Effects of a neurodynamic sliding technique on hamstring flexibility in healthy male soccer players. A pilot study

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Abstract

Purpose: To compare the short-term effects of a neurodynamic sliding technique versus control condition on hamstring flexibility in healthy, asymptomatic male soccer players.

Subjects: Twenty-eight young male soccer players from Palencia, Spain (mean age 20.7 yrs ± 1.0, range 19–22) with decreased hamstring muscle flexibility.

Methods: Subjects were randomly assigned to one of two groups: neurodynamic sliding intervention or no intervention control. Each subject’s dominant leg was measured for straight leg raise (SLR) range of motion (ROM) pre- and post-intervention. Subjects received interventions as per group allocation over a 1 week period. Data were analyzed with a 2 (intervention: neurodynamic and control) × 2 (time: pre and post) factorial ANOVA with repeated measures and appropriate post-hoc analyses.

Results: A significant interaction was observed between intervention and time for hamstring extensibility, F(1,26) = 159.187, p < .0005. There was no difference between the groups at the start, however, at the end of the study, the groups were significantly different with more range of motion in the group that received neurodynamic interventions, p = .001. The group that received neurodynamic interventions improved significantly over time (p < .001), whereas the control group did not (p = .684).

Conclusion: Findings suggest that a neurodynamic sliding technique can increase hamstring flexibility in healthy, male soccer players.

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1. Introduction

Hamstring injuries are common in physically active people and athletes participating in competitive sports such as sprinting, rugby, football, and soccer (Bahr & Holme, 2003; Davis, Ashby, McCale, McQuain, & Wine, 2005; Decoster, Cleland, Altieri, & Russell, 2005; Malliaropoulos, Papalexandris, Papalada, & Papacostas, 2004). Hamstring strains accounted for 11% of injuries in British professional soccer and for 12.7% in the two highest divisions in Iceland (Arnason, Sigurdsson, Gudmundsson, Holme, Engebretsen, & Bahr, 2004; Dadebo, White, & George, 1998). Many predisposing factors for hamstring injury have been suggested within the literature, including: insufficient warm-up (Safran, Garrett, Seaber, Glisson, & Ribbeck, 1988); poor flexibility (Witvrouw, Danneels, Asselman, D’Have, & Cambier, 2003); muscle imbalance (Crosier, 2004; Crosier, Forthomme, Namurois, Vanderthommen, & Crielard, 2002); neural tension (Turl & George, 1998); and previous injuries (Bennell et al., 1998; Verrall, Slavotinek, Barnes, Fon, & Spriggins, 2001). Among risk factors for hamstring injury, inadequate extensibility within the posterior thigh compartment appears to be one of the more commonly accepted causes (Davis et al., 2005; Decoster, Scanlon, Horn, & Cleland, 2004) and it has been suggested that stretching before physical activity may increase extensibility of the stretched muscle, fascia and neural tissues, which may in turn decrease the chance for injury (Halbertsma, Mulder, Goeken, & Eisma, 1999; Hartig & Henderson, 1999; Ross, 1999).

Hamstring stretching is considered an appropriate intervention in both the prevention and treatment of hamstring injury. Although stretching for the prevention of injury is common practice in many

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http://dx.doi.org/10.1016/j.ptsp.2012.07.004

Please cite this article in press as: Castellote-Caballero, Y., et al., Effects of a neurodynamic sliding technique on hamstring flexibility in healthy male soccer players. A pilot study, Physical Therapy in Sport (2012), http://dx.doi.org/10.1016/j.ptsp.2012.07.004
sports (Witvrouw, Mahieu, Danneels, & McNair, 2004), evidence for decreased hamstring flexibility as a risk factor for hamstring injury remains equivocal (Hennessey & Watson, 1993; Witvrouw et al., 2003) and a recent Cochrane review found no evidence for stretching as a sole intervention for prevention of hamstring injury (Goldman & Jones, 2010). Accordingly, flexibility has been suggested as but one factor in the multi-factorial etiology of hamstring strain injury (Worrell & Perrin, 1992). In a review on risk factors for recurrent hamstring strains, Croisier (2004) noted only limited evidence for stretching but suggested at least normalizing hamstring length. In a Cochrane review, Mason, Dickens, and Vail (2007) reported evidence for a higher frequency of daily stretching in the rehabilitation of hamstring injuries, and in another study, Witvrouw et al. (2004) suggested that stretching might be most relevant for sports that predominantly include plyometric activities.

