Fontys Paramedic University of Applied Sciences

Physiotherapy, English Stream
Bachelor Thesis

Self administered soft tissue intervention to the plantar fascia and its immediate and short term effects on hamstring and lumbar spine ROM

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8 June 2015
Version 1.0

PREFACE

Thank you for taking the time to read my graduation thesis. It is the result of many hours of work from not only myself but also my supervisors and peers. Firstly, I would like to thank Jaron Schnitzer, my supervisor who has been exceptionally helpful and professional throughout the entire process and Anke Lahaije who, at all times has shown support for myself and the other english stream students. Additionally, I would like to thank those who assisted me when I was in need of advice or helped me review the final product, namely Madelon Pijnenburg, Steven Onkelinx, Annelies Simons, Sara Sindre, Matti Weitz, Robin Reissbacher, Joseph Lee, Stella Veith and Gard Patturson. Also, I would like to thank all those who participated in my study, whom without, I would not of been able to complete my research. Lastly, I would like to thank my parents and brothers for the support they have given me over the last four years to allow me to follow my interests and pursue my studies. Each member of my immediate family has personally sacrificed to allow me the opportunity to study in the Netherlands and for that I am truly grateful.

ABSTRACT

Background: Improving range of motion in joints is often a primary goal for physiotherapists. Some advocate that improved extensibility of the hamstrings and lumbar spine is possible by soft tissue release techniques applied to the plantar fascia. A study by Grieve et al. (2014) has shown preliminary support of such an effect. However the reliability of this research is low.

Objective: To investigate the effects of repeated plantar fascial interventions on the performance of a sit and reach test.

Design: Randomised control trial

Method: 42 subjects were divided randomly between either an intervention group or a control group. Participants were to undertake a baseline sit-and-reach test before either performing a self administered myofascial release technique to the plantar fascia or a sham treatment before being retested. Those in the intervention group were then requested to perform the intervention twice daily for 6 days before a final sit-and-reach test for both groups on the seventh day.

Results: No significant differences could be found between the groups. however there were generally greater median improvements in the intervention group after a week ($P = 0.121$). The trend was the strongest for males in the intervention group ($P = 0.054$) and very weak for females ($P = 0.757$)

Conclusion: Contrary to previous study the effects of the plantar fascial intervention on sit-and-reach scores are inconclusive, there appeared to be more improvement with the intervention over a longer duration however this is not supported by statistically significant data. More research is required on a larger sample size to draw conclusions.

Keywords: Sit-and-Reach test, plantar fascia, anatomy trains, myofascial release, fascia, flexibility, self-myofascial release, Physiotherapy.

1. Introduction

1.1 Background

Athletes, coaches and therapists are constantly searching for new and safer ways to improve the functional range of motion (ROM) of hypo-mobile joints in the body. A variation from the optimal ROM of some joints, particularly in the lower limb, is associated with a higher risk of injury (1). Reduced ROM can alter biomechanics and cause compromises in athletic performance (2). Additionally, ROM tests are featured as part of the screening process to determine injury risk in athletes (3) and sufficient ROM is a crucial element of performance in many athletic functions. Extensive mobility is for example, a fundamental feature of gymnastics, weightlifting and dance. Historically static stretching has been a prime method for improving ROM. More recent evidence however has indicated potentially detrimental effects of static stretching on athletic performance (4). As a consequence dynamic stretching, angular mobilisations, proprioceptive neuromuscular facilitation (PNF) and soft tissue intervention techniques (STIT) are increasingly utilised and recommended by clinicians as alternatives to improve ROM and aid recovery (5).

STIT vary widely in their applications and generally involve any technique which aim to alter the tension characteristics or pain perception of a person's soft tissues. All forms of massage are included in the definitions of STIT as well as some forms of taping. STIT are most commonly used to treat injuries, reduce soft tissue tension, promote healing or as a relaxation modality (6). One particular subset of STIT are Myofascial release (MFR) techniques. MFR involve interventions that apply external pressure into soft tissue with the aim of achieving a 'release' of tension in hypertonic tissue (7). Types of MFR include trigger point massage, friction therapy and self myofascial release (SMR). SMR is effectively the same as Myofascial Release but enables a tool to be utilised in the intervention instead of requiring a therapist. This allows a flexibility in the application of the intervention outside of the treatment setting (8) and is most commonly employed with the use of a foam roller or a treatment/massage ball. MFR techniques have substantial evidence for their capability in safely influencing soft tissue mechanics and tension (9, 10). In particular, trigger point therapy for improving ROM and reducing pain, and SMR (specifically foam rolling) for improving ROM and reducing delayed onset muscle soreness in those who undertake athletic activity. These advantages have been noted in studies without causing a detrimental impact to athletic performance (8, 11, 12). Although the exact physiological mechanism by which these improvements are achieved is not yet fully understood; MFR is believed to be effective in improving function and ROM by influencing the viscoelastic properties of the fascia (13).

There are various hypotheses about how the viscoelastic properties of the soft tissue are receptive to MFR. Many theories suggest that the soft tissue is influenced by the neurological response to the stimulus given by MFR (14). However other recent theories have based their explanations on local tissue responses in the fascia itself in combination with neurological responses as the cause of these mechanical changes (15). It is even purported that these changes to the fascia may physically influence the function of tissues seemingly distant from the site of the intervention (16, 17). These hypotheses form part of a much larger field of study which is investigating the exact function of fascia in the body.

In order to further explore the background of this subject, one must first define what fascia is. Fascia is often defined as the soft tissue component of the connective tissue system and is found extensively throughout the entire human body (18). Fascia is continuously interwoven throughout the somatic, neurological, cardiovascular and visceral systems and is an inseparable extension of the connective tissue coverings of the muscles and of the periosteum and joint capsules of the bones (19). Fascia is often described as the body's exoskeleton; or soft tissue skeleton, in which it functions as the scaffolding for all soft tissues in the body (20). Fascia is highly innervated and consists of overlapping sheets of regular and irregular collagen fibres that together create a viscous crystalline matrix of connective tissue. These features make it capable of altering its structure and rigidity in response to changing environments (21) and potentially influencing the tension of the local area (17) The role of fascia in the body however is relatively unknown. Modern western medicine has historically regarded fascia as generally a passive structure, although there is increasing speculation that suggests otherwise (15, 21-23). Varying beliefs about the roles of fascia are also the basis for many of the world's most prominent alternative medicines and therapies, including osteopathy, acupuncture, chiropractic and ancient Chinese medicine. It is also a fundamental influence in the theories of Feldenkras and the Rolf Institute (19).

According to current research, some evidence now suggests that fascia is not the passive structure it was once thought to be (20). Fascia is capable of contraction through the activation of specialised fibroblasts called myofibroblasts (24) and can increase the strength of its resistance to mechanical stress after receiving a previous mechanical stress (25). Dupuytren's disease and frozen shoulder are for example, dependent on the dysfunction of those very contractile features of the fascia (26). Historically, a lack of research and acknowledgement of fascia can likely be attributed to anatomists. Typically anatomists have dissected the body in a way that involved cutting away fascial tissue in order to display the body as one with definitive boundaries between structures (19). Recent anatomical dissections have shown that it is impossible to separate fascia from the tissue it surrounds; particularly in muscle tissue, where there is a complete continuity between muscle and fascia that extends across joint and muscle boundaries (16). These continuations of fascia are found to be particularly prominent in certain lines throughout the body and bear a striking resemblance to those of acupuncture meridians (27). Such findings have led the way for other specialists to hypothesise about the role of fascia and its influence on a wide variety of pathologies (23, 28) and also to theorise the ramifications on biomechanics (29, 30). These theories promulgate that fascia and fascial tension form the basis of functional stability in the entire human body (17, 31).

Despite a long history of speculation, only recently has high quality research been conducted on the functions of fascia (20, 32). Interpretations over new evidence and a history of poor quality and conflicting evidence has resulted in much that remains unknown about fascia. Critically debated points include, the extent to which tension is maintained by fascia and whether fascia is capable of transmitting tension across multiple joints lines. There is also an ongoing debate about the precise role of the contractile cells in the connective tissue and the exact physiological mechanisms by which fascia could potentially be responsive to soft tissue intervention (19).

