THE IMMEDIATE EFFECT OF AN INCREASED DURATION OF UNILATERAL LUMBAR Z-JOINT MOBILISATIONS ON POSTERIOR CHAIN NEURODYNAMICS - A RANDOMISED CONTROLLED STUDY PROGRESSING CONCEPTS FROM A PRELIMINARY STUDY

Manual Therapy Manuscript Draft

Key words: Neurodynamics, joint mobilisation, neural mobilisation, neural tension

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ABSTRACT

Hamstring Injuries are a common place in many mainstream sports and can often lead to lengthy recovery periods and high reoccurrence rates. Effective prevention and therapeutic management of these injuries is vital in order to maximize performance. At present, clinicians employ stretching and posterior neural chain mobilisation techniques as part of pre-participation and rehabilitational programs. However, the efficacy of stretching regarding duration, dose, and mode remains controversial despite extensive research. Recent research also suggests that lumbar spine mobilisations produce sympathetic changes in the lower limbs. The results of a conducted preliminary study found that 3-minutes of unilateral zygoapophyseal joint posteroanterior mobilisations significantly improved passive straight leg raise (SLR) measurement in comparison to 3-minutes of a prolonged static posterior chain muscle stretch. These results indicate that lumbar spine mobilisations can immediately restore posterior chain neurodynamics. The current study is a follow up of the preliminary study and aims to investigate the immediate effects of 6 minutes of unilateral zygoapophyseal mobilisations in comparison to 6 minutes of static posterior chain stretch on passive SLR measurement. Using a single blinded, randomised controlled study design, 36 healthy participants were allocated into one of three groups (control; mobilisation; static posterior chain muscle stretch).

Measures of SLR were taken before and after intervention for each group on the day of testing. A Generalised Linear Model (GLM) analysis and a paired sample t-test showed a significant difference between base line and post-intervention for the mobilisation group only ($p<0.001$), and the stretching group ($p<0.001$) suggesting that a duration of 6 minutes of unilateral lumbar spine zygoapophyseal joint mobilisation or static posterior chain stretching has a significant influence in restoring posterior chain neurodynamics.

INTRODUCTION

Hamstring Injuries are a common place in many mainstream sports and can often lead to a lengthy time off sport due to their slow recovery (Orchard and Seward, 2002). The cause of hamstring strains is complicated and has been studied as in depth as any other sporting injury, yet it remains unclear. While the age of the sportsperson and prior history of hamstring strains have been consistently recognized as risk factors, these are unchangeable. The modifiable factors that have been associated with these injuries include fatigue, weakness, lack of soft tissue flexibility and motor control (Worrell, 1994) (Foreman et al, 2006). Most support is tending towards a strength imbalance between the hamstrings and quadriceps as being the primary factor in hamstrings strains. A study by (Yeung et al., (, 2009) found a 17-fold increase in risk of hamstring injury if the athlete has a hamstring : quadriceps peak torque ratio of less than 0.60 at an angular velocity of 180°/second.

In addition to these factors, adverse posterior chain neurodynamics have also been found to be an important clinical feature associated with repetitive hamstring strain injuries (Turl and George, 1998). Neurodynamics is the term used to describe the integrated morphological, biomechanical and physiological functions of the nervous system (Shacklock, 2005; Butler, 2000). In regards to the lower limb and posterior chain, the most common measure of lower quarter neurodynamics is what is known as the passive SLR test. (Coppieters et al., 2005) According to Turl and George (1998), effective methods aimed at reducing posterior chain neurodynamics are neural mobilisation techniques.

In 2010, a preliminary study was conducted by Szlezak, Georgilopoulos, Bullock-Saxton & Steele (submitted) et al, - this looked at the immediate effect of 3-minutes of unilateral lumbar spine Z-joint mobilizations versus static hamstring stretching on posterior chain neural tension. The results of this study showed that unilaterally applied grade III oscillatory PA mobilisations at a frequency of 2Hz from T12/L1-L5/S1 Z-joints for 30 seconds per joint (3 minutes total time) produced an immediate increase in mean SLR measure from pre-intervention base line. This result was highly significant and indicated a reduction in posterior chain neurodynamics post intervention. On the contrary, the results of the prolonged 3-minute static hamstring stretch displayed no significant improvement in hamstring range of motion measurements.

