JOURNAL OF MANUAL & MANIPULATIVE THERAPY, 2017
VOL. 25, NO. 2, 91–97
http://dx.doi.org/10.1080/10669817.2016.1200216

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Effect of leg dominance, gender and age on sensory responses to structural differentiation of straight leg raise test in asymptomatic subjects: a cross-sectional study

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ABSTRACT

Study design: Cross-sectional study.

Objectives: To assess the effect of structural differentiation on sensory responses of asymptomatic individuals to standard neurodynamic tests of straight leg raise (SLR) and to evaluate the relevance of leg dominance, gender, and age.

Background: SLR test is a well-known neurodynamic test among physical therapists; no studies to date have investigated the influence of gender, age, and leg dominance to the sensory responses of this neurodynamic test and its structured differentiating maneuver.

Methods: Thirty (16 women) asymptomatic individuals enrolled in this study. Dominancy test was performed for each participant. Pain intensity using visual analogue scale (VAS), symptoms location in a body chart, nature of symptoms evoked, and hip range of motion (ROM) were recorded and compared at ankle neutral position (N-SLR) and dorsiflexion (DF-SLR) in both legs at the point of pain tolerance during SLR (P2). In addition, hip ROM was recorded at the onset of pain (P1).

Results: There was a statistically significant sex main effect for P1 and P2 between N-SLR and DF-SLR ($p < 0.05$). Mean hip ROM during the SLR was more than 10° greater in women than men. There was no statistically significant interaction between leg dominance and age group in N-SLR, DF-SLR, and VAS. Pain intensity was moderate for each SLR test. Symptoms most often described were stretch (96.7%), followed by tightness (70%) in the posterior thigh and leg.

Conclusions: SLR hip ROM is influenced by sex in asymptomatic individuals, leading to a greater hip ROM in SLR in women. Age and limb dominance are not relevant to SLR hip ROM or pain intensity.

KEYWORDS
Straight leg raise; leg dominance; sensory response

Introduction

Straight leg raise (SLR) is a common neurodynamic test used to detect increased nerve mechanosensitivity of the lower limbs in individuals with low back pain or leg-related low back pain.[1–4] Mechanosensitivity is heightened in presence of minor nerve damage, where inflammatory mediators are present.[5,6] During this process, any mechanical stimulation to the nerves results in sensory responses that neurodynamic tests may detect.[7]

Structural differentiation is a useful maneuver applied in a neurodynamic test to assess neural tissue sensitivity. When a test evokes symptoms, this maneuver implies moving a joint that is remote from the location of symptoms so it can change neural tissue load but does not change load on non-neural tissues in the area of provoked symptoms. Several differentiations have been suggested, such as ankle dorsiflexion, ankle plantar flexion, medially hip rotation, and hip adduction.[4,8,9] Previous studies have shown that ankle dorsiflexion increased the strain in nerves and the roots of the lower limbs compared to neutral position in the SLR.[10,11] The pre-positioning of the ankle in dorsiflexion during the SLR allows distinguishing SLR neurodynamic test from hamstring length test responses.[1,8]

Normal sensory responses with SLR have been previously reported.[1,12,13] Range of motion (ROM) has been correlated to demographic factors, such as weight, gender, and body mass index.[12] To our knowledge, leg dominance has never been taken into account during the SLR. Leg dominance has been studied in femoral slump test,[14] where the dominant leg achieved less ROM than non-dominant leg, but nerve tension following the application of structure differential maneuver was independent of dominance.

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Supplemental data for this article can be accessed at http://dx.doi.org/10.1080/10669817.2016.1200216.

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In addition, symptoms' location, quality, and intensity have been assessed during SLR.[1] However, no relationship has been studied previously between demographic factors mentioned above and pain intensity or the location of normal sensory responses for the SLR. For the upper limb, pain intensity values were higher in women during the ulnar upper limb neurodynamic test (ULNT3) and lesser ROM was assessed in this group.[15]

To recognize altered mechanosensitivity in patients during SLR, it is mandatory to explore influences of demographic factors, leg dominance, and structural differentiation in ROM and sensory responses elicited in the test in asymptomatic individuals. The aim of this study was to investigate the influence of age, gender, and leg dominance on pain intensity and sensory response. In addition, the influence of demographic factors in ROM during SLR neurodynamic test, performed either in neutral position and ankle dorsiflexion, at the onset of pain (P1) and point of pain tolerance (P2) were evaluated. Finally, reliability of SLR testing was carried out.