The research in the field of fascial study is of high significance to medical and paramedical specialists. An understanding of the mechanisms of soft tissue tension could allow advances in the treatment of soft tissue dysfunction by intervening more specifically with the cause or mechanism of the tension response.

Physiotherapists in particular; along with all other movement therapists, would consequently be able to implement more effective soft tissue management strategies. Such implications may improve the treatment outcomes by reducing treatment times for soft tissue injury, improving chronic postural related injuries, aiding performance and reducing pain that originates from the soft tissues. Understanding whether soft tissue tension can be transferred across muscle and joint lines may also encourage a more holistic evaluation of the body's biomechanics. This would increase the importance of global postural assessment and adjacent joint assessments in the clinical setting. These improvements in soft tissue treatment would transpose benefits for those suffering from some soft tissue pathologies such as hyper-tension related postural complaints and chronic repetitive strain injuries. Additionally, benefits could potentially exist for the broader population of asymptomatic people who participate in sports and physical activity. These prospective advantages would be the result of new training, flexibility and warm up modalities which are uncovered due to a better understanding of the mechanics and influence of tension and soft tissue throughout the body.

Using clinical experience, anatomical dissections, the principles of fascial contractility and the assumed influence of fascia on functional stability, manual therapist Thomas Myers has written a schematic overview of the body. In his text titled: Anatomy Trains (17), Myers links these apparent fascial connections throughout the body by what he calls Myofascial Meridians (MM) (17). Myers claims that through precise soft tissue intervention one can positively influence the function and extensibility of the entire MM. One of these continuations detailed in Myers literature is the superficial back line (SBL). The SBL is comprised of muscles and connective tissue of the posterior aspects of the lower limb and torso of the body. The SBL begins at the plantar fascia of the foot and ends at the epicranial fascia of the cranium via the m. erector spinae (17). The SBL is responsible for extension of the joints of the hip and spinal column and flexion of the knee. Myers advocates that through the application of a SMR to the plantar fascia with a ball, not only will there be improvements in local flexibility, as has been seen in earlier studies (33) but can also be a reduction of tension throughout the entire SBL, consequently improving the extensibility of the hamstrings and forward flexion capacity of the lumbar spine (17).

Such a claim has almost no theoretical evidence to suggest its plausibility. The concept of an intervention into the foot having an influence on hip and lumbar spine ROM is a bold and remarkable claim. Moreover, there has to date, been little quantitative research exploring the efficacy of such a phenomenon. Numerous anecdotal accounts however appear to support the intervention (34, 35). The potential for clinical benefits, coupled with the uncertainties amounting from emerging evidence in relation to fascia, is the motivation of the researcher to examine the extent to which the characteristics of soft tissue may be influenced by specific interventions to other seemingly distant parts of the body.

A pilot study conducted by Grieve et al. (36) was aimed at investigating Myer's proposed soft tissue intervention into the plantar fascia and its effect on SBL extensibility. The study found a moderate improvement in hamstring and lumbar spine ROM; as measured by a sit and reach test (SRT), immediately after a self administered plantar fascia intervention with a tennis ball ($P = 0.03$). According to a review of available literature conducted by the author; the study was the first known to have empirically investigated the effects of a STIT to the plantar fascia on the SBL extensibility. It also appears to be the first empirical evidence of an intervention into soft tissues improving the ROM of joints that are not directly adjacent. How-

ever, despite the researchers findings, there were many design limitations to the study. Including a small sample size (n=24) and a strong female bias in the sample of the study (n= 16 women, 8 men). Additionally the Grieve et al. study only investigated the immediate effects of the intervention and the participants. Therefore, much remains unknown about the efficacy of soft tissue interventions to the plantar fascia and the supposed positive effects on ROM of the hamstrings and lumbar spine.

If the results observed in Grieve et al. (36) are valid, such an intervention has various positive consequences. SMR to the plantar fascia could then be potentially advocated as a means to immediately improve of the extensibility of the hamstrings and forward flexion ROM of the lower back. These findings hold plausible benefits to those with chronic conditions including some lower back pains which arise from limited mobility, as an increase in ROM may improve function and reduce pain associated with the disorder. Also those who struggle with limited hamstring flexibility may have a reduced chance of injury by improving the extensibility of those muscles. The simplicity of the intervention would allow its use in a broad range of settings and could be utilised by almost all people, which therefore makes it highly practical. Naturally, physiotherapists stand to benefit from the validation of such findings as they are often responsible for treating such hamstring and lumbar spine complaints and would thus, be able to employ plantar fascial interventions to improve patient outcomes for certain complaints. Unfortunately current research is too limited to advocate the intervention and more study would be required to determine its effects on specific pathologies, athletic performance and injury risk. Although if the effects are similar to that of other SMR techniques, then plantar fascial intervention also has the potential to become a viable treatment protocol and a warmup tool for those who undertake sporting activities.

1.2 Problem Description

There is early evidence to suggest that a positive improvement in forward flexion extensibility is possible by administering an STIT to the plantar fascia. This is consistent with a variety of theoretical research that advocates soft tissue connectivity throughout the body. However, the Grieve et al. (36) study is the only quantitative evidence that supports such a connection and the study is of low reliability due to design limitations. Therefore it is imperative that new investigations are attempted to validate the preliminary findings of Grieve et al. (36) and thereby encourage more diligent research into the phenomenon and its potential clinical applications.

1.3 Objective and research question

It is the purpose of this study to investigate the effects of a soft tissue intervention to the plantar fascia and its effects on posterior chain flexibility in young adults. Specifically the objective of the research is to expand on the study by Grieve et al. (36) which was originally suggested by Myers (17). The aim of the study is first to replicate the framework of Grieve et al.(36) by testing the hypothesis that a soft tissue intervention to the plantar fascia can improve SRT performance of the participants, whilst making some design changes to improve the validity of the results. Such changes involve implementing a sham control group, exploring if a more clinically significant result can be observed when a firmer intervention tool is used (8) and performing multiple applications of the intervention over a period of 7 days. The subgoals of the study are to attempt to draw conclusions from both sexes, to minimise some of the potential placebo or con-

founding factors noted in the previous study and to measure the effects of repeated self administered soft tissue interventions to the plantar fascia on SRT performance.

What are the immediate and short term effects of repeated self administered soft tissue interventions to the plantar fascia on the forward flexion extensibility of the hamstrings and lumbar spine ROM when compared to a sham intervention in young adults?

2. Method

2.1 Design

The qualitative empirical research design is a randomised control trial measuring the effects of a soft tissue intervention to the plantar fascia on sit-and-reach test (SRT) performance of the participants. The investigation took place over a seven day period at Fontys University of Applied sciences, building TF in Eindhoven, The Netherlands. The experiment involved two contact sessions with the researcher; one at the beginning and one at the end of the seven day period and was separated into two distinct periods (P1 and P2) and three separate test moments (T0, T1, T2 see **figure 1.**). The participants were divided into two groups, an intervention group and a control group. The intervention group involved the subject performing a SMR of the plantar fascia with a golf ball. The control group undertook a sham intervention in P1 followed by acting as a passive control in P2. The sham intervention had been included for the control group to maximise the internal validity of the design (37, 38). For all tasks the participants were instructed by a written protocol and the subject was allowed to verbally clarify with the researcher anything that they may have remained unsure about.

2.1.1 P1 Summary

All participants began P1 with an introduction of the study from the researcher. During this time the participant was provided with an opportunity to ask any questions, were screened for selection criteria and signed the consent form (See appendix I). The subjects then performed the baseline SRT test (T0) before being randomly assigned to a group. Following this the intervention group performed the plantar fascia SMR (Appendix II) before being immediately retested (T1). While the control group undertook a sham control intervention (Appendix III) before also being retested. Participants undertook P1 one at a time and were entirely supervised by the researcher. P1 lasted roughly 10 minutes for each participant.