Although there are various theories, evidence is lacking for any credible explanation for the observed increases in muscle extensibility following intermittent stretching. In a recent review article, Weppler and Magnusson (2010) suggested that increases in tissue extensibility come not from affecting the mechanical properties of the muscle being stretched but result from changes in the individual's perception of stretch or pain. In other words, the point of limitation in hamstring range is increased not because of changes within the muscle structure but rather, because the individual receiving the stretching interventions has adopted a ‘new stop point’ for limitation in hamstring range based on altered perceptions of stretch or pain. This is known as the ‘sensory theory’ and it proposes that increases in muscle extensibility after stretching are due to modified sensation (Weppler & Magnusson, 2010). Changes in neurodynamics (movement of the nervous system) could modify such sensations. Neurodynamics is the term used to describe the integration of the morphology, biomechanics and physiology of the nervous system (Butler, 2000; Shacklock, 2005).

An individual with decreased hamstring extensibility may demonstrate limited range in the passive straight leg raise test (SLR) because of altered neurodynamics affecting the sciatic, tibial and common fibular nerves (Kornberg & Lew, 1989). Abnormal posterior lower extremity neurodynamics may influence resting muscle length and lead to changes in the perception of stretch or pain (Marshall, Cashman, & Cheema, 2011). It follows that providing a movement/stretching intervention could alter the neurodynamics and lead to modification of the sensation and ultimately, increased extensibility.

The purpose of the current paper, therefore, is to explore the effect of a specific neurodynamic intervention on passive SLR in healthy soccer players, and specifically investigate the hypothesis that neurodynamic mobilizations (sliders) would produce a greater ipsilateral increase in SLR than control treatment.

2. Methods and materials

2.1. Subjects

We recruited a convenience sample of 28 subjects (all male; mean age 20.8 ± 1.0, range 19–22) who were active in the Palencia non-professional soccer leagues. Subjects had to be aged between 18 and 25 years, and actively participating in soccer (training and competitive matches) for at least 5 h/week and at least 3 days/week. Exclusion criteria were as follows: a) any hamstring injury within the past year; b) presence of any history of neurological or orthopedic disorder affecting the lower extremities (e.g. peripheral neuropathy, femoral fracture, meniscal injury, low back pain, etc.); and/or c) exceeding 75° in the initial passive SLR. Subjects signed a consent form and agreed to participate in two testing sessions separated by one week. Recruitment occurred between April and July 2010. This study received ethical approval from the Ethical Committee of the University of Granada, Spain.

2.2. Measurement of hamstring flexibility

All physical measurements were obtained by the same pair of trained evaluators who were blinded to each subject’s group allocation and included height and weight to determine body mass index (BMI = kg/m²). The passive SLR test was used to determine changes in hamstring muscle extensibility. With the subject in the supine position, the lateral condyle of the femur was pinpointed with a marker, as were the head of the fibula and the fibular malleolus. The axis of a goniometer was placed on the projection of the greater trochanter of the femur. One of the arms of the goniometer was placed parallel to the table (checking with a level). The knee and ankle were kept in the extension position. Holding the talus and without rotating the hip, flexion of the hip was gradually increased, lifting the subjects’ lower limb until they first complained of pain in the region of the posterior thigh. The point of first onset of pain has traditionally been referred to as P1 (Maitland, Hengeveld, Banks, & English, 2005). Care was taken to ensure that they did not bend their knee, or begin to swing the pelvis in retroversion. At that moment, the other arm of the goniometer was placed in the direction of the line between the head of the fibula and the fibular malleolus, and the degree of elevation of the straight leg was noted. One evaluator was tasked with performing the passive SLR to P1, while the other was tasked with taking the goniometric measurement (Fig. 1). This measurement has been shown to have high reliability and validity in various studies. Boyd (2012) reported intra-rater reliability ICCs to be 0.95–0.98; the standard error of measurement (SEM) was between 0.54° and 1.22°; and minimal detectable change was between 1.50° and 3.41°. Walsh and Hall (2009) found substantial agreement between SLR and slump test interpretation (kappa = 0.69) and good correlation in ROM between the two tests (r = 0.64). Measurements were taken before the intervention and re-evaluated after the intervention (moving to end of ROM). Between-session intra-rater reliability was established on the first 10 subjects as sufficient for clinical measurement (ICC = .91).

