A Comparison of the Effect of Muscle Energy Technique (Greenman Method) and Passive Stretching on Hamstring Extensibility

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ABSTRACT:

The purpose of this study was to compare the effect of Muscle Energy Technique (MET), as described by Greenman (Greenman 1996), to a static stretch of 30 seconds duration for increasing the extensibility of the hamstring muscles. Sixty-three asymptomatic participants (40 female and 23 male; mean age = 22.2 ± 2.8 years) were examined for hamstring extensibility using a modified active knee extension (AKE). Participants were then directed to another room where they were randomly allocated to either a 30-second static stretch or MET group. Following intervention, participants returned immediately to the examination room for AKE measurement, and then once again 30 minutes later. The results showed a mean increase of 3.55 degrees in the MET group (SD = 5.66), whereas passive stretching produced a mean increase of 2.79 degrees (SD = 3.93). Upon analysis of the data using a SPANOVA, a significant change over time in the AKE values was found ($F_{1.47, 89.85} = 16.75$, $p = 0.00$), however, there were no significant differences between the two groups over time ($F_{1} = 0.92$, $p = 0.34$). The between-group effect size was small ($\eta^{2} = 0.015$). Although the measurement procedure was determined to be repeatable, modifications to the AKE methodology may have resulted in under-estimation of the error range, and raise major concerns about the validity of the measurement procedure. In view of this methodological flaw, no conclusions can be made regarding the effectiveness of the two manual techniques. Future studies are recommended using the accepted AKE methodology.

INTRODUCTION:

Muscle stiffness of the lower extremities and the consequential decrease in joint flexibility are considered to be major aetiological factors in musculoskeletal injuries (Halbertsma *et al* 1996). Muscle energy technique (MET) is a manual treatment that is claimed to increase muscle extensibility and range of motion in joints (Greenman 1996, Ballantyne *et al* 2003). However, other authors have claimed that static stretching also produces increases in extensibility and range of motion (Bandy *et al* 1998). It is important to determine which method is more effective in order to help manual therapists choose the most effective treatment procedure to prevent injuries, and to help their patients maintain adequate flexibility of muscles during recovery from injury.

MET is a manual medicine treatment procedure that involves the voluntary contraction of patient muscle in a precisely controlled direction, at varying levels of intensity, against a distinctly executed counterforce applied by the operator (Greenman 2003). Greenman (2003) proposed that MET has many clinical uses, including lengthening a shortened, contractured, or spastic muscle, strengthening a physiologically weakened muscle or group of muscles, and reducing localised oedema.

Although few studies have examined the effects of MET application (as described by Greenman), researchers have examined the short-term effects of a number of similar isometric stretching techniques on hamstring extensibility. (Ballantyne *et al* 2003, Feland *et al* 2001, Ostering *et al* 1990, Sady *et al* 1982). MET (and similar isometric stretching techniques) have been demonstrated to produce a significant increase in the range of motion at the knee (Ballantyne *et al* 2003, Feland et al 2001, Sady et al 1982). Some researchers have compared isometric stretching with static stretching (Feland et al 2001, Magnusson et al 1996b, Ostering et al 1990, Sady et al 1982), but fewer studies have analysed the differences between techniques in regards to the longevity of their treatment effect (Gribble et al 1999, Spernoga et al 2001).

Passive stretching of the hamstring muscles has been reported to increase extensibility (*Bandy et al 1998*, Feland *et al* 2001), but there are studies that have reported conflicting results (Halbertsma *et al* 1996, Halbertsma *et al* 1999, Sady *et al* 1982, Feland *et al* 2001). Some authors (such as Halbertsma *et al* 1996, *Bandy et al 1998* and Feland *et al* 2001) found a significant difference between groups, whereas others reported no significant differences between passive stretching and a control group (Halbertsma *et al* 1999, Sady *et al* 1982).