2.1.2 P2 Summary

Immediately succeeding P1, P2 lasted a period of 7 days. During this period the intervention group followed the take home protocol (Appendix IV) which involved performing the same intervention as seen in P1 twice daily for six days. The intervention participants then returned on the seventh day for the third and final SRT (T2). Participants in the intervention group were required to declare on the take home protocol handout when the intervention was performed so as to determine the percentage of adherence to the protocol. During P2 the control group acted as a standard control with no prescribed sham or intervention and were also retested on the seventh day.

2.1.3 Design overview

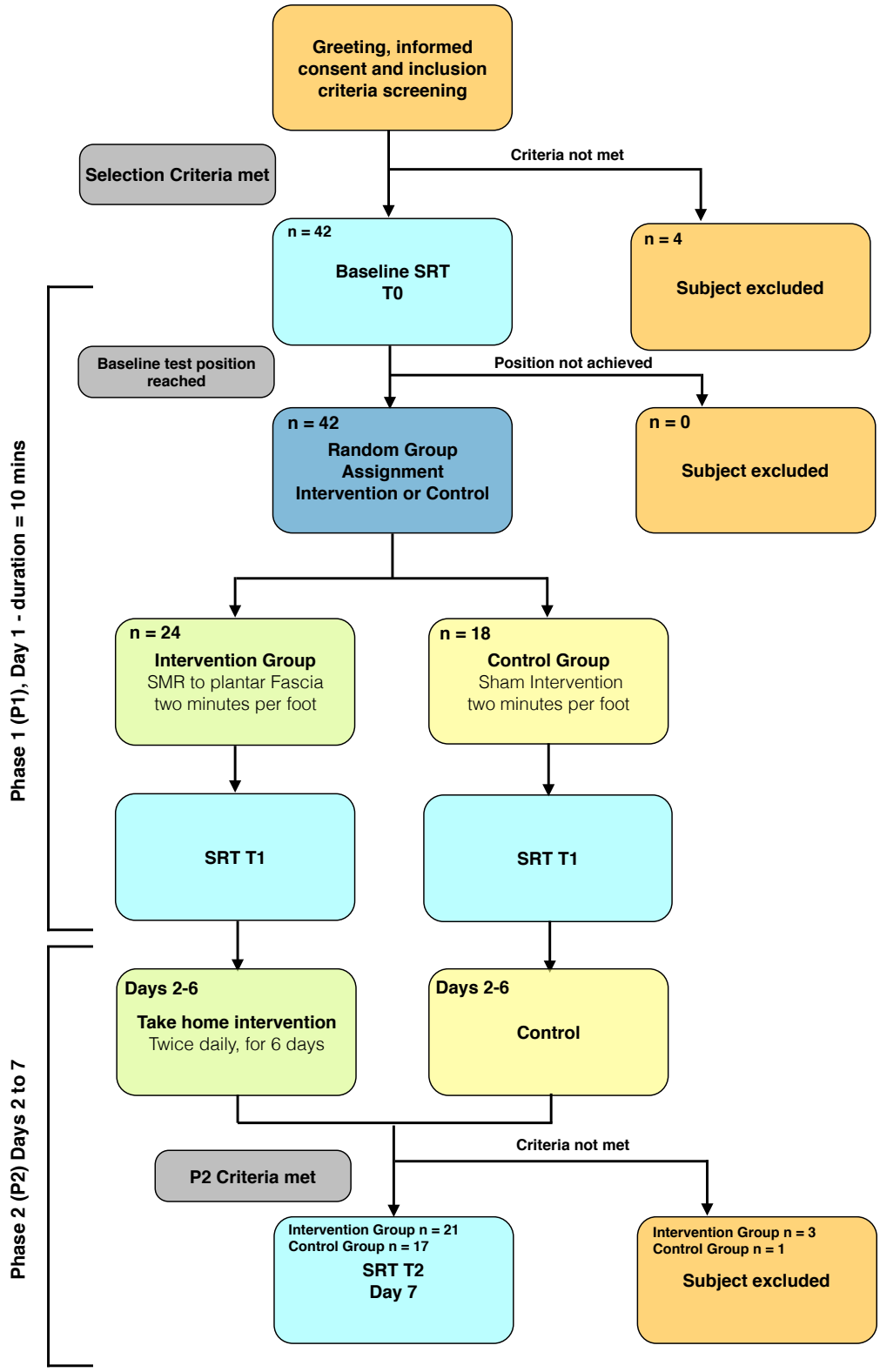

figure 1. - Flow chart. *SRT = sit and reach test, n = number of participants, SMR = Self myofascial release of plantar fascia

2.2 Participants and selection criteria

42 healthy asymptomatic male and female students from the Fontys University of Applied science in Eindhoven, The Netherlands were recruited in the sample group for this study. The sample size of 42 had been decided upon due to a compromise between the practical constraints of the researcher and an attempt to use the largest sample size possible. This was done to strengthen any possible conclusions draw from the study. The participants were recruited by information flier (see Appendix V), class visits and online queries. All subjects participated voluntarily.

2.2.1 Inclusion criteria

Included participants must have been students between the ages 18-30, capable and willing to undertake the intervention for a period of one week and consented to two screening sessions. Also for inclusion in the study results participants must have been able to complete the study protocol assigned to them without any negative or adverse reactions.

2.2.2 Exclusion Criteria

Excluded participants were those who:

- Undertook regular physical activity requiring rigorous stretching (yoga, gymnastics and regular use of SMR etc.). These participants were excluded as they likely had an overlap in their regular behaviour with that of the intervention or are already excessively flexible and it was unlikely that they could derive any benefit from the intervention. These subjects were to be excluded by an initial screening conducted in conjunction with the information handout.
- Participants who in the last 3 months acquired soft tissue injuries to the posterior leg muscles or back or those with a history of serious pathology or trauma to any of the lower limb joints and lower back. Also participants with any systematic or pathological conditions which would impair soft tissue intervention or in which soft tissue intervention would be contraindicated. For ethical and safety reasons the sample group is to be made up of asymptomatic individuals, this limits any risk of adverse reactions to the treatment and also limits the variability of external factors within the sample groups.
- Those who are to undertake strenuous irregular activity over the testing period (i.e running a marathon) were excluded because of the effects that irregular strenuous activity can have on injury risk and perceived flexibility in the joints (39). It is also unknown if the intervention can cause an additional increase in injury risk or change the subjects perceptions of flexibility, which may affect reliability of the testing. Although the researcher could not prevent a participant from undertaking irregular activity. Participants were asked to report any irregular activity and participation in the study is thereafter ceased.
- Subjects who were unable to reach the minimum base testing position of the SRT (-30 cm. *See* ***figure 2a.***). Such subjects would be unable to register test data due to limitations with the testing equipment.
- Those in the intervention group that performed less than 60% of prescribed interventions. This was chosen as a reasonable level to maintain the independent variable between the groups.

2.3 Testing, randomisation and intervention protocols

2.3.1 Screening

Participants were screened for selection criteria in conjunction with the completing of the informed consent form (see Appendix I). The participants were queried regarding the selection criterion on the background information handout (see Appendix V) and subjects were to report if they did not meet the stated criteria and were encouraged to check if they were unsure.

2.3.2 Randomisation

Participants were randomly assigned to either the intervention or control group. Participants were assigned to either group by way of a lottery system. The lottery consisted of two boxes each filled with 30 cards with either group written on each card (15 Intervention, 15 Control). There was a separate box for males and females in order to distribute the sexes evenly between the two groups. Participants were required themselves to draw the card out of their genders respective box. The cards were folded in half making it impossible for the participants or the researcher to determine the group assignment before it was drawn.

2.3.2 Testing Protocol

The testing protocol (see Appendix VI) for all three test periods (T0,T1,T2) remained identical. All testing was carried out by the sole researcher for consistency and participants were unaware of their results to prevent bias. The Participants sat on the apparatus with their knees extended assuming the position seen below in figure 2.

