Journal of Novel Physiotherapies

Curtis et al., J Nov Physiother 2016, 6:1
http://dx.doi.org/10.4172/2165-7025.1000283

Research Open Access

Acute Effects of Neural Mobilization and Static Hamstring Stretching on Multi-joint Flexibility in a Group of Young Adults

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Rec date: January 25, 2016**; Acc date:** February 17, 2016**; Pub date:** February 27, 2016

Abstract

Neural tension has been proposed to be a factor influencing multi-joint movements such as sprinting, kicking and bending to pick up an object. Neural mobilizations have been demonstrated to increase range of motion in one joint, however the effect on flexibility across multiple joints has not been described nor compared to the traditional static stretch response. The aim of this study was to compare the effect on flexibility across multiple joints of neural mobilization to the traditional static stretch response. Fifty-two young adults (F = 32, M = 20; aged 18 – 25 years) were recruited from Charles Sturt University and a NE Victorian cross country ski camp and randomly allocated to receive a neural mobilization or static hamstring stretching intervention. The neural mobilization group received three, thirty-second passive Grade III neural mobilizations and the static stretch group received three, thirty-second passive static hamstring stretches. Effects of intervention were evaluated using the Mann-Whitney U test for unmatched samples. Pre-post difference in flexibility/range of motion was assessed using the Wilcoxon Signed Ranks test for matched samples. Spearman's Rank Order Correlation analysis was performed to assess correlations between participant characteristics and the change in flexibility following intervention. Post-intervention toe touch distance increased significantly following neural mobilization (median change = 22.5 mm; $p < 0.01$) and static hamstring stretching (median change = 25.0 mm; $p < 0.01$). There was no significant difference between the effects of either intervention on toe touch distance. A single session of neural mobilization produces a similar increase in toe touch distance to static hamstring range of motion, suggesting that neural tension may be a factor influencing multi-joint range of motion.

Keywords: Neural mobilization; Static hamstring stretching; Toe-touch distance; Slump test

Introduction

Flexibility, the available range of motion at a joint [1], is believed to be limited mainly by muscles and joint capsules [2]. Joint range of motion (ROM) is limited to a greater extent by muscles crossing multiple joints, such as the hamstrings, because they generally lack sufficient length to allow full range of motion at both joints [3]. More recently researchers have proposed that neural tension may also limit joint range of motion [4,5].

Neural tension in the lower limbs is assessed using neurodynamic tests such as the slump test described by [6] during which a subject sitting in a slumped posture with lumbar, thoracic and cervical flexion progressively adds knee extension and ankle dorsiflexion to increase tension on the neural system. Neurodynamic refers to the extent the nerve axons and sheath are stretched during tests such as the slump test. It has previously been demonstrated that the addition of components in neurodynamic tests causes restrictions in available joint range of motion, suggesting that neural tension may limit range of motion [7-9]. During picking up an object, movement occurs at both the lumbar spine and hips to facilitate these actions [10]. Similarities exist between these movements and those occurring during the slump test. Neural tension may be a factor that could limit range of motion during various activities including the slump test.

While it has been shown that tension in neural structures increases during neurodynamic tests [11] and that movement of neural structures occurs [12] there is some contention that other structures, such as muscles or fascia, could also be stressed by these tests [13,14]. Although it has been found that symptoms produced during the slump test are not related to hamstring muscle tension [15] there is evidence to support range of motion in upper and lower limb neural tension tests being limited by other anatomical structures. Anatomical studies have shown that the cervical nerves have extensive attachments to structures they innervate (and that the lumbar fascia, a structure capable of transmitting tension, extends extensively throughout the body [16]. Other authors believe that the progressive decrease in range of motion seen in neural tension tests suggests a continuous structure, such as nerve axons, is the limiting factor [8].

Muscle stretching or neural mobilization efficacy depends on the required outcome and more importantly on the individual and whether muscle or neural tissue is involved. Static stretching has been shown to be more effective than dynamic stretching for those recovering from hamstring strains [5] but if neural tissue is involved as a cause of limited ROM then neural mobilization may be a better treatment option [4]. Neural mobilization can be used to alter range of motion where neural tension is believed to be restricting range of motion due to tension resulting in clinical symptoms [17] described two neural mobilization techniques that can be used to mobilise neural tissue. The 'tensioner' technique uses movements that increase tension along the course of the entire nerve, while the 'slider' technique uses alternate movements that increase tension at either end of the nerve tract to slide the nerve in its surrounding structures. Multiple studies have demonstrated that neural mobilizations increase range of motion [17-23], however all have only monitored the effects at one joint. Further research is required to identify the effects of neural mobilization on the movement systems observed during sprinting, kicking and picking up a ball, which hall involve multiple joints.

