Evaluation of the Ability of Physical Therapists to Palpate Intrapelvic Motion With the Stork Test on the Support Side

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Background and Purpose

Clinical indicators of pelvic girdle dysfunction are limited. However, research has shown that the pattern of intrapelvic motion is altered during single-leg support in subjects with pelvic girdle pain (PGP). Functionally, no relative motion should occur within the pelvis during load transfer, whereas anterior rotation of the innominate bone relative to the sacrum occurs during weight bearing in the presence of PGP. The aim of this study was to investigate whether the pattern of intrapelvic motion could be detected reliably during a new clinical assessment test for functional load transfer: the Stork Test on the support side.

Subjects and Methods

Three physical therapists were randomly assigned to palpate the motion of the innominate bones and sacrum in 33 subjects during the Stork Test on the support side. The direction of bone motion was indicated on 2-point and 3-point scales.

Results

When a 2-point scale was used, intertherapist agreement on the pattern of intrapelvic motion occurring during load transfer showed good reliability (left κ=.67, right κ=.77), and the percentage of agreement was high (left=91.9%, right=89.9%). A 3-point scale resulted in moderate reliability for both the left and the right sides (left κ=.59, right κ=.59), and the percentage of agreement decreased to 82.8% (left) and 79.8% (right).

Discussion and Conclusion

The ability of the physical therapists to reliably palpate and recognize an altered pattern of intrapelvic motion during the Stork Test on the support side was substantiated. The ability to distinguish between no relative movement and anterior rotation of the innominate bone during a load-bearing task was good. Further research is needed to determine the validity of this test for detecting pelvic girdle dysfunction.

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Sacroiliac joint (SIJ) pain is reported most commonly in the posterior region of the pelvic girdle[1] and affects people from various backgrounds, such as sporting, postpartum, and working populations. It is estimated that SIJ pain occurs in over 15% of people classified as having nonspecific chronic low back pain[2]; however, at present few reliable diagnostic procedures are available to assist in the clinical evaluation of impaired pelvic girdle function[3] and resultant pelvic girdle pain (PGP).

The focus of clinical assessment procedures for pelvic girdle function has shifted in the last decade from SIJ mobility testing to functional assessment procedures that test the ability of the pelvis to maintain stability during load transfer between the spine and the lower limbs. This shift is partially attributable to an increased understanding of the role of the pelvis in load transfer, as well as the poor reliability and validity of many SIJ mobility assessment tests. Assessment tests for SIJ mobility, such as the unsupported hip flexion component of the Gillet test and the standing forward flexion test, have been shown to have low interrater reliability for therapist palpation.[4,5] Pain provocation tests have been shown to have moderate to good reliability[6]; however, pain is not always an accurate indicator of altered biomechanical function.[7]

Impairment of SIJ and pelvic function encompasses more than pain produced by the SIJ. The soft tissues surrounding the SIJ and their function in maintaining pelvic stability during weight transfer and movement are equally important to the normal biomechanical function of the pelvis.[8–10] The assessment of pelvic stability during activities that induce load transfer across the pelvic articulations, therefore, is relevant. The Active Straight-Leg-Raise Test is a functional assessment procedure that evaluates the integrity of the pelvis for maintaining stability during load transfer in a supine position.[11] The Active Straight-Leg-Raise Test has been validated as a reliable means of ranking disease severity for women with posterior pelvic pain following pregnancy[12] while also providing a means of assessing com-