MET is a manual technique largely advocated by authors in the field of osteopathy (Chaitow 1996, Greenman 2003). Different authors have advocated slightly different methods of applying MET to increase muscle extensibility. Greenman (2003) advocates passively stretching the muscle to a sense of palpated resistance (the 'barrier'), and having the patient contract the muscle against an equal and opposite counterforce provided by the practitioner for 5 – 7 seconds. Following this, the patient will relax and the practitioner will further stretch the muscle to the next barrier. In contrast Chaitow (1996) recommends a seven second isometric contraction against the resistance of the practitioner. Following a few seconds of relaxation, the patient is then encouraged to reach the new barrier and increase ROM by active contraction of the muscle group antagonistic to the stretched group (Chaitow 1996). This is then followed by thirty seconds of passive stretching at the point of maximum stretch tolerance.

The aim of the study was to investigate the relative effect of MET (Greenman method) and static stretching, immediately after and 30 minutes post treatment, for increasing the extensibility of the hamstring muscle group. Although some researchers have investigated the effect of isometric stretching techniques, such as PNF and contract-relax, there are differences in the application of these techniques and the commonly advocated application of MET. As there has not yet been an investigation on MET as advocated by Greenman versus static stretching and as the Greenman method of MET is likely to be commonly used by members of the osteopathic profession, this study aimed to examine the relative effectiveness of these two techniques. The results of this study may assist practitioners of manual therapy to select the most efficacious technique and treat patients with myofascial dysfunction with more confidence in the effectiveness of such a technique.

MATERIALS AND METHOD

Participants:

Sixty-three participants were recruited (40 female and 23 males; mean age = 22.2 ± 2.8 years, range 19 - 33 years) from the student body at Victoria University.

Volunteers were excluded if they had any injury and/or pain within their lower limbs and / or lower back, if they had a permanent injury and / or disability to their lower limbs or back. Volunteers were also excluded if they had a pre-test AKE of greater than 180 degrees, because they were deemed to be too flexible for reliable measure of AKE. Forty-six volunteers were excluded from the study for this reason. Although some studies have used 150 degrees of AKE as a cut-off point, the present study used asymptomatic participants and allowed a limit of 180 degrees. Given that the thigh would be fixed at 90 degrees of hip flexion and knee hyperextension of 5 – 10 degrees is considered to be within normal limits (Levangie & Norkin 2001), 180 degrees would still allow further movement following improvements in muscle extensibility.

This study (Figure 1) was approved by the Human Research Ethics Committee of Victoria University. All participants gave written consent to participate in this study.

Insert "Figure 1: Study design" here

Measures:

To measure the ROM at the knee, a modified AKE was performed. The participant was asked to lie supine with the leg being investigated strapped onto a frame bringing this leg into approximately 90 degrees of flexion at the hip, whilst the leg not being investigated remained in a neutral position and was strapped onto the treatment bench to reduce the chance of rotation from the pelvis (Figure 2).

The stabilising bar was found to be easily displaced by the participant's extending leg. For this reason the setup of the testing apparatus was modified without validation by placing the bar on the posterior surface of the thigh, which appeared to improve the stability of the thigh and the stability of the frame (Figure 2). This modification was later found to affect the maximal angle of extension of the thigh and therefore resulted in a serious flaw in the validity of the procedure, which will be discussed later.

Another flaw regarding angles of extension at the knee joint was the choice of bony landmarks used as reference points in the digital images, which were set up as follows: Using a marker pen, the greater trochanter, the lateral malleolus and the head of the fibula were marked with a round black dot in all participants. The participant was asked to extend the knee as far as possible, and when that point was reached, a photo was taken using a digital camera. This procedure was performed three times, and the mean of the three measures was used for analysis. The digital images were later analysed using "SiliconCOACH Pro" software to determine the angle of AKE.

