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Physical Therapy in Sport 6 (2005) 137–145
Physical Therapy in sport
www.elsevier.com/locate/yptsp

Original research

Evaluation of the effect of two massage techniques on hamstring muscle length in competitive female hockey players

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Received 22 December 2004; revised 4 April 2005; accepted 9 April 2005

Abstract

Background: Massage is frequently used in prevention and management of soft tissue injuries in sport. There is little scientific evidence to support its use.

Objective: The primary purpose of this study was to evaluate the effect of dynamic soft tissue mobilisation (DSTM) in comparison with classic massage on hamstring muscle length in competitive female field hockey players.

Design: A randomised, self-controlled comparative clinical trial, with a blinded measurer. Thirty-nine players were recruited and randomly allocated into two groups. One group received classic massage and the other DSTM.

Outcome measures: Passive straight leg raise (PSLR) and passive knee extension (PKE) were used to measure indirect hamstring length, before, following and 24 h post-intervention.

Result: The PKE test demonstrated a significant improvement in hamstring length immediately following massage in both groups ($F=7.66$, $p=0.01$). This increase was comparable between the two massage groups ($F=0.164$, $p=0.69$). Post-hoc linear contrast showed no maintenance over 24 h in either group, (classic $F(1,18)=2.106$, $p=0.164$, DSTM $F(1,15)=0.599$, $p=0.451$).

Conclusion: Passive KE showed that both classic massage and DSTM had an immediate, significant effect on hamstring length in competitive female field hockey players.

Keywords: Massage; Hamstring; Straight leg raise test; Knee extension test

1. Introduction

Massage dates back to early civilisation and has a long history of use in sports medicine (Hemmings, 2001; Stamford, 1985). Massage has been widely used in the prevention and management of injuries in sport, with recent recognition and acceptance in Olympic sport (Hemmings, 2001). A recent study found that massage accounted for a significant proportion (24–52.2%) of physiotherapists' treatment time at athletics events (Galloway & Watt, 2004), there is however, a paucity of evidence to support its efficacy and effectiveness.

Within the narrative literature there are frequent claims discussing the benefits of massage. Two of the benefits proposed are the relief of muscle tension (Stamford, 1985) and improved stretching of connective tissue (Samples, 1987). There are however, limited studies examining the physiological benefits of massage. Those available are difficult to evaluate and compare as they do not mention or define the pressure, time, speed and technique parameters for massage (Hilbert, Sforzo, & Swensen, 2003; Robertson, Watt, & Galloway, 2004; Tiidus & Shoemaker, 1995). A dynamic soft tissue mobilization (DSTM) model was developed with the aim of improving muscle length (Hopper, 1991). This model utilizes a combined technique of classic massage, followed by a dynamic component, where the limb is moved through its range. Determining a specific area of tightness, where the treatment is concentrated, precedes the dynamic component. In addition the DSTM model has standardized massage parameters for the most time effective

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doi:10.1016/j.ptsp.2005.04.003

clinical use. Currently there is no published evidence to support the effectiveness of this model.

Hamstring muscle injuries represent a significant proportion of lower limb injuries in athletes and are a major cause of time lost from sport (Ekstrand & Gillquist, 1983; Garrett, Ross, & Nikolaou, 1989; Hawkins, Hulse, & Wilkinson, 2000). A reduction in muscle length has been proposed as a predisposing factor for developing hamstring muscle injury (Ekstrand & Gillquist, 1982; Hartig & Henderson, 1999; Kujala, Orava, & Jarvinen, 1997; Worrell, 1994; Worrell, Perrin, Gansneder, & Gieck, 1991). A study of injury pattern among female field hockey players found that 38 out of 239 lower limb injuries were muscle strains (Murtaugh, 2001). Similarly Sherker and Cassell (2002) found muscle strains of the calf and hamstring accounted for 11% of all field hockey injuries. The decreased length of the hamstring muscles often seen in patients with disorders has been suggested to result from muscle and connective tissue shortening adaptation (Gajdosik, 1991). One of the roles of a physiotherapist is to address limitations in muscle length in order to minimize injury.

