Correlation between Ball Exercise Level and Lumbar Stability Level in Patients with Non-specific Chronic Low Back Pain

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Abstract

This study aimed to investigate the correlation between the difficulty levels of ball exercise and levels of modified isometric lumbar stability (MIST) in patients with non-specific chronic low back pain (CLBP). Fourteen participants with non-specific CLBP aged 20 to 68 years were recruited. The difficulty levels of ball exercise and the levels of MIST were assessed at the beginning of each week of exercise. The participants performed the core stabilization exercise with ball according to the highest level they could do without pain. The ball exercise was performed three days per week for four weeks. The progression of the exercise depended on the testing level of ball exercise which was tested at the beginning of the week. The ball exercise and MIST consisted of 4 and 6 difficulty levels, respectively. The results showed high correlation between the difficulty levels of ball exercise and MIST ($r = 0.76$, $p < 0.05$, n= 56). The findings from this study indicated that the levels of MIST can be used to evaluate the proper level of ball exercise in the patients with non-specific CLBP. The patients would exercise in more difficult position if they have a high level of MIST. The findings can be applied to clinics to assign the appropriate level of ball exercise to the patients with non-specific CLBP.

Keywords**:** *chronic low back pain, core stabilization exercise, level of lumbar stability, exercise position*

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างระดับความยากของท่าออกกำลังกายด้วยลูกบอลและระดับความมั่นคงของหลังโดยใช้ modified isometric stability test (MIST) ในผู้ป่วยที่มีอาการปวดหลังส่วนล่างเรื้อรังแบบไม่จำเพาะ ผู้เข้าร่วมวิจัยที่มีอาการปวดหลังส่วนล่างเรื้อรังแบบไม่จำเพาะ จำนวน 14 คน มีอายุระหว่าง 20-68 ปี ถูกคัดเลือกเข้าร่วมงานวิจัย ผู้เข้าร่วมวิจัยได้รับการประเมินระดับความยากของท่าออกกำลังกายด้วยลูกบอลและระดับความมั่นคงของหลังในช่วงต้นของแต่ละสัปดาห์ของการออกกำลังกาย ผู้เข้าร่วมวิจัยออกกำลังกล้ามเนื้อแกนกลางลำตัวโดยใช้ลูกบอลร่วมด้วย 3 ครั้งต่อสัปดาห์ เป็นเวลา 4 สัปดาห์ ความก้าวหน้าของการออกกำลังกายขึ้นอยู่กับการทดสอบระดับของท่าออกกำลังกายด้วยลูกบอลซึ่งถูกทดสอบในช่วงต้นสัปดาห์ ท่าออกกำลังกายด้วยลูกบอลมี 4 ระดับ และระดับความมั่นคงของหลังโดยใช้ MIST มี 6 ระดับ ผลการวิจัยพบความสัมพันธ์ในระดับสูงระหว่างระดับความยากของท่าออกกำลังกายด้วยลูกบอลและระดับความมั่นคงของหลังโดยใช้ MIST ($r = 0.76$, $p < 0.05$, n= 56) ผลที่ได้จากงานวิจัยนี้ชี้ให้เห็นว่าระดับความมั่นคงของหลังสามารถนำไปใช้ประเมินท่าที่เหมาะสมในการออกกำลังกายด้วยลูกบอลในผู้ป่วยที่มีอาการปวดหลังส่วนล่างเรื้อรังแบบไม่จำเพาะ ผู้ป่วยที่มีระดับความมั่นคงของหลังในระดับที่สูงจะสามารถออกกำลังกายในท่าที่มีความยากได้ ผลจากงานวิจัยนี้สามารถนำไปประยุกต์ใช้ในการกำหนดท่าที่เหมาะสมสำหรับการออกกำลังกายด้วยลูกบอลแก่ผู้ป่วยที่มีอาการปวดหลังส่วนล่างเรื้อรังแบบไม่จำเพาะ

คำสำคัญ: *อาการปวดหลังส่วนล่างเรื้อรัง การออกกำลังกล้ามเนื้อแกนกลางลำตัว ระดับความมั่นคงของหลัง ท่าออกกำลังกาย*

1. Introduction

The interaction of trunk stability and lumbopelvic stability has an influence on spinal stability. Moreover, the coordination of trunk control and lumbopelvic control is very important to stability (Hodges, 2003; Willardson, 2007). The spinal stability is necessary to improve movements of upper and lower extremities, decrease loads on the spine and help protect the spinal cord. Function of the stabilizing system is to provide stability control for the spine associated with movement changes in spinal posture, static and dynamic loads (Panjabi, 1992).