The findings of this study had a highly relevant outcome, as there is such little research around the effects of lumbar spine mobilisations on passive SLR measurements and thus posterior chain neurodynamics. These results support the findings of a study by Turl and George (1998) who found that neural mobilising techniques could reduce injury rates ~~of~~ for athletes sustaining a ~~with~~ grade one hamstring strain. In addition, these findings also ~~validate~~ support the ~~results to~~ research describing ~~into~~ the effects of cervical spinal mobilisation on peripheral nervous system function, neural tension and muscle activation (Sterling et al., 2001). Results were also consistent with a study by Perry and Green (2007) who found that unilateral lumber joint mobilisations of 2 Hz, to the left L4/5 lumbar zygoapophyseal joint (Z-joint) results in side-specific peripheral sympathetic nervous system changes in the lower limb. Ultimately, ~~As~~ the body of research in this field remains thin with multiple questions remaining to be answered. For example, what is the ideal duration of spinal mobilization techniques to gain the best clinical outcome?

On the contrary, the results to the prolonged static stretch in the study by Szlezak et al (~~2010~~submitted), raised significant ~~a cloud of~~ doubts into ~~into~~ the effectiveness of stretching as an intervention. Stretching to achieve improved flexibility is of widespread use in the recreational, sporting and rehabilitation setting, with a general acceptance that it decreases the chance of injuries and allows for enhanced performance. The literature on stretching to improve flexibility is controversial with an array of studies producing conflicting evidence. A study by Bandy et al (1997) demonstrated that 30 and 60 seconds of static stretching of the hamstrings 5 days/week for 6 weeks increases flexibility significantly more than 15 seconds or no stretch. Norez et al (2006) also demonstrated range of motion gains post static stretching.

Research on the best mode, type and duration of stretching remains undefined and this is largely due to a lack of homogeneity in the research combined with poor methodological quality. It would be premature to disregard stretching as a valid means for increasing flexibility with the current evidence. The optimal dose rate ~~In understanding the mechanisms for which there was no change in range of motion with a static hamstring stretch remains unclear. Stemming the question of whether 3-minutes~~ of static stretching may need further exploration ~~is enough time~~ to see gains in range of motion.

This study aims to investigate the hypothesis that 6-minutes of unilateral lumber z-joint posteroanterior (PA) mobilisations (2Hz) would increase ipsilateral SLR significantly greater than 6 minutes of prolonged static hamstring stretching and no intervention. In addition, the results will provide further insight into the effectiveness of a lengthened stretching and mobilisation time period when comparing it with the results from the preliminary study completed in 2010.

METHODS

Subjects

The study recruited 36 subjects between the age of 18 and 65 years of age from the local community, University and running clubs. Subjects were recruited through information flyers indicating the subjects need to be musculoskeletally asymptomatic.

All volunteers underwent a screening process that ensured subjects were healthy with no contraindications or precautions to manual therapy (Grieve, 1984). Subjects suitability also involved using the following inclusion/exclusion criteria: SLR test- 70 degrees or less, a negative hip quadrant test (to eliminate hip joint pathology), and nil reported history of spinal surgery or severe spinal pathology.

Subjects were randomly allocated into one of three groups, using an opaque sealed, numbered envelopes prepared from random number table groups. The subjects gave their written consent following verbal and written explanation of the study. All ethics were approved through the Bond University Research Ethics Committee.

Research design

A single blinded randomized controlled research design was used, with each subject being randomly allocated into the *control group*, *stretching group* or the spinal *mobilisation group*. Internal validity of the study was enhanced by single blinding. All of the interventions were performed in a private room. There were two researchers who conducted the study. Researcher one applied the equipment and passively raised the limb into straight leg raise to gain the reading of hip flexion achieved. Researcher one then exited the room and Researcher two then entered. Researcher two opened the envelope and completed one of the three interventions and then exited the room. Researcher one then re-entered the room and re-assessed straight leg raise measurement. Blinding was ensured as no communication occurred between the two researchers from when researcher 2 entered the room to the point where the following re-assessment of straight leg raise was carried out by researcher 1.

