Literature Review

Manipulative Therapy for Lower Extremity Conditions: Update of a Literature Review

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Abstract

Objective: The purpose of this study is to update a systematic review on manipulative therapy (MT) for lower extremity conditions.

Methods: A review of literature was conducted using MEDLINE, MANTIS, Science Direct, Index to Chiropractic Literature, and PEDro from March 2008 to May 2011. Inclusion criteria required peripheral diagnosis and MT with or without adjunctive care. Clinical trials were assessed for quality using a modified Scottish Intercollegiate Guidelines Network (SIGN) ranking system.

Results: In addition to the citations used in a 2009 systematic review, an additional 399 new citations were accessed: 175 citations in Medline, 30 citations in MANTIS, 98 through Science Direct, 54 from Index to Chiropractic Literature, and 42 from the PEDro database. Forty-eight clinical trials were assessed for quality.

Conclusions: Regarding MT for common lower extremity disorders, there is a level of B (fair evidence) for short-term and C (limited evidence) for long-term treatment of hip osteoarthritis. There is a level of B for short-term and C for long-term treatment of knee osteoarthritis, patellofemoral pain syndrome, and ankle inversion sprain. There is a level of B for short-term treatment of plantar fasciitis but C for short-term treatment of metatarsalgia and hallux limitus/rigidus and for loss of foot and/or ankle proprioception and balance. Finally, there is a level of I (insufficient evidence) for treatment of hallux abducto valgus. Further research is needed on MT as a treatment of lower extremity conditions, specifically larger trials with improved methodology. (J Manipulative Physiol Ther 2012;35:127-166)

Key Indexing Terms: *Manipulation; Chiropractic; Physical Therapy; Musculoskeletal Manipulations; Lower Extremity; Hip; Knee; Ankle; Foot*

In 2006, the first extensive, systematic review of chiropractic treatment of lower extremity conditions was published.[1] Building upon this effort and using similar methodology and structure, the first general systematic review of manipulative therapy (MT) for lower extremity disorders was published.[2] This present work is an update of the previous 2009 systematic review. However, the conclusions in this manuscript are solely those of the authors of this review.[1,2]

Earlier, "chiropractic treatment" was operationally defined as some form, technique, or procedure using applied MT (manipulation, mobilization, and/or other manual or

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functional procedures) with and without adjunctive treatment.[1] In the article of Brantingham et al,[2] the term *chiropractic* was replaced by the term *manipulative therapy* to facilitate inclusion of literature from all accessible peer-reviewed sources.[3] Although the public generally associates chiropractic primarily with the treatment of back pain, only a minority of practitioners perceive themselves solely as spine specialists.[4] The data suggest that many doctors of chiropractic (DCs), based upon their professional and/or postgraduate training, routinely diagnose and treat extremity conditions. It is of great importance to the chiropractic profession to elevate the awareness of the general public, government, and third-party payers as well as other stakeholders regarding the training and competency of DCs to care for extremity conditions. Although DCs can easily document the use of MT (with and without adjunctive treatment) for lower extremity neuromusculoskeletal problems and disorders for over 100 years, other health care providers, such as physical therapists, general and family physicians, and acupuncturists, are more commonly recognized as able to care for the entire axial and appendicular neuromusculoskeletal system.[1,5-10] Depending upon the study, type of practice (ie, general or sports), or practice location, extremity problems (upper and lower) have been reported to account for as low as 3.3% to as high as 20% of chiropractic care.[4,5,11-19] Lower extremity pain and injury have been reported to specifically account for amounts ranging from less than 2.5% up to 10% of common chiropractic practice with most practitioners using extremity MT based upon training, location, methodology, and philosophy.[4,5,11-20] This significantly contrasts to treatment of nonmusculoskeletal conditions such as chest, abdominal pain, and wellness that, at their greatest reported extent, may amount to 5.3%, 3.7%, and 8.0%, respectively.[4,5] According to Christensen et al,[4] extremity treatment is the second most frequently applied procedure within the chiropractic profession with 76.1% reportedly using spinal and extremity procedures as compared with 18.7% who limit their practice to the spine only. Indeed, chiropractic academic curricula are significantly directed toward neuromusculoskeletal disorders associated with the full appendicular (including axial) skeleton and include training in anatomy, biomechanics, differential diagnosis, radiology, radiographic positioning, orthopedics, sports medicine, first aid, rehabilitation, and extremity diagnosis and treatment.[1] Based upon these academic training standards, the current chiropractic graduate should be well qualified to manage common peripheral musculoskeletal disorders.