The camera was set up perpendicular to the participant's leg, the treatment table and the stabilizing frame in order to decrease the chance of miscalculations regarding the angle being recorded (i.e. to reduce the chance of parallax errors). It was set up by creating a line coming from the point where the stabilizing bar and the bench cross each other out toward where the camera was to be set up at 90 degrees. The camera itself was set up on a tripod in line with this perpendicular line that was previously set up, and the tripod was taped into place for the duration of the testing period, in order to maintain consistency in measurements also.

AKE reliability pilot study

A pilot study was performed prior to the main study to determine the reliability of the measurement protocol. In this study, twenty participants (recruited from students and staff at Victoria University) were measured using AKE (as previously described) on two separate occasions, approximately five minutes apart. After the first measurement, participants were unfastened from the treatment bench, asked not to participate in any intense physical activity, and left the measurement room. They returned to the measurement room approximately five minutes later for the second measurement of AKE.

Using SPSS version 12, the average measure Intraclass Correlation Coefficient (ICC) for the two AKE readings was found to be 0.98, which indicated that the testing procedure was highly repeatable. The error range (mean difference + standard deviation of mean difference) between the first and second measurements was calculated to be 2.93 degrees (0.45 + 2.48).

Insert Figure “2: Active knee extension (AKE) measurement procedure” here

Procedure:

The study used a controlled and blinded experimental procedure. After the participant's initial AKE was determined by Examiner 1, they were sent to another room where they were randomly allocated by Examiner 2 into either the Greenman MET group (n=31; male=14, female=17) or stretch group (n=32; male=9, female=23). Examiner 2 was blinded to the allocation of the participants. The participants in the "Greenman MET" group were treated with a standard Greenman MET to the hamstring group of muscles, whereas the participants in the "Stretch" group were treated with a 30 second static stretch. Immediately after the techniques were performed, the participant returned to the initial room for re-measurement, and then once again 30 minutes after the technique was performed for the final measurements of their knee ROM.

Muscle Energy Technique:

The MET procedure (Figure 3) was performed as outlined by Greenman (2002): firstly, the muscle was stretched until their point of tolerance of posterior thigh discomfort ended, then the participant contracted the hamstring muscle (using sub maximal force of approximately 70%) against the practitioner, who provided an equal and opposite counterforce for 7 seconds. The participant relaxed and the practitioner stretched the muscle to the new point of discomfort, taking 3 seconds to get to this new barrier. This procedure was performed for a total of 3 times (adding up to a total of 30 seconds of treatment time).

Insert "Figure 3: Greenman Muscle Energy Technique" here

Static stretch:

The static stretch that was used (as seen in Figure 4) was performed as follows: firstly, the hamstring was stretched until the point of tolerance, this position was maintained for 30 seconds, after which the participant's leg was returned to a neutral position. This was performed once only. The reason behind selecting a 30-second stretch was based upon previous research by Bandy and Irion (1994) who tested a 30 and 60 second stretch and found that 30 seconds was equally as effective as 60 seconds of stretching for increasing ROM, and more effective than a 15 second stretch. In the interest of efficiency, the 30 second stretch was selected. This was the same reasoning behind the selection of using a 30 second stretch in the investigation by Gribble *et al* (1999).

Insert “Figure 4: Static stretch” here

Analysis:

After determining the ROM measurements using SiliconCOACH Pro software, the AKE measurements data was collected using Microsoft Excel, and then analysed with SPSS v12. Within and between-group differences were analysed using a SPANOVA (split-plot ANOVA), and post hoc testing with dependent t tests. An overall effect size for the between-group effect was calculated using eta squared (η^2), where 0.01 can be interpreted as small, 0.06 as medium effect, and 0.14 as a large effect size. Pre-post effect sizes for each group were calculated using Cohen’s *d* (mean difference / SD differences), where 0.2 is interpreted as small, 0.5 as medium effect, and 0.8 as a large effect size.

RESULTS:

The mean differences for the MET group between the AKE pre and AKE post-treatment was calculated at 3.55 degrees (immediately post-treatment) and 1.90 degrees (30 minutes post-treatment). The mean differences in the group receiving the static stretch was calculated at 2.79 degrees (immediately post-treatment) and 2.24 degrees (30 minutes post-treatment) (Table 1).

