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RELATIONSHIP OF ASLR AND MOTOR CONTROL IMPAIRMENT TESTS IN PHYSICALLY ACTIVE INDIVIDUALS WITH AND WITHOUT LOW BACK PAIN

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Abstract: With high rates of active population experiencing undiagnosed, non-specific low back pain, a new approach is needed with consideration of dysfunctional movement patterns that may lead to chronic back pain. Active straight leg raise (ASLR) is widely used diagnostic tests for LBP, but there is a lack of evidence of association with other clinical parameters, and functional analyses used in evaluation of LBP. Hence, the primary aim of this study is to investigate association of ASLR test with the movement deficiencies in muscles and joints responsible for lumbo-pelvic stability in populations with and without low back pain. 100 physically active participants with (n=50) and without LBP (n=50) volunteered for the study. One-way ANOVA was used to examine for potential differences between two groups, and multiple correspondence analysis (MCA) to examine the pattern of relationships between the measured variables. Participants without pain had significantly higher ASLR score ($p < 0.001$), demonstrated better hamstring flexibility ($p < 0.001$) and better gluteal activation pattern ($p < 0.01$). On the other hand, participants with LBP had greater incidence of pelvic rotation during knee flexion, and hip internal rotation, relative to participants without LBP ($p < 0.001$). Results also demonstrate that participants with pain scored largely 1 on the ASLR which was also associated with hamstring tightness, calf tightness, limited trunk flexion, hypo-mobility of the trunk, and posterior pelvic tilt. These findings indicate a strong association of low back pain

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with functional movement impairment and weakness in movement motor control. ASLR test should be used conjunction with other functional evolution tests to isolate the cause of LBP in physically active individuals.

Keywords: *ASLR test, low back pain, motor control impairments.*

INTRODUCTION

Over 80% percent of people experience low back pain (LBP), and despite the growing research on assessment and treatment of LBP, 85% of the cases go undiagnosed and remain characterized as non-specific LBP (O’Sullivan, 2005; Dankaerts *et al.*, 2007; O’Sullivan and Beales, 2007; Monie, Fazey and Singer, 2016). Up to 40% percent of those cases will become chronic (O’Sullivan, 2005). To identify primary cause(s) and better predictability of the non-specific LBP, researchers are proposing a multimodal approach to the assessment and management of the LBP, and classification of patients based on the functional movement impairment (O’Sullivan, 2005; Dankaerts *et al.*, 2007; Jull and Moore, 2012). Active straight leg raise (ASLR) is the most widely used diagnostic tests for LBP (Hu *et al.*, 2012), but there is a lack of evidence of association with other clinical parameters, and functional analyses used in evaluation of LBP.

There are several mechanisms which may lead to movement impairment and consequent abnormal tissue loading. Increased lumbar lordosis, decreased back extensor muscle endurance and flexibility, reduced abdominal muscle length and strength, length of iliopsoas, body composition, and hamstring flexibility are all factors associated with LBP (Mistry, Vyas and Sheth, 2014). Considering the pathophysiology of these factors, abnormal tissue loading may stem from the movement dysfunction during load transfer between the trunk and the legs (Roussel *et al.*, 2007). Hence, tension in the muscles and ligaments crossing the sacroiliac joint (SIJ) may lead to higher stiffness stabilization at the joint, allowing dynamic accommodation at the SIJ to the specific loading situation (van Wingerden *et al.*, 2004). In addition, in physically active population combination of factors such as training intensity, duration and lack of movement control may result in abnormal tissue loading which may lead to chronic LBP and movement deficiency (O’Sullivan, 2005).

