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SYSTEMATIC REVIEW

Can Myofascial Interventions Have a Remote Effect on ROM? A Systematic Review and Meta-Analysis

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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 the range of motion at a distant body segment. ***Evidence Acquisition:*** In November 2018, the authors searched 3 electronic databases (CENTRAL, MEDLINE, and PEDro) and hand-searched journals and conference proceedings. Inclusion criteria were randomized controlled trials comparing remote myofascial techniques with passive intervention (rest/sham) or 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 randomized controlled trials, comprising N = 354 participants were included (mean age range 22–36 y; 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 2 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 (standard mean difference 0.23; 95% confidence intervals; −0.09 to 0.55; 4 studies) at immediate follow-ups. Effects sizes were small, corresponding to mean differences of 9% or 5° in cervical spine ROM, and 1 to 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

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 system.[2] 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 spina.[3] 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 cadaveric[5] and in vivo research[6] 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 latissimus[7] 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] Others[9] 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 1 part of a myofascial chain incurs a remote effect on range of motion, either caudally or cephalically. 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 medicine[11] 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 the range of motion at a distant body segment.

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Methods

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 where appropriate, or keywords ("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 crossover designs. Treatment comparisons were made to either no intervention, sham, or a more localized intervention.

Study quality was assessed by 2 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 1 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 (S.L.). Study characteristics were extracted (Connor Burk) and validated by a secondary researcher before tabulating (Chris Bleakley). 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 2 or more studies were deemed to be clinically homogenous in terms of participant, intervention type, and outcome assessment, data were assessed for statistical heterogeneity using chi-squared (χ^2) test in conjunction with the I^2 statistic ($P < .1$). The I^2 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 studies[13–20] 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.

The PEDro criteria and final scores assigned to each study are presented in Table 1. All studies provided adequate information on the eligibility criteria. Although all studies stated that group allocation was random, none incorporated adequate concealment. Baseline comparability was evident in 5 studies.[13,15–17,20] Blinding of participants or caregivers would not have been possible given the nature of the interventions but 3 studies[13,19,20] use blinded outcome assessment. Adequate follow-up was present in 4 studies with 2 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.

Table 2 summarizes the 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 one[16] using a randomized crossover 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]

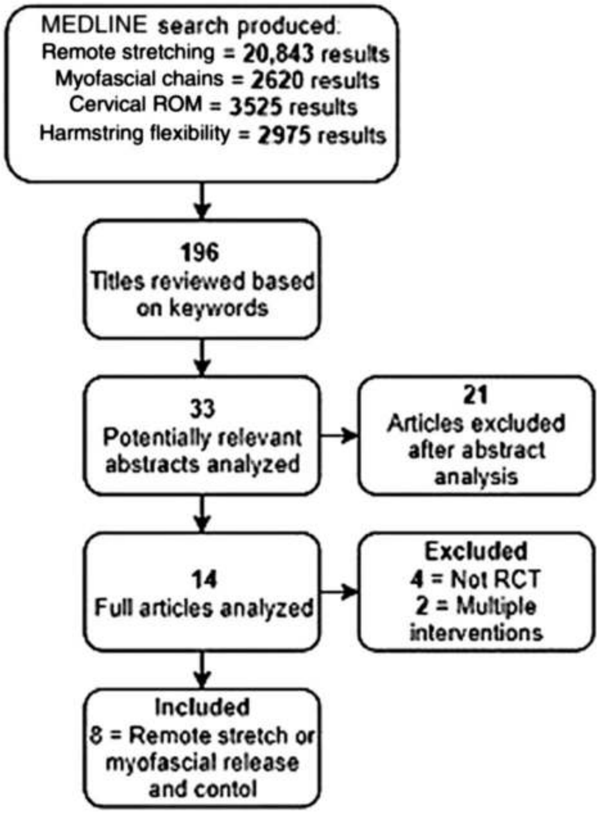

Figure 1 — QUORUM flow chart for search strategy and inclusion criteria. ROM indicates range of motion; RCT, randomized controlled trials.