When analysed using a SPANOVA, Mauchly's Test of Sphericity was found to be significant ($p = 0.00$), so the degrees of freedom were adjusted by using the Greenhouse-Geisser output (Coakes & Steed 2000). The analysis demonstrated a significant change over time ($F_{1.47,\ 89.85} = 16.75$, $p = 0.00$), however, there were no significant differences between groups over time ($F_{1} = 0.92$, $p = 0.34$). The partial Eta squared value for between-subjects effects was small (0.015). These data show that 1.5 % of the variance in hamstring extensibility is due to group membership (i.e. treatment type). The pre-post effect size was medium for the MET technique (d = 0.62) and medium-large for the Stretch technique group (d = 0.71) for the increases immediately following treatment.

On further analysis of the within group changes using a dependant t-test, the Greenman MET group was found to have a significant increase in range of motion pre – post 1, ($t(30) = -3.487$, $p=0.002$) with a mean of -3.55 ± 5.66 degrees, but the pre – post 2 group was not found to be significant ($t(30) = -1.786$, $p=0.08$) with a mean of 1.90 ± 5.929 degrees. Both time periods for the passive stretching group were found to be significant with the results of the stretch pre – post 1 being $t(31) = -4.019$, $p=0.000$ with a mean of -2.792 and a standard deviation of 3.93. The pre stretch –

post 2 group was calculated at t(31) = -2.922, p=0.006 with a mean of -2.24 and a standard deviation of 4.336.

Insert "Table 1: Descriptive statistics for Greenman MET and Stretch Techniques" here

DISCUSSION:

The results of this study suggested that there was a small but significant increase in hamstring extensibility following the application of both the Greenman MET technique and 30 seconds of passive stretching. Mean differences in AKE were greater in the MET group immediately post-treatment, whereas the stretch group was found to have a larger mean difference at 30 minutes post-treatment. Pre-post effect sizes were slightly greater in the stretch group at both time intervals, but both could be considered as medium-large effect sizes. There were no significant differences between the gains made by the two techniques ($p = 0.34$) when analysed with SPANOVA, and the between-group effect size was small. These results suggest that the two treatments were equally effective in producing small increases in hamstring extensibility. However, since the collection of data, the authors of this study have become aware of serious flaws in the methodology for the measurement of AKE. Due to these flaws, no conclusions can be made concerning the relative effectiveness of these two manual techniques.

The findings of the present study suggested that there were no differences between isometric and passive stretching, which concurs with other studies that have similar results. Gribble *et al* (1999) compared the effects of static and hold relax stretching on hamstring muscles, finding that they were both equally effective in improving hamstring ROM. Feland *et al* (2001) discovered that "contract and relax" (CR) and static stretching had similar benefits in improving flexibility.

It is possible that the force of contraction performed by the participant is a variable that could explain the varied results in previous, similar studies. Magnusson *et al* (1996a) applied a CR technique involving a six-second forceful isometric contraction, and their results revealed that the CR techniques produced a significant increase in maximum joint ROM. In contrast to Magnusson *et al* (1996a), Feland *et al* (2001) applied a CR technique involving six seconds of "maximum voluntary contraction", resulting in the CR technique having similar results as the static stretch. In this experiment, we did not utilize maximal contraction by the participant. Despite this, our results still reflected those of Feland *et al* (2001), however it should be noted that our results could have been affected by the errors in the measurement protocol as discussed in other sections of this paper. It might be deduced from this that the strength of contraction does not influence the increase in ROM. However, Feland *et al* (2001) used participants whose ages ranged from 55 – 79 years old (mean = 65), so the force (in Newtons) of a maximal contraction in the average 65 year old would be different to the force (in Newtons) of a maximal contraction of a 22 year old. For this reason a future study could be performed using a pre-determined measure of force of knee flexion contraction as part of the MET protocol.