Although ASLR is commonly used for the assessment of effective load transfer (Roussel *et al.*, 2007) and hamstring shortness (Cook *et al.*, 2014), it does not identify the underlying cause of the muscle shortness, nor the compensatory movement during this test such as pelvic rotation (Hu *et al.*, 2012), which has been associated with LBP (Marras *et al.*, 1993). Hamstring shortness may also be a common compensation resulting from the gluteal inhibition in order to stabilize sacroiliac joint (van Wingerden *et al.*, 2004; Arab, Nourbakhsh and Mohammadifar, 2011). It has also been considered a compensatory mechanism for controlling the excess lumbar lordosis or that induces posterior pelvic tilt and decreased lumbar lordosis, all which can result in LBP (Arab and Nourbakhsh,

2014). On the other hand, ASLR test as a part of the functional movement screen identifies hamstring flexibility, active mobility of the flexed hip, and requires adequate extension of the passive leg, adequate mobility and flexibility of the elevated leg and appropriate pelvic stabilization prior to and during the leg raise (Cook, Burton and Hoogenboom, 2006).

Therefore, the exact association of ASLR test with potential cause of the LBP is not fully understood. During evaluation of the joint mobility and coordination, the influence of muscle activation patterns must also be considered (van Wingerden *et al.*, 2004). Consequently, ASLR should be paired with simple and reliable tests that could be used in practical settings for identifying primary causes of LBP. Hence, the primary aim of this study is to investigate association of ASLR test with tests evaluating movement deficiencies in muscles and joints responsible for lumbo-pelvic stability in populations with and without low back pain.

MATERIALS AND METHOD

Participants

A total of 100 physically active participants (age = 24.5 ± 7.8 yrs) between ages 18 and 59 were recruited for the study. Physically active individuals were defined in this study as those who participate in some form of regular physical activity at least 3 times per week for at least one hour per session. Participants were included in the study if they did not have a history of spinal surgery, spinal or pelvic fracture, episode of sciatica, history of any systemic disease that may affect the musculoskeletal system such as arthritis. Participants with LBP were included in the study if they had a history of LBP for at least six weeks before the study, or had at least three episodes of LBP (Arab and Nourbakhsh, 2014). Therefore, the LBP could be constant or reoccurring within these guidelines. Participants were categorized in to two groups: LBP group (n = 50, mean age = 29.0 ± 8.4) and those without LBP (n=50, mean age = 20.1 ± 3.3).

Procedures

The study was approved by the Research Ethics Committee of the Stellenbosch University. Participants were the clients of the Fitness Medico clinic (Belgrade, Serbia) who were asked to participate in the study if they met the inclusion criteria. Volunteers were asked to sign the informed consent prior to participation. Participants underwent a standardized physical examination and history which included mechanism of injury, nature of current symptoms, and prior episodes of LBP. Mobility tests described below were used to asses joint range of motion (ROM) and symmetry, which was categorized as normal (score of 2), hyper- (score of 3) or hypo- mobile (score of 1). Considering that tests use in this study are standard evaluation procedures only brief description will be provided.

ASLR test was conducted as part of the functional movement screen and as described in Cook *et al.* (2014). The ASLR was conducted bilaterally three times, and best out of 3 attempts was recorded.

Pelvic tilt, an angle between anterior-superior iliac spine (ASIS) and the posterior-superior iliac spine (PSIS) was measured with a digital pelvic inclinometer (Sub4 Technologies, Staffordshire, UK) in standing position. Normal/neutral angle was considered between 0-5 degrees in males, and 7-10 degrees in females (Herrington, 2011).

For *trunk flexion (thoraco-lumbar range of motion)*, the participants were asked to stand straight, with feet shoulder width apart, and arms resting comfortably next to the body. While in standing position, the distance between C7 and S1 spinous processes was measured with a standard measuring tape. The participants were then asked to flex forward as far as possible, and the distance between the same spinous processes was measured. The difference between the two measures is the thoracolumbar spinal ROM, with 10 cm being considered normal ROM (Palmer and Epler, 1998).

Trunk extension - The participants were asked to stand up straight, with feet shoulder width apart, and arms resting comfortably next to the body. While in standing position, the distance between C7 and S2 spinous processes was measured with a standard measuring tape. The participants were then asked to extend as far as possible, and the distance between the same spinous processes was measured. A decrease in distance between C7 and S1 of 5 cm or more was considered to be a normal range of motion (ROM) (Palmer and Epler, 1998).

