

A BIOMECHANICAL INVESTIGATION OF SELECTED LUMBOPELVIC HIP TESTS: IMPLICATIONS FOR THE EXAMINATION OF WALKING

Robert Walter Bailey, PhD,^a Jim Richards, PhD,^b and James Selfe, PhD^b

ABSTRACT

Objectives: The purpose of this study was to compare lumbopelvic hip ranges of motion during the Trendelenburg, Single Leg Squat, and Corkscrew Tests to walking and to describe the 3-dimensional lumbopelvic hip motion during the tests. This may help clinicians to select appropriate tests when examining gait.

Methods: An optoelectronic movement analysis tracking system was used to assess the lumbopelvic hip region of 14 healthy participants while performing Trendelenburg, Single Leg Squat, and Corkscrew Tests and walking. The lumbopelvic hip 3-dimensional ranges of movement for the clinical tests were compared with walking using a repeated-measures analysis of variance with pairwise comparisons.

Results: No significant differences were found between the pelvic obliquity during the Trendelenburg Test and walking (Trendelenburg Test: L, $11.3^\circ \pm 4.8^\circ$, R, $10.8^\circ \pm 5.0^\circ$ vs walk: L, $8.3^\circ \pm 4.8^\circ$, R $8.3^\circ \pm 5.1^\circ$, L, $P = .143$, R, $P = .068$). Significant differences were found between the hip sagittal plane range of movement during the Single Leg Squat and walking (Single Leg Squat: L, $44.2^\circ \pm 13.7^\circ$, R, $41.7^\circ \pm 10.9^\circ$ vs walk: $38.6^\circ \pm 7.0^\circ$, R $37.8^\circ \pm 5.1^\circ$, $P < .05$), the hip coronal plane range of movement (Single Leg Squat: L, $9.1^\circ \pm 5.8^\circ$, R, $9.0^\circ \pm 4.6^\circ$ vs walk: L, $9.4^\circ \pm 2.3^\circ$, R $9.5^\circ \pm 2.0^\circ$, $P < .05$), and the hip coronal plane range of movement during the Corkscrew Test and walking (Corkscrew: L, $5.7^\circ \pm 3.2^\circ$, R, $5.7^\circ \pm 3.2^\circ$ vs walk: L, $9.4^\circ \pm 2.3^\circ$, R $9.5^\circ \pm 2.0^\circ$, $P < .05$).

Conclusions: The results of the present study showed that, in young asymptomatic participants with no known lumbopelvic hip pathology, the pelvic obliquity during the Trendelenburg Test and walking is similar. During the Single Leg Squat, the hip moved more in the sagittal plane and less in the coronal plane when compared with walking. There was more movement in the hip transverse plane movement during the Corkscrew Test than during walking. These results suggest that for the Trendelenburg Test to be interpreted as normal, the pelvis should achieve at least 10° of pelvic obliquity; during the Single Leg Squat, the hip should move through 43° in the sagittal plane and under 10° in the coronal plane; and for the Corkscrew Test to be interpreted as normal, the hip should move through 6° of rotation and the trunk through 27° of rotation. (*J Manipulative Physiol Ther* 2016;xx:1-9)

Key Indexing Terms: *Lumbopelvic Hip; Range of Motion; Articular; Biomechanical Phenomena*

Clinicians commonly use tests including the Trendelenburg,¹ Single Leg Squat,² and Corkscrew Tests during the examination of the lumbopelvic and hip complex. These tests are used to examine the movements of the lumbar, pelvic, and hip regions in a weight-bearing position.¹⁻⁴ They may be used in isolation^{5,6} or to compliment the examination of functional tasks including walking.^{3,7} The clinical assumption is that the

lumbar, pelvic, and hip movements generated during these tests are similar to those of walking.³ However, there are few biomechanical investigations of the normative kinematics of these tests and a limited number of previous studies that compare the kinematics of these tests to walking.⁸