Further exemplifying the chiropractic profession's contribution as the forerunner to extremity care, a recent trial of high-velocity, low-amplitude axial elongation thrust manipulation (hereafter HVLA manipulation) of the hip (with associated stretching) conducted to determine efficacy in treatment of hip osteoarthritis (OA) (including grade 4 radiographic degeneration with severe pain and stiffness), determined HVLA MT, was substantially superior to an evidenced based hip exercise protocol.[21,22] A basically similar protocol was used in a newly published trial (HVLA axial elongation thrust manipulation with associated stretching) and achieved similar significant and beneficial results, this time with the valid and reliable Western Ontario and McMasters Osteoarthritis Index (WOMAC) as well as the previously used Harris Hip Scale.[23] Notably, these trials used the most common and, possibly, oldest chiropractic manipulative procedure used for hip disorders and OA over the last century, further supporting previous, preliminary studies and reports completed on and before 2004.[23-27] Significantly, these trials suggest a possible alternative treatment for (1) those who may not or should not have surgery, (2) those who may not or should not chronically use nonsteroidal anti-inflammatory drugs (NSAIDS), and (3) those in whom exercise alone is not effective.[28-35] Although research and publications on MT in the treatment of peripheral disorders have recently exploded, much more study is required.[1,36-40] It is clear that extremity care is not the exclusive domain of any singular health care discipline, and in that spirit, the authors encourage chiropractic, physical therapy, medical, and other researchers to work collaboratively in the search for improved clinical methods for the treatment for patients with lower extremity conditions.[21,27,41-43]

In the presence of this rapidly expanding area of research as well as the growing attention to the usefulness of treating peripheral disorders by MT management, the authors believed that it was time to revisit and update the evidence. The purpose of this current review is to update previous reviews; evaluate the quantity, quality, and types of published lower extremity MT research; and rank, grade, and present the characteristics of this evidence.

Methods

A review of literature was conducted by the Cleveland Chiropractic College librarian with input from the authors; an update of previous review articles[1,2] was undertaken using MEDLINE, MANTIS, Science Direct, Index to Chiropractic Literature, and PEDro from March 2008 to May 2011. Search terms including *chiropractic*, *osteopathic*, *orthopedic*, or *physical therapy* with MeSH terms for each region. Inclusion criteria required peripheral diagnosis and MT (mobilization and manipulation grades I-V) with or without adjunctive care. Articles were excluded when pain was referred from spinal sites (without peripheral diagnosis), referral for surgical intervention (without full postsurgical healing), and conditions contraindicated or not amendable to MT. Limits were set to English abstract and human. Search terms including *chiropractic*, *osteopathic*, *orthopedic*, or *physical therapies* were searched with MeSH terms for each region. *Manipulation* or *mobilization treatment* for the lower extremity was

also searched using MeSH terms. For the hip, this included terms such as *hip injuries*, *hip dislocation*, and *hip joint*. For the knee, this included the terms *knee dislocation*, *knee injuries*, *knee joint*, *collateral*, *meniscus*, and *patellofemoral*. For the ankle, this included *ankle injuries*, *tarsal bones*, and *ankle joint lateral ligament*. Finally, for the foot, terms included *foot bones*, *foot injuries*, *foot joint*, and the term *interphalangeal*.

After the abstracts were reviewed, the literature was placed into 3 broad categories. Category 1 included randomized controlled or clinical trials (RCTs) with MT (with and without adjunctive or multimodal therapy such as exercise/rehabilitation, modalities, NSAIDS, and activity modification, etc).[1]

The category 1 evidence table included (1) RCT, which indicates these studies were placebo controlled; (2) RCT^, which denotes a comparative study (treatment vs treatment; usually with evidence superior to placebo); (3) controlled or clinical trials (CTs), which are generally pseudo or nonrandomized (with systematic assignment or purposive allocation) containing a range of controlled variables, diagnosis, MT vs placebo, comparative treatment or both; and (4) studies that are prospective, measurable, and generally include valid and reliable outcome measures with appropriate statistical analyses.