The primary aim of the current study is to compare the effects of neural mobilisation in a slump position and static hamstring stretching on the toe touch test in healthy individuals. The secondary aim is to explore the effects of these interventions on other measures of range of motion to learn more about the factors influencing the toe touch test. It is hypothesised that neural mobilisations will result in a greater increase in the distance reached in the toe touch test than static hamstring stretching. Furthermore, it is hypothesised that neural mobilisation will also improve slump test range of motion but not hamstring range of motion, and that the converse will occur following static hamstring stretching.

Methods

Fifty-two individuals (F = 32, M = 20) aged 18 – 25 years were recruited from Allied Health students attending Charles Sturt University and a North-East Victoria cross-country skiing camp. Participants were randomly allocated a number drawn by the researcher performing the intervention to either receive static hamstring stretching or neural mobilization. The study was approved by the University Human Ethics Committee and participants provided informed consent prior to commencing the research. All participants regularly participated in regular physical activity. Participants were free of current ankle, knee, hip or spinal injury that could cause pain or restrictions in (Figure 1) joint movement. Four participants reported a previous hamstring injury, however none had occurred in the previous two years and these participants were allowed to participate. All participants had sufficient range of motion to permit 90° of flexion at the hip.

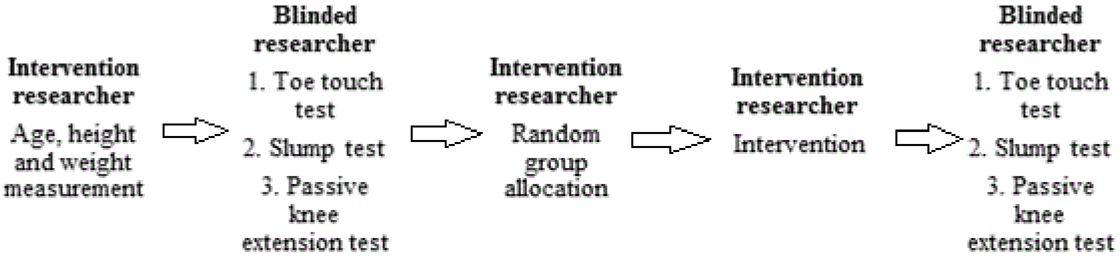

Figure 1: Data collection process.

Interventions

Twenty-six participants were randomly assigned to both the neural mobilization group (F=17, M=9) and the static stretch group (F=15, M=11). No significant differences in age, height or weight were detected between these groups (p > 0.05) (Table 1).

The neural mobilization group received three, thirty-second Grade III passive mobilizations (oscillating between knee flexion and extension) for left and right hand side in the slump position. Mobilizations were performed under the Maitland paradigm, whereby the grade of mobilisation is determined according to whether resistance or pain is the limiting factor [6,24]. The number of repetitions was chosen to maintain the same treatment time between the stretch and neural mobilization groups.

The static stretch group received three, thirty-second passive static hamstring stretches administered alternately and in direct succession for each leg. Stretches were performed with the participant in a supine position with their hip flexed to 90°.

Cohort	Parameters	Results	p test
Total (n=52)	Age (y)	21.8 ± 1.8*	ns
	Height (cm)	175.8 ± 7.9	ns
	Weight (kg)	70.0 ± 10.5	ns
Males (n=20)	Age (y)	22.3 ± 1.8	ns
	Height (cm)	182.6 ± 6.3	ns
	Weight (kg)	78.3 ± 11.0	ns
Females (n=32)	Age (y)	21.5 ± 1.8	ns
	Height (cm)	171.5 ± 5.3	ns
	Weight (kg)	64.9 ± 6.0	ns

* Mean ± SD; ns – not significant.

Table 1: Participant characteristics.

The researcher passively extended the knee until the participant reached the maximum extension possible without painful stretching sensation occurring. The intervention for each individual took approximately 5 to 10 minutes.

Outcome measures

Pre- and post-intervention range of motion was assessed by two blinded sport and exercise experts who were blinded with respect to the intervention. The toe touch test was used as a measure of multi-joint ROM. The slump and passive knee extension angle tests were used to discern whether a change in neural mobility or hamstring ROM was responsible for any changes in toe touch distance. Passive range of motion tests places the hamstring muscle into a predefined stretched position for this muscle group with the pelvis stabilized.