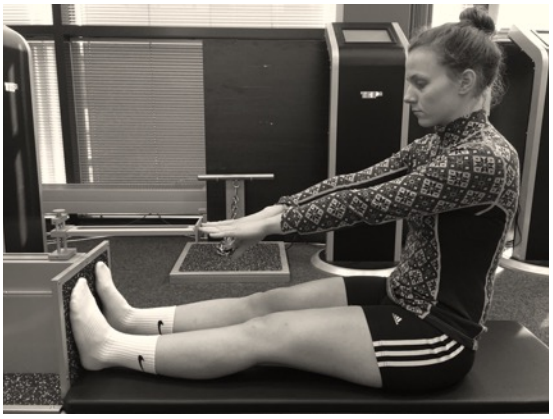

Figure 2a, Sit and reach base position

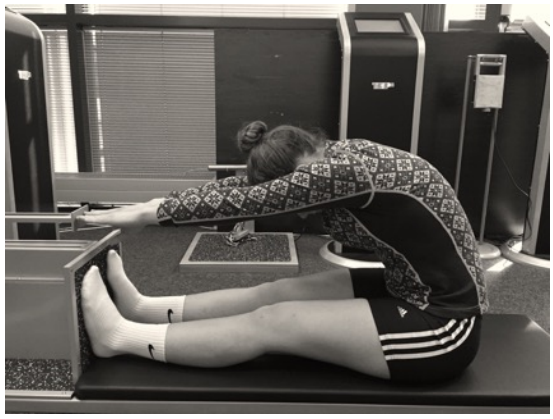

Figure 2b, Sit and reach end position

The participants were to reach forward gradually pushing the finger-plate as far forward as possible without flexing their knees and then hold that position for two seconds (40). The subject was to only feel mild discomfort (NRS=3) and no sporadic movements or shaking was to occur during the test. The test will determine the furthest distance in centimetres (cm) that the finger-plate can be pushed forward and recorded as its distance from the foot-plate. The finger-plate begins at the position of -30cm (meaning 30cm from the foot-plate) and can be pushed as far as 30cm past the foot-plate. The participant will undertake the SRT three times each testing period (41). Tests in which the researcher noticed sporadic movements,

marked shaking or the subject reported pain or discomfort (NRS=>3) were subsequently excluded from the test calculations.

2.3.3 Intervention Protocol

The P1 intervention for the intervention group was for participants to undertake 4 minutes (2 minutes per foot) of rolling a golf ball into the plantar aspect of their feet. The ball was to be rolled around in short repetitive motions from the anterior aspect of the base of the calcaneus to the tuberosities of metatarsals I-V whilst sitting on a chair (see Appendix II); as instructed by an information handout (12) and was clarified further if necessary by the researcher.

The P2 Intervention was exactly the same as the intervention in P1 however was to be carried out at home and for shorter duration (one minute each foot). A take home protocol sheet (see Appendix IV) and a golf ball was given to those in the intervention group for P2. The protocol lists the instructions to perform the P2 intervention twice daily (once in the morning and once in the afternoon/evening) for 6 consecutive days and the intervention was not to be performed on the day of T2. The participants in the intervention group were required to initial the handout when they completed the interventions and to sign a form declaring the information on the form to be valid.

2.3.4 Control/Sham Protocol

After the baseline SRT measurements the control group participants were instructed to follow an alternative sham intervention during P1 (see Appendix III). The sham intervention was demonstrated by way of a protocol sheet. The intervention mimicked the procedure of the intervention group without placing pressure into the plantar fascia itself. This was aimed at facilitating both groups into believing that they had received an intervention and was attempted to replicate any placebo effects present in the intervention group (37). There was no sham control intervention to be carried out over the intervention week. The control group was retested again seven days later at the end of P2.

2.4 Measurement tools

The sit and reach test (STR) was chosen as a reliable method for determining hamstring ROM (r=0.63) (42) and is moderately correlated with lumbar spine flexibility (r=0.42) (43). The standard SRT is as reliable as alternative procedures of the sit and reach test and was therefore chosen due to its practicality (44) and it's common useage in physiotherapy practise. The SRT has only a small margin for subjective interpretation and has a high intra-tester reliability (intraclass correlation coefficient =0.92) (42). The sit and reach testing apparatus used was a NURYTEC THP2 (NURYTEC Inc. Korea), which provides digital measurements to one-tenth of a centimetre. The Numeric Rating Scale (NRS) was chosen as a reliable (r=0.67-0.96) (45) and practical (46) method of determining discomfort during both testing and the intervention and was chosen above the Visual Analogue Scale (VAS) to allow participants to answer verbally rather than requiring a pen and paper.

2.5 Data Collection

All data collected was recorded on a single test form for each participant (See Appendix VII). Global descriptive sample data was collected from all participants (self reported age, sex, weight, height) and will be

represented in the results as a mean descriptor for each sample group. The T0,T1 and T2 SRT test scores were calculated by averaging the 3 individual results of each test phase and all data was recorded to the single decimal as given by the SRT apparatus. All tests were recorded by a single researcher. At the end of testing, all data were transcribed onto a single spreadsheet document which was securely saved on the researchers notebook. There was no recording of the subject identities on the spreadsheet document and all original testing forms were destroyed after the transcription. Once all the data was collected the change between test periods T0 to T1 and T0 to T2 in centimetre was calculated for each subject.

2.6 Statistical analysis

Statistical analysis was used to determine the probability of the intervention altering the outcome of the SRT performance between the two groups. Firstly the data were tested to determine if it was normally distributed. This was done by performing a Shapiro-Wilk Test on all recorded data variables (47). The groups were then compared to each other to check for any significant differences between their respective samples samples by performing T-tests on each of the four recorded descriptive variables (height, weight, age and baseline SRT score). Following this, the significance of the effects of the group allocation (Independent variable) on the SRT scores (dependant variable) was calculated by performing two tailed Mann-Whitney U tests on the data (48). The chosen test will compared two measurement changes during the experiment the change of T0 to T1 and the change of T0 to T2. The groups were compared to each other as a whole and also by gender. For this study a confidence interval of 95% (P =0.05) (48) was required for statistical significance. All statistical analyses conducted in this research paper was performed by statistical software package SPSS 21 (IBM, Armonk, NY, USA).

2.7 Ethical Considerations

The potential subjects of this study were all given an information briefing highlighting the general procedure of the experiment. All subjects participated voluntarily and signed an informed consent form (see Appendix I). Asymptomatic individuals were chosen to minimise the possibilities of causing a negative intervention outcome and selection criteria was stringently selected in order to minimise any risks associated with participation in the study. Subjects were given clear instructions on what to expect from the testing and interventions and advised not to undertake any irregular strenuous activity which may increase injury risk. Participants could, at any time and for any reason of their choosing decide to exit the study. Researcher contact details were given and subjects were able to contact the researcher at any time. Participants remained anonymous and all personal data will be destroyed after the completion of this paper. The possible advantages of the study for the participant include improvement in forward flexion capabilities and minimal required time commitment for participation. Whilst the disadvantages of participation potentially include possible slight discomfort from the intervention and receiving a sham intervention which provides no potential benefit. Ethical considerations were made in consultation with the lectureship of Fontys University of Applied Sciences and specific approval was deemed not to be required. The author of this paper declares that there were no conflicts of interest whilst undertaking this study.

3. Results

3.1 Participants

In total 42 physiotherapy students (20 Female; 22 Male) from Fontys University of Applied Sciences in the Netherlands participated at the beginning of the study. Three students were excluded from participation during the screening process (one was excluded due to nervous system disease, another for medications being consumed and one for a recent traumatic injury to the knee) and four participants failed to meet the selection criteria over the second phase of testing (two participants dropped out, another did not sufficiently complete the required interventions and one subject ceased their participation because of unrelated lower back complaints). Participants were randomly divided into two groups. 24 participants were placed into an intervention group and 18 participants into a control group. The intervention group consisted of 11 females (45.8%) and 13 males (54.2%) whilst the control group consisted of 9 females (50%) and 9 males (50%). A summary of the descriptive data of the sample groups can be seen below in **table 1**. All descriptive data was normally distributed. There were some average differences in the descriptive measurements between the groups, particularly in the baseline SRT measurements (intervention group = 3.46cm, control group = - 1.74cm, P = 0.112), however the differences were identified to be non-significant by Independent Sample T-tests.