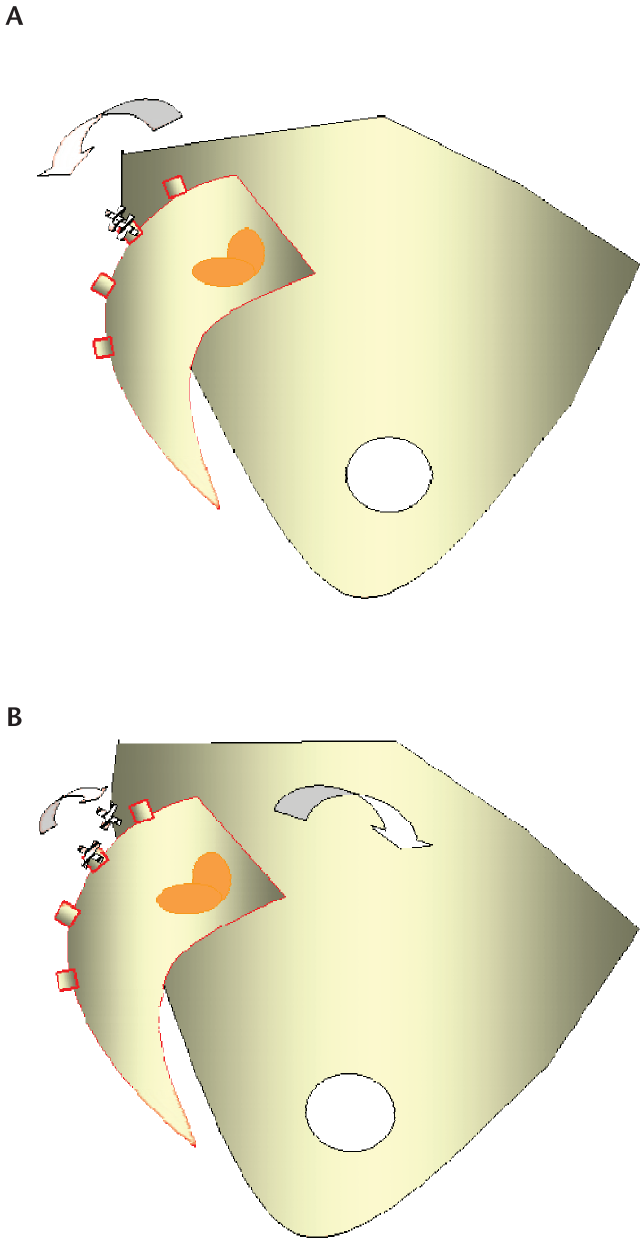

Figure 1.
Relative motion between the innominate bone and the sacrum. (A) Posterior rotation of the innominate bone relative to the sacrum during single-leg support in subjects who were healthy. (B) Anterior rotation of the innominate bone relative to the sacrum during single-leg support in the presence of pelvic girdle pain. Crosses indicate the palpation points during the Stork Test on the support side. The Advanced Manual Therapy Associates Pty Ltd (AMTA P/L) (Director: Barbara Hungerford) retains copyright ownership of Figures 1A and 1B, which may not be used or reproduced without written permission of the AMTA P/L.

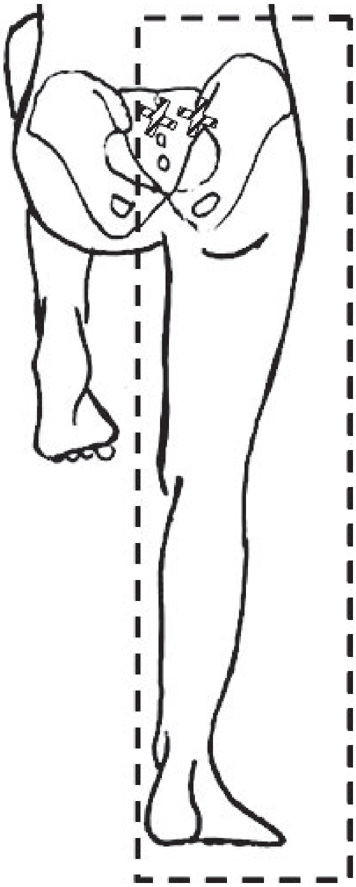

Figure 2.
Left Stork Test with support phase on the right side. Crosses indicate palpation points for a right-side support-phase test. The Advanced Manual Therapy Associates Pty Ltd (AMTA P/L) (Director: Barbara Hungerford) retains copyright ownership of Figure 2, which may not be used or reproduced without written permission of the AMTA P/L.