A simplified version of the toe-touch test described by [10] was used for this study, exchanging video analysis of movement for a more basic measurement of distance reached using a ruler. Participants stood with their feet together on a raised platform with a ruler attached to the front such that the scale extended above and below the platform. For the toe-touch test, participants were instructed to place one hand over the other and gently bend forward, keeping their knees straight and their head in a neutral position, to move their fingertips as close to the ground as possible. Three trials were performed at the participant's own pace to familiarise themselves with the test procedure. The distance from the ground was then measured at the fourth trial from the distal end of the third digit. Toe touch distance was recorded as the distance between the participant's fingertips and the ground when the participant had moved as far as they felt they could. Negative values indicated that the participant's fingers did not reach the platform, while positive values indicated that the participant had reached past the level of the platform [10].

The slump test was used in this study as a measure of neural tension and has previously been shown not to be affected by hamstring muscle tension [15]. This study used the slump test procedure as described by [17]. Briefly, participants sat on a plinth with their sacrum stabilised to control pelvis position and their legs fixed to the plinth using a nylon strap to minimise undesired hip movement. Participants then moved into a slumped trunk position while a second nylon strap was fixed over the participant's shoulders, just below the seventh cervical vertebrae, to ensure a consistent overpressure was maintained. The participant then flexed their cervical spine by tucking their chin into their chest whilst flexion overpressure was applied by the research assistant. The participant's left ankle was then dorsiflexed to an angle approximating plantar grade and the knee moved into extension until the onset of resistance. Range of motion was measured using a transparent 30 centimetre double-armed goniometer placed with the axis over the participant's lateral femoral epicondyle and the arms lined up with the lateral malleolus of the fibular and the greater trochanter of the femur. Joint angle was recorded as the number of degrees from full extension (0°). The procedure was then repeated for the right side.

The passive knee extension test was used as a measure of hamstring muscle tightness. Pelvic rotation has been shown to be less during this test [25] than in the straight leg raise test of the hamstring muscle [7], which has led some authors to conclude that it is the most valid measure of hamstring length currently available [26]. Any change in knee extension angle following intervention was likely to be indicative of changes in hamstring muscle ROM rather than neural tension and associated with a change in muscle tightness [26]. Briefly, participants reclined in supine on a plinth with the non-test leg fixed to the plinth in full knee extension using a nylon strap placed just above the knee. The research assistant then passively flexed the subject's left hip to 90° (measured using a plumb line through the lateral femoral epicondyle and the greater trochanter). A frame was placed over the participant to rest against their anterior thigh to maintain the hip joint position. The research assistant then passively extended the participant's knee, ensuring the foot was kept in a plantar flexed position, until the participant felt a strong but not painful stretch. The researcher measured and recorded the joint angle at the knee using a goniometer aligned with anatomical landmarks as for the slump test [27]. This process was repeated for the right leg.

Statistical analysis

A priori power analysis was carried out with the requirement of 0.8 power and $p < 0.05$. Effect size was included as moderate. Result of the power analysis indicated that the study was sufficiently powered to allow for type 1 and type 2 errors. Data was analysed using PASW Statistics Version 22.0 (SPSS Inc, Chicago, IL). The average of the left and right side measurements was used in the statistical analysis of the slump and passive knee extension test results. Descriptive statistics were generated from the data on basic group characteristics. Normality of data distribution was assessed using the Shapiro-Wilk test and non-parametric statistics (Mann-Whitney test) were used when the assumption of normality was violated. Differences between the pre-intervention characteristics (age, height, weight and ROM) of each group and the effects of each intervention were evaluated using the Mann-Whitney U test for unmatched samples. Pre-post difference in ROM was assessed using the Wilcoxon Signed Ranks test for matched samples. Spearman's Rank Order Correlation analysis was performed to search for correlations between participant characteristics and the change in ROM following intervention. Two-way analysis of variance (ANOVA) testing was used to further investigate significant results from the correlation analysis.

Results

Effect of intervention on toe touch distance

No statistically significant differences were found between groups for pre-intervention toe touch ROM ($U = 291.5$, $p = 0.395$). A Wilcoxon Signed Ranks Test showed a statistically significant increase in toe touch distance following intervention for participants in the neural mobilization group ($Z = -4.027$, $p < 0.01$) and static stretch group ($Z = -3.704$, $p < 0.01$). The median change in toe touch distance was 22.5mm and 25.0mm for the neural mobilization and static stretch groups respectively (Table 2). There was no statistically significant difference between the effects of either intervention on toe touch distance ($U = 326.5$, $p = 0.833$).