Spinal stability depends not only on the muscles but also on the central nervous system (CNS). Panjabi (1992) stated that the spinal stabilizing system consisted of three subsystems: passive, active and neural subsystems. The passive subsystem consists of several structures such as the osseous, spinal

ligaments, capsules and articular structures. These structures provide stability to the spine by reactive force to restrain spinal movement at the end of range of motion. The active subsystems are composed of muscles and tendons. The muscle subsystems are divided into global and local muscle groups. The active subsystem functions are to control spinal stability, prevent lumbar spine from over spinal motion and control loads on the lumbar spine (Bergmark, 1989). The neural subsystem receives information from a variety of transducers such as the nerve, ligaments and the CNS. Moreover, this system receives signals from muscles spindles, Golgi tendon organs and spinal ligaments. The neural subsystem has the complex task of continuously adjusted muscle forces. Three subsystems of the spinal stabilizing system work together (Bergmark, 1989; Willardson, 2007).

The lumbar instability was reported to be commonly found in the patients with low back pain (LBP) (Biely, Smith, & Silfies, 2006; Hodges, 2003; O'Sullivan, Phyty, Twomey, & Allison, 1997; Panjabi, 1992, 2003; Lee & Kim, 2015). Such patients were deficient in the stability system and their global and local muscles were commonly weak. Moreover, their core stabilizer muscles had delayed onset of muscle contraction resulting in the loss of functional ability (Costa et al., 2009). The patients with LBP had poor CNS control and delayed feedforward activation (Costa et al., 2009; Janda, 1978). The loss of stability function affected various aspects (e.g. society, economic and quality of life) in the patient with LBP (Guo, Chang, Yeh, Chen, & Guo, 2004; Nachemson & Andersson, 1982; Sherman et al., 2004; Tomita et al., 2010; Van Tulder et al., 2006).

Stabilization exercise is one of physical therapy treatments yielding good results. This exercise was reported to decrease pain and disability, as well as, to increase lumbar stability (Cairns, Foster, & Wright, 2006; França, Burke, Caffaro, Ramos, & Marques, 2012; França, Burke, Hanada, & Marques, 2010; Muthukrishnan, Shenoy, Jaspal, Nellikunja, & Fernandes, 2010; O'Sullivan et al., 1997; Rasmussen-Barr, Nilsson-Wikmar, & Arvidsson, 2003).

Choosing an appropriate position for the exercise in the patients with LBP is necessary. Posture exercises should be suitable for the patient's abilities. The core stabilization exercise program has the ability to control trunk in the neutral position. If the exercise position is more difficult than the patients' ability, this mismatch may lead to high stresses on muscles and injury (Hagins, Adler, Cash, Daugherty, & Mitrani, 1999).

The modified isometric stability test (MIST) is a tool used for determining lumbar stability level (Hagins, Adler, Cash, Daugherty, & Mitrani, 1999). Hagins et al. (1999) evaluated inter-tester and intra-tester reliability of the MIST and used the MIST to evaluate the effect of stabilization exercise. The results demonstrated good agreement for both inter-tester and intra-tester reliability. Moreover, the MIST score was increased after exercise. Wohlfahrt et al. (1993) investigated ability to perform curl-up exercise. Isometric stability test with progressing from level 1 to 5 was chosen. The results showed that the performance of curl-up exercise highly affected the level of isometric stability test.

Ball exercise has been popularly used for many years. The ball is one of handy equipment commonly used for increasing the core muscle activities in the patients with LBP. However, the exercise with ball generally challenges the patients. The evaluation of lumbar stability level before exercise is important to choose the positions of exercise. Therefore, this study was carried out to determine correlation between the MIST scores and the exercise level during performing the core stabilization exercise with ball. If the two variables are related, it can be applied to design individually proper exercise for the patients with LBP.