Objective measures assessing hamstring muscle length include the sit and reach test (Sincair & Tester, 1993), passive toe touch test (Brown, Salmond, & Maxwell, 1993; Orchard, Marsden, Lord, & Garlick, 1997), the straight leg raise (SLR) test (Gajdosik & Lusin, 1983) and the knee extension (KE) test (Brown et al., 1993; Cameron & Bohannon, 1993; Gajdosik, Rieck, Sullivan, & Wightman, 1993). A comparative study on the reliability of different indirect measures of hamstring length did not conclude any test to be superior to the others (Gajdosik et al., 1993). This study reported a significant relationship between passive SLR and active KE, and between passive SLR and passive KE. The passive SLR is a commonly used indirect test, which has shown good reliability (Hall, Cacho, McNee, Riches, & Walsh, 2001) and similarly has the KE test (Fredriksen, Dagfinrud, Jacobsen, & Maehlum, 1997; Gajdosik & Lusin, 1983). An advantage of the KE test is the minimal pelvic motion which occurs when compared to the SLR test (Gajdosik & Lusin, 1983).

The primary purpose of this study was to evaluate the effect of the DSTM model on hamstring muscle length in female field hockey players in comparison with a classic massage intervention. A secondary purpose was to compare the utility of the passive SLR (PSLR) and passive KE (PKE) tests for indirectly measuring hamstring length.

2. Methods

2.1. Subjects

Healthy female field hockey players were recruited from the Premier League Competition in Western Australia. Five clubs including 50 players agreed to participate in the study. All players completed a short questionnaire followed by a brief physical examination to determine suitability. Suitable players had hamstring tightness, defined as the onset of a stretching sensation on the posterior thigh at less than 70° SLR. In addition all players were able to achieve full range of knee extension and ankle plantar grade.

Eleven players were excluded, due to having flexibility greater than 70° SLR ($n=4$), a hamstring tear within the last month ($n=1$), moderate to severe low back pain or neural signs ($n=6$). Of the 39 suitable players, four failed to attend the first measurement session. Thirty-five subjects between the ages of 15 and 31, with a mean (SD) of 19.8 (3.7) years completed the study.

Written informed consent was obtained from all of the participants, including parent's consent for those individuals under the age of 18 years. Ethical approval was granted by Curtin University of Technology Human Ethics Committee.

2.2. Study design

The study was randomised and comparative in design. Using a double envelope method, subjects who fulfilled the inclusion criteria were randomised into the order of testing procedure, PSLR or PKE and into one of the two treatment groups. One group received standardised classic massage intervention and the second group received the DSTM intervention. In addition, each subject served as their own control, which involved lying prone for 8 min without intervention.

The study was conducted over three consecutive days and the subjects were asked to continue normal activities, but refrain from additional massage, resistance or stretching programs during the intervening time. The 1st and 2nd day of testing required each subject to be measured before and after control and intervention periods, respectively. On the 3rd day, 24 h post-intervention, one final measurement was conducted (Fig. 1). All measurements were held prior to hockey training and occurred at the same time of the day between 4.00 and 7.30 p.m.

2.3. Measurement protocols

Hamstring flexibility was measured indirectly using passive PSLR and PKE to the onset of the subject's perception of hamstring stretch. Passive SLR range of motion was conducted using a procedure previously described by Hall et al. (2001). To standardise the measurement, a Richards splint and an ankle foot orthosis were applied to the left leg to maintain the knee in full extension and the ankle in neutral plantargrade. An inclinometer was attached to a belt, which was placed around the pelvis at the level of anterior superior iliac spines (ASIS) (Chattanooga Group Baseline, Hixson, TN 37343, USA). A second inclinometer was then attached to the Richards splint at the level of the knee joint line (Hall et al., 2001, Fig. 2).

Passive KE was measured as described by Gajdosik and Lusin (1983). Each subject was positioned in supine