Table 1. Mean values of descriptive data

	Height (SD) [cm]	Weight (SD)	Age (SD)	Baseline SRT (SD)
Female Participants				
Intervention Group (n=11)	168.27 (6.65)	63.91 (8.56)	23.76 (3.09)	7.35 (13.14)
Control Group (n=9)	170.22 (8.26)	70.78 (11.52)	22.38 (1.79)	-1.02 (6.77)
P-Value Comparison	0.565	0.143	0.251	0.101
Male Participants				
Intervention Group (n=13)	180.85 (5.81)	78.08 (8.31)	23.40 (2.07)	0.17 (9.91)
Control Group (n=9)	183.89 (8.16)	84.78 (15.17)	23.36 (2.80)	-2.46 (8.78)
P-Value Comparison	0.318	0.196	0.971	0.530
Total Participants				
Intervention Group (n=24)	175.08 (8.82)	71.58 (10.95)	23.56 (2.53)	3.46 (11.82)
Control Group (n=18)	177.06 (2.53)	77.78 (14,92)	22.87 (2.33)	-1.74 (7.64)
P-value Comparison	0.515	0.128	0.368	0.112

n = sample size, SD = Standard Deviation, cm = centimetres, kg = kilograms, y = years, Baseline SRT = Baseline sit and reach test score in cm, P-value comparison = Calculated by Independent Sample T-tests.

3.2 Outcome measurements

The change between SRT T0 and T1 was calculated in centimetres and compared between the groups. An analysis of the results in P1 (shown in **table 2.)** show that group allocation appeared to have little effect on Sit and Reach test performance (P =0.819). In fact the sham group experienced a larger median improvement than the intervention group. The intervention group had a median improvement of 1.90cm (IQR = 2.39cm) whilst the control group had a median improvement of 2.01cm (IQR = 3.21cm). When looking at the genders in isolation, females in the control group improved more than those in the intervention group. Conversely, males in the intervention group improved more that than those in the control group. Neither of these differences however were statistically significant according to Mann-Whitney U tests.

Table 2. Phase 1, Sit and Reach Improvement immediately after intervention. T0 to T1

	Median SRT Improvement	**IQR**	**Significance**
Female Participants			
Intervention Group (n=11)	1.60cm	1.93cm	
Control Group (n=9)	2.30cm	2.56cm	
			P-Value = 0.160
Male Participants			
Intervention Group (n=13)	2.68cm	2.13cm	
Control Group (n=9)	0.53cm	3.39cm	
			P-Value = 0.171
Total Participants			
Intervention Group (n=24)	1.90cm	2.39cm	
Sham/Control Group (n=18)	2.02cm	3.21cm	
			P-Value = 0.819

SRT = Sit and reach test, IQR = Interquartile Range, n= Sample Size,
Significance = Significance of comparison between the groups, calculated by 2 tailed Mann-Whitney U tests.

The results in P2 were compared after calculating the participants change in sit-and-reach scores between T0 and T2. The comparison between the groups (shown in **table 3.**) show a greater median improvement in SRT score for those in the intervention group between baseline measurements and the retest a week later than those participants in the control group (Intervention group median = 1.73cm, Control group median = -0.33cm. see **figure 3.**). Additionally the intervention group was on average much less variable than the control group (Intervention group IQR = 2.56, Control group IQR = 7.59). Despite the difference in median improvements, the dissimilarity between the groups was not strong enough for statistical significance when comparing the groups as a whole (P = 0.121). A trend however, can be seen visually in **figure 3.** which shows a substantially larger proportion of participants in the intervention group laying above the zero point of the graph (particularly in males). Males in the intervention group had a median improvement

of 1.85cm whilst the males in the control group had a 1.63cm median reduction in there SRT scores (P-value = 0.54). A comparison of the improvement of the females in P2 shows a small improvement in the median score of the intervention group when compared to the control however this is far from statistically significant (P = 0.757).

Table 3. Phase 2, Sit and reach test Improvements from Test T0 to T2

	Median SRT Improvement	**IQR**	**Significance**
Female Participants			
Intervention Group (n=9)	1.60cm	2.10cm	
Control Group (n=9)	0.80cm	9.57cm	
			P-Value = 0.757
Male Participants			
Intervention Group (n=12)	1.85cm	4.07cm	
Control Group (n=8)	-1.63cm	5.68cm	
			P-Value = 0.054
Total Participants			
Intervention Group (n=24)	1.74cm	2.56cm	
Control Group (n=17)	-0.34cm	7.59cm	
			P-Value = 0.121

SRT = Sit and reach test, IQR = Interquartile Range, n= Sample Size, Significance = Significance of comparison between the groups, calculated by 2 tailed Mann-Whitney U tests.

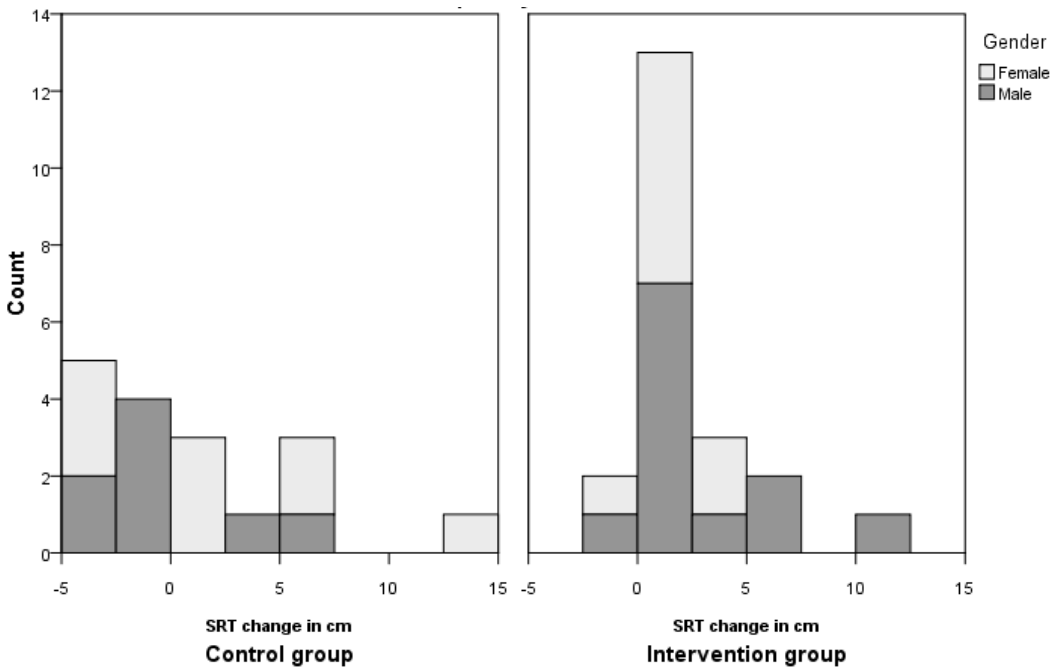

Figure 3. Scatterplot of Gender improvements between baseline (T0) and retests after a week (T2).

4. Discussion

4.1 Overview

The study was undertaken to determine whether a self myofascial release technique administered to the plantar fascia resulted in an improvement of sit and reach test performance of the student participants. The experimental design was constructed to test both the immediate effects and the effects of repeated interventions over seven days. The results in the first phase of the study which tested the immediate effects of the intervention, show that group allocation appeared to have little effect on the immediate improvement of the SRT scores of the subjects, in fact the median improvement was actually greater in the control group than those in the intervention group. The statistical significance of the results ($P = 0.819$) reveals that similar observations would be the found in random group allocations of that size in over 80% of the time. This is fairly strong evidence to suggest that the effects of either the plantar fascia intervention or the sham intervention did not markedly alter the immediate performance of the sit and reach retest when compared between the groups.

