**Abstract**

Context: Anatomical and in vivo studies suggest that muscles function synergistically as part of a myofascial chain. A related theory is that certain myofascial techniques have a remote and clinically important effect on range of motion (ROM).

Objective: To determine if remote myofascial techniques can effectively increase range of motion at a distant body segment.

Evidence Acquisition: In November 2018, we searched three electronic databases (CENTRAL, MEDLINE, PEDro) and hand searched journals and conference proceedings. Inclusion criteria were: Randomized controlled trials (RCT) comparing remote myofascial techniques with: passive intervention (rest/sham), or a local treatment intervention. The primary outcome of interest was ROM. Quality assessment was performed using the PEDro Scale. Three authors independently evaluated study quality and extracted data. RevMan software was used to pool data using a fixed-effect model.

Evidence Synthesis: Eight RCTs, comprising n=354 participants were included (mean age range 22-36y; 50% female). Study quality was low with PEDro scores ranging from 2 to 7 (median scores 4.5/10). None of the studies incorporated adequate allocation concealment and just two used blinded assessment of outcomes. In all studies, treatments and outcomes were developed around the same myofascial chain (superficial back line). Five studies included comparisons between remote interventions to sham or inactive controls; pooled results for ROM showed trends in favor of remote interventions (SMD 0.23 [95% CIs -0.09 to 0.55], 4 studies) at immediate follow ups. Effects sizes were small, corresponding to mean differences of 9% or 5 degrees in cervical spine ROM, and 1-3 cm in sit and reach distance. Four studies compared remote interventions to local treatments, but there were few differences between groups.

Conclusions: Remote exercise interventions may increase ROM at distant body segments. However, effect sizes are small and the current evidence base is limited by selection and measurement bias.

**Keywords:** Remote interventions, Range of motion, Myofascial chain

**Context**

Skeletal muscles were traditionally considered to be independent structures, limited to force transmission via their myotendinous junctions.1 There is growing evidence that muscles are more likely to function synergistically, working as larger interconnected anatomical chains. Indeed, a recent review of 62 cadaveric studies describes a series of commonly occurring myofascial transitions (referred to as myofascial chains), whereby explicit muscle groups were consistently united by a diverse fascial system2. One of the most commonly reported myofascial chains was the superficial back line, consisting of the plantar fascia, achilles tendon, gastrocnemius, hamstrings, sacrotuberous ligament and erector spina3. It is proposed that the anatomical integration of the superficial back line facilitates effective force transmission between the spine, pelvis, legs and arms.4. This is supported by cadaveric5 and in vivo research6 reporting a functional coupling between the thoracolumbar fascia and the latissimus dorsi, gluteus maximus and erector muscle, and the biceps femoris.

The concept of myofascial chains influences the diagnosis and treatment of some musculoskeletal conditions. For example, the correlation between sacroiliac pain and hyperactivity of the gluteus maximus and the contralateral latissimus7 may be underpinned by the anatomical connection between these structures. Recent research also shows that clinical tests, which incorporate multiple joints (both proximal and distal to the point of pathology), are most likely to discriminate between healthy and injured subjects.8 Others9 highlight the importance of incorporating global movements into musculoskeletal rehabilitation, on the basis that myofascial connectivity facilitates the propagation of forces from healthy tissue to adjacent injured tissue. A related hypothesis is that myofascial connectivity contributes to ‘remote exercise’ effects. Remote effects might occur when mechanical manipulation at one part of a myofascial chain incurs a remote effect on ROM, either caudally or cephalically. A commonly reported clinical example is when treatment of the plantar fascia results in increased hamstring flexibility and hip ROM A commonly reported clinical example is when treatment of the plantar fascia results in increased hamstring flexibility and hip ROM.10

It is important to gain a consensus around the role of fascial tissue in the field of sports medicine and physical therapies. Central to this is developing an understanding of the mechanical properties of the fascial system and its response to physical exercise, manual therapy, and other physiological challenges. Finding consistent and strong evidence for remote effects due to exercise, stretching, or massage would provide further evidence of the importance of myofascial chains in human movement, etiology and rehabilitation. A recent consensus statement on fascial tissue research in sports medicine11 suggests preliminary evidence that remote exercise effects are clinically important, but this has not yet been systematically evaluated in the literature. The aim of this review is to determine if remote myofascial techniques based on exercise, stretching, or massage, can increase range of motion at a distant body segment.