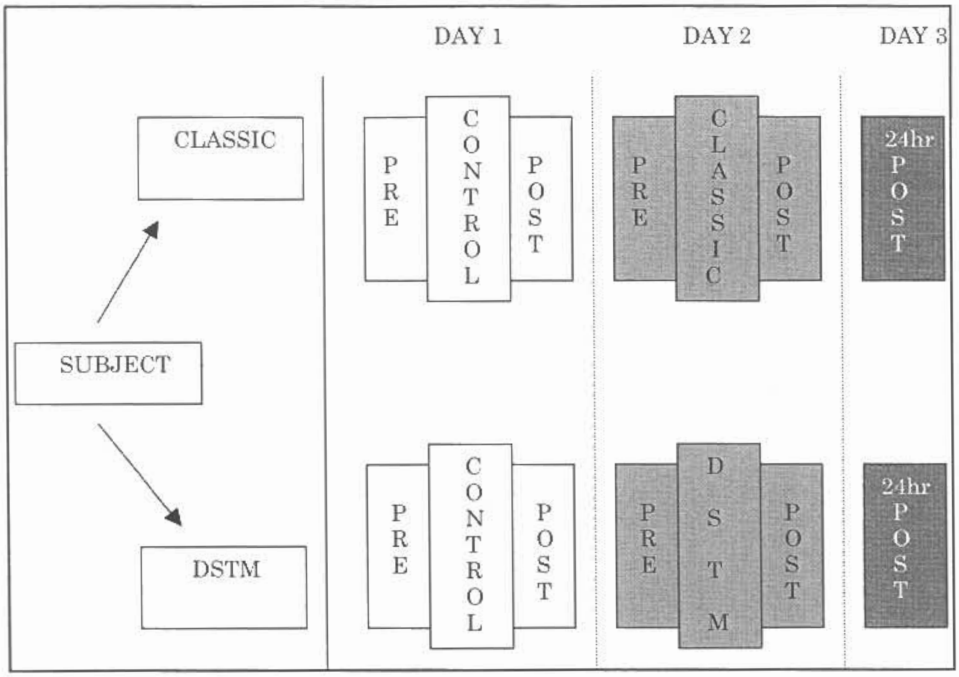

Fig. 1. Illustrative chart of study design. The flow chart indicates randomisation to one of two massage intervention groups. Classic massage and dynamic soft tissue mobilisation (DSTM) represent the two different standardised massage techniques. Each subject was tested using both the passive straight leg raise (PSLR) and passive knee extension (PKE) measuring tools. The testing tools were randomised on the first measuring session to prevent bias from one tool being tested first. On day 1, the subjects were measured pre and post a control period. On day 2, the subjects were measured pre and post an intervention period and as indicated on day 3, one final measurement was taken.

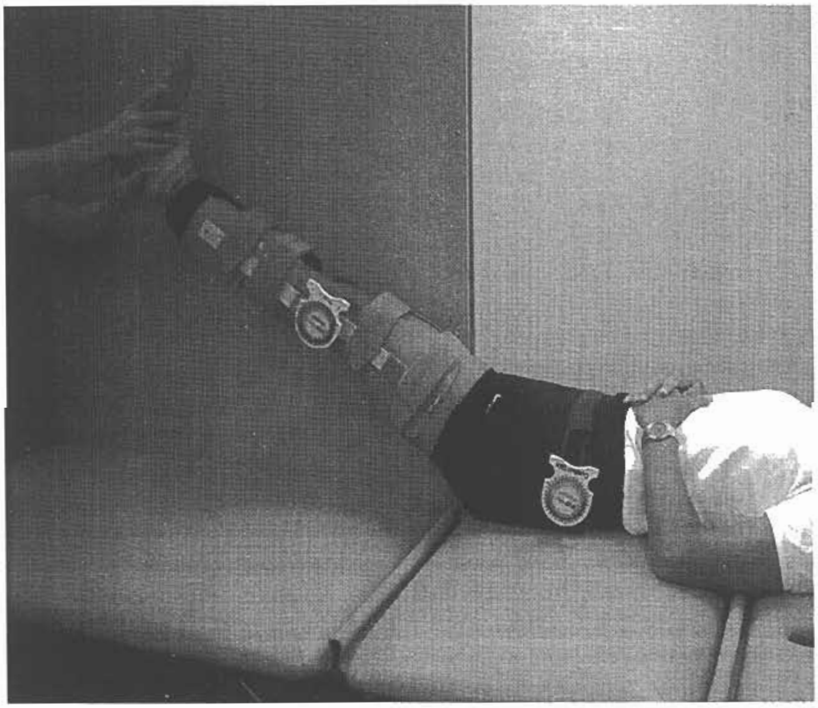

Fig. 2. Measuring tool passive straight leg raise (PSLR). The PSLR was performed with a Richards splint and an ankle foot orthosis in situ to maintain the knee in full extension and the ankle in plantargrade. Two inclinometers were used, one was positioned on the knee joint line and the other on the anterior superior iliac spine. The measurer passively raised the leg until the subject perceived the first onset of stretch in the hamstring. At this point the measurement on the two inclinometers was recorded. The value used for data analysis was the knee inclinometer reading minus the pelvic inclinometer reading.