Trendelenburg's sign is used to identify weakness in the hip abductor muscle, primarily gluteus medius. The participants were asked to stand on one leg for 30 seconds, during which the examiners evaluates the position of the pelvis. Test is considered positive if the pelvis doesn't stay level during the 30 seconds (Kendall *et al.*, 2005).

Specific *hamstring tightness* was evaluated by a simple seated toe touch test. Inability to touch toes was scored as 1, and normal flexibility as 2.

Hip internal and external rotation was measured using goniometer in prone position with the knee bent to 90 degrees. The center of the goniometer was placed on the anterior aspect of the patella, with moving arm on the anterior midline of the tibia and stationary arm remaining vertical during active internal rotation (Ellenbecker *et al.*, 2007). Pelvis has been stabilized manually by assistant's hands. Participants scored 1 for decreased hip internal rotation of less than 30 degrees, 3 for hypermobility of more than 40 degrees, and 2 for normal range of motion. For *external rotation* participants scored 1 for decreased hip external rotation of less than 40 degrees, and 3 for hypermobility of more than 50 degrees, and 2 is indicative of normal range of motion.

(Bi) *Lateral trunk bend test*– The angle between S1 and C7 measured after lateral bending represents lateral flexion range of motion. While standing with

feet shoulder width apart, participants were instructed to perform lateral bend. A fulcrum of the Baseline goniometer was placed on S1, with the reference arm perpendicular to the floor, and moving arm at C7. Normal range of motion is considered 35 degrees (Magee, 2006).

Hip flexion –Participants were placed asked to lay in a supine position with legs fully extended. The examiner placed the fulcrum of the goniometer over the greater trochanter, with the stationary arm aligned with the lateral mid-line of the abdomen, and moving arm with the lateral epicondyle of the femur. Participants were asked to bring their leg as close to the trunk as possible with the knees flexed. Normal range of motion is between 110-120 degrees (Magee, 2006).

While in supine position, *knee flexion* was measured with the fulcrum of the goniometer over lateral epicondyle, stationary arm aligned with the greater trochanter, and the moving arm aligned with the lateral malleolus. Participants were asked to flex the knee as much as possible. Normal knee flexion ROM is considered ≥ 150 degrees (Magee, 2006).

Gluteal activation (Prone hip extension test with the knee bent): Participants were places in prone position with one knee bent at approximately 90 degree. Examiner palpated the insertion points of gluteal muscles, hamstring and contralateral erector spine. The participants were then instructed to lift the leg toward ceiling (extend the hip) three times. The correct activation sequence is gluteus, hamstring, and erector spinae. In case of absent or delayed gluteal activation, the test is considered positive (Sakamoto *et al.*, 2009).

Statistical analysis

Considering that all the tests were categorized according to relative norms, for the purpose of statistical analysis, categories were assigned numerical values as following: positive tests = 1 and negative = 2; normal ROM = 2, limited mobility = 1, and hypermobility = 3.

One-way ANOVA was used to examine for potential differences between participants with and without pain. Score distributions of individual tests scores were also tabulated. Chi-square tests were used to evaluate if there were any significant differences in motor control tests relative between groups with and without pain, and relative to ASLR score. We used multiple correspondence analysis (MCA) to examine the pattern of relationships between several categorical dependent variables. All analyses were carried out with Statistica version 13 (Dell, Round Rock, TX), with significance level of $p \leq 0.05$.

RESULTS

There were no significant differences in age between male and female participants, although expectedly, male participants were taller with greater body mass ($p < 0.001$). However, weight and height were not significant confounding factors in differences between groups in motor control tests. More female

participants were in pain group than male ($p < 0.01$), although these differences are likely due to larger number of males participating in the study.