2. Objective

The purpose of this study was to examine the correlation between the difficulty levels of ball exercise and lumbar stability levels in the patients with non-specific CLBP.

3. Materials and methods

3.1 Participants

Fourteen participants with non-specific CLBP participated in this study. Ethic approval for this study was permitted by Ethical Committee of Mahidol University, Thailand. The criteria for inclusion were ones whose age were at least 19 years and had LBP symptoms more than three months. All participants had symptoms of non-specific LBP according to Childs et al. (2011) and Chou et al. (2007) criteria. The criteria for exclusion which affected the exercise performance were details as follows: ones who had former surgery or fracture and red flags (e.g. trauma, tumor cancer, infection and cauda equina syndrome), the patients with high pain intensity (VAS > 60 out of 100 mm), the patients who were experienced in the core

stabilization exercise and Swiss ball exercises, and ones with body mass index (BMI) > 25 kg/m^2, hip and knee stiffness, neurological impairments, CNS impairments, respiratory or cardiovascular impairments.

3.2 Procedures

All participants performed the core stabilization exercise with ball for three sessions per week for four weeks. During each session of the exercise, the participants exercised 15 times per set for three sets with 1-minute rest between each set. At beginning of each week, before the exercise program, the lumbar stability levels were evaluated by the MIST and the ball exercise levels were also determined.

3.3 Outcome measures

The outcome measurements consisted of the MIST levels and ball exercise levels. The ball exercise position consisted of four levels. The levels were increased from easy to difficult.

The participants were asked to lie in supine position with arms beside their trunk and palms facing down. The ball was placed under their knees. Each participant's exercise was evaluated weekly. The exercise position was determined by the patient's ability. If the participant was able to control the trunk without oscillation motion of the trunk, hip and the ball, the patient's ability was considered to be accurate. The details of ball exercise levels were given as follows. The ball exercise level was shown in Figure 1.

Ball exercise level 1: during exhalation, the participants performed abdominal contraction. The examiner instructed the participants to perform the abdominal contraction by saying the following statement: "Please draw in your lower abdomen without moving your spine or pelvis while maintaining these contractions. Please also control pelvis and lower extremities in static position". The participants were asked to maintain the abdominal contraction for three breathing cycles.

Ball exercise level 2: the participants performed the abdominal contraction as stated in the level 1 with raising the pelvis and maintaining the pelvic lift in neutral hip flexion angle.

Ball exercise level 3: the participants performed the abdominal contraction as stated in the level 2 with left leg lifted off the ball in nearly full knee straight position and the right leg placing on a ball.

Ball exercise level 4: the participants performed the abdominal contraction as stated in the level 3 with both arms lifted off the ground in nearly full extension position and both arms vertically extended towards the ceiling.

The lumbar stability levels were evaluated by the MIST with the pressure biofeedback unit (PBU). The PBU was used to determine the lumbopelvic control for each level. This device was placed between posterior superior iliac spines. The participants were asked to control the pressure in the range 40 ± 4 mmHg for three breathing cycles to indicate passing the level. For examining all levels, the participants were asked to lie in supine position with knees bent and feet flat on the floor (Figure 2). The participants performed abdominal hollowing while breathing in and out normally until they were relaxed. After that, they draw their navel back toward the spine, and relaxed the abdomen. While exhalation, the participants draw the navel toward the spine and maintained pressure for three breathing cycles. The following instruction was given to the participants: "Please draw in your lower abdomen without moving your spine or pelvis".

The levels of MIST consisted of six levels: level 1: abdominal hallowing, level 2: abdominal hallowing with abducting the right leg to approximately 45 degrees, level 3: abdominal hallowing with extending the right knee joint to nearly zero degree with both thighs in the same level of each other, level 4: abdominal hallowing with raising the right leg toward the chest until the hip was bent approximately 90 degrees, level 5: abdominal hallowing with raising the right leg toward the chest until the hip was bent approximately 90 degrees and raising another leg to the same level, and level 6: abdominal contraction with raising both legs toward the chest until the hip was bent approximately 90 degrees.