Research Method

All treatment groups began with a straight leg raise measurement. This was achieved using a special device to maintain the leg in full extension with the ankle in plantar grade (see Figure 1). Not only was this device able to standardize leg position when measuring, it positioned the leg with increased neural tension in the posterior chain. (Boyd et al., 2009) The degree of hip range of motion was calculated in degrees relative to the horizontal using a bubble inclinometer, which was attached to the SLR device.

Each subject lay on a treatment plinth in a standardized position. The non tested limb remained in full extension with the patient being asked to keep this limb flat on the plinth and not to raise it as any time. The tested limb was fitted into the straight leg raise device and passively raised into hip flexion until resistance one (R1), as determined by the researcher was achieved (see Figure 2). Testing of range did not go to resistance 2 (R2) as although it may have high repeatability, it carries with it risks, such as overstretching and further irritation of the nervous system. (Boyd et al., 2009) Measurement of this angle on the inclinometer was recorded ~~by another examiner??~~ ~~reported~~ and the leg was then brought back down to the plinth. Movement of the limb was controlled ~~in the~~ within the sagital plane. This measurement process was performed two more times on the tested leg and then repeated on the contralateral leg. The leg with the lowest range of motion was then termed the "testing leg".

Researcher 1 then exited the room and researcher 2 entered after being notified of the "testing leg". This researcher performed one of the three randomized interventions and then left the room. Researcher one then re-entered and repeated the measuring protocol described earlier. No contact was made between researchers at the last change over. The three intervention groups are as follows:

- *ontrol group:* subject lay in supine position for six minutes (in the presence of researcher 2)
- *tretching group*: subject underwent six minutes of sustained static stretch on the testing leg to point R1 as determined by researcher 2.
- *obilisation group*: subject lay prone on plinth and researcher 2 applied unilateral grade III oscillatory PA-mobilisation at a frequency of 2Hz to T12/L1, L1/L2, L2/L3, L3/L4, L4/L5 and L5/S1 zygoapophyseal joints for 1-minute per joint. This meant 6 minutes of total treatment of the ipsilateral side to the testing leg.

Data analysis

A general linear model analysis was used to determine if there was a significant difference from pre to post intervention in each of the 3 three treatment groups. A post hoc paired sample t-test was then used to determine if there were differences between the 3 treatment groups with a level of significance set at a p value of less than 0.05.

RESULTS

The mean and standard deviation of all demographic data for the 36 participants are displayed in Table 1. The control group consisted of 3 females and 9 males; mobilisation group consisted of 3 females and 9 males and the stretching group consisted of 2 females and 10 males. An analysis of variance was completed to detect any differences between the three treatment groups. Results to this analysis found no significant differences between all three groups in terms of height ($p = 0.894$), weight ($p = 0.543$) and Age ($p=0.726$).

Ipsilateral SLR and time

A general linear model analysis of SLR measurements when compared to time demonstrated a significant change ($p<0.001$) between treatment groups pre-post intervention. A repeated measures ANOVA was then completed to indicate where the significant change rests. The results indicate a significant change in SLR between pre-post mobilisations ($p<0.001$) and pre-post stretching ($p<0.001$) (See Figure 5). The *control group* was the group that was different to the other two treatment groups. When this measure was repeated without the *control group* there was no treatment effect, ($p= 0.243$) but an improvement regardless of treatment group ($p <0.001$) was evident.

Contralateral SLR and time

A general linear model analysis of the contralateral SLR measurements demonstrated no significant changes from pre-post intervention when compared against time in all three groups (see Figure 6).