Over the week long intervention period (P2) however, there was larger SRT improvement in subjects who were in the intervention group. A median improvement of 1.73cm was found in the intervention group compared to a median change of minus 0.33cm in the control. Additionally there is an obvious visual trend in the data supporting better SRT improvement in the intervention group than the control, which can be seen in **figure 3.** In the graph, you can see that although the improvements of the intervention group are on average small, they are occurring almost universally with much less variability than what is being seen in the control. Only two people in the intervention group (11.8%) failed to improve their SRT scores compared to 9 in the control group (52.9%). Despite such indications however the statistical significant is still rather weak ($P = 0.121$) and far from the $P<0.05$ required for statistical significance in this study. Additionally, contrary to the aforementioned trend, the largest improvement in the second phase came from a participant in the control group (14.03cm) and of the seven participants in the total sample who improved there SRT scores by more than 4cm, four were in the control group. The large improvement recorded by these four control group participants were likely the cause of the low statistical significance. Such observations are a testament to the roll of natural variability on repeated sit and reach tests and questions the test-retest reliability of the SRT when separated by a week or longer.

There was also large variations in the changes of SRT results between the individual genders. During the first phase, males in the intervention group improved slightly more than those in the control group and females in the intervention group performed slightly worse than their fellow participants in the control group. However neither of these differences were statistically significant. During the second phase the difference is considerable. In the second phase (P2) males who undertook the intervention had a median improvement of 1.85cm, whilst the males who took part in the control reduced there score by 1.63cm. This comparison resulted in a P value of 0.054 which is narrowly outside the requirements of statistical significance but can be assumed to be a likely indication that the group assignment made some difference in participants performance. This is contrasted however by the female performance during the second phase in which; although the intervention group improved more than the control group (Intervention group median improvement = 1.60cm vs Control group mediant improvement of 0.80cm), the statistical significance was

very low (P = 0.757). Ultimately the results observed in the gender comparisons need to be treated with caution as there is no obvious reason for such a discrepancy between males and females. Additionally, each sample size for the gender split groups is roughly 10 participants and therefore, such groups are much too small to be able to draw strong conclusions, considering the variability of results observed in the control group.

The findings of this study suggest that there may be an effect on the ability of a person to improve their sit and reach test performance when performing repeated interventions of plantar fascia SMR. This assumption can be obtained by evaluating the average improvement of the groups and the trends visually represented by both the males and females in the study. The trend however does not speak at all of the size of the effect of the intervention or whether it is of any clinical relevance. Considering that the results themselves are contradictory it could easily be concluded that the hypothesis tested in this study is neither confirmed nor is it adequately discredited. The author however, believes one could reasonably conclude that it is unlikely that the intervention itself has made an immediate positive effect on SRT performance. These findings encourage further investigation into the effect of plantar fascial intervention and what the potential effects of soft tissue techniques may have of the flexibility of distant structures. The outcomes of this study do not dismiss the possible advantages of the intervention over a prolonged and repeated intervention period, however this study failed to observe any significant improvement in the limited scope in which it was investigated.

4.2 Relation to other studies

When comparing the results to that of the previous study on the hypothesis conducted by Grieve et al. (36) some results appear conflicting. Grieve et al. (36) found a moderate and statistically significant improvement in the group that undertook the plantar fascial intervention when compared to a group that performed no intervention. On the surface this seems to be contradictory to the findings of this study, however there are a few possible reasons for such a discrepancy. One explanation is that the use of a tennis ball by Grieve et al. (36) rather than a golf ball, used as the implementation tool for the soft tissue intervention may have caused a difference in the effectiveness of the intervention, however the author of this paper believes that would be highly unlikely. A more plausible explanation could be the larger sample size used in this study. Grieve et al. (36) used a sample size of 24 participants, which was just over half the sample size of this paper. This meant that the Grieve et al (36) study captured a smaller sample of natural variability and improvements in the participants. It was possible that a higher percentage of participants who would naturally, regardless of intervention, have a large improvement in SRT scores were placed in the intervention group rather than in the control group. Other factors that may have had a confounding influence in the outcomes included differences in baseline SRT performance between the groups in this study and the awareness of group allocation of the participants in Grieve et al. (36). Specifically, those in the control group of Grieve et al. (36) knew that they had not undertaken any intervention and may have been less inclined to attempt to improve on their previous score. In turn, the sham intervention included in this study may have reduced that confounding factor and resulted in the participants from both groups equally attempting to improve their second SRT test. Other influencing factors may have been differing instructions given to each participant or an unclear intervention protocol which may have reduced the number of participants receiving the proper application of the intervention in this study. Despite differing outcomes

between studies, this paper also observed a similar yet less significant trend to what was recorded in Grieve et al. (36) Therefore the results of this paper question but do not disprove the outcomes reported in the Grieve et al. (36) study.

There has also been studies that have questioned the benefit of SMR techniques when used in isolation to improve sit and reach test results. For example, Roylance et al. (11) found significant increases in sit and reach testing capacity when using foam rolling (a form of SMR) on the posterior leg muscles in combination with static-stretching or postural correction exercises. While, Škarabot et al. (49) found that foam rolling of the calf in combination with static stretching improved dorsiflexion capacity of the ankle greater than static stretching alone. No such significant effect was found when utilising foam rolling in isolation. The outcomes of both of these studies may suggest that the efficacy of SMR of the plantar fascia may be ineffectual on improving ROM when used in isolation but may be beneficial when combined with other clinical practises. This is a conclusion that may explain both the existence of the anecdotal evidence supporting the intervention and the results of this study.

4.4 Clinical relevance

Although inconclusive, the results of this experiment do have some clinical relevance for the wider healthcare community. Critically, it must be stated that the effectiveness of this intervention for increasing extensibility of the SBL is highly questionable and the effects of the intervention on symptomatic people has not been studied. Therefore a clinician or therapist should acknowledge that it may not form part of an evidence based practise protocol for improving the extensibility of the hamstrings and lumbar spine. No participants however reported any adverse reactions from the intervention as was also the case in the previous study on the topic (36) which may suggest that whilst it has not been proven to be effective it can be investigated safely in asymptomatic individuals and there appears to be no drawbacks from researching such an intervention. Additionally, the results of this study cast some doubt on ability to influence soft tissues through the paths of Thomas Myers myofascial meridians however the study undertaken has investigated these connections in a largely limited scope and therefore draws no concrete conclusions.

4.5 Limitations of the study

Despite attempting to improve the experimental design of previous studies, the design of this study had shortcomings. Most evidently, the first criticism of the study design was the relatively small sample size. The sample size of 42, whilst normally large enough to draw some basic conclusions was not large enough to account for the large variability of the SRT performance between the groups. Moreover, the study consisted of both males and females; each with a gender-split group of roughly 10 participants, therefore the strength of the conclusions drawn by an analysis of such small groups has further additional limitations.

The sample size did not allow for a true randomisation protocol and the small samples prevented the groups from being more closely homogenous in their demographic variables. Whilst there was no statistically significant difference between the groups descriptive measurements, notable differences did exist in

average weight and baseline test performance. Judging by the possibility that baseline flexibility may have been an influencing factor on the ability of a subject to immediately improve their scores (regression to the mean). It may be possible that someone who is less flexible may improve more with their fourth to sixth attempt at a stretch than those who have good baseline flexibility. This may have influenced the results seen in the first phase of testing.

Another plausible limitation to the study involves the partial application of a sham intervention for the control group. The control group was not instructed to follow the sham intervention for the 6 day period between T1 and T2, this may have excluded a potential placebo affect that could have occurred during the retest at the end of the week and weakened the possible conclusions that could be drawn from the results in P2. Additionally, all the participants were physiotherapy students and therefore would likely have been more astute at detecting the sham intervention when it was utilised. The detection of the sham intervention would have compromised the subject's blinding and also mitigated any placebo affects derived from the sham.

