Extending the Straight Leg Raise Test for Improved Clinical Evaluation of Sciatica: Reliability of Hip Internal Rotation and Ankle Dorsiflexion

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Research article

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Abstract

Background: The straight leg raise (SLR) is the most commonly applied physical tests on patients with sciatica, but the sensitivity and specificity ratings for disc hernia and neural compression leave areas for improvement. Hip internal rotation tensions the lumbosacral nerve roots and ankle dorsiflexion tensions the sciatic nerve along its course. We added these movements to the SLR (extended SLR=ESLR) as structural differentiators and tested inter-rater reliability in patients with LBP, with and without sciatica.

Methods: Forty subjects were recruited to the study by the study controller (SC), 20 in the sciatic group and in the control group. Two independent examiners (E1&E2) performed the ESLR and did not communicate to the subjects other than needed to determine the outcome of the ESLR. First, SLR was performed traditionally until first responses were evoked. At this hip flexion angle, a location-specific structural differentiation was performed to confirm whether the emerged responses were of neural origin. Cohen's Kappa score (CK) for interrater reliability was calculated with sensitivity and specificity to detect sciatic patients was calculated.

Results: CK of the ESLR result between the independent examiners was 0.85. CK between SC/E1 was 0.90, and 0.95 between SC/E2. Sensitivity and specificity to detect sciatic patients were 0.95 and 0.98, respectively.

Conclusions: ESLR with the addition of location-specific structural differentiation is a reliable and repeatable tool in discerning neural symptoms from musculoskeletal in patients with radiating low back pain. We recommend adding these movements to the standard SLR with aim of improving diagnostic efficacy.

Background

Low back pain (LBP) is a common musculoskeletal ailment worldwide in which radiating leg pain is present in approximately 60% of the patients [1]. Referred pain into the lower extremity is often called sciatica, since it follows the course of the sciatic nerve. Even though there are many possible causes of the radiating pain of sciatica, a commonly considered aspect is mechanical compression of the nerve roots that form the sciatic nerve due to lumbar intervertebral disc herniation [2].

The straight leg raise (SLR) test is the most commonly performed physical test for diagnosis of sciatica and lumbar disc hernia [3]. The SLR is considered positive when it evokes radiating pain along the course of the sciatic nerve and below the knee between 30–70 degrees of hip flexion [2]. Studies of its capacity to diagnose lumbar disc hernia show high sensitivity but heterogeneous/low specificity [3, 4]. The reference standard has usually been magnetic resonance imaging (MRI) and occasionally electrodiagnosis, in which imperfect diagnostic efficacy may link to heterogeneity in the interpretation of the test.

Bragard test is a modification of the SLR, where ankle dorsiflexion is applied at the end of the SLR. Dorsiflexion reduces the SLR angle at which the test is positive [5] and can be used to discern neural symptoms from musculoskeletal [2]. However, problems with this exist: there is no clear procedural definition and it is unclear whether it applies above 70 degrees. In addition, research on Bragard test is sparse. There is some evidence it increases specificity for detection of sciatic symptoms [6], but its reliability and repeatability have not been studied.

To understand the value (application and effectiveness) of the SLR, it is imperative to acknowledge problems with the reference standards. The prevalence of asymptomatic disc hernias on MRI is high [7], radiologically detected nerve root compression does not always coincide with a 'positive' SLR nor clinical symptoms [8, 9] and electrodiagnostic tests do not always detect nerve root lesions [10]. Herein also lies the issue in the literature: The reference standard against which the tests are compared may be imperfect which could render interpretation of the SLR erroneous.

The SLR moves the sciatic nerve up to the nerve roots and a positive test may arise from problems anywhere along this course – thigh, buttock, and spine [11, 12]. With published data on neural movement during the SLR (with or without pathology) [9, 13–17], and the fact that sciatic symptoms can be caused variously, we modified the SLR to address these issues.

As low specificity of SLR may be linked to heterogeneity in its interpretation, we addressed the above problems by defining the application and interpretation of an extended SLR (ESLR) for it to detect sciatic patients. We tested ESLR's interrater reliability to ascertain if hip internal rotation and ankle dorsiflexion would produce consistent responses in patients with LBP, with and without sciatica.

Methods

The institutional ethics committee granted ethical approval for this study. Subjects were given information about the study and they gave written consent to participate and were able to withdraw from the study at any time. The protocol for this study was designed in accordance with recommendations for reproducibility studies for diagnostic procedures [18] and followed the Declaration of Helsinki.

Setting and study population

Forty subjects were recruited to the study, 20 to each sciatica and control groups. We recruited subjects to the study of consecutive patients as they appeared in the institutional spine center. The Study Controller initially examined all patients and recruited them after performing a clinical examination with a thorough patient history. This was done to determine which patients were likely to have exhibited sciatica and a lumbar nerve root disorder affecting the possible mechanosensitivity and/or mechanical behavior of the lumbosacral nerve roots. The sciatic symptoms were not required to reach below the knee. The subjects allocated to sciatic group were selected using a combination on patient history and clinical findings to detect sciatic patients [19, 20]. The subjects included in the control group reported pain in one or more

regions of the low back, greater trochanter and/or hip with or without tightness in the posterior thigh. Complete inclusion and exclusion criteria are shown in Table 1.