Ballantyne *et al* (2003) researched the effect of MET on hamstring extensibility using PKE rather than AKE and found a significant increase in hamstring extensibility after MET in comparison to control subjects. Ballantyne *et al* (2003*)* and Halbertsma et al (1996) concluded, however, that the treatment did not actually produce a biomechanical change to muscle, but simply increased the tolerance to stretch in the hamstring, however it is important to remember that this was not proven conclusively and it is still in part an assumption. Torque-controlled PKE would be a useful measure in further studies because it can be used to specifically measure changes in the physical property of a muscle, and help determine the cause of increased muscle extensibility. This is highlighted by Magnusson et al (1996a, Ballantyne et al (2003) and McHugh et al (1992) who all demonstrated that the increase in ROM in their respective studies was merely due to an increase in stretch tolerance.

Because most of the participants recruited for this investigation were osteopathic students, it was possible that they may have exhibited bias towards the MET group, (they may have pushed themselves a bit harder compared to those who received the static stretch as their intervention.) However, given the results of this study, the fact that the participants were blinded to the measurements and the participants were instructed to actively extend their knee as far as possible, subject naivety may not have been an important factor in this study. In future, however, it may be preferable to use participants who are unfamiliar with such manual therapy techniques, or included a realistic sham treatment as a control.

Various researchers (Gribbe *et al* 1999, Ballantyne *et al* 2003, Feland *et al* 2001, Sady *et al* 1982) have found that MET (or similar isometric stretching techniques), were effective in increasing joint range of motion (ROM), however, many of these studies only examined the immediate effect of the treatment intervention. Of the few studies that have examined the longevity of isometric stretching techniques, there have been two main types of experimental protocols: a single session of a hold-relax stretching protocol (Spernoga et al 2001), and static stretching and hold-relax training applied over a longer (6 week) period (Gribble *et al* 1999). Spernoga *et al* (2001) found that the gains in ROM only lasted 6 minutes after the final hold-relax stretching technique was performed. These results differed from the findings of Gribble *et al* (1999), who reported that using a static stretch and the hold-relax straight leg raise (SLR) technique four times a week over a 6-week period produced similar increases in both groups, with a plateau for increases in ROM occurring at weeks 4-5.

Magnusson *et al* (1996b) and Osternig *et al* (1990) compared the effects of CR techniques with static stretching. Their studies revealed that CR techniques brought about a significant increase in maximal joint range of motion. Magnusson *et al* (1996) found a significant increase in CR techniques when compared to a static stretch, however this was only when they were stretched to the end point of their pain tolerance, this shows that there was no biomechanical change, just an increased stretch tolerance. This differs from the results from our study which revealed a significant increase in both groups separately, however, no significant differences between the Greenman MET and the static stretch groups. Magnusson *et al* (1996b), Osternig *et al* (1990) and Spernoga et al (2001) all measured change in joint ROM using PKE, whereas Gribble *et al* (1999) used AKE measurements. Sady *et al* (1982) and Wallin *et al* (1985), also found CR stretching to provide a greater increase in ROM than static stretching, however it is difficult to deduce whether they used an active or a passive ROM for their testing procedure. Further research comparing AKE and PKE measurements may be useful for determining the most suitable testing protocol for future investigations of various techniques performed to increase the length of shortened muscles.

Several researchers have reported (in studies of repeated treatments over multiple weeks being compared with a placebo treatment of the same frequency) that multiple treatment interventions over a few weeks may have a longer lasting benefit than a single treatment in increasing the ROM in the knee (Bandy *et al* 1998, Willy *et al* 2001 and Gribble *et al* 1999). Gribble *et al* (1999) compared hold-relax techniques to static stretches four times a week over a six-week period. These researchers found that the benefits of static and hold-relax stretching reached a flexibility plateau between weeks 4 and 5. Bandy *et al* (1998) also found that there was a significant increase in ROM after 6 weeks, however, it was not clinically significant (in that the increase was less than 1 degree per week). In order to better simulate treatment in clinical practice, researchers should compare the effect of Greenman MET and static stretching following multiple sessions over several weeks. It may be possible that differences in muscle extensibility between the treatments become apparent over longer treatment duration. Willy et al (2001) reported that 4 weeks after completion of a 6-week stretching regimen, there was no retention of the initial increase in ROM that was measured on the final day of stretching. It would be useful to conduct a similar study using a MET to determine if this technique results in a longer duration of increased ROM retained at the knee.