**Methodology**

Evidence Acquisition

We undertook a computerized literature search across MEDLINE (R) and CENTRAL (from their inception through to November 2018) accessed via Ovid. Population and intervention specific search terms were combined, in the form of Medical Subject Headings (MeSH) where appropriate, or key words (“remote interventions” “cervical ROM” “myofascial meridians” and “hamstring flexibility”). PEDro was also accessed, using a modified search strategy. English language restrictions were applied. This was complimented with citation tracking of key primary and review articles (n=5). Details on the titles read, abstracts read, full text articles retrieved, and the excluded and included studies were compared for each author with any disparities resolved by consensus discussion.

Only studies examining remote flexibility gains associated with stretching or myofascial release were included. No restrictions were made by body region or myofascial chain. Flexibility gains were measured at any point on the myofascial chain, cephalad, or caudal to the targeted treatment area. Studies used either randomized controlled or randomized cross over designs. Treatment comparisons were made to either no intervention, sham, or a more localized intervention.

Study quality was assessed by two independent authors using the PEDro scale. This is a valid 10 item scale that is commonly used to assess the methodological quality of clinical trials involving physiotherapeutic interventions.12 Reviewed studies were awarded one point for each criterion that was clearly satisfied. As criterion 1 is a measure of the study’s external validity, it was not included in the final PEDro score, giving each study a possible maximum score of 10 on the PEDro scale. Any disparities in scoring were reviewed and if required a consensus reached using a third author. Study characteristics were extracted (CB) and validated by a secondary researcher before tabulating (CD). Key participant and study characteristics included: mean age, male:female ratio, and health status.

There was no blinding to study author, institution, or journal. We extracted data recorded immediately after the intervention. Where possible, effect sizes with 95% confidence intervals [CIs]) were calculated in the form of mean differences [MDs] for continuous outcomes. When two or more studies were deemed to be clinically homogenous in terms of participant, intervention type, and outcome assessment, data was assessed for statistical heterogeneity using chi-squared (Chi2) test in conjunction with the I2 statistic (P<0.1). I2 values greater than 50% were considered to represent substantial heterogeneity. We pooled data on range of motion outcomes assessed immediately after treatment with meta-analysis undertaken using RevMan software (version 5.3; Nordic Cochrane Centre, Copenhagen, Denmark). It was our preference to extract data on change scores (baseline to follow up), however, sufficient data were only available to undertake meta-analyses using follow up scores. We had planned to incorporate subgroup analyses based on intervention type and on body part, however there were insufficient study numbers. We had planned to undertake sensitivity analysis to determine if study quality influenced pooled effect sizes, however, there were insufficient study numbers.

**Results**

Evidence Synthesis

The initial literature search yielded a total of 29,964 citations, from which 196 were included for further reading. After review of full texts, 188 studies were excluded leaving 8 eligible randomized controlled studies13-20 to be included in the review. Figure 1 shows the QUORUM flow diagram, summarizing the selection process and the number of studies excluded at each stage with reasons.

Insert Figure 1

The PEDro criteria and final scores assigned to each study are presented in Table 1. All studies provided adequate information on eligibility criteria. Although all studies stated that group allocation was random, none incorporated adequate concealment. Baseline comparability was evident in five studies.13 15-17 20 Blinding of participants or caregivers would not have been possible given the nature of the interventions but three studies13 19 20 use blinded outcome assessment. Adequate follow up was present in four studies with two undertaking intention-to-treat analysis. The majority of studies reported between group statistical comparisons and measures of group variability. Final PEDro scores of included studies ranged from 2 to 7 and mean and median scores were 4.5/10.

Insert Table 1

Table 2 summarizes key study characteristics. The 8 included studies used a total of 354 participants, of which 50% were female. Seven studies used a randomized controlled design, with one16 using a randomized cross over design. Participants were young with average ages ranging from 22 to 36 years. All studies recruited adult participants currently free from pain and musculoskeletal injury. However, the majority of studies also restricted their inclusion criteria to participants with an existing restriction in ROM at a relevant joint; these criteria included: knee joint extension of <165°;17 a Beightons score of <4;16 20 or not exhibiting hypermobility on the Beighton index;19 inability to reach the floor on a Toe Touch test;18 or presence of short hamstring syndrome 13 classified as having a straight leg raise <80 degrees, a popliteal angle of 15 degrees or more, a finger to floor test of -5 cm or less and the presence of myofascial trigger points in hamstring.

Insert Table 2

All studies applied a remote intervention to a region of the superficial back line. In three studies,14 15 the remote interventions involved static stretching of either the hamstring or hamstring and calf muscles for 30 seconds by 3 repetitions. The remainder were based on myofascial release techniques (2 - 4 minutes) applied to the plantar fascia and/or sub-occipital muscles. The majority of studies employed a single remote intervention with just one examining the cumulative effects of remote treatments undertaken over a 3-week period. Outcome measures focused on ROM at body regions that were either caudal or cephalad to the remote treatment area with the majority limited to a single follow up immediately after treatment completion. One study examining the cumulative of remote interventions included follow ups at 2 and 3 weeks. Remote interventions were compared to either quiet sitting 14 15 19 sham therapy13 18 or a local treatment intervention 15 16. Local interventions involved either stretching or myofascial release applied directly to the body region where outcomes were assessed.