Category 2 included case series (≥3 patients per study) or single group pretest-posttest designs.[44,45] Category 3 included case reports (≤2 patients) but reports not included in an earlier review.[1]

Inclusion criteria required peripheral (extremity) diagnosis and some variety or mode of MT. Articles were excluded when (1) pain was referred from spinal sites (without peripheral or extremity diagnosis), (2) there was referral for surgical intervention (unless there was documented full postsurgical healing with or without rehabilitation), (3) the condition was not amendable for MT (rheumatoid arthritis [RA], fracture, ligament tear with instability, etc), (4) a red flag diagnosis was identified, or (5) there was a peripheral diagnosis absent a description of management or intervention. In the current review, osteopathic, physical therapy, and other medical literature was included; however, review-type articles were excluded. Non–peer-reviewed literature, conference proceedings, grand rounds, and discussion articles with no rendered treatment were also excluded.

After abstraction of data and articles was completed, they were blindly ranked by 3 independent authors using set criteria. Articles were retrieved as hard copy, PDF, or electronic format from the Cleveland Chiropractic College Los Angeles library or from associated library collections. All new and/or previously overlooked (after Brantingham et al[2]) clinical trials found relevant were assessed, reviewed, and ranked using a modified adaptation of the Scottish Intercollegiate Guidelines Network or "SIGN" ranking system of Liddle et al[46] (instead of the Physiotherapy Evidence Database or "PEDro" scale used the earlier review[1]).[46-49] General use of SIGN is in conformity with the Council on Chiropractic Guidelines and Practice Parameters systematic reviews (www.ccgpp.org). When documenting treatment, standardized terminology was used; therefore, the term *manipulative therapy* indicated any the following terms: (1) all types, methods, modes, techniques, and procedures of mobilization and manipulation grades I through V; (2) all adjustment/adjustive procedures; and (3) manual or MT procedures.[3,29,50-52]

The SIGN Scale, Modified Liddle et al Revision, and Limitations of SIGN

One methodological difference between this and an earlier review[1] grew out of the disproportionately inflexible weighting structure represented by singular SIGN components that makes the application to burgeoning areas of historical but weakly supported research, such as is the case with manual therapy, difficult at best and was believed to potentially and otherwise mask the helpful information that could be yielded through the assessment of this literature base. Current SIGN checklist and component explanations discard older, previously acceptable randomization techniques and completely rejected any older noncomputerized randomization methods. However, the literature supports the appropriateness of the restricted use of manual and mechanical randomization methods (such as flipping a coin), particularly in small samples.[53-56] In addition, SIGN overemphasizes a few scale components, excluding all other methodological considerations. This is inconsistent with other validated, widely accepted critical appraisal methods such as JADAD or PEDro where randomization and intention-to-treat (ITT) analyses are considered as one of a number of important methodological concerns, reducing overall trial quality but not excluding a trial from the overall assessment of clinical effectiveness.[56,57]

Since publication of Brantingham et al[2] in 2009, Bronfort et al[40] published a comprehensive summary of the scientific evidence regarding the effectiveness of manual therapy in the management of a broad spectrum of disorders including common musculoskeletal conditions and disorders of the spine seen by DCs. Of interest to the current review, Bronfort et al appraised the literature regarding manual and MT for the lower and upper extremities. However, Bronfort et al restricted their selection of evidence to the largest, highest quality, and methodologically "best" RCTs.[2,40] Using such a limited number of studies does not wholly align with evidence-based medicine or care as conceived by Sackett et al[58] and others.[59] Stringent, higher (or highest) quality, methodologically "rigorous" RCTs may be later determined less effective in clinical practice due to the heterogeneity of patient populations, comorbidities, and later problems with patient compliance. Furthermore, patient and practitioner preferences cannot be accounted for solely through RCTs

++ applies if all or most criteria from the checklist are fulfilled; where criteria are not fulfilled, the conclusions of the study or review are thought very unlikely to alter.
+ applies if some of the criteria from the checklist are fulfilled; where criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought unlikely to alter.
− applies if few or no criteria from the checklist are fulfilled; where criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought likely or very likely to alter.[47,48]