Methods

Study design

A cross-sectional study was carried out in the research facilities of University Alcalá, from November 2013 to February 2014. This study methodology was based on a previous study by Boyd and Villa[12].

Participants

Thirty-two healthy individuals aged between 18 and 65 years were recruited from University of Alcalá. Participants had to be able to achieve at least 90° hip flexion with knee flexed, complete knee extension, ankle dorsiflexion of 15° or more, and plantar flexion of 0°. Exclusion criteria were: low back or leg pain during 3 days in the past 3 months, lumbar spine or lower limb surgeries, ostheoarthritis, arthritis or any other inflammatory disease, fibromyalgia, lower leg or lumbar spine fractures in the last 3 months, diabetes mellitus, peripheral neuropathy, neurological signs, complex regional pain syndrome, history of alcohol abuse, chemotherapy in the past year, and/or Beighton scale > 4/9. Beighton scoring system[16] has been considered before in neurodynamic testing[15] to screen generalized joint hypermobility individuals that may confound sensory results in SLR test. Leg dominance criteria were used based on the following tests: preferred leg to kick a ball, spontaneously chosen leg to step up a platform (20 cm), and leg which subject stepped out to prevent a fall after pushed from behind between the shoulders. The dominant leg was defined as the leg that was dominant in at least two of the three tests.

The study was approved by the Research Ethics Committee of the University of Alcalá.

Procedures (see video, supplemental data)

Prior to this study, a reliability study was carried out for the hip flexion and knee extension angle measurements during the SLR. Ten participants were selected and assessed by the same researcher of this study (ES). Ankle was secured at 0° and 15° using an ankle brace and straps (Orliman, S.L.U., Valencia, Spain), prior to the hip flexion. A twin-axis electrogoniometer was placed laterally across the knee to monitor full knee extension (MLTS700, ADInstruments, New Zealand) during SLR. Additionally, a digital inclinometer (926621, Baseline®, NY) was attached proximal to the lateral femoral condyle to measure hip flexion during the neurodynamic test. Participants were supine lying, with arms resting by their side and head resting without any pillow. A custom-made trigger was given to the participants who held it with their dominant arm resting by their side. Trigger and electrogoniometer data were collected and synchronized at 1000 k/s using a PowerLab 26T data acquisition system and synchronized using Chart software v5.5 (ADInstruments, New Zealand).

During the reliability study, SLR was performed thrice for each ankle position and leg, with 30 s rest between tests. The examiner placed the knee in full extension (end range) and flexed the hip until the patients push the trigger when perceived symptoms too uncomfortable to continue (P2, point of pain tolerance). Hip flexion and knee extension were recorded at that moment.

Once the reliability study was completed, the normal sensory response to the SLR neurodynamic test study was carried out. One physical therapist (MT) collected demography data and another physical therapist (ES), with three years of postgraduate training in manual therapy, accomplished the SLR neurodynamic tests and collected the following variables: pain intensity, pain location, and quality of symptoms evoked at P2 and hip flexion (P1 and P2).

The procedures were explained to the participants who met the inclusion criteria and signed informed consent. Patient position, number of repetitions for each SLR test and condition, and P1 and P2 of the tests were recorded as described in the reliability study. Physical therapist placed the proximal hand immediately above the knee to keep knee extension during SLR. Distal hand held the ankle brace. While maintaining knee in full extension, hip was slowly flexed with caution to avoid hip adduction/abduction or rotation. The mean of the hip ROM was calculated with the values of the three repetitions for each test, condition, and limb.

Each individual was instructed to use the trigger during the SLR test at the onset of pain (P1) and once again at the point of pain tolerance (P2), described above. In addition, they were asked to remember the location, quality, and intensity of these feelings of the third repetition only. Then, they were given a body chart to reflect symptoms' location at S2, as described by Boyd et al.[1] Moreover, they had to report their sensations at P2 from a list of quality descriptors, which included: pain, burning, numbness, tingling, stretch, tightness, others, or a combination of these. A visual analogue scale (VAS) was used to score the intensity of pain at P2. VAS reliability and validity have been previously tested.[17] This procedure was repeated for each ankle position, neutral or dorsiflexion, on every leg. One trial was performed in a randomly assigned leg to verify indications prior to the examination. The order of the tests in each leg was randomized to avoid bias.