Remote vs sham/inactive control

Two studies14 15 examined the effects of hamstring and triceps surae stretching vs inactive sitting on cervical ROM. A pilot study by Wilke et al. 14 recorded greater cervical ROM in the sagittal plane immediately post treatment in the remote intervention group (MD 4.9 degrees; 95% CIs -6.9 to 16.8 versus control). A follow up study by the same research group15 assessed cervical ROM across three planes of movement and reported between group differences ranging from 3.5% (rotation) to 9% (lateral flexion) in favor of the remote intervention.

Three studies examined the effects of remote myofascial release vs either a sham treatment13 18 or inactive sitting.19 Myofascial release was undertaken as either a self-administered intervention on the plantar fascia18 19 or a therapist led treatment on the sub occipital muscles13. All studies assessed spinal ROM immediately post treatment using a finger to floor test or sit and reach distances. All studies reported effects in favor of the myofascial release group. The largest effects were reported by Do18 based on a mean difference of 3.1cm (95%CIs -2.3 to 8.5 versus control) with smaller effects reported by Grieve19 (MD 2.1cm 95% CI -6.6 to 10.8) and Aparicio et al.13 (MD 0.89cm 95% CI -2.05 to 3.83)

A meta-analysis was undertaken using immediate post treatment follow up data on ROM from 4 studies 13 14 18 19 (incorporating a total of 248 participants) using a fixed effect model (Chi² = 0.38, df = 3 (P = 0.94); I² = 0%). Figure 2 highlights a small effect in favor of the remote intervention versus sham/inactive control (SMD 0.23 [95% CIs -0.09 to 0.55])

Insert Figure 2

Remote vs Local

In two studies 16 20 remote interventions involved sub occipital or plantar fascia release, with comparisons made to a either hamstring stretching or myofascial release. Jung16 used a three arm design and recorded outcomes immediately post treatment. Their results show very weak trends in favor of plantar fascia release vs hamstring release for sit and reach distance (MD 0.6cm 95% CI -5.1 to 6.3), active straight leg raise (MD 2.15 degrees SMD -4.6 to 8.9) and passive straight leg raise (MD 1.4 degrees SMD -5.9 to 8.7). Between group differences were even smaller when sub-occipital release was compared to hamstring release for these outcomes: sit and reach distance (MD 0.5cm 95% CI -6.4 to 5.4), active straight leg raise (MD 0.6 degrees SMD -5.5 to 6.7) or passive straight leg raise (MD 0.2 degrees SMD -6.7 to 7.1). Joshi20 incorporated a three week treatment period comparing myofascial release of the sub occipital muscles and plantar fascia, to local hamstring stretching. At the end of the treatment period there were only small effects in favor of local hamstring stretching group in sit and reach distance (MD 1.3 cm 95% CI -3.58 to 6.18 vs remote treatment) and passive knee extension (MD 1.0 degree 95% CIs -5.77 to 7.77)

Wilke et al. 15 compared remote stretching of the hamstring and calf to a local cervical stretching intervention. Cervical ROM was assessed immediately post treatment across three planes of movement; although both interventions were associated with an increase in ROM, there were no between group differences.

Finally, Hyong et al 17 compared the effectiveness of hamstring stretching with combined stretching of the hamstrings and triceps surae muscles, on cervical flexion ROM. Again, both treatments were associated with an immediate increase in cervical flexion ROM, but there were no differences between groups ROM (MD 0.4 degrees SMD -4.6 to 5.4).

**Discussion**

Rather than being independent structures, muscles are considered to function synergistically as part of a larger ‘anatomical chain’. Groups of muscles united via deep fascia are often referred to as myofascial chains. The superficial back line, which connects the entire rear side of the body from underneath the foot to the top of the skull, has been consistently identified in multiple human cadaveric studies. Applying low load, mechanical manipulation of a specific region of the superficial back line is proposed to propagate a range of holistic effects. This is the first systematic review examining whether application of myofascial interventions can enhance ROM at a distant joint. We identified eight randomized studies comprising n=354 participants. The main findings were that remote myofascial techniques are associated with increased ROM at distant body segments, however the strength of these findings are limited by small effect sizes, wide confidence intervals and high risk of bias across the majority of studies.