2.3. Procedures

All subjects began with a single measure of the passive SLR on their dominant (kicking) leg. As long as range of motion was ≤75°,

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Fig. 1. Measurement of hamstring flexibility pre- and post-intervention using the passive straight leg raise (SLR) test with universal goniometer.
they were accepted into the study. We chose to limit passive SLR range of motion to ensure we would have subjects with bilateral short hamstring syndrome as described by Ferrer (Ferrer, 1998; Ferrer, Santonja, Carrion, & Martinez, 1994; Verrall, Slavotinek, & Barnes, 2005). Using a random numbers table, subjects were randomly assigned to either an intervention group or a control group. Subjects in both groups were measured for passive SLR as described above and the average of 3 measurements was obtained for each subject. Subjects in the intervention group were then treated with neurodynamic sliding techniques on 3 different days over 1 week, and instructed to continue their routine soccer training sessions and matches as scheduled during the study. Subjects in the control group were given no specific treatment and instructed to continue their routine soccer training and matches as per usual. Both groups were allowed to continue their hamstring stretching and warm-up procedures before soccer training sessions and matches during the study. After 1 week, subjects in both groups had their passive SLR re-measured, with an average of 3 measurements once more. The study design is shown in Fig. 2.

The neurodynamic sliding techniques administered to the intervention group consisted of ‘seated straight leg sliders’, and were provided by a researcher blinded to SLR measurements. These neurodynamic sliders are maneuvers performed in order to produce a sliding movement of neural structures relative to their adjacent tissues (Butler, 2000; Mintken, Puentedura, & Louw, 2011). Sliders involve application of movement/stress to the nervous system proximally while releasing movement/stress distally, and then reversing the sequence. Research has shown that sliders actually result in greater excursion than simply stretching the nerve (Coppieters & Butler, 2008). Each subject sat with their trunk in thoracic flexion (slump) and while maintaining that posture, they performed alternating movements of knee extension/ankle...
dorsiflexion with cervical extension, and knee flexion/ankle plantarflexion with cervical flexion (Fig. 3). Subjects performed these active movements for approximately 60 s and repeated them 5 times. At present, there is no research evidence on the appropriate dosage for active neurodynamic slides; however, we chose 60 s and 5 repetitions based on clinical experience and suggestions from authors (Butler, 2000; Nee & Butler, 2006). Each of the subjects in the intervention group was treated with the neurodynamic sliders for 3 sessions on alternate days over 1 week. All interventions were provided by the same researcher in the training rooms at the soccer club.

2.4. Statistical analysis

Descriptive statistics (mean, standard deviation, 95% CI) were calculated for pre-test and post-test SLR averaged values for the 2 groups. SLR responsiveness data were calculated using the between-session ICC established in this study (ICC = .91) and the formula: SEM = SD × √(1 – ICC) (Weir, 2005) and MDC95 = 1.96 × √SEM (Stratford, 2004). To analyze the difference between groups over time on hamstring extensibility (SLR), one 2 (group: intervention and control) × 2 (time: pre and post) mixed factorial ANOVA with repeated measures on both factors was conducted, with appropriate post-hoc analysis. Significance level was set at .05. A Bonferroni corrected alpha of .0125 (four t-tests) would be utilized for simple main effects (SME) analyses.

