Multiplanar lumbopelvic control in patients with low back pain: is multiplanar assessment better than single plane assessment in discriminating between patients and healthy controls?

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Objectives: Patients with low back pain (LBP) commonly have lumbopelvic control deficits. Lumbopelvic assessment during sagittal motion is incorporated into commonly used clinical examination algorithms for Treatment Based Classification. The purpose of this study was to investigate whether combined assessment of lumbopelvic control during sagittal and frontal plane motion discriminates between people with and without LBP better than single plane assessment alone.

Methods: Nineteen patients with LBP and 18 healthy control participants volunteered for this study. The active straight leg raise (ASLR) and active hip abduction (AHAbd) tests were used to assess lumbopelvic control during sagittal and frontal plane motion, respectively. The tests were scored as positive or negative using published scoring criteria. Contingency tables were created for each test alone and for the combined tests (both positive/both negative) with presence/absence of LBP as the reference standard to calculate accuracy statistics of sensitivity (sn), specificity (sp), likelihood (+LR and -LR), and diagnostic odds ratios (OR).

Results: Active straight leg raise and AHAbd tests alone had sn of 0.63, 0.74, respectively, sp of 0.61, 0.50, respectively, and OR of 2.7, 2.8, respectively. The combined tests had sn=0.89, sp=0.60, and OR=12.0. Forty percent of patients with LBP had control deficits in both planes of motion.

Discussion: The AHAbd and ASLR tests appear to have greater diagnostic discrimination when used in combination than when used independently. A percentage of patients with LBP had control deficits in both planes, while others demonstrated uniplanar deficits only. These findings highlight the importance of multiplanar assessment in patients with LBP.

Keywords: Low back pain, Lumbopelvic assessment, Active straight leg raise, Active hip abduction

Level of Evidence: 2b (Diagnosis – exploratory cohort study with independent reference standard).

Objectives

Low back disorders are a significant health care issue in North America with an age-adjusted rate of 27.8% of all people over the age of 18 years reporting low back pain (LBP) each year,¹ and 80% of all individuals experiencing an episode of LBP during their lifetimes.² The economic and social impact of LBP is large, accounting for 1 in 25 health care resource visits resulting in an annual cost of

\$193.9 billion.¹ Despite the enormous resources that are dedicated to management of LBP, successful outcomes remain relatively low, having variable recurrence rates (5–60%) with an estimated 20% progressing into chronicity.³

The majority of individuals seeking treatment for LBP have no detectable structural cause with current imaging techniques and are therefore given the diagnosis of non-specific LBP (ns-LBP).⁴ Dysfunctional movement strategies, including kinematic and muscle activation differences, have been identified in people with ns-LBP when compared to healthy controls.^{5–8} Asymptomatic people who reported a LBP response to a functional standing task also demonstrated differences in movement strategies,

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especially in the frontal plane, compared with those who did not report LBP during the task.^{9–12} These findings of altered movement strategies prior to pain development imply that aberrant movement strategies may be present prior to clinical manifestations of ns-LBP and may be linked to underlying mechanisms in the absence of acute injury or structural defect.

Physical therapists are a major part of the health care team in the management of LBP disorders, with 30% of patients with LBP receiving care from a physical therapist.² In addition to multiple forms of assessment, including passive mobility testing and provocation tests, physical therapists rely on observation-based assessment of actively performed functional movements as a major component of their clinical examination.^{13,14}

Two tests of lumbopelvic control during dynamic lower extremity movement include the active straight leg raise (ASLR) test for assessment during sagittal plane movement and the active hip abduction (AHAbd) test for assessment during frontal plane movement. The ASLR test is administered in supine with the patient actively flexing the hip while maintaining knee extension and self-rating the difficulty of the maneuver on a 0–5 ordinal scale.¹⁵ For the AHAbd test, the patient is placed in sidelying with both lower extremities extended and without upper extremity support. The patient is asked to actively abduct his/her uppermost lower extremity while attempting to maintain pelvic, trunk and shoulder stability.¹⁶ An examiner scores the test on a scale of 0–3 based on the appearance of aberrant lumbopelvic movement and control.¹⁷