Fig 1. *SIGN checklist rating (Liddle et al).*[46-48]

yet may be found, at least to a limited degree, in a variety of other studies.[55,58,60-63] Moreover, all types of studies and research designs, including the highest quality RCTs, have flaws. Researchers must be cognizant of these limited parameters and interpret the findings carefully, not simply discount and jettison all findings outside the most stringent of RCTs. A broad range of RCTs and CTs as well as single-group pretest-posttest designs (SGPPDs), case series, reports, and expert consensus observations are still needed in the context of a larger appraisal as vital components in guiding delivery of "best patient care" and in developing new directions and areas of research.[55,58,60-64]

Sackett et al[58] described the purpose of evidence-based medicine to "…improve practice and best patient care."[65] Sackett et al never intended such care to be derived solely from RCTs but rather developed from "tracking down the best external evidence."[58,66] Haldeman and Underwood[60] and others[59] state that, even today, up to 80% of the practice of medicine (in some areas and specialties) is still based on sources with lesser levels of evidence than merely large, high-quality, or very high quality, methodologically faultless RCTs. Therefore, it appears prudent to use evidence from the full range of studies as noted above.[59,60,66,67] Therefore, in accordance with the above-stated approach, controlled and clinical trials were ranked using the modified revision of the SIGN scale of Liddle et al.[1,46-48] Although the SIGN RCT checklist rates studies as high quality (+), low quality (−), or neutral (n), the modified SIGN scale of Liddle et al (Fig 1 and further discussion below) uses (++) for high quality with very low risk of bias; (+) for well-conducted studies, with low risk of bias; or (−) for studies with few, no, or inadequately fulfilled or described criteria, with high risk of bias.[47,48]

The SIGN revisions of Liddle et al have undergone rigorous development and validation procedures, part of a hierarchy of studies widely accepted as reliable.[46,49] Furthermore, the SIGN revisions of Liddle et al have been evaluated, adapted, and developed by multiple review groups and assessed for methodological rigor, clarity, and practicality in clinical use (principally for diagnosis but used in this review to rank trials) with studies repeatedly finding their checklists producing reliable and consistent results.[46,48,49]

Interestingly, these procedures, such as blindly picking obscured folded slips of paper out of a box, succeeded in concealing allocation. These older procedures, long used in medicine before easily accessible computerization software, generally remain acceptable for smaller samples of 60 or less ($n \leq 30$ per group).[53-55] Consequently, this review's use of a modified SIGN ranking means that manual and mechanical randomization procedures were given decreased methodological weight, indicating lesser quality, but not rejected.[56,57]

Evidence-based care, with its hierarchy of evidence, notably includes private practice, field, and expert advice and does not posit care rendered only by evidence from RCTs as economically feasible, practical, scientific, or ethical.[55] With these considerations in mind, this review includes pseudo or nonrandomized, systematically assigned, and controlled or clinical trials designated as CTs as well as the addition of unlisted, previously undetected, or new case series and reports and single-group pretest-posttest studies excluded by previous criteria and added into the ranked and/or updated case report and series sections. In addition, studies using systematic assignment (with less bias) but no longer considered validly randomized have been, after consideration, included in this review because, as some of the first and foundational manipulative studies ever performed, they frequently used or contain significant innovative methodological controls, concepts, and insights. Such studies, evaluated by the present authors as certainly equal to or superior to retrospective case series, have recently been treated as if they constitute no evidence at all, discarded as worthless, and incorrectly excluded from the "evidence-based" hierarchy.[47,53-57,68]

Arguably, CTs could be placed in category 2 but increased controls within these CTs often markedly exceed typical case series. In comparing against many peer-reviewed, published RCTs, with high levels of inadequate, erroneous, and/or incorrect report of per protocol or ITT analysis as well as disagreement, lack of consensus, or standards regarding blinding and blind assessment, there is a sufficient justification and rationale for inclusion of these RCTs and CTs.[1,21,38,69-80]