Statistical analysis

All data were analyzed using SPSS software, version 15.0 (SPSS Inc, Chicago, IL). In the reliability study, intraclass correlation coefficient ($ICC_{3,3}$) with the minimal detectable change (MDC)[18] was used for repeated measurements of hip flexion and knee extension angles at P2 and reported with the 95% confidence interval (CI).

Descriptive statistics were used to describe the mean ± standard deviation for age, hip flexion, knee extension, and pain intensity. Dominant leg, sex, location, and quality of symptoms were expressed in terms of frequency and percentages. Normal distribution of the data and sphericity were verified with the Kolmogorov–Smirnov test and Mauchly's sphericity test.

A paired-samples *t*-test was used to compare hip ROM angle between SLR and SLR/DF at P1 and compare ROM between SLR and SLR/DF at P2. In addition, paired-samples *t*-test was used to compare ROM between P2 and P1 during SLR and to compare ROM between P2 and P1 during SLR/DF. The influence of sex, age, and leg dominance on pain intensity and hip ROM angle during SLR at P1 and P2 was analyzed using a two-way, repeated-measures analysis of variance, with sex and age as the between-subject variables and leg dominance as the within-subject variable. Age variable was divided into three levels for analysis: 18–30, 31–45, and older than 46 years old (adapted from Huberman).[19] The dependent variables were pain intensity, hip ROM angle in SLR at P1 y P2, and the quality and distribution of symptoms, and were all recorded at the point of pain tolerance (P2), and for hip ROM, also at the onset of pain (P1). Sex, leg dominance, and ankle position during the SLR were considered independent variables.

Quality of symptoms was recorded into five dichotomous groups: numbness, stretch, tightness, tingling, or others. Distribution of symptoms was registered on a body chart, which was divided into 20 areas as in a previous study.[1] Frequencies were used in each area to summarize location of symptoms.

For statistical analysis purposes, confidence interval was fixed at 95% and values were considered significant when $p < 0.05$.

Results

Thirty participants ($n = 30$) formed the sample, mean age was 39.57 ± 14.11 (range 19–65) and included 14 men (46.7%). Regarding age stratification, 11 individuals (36.7%) were between 18 and 30 years, 8 were aged from 31 to 45 (26.7%), and 8 participants were older than 46 years old (36.7%). Right leg was dominant for 25 individuals (83.3%). Normal distribution and sphericity assumption were met.

Reliability study

The reliability study for the electrogoniometer at the knee and the inclinometer at the hip was carried out for P2 in SLR with neutral ankle position and ankle dorsiflexion. Electrogoniometer and inclinometer measurements indicated a strong agreement (ICC > 0.90, Table 1).

Table 1. Intraclass correlation coefficients assessing intra-rater reliability of ROM measured at the point of pain tolerance (P2).

		Dominant leg			Non-dominant leg		
		ICC (95%)	SEM	MDC (95%)	ICC (95%)	SEM	MDC (95%)
SLR DF	Knee extension	0.99 (0.98–0.99)	0.55	1.52	0.99 (0.98–0.99)	0.55	1.52
	Hip flexion	0.95 (0.86–0.98)	1.91	5.3	0.97 (0.93–0.99)	1.2	3.33
SLR N	Knee extension	0.99 (0.99–0.99)	0.55	1.52	0.99 (0.98–0.99)	0.57	1.57
	Hip flexion	0.93 (0.82–0.98)	2.02	5.59	0.94 (0.82–0.98)	2.22	6.03

Notes: SLR DF: SLR with ankle dorsiflexion; SLR N: SLR in neutral position; ICC = intraclass correlation coefficient (95% confidence interval); SEM = standard error of measurement; and MDC (95%) = minimal detectable change at 95% confidence interval, expressed in degrees.

Table 2. Pairwise comparisons between hip flexion angle at P1 and P2 during SLR neurodynamic tests (rows). Inter-limb differences between dominant and non-dominant leg (columns).