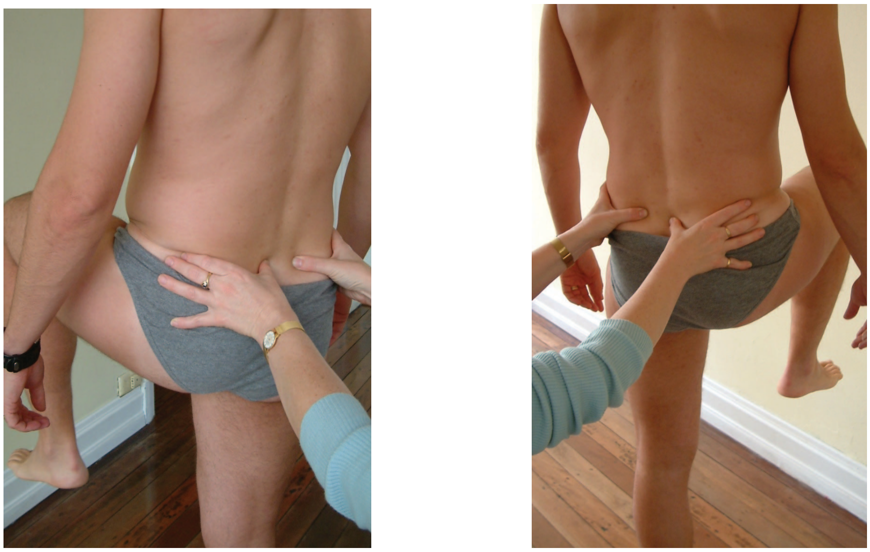

Figure 3.
Subject palpation for the Stork Test. (Left) Negative right-side support-phase test. (Right) Positive left-side support-phase test with cephalad motion of the left posterior superior iliac spine relative to central S2.

pensatory strategies of the musculoskeletal system in people with pelvic pain.[13]

The articular surfaces of the SIJ assist in load transfer from the lumbar spine through the pelvis to the lower limbs by way of their shape and alignment.[14] Research has shown that small amounts of movement occur at the SIJ and that this movement is controlled during load transfer through engagement of the self-bracing mechanism of the SIJ.[8,15] The self-bracing mechanism is induced through preactivation of the local muscle system of the lumbopelvic region prior to movement,[16] with subsequent tensioning of the pelvic ligaments and thoracolumbar fascia and compression of the joint surfaces.[8,9] During activities that involve weight transfer through the pelvis (eg, moving from standing to standing on one leg or lying to standing), a concurrent pattern of sacral nutation or relative posterior rotation of the innominate bone engages the SIJ into its closed pack position (ie, articular surfaces are fully congruent, in maximal contact, and tightly compressed so that no further movement is possible).[15,17]

A previous investigation of motion between the innominate bone and the sacrum on the side of single-leg support during a standing hip flexion movement (Stork Test support phase) revealed that the innominate bone on the side of single-leg support rotated posteriorly relative to the sacrum in subjects who were healthy[17] (Fig. 1A). This pattern of motion also was shown to be altered reliably in the presence of PGP. The innominate bone rotated anteriorly relative to the sacrum on the side of PGP (Fig. 1B), indicative of a failure of the self-bracing mechanism to maintain the SIJ in its closed pack position. Because the difference in the pattern of bone motion directly reflected the ability (posterior rotation) or inability (anterior rotation) of subjects to maintain pelvic stability for load transfer through the pelvis,[17] Lee[18] suggested that the Stork Test on the support side (Fig. 2) may provide a useful tool for clinical evaluation of a subject's ability to stabilize intrapelvic motion. The reliability of therapists' ability to palpate pelvic bone motion, therefore, requires investigation in order to determine whether the Stork Test on the support side may be clinically relevant. The range of palpable motion between the innominate bone and the sacrum is small,[15,17] and this property may affect the reliability of clinicians' ability to palpate pelvic bone motion in vivo.