The retrospective requirement of ITT levied on all previous studies, including some otherwise methodological improved smaller trials, can, at times, result in completely discounting evidence that should be considered on some level of the hierarchical ladder.[55,75,76] Furthermore, in many studies with ITT, particularly in systematic reviews of ITT, it is evident that many authors have significant and serious objections to ITT being a sole or the sole arbiter of a valid or legitimate trial (SIGN without modification simply rejects studies that do not use ITT).[81-84] For this reason, like randomization, it is of utmost importance to use a ranking methodology that balances rigor with reason so as to yield the best evidence possible from the existing

Grade A: Good evidence from relevant studies.
- Results from studies with appropriate designs of sufficient strength to answer the questions addressed.
- The results are both clinically important and consistent with minor exceptions at most.
- The results are free of any significant doubts about generalizability, bias, and flaws in research design.
- Studies with negative results have sufficiently large sample sizes to have adequate statistical power.

Examples
- Systematic review of RCTs or several RCTs with comparable methodology/results.
- For diagnostic tests: systematic review or at least one study meeting standards of diagnostic accuracy
- For natural history, if no evidence to contrary, evidence might be results from 1 well-done cohort study.

Grade B: Fair evidence from relevant studies.
- Studies of appropriate designs of sufficient strength but inconsistencies among results or minor doubts about generalizability, bias, and research design flaws or adequacy of sample size.
- Evidence consists solely of results from weaker designs, but results confirmed in separate studies.

Examples
- Several RCTs with differing results, although overall, the results support the conclusion.
- Single RCT with a clinically significant conclusion but doubtful generalizability.
- Systematic review of RCTs with similar methodologies but differing results.
- Diagnostic tests: cohort studies or instrumentation studies of reliability and validity.
- Harm or adverse events: ≥2 case-control studies with minimal bias and research design flaws.

Grade C: Limited evidence from studies/reviews.
- Studies of appropriate but substantial uncertainty due to design flaws or adequacy of sample size.
- Limited no. of studies or because of weak design for answering the question addressed.

Examples
- Systematic or narrative reviews or RCTs with contradictory results and/or serious methodological flaws.
- From relevant cohort, case control, ecological studies, and outcomes research.
- Individual case series.
- For diagnostic studies, nonconsecutive studies without appropriate reference standards and case-control studies unconfirmed by other studies.
- For harm, the evidence might consist of results from a single case-control study or case series.

Grade I: No recommendation can be made because of insufficient or nonrelevant evidence.
- There is no evidence that directly pertains to the addressed question because either the studies have not been performed or published or are nonrelevant.

Examples: No studies could be identified using optimal search strategies of appropriate databases or by hand searching. Alternately, the literature cited does not have direct bearing on the question being addressed.[87]

Fig 2. *Grading of recommendations.*

literature.[64] Therefore, in this review, the absence of ITT results in a lower study rating. Furthermore, if essentially all subjects who began the trial completed the trial, ITT was rated as adequate.[55,64,81-86]

The initial step of using the modified SIGN of Liddle et al to rank study methodology was followed by a synthesis and considered judgment, whereby the authors scored the evidence with grades of "A, B, C, and I," as outlined in the *Handbook for the Preparation of Explicit Evidence-Based Clinical Practice Guidelines* (Fig 2).[87] The "considered judgment on quality of evidence" was applied to all reviewed materials, including newly added SGPPDs and case series, and reports from the previous reviews and assessed per the grading recommendations as listed in Fig 2.[1,2,48,87]

Results

Of the total additional 399 citations located since the review of Brantingham et al,[2] 142 were determined to be relevant (and, thus, supplementary to the clinical or controlled trials previously found).[1,2] Of these 142 studies, 8 pertained to conditions effecting the knee, 4 regarding the hip, 5 regarding the ankle, and 2 regarding the foot. These studies, randomized controlled and/or clinical trials (a few by systematic assignment or purposive allocation), were assessed. The case series and reports previously incorporated[1] have not been cited in this investigation; therefore, readers are referred to that review; however, since the review of Brantingham et al,[2] 4 single-group pretest-posttest studies and 11 case series and reports excluded and/or not previously reported in a single source are included (Tables 1-7).