The ASLR test has been validated for use in patients with pregnancy-related LBP.^{15,18,19} Recently, the ASLR test has also become a common assessment tool for lumbopelvic stability during sagittal plane movement in patients with ns-LBP.^{13,20–22} Altered movement control strategies have been identified during the ASLR test in patients with chronic groin pain²³ and LBP.²⁴ The AHAbd test was found to be the best clinical predictor for development of LBP during standing in previously asymptomatic individuals^{11,16} with a diagnostic odds ratio (OR) of 3.85. The test also has been shown to have moderate to high intra-rater (ICC=0.70) and inter-rater (ICC=0.74) reliability when scored by practicing physical therapists.¹⁷

Assessment of sagittal plane movements, such as the ASLR test and standing forward flexion, are included in current clinical prediction rules for determining appropriate intervention, specifically for Treatment Based Classification.^{25–27} Despite evidence to support the importance of lumbopelvic control during frontal plane movements in patients at risk for and with current LBP,^{12,14,16,28–30} clinical assessment in multiple movement planes has not been

fully incorporated into the clinical examination algorithm used for Treatment Based Classification. The purpose of the current study was to explore multiplanar assessment through investigating the ability of two clinical assessment tools, the ASLR and AHAbd tests, to discriminate between patients with LBP and healthy controls when used independently and in combination. It was hypothesized that the tests used in combination would perform better than each test used independently in accurately discriminating patient cases from healthy controls.

Methods

This study was reviewed and approved by Regis University's Institutional Review Board, and signed informed consent was obtained from all participants prior to participation in the study. The study is registered as a clinical trial through ClinicalTrials.gov, NCT02089321.

Thirty-seven participants (19 with LBP, 18 controls) were recruited through poster advertisements, local physical therapy clinics, and word of mouth throughout the Denver metro area. Patients with LBP were included if they were between the ages of 18 and 70 years and were currently seeking, but had not initiated, treatment from a health care professional (PT, MD, DO, and DC) for a chief complaint of pain between the level of the twelfth thoracic vertebrae and the coccyx. Patients with radicular pain symptoms were included, however, were not enrolled if there were signs of neurological impairment including diminished myotatic reflex, sensory impairment, or strength deficits in a myotomal pattern. Control participants were required to meet inclusion criteria of no LBP episodes requiring clinical care by a health professional and/or greater than 3 days absence from work/school/recreation within the previous 5 years. Exclusion criteria for all participants included previous spine or hip surgery, serious spinal or systemic pathology, inability to transition between standing, supine, side-lying, and prone, pregnancy within the previous 12 months, inability to stand longer than 20 minutes, or inability to understand written and verbal instructions in English.

Patients with LBP completed the Oswestry disability index (ODI)³¹ to establish the level of disability related to their LBP, as well as the fear avoidance beliefs questionnaire (FABQ) to determine whether fear-avoidance was present in these participants.³² Anthropometric measures of height and weight were collected to calculate body mass index (BMI). Current LBP status was reported on a 100-mm visual analog scale (VAS) with end-point anchors of 'no-pain' and 'worst pain imaginable'.^{33,34}

Participants completed the AHAbd and ASLR tests in sequential order, with testing conducted on

the right lower extremity first. Participants performed three trials of each test, however, only the first trial was scored for the present study in order to be consistent with how these tests are used in clinical practice. For the AHAbd test, participants were positioned in unsupported sidelying on a plinth, with both lower extremities extended and aligned with the pelvis, trunk, and shoulders in the frontal plane. The participant's upper arm was allowed to rest across the chest but not in contact with the plinth. The limb to be tested was then passively abducted through the available range of motion by an examiner to demonstrate the desired movement. The AHAbd test was performed on each lower extremity with the following verbal instructions: 'Please keep your knee straight and raise your top thigh and leg towards the ceiling, keeping them in line with your body. Try not to let your pelvis tip forwards or backwards'. Two experienced examiners simultaneously scored the participants' performance according to established criteria.¹⁷ The AHAbd test is scored based on the degree of frontal plane control where a score of 0 represents good lumbopelvic control and a score of 3 represents poor lumbopelvic control. Table 1 provides more detailed scoring criteria. Test scores were dichotomized into 'positive' and 'negative' scores based upon previous work that used a receiver operating characteristic (ROC) analysis to establish optimal cutoff threshold¹⁶ so that a score ≥ 2 was considered 'positive' and a score < 2 was considered 'negative'.