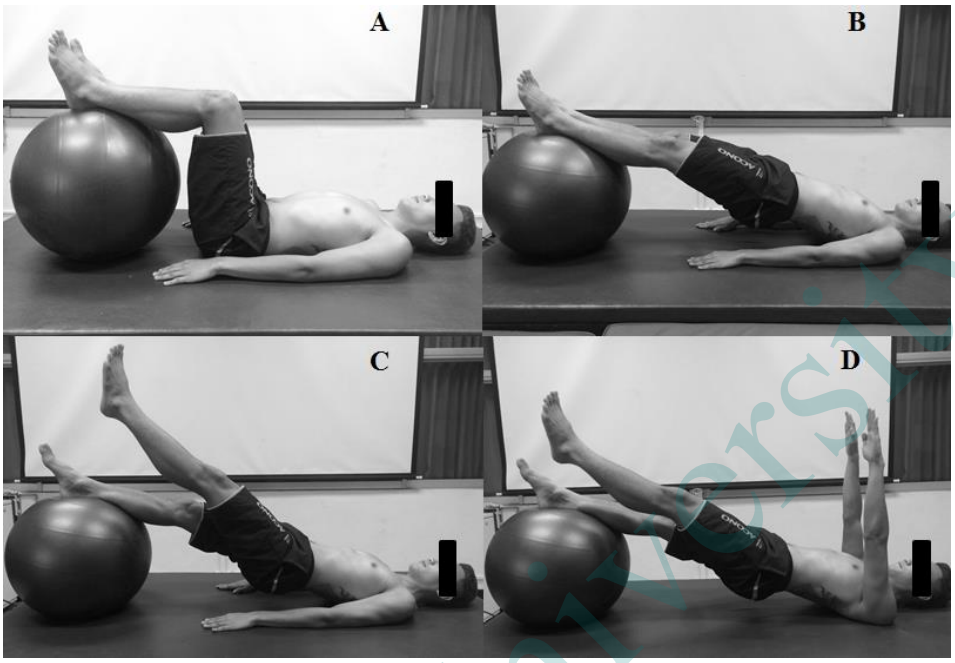

Figure 1 Ball exercise level: A = exercise level 1, B = exercise level 2, C = exercise level 3, D = exercise level 4

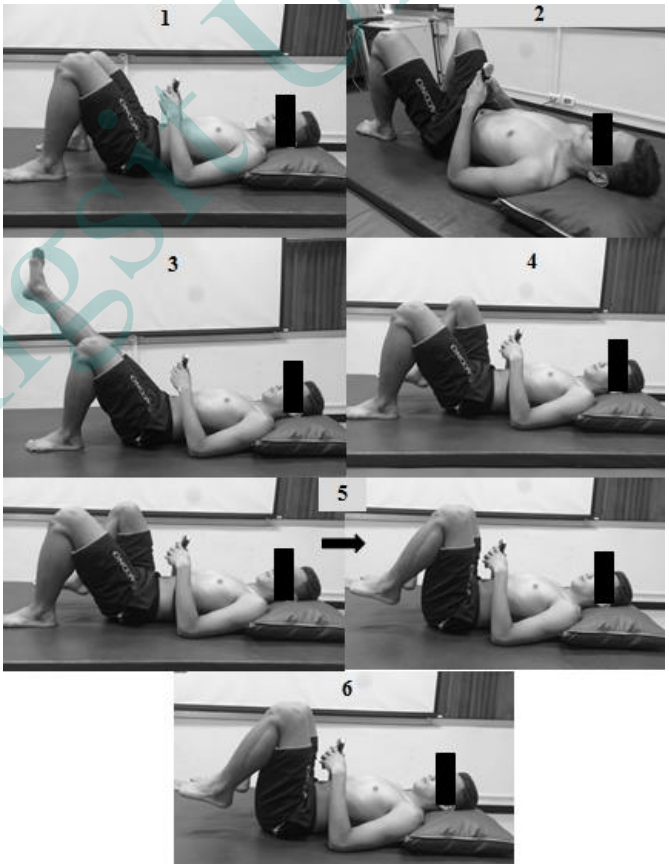

Figure 2 Lumbar stability level

3.4 Statistical analysis

The SPSS version 18.0 was used for statistical analysis. Spearman's rank correlation coefficient was used to evaluate correlation between the difficulty levels of ball exercise and lumbar stability levels. The level of statistical significance was set at $p<0.05$.