Evidence

There is a level of B (fair evidence) for MT combined with multimodal or exercise therapy for short-term treatment of hip OA and a level of C (limited evidence) for MT combined with multimodal or exercise therapy for long-term treatment of hip OA. There is a level of B for MT of the knee and/or full kinetic chain and of the ankle and/or foot, combined with multimodal or exercise therapy for short-term treatment of knee OA, patellofemoral pain syndrome, and ankle inversion sprain and a level of C for MT of the knee and/or full kinetic chain and of the ankle and/or foot, combined with multimodal or exercise therapy for long-term treatment of knee OA, patellofemoral pain syndrome, and ankle inversion sprain. There is also a level of B for MT of the ankle and/or foot combined with multimodal or exercise therapy for short-term treatment of plantar fasciitis but a level of C for MT of the ankle and/or foot combined with multimodal or exercise therapy for short-term treatment of metatarsalgia and hallux limit-us/rigidus and (for a new category) for loss of foot and/or ankle proprioception and balance. Finally, there is also a level of I (insufficient evidence) for MT of the ankle and/or foot combined with multimodal or exercise therapy for hallux abducto valgus. Further research is needed to include larger trials with improved methodology. Funding is needed for randomized, controlled, and clinical trials as well as

Table 1. *Evidence table of MT for patients with lower extremity disorders (note: see below for explanation of use of Liddle et al variation of SIGN: ++, +, −, and for RCT, RCT^, CT, definitions/explanations and abbreviations below)*

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
Hip							
Hoeksma et al[21]	RCT^ (see § below)	Hip OA	n = 109 Age, 60-85 y Mean age, 71.5 y	HVLA axial elongation hip manipulation with stretch vs exercise 9 Tx over 5 wk FU, 5, 17, and 29 wk	Significant in favor of MT + stretch: primary (GROC or patient self-report of satisfaction % improved vs % not improved dichotomizing a Likert scale) percent improved, 81% at ninth visit, 50% for exercise therapy but not reported at 5 mo FU visit; second outcomes measures, Harris Hip Score and a functional questionnaire, scale made up of 4 questions using VAS (100 worst, 0 best) measurement = 32% overall decrease at ninth visit and 34.5% decrease at 5-mo FU and significant ↑ROM. Generally, all secondary outcome measures are significant for MT vs exercise, $P \leq .05$.	Adequate power Adequate blinding ITT covered No serious but minor ↑ side effects: 3 left manipulation group, 2 exercise	++
Brantingham et al[23]	RCT^	Hip OA	n = 111 Age, 40-85 y SC group, n = 58 Mean age SC, 42.8 y FKC n = 53 Mean age FKC, 42.7 y	HVLA axial elongation hip manipulation with stretch (SC, note this term will probably change) a similar protocol to Hoeksma et al 2004 vs FKC protocol: above SC hip MT and stretch + FKC MT to lumbosacral, knee, ankle, and foot as indicated 9 Tx over 5 wk FU: 3 mo	No significant difference between groups (WOMAC, HHS, OTE) at any outcome measure after ninth treatment or at 3-m FU per ANCOVA; $P > .05$ Significant within-group changes for both groups for all outcome measures after the ninth and last treatment and at the 3-mo FU; all $P < .05$. WOMAC SC group at ninth visit ↓ overall 47% FKC group at ninth visit ↓ overall 36% (WOMAC MCID, 20%) HHS SC group at ninth visit ↑ 10 points FKC group at 9th visit ↑ 10 points	Full power Adequate blinding Blind assessors ITT covered	++