3. Results

Characteristics of the study sample are summarized in Table 1, and demonstrate that there were no significant differences between the groups at the start of the study. Standard deviations for SLR measurements ranged from 5.9 to 7.0. This allowed us to calculate a range of SEM from 1.8 to 2.1 and subsequently a range for the MDC95 of 5.0–5.8. The neurodynamic intervention group had a pre-test mean range of 58.1 (95% CI: 54.3–61.8) and post-test mean range of 67.4 (95% CI: 64.2–70.7). The control group had a pre-test mean range of 58.9 (95% CI: 55.2–62.7) and post-test mean range of 59.1 (95% CI: 55.9–62.4). The pre-test-to-post-test differences in average SLR values for the neurodynamic intervention (9.4°) but not for the control group (0.2°).

A statistically significant interaction was observed, \( F(1,26) = 159.187, p < .0005 \) (Fig. 4). There was no difference between the groups at the start, \( p = .743 \); however, at the end of the study, the groups were significantly different with more range of motion in the group that received neurodynamic interventions (\( p = .001 \)). The group that received neurodynamic interventions improved significantly over time (\( p < .001 \)), whereas the control group did not (\( p = .684 \)).

4. Discussion

The results from this study showed a significant between-group difference favoring the neurodynamic intervention with regard to increasing post-intervention hamstring flexibility. Furthermore, a within-group difference was observed for the intervention group over time (\( p < .001 \)) whereas no within-group difference was observed for the control group over time (\( p = .684 \)). Pre-test-to-post-test differences in average SLR values for the intervention group exceeded the MDC95 suggesting the changes observed were not a result of measurement error and represent a true change in hamstring flexibility following the neurodynamic sliders.

Increasing hamstring flexibility may play an important role in preventing lower extremity overuse injuries. In fact, a study on 298

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military basic trainees found that the numbers of lower extremity injuries were reduced after introduction of a hamstring stretching regimen that significantly increased hamstring flexibility (Hartig & Henderson, 1999). Another study by Malliaropoulos et al. (2004) followed 80 Greek athletes who were diagnosed as having second-degree hamstring strains. Subjects were divided into 2 groups and both groups performed the same stretches, although with a different frequency each day. Researchers found that the group who stretched more frequently regained normal knee extension range of motion (ROM) in an average of 5.6 days compared to 7.3 days for the control group \( (p < .001) \). The intervention group also returned to normal, unrestricted activities in an average of 13.3 days compared to 15.0 days for the control group \( (p < .001) \).

Most of the existing research on hamstring flexibility has focused on different modes of stretching, such as Proprioceptive Neuromuscular Facilitation (PNF) (Puentedura et al., 2011; Wallmann, Gillis, & Martinez, 2008); static stretching (Puentedura et al., 2011; Wallmann et al., 2008, 2011; McWhorter, 2005); plyometric stretching and ballistic stretching (Samuel, Holcomb, Guadagnoli, Rubley, & Wallmann, 2008). They have also compared different stretching intensities (Marshall et al., 2011) and frequencies (Feland & Marin, 2004). We could only find one older study (Kornberg & Lew, 1989) which examined the effect of neurodynamic ‘stretching’ on Australian Rules football players with grade one hamstring injuries. That particular study involved 28 subjects with grade one hamstring injuries, who also demonstrated positive responses to the slump test (neurodynamic test). The researchers randomized 16 subjects to receive traditional physical therapy management, and 12 to receive traditional management plus slump stretching. The results indicated that adding the slump stretch technique to traditional care was more effective \( (p < .001) \) in returning players to full function than the traditional management alone (Kornberg & Lew, 1989). In that particular study, researchers used a neurodynamic ‘stretch’ or what is now referred to as a ‘tensioner’ (Butler, 2000; Mintken et al., 2011) instead of the ‘slider’. We believe that this present study is the only one in the current literature to apply a neurodynamic slider technique to healthy subjects with shortened hamstrings. We chose to use a neurodynamic slider technique rather than a ‘tensioner’ because we wanted to assess for the effect of movement rather than stretch (which is a part of the ‘tensioner’) in altering perceptions of stretch or pain associated with the SLR.