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Table 1 Study Quality

	Criterion											
Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Aparicio et al[13]	Y	Y	N	Y	N	N	Y	N	N	Y	Y	5/10
Do et al[18]	Y	Y	N	N	N	N	N	Y	N	Y	Y	4/10
Grieve et al[19]	Y	Y	N	N	N	N	Y	N	N	Y	Y	4/10
Hyong et al[17]	Y	Y	N	Y	N	N	N	N	N	Y	Y	4/10
Wilke et al[14]	Y	N	N	N	N	N	N	N	N	Y	Y	2/10
Wilke et al[15]	Y	Y	N	Y	N	N	N	Y	Y	Y	N	5/10
Jung et al[16]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5/10
Joshi et al[20]	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7/10

Note: 1. eligibility criteria, 2. random allocation, 3. concealed allocation, 4. baseline comparability, 5. blind subjects, 6. blind therapists, 7. blind assessors, 8. adequate follow-up, 9. intention to treat, 10. between-group comparisons, and 11. Point estimates and variability. Y, yes; N, no.

classified as having a straight leg raise <80°, a popliteal angle of 15° or more, a finger to floor test of −5 cm or less, and the presence of myofascial trigger points in hamstring.

All studies applied a remote intervention to a region of the superficial back line. In 3 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 studies were based on myofascial release techniques (2–4 min) applied to the plantar fascia and/or suboccipital 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 with either quiet sitting,[14,15,19] sham therapy,[13,18] or local treatment intervention.[15,16] Local interventions involved either stretching or myofascial release applied directly to the body region where outcomes were assessed.

Remote Versus Sham or Inactive Control

Two studies[14,15] examined the effects of hamstring and triceps surae stretching versus inactive sitting on cervical ROM. A pilot study by Wilke et al[14] recorded greater cervical ROM in the sagittal plane immediately posttreatment in the remote intervention group (MD 4.9°; 95% CIs, −6.9 to 16.8 vs control). A follow-up study by the same research group[15] assessed cervical ROM across 3 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 versus either a sham treatment[13,18] or inactive sitting.[19] Myofascial release was undertaken as either a self-administered intervention on the plantar fascia[18,19] or a therapist led treatment on the suboccipital muscles.[13] All studies assessed spinal ROM immediately posttreatment 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 Do et al[18] based on a mean difference of 3.1 cm (95% CIs, –2.3 to 8.5 vs control) with smaller effects reported by Grieve et al[19] (MD 2.1 cm; 95% CI, −6.6 to 10.8) and Aparicio et al[13] (MD 0.89 cm; 95% CI, −2.05 to 3.83).

A meta-analysis was undertaken using immediate posttreatment follow-up data on ROM from 4 studies[13,14,18,19] (incorporating a total of 248 participants) using a fixed-effect model ($\chi^2 = 0.38$, $df = 3$ [$P = .94$]; $I^2 = 0\%$). Figure 2 highlights a small effect in favor of the remote intervention versus sham or inactive controls (standard mean difference [SMD] 0.23; 95% CI, –0.09 to 0.55).

Remote Versus Local

In 2 studies,[16,20] remote interventions involved suboccipital or plantar fascia release, with comparisons made either to a hamstring stretching or to a myofascial release. Jung et al[16] used a 3 arm design and recorded outcomes immediately posttreatment. Their results show very weak trends in favor of plantar fascia release versus hamstring release for sit and reach distance (mean difference [MD] 0.6 cm; 95% CI, −5.1 to 6.3), active straight leg raise (MD 2.15°; SMD –4.6 to 8.9) and passive straight leg raise (MD 1.4°; SMD −5.9 to 8.7). Between-group differences were even smaller when suboccipital release was compared with hamstring release for these outcomes: sit and reach distance (MD 0.5 cm; 95% CI, −6.4 to 5.4), active straight leg raise (MD 0.6°; SMD −5.5 to 6.7), or passive straight leg raise (MD 0.2°; SMD −6.7 to 7.1). Joshi et al[20] incorporated a 3-week treatment period comparing myofascial release of the suboccipital 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°; 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 posttreatment across 3 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°; 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

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Table 2 Study Characteristics