Variable		P1 Hip flexion angle (°)	P2 Hip flexion angle (°)	Differences (95% CI)	*p* value
SLR DF	Dominant	58 ± 14.9 (30, 84.3)	74.8 ± 14.3 (41.7, 100)	−16.81 (−19.93, −13.69)	0.001*
	Non-dominant	58.7 ± 14.4 (32.3, 91.7)	74.5 ± 13.9 (41, 105)	−15.97 (−19.04, −12.89)	0.001*
	Difference (95% CI)	−0.79 (−4.4, 2.8)	0.24 (−3.32, 3.81)		
SLR N	Dominant	62.2 ± 16.1 (29, 90)	78.2 ± 14.6 (38.7, 103.3)	−15.78 (−18.77, −12.79)	0.001*
	Non-dominant	62.5 ± 14.2 (36.7, 92)	77.3 ± 13.8 (45.3, 108)	−14.83 (−17.53, −12.14)	0.001*
	Difference (95%)	−0.2 (−2.31, 1.82)	0.89 (−1.35, 3.13)		

Notes: SLR DF: SLR with ankle dorsiflexion; SLR N: SLR in neutral position; P1: point of onset of symptoms; and P2: point of pain tolerance.Values are mean ± SD (95% confidence interval).
*Statistically significant difference ($p < 0.05$).

SLR study

Hip flexion ROM

Hip flexion was significantly greater at P2 than P1 for both SLR with ankle dorsiflexion and in neutral position ($p < 0.001$, Table 2).

In the comparison of P1 between SLR in neutral position and SLR with ankle dorsiflexion, there were 4.3° (CI 95%: 1.8, 6.8; $p < 0.001$) lesser hip flexion at P1 in SLR with ankle dorsiflexion for the dominant limb. In the non-dominant limb, this difference was 3.7° (CI 95%: 2.1; 5.4; $p < 0.001$). At P2, there were 3.4° (CI 95%: 1.3,

Table 3. Hip flexion angle and pain intensity during SLR neurodynamic test.

Variable		Men		Women		*p* value
		Dominant leg	Non-dominant leg	Dominant leg	Non-dominant leg	
SLR DF	P1 Hip flexion angle (°)	52.1 ± 14.6 (30, 84.3)	51.4 ± 13.1 (32.3, 75.7)	63.0 ± 13.6 (35.3, 83.0)	65.2 ± 12.4 (46.7, 91.7)	0.012*
	P2 Hip flexion angle (°)	70.6 ± 13.5 (41.7, 91)	68.5 ± 13.5 (41, 87)	78.4 ± 14.4 (48.7, 100)	79.8 ± 12.4 (58.7, 105)	0.049*
	VAS (0–10)	4.6 ± 2.0 (1.2, 8.0)	4.4 ± 2.4 (0.3, 8.3)	4.2 ± 2.3 (0, 7.5)	4.1 ± 2.6 (0.8, 8.5)	0.71
SLR N	P1 Hip flexion angle (°)	53.6 ± 15.1 (29, 78)	55 ± 14.4 (36.7, 84.7)	69.8 ± 13.1 (41.7, 90)	69 ± 10.6 (48.3, 92)	0.004*
	P2 Hip flexion angle (°)	71.7 ± 14.7 (38.7, 90.3)	71.5 ± 13.9 (45.3, 93.3)	83.9 ± 12.3 (54.3, 103.3)	82.4 ± 12 (59, 108)	0.021*
	VAS (0–10)	4.2 ± 2.1 (1.0, 8.0)	4.1 ± 2.4 (0.2, 8.6)	4 ± 2.1 (0.5, 7.2)	3.8 ± 2.4 (0.7, 8.2)	0.77

Notes: SLR DF: SLR with ankle dorsiflexion; SLR N: SLR in neutral position; VAS: visual analogue scale; P1: point of onset of symptoms; and P2: point of pain tolerance. P-value is referred to the result of two-way, repeated-measures analysis of variance sex main effect differences for P1 and P2 in each SLR condition and VAS.

*Statistically significant difference ($p < 0.05$).