4. Results

Fourteen participants whose age ranged from 20 to 68 years were recruited in this study. The baseline characteristics were demonstrated in Table 1.

Table 1 Participants' baseline characteristics

Parameters	
Age (years) Mean (SD)	39.7 (16.9)
Weight (kg) Mean (SD)	62.3 (13.2)
Height (cm) Mean (SD)	162.6 (8.2)
BMI (kg/m^2) Mean (SD)	21.9 (1.7)
Exercise levels Median (Q1,Q3)	2 (1, 2)
MIST Median (Q1,Q3)	1 (1, 2)

The correlation between the difficulty levels of ball exercise and lumbar stability levels is presented in the scatter plots (Figure 3). The results showed significant correlation between these two parameters ($r=0.76$, $p<0.05$).

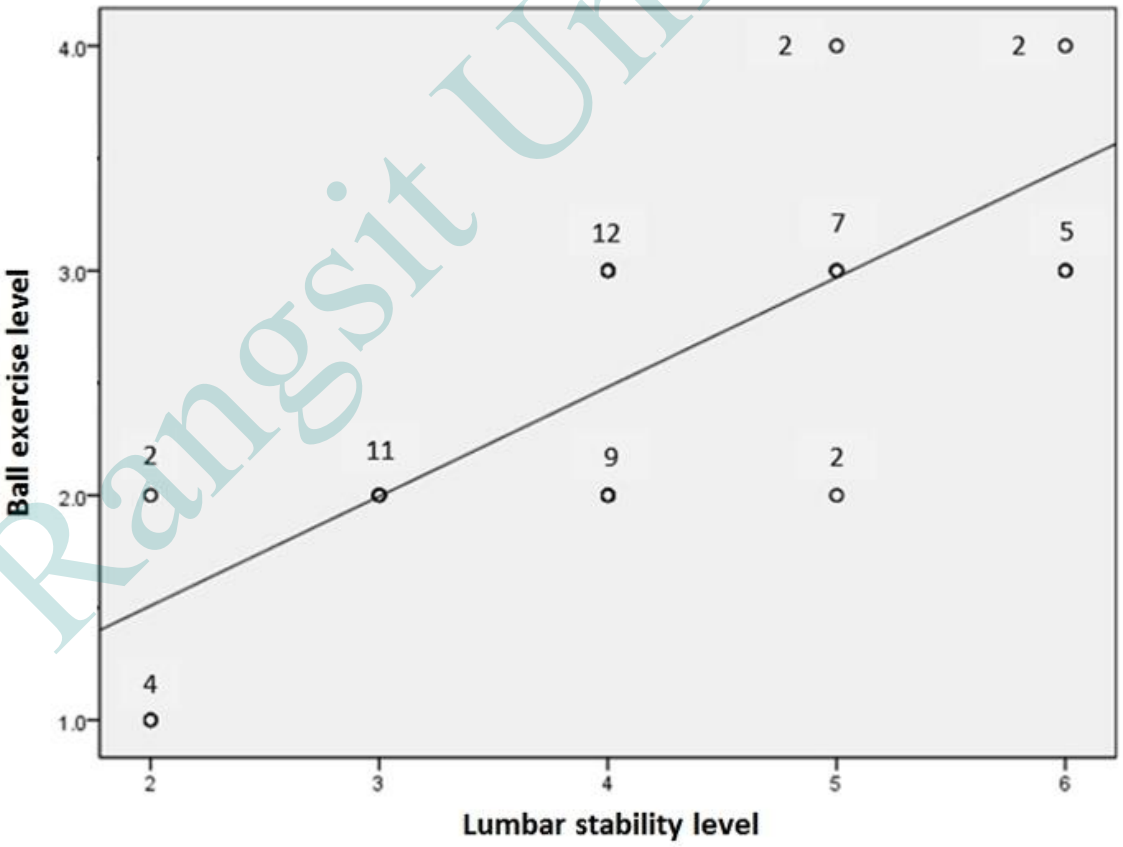

Figure 3 Scatter plot between ball exercise level and lumbar stability level (n=56)
The number of participants was demonstrated above each dot.