The application of the Stork Test on the support side involves palpation of the posterior superior iliac spine

Table 1.
Number of Subjects With Back Pain or Leg Pain in the Last 12 Months or Pain in the Previous 24 Hours

Factor	Men	Women
Sex	14	19
Back pain in last 12 mo	7	16
Leg pain in last 12 mo	5	11
Pain reported at time of testing, as assessed with:		
McGill Pain Questionnaire	3	13
Visual analog scale	4	11
Present Pain Index	3	9

(PSIS) and innominate bone on the side of the pelvis to which weight is to be transferred for single-leg support, and the therapist's other hand palpates the sacrum centrally at S2. The direction of bone motion or lack of bone motion then is palpated as the contralateral foot is lifted off the ground (Fig. 3). Clinically, the results have been described either by the direction of PSIS movement (cephalad, caudad, or no movement relative to S2) occurring with innominate bone motion or as a positive or negative result. In the second description, a negative result is assigned when no relative motion between the innominate bone and the sacrum is palpated (Fig. 3, left), whereas cephalad motion of the PSIS relative to the sacrum (Fig. 3, right) is considered to be a positive result.[18]

The aim of this study was to determine whether experienced therapists could reliably detect the pattern of motion occurring between the innominate bone and the sacrum (intrapelvic motion) on the support side in a group of subjects with and without lumbopelvic pain.

Method

Subjects

A total of 33 subjects who were 36.2±13.4 ($\overline{X}$±SD) years of age and had a body mass of 71.2±13.6 kg and a height of 170.2±8.1 cm participated in the study. The subjects were volunteers who responded to notices placed at private physical therapist practices in Sydney, New South Wales, Australia. There were no exclusion criteria, except that subjects must have been more than 18 years of age. The subjects varied in sex, history of back or leg pain in the preceding 12 months, and presence of pain at the time of testing (Tab. 1). Eleven women and 4 men had pelvic-girdle pain (visual analog scale [VAS] score of $>$0) at the time of testing. No subjects reported that they were pregnant at the interview. Of the subjects who noted the presence of pain at the time of testing, the average scores on the McGill Pain Questionnaire, the VAS, and the Present Pain Index (PPI) were 5.0±5.2, 1.8±1.9, and 1.7±1.0, respectively.

To reduce the possibility of order effects, a Latin square design was used to produce a series of "order-of-therapist" possibilities. Each subject was randomly assigned an order of therapist prior to undergoing testing. All participants gave informed consent prior to the study.

Procedure

Three experienced manual therapists (mean of 14.7 years in practice [range=7–21], age range=37–42 years) were included in the study because they regularly used the Stork Test on the side of single-leg support as part of their assessment protocols. The average length of time of their use of the Stork Test on the support side was 4.5 years.

The subjects and the therapists were given a set of standard instructions for the performance of the test. First, each subject was instructed to sit with both feet placed equally on the ground prior to starting the examination and between repetitions of the examination for each therapist. Once the therapist entered the room, the subject was instructed to stand, placing equal weight through each leg and allowing the therapist to palpate the innominate bone, PSIS, and sacrum to obtain the testing position. The therapist then performed the test. The hand position for application of the right Stork Test on the support side (Fig. 3, left) was to place the right thumb directly on the right PSIS, allow the rest of the right hand to contact the right innominate bone, and palpate the S2 spinous process of the sacrum with the left thumb. The therapist then instructed the subject to raise the contralateral leg into 90 degrees of hip flexion and 90 degrees of knee flexion while the therapist continued palpating the right PSIS and innominate bone relative to the sacrum. The test movement was repeated 3 times. The hand position for application of the left Stork Test on the support side (Fig. 3, right) was to place the left thumb on the left PSIS, allow the rest of the left hand to contact the left innominate bone, and palpate the S2 spinous process of the sacrum with the right thumb. The subject then was instructed to raise the contralateral leg 3 times and to return to a neutral stance after each movement.

The therapists graded the test with 2 scales. In part 1, the therapist was asked to rate the direction of intrapelvic motion with a 3-point scale indicating whether the PSIS

Table 2.
Agreement Matrix for Number of Agreements Among 3 Raters for 3 Categories (Cephalad, Neutral, and Caudad) for Each Participant