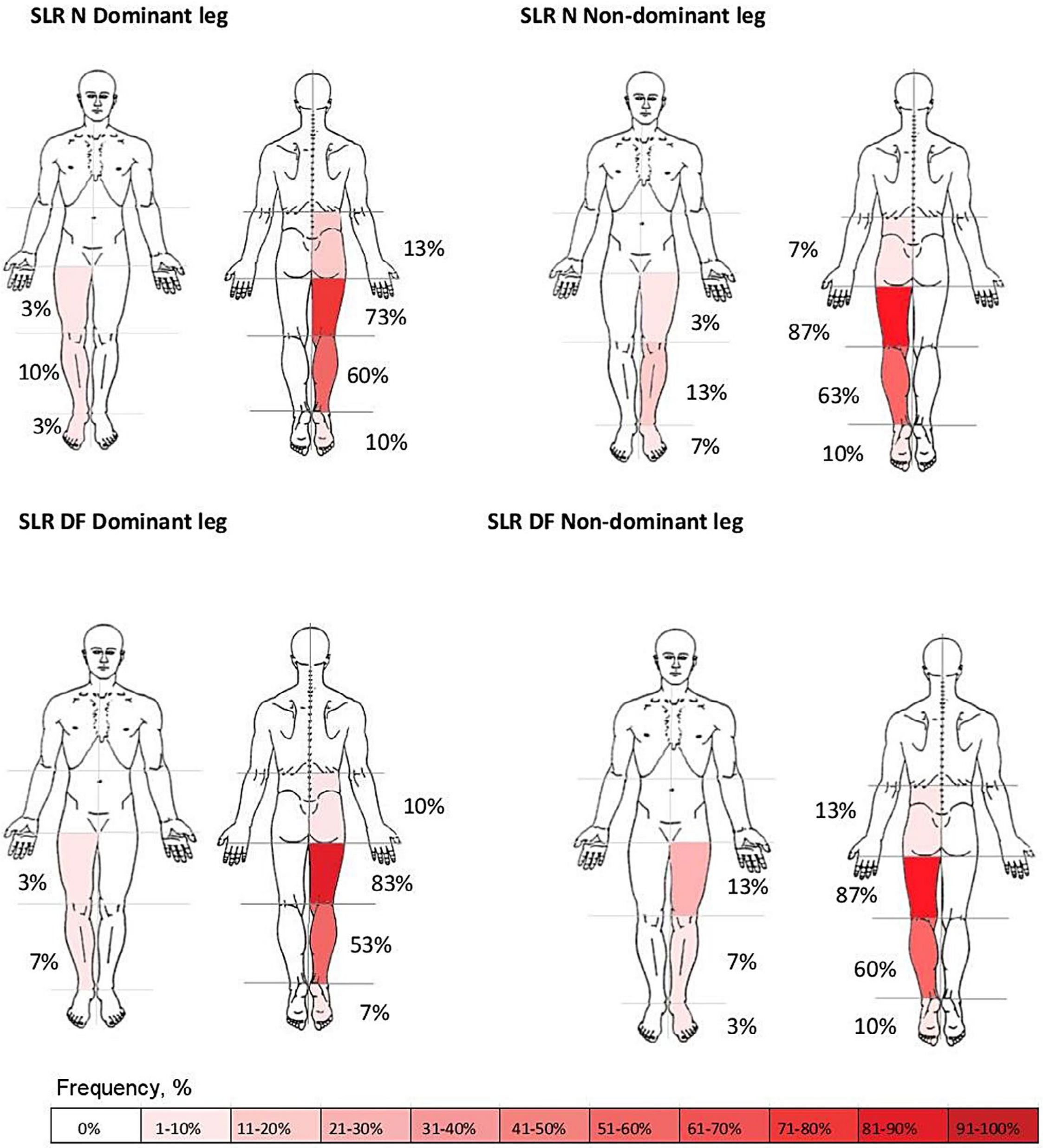

Figure 1. Symptoms' location in SLR DF and SLR N neurodynamic tests. Body chart adapted from Boyd et al.[1]

5.6; $p < 0.003$) lesser hip flexion in the dominant limb in SLR in neutral position. For the non-dominant limb, the amount of difference diminished to 2.8° (CI 95%:1.5, 4.1; $p < 0.001$). These differences might be due to measurement error considering the MDC (Table 3).

No significant inter-limb differences were found at P1 and P2 during SLR in neutral ankle position and in ankle dorsiflexion ($p > 0.05$, Table 2).