Study	N	Age, y	% Female	Myofascial chain (proposed direction of effect for the remote Rx)	Remote treatment site (nature of Rx; dose)	Comparison	Outcomes[a]
Aparacio et al[13] RCT	70	23 ± 4	33	Superficial back line Caudal	Suboccipital muscles (muscle inhibition technique; 2 min)	Sham	Hamstring flexibility: Finger to floor Straight leg raise
Grieve et al[19] RCT	24	28 ± 11	66	Superficial back line Cephalad	Plantar fascia (self-myofascial release; 4 min)	Inactive sitting	Hamstring flexibility: Sit and reach test
Wilke et al[14] RCT	26	30 ± 6	38	Superficial back line Cephalad	Hamstring and triceps surae muscles (active stretch at mild discomfort; 30 s × 3 for each body part)	Inactive sitting	Cervical ROM: Flexion
Wilke et al[15] RCT	63	36 ± 13	49	Superficial back line Cephalad	Hamstring and triceps surae muscles (active stretch at 7/10 intensity; 30 s × 3 for each body part)	(1) Inactive sitting (2) Local Rx: cervical flexion stretch	Cervical ROM: Flexion (immediate, 5-min post-Rx)
Do et al[18] RCT	31	20 – 34	39	Superficial back line Cephalad	Plantar fascia (self-myofascial release, as much pressure as possible without pain; 5 min)	Passive ankle mobilizations	Hamstring flexibility: Toe touch test Straight leg raise
Hyong et al[17] RCT	60	21	57	Superficial back line Cephalad	Hamstring and Triceps surae muscles (simultaneous stretch of both muscles, 30 s × 3, pain free)	Local Rx: hamstring stretch only	Cervical ROM: Flexion
Jung et al[16] Randomized crossover	22	23	36	Superficial back line (1) Caudal and (2) Cephalad	(1) Suboccipital muscles (self-myofascial release; 4 min) (2) Plantar fascia (self-myofascial release; 4 min)	Local Rx: hamstring muscle self-myofascial release	Hamstring flexibility: Sit and reach Straight leg raise
Joshi et al[20] RCT	58	23 ± 3	72	Superficial back line Caudal and Cephalad	Suboccipital muscle and plantar fascia (myofascial release; 6 min; 7 therapist-led sessions over 10 d; followed by x1 per day self-myofascial release over a 2-wk period)	Local Rx: hamstring stretch	Hamstring flexibility: Sit and reach Passive Knee extension (follow-up at weeks 1 and 3)

Abbreviation: RCT, Randomized controlled trials; Rx, Treatment.

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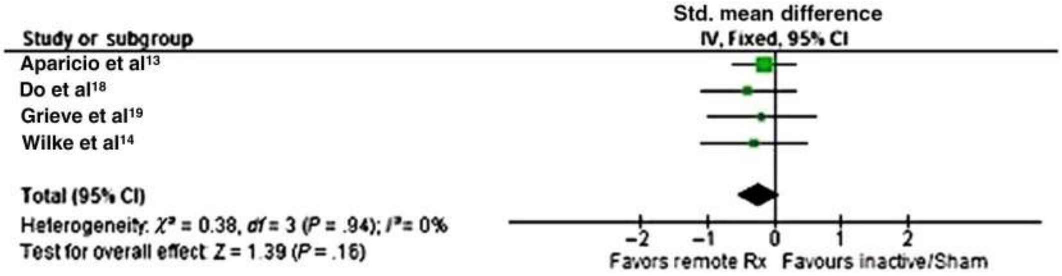

Figure 2 — Forest Plot Diagram and Standard Mean Differences. CI indicates confidence interval, IV independent variable.

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 the application of myofascial interventions can enhance ROM at a distant joint. We identified 8 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 CIs, and high risk of bias across the majority of studies.

Five studies compared remote techniques to sham or 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 CIs overlapped 0 (SMD 0.23; 95% CIs, –0.09 to 0.55). The mechanisms underpinning these remote effects are unclear. Some[21] 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 Ruffini 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 stretching[25] or myofascial release[24] 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, for example, due to hypersensitivity, immobilization, or casting, and targeting a remote region of the respective myofascial chain may be appropriate. There may be some concern regarding the magnitude of the clinical effects, however. In this current review, the between-group differences in ROM corresponded to 9% or 5° 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 2 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 and also treatment dosage was generally limited to a single treatment of short duration. Only one study considered the cumulative effects of multiple interventions over a 3-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

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extract the later due to insufficient reporting in the included studies. There is evidence that relying solely on follow-up scores will give a more conservative conclusion; this approach can also produce a bias effect estimate in the event that studies' baseline scores are imbalanced.[29]

Conclusions

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 with sham or 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.

Acknowledgment

The authors have no conflicts of interest to disclose.

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