Participants then transitioned into a supine position for the ASLR test. The right limb was passively raised 20 cm off the plinth by the examiner to demonstrate the desired movement. An examiner marked the 20 cm height with a ruler and verbal cues were provided to maintain knee extension and when they had reached 20 cm to return to the starting position. Participants self-rated the difficulty of performance on an ordinal 0–5 scale, 0 being no difficulty in performance and 5 being unable to lift the limb.^{15,26} A positive score was considered any non-zero self-reported score to be consistent with the

scoring used in test–retest reliability studies of the ASLR test.¹⁵

Independent *t*-tests were conducted on the baseline data (age, BMI, and VAS) to demonstrate group equivalence in demographics and differences in current LBP status. Active hip abduction and ASLR test scores were dichotomized into positive and negative scores based on the criteria previously described, and expressed as frequencies for cases and controls. Contingency tables were constructed and accuracy statistics (sensitivity (sn), specificity (sp), positive and negative likelihood ratios (+LR and –LR), and odds ratios (OR)) were calculated for AHAbd and ASLR tests independently. Additionally, a contingency table was created that included only the participants who scored either positive or negative on both tests. This table was used to calculate accuracy statistics for the tests combined. Criterion threshold for significance was set at $\alpha=0.05$ where appropriate. Comparisons of means and frequencies were conducted using SPSS (version 21.0, IBM Corporation, Armonk, NY, USA), and accuracy statistics were calculated manually with Excel for Mac 2011 (version 14.3.6, Microsoft Corporation, Bellevue, WA, USA).

Results

Baseline characteristics for all participants are presented in Table 2. There were no significant differences between patients with LBP and controls in age or BMI. Patients with LBP were significantly different from controls in current LBP status, averaging 19.88 (± 11.8) mm compared with controls averaging 0.12 (± 0.5) mm on the VAS. Disability in this sample of patients with LBP as assessed by the ODI was minimal with an average score of 15.1 (± 7.3)%.³⁵ Fear avoidance beliefs in this group were also observed to be low with a physical activity subscale score of 12.3 (± 5.1)³⁶ and a work subscale score of 9.3 (± 9.3).³⁷

73.7% of patients with LBP scored positive on the AHAbd test versus 50% of controls. 63.2% of patients with LBP scored positive on the ASLR test

Table 1 Scoring criteria for the active hip abduction (AHAbd) test. A score of 2 or 3 is considered a positive score on the test¹⁷

Score	Cues for the examiner
0=no loss of pelvis frontal plane	<i>Smoothly and easily performs movement. Lower extremities, pelvis, trunk and shoulders remain aligned in frontal plane</i>
1=minimal loss of pelvis frontal plane	<i>Slight wobble at initiation or throughout movement. May show noticeable effort or 'ratcheting' of moving limb</i>
2=moderate loss of pelvis frontal plane	<i>Has at least 2 of the following: Noticeable wobble throughout movement; tipping of pelvis, trunk or shoulder rotation; increased hip flexion and/or rotation of the moving limb; rapid or uncontrolled movement</i>
3=severe loss of pelvis frontal plane	<i>Has ≥ 3 of the above characteristics and/or unable to regain control of movement once lost; may lose balance (has to place hand on table)</i>

Table 2 Participant baseline characteristics (n=37), all values are expressed as mean (SD)

	Age (years)	Body mass index (kg/m ²)	VAS* (mm)	ODI score (%)	FABQ PA	FABQ W
Patients with low back pain (n=19)	27.71 (10.6)	23.42 (3.0)	19.88 (11.8)	15.1 (7.3)	12.3 (5.1)	9.3 (9.3)
Mean (SD) [range]	[19–54]	[19.7–30]	[4–44]	[4–30]	[2–23]	[0–34]
Controls (n=18)	28.52 (10.2)	22.99 (1.9)	0.12 (0.5)	NA	NA	NA
Mean (SD) [range]	[20–55]	[20.8–27.7]	[0–2]			

ODI: Oswestry disability index; FABQ: fear avoidance beliefs questionnaire; PA: physical activity subscale; W: work subscale.