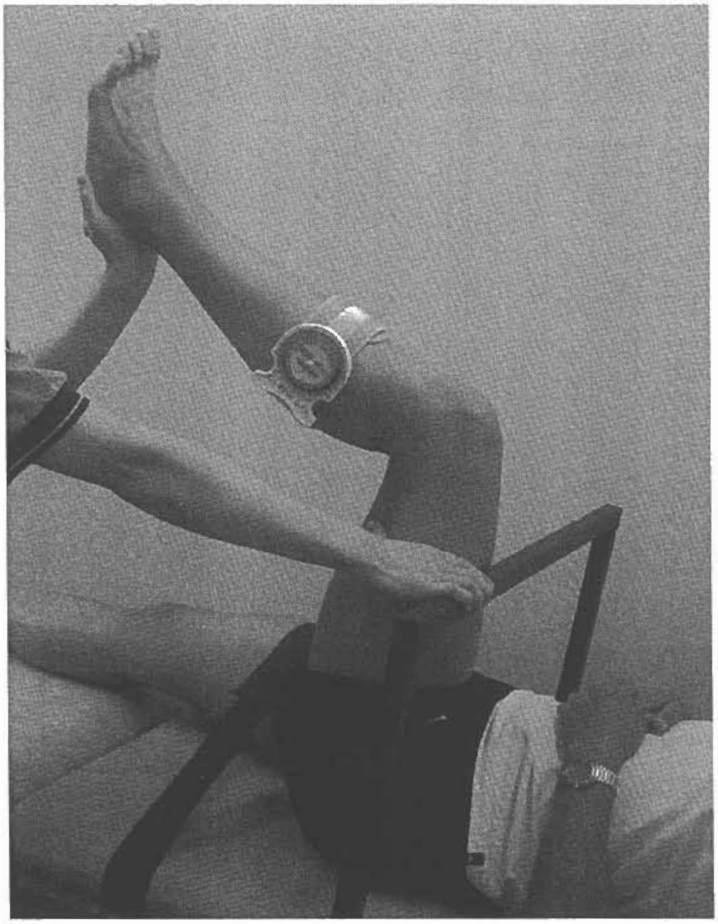

Fig. 3. Measuring tool passive knee extension (PKE). The PKE required the subject to lie supine, whilst the opposite leg was strapped to the plinth. A crossbar was used to maintain the hip at 90° flexion. An inclinometer was placed in line with the fibula and the knee was passively extended until the subject perceived the first onset of stretch in the hamstring. At this point the measurement of the inclinometer was recorded. This value was used for the data analysis.

with the right leg strapped to the plinth (Cameron & Bohannon, 1993; Gajdosik & Lusin, 1983; Gajdosik et al., 1993) A crossbar was utilised to ensure left hip flexion remained at 90° throughout the testing procedure and an inclinometer was placed on the lower leg in line with the fibula (Fig. 3). For both tests, subjects were positioned with their hands on the abdomen, cervical spine in neutral and eyes closed.

Two blinded investigators completed the measurements; one conducted the testing movements using a standardized verbalization protocol, whilst the second recorded the range obtained. To overcome the initial hamstring tightness, minimize the learning response and obtain a constant measure, the test movement was repeated twice through range. This procedure was then followed by three trials, where readings corresponding to the subjects' perception of the first sensation of stretching were recorded. The two most consistent of these three measures were averaged and used for analysis.

A pilot study was conducted prior to the main study. Ten healthy young adult females were measured twice 1 day apart. Intratester reliability of both testing tools was high (ICC of PSLR: 0.87, ICC of PKE: 0.89) and standard error of measurement of 4.8 (PSLR) and 5.0 (PKE). Similarly, there was high intratester reliability of both measurement tools during the control period in the main study (ICC of PSLR: 0.87, ICC of PKE: 0.90) and standard error of measurement of 5.8 for both tools.

2.4. Intervention protocols

Two standardised procedures were performed by two different experienced physiotherapists. Fig. 4 illustrates the two components of both massage interventions.

One group received a standardised classic massage intervention that comprised of distal to proximal effleurage, forward circular movements of kneading, proximal to distal picking up and shaking. Each element was performed five times before progressing to the next element. The massage was performed by an experienced physiotherapist for the duration of 8 min.