Table 1
Exclusion and inclusion criteria

Exclusion criteria:
• Known spinal tumor or malignancy
• Incomplete and/or painful knee extension
• Previously known other joint involvement, such as rheumatoid arthritis or already recognized metabolic bone disease
• Age more than 65 years or younger than 18 years
Sciatic group - Inclusion criteria:
• A combination of sciatic symptoms and clinical findings indicative of sciatica
• A 'positive' ESLR at clinical examination by study controller
• Radiating pain to lower limb either below or above the knee
• Subjects' consent to participate
• No present exclusion criteria at the time of testing
Control group – Inclusion criteria:
• Local low back pain, greater trochanteric/hip/groin pain, with or without hamstring tightness
• No signs of sciatica in clinical examination
ESLR = Extended straight leg raise test

Two independent examiners (physiatry residents; Examiner 1 and Examiner 2) - blinded from each other's results - performed the ESLR on the subjects and did not communicate with them other than absolutely necessary to determine the possible reproduction/provocation of the symptoms during the procedure.

Extended Straight Leg Raise Procedure

The ESLR procedure started the similar way as the traditional SLR. The subjects lay supine and with their head in neutral position supported by a standard pillow. The examiner was positioned facing the patient on the same side of the bed as the lifted limb. The examiner's hands were positioned proximally immediately above patella and distally behind the calf/Achilles tendon. With this grip, the subject's leg was lifted passively towards 90˚with the hip in neutral rotation, knee fully extended and ankle left free, continuing until the first symptoms emerged or symptoms at rest were increased by 30%. In case no responses were evoked, the SLR was ceased at 90˚. The patient was informed by the Study Controller to report emerging responses both vocally and by pointing out the area to Examiner. With the sciatic group, ESLR was performed only on the symptomatic side, while in the control group the Study Controller

selected the tested side randomly. At the hip flexion angle of evoked responses, a structural differentiation movement (hip internal rotation or ankle dorsiflexion) based on the location of the evoked responses (proximal = buttock/hamstring, or distal = below the knee) was performed to determine whether the symptoms were of neural or musculoskeletal origin. These location-specific maneuvers emphasize nerve movement in the relevant area without moving the adjacent musculoskeletal structures.

For subjects whose symptoms occurred in the gluteal and/or hamstring areas, the differentiating movement was passive ankle dorsiflexion (i.e. distal differentiation). This was executed by moving the examiner's proximal hand from above the knee to the ball and toes of the foot while keeping the SLR angle constant and dorsiflexing the ankle gently from neutral (loose) position to 90˚ of dorsiflexion (as in Bragard test, Fig. 1). Ankle dorsiflexion applies tension to, and moves, the sciatic nerve distally without moving biceps femoris muscle [21, 22]. For the proximal nerve movement for patients with distal reproduction of symptoms (below the knee), hip internal rotation was used to differentiate the evoked responses to be of neural origin [23]. This was performed with the same hand positioning as described earlier with the SLR by turning the examiner's wrists to produce internal rotation to the hip joint while keeping the SLR angle at emerged responses stable and avoiding adduction of the hip (Fig. 2). In case the SLR did not provoke any responses before or at 90˚ of hip flexion, the test was judged negative and no structural differentiation was performed. If the subject's symptoms evoked by the test increased by structural differentiation, the ESLR was ruled to contain a neural aspect, and deemed 'positive'. Conversely, the test was deemed negative if the structural differentiation did not increase the SLR-provoked symptoms.

Two aspects were required for a positive test: i) reproduction of the subject's clinical symptoms during the SLR, and ii) increase of those symptoms with differentiating movement (hip rotation or dorsiflexion). An important remark with the ESLR is that it is imperative to perform the differentiating movement only at a location that is anatomically different from the location of the emerged symptoms, i.e. proximal symptoms ◊ distal differentiation, and vice versa. In case the differentiating movement was performed on the same anatomical location as the evoked symptoms, it will likely cause some symptoms/sensations on the site of provoked symptoms, which can be confused with as the worsening of sciatic symptoms.

Statistical analysis

The data were analyzed using Microsoft Excel and IBM SPSS Statistics. The sample size of 40 was required for the Kappa statistic to be significantly greater than 0.40 (assuming 80% power and 5% significance) [18, 24]. Positive/negative findings of Study Controller and both Examiners 1 and 2 were cross-tabulated and we used the Cohen's Kappa statistic was used for interrater reliability between the examiners for the ESLR result. Fleiss' Kappa with 95% confidence intervals (95%CI) was calculated to assess interrater reliability between the Study Controller and Examiners 1 and 2. Using the Study Controller's group allocation as the reference standard, we calculated sensitivity and specificity with 95%CI to detect sciatic subjects.