* $P < 0.05$, independent *t*-test.

Table 3 Contingency table showing the number of positive and negative scores on the active hip abduction (AHAbd) test for participants with low back pain (LBP) and controls

	LBP n=19	Control n=18
+AHAbd test	14	9
–AHAbd test	5	9

compared with 38.9% of controls. 42.1% of patients with LBP had positive scores on both the AHAbd and ASLR tests, compared with 22.2% of controls, while 5.3% of patients with LBP scored negative on both tests compared with 33.3% of controls. The frequencies of positive and negative test scores are displayed as contingency tables (Tables 3–5) for the AHAbd, ASLR, and combined tests, respectively.

A combination of the AHAbd and ASLR tests performed best in discriminating between patients with LBP and controls when either both tests were positive or both tests were negative (sn=0.89, +LR=2.22, and diagnostic OR=12.0). Used independently, the AHAbd test had sn=0.74, sp=0.50, and diagnostic OR=2.8. The ASLR test had a similar discriminative value, with sn=0.63 and sp=0.61, and a similar diagnostic OR=2.7 (Table 6).

Discussion

The purpose of this study was to investigate the ability of the ASLR and AHAbd tests to discriminate

between participants with and without LBP when used alone and in combination. When used independently, neither test performed well in discriminating patients with LBP from healthy controls, with sensitivities of 0.63 and 0.74 for the ASLR and AHAbd tests, respectively, and specificities of 0.61 and 0.50 for the two tests, respectively. The tests performed better when used in combination with sn=0.89, sp=0.60, and a diagnostic OR of 12.0 when participants scored positive on both of the tests.

It is important to note that deficiency in one movement plane did not necessarily indicate a deficiency would be present in the other plane of interest. In this sample, 42.1% (eight cases) of the patients with LBP demonstrated lumbopelvic control deficiencies in both planes with a smaller percentage having deficiencies in only the frontal (31.6%, six cases) and sagittal (21.1%, four cases) planes or no observed lumbopelvic control deficit (5.3%, one case). These findings highlight the importance of including multiplanar assessment in the clinical examination of patients presenting with LBP.

Despite the wealth of resources dedicated to management of patients with LBP, outcomes remain relatively poor, particularly in terms of recurrence and progression into chronicity.³ Clinical algorithms and prediction rules developed to closely match interventions to a patient's clinical presentation (Treatment Based Classification) have become widely

Table 4 Contingency table showing the number of positive and negative scores on the active straight leg raise (ASLR) test for participants with low back pain (LBP) and controls

	LBP n=19	Controls n=18
+ASLR test	12	7
–ASLR test	7	11

Table 5 Contingency table showing the number of participants with low back pain (LBP) and controls scoring positive on both active hip abduction (AHAbd) and active straight leg raise (ASLR) tests or negative on both tests

	LBP n=19	Controls n=18
+Both	8	4
–Both	7	6

Table 6 Accuracy statistics for the active hip abduction (AHAbd) and active straight leg raise tests used alone and in combination (both positive/negative)

	AHAbd test	ASLR test	Combination
Sensitivity (sn)	0.74 (0.51, 0.88)	0.63 (0.41, 0.81)	0.89 (0.57, 0.98)
Specificity (sp)	0.5 (0.29, 0.71)	0.61 (0.39, 0.80)	0.60 (0.31, 0.83)
+Likelihood ratio (+LR)	1.5 (0.86, 2.5)	1.62 (0.83, 3.2)	2.22 (1.0, 4.9)
–Likelihood ratio (–LR)	0.53 (0.22, 1.3)	0.60 (0.30, 1.21)	0.19 (0.03, 1.3)
Odds ratio (OR)	2.8 (0.71, 11.1)	2.7 (0.71, 10.2)	12.0 (1.05, 136.8)

95% confidence intervals provided in parenthesis.

used and have resulted in improved outcomes for some patients,^{26,38} particularly those meeting clinical prediction rules for spinal manipulation.^{39,40} Predicting patient response to stabilization-based exercise has been less successful.^{13,26,27} Given the lack of multiplanar assessments included in the current clinical algorithm for Treatment Based Classification, it is likely that there are a subgroup of patients with deficiencies in frontal plane control, either alone or in combination with a sagittal plane deficiency, that are being missed.