The second group received the DSTM intervention that incorporated the elements of classic massage described above but performed in a shorter period of time. This was followed by the dynamic component during which the clinician identified an area of tissue tightness in comparison

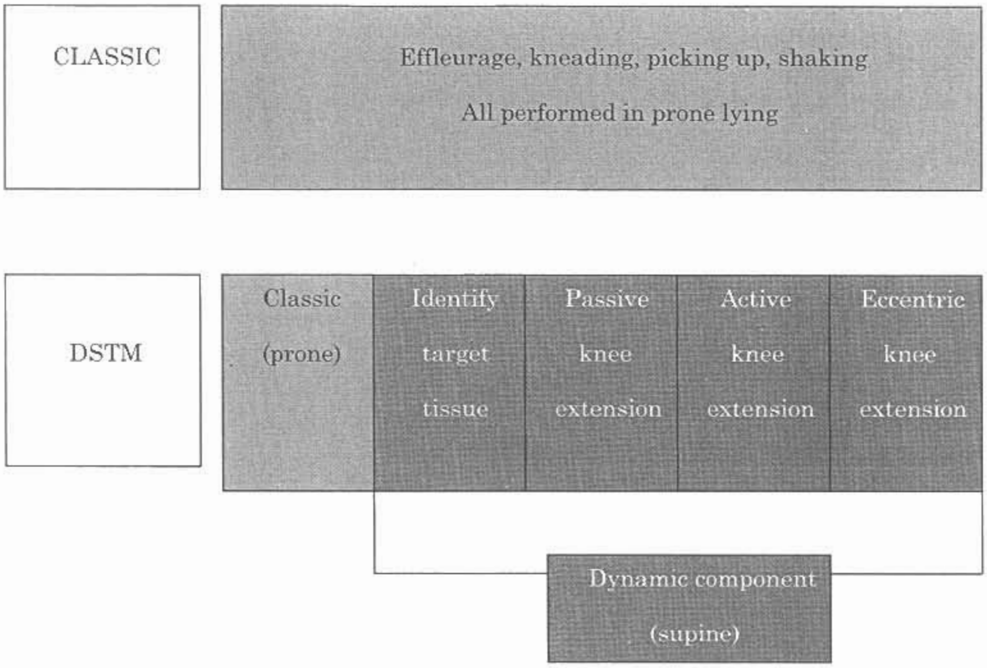

Fig. 4. The components of the two standardised massage interventions. The classic massage component completed in the DSTM intervention followed the same parameters as the standardised classic massage intervention except for the speed of the delivery. The dynamic component of DSTM requires the clinician to support the limb and place the proximal phalanges of a fisted hand onto the subjects hamstring. With the movement of the limb, the fisted hand will move in a proximal to distal direction over the target tissue. The dynamic component utilises passive and active knee extension movements and an eccentric hamstring activation. DSTM, Dynamic soft tissue mobilisation.

to the remaining tissue using longitudinal and cross-fibre strokes along the muscle. This 'target tissue' was massaged with a long slow stroke using the therapist's fisted hand while the knee was moved passively into extension (Fig. 5). This was followed by strokes applied while the subject actively extended the knee and finally eccentrically contracted the hamstring muscles as the knee was extended by the therapist (Hopper, 1991). The DSTM was performed by a second experienced physiotherapist and was also 8 min in duration.

2.5. Data analysis

Data were analysed using the SPSS version 12.0. Descriptive statistics were used to summarise data and determine normality. Comparability of groups at baseline was assessed using unpaired t-tests for continuous variables or a chi squared test for one dichotomous variable. Stability of hamstring length during the control period was assessed within and between groups using two-way ANOVA with pre- and post-control scores as a repeated factor (*time*) and intervention group (*group*) as the second factor. Differences between groups (group) in the extent of change during the intervention phase, compared with the control phase (*response*) were also assessed using two-way ANOVA with the change (post- minus pre-score) for each phase as the dependent variable. Maintenance of the change 24 h later was assessed using another two-way model including pre-intervention, post-intervention and 24 h post-intervention measures as a repeated factor (time) and group as the other factor (group). Post-hoc linear contrasts were used to confirm whether values 24 h after intervention remained significantly greater than the pre-intervention values.

Association between the two measuring tools was assessed at each time-point using Pearson's correlation coefficients. A level of significance was set at $p<0.05$.

3. Results

Baseline data indicates that the subjects in the two groups were comparable with respect to age, years played hockey and number of subjects with a previous hamstring injury (Table 1).