Effect of interventions on slump ROM

Pre-intervention slump test values did not differ significantly between groups ($U = 298.0$, $p = 0.464$). A Wilcoxon Signed Ranks Test showed a statistically significant increase knee extension in the slump test for participants in the neural mobilization group ($Z = -3.584$, $p < 0.01$) but not for those in the static stretch group ($Z = -1.496$, $p = 0.135$). There was a median increase in knee extension of 3° and 0.75° for the neural mobilization and static stretch groups respectively but no significant difference between the effects of either intervention on the slump test ($U = 240.5$, $p = 0.074$) (Table 3).

		Percentiles		
		25th	**Median**	**75th**
Neural mobilization	Pre-test	-127.50[*]	5	96.25
	Post-test	-91.25	35.00[a]	121.25
	Change	10	22.5	41.25
Static stretch	Pre-test	-18.75	45	90
	Post-test	-3.75	70.00[a]	111.25
	Change	5	25	41.25

[*]measures in millimetres (mm). [a] indicates significantly different result compared to pre-test ROM (p<0.01).S

Table 2: Effect of interventions on toe touch distance.

		Percentiles		
		25th	**Median**	**75th**
Neural mobilization	Pre-test	12.875°	25	31.5
	Post-test	12.375	18.25a	24.75
	Change	0.125	3	7.125
Static stretch	Pre-test	12	17.25	24.5
	Post-test	12.25	15	23
	Change	-1.625	0.75	4.125

°- degrees from full extension; [a]indicates significantly different result compared to pre-test ROM (p<0.01).

Table 3: Effect of interventions on slump test.

Effect of interventions on passive knee extension

No significant differences in pre-intervention passive knee extension results existed between the two groups (U = 261.0, p = 0.159). A Wilcoxon Signed Ranks Test showed no statistically significant change in passive knee extension following intervention for participants in the neural mobilisation group (Z = -0.539, p = 0.590) or the static stretch group (Z = -0.956, p = 0.339). The median change in passive knee extension was -0.75° for the neural mobilisation group and 1.0° for the static stretch group (Table 4).

Correlation analysis

A Spearman's Rank Order Correlation analysis was performed to determine the relationship between a participant's pre-intervention ROM and the change in ROM following intervention. There were moderate, negative correlations between pre-intervention toe touch distance, slump test angle and the change in toe touch distance in the neural mobilization group ($\rho\{24\} = -0.478$, p = 0.014; $\rho\{24\} = -0.424$, p = 0.031; $\rho\{24\} = -0.496$, p = 0.01 respectively). There was also a moderate, negative correlation between pre-intervention slump ROM and the change observed in the slump test for the neural mobilization group ($\rho\{24\} = -0.514$, p = 0.007). No relationships between pre-intervention ROM and the change in ROM following intervention were observed in the static stretch group.

		Percentiles		
		25th	**Median**	**75th**
Neural mobilisation	Pre-test	15.375	23.75	32.5
	Post-test	13.125	26.25	33.625
	Change	-2.125	-0.75	2.75
Static stretch	Pre-test	15.625	19	29.375
	Post-test	12.25	16.5	28.625
	Change	-1.625	1	3.125

°- degrees from full extension

Table 4: Effect of interventions on passive knee extension test.

Discussion

Toe touch distance was significantly increased by a single session of neural mobilisations ($p < 0.01$) or static stretching ($p < 0.01$). The effects of the static stretch intervention on toe touch distance are consistent with the findings of [28,29] who reported similar changes in the sit-and-reach test, a highly correlated alternative to the toe touch test [10,30]. The results of this study indicate that neural mobilisations are also an effective method of increasing toe touch distance. Further analysis of the data revealed there was no difference of practical significance between the effects of either intervention on toe touch distance (p = 0.833, d = 0.12). This suggests that both interventions are equally effective methods of increasing toe touch distance when applied for the durations used in this study.

Interpretation of what structures were responsible for the changes in toe touch distance must be performed with care. While video analysis of the toe touch test, as used by [10], would have allowed for identification of where movement was occurring during the test, the method used in this study provided a simpler, low cost method of assessing toe touch ROM. To determine the source of change in toe touch distance, this study related change in toe touch distance to that in the slump and passive knee extension tests. Assertions that changes in toe touch distance following the static stretch intervention were due to changes in hamstring ROM are based on evidence from previous research in this area and cannot be confirmed by the results of this study.