DISCUSSION

The results to this study show that 6 minutes (1 minute per z-joint) of grade III unilaterally applied PA mobilisations to T12/L1, L1/L2, L2/L3, L3/L4, L4/L5, L5/S1 zygoapophyseal joints significantly increases passive straight leg measurements ($p<0.001$) on the ipsilateral side of treatment when compared to baseline measurements and the *control group*. The results also indicate that 6 minutes of a prolonged static hamstring stretch applied to resistance one also significantly increases passive straight leg raise measurements ($p<0.001$) on the ipsilateral side when compared to baseline measurements and the *control group*. Therefore, both treatments have shown to be effective interventions in increasing passive straight leg raise measurements on the ipsilateral side to treatment. These results reject our original hypothesis that 6 minutes of unilateral z-joint mobilisations would increase unilateral straight leg raise measurements significantly more than 6 minutes of prolonged static hamstring stretching or no treatment. When comparing both treatment groups, the results indicate that the *stretching group* was as effective in increasing passive SLR measurements as the *mobilisation group.* However a slightly higher mean change was evident in the *mobilisation group* (8.67 degrees) when compared to the *stretching group* (6.08 degrees). This could be due to the effectiveness of the intervention or that the baseline passive straight leg raise measurements were, although non significant, slightly higher in the *stretching group*. When analyzing the subjects, there were an overall higher number of males than females who took part in the study. However, when comparing the three treatment groups there were no significant differences in each group, indicating that all of the three treatment groups had an even male to female ratio and that this could not have an influence on the outcome of the study.

The significant increase in passive SLR measure seen in the *mobilisation group* is in accordance with the results from the preliminary study completed in 2010. Again, these changes are likely to be due to restoration of normal neurodynamics. Furthermore, when comparing the amount of overall change post 3 minutes to 6 minutes of mobilisation there is minimal difference. In the preliminary study by Szlezak et al (submitted), the mean increase in ROM was 8.5 degrees. The results to the current study illustrate an overall mean increase of 8.67 degrees in ROM. This indicates that the gains of grade III mobilizations on the z-joint joint as an intervention, may peak around a duration of 30 seconds and begin to plateau if mobilisation were to continue. The underlying mechanisms for this effect remains undefined, as is the mechanism by which mobilisation can cause changes in peripheral sympathetic nervous system activity. (Perry and green, 2008). Szlezak et al (submitted) postulated that mobilisations might play a role in resetting the activity of gamma motor neurons (gamma gain) due to their role in regulating muscle spindle fiber length. However, it could be in line with a theory by Zusman (1986) who believes the effects of mobilisation are more anatomical and related to a direct effect on the articular and periarticular structures of the spine. In addition, the neurophysiological effects following mobilisation have revealed that mobilisations can also produce an immediate hypoalgesic and sympathoexcitatory effect on both asymptomatic and symptomatic subjects. (Vincenzino 1995; Sterling et al 2001) Therefore, could a significant change in SLR measurement be attributed to altered sensation that is a result from a hypoalgesic response? Ultimately, the findings suggest a strong neurophysiolgical and anatomical inter-relationship exists and that this can be altered with mobilisation techniques.

The significant effect of the stretching group on reducing posterior chain tissue extensibility is not in accordance with results from the preliminary study. When comparing 3 minutes to 6 minutes of prolonged static stretching, the results suggest a longer duration is required to achieve gains in ROM.
These findings are in accordance with findings within the literature. When looking into the effects of different durations of static stretching on range, 4 x 30 seconds of static plantar flexor stretch had no effect on resistance (Muir et al., 1999). Similarly, 2 x 45seconds of static hamstring stretches had no effect on resistance to passive stretch. (Magnusson et al., 2000b). On the contrary, research looking at prolonged periods of static stretching found different outcomes. McHugh and Nesse (2008) demonstrated that a 5x90 second static hamstring stretch reduced passive resistance to stretch up to 8.3%. In

addition, Ryan et al (2008a) concluded that the effects of a 4 minute stretch duration were still apparent after 10 minutes and that this may be the minimal stretch duration required to provide a prolonged effect. At present, there are various theories proposed to explain the changes in muscle extensibility following stretching. The mechanical theories attribute changes in muscle extensibility to viscoeleastic deformation, plastic deformation, increased sarcomeres in series, and neuromuscular relaxation. However, the most contemporary theories attributes increases in muscle extensibility to what is termed the "sensory theory". (Magnusson and Weppler, 2010) Postulating that increases in tissue extensibility do not come from affecting the mechanical properties of the muscle but are the result of changes in the individual's perception of the specific sensation. When evaluating the results of this literature, it is apparent that in order to see gains in ROM, prolonged stretching times of 4-6 minutes are required. In the sporting arena, such an intervention would appear unrealistic and is distant from what is being achieved currently in pre-participation stretching practices.