					(HHS MCID, ≥4 points) OTE SC group at ninth visit ↑ overall improved 89% OTE FKC group at ninth visit ↑ overall improved 79% (MCID ↑ 30%)		
Mosler et al[97]	RCT^ Randomized crossover design	Hip ROM and function assessed: Does MT to the hip improve athletic performance? "Eggbeater performance (a specialized swimming technique to keep body up out of the water and the ability to jump" believed dependent on hip ROM, function, and pain assessed in water polo players.	n = 16 Mean age, 17.6 y Elite water polo team.	Group 1: MT to the hip and associated hip joint soft tissues: Trigger point therapy on TFL, psoas, iliacus, adductors, and gluteals Passive tissue tension to luteals and hip ext rotators TFM to iliolumbar ligt and L4-5 interspinous space Stretches to anterior hip joint capsule, gluteal, and piriformis muscles Lateral hip distraction (mobilization) with a seat belt. Group 2: usual training and recovery for water polo 8 Tx at 2/wk for 4 wk Premeasurement and postmeasurements Then a 4-wk "wash-out" with no Tx, then both groups crossed over and received the opposite treatment.	ROM was measured at baseline and at end of care for internal and external rotation and for abduction and summed for total passive and active ROM. Eggbeater swimming endurance was assessed (keeping out of the water up to the sternal notch). Jump out of the water, height was assessed. A qualitative likelihood of clinically relevant outcome was assessed for improvement for eggbeater and jump (a Likert-like scale) was assessed. Group 1 Tx significant in favor of passive overall ROM and for a 5% likely improvement for the jump; and a 5 and 7 s or likely and possible improvement in eggbeater endurance; all $P \leq .05$. Otherwise, there is no other statistical significance between groups.	Power not calculated, small sample size (low power) Blinding adequate Assessors ITT inadequate	+
Brantingham et al[27]	CT ¥ Systematic assignment randomized first patient (then A,B, etc)	Hip OA	n = 8 Mean age, 69.8 y	HVLA axial elongation and other manipulations and mob of hip joint vs placebo 6 Tx over 3 wk FU: 1 wk 2 withdrew (n = 10)	Significant effect size for MT: WOMAC, NRS vs placebo ROM, Fabere unchanged in Tx group No side effects. One excluded got PT. One sham left, pain to high	Cohens *d* Large effect size changes Blind assessor 1 unblinding	+

(*continued on next page*)

Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
Cibulka and Delitto[98]	RCT^	Hip strain Hip pain with either anterior or inguinal pain anteriorly with pain on stretching hip or hip muscles and a + or painful Patrick-Fabere test. Hip pain required a + Patrick-Fabere ↓ internal rotation and with associated joint dysfunction)	n = 20 Group 1 age, 16 y (SI HVLA grade V manipulation) vs group 2 age, 24 y (hip mobilization in axial elongation grade IV 2× 10 oscillating mobs)	Group 1, SI HVLA grade V manipulation only to decrease hip pain vs group 2, hip mobilization in axial elongation grade IV, 2× 10 oscillating mobs 1 Tx FU: ~4 d	Apparent significant and clinically meaningful differences in ↓ hip pain in favor of Tx group 1 for NRS (↓ 3.8 points of 10, SI HVLA) compared with group 2 (↓ 0.80 points, mob). Used Mann-Whitney *U* test (due to a decision to not use data immediately after Tx; probably should have used nonparametric ANOVA such as Kruskal-Wallis test) Apparently significant in favor of group 1 for ↓ pain and ↑ ROM on stress for Patrick-Fabere (9/10 subjects had no pain) vs group 2 (3/10) χ^2 No difference between group regarding ↑ internal rotation Both groups had some apparent descriptive improvement.	Power not calculated and low with n = 20 (small sample size) Blind assessor single-blind assessment for Patrick-Fabere only (not NRS or for ROM) ITT not adequate	–
Knee							
Deyle et al[73]	RCT	Knee OA	n = 83 Mean age, 61 y	MT of knee and FKC SI, foot vs placebo, nontherapeutic ultrasound Knee man: mob knee ↑ flex, ext, patellar mob (gradually up to 4++ or thrust) 8 Tx over 4 wk FU: 4, 8, and 52 wk	Significant in favor of MT: at 4 and 8 wk. 8 wk WOMAC ↓ 55%, ↓ time 6-min walk. 1-year FU, WOMAC, walk significant. Arthroplasty 20% placebo, 5% in Tx group.	Adequate power ITT covered	++
Deyle et al[159]	RCT^	Knee OA	n = 134 Mean age, 63 y	MT of knee and FKC, SI to foot vs home exercise Knee man: mob knee ↑ flex, ext, patellar mob (gradually up to 4++ or thrust) 8 Tx over 4 wk with FU at 4, 8, and 52 wk	Significant in favor of MT at: 4 and 8 wk with WOMAC 52% to exercise 26%. 1-y FU both significantly improved but: man ↑ satisfaction, ↓ meds	Adequate power ITT well covered	++