Participant	No. of Raters Who Agreed on the Indicated Category for Each Participant					
	Left Side			Right Side		
	Cephalad	Neutral	Caudad	Cephalad	Neutral	Caudad
A1	0	3	0	0	3	0
A2	0	0	3	2	1	0
A3	0	3	0	3	0	0
B1	0	3	0	3	0	0
B2	0	3	0	3	0	0
B3	1	1	1	1	1	1
C1	1	2	0	0	3	0
C2	0	2	1	0	2	1
C3	0	3	0	0	3	0
D1	0	3	0	3	0	0
D2	0	3	0	0	3	0
D3	0	3	0	0	3	0
E1	0	3	0	1	2	0
E2	0	3	0	3	0	0
E3	0	3	0	0	3	0
F1	0	3	0	2	1	0
F2	0	3	0	0	1	2
F3	0	3	0	3	0	0
G1	1	2	0	0	3	0
G2	3	0	0	0	3	0
G3	3	0	0	0	3	0
H1	0	2	1	0	3	0
H2	0	3	0	0	3	0
H3	0	3	0	2	1	0
I1	0	1	2	0	2	1
I2	3	0	0	0	3	0
I3	0	3	0	0	3	0
J1	0	3	0	0	3	0
J2	0	3	0	3	0	0
J3	2	1	0	0	3	0
K1	0	3	0	3	0	0
K2	0	3	0	0	2	1
K3	0	3	0	0	2	1

moved cephalad relative to the sacrum, the PSIS stayed neutral relative to the sacrum, or the PSIS moved caudad relative to the sacrum. In part 2, the therapist was asked to rate the direction of intrapelvic motion with a 2-point scale indicating a positive result if the PSIS moved cephalad relative to the sacrum or a negative result if the PSIS stayed neutral or moved caudad relative to the sacrum.

Data Analysis

Data analysis was performed by an assistant who was independent of the testing and unaware of the order of therapist. Interrater reliability was assessed with a Cohen kappa reliability coefficient (κ). Manual calculation of κ for more than 2 therapists was done as described by Pittenger[19] and interpreted as poor (<.20), fair (.21–.40), moderate (.41–.60), good (.61–.80), and excellent (.81–1.0). When more than 2 therapists are compared, κ calculations may be made by use of rater agreement on a category for each subject.[19] Percent close agreement (PCA) also was calculated to assess agreement among therapists. The Pearson chi-square test of association (calculated with SPSS version 11.5* for Windows†) with exact 2-sided significance was used to determine whether sex, back pain in the last 12 months, leg pain in the last 12 months, and present pain, as assessed with the McGill Pain Questionnaire, the VAS, and the PPI, showed an association with the therapists' ratings.

Results

The interrater reliability for part 1, in which the therapist was asked to rate the direction of intrapelvic motion with a 3-point scale (cephalad, neutral, or caudad), was moderate for both the left and the right sides

* SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.
† Microsoft Corp, One Microsoft Way, Redmond, WA 98052-6399.

Table 3.
Chi-Square (Observed and Expected) Results for Association of Number of Agreements Among Raters With Sex, Back Pain in Last 12 Months, Leg Pain in Last 12 Months, and Presence of Pain in Previous 24 Hours[a] When a 3-Point Scale Was Used

Factor	Observed (Expected) Result for the Following Category			χ^2	P
	Cephalad	Neutral	Caudad		
Sex				5.203	.076
Men	24 (19.5)	51 (58.1)	9 (6.4)		
Women	22 (26.5)	86 (78.9)	6 (8.6)		
Back pain in last 12 mo				4.447	.118[b]
Yes	31 (32.1)	100 (95.5)	7 (10.5)		
No	15 (13.9)	37 (41.5)	8 (4.5)		
Leg pain in last 12 mo				2.628	.273
Yes	26 (22.3)	65 (66.4)	5 (7.3)		
No	20 (23.7)	72 (70.6)	10 (7.7)		
Pain present in previous 24 h, as assessed with:					
MPQ				3.502	.176
Yes	25 (22.3)	67 (66.4)	4 (7.3)		
No	21 (23.7)	70 (70.6)	11 (7.7)		
VAS				2.328	.323
Yes	22 (20.9)	64 (62.3)	4 (6.8)		
No	24 (25.1)	73 (74.7)	11 (8.2)		
PPI				4.445	.105
Yes	20 (16.7)	50 (49.8)	2 (5.5)		
No	26 (29.3)	87 (87.2)	13 (9.5)		

[a] As assessed with the McGill Pain Questionnaire (MPQ), the visual analog scale (VAS), and the Present Pain Index (PPI).
[b] Significance was determined with the Fisher exact test (2 tailed) because one cell had an expected count of less than 5.