Unsurprisingly, the results indicate that there is no crossover effect following unilateral mobilisation or prolonged stretching to the contralateral limb. This is supported by previous research by Perry and Green (2008), who established a significant side specific effect to unilateral PA lumbar mobilsation as measured by skin conduction. Therefore, the response to mobilisation was localized and not systemic. In addition, Sterling et al, (2001) reported an increase in 22.5% in pain pressure threshold (PPT) measures isolated to the side of treatment following unilateral PA mobilisation in the cervical spine. There was only a minimal change of less than 5% on the contralateral side to treatment. In a clinical context, it would therefore deem inappropriate for a therapist to treat the non-painful side of a patient's body in an effort to gain benefits on the contralateral or painful side.

The use of the passive SLR measure as the sole outcome measure included in the study is again a major limitation. In addition, having only one investigator to perform the SLR measurement may have lead to possible observer error or bias. However, it was not feasible to have a third investigator present in the practice for the length of the data collection period. Future recommendations for research should firstly examine the lasting effects of each of these interventions for clinical relevance. It would also be beneficial to examine the combined effects of both mobilisations and stretching on passive SLR measurements to determine if there is an excess advantage. This may also push us another step closer to understanding the underlying mechanisms of action. Due to the broad inclusion criteria for the study, future consideration may focus on the athletic population to gain further insight into the prevention and rehabilitation of Hamstring strains.

In conclusion, this study has compared both old and new concepts and has established treatment techniques, which can influence posterior chain neurodynamics. It has provided evidence for treatment dosages, revealing that a shorter duration of spinal mobilisations (30 seconds) is sufficient to produce maximal gains from the joint. It has also established that the benefits of passive stretching can only be seen following a prolonged period (6 minutes), ultimately questioning its use within the clinical setting. Finally, these findings and the new themes presented within the study provide knowledge to facilitate clinicians in their clinical reasoning processes when faced with symptoms in the posterior chain.

Measure	Control group (3F, 9M)	Mobs group (3F, 9M)	Stretch group (2F, 10M)

Height	Mean ± SD	178.875 ± 5.753	177.583 ± 7.134	178.083 ± 7.185
Weight	Mean ± SD	88.363 ± 29.38	81.858 ± 11.11	79.738 ± 13.47
Age	Mean ± SD	31.92 ± 15.006	32.25 ± 14.4	28.42 ± 8.295
SD: standard deviation; Height: centimeters; Weight: kilograms; Age: years; M: male; F: female				

Table 1: Anthropometric data of all participants within the study

Figure 1: Straight Leg Raise Measuring Device

Figure 2: Straight Leg Raise Measuring

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Figure 3: Demonstration of Passive Stretch applied in the stretching group

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Figure 4: Demonstration of Unilateral Posterior to Anterior Grade III mobilisations applied in the mobilisation group

