelvic rotation angles of both leg movements was significant (p<0.05) (Table 1). When performing SLR or bent knee fallout movements with AB maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR or AH maneuver (p<0.05). When performing SLR or bent knee fallout with AH maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR (p<0.05) (Figure 2).

DISCUSSION

During limb movements, increased lumbopelvic motion is thought to contribute to LBP. Therefore, reducing lumbopelvic motion could be an important component of LBP physical therapy treatment. Insufficient control of lumbar rotation is the cause of a large percentage of LBP.[5] In patients with chronic LBP, rotation-extension or rotation of lumbar spine is common cause of symptoms and in over 50% of the patients, it is categorized as nonspecific.[26] AB and AH are the most common lumbopelvic stabilization exercises

Table 1. Comparison of pelvic rotation angle during leg movements with AR, AH, and AB (N=20)

Leg movements	Conditions	Pelvic rotation angle (Mean±SD)	Type III sum of squares	*df*	Mean square	*F*	*p*
SLR	AR	2.59±0.88	23.58	2	11.79	79.33	0.01*
	AH	1.82±0.68					
	AB	1.13±0.46					
Bent knee fallout	AR	3.68±1.94	61.54	2	30.77	39.85	0.01*
	AH	2.31±0.96					
	AB	1.33±0.68					

SD, standard deviation; SLR, straight leg raise; AR, abdominal resting; AB, abdominal bracing; AH, abdominal hollowing.
*p<0.05.

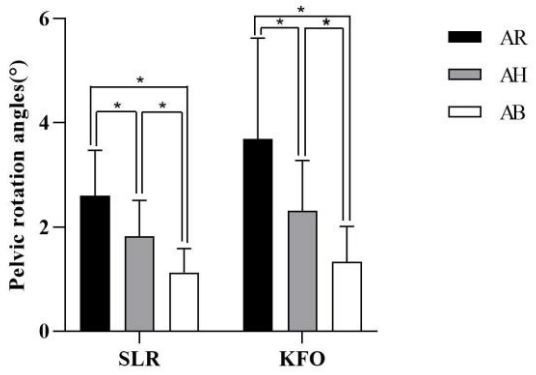

Figure 2. Comparison of pelvic rotation angle during leg movements with AR, AH, and AB $^{*}p<0.05$, Abbreviation: SLR, Straight leg raise; KFO, knee fallout; AR, abdominal resting; AH, abdominal hollowing; AB, abdominal bracing.

used in rehabilitation and training programs. Thus, this study investigated the effect of AH and AB maneuvers on the pelvic rotation angle during two leg movements.

The results of this study showed that there was a significant difference among three conditions, AB, AH, and AR maneuvers, for pelvic rotation angle during SLR or bent knee fallout movements. When performing SLR or bent knee fallout with AB maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR or AH maneuver. Moreover, the results of this study are consistent with those of previous studies demonstrating that the AB maneuver is more effective than the AH maneuver in maintaining the lumbopelvic stability.[7,16] Kim and Kim[14] reported that the pelvic lateral rotation angle in side-lying hip abduction with AB maneuver was significantly more decrease than that in side-lying hip abduction with AH maneuver and without any condition. Therefore, we suggest that the AB maneuver is more effective in leg movement with lumbopelvic stabilization exercise than the AH maneuver.

One of the reasons why the AB maneuver is more effective in leg movement with lumbopelvic stabilization exercise than the AH maneuver is that the AB maneuver recruited more abdominal muscles than the AH maneuver. During the asymmetrical limb movements such as SLR or bent knee fallout, a rotation force is transmitted to the lumbopelvic region.[18,19] The performance of abdominal muscles is important to prevent unnecessary rotation motion of the lumbopelvic. Especially, the external oblique and internal oblique muscles are important in controlling rotational force.[27] The AB maneuver is a method of isometric contraction of the abdominal muscles, TrA, internal oblique, external oblique, and rectus abdominis. On the other hand, the AH maneuver is a method of selectively contracting the TrA muscle.[10,12] Sahrmann[26] suggested that the TrA muscle acted to control the translation and rotation of the lumbar spine. However, performing AH maneuver by using only the TrA was insufficient to control the rotation of lumbopelvic resulting from the leg movement.[16] The biomechanically based assessment suggests that AB maneuver of the abdominal muscles provides greater lumbar spine stability than AH maneuver.[16] Thus, the AB maneuver is more effective in lumbopelvic stabilization by recruitment of more abdominal muscles to limit pelvic rotation than the AH maneuver. Liebenson et al.[18] also reported that, during active SLR, AB can improve the stability of the lumbar spine. Besides, Page et al. demonstrated that the AH maneuver does not ensure or enhance spinal stability.[29] Thus, it is clear that the AB maneuver can ensure sufficient lumbopelvic stability.

Another reason is that the AB maneuver generated great levels of antagonist co-contraction. It is reported that the activation of erector spinae has been reported to be greater in AB maneuver than the AH maneuver.[13] Vera-Garcia et al.[28] also reported that AB maneuver generated great levels of erector spinae co-contraction, which stiffens the trunk and increases spinal stability. The erector spinae muscles are considered important global guy wires which control the trunk against postural perturbations, and along with multifidus, quadratus lumborum contributes to lumbopelvic stabilization.[30] Therefore, we would suggest that the erector spinae activation contributes to preventing pelvic rotation during leg movements with AB maneuver.

The AH maneuver is more selective in co-activating the TrA and multifidus muscles. Thus, for patients with an altered abdominal motor pattern learns to activate the deep segmental musculature, the AH maneuver may be useful.[15] For patients with lumbar or pelvic pain due to lack of lumbopelvic stability, AB maneuver fostered torso co-contraction, reduced lumbar displacement, and increased trunk stability.[18] Also, in healthy subjects, AB could be better than AH for lumbopelvic stabilization training.[15]

Therefore, we suggest the following recommendations: in lumbopelvic stabilization exercise, AH or AB maneuver should be selected according to exercise purpose. In the early stage of rehabilitation, AH maneuver should be performed mainly to promote the contraction of TrA. In the later stage of rehabilitation of LBP patients, AB maneuver should be performed as a technique for lumbopelvic stabilization with leg movements.

There are a few limitations regarding the study. First, this

study did not directly measure the muscle activity of abdominal muscles. Second, the study included 20 healthy male participants; thus, it is difficult to generalize its results. Thus, further studies are needed to measure the muscle activity of abdominal muscle during leg movements with AH or AB maneuver. Also, we need further studies on subjects with lumbar rotation syndrome or female subjects.

CONCLUSIONS

In this study, we investigated the effect of AH and AB maneuvers on the pelvic rotation angle during leg movement. In performing SLR and bent knee fallout movements with AB maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR or AH maneuver. Furthermore, the AB maneuver is more effective than the AH maneuver in maintaining the lumbopelvic stability in leg movements. Thus, we recommend that the AH maneuver should be performed mainly to promote the contraction of TrA in the early stage of rehabilitation, and the AB maneuver should be performed as a technique for lumbopelvic stabilization with leg movements in the later stage of rehabilitation of LBP patients.

Key Points

Question What is the effective lumbopelvic stabilization exercise among AB and AH maneuvers during leg movements?

Findings In performing SLR or bent knee fallout with AB maneuver, the pelvic rotation angle decreased more significantly than that in performing movements with AR or AH maneuver.

Meaning The AB maneuver is more effective in leg movement with lumbopelvic stabilization exercise than the AH maneuver.

Article information

Conflict of Interest Disclosures: None.

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