5. Discussion

This study found significant positive correlation between the difficulty levels of ball exercise level and lumbar stability levels (r=0.76, p<0.05). The finding indicated that the patients with high lumbar stability level were likely to perform high difficult position for the ball exercise. Moreover, the patients who were able to exercise in a difficult position indicated their high stability level. This finding was in agreement with the findings stated in the study of Hagins et al. (1999). The authors in that study found that increasing speed of curl-up exercise was reflected by high ability to control the lumbopelvic stability. The positive correlation between the ball exercise level and lumbar stability level was used to select the suitable exercise positions for the individual patient. Thus, the lumbar stability level should be evaluated before exercise. Then, the exercise positions in relation to the lumbar stability level were chosen. If the patients had low stability level, they might begin with a simple exercise level to prevent injury. On the other hand, the patients with high lumbar stability level performed the core stabilization exercise in more difficult position. The exercise with ball was shown to be more difficult in exercise levels. The ball provided external perturbation making control of the body difficult (Behm, Anderson, & Curnew, 2002; Gantchev & Dimitrova, 1996; Marshall & Murphy, 2005; Stanton, Reaburn, & Humphries, 2004). Additionally, the exercise with ball required greater recruitment of the core stabilizer muscles more than exercise on the floor (Behm et al., 2002; Cosio-Lima, Reynolds, Winter, Paolone, & Jones, 2003). If the exercise position had been inappropriate, the pain would be aggravated. The MIST is a great option to predict the level of exercise to patients. The results from this study presented the correlation between the difficulty levels of ball exercise levels and lumbar stability levels. From Figure 3, the participants showed the MIST scores in level 2 could perform the ball exercise position in level 1. Moreover, most of participants demonstrated consistency between the MIST level 3 and the ball exercise level 2, the MIST level 4 and the ball exercise level 3, the MIST level 5 and the ball exercise level 3, as well as, the MIST level 6 and the ball exercise level 3. Only two participants exercised in level 4 because the ball exercise in level 4 was too difficult. Most participants could not perform exercise in level 4. It was possible that the patients could not change to the next exercise positions as higher lumbar stability level was required. The PBU is a standard device used to measure the lumbar stability during the MIST performance. This device showed excellent reproducibility (de Paula Lima et al., 2012). As stated earlier, the MIST is a standard and reliable method of evaluating the lumbar stability (Hagins, Adler, Cash, Daugherty, & Mitrani, 1999). The assessor in this study received training for the MIST before exercise to understand the scoring of MIST level correctly. Moreover, the assessor showed excellent intra-tester and inter-tester reliability. Besides, the researcher selected the highest data from three repeated measures to prevent error from data collection. In addition, the ball exercise was previously reported to provide perturbation that improved balance, proprioception, and neuromuscular recruitment (Behm, Anderson, & Curnew, 2002; Cosio, Reynolds, Winter, Paolone, & Jones, 2003; Gantchev & Dimitrova, 1996; Marshall & Murphy, 2005). The ball exercise mainly stimulated function of the local stabilizer muscles (Gardner & Stokes, 1998). It also stimulated more coordination of the global and local muscles provided for the lumbar stability, compared with the exercise on the floor. The perturbation of the ball is the importance of neuromuscular adaptations encouraging stretch reflex of muscles (Dietz, Mauritz, & Dichgans, 1980).

6. Conclusion

The results of this study showed significant correlation between the difficulty levels of ball exercise and lumbar stability levels while performing the core stabilization exercise with ball. The results indicated that the participants with high lumbar stability level could perform higher ball exercise positions. If the participants demonstrated low lumbar stability level, they would begin with the simple exercise positions. Therefore, patients with low lumbar stability level should not begin the exercise using balls with high exercise level because injury might occur. Some patients with non-specific CLBP may not be able to perform any level of the ball exercise. The findings obtained from this study can be applied to design exercise programs for such patients.

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