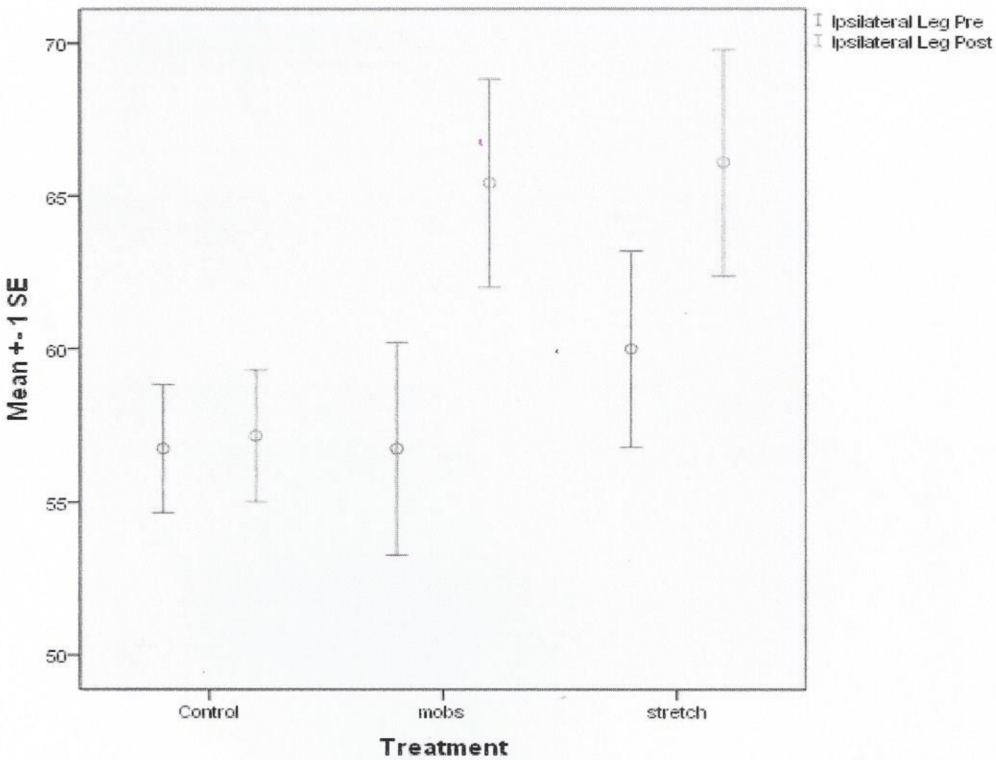

Figure 5: Error bar chart illustrating the mean SLR measurements ± Stand error (S.E) pre and post interventions on the ipsilateral side to treatment

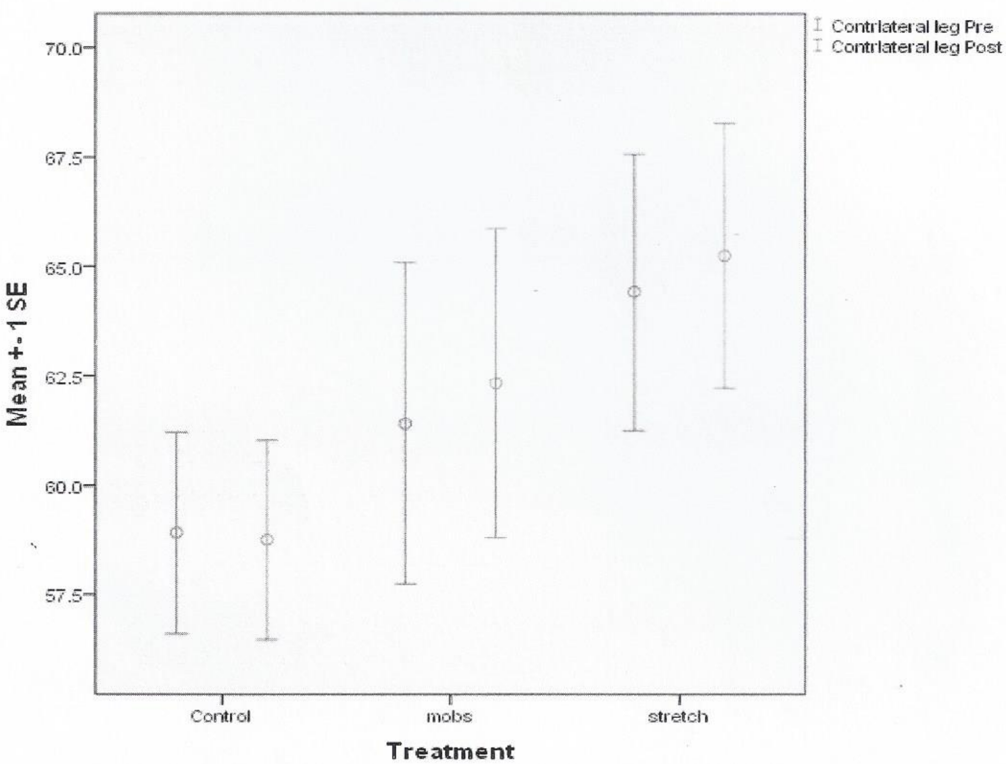

Figure 6: Error bar chart illustration the mean SLR measurements ± Standard error (S.E) pre and post interventions on the contralateral side to treatment

BIBLIOGRAPHY

Bandy WD, Irion JM; Briggler M, The effect of time and frequency of static stretching on the flexibility of the hamstring muscles, Physical Therapy, 1997; 77(10); 1090-6

Boyd BS, Wanek L, Gray AT, Topp KS. Mechanosensitivity of the lower extremity nervous system during straight-leg raise neurodynamic testing in healthy individuals. Journal of Orthopaedic & Sports Physical Therapy 2009; 39(11): 780- 790.