There was no statistically significant interaction within-subjects between leg dominance, age group, and sex for hip flexion ROM during both SLR tests ($p > 0.05$). A significant sex main effect difference was found for P1 and P2 in both SLR tests, where the mean hip ROM during the SLR was more than 10° greater in women than men (Table 3).

Pain intensity

Pain intensity was moderate measured with VAS at P2 in both SLR tests. No statistical differences were found in VAS between dominant and non-dominant leg at P2 ($p > 0.05$). In addition, age, sex, and leg dominance did not influence VAS scores in any SLR test ($p > 0.05$, Table 3).

Location of symptoms

Regardless of the type of test performed, the most common region for evoked symptoms at P2 was the posterior part of the thigh, followed by the posterior part of the leg (Figure 1).

Quality of symptoms

Most commonly reported symptom was stretch followed by tightness in the dominant and non-dominant limb during SLR in neutral position and with ankle dorsiflexion (Figure 2).

Discussion

To the best of our knowledge, this is the first study to investigate the influence of leg dominance and age on SLR normal responses in asymptomatic individuals. Results showed that SLR and pain intensity were not influenced by age or leg dominance. This finding confirms previous study results.[12] With regard to age, changes have been observed in the structural organization and composition of extracellular matrix of the sciatic nerve in rats,[20] decreasing collagen fibril content in the perineurium, as well as degeneration of nerve fibers. In spite of the changes in sciatic nerve described above due to age, these might not affect mechanosensitivity of the sciatic nerve during SLR.

Our results on leg dominance contrast with previous studies, which consider dominance as an important factor in different neurodynamic tests.[12,14,15] Participants in this study were mainly dominant with right leg (83%), which might have influenced the results. Lai et al.[14] showed that the dominant leg has a smaller ROM compared to the non-dominant side on femoral slump test. Regarding hand dominance, Arguisuelas-Martínez et al.[15] also found that the dominant hand has smaller shoulder ROM compared to the other hand in the ulnar nerve neurodynamic test. However, Boyd and Villa[12] observed that hand dominance was not associated to SLR hip ROM. It is known that hand dominance may not be correlated with leg dominance[21] and that leg dominance may influence human neuromuscular performance.[13] Further studies are needed to clarify if leg dominance has an effect on SLR.

Sex has a significant main effect on the hip ROM in SLR in neutral and ankle dorsiflexion. Women had greater ROM than men in each SLR condition. This result is in agreement with previous studies.[12,13] In healthy people, women are more flexible than men.[22] Considering our sample of asymptomatic patients, hip ROM may be limited due to hamstring flexibility rather than nerve mechanosensitivity. Nevertheless, the addition of ankle dorsiflexion and the consequent reduction in hip ROM compared to the neutral ankle position suggest nerve mechanosensitivity might be involved.[12]

The results of this study, in regard to hip ROM, are consistent with previous studies in SLR.[1,8,23,24] As expected, ankle dorsiflexion significantly restricted hip ROM for each SLR and limb. Although the significant differences, our results were less impressive than other authors' results. Gadjosik et al.[8] found differences of 9° in asymptomatic individuals between SLR in ankle dorsiflexion and SLR in ankle plantar flexion. Boyd et al.[1] used ankle position variation of 30° between dorsiflexion and plantar flexion during SLR, leading to 5.5° and 10.1° differences at P1 and P2. These differences may be due to ankle position. While Gadjosik et al. [8] and Boyd et al. [1] performed the SLR in ankle dorsiflexion and ankle plantar flexion or neutral, in the current study, we preferred to use ankle dorsiflexion and neutral ankle position, with a variation of only 15° between them, which may have explained the lesser amount of ankle ROM between tests. Further studies are needed to explain these differences comparing plantar flexion, neutral position, and ankle dorsiflexion in a larger sample.

Pain intensity was moderate in each SLR test and demonstrated little change between dorsiflexion and neutral ankle position, in correlation to previous results.[1] Other studies suggested that women perceived greater intensity during neurodynamic tests.[15] Our results, on the contrary, did not find differences regarding gender in pain intensity during SLR. Considering that in our sample there were more women than men, more studies are needed to evaluate possible differences, controlling the number of men and women in each group and other factors, such as psychosocial, that might be contributing to pain experience.