The test periods for the subjects were not standardised and therefore some participants undertook the first test session at around 9am. While the retest for example may not have been performed until 2:00pm a week later. The participants flexibility was therefore subject to whatever activities occurred previous to the testing. Some participants may have come straight to the test from bed whilst others may have already walked a considerable distance during that day. No warmup or pre-testing preparation protocol was followed either which could have exacerbated any of these issues. Such variability may also have affected the results in a small sample.

Also there was no attempt to standardise or quantify the intervention to the subjects. Participants were given only a protocol to follow and this allowed limited feedback to the researcher as to the quality of the intervention being performed. Moreover, the researcher was unable to supervise the participants during the week of P2 and was therefore unable to accurately determine how much of the intervention was undertaken during the week by those in the intervention group. Additionally, the exercise and activity habits of the participants were unreported from both groups during this week, meaning that the type and quantity may possibly have had a larger effect on SRT performance than group allocation and yet this information was unrecorded.

A final limitation to this study was that the study was conducted by a single researcher who was of limited experience. Although all research was conducted under supervision of the lectureship this could possibly cause a reduction in reliability of the results and conclusions drawn from this study (50). Additionally, because the researcher was alone in conducting the experiment he was unable to be blinded to the participants group allocation during the testing. Having the researcher aware of the group allocation of the participants may have made it possible for the researcher to have encouraged a certain outcome over another or to assert his specific biases in other ways.

4.6 Recommendations for future research

Recommendations for further research on the topic would suggest any future studies to use a large sample size with a roughly even spread of males and females and most critically, similar baseline measurements. Such a sample would mitigate the individual outliers that appeared in this study as well as more accurately determine the significance of the effect of any of the given interventions. Also, studies should make an attempt to record or control for the types of activity performed during the period of testing, such data may allow a researcher to control for the effects of varying levels of activity on the SRT scores of the studies participants. Additionally, further studies should investigate the effects of the SMR intervention to the plantar fascia over a longer duration. This study seemed to produce a stronger trend over a week rather than what was seen in the immediate effects. Hence, a study that investigates the intervention with multiple repeated measurements over, for example, 6 weeks should be much more likely to detect any significant changes between the groups. Also, it would be beneficial to study the effects of the intervention in combination with more proven methods of improving SRT scores. The strengths of such a study would be twofold. First, the study may be able to question whether the intervention is effective when used in isolation or whether it provides greater benefit when coupled with another intervention. Secondly, in a single study it may be possible to not only determine if the intervention is effective, but to quantify its effectiveness in relation to more commonly used methods for improving hamstring and lumbar spine flexibility. This would be beneficial because, while such an intervention may improve SRT scores there is limited clinical relevance for such a finding if such improvements are minute when compared to improvements of other conventional techniques.

5. Conclusion

Contrary to previous preliminary findings the effects of a plantar fascial intervention on a subjects capacity to improve their sit and reach remains unclear. Those in the intervention group found improvement in sit and reach scores, particularly after repeated interventions over a week. However, generally the improvements were inconsistent and were coupled with low statistically significance. Further research featuring larger sample groups and research in combination with other interventions is suggested to determine whether an intervention into the plantar fascia is able to positively affect the extensibility of the hamstrings and forward flexion capacity of the lumbar spine.

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7. Appendices

Appendix I. Consent form

Consent to Participate in a Research Study.

Fontys University of Applied Sciences. Eindhoven, The Netherlands

Title of Study: *Self Administered Soft tissue intervention to the plantar fascia and its immediate and short term effects on hamstring and lumbar spine ROM.*

Researcher: Nicholas Quinn, Student Physiotherapy, Fontys University of Applied Sciences.

Your signature below indicates that you have decided to volunteer as a research participant for this study and that you have read, understood and agreed to the following points.

- I have read the information handout given to me relating to the study titled: *Self Administered Soft tissue intervention to the plantar fascia and its immediate and accumulative effects on hamstring and lumbar spine ROM.*
- I have been given an opportunity to ask any questions that I may have pertaining to my participation in the study.
- I understand that I have the right to at any time withdraw my participation from the study
- I declare that I have not withheld any information about myself that would disqualify myself from inclusion in the study.
- I consent to having the information collected about me in this study used for the scientific research outlined in the information handout.
- I agree that in the unlikely case of an injury the researcher cannot be held responsible.
- I agree to participate in the research.

Name (print):

Place and Date:_____ Signature:_____

I herewith declare that the information provided to you is accurate and that I have fully informed those voluntarily participating in my research design. I agree that, should any of the information previously given to participants change that I will notify all peoples immediately.

Nicholas Quinn (Researcher)

Place and Date:_____ Signature:_____

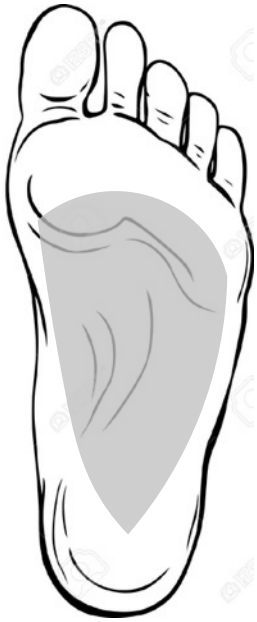
Appendix II. Intervention Protocol

Intervention Group Protocol

Please note: The intervention Protocol is Identical for each individual intervention!

What is required: A chair (fixed base, no wheels), a golf ball and a timer of any sort.

- *First you are to remove your shoes and socks, and take a seat.*
- *Whilst seated, place the golf ball under one of your feet.*
- *Applying moderate pressure you should roll the ball underneath your foot making small circular motions in the area described: from the anterior aspect of the plantar heel to the ball of the foot and across to the distal end of the 5th metatarsal. as shown in grey in the figure!*
- *The intervention should not be painful with a maximum of NRS 4, However you should aim to achieve a very mild discomfort NRS 1-3 throughout the entire intervention.*
- *If any pain or strange sensations occur during the intervention, stop immediately and let the researcher know.*
- *Circle with the golf ball longer in the areas that feel the most sensitive.*
- *Continue the intervention for a period of 2 minutes before switching to the other foot for another 2 minutes (one minute per foot during the take home intervention).*
- *There will be a timer provided during the initial intervention. Whilst at home you will required to time the intervention for yourself.*
- *The total intervention time should be 4 minutes.*



Appendix III. Sham Intervention Protocol

Intervention Protocol for Control Group (sham)

What is required: A chair (fixed base, no wheels), a golf ball and a timer of any sort.

- *First, make sure your shoes are on.*
- *Whilst seated, place the golf ball under one of your feet.*
- *Applying little downward pressure you should roll the ball underneath your foot making repetitive motions in the area described.*
- *Maintain your knee bend between 85-95º flexion (limit knee movements)*
- *There should be minimal tension in your hip and you should feel no pain whilst doing the intervention.*
- *Continue the intervention for a period of 2 minutes before switching to the other foot for another 2 mins.*
- *The total intervention time should be 4 minutes.*

Appendix IV. Take home intervention protocol

Take Home Intervention Sheet

As part of the research experiment you are participating in, you are requested to undergo the intervention twice daily for a period of 6 days.

These interventions are to occur once in the morning (AM) and once in the evening (PM)

Participants should separate the interventions by at least 6 hours.

In each of these interventions you will follow the exact same process as the one carried out with the researcher on the first day of the intervention and testing (as attached to this form). However during this home intervention phase of this experiment you will only be required to roll the ball under each foot for 1 minute.

During the intervention period, should any participant begin to feel pain, to bruise or to feel any kind of unfamiliar sensation during or after the interventions she/he is to stop the intervention immediately and contact the researcher with the contact information given below before resuming any interventions.

Nicholas Quinn: - n.quinn@student.fontys.nl

Due to the necessity of the researcher having to know exactly how much of the intervention prescription is followed, you will be required to initial next to each intervention session to convey that you have undertaken the prescribed intervention and thereafter you are requested to sign a declaration stating that the information on the sheet provided is correct.