Butler DS. The Sensitive Nervous System. Adelaide, Australia: Noigroup Publications, 2000. 1st ed.

Foreman T, Addy T, Baker S, Burns J, Hill N, Madden T. Prospective studies into the causation of hamstring injuries in sport: a systematic review. Physical Therapy in Sport, 2006; 7: 101–109.

Magnusson SP, Aagaard P, Nielson JJ. Passive energy return after repeated stretches of the hamstring muscle– tendon unit. Med Sci Sports Exercise 2000b: 32: 1160–1164.

McHugh MP, Nesse M. Effect of stretching on strength loss and pain after eccentric exercise. Med Sci Sports Exerc 2008: 40(3): 566–573performance. J Strength Cond Res 2008: 22: 781–786.

Muir IW, Chesworth BM, Vandervoort AA. Effect of a static calf-stretching exercise on the resistive torque during passive ankle dorsiflexion in healthy subjects. J Orthop Sports Physical Therapy 1999: 29: 106–115.

Nordez A, Cornu C, McNair P. Acute effects of static stretching on passive stiffness of the hamstring muscles calculated using different mathematical models, Clinical Biomechanics, 2006; 21: 755-760.

Orchard J, Seward H. (2002) Epidemiology of injuries in the Australian Football League, seasons 1997-2000, British Journal of Sports Medicine, 36(1): 39–44.

Perry J, Green A. An investigation into the effects of a unilaterally applied lumbar mobilisation technique on peripheral sympathetic nervous system activity in the lower limbs. Manual Therapy 2008; 13(6): 492-499.

Ryan ED, Beck TW, Herda TJ, Hull HR, Hartman MJ, Costa PB, Defreitas JM, Stout JR, Cramer JT. The time course of musculotendinous stiffness responses following different durations of passive stretching. J Orthop Sports Phys Therapy, 2008a; 38: 632–639.

Shacklock MO. Clinical Neurodynamics: A New System of Neuromusculoskeletal Treatment. Oxford, UK: Butterworth-Heinemann, 2005.

Sterling M, Jull G, Wright A. Cervical mobilisation: Concurrent effects on pain, sympathetic nervous system activity and motor activity. Manual Therapy 2001; 6: 72-81.

Szlezak AM, Georgilopoulus P, Bullock-Saxton JE, Steele MC. The immediate effect of unilateral lumbar Z-joint mobilisation on posterior chain neural tension: a randomized controlled study. Manipulative Therapy (submitted)

Turl SE, George K. Adverse neural tension: A factor in repetitive hamstring strain? Journal of Orthopaedic & Sports Physical Therapy 1998; 27: 16-21.

Vicenzino B, Gutschalg F, Collins D, Wright A. An investigation of the effects of spinal manual therapy on forequarter pressure and thermal pain thresholds and sympathetic nervous system activity in asymptomatic subjects: a preliminary report. In: Shacklock M, editor. Moving in on pain. Adelaide: Butterworth- Heinemann; 1995.

Weppler CH, Magnusson SP. Increasing muscle extensibility: a matter of increasing length or modifying sensation? Physical Therapy 2010; 90 (3): 438-449

Worrell, T. Factors associated with hamstring injuries. An approach to treatment and preventative measures. Sports Med, 1994;17: 338–345.

Yeung SS, Suen AM, Yeung EW, A prospective cohort study of hamstring injuries in competitive sprinters: preseason muscle imbalance as a possible risk factor, Br J Sports Med 2009; 43: 589-594

Zusman M. Spinal manipulative therapy. Australian Journal of Physiotherapy 1986; 32(2): 89–99.