Effect of interventions on slump ROM

The neural mobilisation technique used was an effective method of improving knee range of motion in the slump test. The true cause of changes in range of motion following neural mobilisations is not clearly known. Although nerve excursion and changes in the tension of nerves has been demonstrated to occur in positions purported to increase neural tension [11,12], fascia may also be a limiting factor in these positions [16,31]. Differences in range of motion following neural mobilisation may reflect fascia or neural tissue changes, or a combination of both, however it is beyond the scope of this study to determine the anatomical effects of the intervention used.

The magnitude of change in knee range in the slump test was similar to that observed by Herrington, who reported a significant decrease in knee flexion angle (P=0.003) with a mean percentage change of 14.7+/-11.8% (3.4+/-2.5°) improvement following ten repetitions of a similar neural mobilization technique [17]. It is worth noting that despite using a greater total treatment time, the neural mobilization intervention used in the current study did not result in greater changes in the slump test than that observed by [17].

This suggests that there is little value in increasing the repetitions of tensioner style neural mobilisations past the amount used by [17], as more repetitions did not appear to increase the effect following a single session of neural mobilisation.

The results of this study support the expectation that the static stretch intervention would have no effect on neural mobility. Static stretch was performed with the spine in a neutral position and the ankle plantar-flexed. It is unlikely to have influenced neural tension as moving towards these joint positions eases sensory changes and range of motion limitations during neurodynamic testing [6,32,33]. There was no statistically significant difference between the effects of either intervention on slump test ROM ($p = 0.074$), although Cohen's effect size value suggested moderate practical significance of the difference in effectiveness of the two interventions.

Effect of interventions on hamstring ROM

No changes were observed in passive knee extension angle following neural mobilization, suggesting no acute effect on hamstring ROM. This result is in contrast with some previous findings, who noted a significant increase in hamstring ROM following a six-week program of 30 seconds of neural mobilization performed twice daily [21]. The disparity in the results may be due to the use of active mobilization rather than the passive technique used by the current study, may reflect a cumulative effect of neural mobilization on hamstring ROM or be due to the length of the intervention program [34].

The finding that the static stretch intervention did not alter hamstring ROM conflicts with existing literature in this area. Previous studies using similar stretch durations have demonstrated significant acute gains in hamstring ROM [35,36], suggesting that the stretch used in this study should have been adequate to improve hamstring ROM. The absence of the expected change in passive knee extension angle may be a consequence of its position relatively late in the testing sequence. It has been reported that while range of motion increases immediately following 80 – 120 seconds of total static stretching time, it returns to its baseline levels within six to ten minutes after the intervention is ceased [35,37,38]. It is possible that as the last ROM measure in the testing sequence, any changes in range of motion may have diminished by the time that passive knee extension was measured.

Limitations

The findings of the current research are limited to a young population, aged 18 – 25 years, free from lower limb or vertebral pathology. Participants included in this study ranged in ROM from those who were highly flexible, to those who displayed high restrictions in the ROM measures tested. This is in contrast with previous studies investigating ROM interventions that excluded participants with high ROM [36,39], to ensure a response to the interventions would occur [35]. The lack of such an exclusion criterion may account for the magnitude of changes observed relative to the existing literature.

The absence of a control group in this study means that the possibility that observed variations in pre- and post-intervention ROM were not due to factors other than the interventions participants received [40]. The practical limitations of conducting a study involving physical interventions meant that participants were not blinded to group allocation and consequently, results may have been influenced by participants' expectations [41].

While the measurement protocols used in this study have previously been reported to have good test-retest reliability [4,9,17,42], it is not known if the same level of reliability exists in this study. Interpretation of the slump and passive knee extension test results were performed with care to reduce the likelihood of the observed pre- and post-intervention measures falling within the expected standard error of measurement.

Conclusion

This study investigated the acute effects of neural mobilization versus passive hamstring stretching on ROM using the toe touch test and provides further insight into the factors influencing it. A single session of neural mobilisation in the slump position increased toe touch distance to a similar extent as static hamstring stretching. This suggests that neural mobility may be a factor influencing movements such as bending to the ground. Neural mobilisation may be considered as an alternative method to static stretching of the hamstrings to improve ROM in these movements.

Conflict of Interest Statement

No conflict of interest is declared.

Author Contributions

BC, TR and HJ conceived and designed the study. Acquisition of data was performed by BC. All authors contributed equally to interpretation of data, drafting and revising the paper for critical content and gave final approval for submission and publication. All authors are accountable for content.

Funding

No funding from any source was received for this research.

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