The passive stretch technique performed in this study was quite strong, comprising of 30 seconds at maximal stretch tolerance, and therefore likely to be effective in altering the hamstring extensibility. The MET was performed to the same point of stretch tolerance, however, the time taken for the MET to be performed three times was still less than 30 seconds in duration of end range stretching. Future studies should ensure that the duration of passive and isometric stretching are the same, so that any differences are not attributable to this factor.

Had the results of the present study been reliable and valid, they would have concurred with the findings of Feland *et* al (2001), Bandy *et al* (1998), Willy *et al* (2001) and Halbertsma *et al* (1996), who found that stretching of the hamstrings caused a significant increase in the ROM. Feland *et al* also found that a 32-second static stretch was enough to produce a significant increase in knee ROM. However, Halbertsma *et al* (1996) used a series of stretches, whereas Bandy *et al* (1998) and Willy *et al* (2001) used a 6-week stretching protocol, and so these stretching protocols were quite different from the one used in the present study.

Cameron et al (1993) investigated the validity of using AKE measurements in determining hamstring ROM changes by comparing AKE and active straight leg raise (ASLR). It was concluded that the AKE test may be a useful alternative to the straight leg raise test for providing an indication of hamstring muscle length. AKE was chosen as the method of measurement for the present study because it is simple to perform, reliable, and many researchers have demonstrated changes to hamstring length following manual treatment using this measurement (Handel et al 1997, Gribble et al 1999, Spernoga et al 2001, Funk et al 2003).

During the collection of data there were several major flaws in the methodology used to measure AKE, affecting the validity of the measurement and may have led to our error margins being larger than initially believed. As a result, the results of this study cannot be interpreted as being valid. The major flaw in the methodology of this research project occurred due to the modification of the AKE measurement procedure. Normally AKE is measured with the stabilisation bar on the anterior surface of the thigh and the thigh flexed to 90 degrees (Ballantyme *et al* 2003, Feland *et al* 2001, Spernoga et al 2001, Gribble *et al* 1999). The researchers in the present study were concerned about the movement occurring at the bar during active extension, as it had a substantial amount of play whilst the participant was moving their leg against it. In an attempt to overcome this problem, the researchers moved this bar behind the thigh to provide better stability and reduce the movement of the frame. On reflection, this was a major methodological error, as it resulted in the thigh being no longer maintained at 90 degrees of hip flexion, which changed the angle being measured and would have resulted in the under-estimation of change in AKE.

Another possible error was that the pressure on the hamstring muscle from the stabilisation bar may also influence the degree of extensibility of the hamstrings. In order to prevent excess movement of the participant's thigh while they were fixed onto the treatment table, their thigh was fixed with the stabilisation bar against the posterior thigh. It was considered during the testing procedure that this would allow for greater repeatability during testing, because the thigh appeared to be more stable in this position during AKE. However, since the collection of data, the authors have considered the possibility that hamstring muscle compression against the stabilization frame may have affected the measurement of true hamstring extensibility. This procedure was determined to be highly repeatable, however these methodology flaws may have lead to an under-estimation of the error in the reliability study, and therefore this method cannot be considered reliable or valid. In view of these issues, no conclusions can be made from the results of this study.