Hamstring length, assessed using both PSLR and PKE, was stable within (time $p>0.36$) and comparable between (group×time, $p>0.38$) groups during the control period.

Change in hamstring length measured using PSLR did not differ between the control and intervention periods in either group and there was no detectable difference in change between control and intervention periods response to treatment (group×response $F_{(1,33)}=0.39$, $p=0.54$; response $F_{(1,33)}=1.39$, $p=0.25$) (Fig. 6). However, when hamstring length was measured using PKE, there was a significant increase in length during the intervention period (response $F_{(1,33)}=7.66$ $p=0.01$), but this increase was

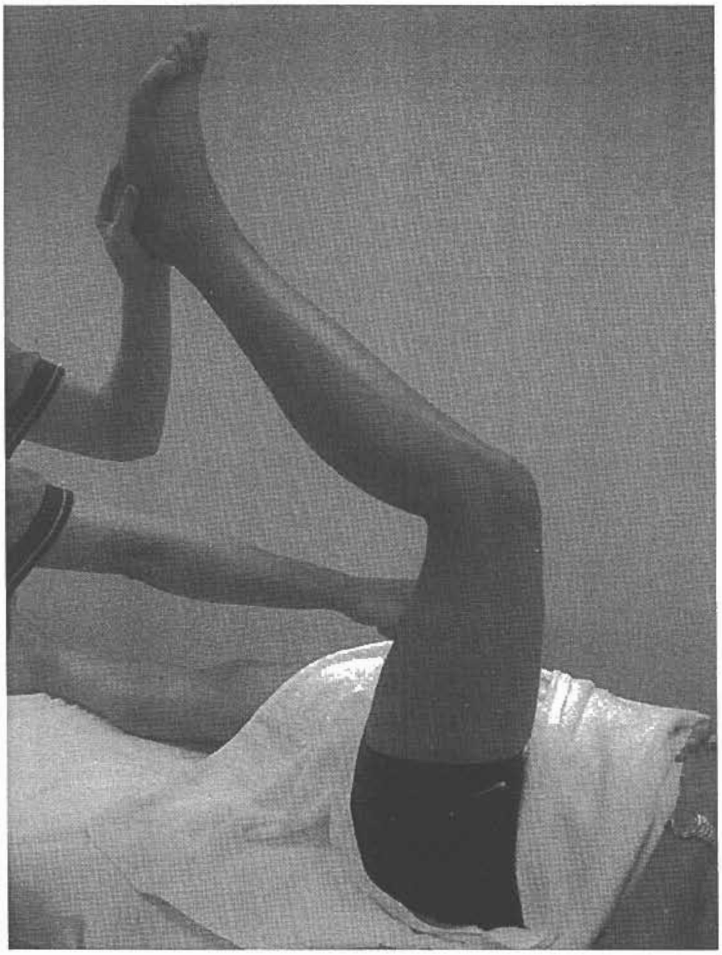

Fig. 5. Dynamic soft tissue mobilisation (DSTM). The fisted hand is placed on the posterior aspect of the hamstring over the identified 'target tissue'. The first element of the dynamic component requires the operator to passively straighten the leg to the end of the available range with one hand, whilst applying a deep longitudinal stroke with the fist of the other hand. The DSTM intervention involves five repetitions of each of the three components. The second and third elements of the dynamic component requires the operator to actively and then eccentrically resist the hamstrings to the end of the available range with one hand, whilst applying a deep longitudinal stroke with the fist of the other hand.

comparable for both interventions (group×response $F_{(1,33)}=0.164$, $p=0.69$) (Fig. 7).

As significant differences in hamstring length were only detectable using the PKE test, the maintenance of improvement in hamstring length 24 h following intervention was assessed only for this test. Post-hoc linear contrasts comparing PKE 24 h after treatment with pre- and post-intervention scores showed that the significant increase in range achieved after intervention was not maintained 24 h later in either group (Classic $F(1,18)=2.106$, $p=0.164$, DSTM $F(1,15)=0.599$, $p=0.451$) (Fig. 8).

Table 1
Baseline data: subjects age, playing history and history of hamstring injury

	Classic ($N=19$)	DSTM ($N=16$)[a]	p-value
Age (years)	20.87±4.09	19.13±3.15	0.329
Playing hockey (years)	11.50±4.33	10.70±3.85	0.583
Premier league (years)	3.05±2.46	4.00±3.40	0.370
Past hamstring injuries (number)	7	2	0.135[b]

[a] DSTM, dynamic soft tissue mobilisation.
[b] Fisher's exact test.