Regarding symptom descriptors, stretch and tightness were the most commonly reported symptoms.

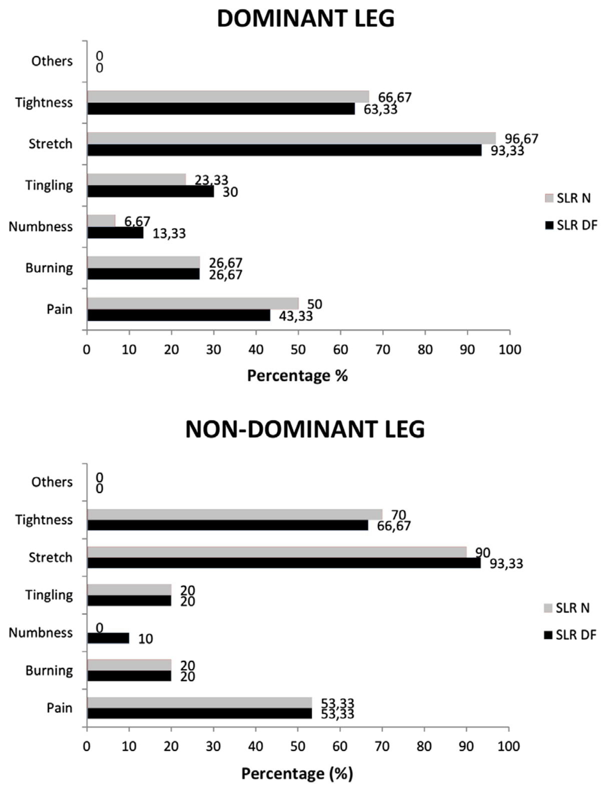

Figure 2. Frequency of symptoms measured at P2. (a) Dominant leg and (b) non-dominant leg.

In the dominant limb, ankle dorsiflexion increased the numbness and tingling, suggesting a neurogenic involvement. Boyd et al. [1] showed similar results during SLR with structural differentiation, although his percentages were slightly lower (stretch ranging from 65 to 75%, compared to ours, 90–96.67%; tightness from 25 to 50%, compared to 63.33–70%, in our study). The higher presence of stretching, tightness, tingling, and numbness might be because ankle dorsiflexion was performed in this study. As previously described in cadaveric studies[9,10,25] and healthy population,[8,23] ankle dorsiflexion increases the strain in the sciatic nerve. Participants in our study might be exposed to a higher strain in SLR tests, leading to a more frequent presence of symptoms.

In addition, the most common locations of symptoms were the posterior thigh and leg. These results are in agreement with previous findings that showed similar percentages.[1]

Our work shows precise sensory responses in the SLR. Clinicians should be aware that neither age nor gender influenced these responses. Moreover, women would reach higher ROM during SLR, even with ankle dorsiflexion and this might be taken into account when performing this test. It would be common when evaluating our patients that they referred tightness and stretch on the posterior region of the thigh and leg and testers may expect changes in the distribution if ankle position is modified.

This study presents several limitations. First of all, results might be limited due to the small sample. In addition, a reliability study was not carried out for the ankle brace. Previous studies had used an ankle brace and adequate reliability has been reported, but this model was not present in any of them.[1,8] Ankle dorsiflexion instead of ankle plantar flexion in SLR might restrict the hip ROM. Accordingly, the use of this structural differentiation could have produced different results. Moreover, hip rotation or adduction/abduction and/or lumbar flexion were not measured in this study and might influence our results. Lastly, extrapolation of this study to the clinic might be limited. Asymptomatic participants formed the sample.

In conclusion, this study suggests that SLR hip ROM is influenced by sex in asymptomatic individuals, leading to a greater hip ROM in SLR in females. Age and limb dominance are not relevant to SLR hip ROM or pain intensity. Most common descriptors used in asymptomatic individuals to describe sensory responses in SLR are stretch, followed by tightness in the posterior thigh or leg. Pain intensity experienced by healthy individuals is moderate in SLR during ankle dorsiflexion and in neutral position.

Ethical approval

This protocol study was approved by the Research Ethics Committee of the University of Alcalá, Madrid, Spain. Each author certifies that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Eva Sierra-Silvestre completed her Pt and MSc. Her research interests include neural mobilization and neuropathic pain.

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