Another error in the measurement procedure was the marking of only the fibular head, lateral malleolus and the greater trochanter as reference points and calculation of the angle between these points. The midpoint of the lateral femoral condyle should have been marked in addition to these three points and used in the calculation of the measured angle, and this also could have resulted in a miscalculation and under-estimation of movement (because it is being treated as one complex instead of breaking it down into two parts – the line created by only the femur and the line created by only the fibula). Ballantyne et al (2003) measured knee extension from points on the greater trochanter, lateral femoral condyle and lateral malleolus. This was a better choice of points than the current paper because it was not influenced by the anterior and posterior displacement of the tibia and fibula on the femur with flexion and extension as much, however it still is not as sound a procedure as marking all four points.

The data from the pilot study were analysed using Intraclass Correlation Coefficient (ICC) for the two AKE readings and found to be 0.98, which indicated that the testing procedure was highly repeatable. The error range (mean difference + standard deviation of mean difference) between the first and second measurements was calculated to be 2.93 degrees (0.45 + 2.48). This was only slightly lower than the mean difference between the AKE pre and AKE immediately post-treatment in the group receiving the Greenman MET (3.55 degrees) and was marginally higher than the immediately post-treatment mean difference in the group receiving the static stretch (2.79 degrees). However, as previously discussed, the angle measured for AKE may have seriously underestimated any change, and therefore underestimated the error range of this procedure.

There was a relatively even ratio of males to females in the MET group (M:F = 14:17), however the ratio in the group receiving the static stretch was not even (M:F = 9:23). It is possible that women might exhibit a greater increase in ROM in response to any form of treatment intervention when compared to males. If this was the case, this could help to explain why the stretch group had a larger effect size when compared to the MET group. In future, researchers should attempt to match the ratio of males to females in each group, or have separate male and female groups to compare against each other. Researchers should also investigate the effect of stretching in a group of pregnant women to see if the increase in pregnancy related hormones may have an impact on muscular extensibility following treatment interventions.

The lack of a control group was yet another limitation of the current study. Although it is well established that passive stretching can produce increases in hamstring extensibility (Bandy et al 1998, Gribble et al 1999, Feland et al 2001), in order to be certain that the increase in extensibility was due to treatment intervention, and not due to the repeated testing, AKE gains should have been compared to a control group. This may be important for future examiners to consider, because it reduces the number of possible reasons for the increase in ROM.

This study examined asymptomatic participants only, which is not typical of the patients that would usually consult a manual therapist. It is possible that ROM gains following treatment may be more substantial than that which occurs following stretching in asymptomatic subjects. It is also possible that the ceiling effect may also be into play (i.e. the results were already up at the top end of the ROM scale anyway, so therefore there was not much room for improvement). To prove or disprove this in future studies, symptomatic patients might be included in such a study, or subjects with a history of hamstring injury or chronically shortened hamstrings.

One of the reasons that could possibly have a bearing on why the results may be influenced by the ceiling effect is that our initial readings were different to the initial readings of the normal population. For example, Sady et al (1982) studied active college students where the mean age was 22 ± 3.32 years with an initial average AKE reading of 169 degrees, whereas our groups had initial mean readings of 161.28 and 164.18 degrees. In the study by Willy et al (2001), they also examined college students, however these were inactive students with a mean age of 21 years, their baseline measures were 145 ± 8 degrees . Bandy et al (1998) used a control group whose ROM measurements were 131 degrees, however these participants were a little older (28.35 ± 7.58 years) than the participants in the present study.

In summary, there was an immediate change, however this change decreased over time. This is basically highlighting the fact that both techniques were responsible for an immediate significant increase in ROM, however after that, the ROM started dropping down, with the Greenman group dropping down at a much faster rate than the static stretch group, the Greenman group dropped down so far that it was no longer within the significant range, whereas the static stretch group dropped but still remained within the significant range. We must still be careful in accepting this because of the flawed methodologies as discussed throughout this paper. A possible explanation for this difference in rates of decline might be because the group means of the initial measurements were different (the MET group was almost 3 degrees less than the static stretch group). As for the reasoning for the rapid rate of decline in general could be because there was only a one off treatment intervention, it may be beneficial if in future studies, multiple treatments were compared to a one off treatment.