(left κ=.59, right κ=.59). Table 2 shows each participant's kappa agreement matrix for each side. One hundred percent agreement among raters was seen 82.8% and 79.8% of the time for the left and right sides, respectively. The Pearson chi-square test of association for factors possibly affecting therapists' ratings revealed that sex, back pain in the last 12 months, leg pain in the last 12 months, and present pain, as assessed with the McGill Pain Questionnaire, the VAS, and the PPI, showed no association with therapists' ratings (Tab. 3).

The interrater reliability for part 2, in which the therapist was asked to rate the direction of intrapelvic motion as positive or negative (a 2-point scale), was good for both the left and the right sides (left κ=.67, right κ=.77). Table 4 shows each participant's kappa agreement matrix for each side. One hundred percent agreement among raters was seen 91.9% and 89.9% of the time for the left and right sides, respectively. Again, the Pearson chi-square test of association revealed that sex, back pain in the last 12 months, leg pain in the last 12 months, and present pain, as assessed with the McGill Pain Questionnaire, the VAS, and the PPI, showed no association with therapists' ratings (Tab. 5).

Discussion and Conclusion

The purpose of the present study was to investigate whether experienced manual therapists could reliably detect a pattern of intrapelvic motion during a weight-bearing task. Pittenger's[19] guidelines for the interpretation of κ values showed that the interrater reliability for the Stork Test on the support side varied according to whether a 2-point or a 3-point scale was used. When a 2-point scale was used to determine a negative or positive result in the Stork Test on the support side, the interrater reliability was good for both sides, and the PCA was high. In comparison, the interrater reliability and agreement were reduced to moderate when a 3-point scale was used. The difference found between the 2 scales may be attributable to probability alone, as an increase in the number of choices would statistically decrease reliability. However, the results do indicate that multiple therapists showed good reliability for determining a positive or negative result in the Stork Test on the support side. The application of the Stork Test on the support side will be more reliable if clinicians describe their palpation findings as either negative results, that is, no relative movement between the innominate bone and the sacrum, or positive results, that is, cephalad motion of the PSIS relative to the sacrum. Increasing the choices by describing the direction of intrapelvic motion is only likely to decrease the interrater reliability of the test.

In comparison with many tests previously described as measures of SIJ dysfunction, the Stork Test on the support side is not reliant on a provocation of pain[6] or a clinical comparison of degrees of joint mobility between sides of the body or between subjects.[4,20] Instead, the Stork Test assesses the ability of a subject to maintain a stable alignment of the innominate bone relative to the sacrum during a functional load transfer task. Failure to maintain this alignment, with resultant motion of the PSIS in a cephalad direction or anterior rotation relative to the sacrum (Fig. 3, right), is rated as a positive result. Performance of the Stork Test on the support side challenges the self-bracing mechanism of the SIJ by increasing weight transference onto one side of the pelvis. In normal function, minimal intrapelvic motion should occur between the innominate bone and the sacrum during a weight-bearing task, such as standing on one leg, because of compression of the articular surfaces with activation of the self-bracing mechanism.[8,9] With the 2-point scale of the Stork Test on the support side, this normal function would be indicated as a negative test. A positive test would suggest an inability of the SIJ to engage the self-bracing mechanism and maintain alignment of the innominate bone relative to the sacrum in the closed pack position; that is, the innominate bone would tend to rotate anteriorly relative to the sacrum.

The ability of the therapists to show good interrater reliability in detecting an altered pattern of intrapelvic motion suggests that the recognition of altered movement patterns is possible. However, it is beyond the scope of this article to suggest how the intrapelvic movement was occurring or at which joint it was occurring. Further research into the validity and specificity of the Stork Test on the support side is needed to determine the relevance of altered pelvic motion patterns to the existence of pelvic pain or dysfunction.