A fairly high number of healthy controls in this study demonstrated control deficits (false positives) in both (22.2%, eight cases), frontal (27.8%, five cases) and sagittal (16.7%, three cases) planes with only 33.3% (six cases) having no observed control deficit (true negatives). The percentage of false positives is aligned with results from studies of induced, transient LBP in previously asymptomatic individuals where 40–70% of healthy participants reported clinically meaningful levels of LBP when exposed to a 2-hour period of standing.^{9,10,12,41} In these studies, lumbopelvic control deficits in the frontal plane, including a positive AHAbd test, were the most important predictors of whether an individual would develop LBP during the standing protocol.¹⁶ It was suggested from these findings that the pain developer group constituted a ‘sub-clinical’ group that was at increased risk for future LBP based on faulty movement patterns that were observed prior to LBP development.¹¹ In further support of this hypothesis, participants who developed LBP during standing were also shown to respond favorably with decreased subjective pain scores, improved muscle activation strategies, and improved lumbopelvic control in the frontal plane following a stabilization-based exercise intervention that included both sagittal and frontal plane exercises.⁴² A recent follow-up longitudinal study has shown that LBP during standing in a previously asymptomatic and healthy individual is predictive of future LBP requiring clinical intervention.⁴³ It is therefore likely that a percentage of the healthy control group in the current study would be considered to have increased risk of future LBP. Multiplanar assessment of lumbopelvic control may have utility in screening for such risk and could potentially have a place in prevention and early intervention programs for patients with LBP. Research into implications of multiplanar control deficits in patients with LBP and potential impacts on response to intervention is currently ongoing. Future investigations should also focus on whether inclusion of multiplanar lumbopelvic control assessment within the clinical examination positively impacts patient outcomes.

The sample size was a clear limitation for this study. This study was conducted as a part of a larger laboratory-based biomechanical study that included extensive instrumentation, full 3D kinematics, and multiple electromyography channels, which, by necessity, limited the sample size that could be included. The investigators were not blinded to the participants’ LBP status, which had the potential to introduce bias in scoring of the clinical tests. Every attempt was made to prevent bias and the two examiners scored the tests independently and simultaneously and were in agreement with each other in all cases on the categorization as positive or negative. The participants with LBP in this study had minimal disability based on the ODI assessment, however, they were actively seeking physical therapy intervention for their LBP. It is not known whether findings would be similar in a sample with more severe LBP and this should be an area for future investigation.

Conclusion

Findings from this study indicate that a percentage of patients with LBP may have lumbopelvic control deficits in multiple planes. When used in combination, the AHAbd and ASLR tests did well in discriminating between patients with LBP and healthy controls. These tests are very easy and time efficient to perform, as a part of the movement analysis portion of the clinical examination, and provide information to the physical therapist about control deficits in sagittal and frontal motion planes. This information could assist clinicians in prescribing specific exercise intervention programs more closely targeted toward individual control deficits, and potentially improve patient outcomes.

Disclaimer Statements

Contributors All listed authors had a role in formulation of the study design, securing funding, recruitment of participants, data collection and analysis, and manuscript preparation. All authors have reviewed and approved the submitted manuscript.

Funding Regis University Research and Scholarship Council.

Conflicts of interest There are no direct or indirect conflicts of interest, financial or otherwise, for any of the authors.

Ethics approval This study was approved by the Regis University Institutional Review Board for Human Subjects Research and written informed consent was obtained from all research subjects prior to participation.

Acknowledgements

The authors would like to acknowledge the University Research and Scholarship Council at Regis University for their financial support in completing this research.

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