Mendez-Sanchez et al. (2010) completed a randomized controlled pilot study on 8 healthy male soccer players to assess the immediate effects of a sciatic nerve slider technique added to sustained hamstring stretching on lumbar and lower quadrant flexibility. Lower quadrant flexibility was assessed by the passive straight leg raise test performed in exactly the same manner as for our study. One group of 4 players were assigned to receive bilateral hamstring stretching while supine for 5 min while the other group of 4 received the same stretching plus a sciatic slider neural mobilization technique on both sides. The slider technique in their study consisted of placing each soccer player in supine with the neck supported in a flexed forward position and then applying hip and knee flexion concurrently, then alternating this with hip and knee extension and repeated the motions for 60 s. Both groups demonstrated improved flexibility over time; however, straight leg raise of the left leg showed a significantly greater improvement in the experimental group \( (Mendez-Sanchez et al., 2010) \). The experimental group also had greater improvements in lumbar and lower quadrant flexibility as measured by the modified Schöber test and slump test. The authors postulated that the observed changes may have been secondary to decreasing neuromuscular sensitivity; however, an alternative explanation may be that the neurodynamic sliders led to a modification of sensation such that the soccer players’ perceptions of stretch or pain were altered (Weppler & Magnusson, 2010).

Such a proposal is further supported by a recent study conducted by Aparicio, Quirante, Blanco, and Sendin (2009). The authors examined the immediate effect of a suboccipital muscle inhibition (SMI) technique on hamstring flexibility (measured by the forward flexion distance test; straight leg raise test; and popliteal angle test) and pressure pain threshold (PPT) over myofascial trigger points (MTrPs) in the hamstring musculature. Seventy subjects comprised of 49 students from the Physiotherapy School of the University of Extremadura (Spain) and 21 soccer players from the Extremadura Football Club, were randomly assigned to receive SMI or a placebo intervention. Results demonstrated that the SMI technique modified the flexibility of the hamstring muscles on all outcome measures, and furthermore, there was a significant difference in pressure algometry (PPT) for MTrPs in the right semimembranosus following the SMI \( (p = .021) \) but not the left semimembranosus \( (p = .079) \). The fact that such a distant technique (suboccipital region) can have an immediate effect on the flexibility and pressure pain thresholds in the

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**Fig. 4.** Mean SLR values \(^\circ\) with 95% confidence intervals of hamstring extensibility before and after intervention and control.
hamstrings may lend support to the ‘sensory theory’ proposed by Weppler and Magnnusson (2010). It appears reasonable to suggest that the observed increases in hamstring tissue extensibility following the SMI would have more likely come from changes in the subjects’ perceptions of stretch or pain associated with the flexibility and pressure pain testing. Although our study does not provide information about the mechanism of action or change, it does suggest that neurodynamic treatment can significantly increase hamstring flexibility in a young male athletic population.

4.1. Limitations

The present research was designed as a pilot study, and its findings should be considered as tentative. Some limitations should be acknowledged. The sample size was small and included only young males; thus, results cannot be generalized to other populations. Additionally, we only looked at differences in flexibility after a week of intervention and it is not possible to determine how long the observed increase in hamstring flexibility might have lasted. Furthermore, we did not conduct any long term follow-up to determine if the observed changes in flexibility resulted in any change in incidence of hamstring injuries with the groups. Future research should involve larger sample sizes, perhaps include female soccer players to assess for gender differences, and examine for more long term effects of neurodynamic interventions. Finally, despite the significant increase in flexibility for the neurodynamic intervention group, none of those players surpassed the 75° mark (upper bound 95% CI = 70.7°) indicating that they continued to have short hamstring syndrome (Ferrer, 1998; Hartig & Henderson, 1999). It is not known whether additional stretching may have enabled these players to improve further and this would need further research.

5. Conclusion

The findings of this study suggest that a neurodynamic sliding technique can increase hamstring flexibility in male soccer players. Future research should compare neurodynamic techniques with other interventions. Such studies should address additional muscle groups and examine the duration of lengthening in repeated measures.

Conflict of interest

None declared.

Ethical approval

This clinical trial received ethical clearance from the Universidad de Granada, Spain and was also approved by Hospital Virgen de las Nieves, Servicio Andaluz de Salud, Spain.

Funding

None declared.

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