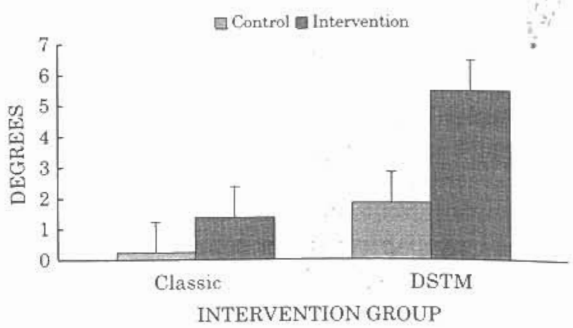

Fig. 6. Change in the hamstring muscle length during the control and intervention periods for SLR measurements. There was no significant difference within and between groups in response to massage intervention using the SLR measuring tools. SLR, straight leg raise; DSTM, dynamic soft tissue mobilisation; Classic, classic massage.

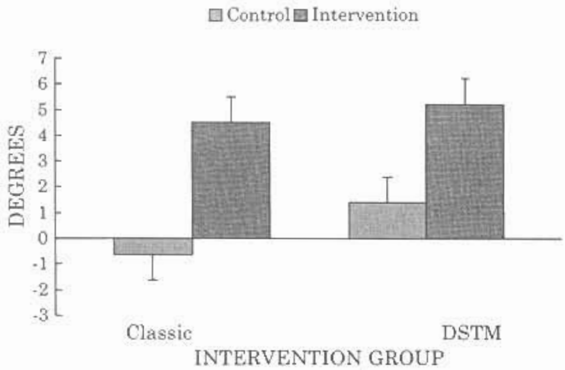

Fig. 7. Change in hamstring muscle length during the control and intervention periods for PKE measurements. There was a significant difference in PKE in response to massage intervention in both groups. PKE, passive knee extension; DSTM, dynamic soft tissue mobilisation; Classic, classic massage.

There was a significant correlation between data collected using the two testing tools at each of the 5 time-points ($r > 0.4$ $p < 0.05$).

4. Discussion

Massage has a long tradition of use in sports medicine (Callaghan, 1993). Despite its continued popularity, the literature does not provide compelling evidence of its effectiveness in improving muscle length.

This study compared the effect of a defined classic massage technique and the DSTM model on hamstring length of competitive female athletes. The results demonstrated that both the DSTM and classic massage interventions resulted in immediate improvements in hamstring length in comparison to a control period. The precise clinical implication from this increase in length is unknown at this time. There is no scientific data to indicate how much of an increase in muscle length is required in order to reduce the risk of injury.

The DSTM model was developed as a standardised concise technique for use in the athletic population to improve muscle length. This technique resulted in a significant improvement in hamstring muscle length in the PKE test. The magnitude of the effect was not however, significantly different from the classic massage protocol used in this study. It can be deduced from the results that massage may have an immediate effect on improving hamstring muscle length.

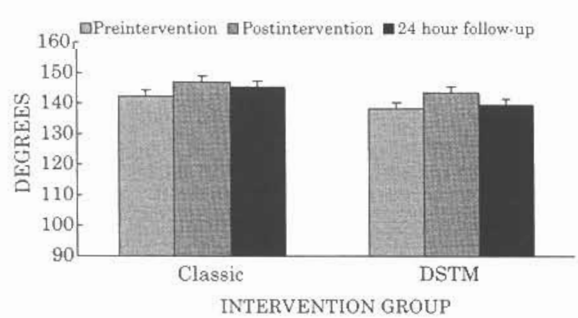

Fig. 8. PKE raw score values pre-intervention, post-intervention and 24 h after intervention. Both groups showed a statistically significant improvement post-intervention ($p < 0.001$) but by 24 h after the intervention PKE range was no longer significantly greater than the pre-intervention value in either intervention group ($p > 0.16$).

The improvement achieved was short term. Significant lengthening was no longer detectable 24 h following either massage intervention. All subjects received only one 8 min massage intervention, however, one single session is not reflective of the clinical management of an athlete with reduced hamstring muscle length. If the massage interventions were used in a series of treatments, which is more reflective of the clinical management, there may be a cumulative effect maintained over a longer time period. The time period of 8 min was guided by the DSTM model which was designed for time effective clinical use.