Table 1. *Difference in participant characteristics between groups*

| | Pain (n= 50) | No-pain (n=50) | Significance, p |
|---------------------|------------------|------------------|-------------------|
| | Mean \pm SD | Mean \pm SD | |
| Age, yrs | 29.0 \pm 8.4 | 20.1 \pm 3.3 | 0.000 |
| Height, cm | 183.4 \pm 14.7 | 182.0 \pm 10.9 | 0.604 |
| Weight, kg | 82.5 \pm 14.5 | 74.4 \pm 11.2 | 0.004 |
| Gender Male (n= 70) | (n=41) 82% | (n=29) 58% | |
| Female (n = 30) | (n=9) 18% | (n=21) 42% | |

Relative to assessment tests, participants without pain had significantly higher ASLR score ($p < 0.001$), demonstrated better hamstring flexibility ($p < 0.001$) and better gluteal activation pattern ($p < 0.01$). Significantly higher incidence of restricted trunk flexion was noted in pain group ($p < 0.001$), and interestingly, as was the greater rate of pelvic tilt ($p < 0.05$) (Figure 1).

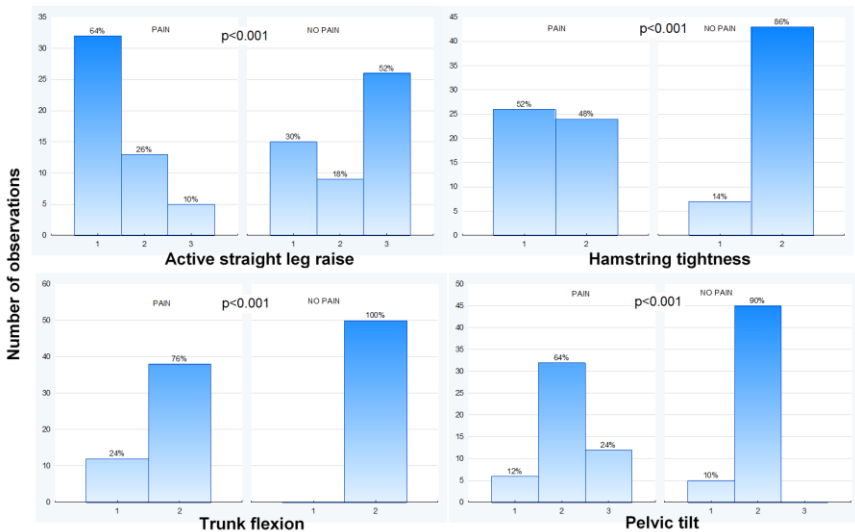


Figure 1. *Differences in range of motion in selected tests between pain and no low back pain groups.*

Multiple correspondence analysis (Figure 2) shows that the participants with pain scored largely 1 on the ASLR which was also associated with hamstring tightness, calf tightness, limited trunk flexion, hypomobility of the trunk, and posterior pelvic tilt.

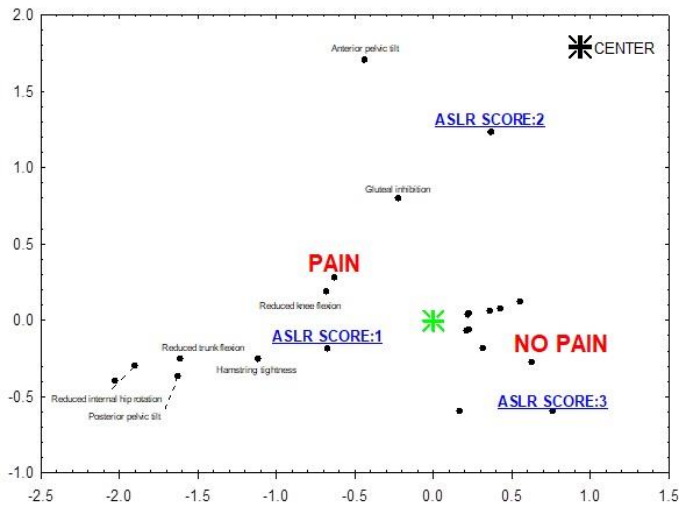


Figure 2. Multiple correspondence analysis depicting the distribution of functional and motor control tests in groups with and without pain, and relative to ASLR score. Markers without labels represent the tests considered normal. Only markers with pathological indications have labels.