Remember!: Your participation in this research is voluntary and you may withdraw from the study at any time. it is more important that the researcher know accurately how much of the intervention protocol was followed than for the participant to follow the protocol 100%.

Day 1	***AM:***	❒	***PM:***	❒	*Initial:*_____	*Date:*_____
Day 2	***AM:***	❒	***PM:***	❒	*Initial:*_____	*Date:*_____
Day 3	***AM:***	❒	***PM:***	❒	*Initial:*_____	*Date:*_____
Day 4	***AM:***	❒	***PM:***	❒	*Initial:*_____	*Date:*_____
Day 5	***AM:***	❒	***PM:***	❒	*Initial:*_____	*Date:*_____
Day 6	***AM:***	❒	***PM:***	❒	*Initial:*_____	*Date:*_____

I hereby declare the information on this form to be accurate and understand that by fraudulently misrepresenting the information reported on this sheet I may be responsible for misleading the scientific results of this study.

Name (print):

Place and Date:_____ Signature:_____

Appendix V. Information Handout

Information Briefing

Nicholas Quinn

Graduation Project: *Self Administered Soft tissue intervention to the plantar fascia and its immediate and short term effects on hamstring and lumbar spine ROM*

Dear fellow student,

I would like to invite you to partake in my graduation project. Please read the following letter to determine whether you would like to consent to being included in the study. The letter will include all the basic information about the upcoming study and will also include my contact details should there be any queries relating to the subject matter, intervention, inclusion criteria or other related questions.

What is the aim of this study?
The aim of this study is to investigate the plausibility of an intervention to the plantar fascia improving the ROM of joints further along the kinetic chain. The theoretical background behind this comes from emerging evidence of fascias ability to withhold tension itself and ever the possibility of it being able to transmit tension along great distances of soft tissue.

What are we going to do?
This study is a random controlled trial of an intervention into the plantar fascia of the foot and to record the effects this intervention has on the sit and reach potential of the test subjects when compared to a control group. The intervention itself shall take no longer than 6 minutes. Afterwards those in the intervention group will undertake the intervention twice daily for a period of 6 consecutive days. Measurements will be taken immediately after the first intervention and at the end of the intervention period (7 days). The control group will follow the exact protocol of the intervention group however will instead receive a sham intervention before acting as a control. Allocation into the control and intervention groups will be done randomly.
Those participating in the study will be asked to provide some global information at the beginning of the study(age, sex, height, weight). This data will remain completely anonymous.

Who may participate in this study?
Those people who find that any of the below statements apply to themselves unfortunately will be **unable** to take part in the experiment. All others should meet the inclusion criteria.

- Under the age of 18 or over the age of 30
- Regularly participate in sports or activities that require or involve rigorous stretching or mobility work i.e, Gymnastics, Yoga, Foam rolling ect.
- Undertaking any irregular activity during the testing/intervention week.
- Those with history of soft tissue injury to their posterior legs or back in the last 3 months
- Those with any serious traumatic injury occurring below the midline of the body in the last 12 months
- Participants with any systematic or neurological disease that would impair soft tissue intervention and/or testing or for which these activities would be contraindicated.
- Those who are unwilling to sign the Informed consent form (see attached.)

Are there potential risks?

If a subject meets the Inclusion criteria to take part in the intervention there are minimal risks associated with the participation in this study. Protocol for all activities involved in the study are clearly defined and with the adherence to protocol the risk for injury is controlled. Mild discomfort is possible when undertaking the intervention, however this is self controlled and regulated by the participant themselves. The researcher will be available for contact at all times during the intervention week. All participants may at anytime and without explanation exit the study.

What happens with the data?

The data will remain anonymous for all participants and the researcher will be blinded as to the identity of the subjects. The individual data sets will be kept by the researcher for the period of time taken to write the graduation project and afterward will be destroyed. The raw data however will still exist as represented in the final product of the Project. Under no circumstances will the researcher discuss the identity of the subjects of this study.

I hope you take the opportunity to be involved in this investigation, I certainly believe that the topic is a truly fascinating one and without the participation of volunteers it would not be possible.

If you would like to discuss the content of this investigation or have any queries about your ability to participate please contact myself (Nicholas Quinn). Furthermore if you would like to contact either the graduation project supervisor (Jaron Schnitzer) or coordinator of the program (Anke Lahaije). These contact details can be found below.

Thank you,

Nick

Researcher

Name:	Nicholas Quinn
Student number:	-
Phone number:	-
E-mail:	-

Project supervisor

Name:	Jaron Schnitzer
E-mail:	-
Phone:	-

Program Coordinator

Name:	Anke Lahaije
E-mail:	-
Phone:	-

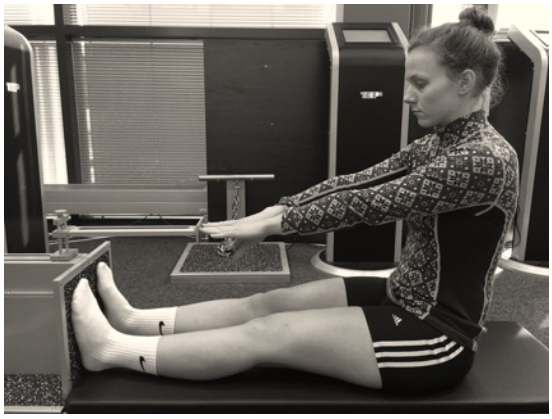
Appendix VI. Testing Protocol

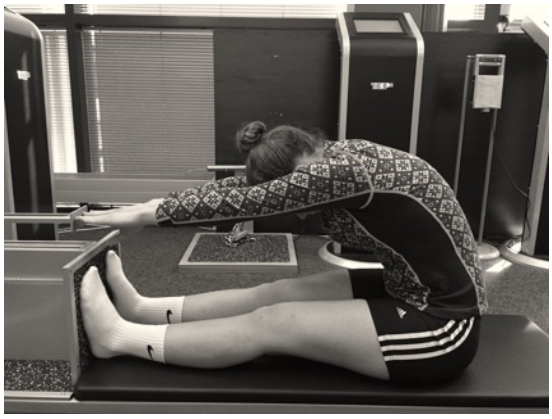
Testing Protocol For SRT

Note: The testing protocol is identical for each testing time.
Participants are NOT to undertake any sort of warm up, or stretching prior to the Testing.

The main outcome measure in this study is the Sit and Reach test (SRT). Each time you (the participant) take the SRT test you will be asked to fill out a brief questionnaire about your experience of the test. The test should take no longer that a few mins for each time.

Sit and reach test





- Participants are to sit on the designated testing position with their shoes off.
- Feet flat on the inside position of the SRT box with there knees in full extension.
- Reaching forward evenly with both hands, the participant will attempt to reach as far forward as they can without compensating in the knees.
- This position will need to be held for a period of 2 seconds before the participant will be instructed to return to a comfortable position.
- The participant is not to push into pain. (maximal discomfort is NRS 3)
- The test is to be repeated 3 times and an average score will be calculated from the 3 attempts.

Appendix VII. Testing form

Test Form

Subject no._____ **Group._____** **Male / Female**

Height:_____ **Weight:_____** **DOB:_____**

Test 1 - Pre-Intervention

Attempt 1:_____

Attempt 2:_____

Attempt 3:_____

NRS (0-10) : Stretch in Back :_____

NRS (0-10) : Stretch in Hamstrings :_____

Subject felt most stretch in:

Hamstrings ❒ Back ❒ Both ❒

Test 2 - Immediately Post Intervention

Attempt 1:_____

Attempt 2:_____

Attempt 3:_____

NRS (0-10) : Stretch in Back :_____

NRS (0-10) : Stretch in Hamstrings :_____

Subject felt most stretch in:

Hamstrings ❒ Back ❒ Both ❒

Test 3 - Post Intervention period completion

Attempt 1:_____

Attempt 2:_____

Attempt 3:_____

NRS (0-10) : Stretch' in Back :_____

NRS (0-10) : Stretch in Hamstrings :_____

Subject felt most stretch in:

Hamstrings ❒ Back ❒ Both ❒