The Trendelenburg Test is interpreted by observing pelvic obliquity during the test.^{3,9} Two previous studies have objectively defined when the pelvic drop (obliquity) becomes positive. Asayama et al⁵ stated that a “tilt angle” (pelvic obliquity) of greater than 2° indicated a positive Trendelenburg Test result. Westhoff et al¹⁰ stated that “Pelvic drop to the swinging limb during single stance phase of more than 4° and/or maximum (peak value) pelvic drop in the stance phase of more than 8° ” indicated a positive test result. There are no published data quantifying sagittal and transverse plane pelvic movement during the Trendelenburg Test. The Single Leg Squat is currently interpreted by observing hip range of movement in the sagittal and coronal planes. Only 1 study, that of Livengood

^a Postgraduate Researcher, Sports and Social Sciences, University of Central Lancashire, Preston, UK.

^b Professor, Sports and Social Sciences, University of Central Lancashire, Preston, UK.

Submit requests for reprints to: Robert, Walter, Bailey, PhD, Atlas Physiotherapy, 29 Sandgate, Penrith, Cumbria. (e-mail: Dr.bailey@Atlasphysiotherapy.co.uk).

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Fig 1. Marker placement based on the calibrated anatomical systems technique.

et al,⁴ has objectively defined when the Single Leg Squat becomes positive: hip flexion greater than 65° , hip abduction/adduction greater than 10° , and knee valgus/varus greater than 10° . There are no published data for sagittal, coronal, and transverse plane pelvic movement during the Single Leg Squat. The Trendelenburg Test requires neuromuscular control of the pelvis in the coronal plane, and the Single Leg Squat requires control of the hip in the sagittal plane. Interestingly, there are currently no existing tests for neuromuscular control of the pelvis requiring hip internal-external rotation movement in the transverse plane documented within the musculoskeletal literature. Hence, a novel clinical test for the assessment of the lumbopelvic and hip region in the transverse plane has started to be used within clinical practice. This test has been termed the *Corkscrew Test*. The method for performing the Corkscrew Test is based upon the Single Leg Squat,⁴ and its interpretation is based upon the Single Leg Squat criterion in combination with kinematic values found within the walking literature.¹¹⁻¹³ The participant stands on the limb being evaluated, with the contralateral leg lifted off the ground, as if walking. The participant rotates the weight-bearing hip first into maximal hip internal rotation and then external rotation, and returns to the start position in less than 6 seconds. The Corkscrew Test is a new test; hence, there are currently no kinematic data to support its use in clinical practice.

Pathologies affecting the lumbopelvic and hip complex include ankylosing spondylitis,^{14,15} Perthes disease,^{16,17} and slipped femoral epiphysis.¹⁸⁻²⁰ These pathologies have



Fig 2. Study Trendelenburg Test method: (A) start/finish position, (B) Trendelenburg Test position.³

been found to be 3 times more prevalent in late teenage males when compared with females^{14,17,20,21} and associated with changes in gait.³ To recommend the use of these tests within clinical practice, there is a need to establish the normal ranges of movement for the tests, particularly in young males, and to compare these to those found during walking. Previous studies of these clinical tests^{5,10} and gait¹¹⁻¹³ have described the ranges of movement to 1 standard deviation. Individuals found to exhibit ranges of movement in excess of 1 standard deviation from the clinical test's normative value could be interpreted as exhibiting an abnormal movement pattern. This will allow clinicians to interpret the tests, identify abnormal responses, subgroup individuals, and better understand their role in the examination of gait.

The purpose of this study was to investigate the biomechanical characteristics of the Trendelenburg, Single Leg Squat, and Corkscrew Tests and their relationship to the kinematics of walking. It was hypothesized that the pelvic obliquity achieved during the Trendelenburg Test, the hip sagittal and coronal plane range of movement during the Single Leg Squat, and the hip rotation range during the Corkscrew Test should be similar to these parameters when walking.

METHODS

Participants

Participants were recruited via posters within the university campus. All participants were informed about the purposes

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