DISCUSSION

The primary results of this study indicate that there is as strong association of active straight leg raise test (ASLR) with the incidence of low back pain. Further results indicate that ASLR may be paired with functional movement assessment to identify potential functional impairments leading to low back pain especially in activity populations.

Firstly, in this study the participants with low back pain were slightly older, with greater body mass, and predominantly male. However, age differences in the context of this study may not be related to the incidence of low back pain, as participants on both groups were predominantly in their 20's. The difference in weight between groups is likely due to larger ratio of men to women in the pain group, which should not be related to the onset of LBP and the subsequent interactions examined in this study (LeResche, 1999).

Participants with LBP scored significantly lower on the ASLR test relative to the non-pain group, which is in agreement with previous studies (Mens *et al.*, 1999, 2002; Roussel *et al.*, 2007). However, still 30% of the participants without pain scored poorly (i.e. score of 1) on ASLR relative to 64% of participants with LBP. Considering that ASLR test performed in this study is not a passive flexibility test, a score of 1 may result from several factors including poor functional hamstring flexibility, poor hip mobility, delayed core activation or iliopsoas inflexibility associated with the anterior pelvic tilt (Cook *et al.*, 2014).

In this study, participants with low back pain had greater incidence of decreased lumbo-pelvic stability and decreased hip flexion which leads to pelvic anterior rotation leading to stretching of the hamstring muscles and providing false indication of hamstring shortness or tightness. Consequently, proximal stability of the pelvis may increase distal mobility of the lower limbs and vice-versa (Moreside and McGill, 2013), whereas decreased hip mobility, in particular hip rotation may increase compensatory lumbo-pelvic movements during athletic activities and, as a result, contribute to LBP (Harris-Hayes et al., 2009). This multifactorial effect associated with LBP may explain relatively high rate of low ASLR score in non-pain group. Consequently, further assessments of factors associated with low ASLR score should provide a further pathologies associated with LBP.

Hamstring shortness or inflexibility examined via simple toe-touch test was also more common in the pain group (Figure 1). Both of these conditions have been associated with LBP previously (Arab and Nourbakhsh, 2014) but may not be considered a sole factor associated with LBP. In this study, although 52% of the participants with LBP could not perform the toe-touch, 86% of those without pain did not have problems reaching their toes. Therefore, while these results may indicate an association between LBP and a hamstring related dysfunction, a simple toe-touch, or any hamstring related test, does not differentiate between the hamstring shortness or the muscle inflexibility, the two distinct conditions. Anatomical muscle shortness of the hamstring may lead to additional pathologies such as pelvic tilt which may lead to the LBP as indicated earlier. In our study, only 24% of participants with LBP were tested positive for posterior pelvic tilt, and scored 1 on ASLR test, in contrast to 44% of participants with LBP without pelvic tilt. Subsequently, anterior pelvic tilt was only present in 4% of participants with LBP and 7% in those without LBP – statistically insignificant difference. Hence, hamstring muscle inflexibility, often the result of lack of adequate physical activity, or in contrast, the result of physical overload not followed by sufficient stretching, may lead to an acute relief of LBP with stretching, massage, or general warming of the muscle.

Previous studies also indicated that hamstring tightness or shortness as assessed with the ASLR, could be associated with the weakness in gluteal muscles (gluteal inhibition)(Arab, Nourbakhsh and Mohammadifar, 2011). In our study, we also demonstrate that gluteal inhibition is common with participants with low back pain, and particularly those with low score on the ASLR (Figure 1). Almost 63% of individuals with gluteal inhibition scored 1 on ASLR and had LBP. In the absence of gluteal activation during hip extension, as a two-joint muscle hamstring muscles will likely perform the function of the main hip extensor and stabilizer which will lead to muscle tightness.

CONCLUSION

Active straight leg raise may be a useful tool for identifying functional movement dysfunctions associated with low back pain, but when used in

conjunction with additional functional movement analysis. Considering active populations are prone to high repetition movements under greater loads, functional compensations will likely result in some form of pelvic compensation. Therefore, the results of active straight leg raise should be interpreted with caution, and complimented with full passive and active upper and lower body functional assessment.

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