Five studies compared remote techniques to sham/inactive controls. Although all of these studies consistently reported effects in favor of the remote interventions, the effect sizes were small. Furthermore, when results from 4 out of the 5 studies were pooled, the overall effect size was small and confidence intervals overlapped zero (SMD 0.23; 95% CIs -0.09 to 0.55). The mechanisms underpinning these remote effects are unclear. Some21 postulate that fascial manipulation induces a piezoelectric effect, whereby the body produces an electric charge in response to applied mechanical stress. However, to our knowledge this has not been validated in vivo. Others suggest effects via mechanical mechanisms whereby stretching or manual therapies can soften and alter the character of myofascial tissue, via a loosening of collagen crosslinks and viscoelastic creep.22 It is important to consider that the included studies incorporated myofascial techniques which were based on brief application of a manual pressure, or short duration of stretching. All techniques induce substantial tensile or compressive loads but they were likely not sufficient to induce plastic deformation of the tissue. It is more likely that any observed trends are due to neurophysiological effects mediated through stimulation of deep or epimysial fascia resulting in relaxation of the muscle spindles and/or stimulation of Pacini Rufini corpuscles and free ending nerves.23 However central adaptation is also possible, whereby increased parasympathetic nervous activity is achieved through the stimulation of mechanoreceptors.24 This is supported by preliminary evidence that static stretching25 or myofascial release24 acutely increases ROM within contralateral limbs.

We found preliminary evidence that joint ROM was similar regardless of whether myofascial treatments were directed remotely or locally on the superficial back line. Future research is required to determine the clinical relevance of these findings. There can be occasions whereby local treatments are contraindicated, eg. due to hypersensitivity, immobilization or casting, and targeting a remote region of the respective myofascial chain may be appropriate. There may be some concern of the magnitude of the clinical effects however. In this current review, the between group differences in ROM corresponded to 9% or 5 degrees in cervical spine ROM, and between 1 and 3 cm in sit and reach distance. Furthermore, few studies incorporated blinded outcome assessment and no study provided details of the minimal detectable changes associated with their outcome techniques.

Studies in this field have focused almost exclusively on joint ROM. However, it is feasible that myofascial interventions could harness other important changes in tissue properties. This should be a focus for future research. Imaging methods such as ultrasound or elastography can explicitly quantify mechanical properties of fascial tissues under in vivo conditions.11 For example cross-correlation calculations derived from real time ultrasound has already been used to estimate relative movements of fascial tissue, including sliding of fascial layers and shear strain.26 Perhaps a related concern is that the majority of studies in this review focused on a single treatment intervention. It is likely that more prolonged periods of physiological loading are required to induce a clinically important change in the mechanical properties of tissues. 27

Study quality was low, with a mean PEDro score of 4.5/10. A recent audit of physiotherapy research undertaken over the past 10 years found an average PEDro score of 6.9.28 An important limitation was although all included studies stated group allocation was random, none incorporated adequate concealment. Further audits of the physiotherapy literature estimate that allocation concealment is undertaken in just 11.5% of trials. This audit also found that trials with inappropriate allocation concealment tended to overestimate treatment effects when compared with trials with adequate concealment of allocation. All of our included studies used objective measures of ROM; therefore, it is surprising that only two used a blinded outcome assessment. There is therefore a high risk of reporting bias particularly as the ROM outcomes primarily involved visual reporting of joint angles and distance, which carries a significant subjective component.

Limitations

We were unable to determine any dose dependent effects associated with the interventions. Primarily, there was an insufficient number of studies but also treatment dosage was generally limited to single treatment of short duration. Only one study considered the cumulative effects of multiple interventions over a three-week period, but found few between group differences. There were also insufficient numbers of studies to determine patterns of effect based on the remote region that was treated, its distance, or orientation (caudal or cephalic) from the outcome site.

It may be important that the mean differences calculated in our meta-analysis were based on follow up data. The choice of mean difference estimates can impact on meta-analysis conclusions. Best practice is to calculate mean differences using both follow up and change scores from baseline,29 however we were unable to extract the later due to insufficient reporting in the included studies. There is evidence that relying solely on follow up scores will a more conservative conclusion; this approach can also produce a bias effect estimate in the event that studies’ baseline scores are imbalanced.29

**Conclusion**

Remote myofascial techniques may increase ROM at distant body segments and there is preliminary evidence that these effects are comparable to local treatment interventions. Pooled data, incorporating a total of 248 participants, shows a small effect in favor of the remote techniques compared to sham/inactive controls. However, the current evidence base is limited due to the high risk of selection and measurement bias and many of the observed effects may be too small to be clinically important.

**Conflicts of interest**: none

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