CONCLUSION:

During the current study, several major methodological flaws occurred in the procedure used to measure hamstring extensibility. Although the results of this study suggested that a single application of either MET (Greenman method) were equally effective in producing small increases in hamstring extensibility, the methodological flaws were likely to cause underestimation of the error range of the testing procedure and affect the validity of the measurement, so that no conclusions can be made concerning treatment effectiveness. It is recommended future researchers further investigate the most efficacious method for increasing hamstring extensibility using measurement methods that have been previously determined to be reliable and valid.

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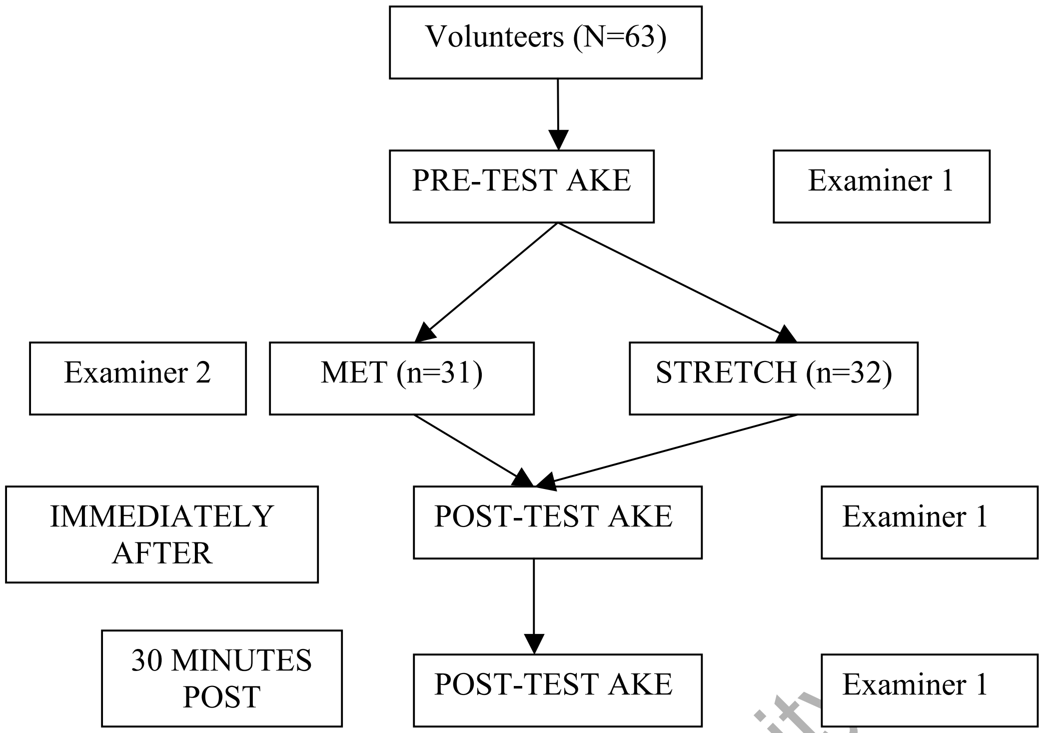

Figure 1: Study design

Fig 2: Active knee extension (AKE) measurement procedure

Figure 3: Greenman Muscle Energy Technique

Figure 4: Static stretch

	AKEpre	AKEpost1	AKEpost2	Difference AKE pre-post1	Difference AKE pre-post2	Cohen's *d* (pre-post1)	Cohen's *d* (pre-post2)
MET	161.28 (14.07)	164.83 (11.78)	163.18 (12.75)	3.55 (5.66)	1.90 (5.93)	0.62	0.32
Stretch	164.18 (11.01)	166.97 (9.61)	166.42 (10.47)	2.79 (3.93)	2.24 (4.34)	0.71	0.52

Table 1: Descriptive statistics for Greenman MET and Stretch Techniques