The higher κ and PCA values obtained in the present study than in

Table 4.
Agreement Matrix for Number of Agreements Among 3 Raters for 2 Categories (Positive and Negative) for Each Participant

Participant	No. of Raters Who Agreed on the Indicated Category for Each Participant			
	Left Side		Right Side	
	Positive	Negative	Positive	Negative
A1	0	3	0	3
A2	0	3	2	1
A3	0	3	3	0
B1	0	3	3	0
B2	0	3	3	0
B3	1	2	1	2
C1	1	2	0	3
C2	0	3	0	3
C3	0	3	0	3
D1	0	3	3	0
D2	0	3	0	3
D3	0	3	0	3
E1	0	3	1	2
E2	0	3	3	0
E3	0	3	0	3
F1	0	3	2	1
F2	0	3	0	3
F3	0	3	3	0
G1	1	2	0	3
G2	3	0	0	3
G3	3	0	0	3
H1	0	3	0	3
H2	0	3	0	3
H3	0	3	2	1
I1	0	3	0	3
I2	3	0	0	3
I3	0	3	0	3
J1	0	3	0	3
J2	0	3	3	0
J3	2	1	0	3
K1	0	3	3	0
K2	0	3	0	3
K3	0	3	0	3

Table 5.
Chi-Square Test (Observed and Expected) Results for Association of Number of Agreements Among Raters With Sex, Back Pain in Last 12 Months, Leg Pain in Last 12 Months, and Presence of Pain in Previous 24 Hours[a] When a 2-Point Scale Was Used

Factor	Observed (Expected) Result for the Following Category		χ^2	*P*
	Positive	Negative		
Sex			2.332	.173
Men	24 (19.5)	60 (64.5)		
Women	22 (26.5)	92 (87.5)		
Back pain in last 12 mo			0.151	.717
Yes	31 (32.1)	107 (105.0)		
No	15 (13.9)	45 (46.1)		
Leg pain in last 12 mo			1.550	.241
Yes	26 (22.3)	70 (73.7)		
No	20 (23.7)	82 (78.3)		
Pain present in previous 24 h, as assessed with:				
MPQ			0.825	.402
Yes	25 (22.3)	71 (73.7)		
No	21 (23.7)	81 (78.3)		
VAS			0.136	.738
Yes	22 (20.9)	68 (69.1)		
No	24 (25.1)	84 (82.9)		
PPI			1.311	.295
Yes	20 (16.7)	52 (55.3)		
No	26 (29.3)	100 (96.7)		

[a] As assessed with the McGill Pain Questionnaire (MPQ), the visual analog scale (VAS), and the Present Pain Index (PPI).

other studies may be indicative of the experience of the therapists, with a mean of 14.7 years of daily performance of SIJ intra-articular motion testing and a mean of 4.5 years of performance of the Stork Test on the support side. Meijne et al[5] reported low intertester reliability of the Gillet test (κ=.00, PCA=76.1%) when performed by 2 final-year students. Meijne et al[5] conducted the study on both the leg swing and the leg stance phases. In total, each subject performed 16 movement patterns for each therapist. It is likely that the performance of the tests by the subjects may have varied over these repeated measures, leading to inconsistent movement patterns. Alterations in performance over time may occur for many reasons, such as learning, fatigue, or pain. The end result would be a loss in reliability among therapists as the movement patterns changed.[4] In the present study, each subject performed the movement patterns a maximum of 9 times with each leg. We expected that less repetition would lead to increased consistency of stabilization strategies during load transfer.

The ability of multiple therapists to show good intertherapist reliability when assessing the pattern of intrapelvic motion during transfer of weight from double-leg support to single-leg support was substantiated in the present study. Minimizing the choice of the therapists to a 2-point scale significantly improved interrater reliability. Further research is needed to determine the clinical relevance, validity, and specificity of the Stork Test on the support side for the assessment of functional load transfer through the pelvis.

All authors provided concept. Dr Hungerford and Dr Gilleard provided research design. Dr Hungerford, Dr Gilleard, and Mr Moran provided writing. Dr Hungerford, Mr Moran, and Ms Emmerson provided data collection, and Dr Gilleard provided data analysis. Mr Moran provided subjects. Dr Hungerford provided facilities and project management. Dr Gilleard provided institutional liaisons. Dr Gilleard, Mr Moran, and Ms Emmerson provided consultation.

The study was approved by the Human Ethics Committee of Southern Cross University.

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