Results

The study group consisted of 40 subjects, 25 women and 15 men: mean age was 41 years (range 22–64 years), height 170 ± 9 cm (mean ± standard deviation), and weight 80 ± 23 kg. The mean ESLR angle for the sciatic group was 60 ± 19˚ (range 30˚- 85˚) while control group's mean ESLR angle was 84˚ ± 8˚ (range 70˚- 90˚).

The interrater agreement for the ESLR was almost perfect as measured by Cohen's Kappa and Fleiss Kappa (Table 2). For detection of sciatic subjects, both Examiner 1 and Examiner 2 showed high sensitivity 0.95 (95%CI 0.73–1.00) and 0.95 (0.73–1.00) with high specificity 0.95 (0.73–1.00) and 1.00 (0.80–1.00), respectively. These translated to ESLR's mean sensitivity and specificity of 0.95 and 0.98, respectively. There were 3/40 subjects whose SLR result was not unanimous: 2 in the symptomatic group (ESLR + 80˚ with both subjects) and one in the control group (hamstring tightness at 70˚).

Table 2. Interrater reliability results

	E1 vs. SC	E2 vs. SC	E1 vs. E2
Cohen's Kappa for ESLR result	0.90	0.95	0.85
Overall agreement on ESLR result (%)	95.0	97.5	92.5
Fleiss' Kappa between E1 / E2 / SC (95%CI)	0.90 (0.75-1.00)		
Overall agreement on ESLR result (%)	95.0		

E1 = Examiner 1, E2 = Examiner 2, ESLR = Extended Straight Leg Raise Test, SC = Study controller, 95%CI = 95% Confidence intervals

Discussion

For the ESLR definition and location-specific structural differentiation movements (ankle dorsiflexion and hip internal rotation), we showed excellent reliability because there was almost perfect agreement between i) the blinded examiners and ii) the examiners and study controller.

The criticism of SLR has been about its heterogeneity in diagnosing lumbar disc hernia, particularly specificity [3, 4]. This is likely due to an imperfect concept as to what the test measures. Many mechanisms and pathologies can relate to radicular pain and the SLR: It is not only lumbar disc hernia but also mechanosensitivity and/or impairment of neural movement, for whatever the cause. Again, lumbar disc hernias are not always symptomatic. The SLR is indirect because it tests physical mechanisms such as mechanical function (excursion) and sensitivity, not pathology or anatomical changes, as noted also by Walsh and Hall [25].

We extended the SLR by adding differentiation movements to it based on the meticulous scientific data on the effects of different components of the SLR to the nervous system [9, 13–17, 21]. Moreover, as the

SLR is employed more than other tests in clinical practice worldwide with LBP, implementing on the execution and interpretation of this test may create a more relevant impact in the scientific and clinical community. By adding a differentiating maneuver to the SLR, a test capable of emphasizing neural symptoms over musculoskeletal is created. These modifications were selected so the examiner can move the nerves without moving the musculoskeletal structures at the site where the symptoms were provoked [21–23]. Specifically, if there is mechanosensitivity or tension in the neural structures, neural movement generated from asymptomatic musculoskeletal location causes the symptom aggravation by which it can be separated from musculoskeletal symptoms. The near-perfect interrater agreement for the ESLR not only increases the value of this test, but also reliability and repeatability in interpretation are of paramount importance and represents the central part of this investigation.

Our subject sample reflects a realistic patient-care setting in a specialized spine clinic. We were able to modify the SLR so that both clinical application and interpretation were reliable and repeatable, and produced constant results between blinded examiners even without the knowledge of patient history, imaging or other clinical tests. The addition of location-based differentiation movements (hip internal rotation and ankle dorsiflexion) to the SLR produced high sensitivity and specificity for detection of sciatic subjects.

This study was designed to test ESLR's repeatability and interrater agreement on the test result rather than testing how different variables predict the existence of a certain (pathologic) condition. This knowledge can lead to a better recognition of patients with sciatic/neural ailments and in planning more sophisticated and focused treatment protocols.

Conclusions

The extended SLR adds hip internal rotation and ankle dorsiflexion to apply more tension to the neural tissues than the SLR. The ESLR is highly reliable in patients with LBP with or without sciatica, and improves diagnostic efficacy for detection of a likely neural element. We recommend the ESLR to improve diagnosis of a neural element to low back pain and sciatica.

Abbreviations

95%CI
95% confidence interval
ESLR
Extended straight leg raise test
LBP
Low back pain
MRI
Magnetic resonance imaging
SLR

Straight leg raise test

Declarations

Ethics approval and consent to participate: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Ethics Committee of Kuopio University Hospital (No. 13.02.00/943/2018). **Each subject signed a written consent to participate to the study.**

Consent for publication: Persons presented in the figures gave their written consent for publication of the image.

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Figures

Figure 1

Distal structural differentiation for proximal symptoms with ankle dorsiflexion (also known as Bragard test)

Figure 2

Proximal structural differentiation for distal symptoms with hip internal rotation