The findings of this study are difficult to compare directly with other studies on massage as few authors define massage or classify the pressure, time, speed and technique parameters used (Hilbert et al., 2003; Tiidus & Shoemaker, 1995; Wiktorsson-Moller, Oberg, Ekstrand, & Gillquist, 1983). An example is a study completed on males with normal hamstrings which analysed the effect of a 15 min massage on improving sit and reach measures (Barlow, Clarke, Johnson, Seabourne, Thomas, & Gal, 2004). In that study, the massage consisted of effleurage and petrissage strokes, but no other specific parameters were provided. The results indicated no significant change between a single bout of the classic massage provided and a control period. In addition to incomplete definition of massage parameters, a further limitation of that study may have been the use of the sit and reach test as the outcome measure. An analysis of the sit and reach test by Sinclair and Tester (1993) indicated that hip flexion contributes only 60% of the reach with spinal flexion providing the remainder. When completing a test that indirectly measures the hamstring muscle length, awareness of the contributing factors of other joints is essential.

A number of indirect measurement tools for detecting changes in hamstring length are available. Three commonly utilised tools include the sit and reach test and both active and passive SLR and KE tests. The knee extension test was developed to minimise recognised limitations of the SLR test (Gajdosik and Lusin, 1983). These limitating factors include the differentiation between a neural or muscular restriction and the degree of pelvic rotation contributing to the SLR range (Gajdosik and Lusin, 1983). The authors, however, question this statement pertaining to the neural system as it is impossible to not affect the nerve with limb movement. In this study to minimize the affecting factors all volunteers were screened for neurological signs and the pelvis movement in the PSLR was measured and deducted from the total range.

In clinical trials there appears to be a tendency to use only one outcome measuring tool in assessing muscle length changes (Funk, Swank, Mikla, Fagan, & Farr, 2003; Halbertsma, Van Bolhuis, & Goeken, 1996; Wiktorsson-Moller et al., 1983). An additional aim of this study was to compare the PSLR and PKE tools in measuring hamstring muscle length. Although the results demonstrate correlation between the two tools at all time-points, improvements in hamstring length detectable using PKE were not apparent using PSLR measurements. An advantage of the PKE tool is that it is more readily replicated in the clinical environment, whereas the PSLR tool may be cumbersome and more difficult to implement in the clinical setting.

For the purposes of this study, measurements were taken when the subjects had the first sensation of stretch. More objective determinants of endpoint had been considered but were discounted due to the complexity of confounding factors such as limb weight. Having used the subjects' perception for measurement in this study, it is postulated a more reliable measurement of hamstring muscle flexibility may be achieved if the therapist detected the first point of muscle resistance. It is also suggested that the therapists' experience in assessing resistance in a muscle tissue may be more accurate.

One of the limitations of this study was the lack of control over this competitive sporting population's level of activity during the study period. These players were in an elite training program and were highly motivated and required to train. The authors endeavoured to structure the data collection around their scheduled training sessions and games to minimise heavy physical activity between measurement sessions. Several subjects had, however, either completed an additional weights or aerobic training session between the control and intervention time periods and this may have influenced the hamstring muscles extensibility prior to measurement.

Apriori power calculations suggested that a sample of 40 subjects would be sufficient to detect a 10° change in length after intervention with a power of 80% and a $p < 0.05$. Only 35 subjects completed the study and randomisation resulted in slightly uneven groups. Due to the study design the time commitment by the subjects was considerable which had a negative influence on recruitment. We did not achieve anticipated subject numbers to gain adequate power to demonstrate the 10° difference expected. With a higher number of subjects a significant change might have been detected using the PSLR test.

Clinically and for future research of hamstring length, the passive knee extension tool can be utilised as an indirect measure of hamstring muscle length. The population under study incorporated uninjured but tight hamstring muscles in competitive hockey players. Worrell et al. (1991) reported that hamstring injured subjects were less flexible than their uninjured counterparts and concluded that the hamstring injured individuals have a greater loss in hamstring length. Perhaps there may have been larger changes in range had the population under study been in the subacute phase post hamstring muscle injury. It is recommended to trial the two standardised massage techniques on this population to determine their effect. In addition, a series of treatments that more closely reflect the clinical setting would be worthy of investigation.

It is concluded that both these standardised classic massage and DSTM treatments have an immediate effect on improving hamstring length. The PKE test is a reliable and effective indirect test for assessing hamstring length.

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