Tucker et al[160]	RCT^ Assessor not blind	Knee OA	n = 63 Mean age, 59.3 y	CMT to the knee (HVLA) vs Meloxicam 1× a day for 3 wk. Knee man: long axis, A-P, P-A, and patellar mob NSAID previously superior to placebo 8 Tx over 3 wk	No difference between Txs. Significant improvement both: NRS, VAS, PSFS. 3 left trial: NSAID side effects: nausea, diarrhea, allergic	No patients left HVLA group	+
Perlman et al[105]	RCT^ Soft tissue only (massage therapy)	Knee OA	n = 68 n = 34 Group 1 Mean age, 70.4 y Group 2 Mean age, 66.2 y	Group 1 (Tx) = MT MT in this case means ST only = massage therapy (used "Swedish massage" techniques) = full body massage, including the knee, with petrissage, effleurage, and tapotement at therapists discretion. 1-h long sessions 2×/wk for 4 wk, then 1×/wk for 4 wk for 12 Txs. Group 2 = UC or conventional medical care for 8 wk and on waiting list = medications (NSAIDs or other medications) exercises or hot and cold therapy. At 8 wk, then crossed over (beginning at ninth week and received group 1 MT or ST massage therapy as outlined for group 1. 12 Txs over 8 wk for MT UC as described for 8 wk then a crossover to receive MT	Statistical and clinically significance in favor of the MT (group 1 massage therapy) vs group 2 or UC with: WOMAC (↓ 17.2 points on global score per conversion to 100 points worse $P = .005$) WOMAC also significantly ↓ in favor of group 1 (MT) for pain, stiffness, and functionality; all $P \leq .05$. Statistical and clinical significance for ↓ VAS pain 17.2 mm in favor of group 1 (MT); $P = .004$. ROM not significant between groups; $P = .15$ Significant in favor of group 1, MT for time (↓ in seconds) to walk 50 ft (15 m), s $P = .02$ Similar outcome in favor of group 1 at 16-wk FU for crossover group; all $P \leq .05$ and in pooling both groups, ROM was significantly increased in favor of MT (ST) vs UC at $P = .03$ (per combined 8-wk FU).	Adequate power Adequate blinding Blind assessor ITT complete Large drop out in both groups (they state… "common" in this age group; dealt with through ITT). No serious adverse reactions but 1 patient reported ↑ discomfort (with MT) and refused to return for the 8-wk FU	+
Moss et al[106]	RCT Allocated to 3 Txs Assessor, patients blind	Knee OA	n = 38 Age, ≥40 y	Supine A-P mobilization of tibia on femur Within subjects repeated measures vs placebo (holding position with measurements) vs no contact with measurements 1 Tx with immediate postintervention	Significant ↓ in pain (↑ in ALG) and ↑ speed in "up and go" (from chair).	Adequate power Adequate blinding ITT adequate No drop outs	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
Bennell et al[34]	RCT^	Knee OA	n = 140 Mean age, 68.6 y	PT program: knee taping, extensive exercises, ST, thoracic spine mobilization vs placebo 8 Txs at 1/wk for 4 wk, then 1×/2 wk for 8 wk	No significant difference between groups Slightly significant outcome for PT at 24 wk for VAS pain, global improvement (2 areas) of 12 assessments (VAS pain and activity, WOMAC, KPS, SF-36, AQoL, quad strength, step test).	Power adequate, In to Tx good, Poor design and internal validity: Thoracic spine manipulation? Double blind Drop out: 13 PT (2 side effects others various reasons) 2 placebo	+
Ko et al[107]	RCT	Knee OA Sx duration: group 1, 5 y Group 2, 4.9 y	n = 35 RT group n = 17 Mean age, 65.3 y MT group n = 18 Mean age, 63.7 y	RT Tx (exercise and ROM treatment) vs MT (RT + manual therapy). RT or exercise: KJ extended, static tension in quads maintained for 6 s, the 10-s break; repeated 10×. Standing with KJ extended and then did knee extensions with elastic band (yellow) 12× for 1.5 min, then did a 1-s concentric contraction and a 2-s eccentric contraction with both legs for 1.5 min. Then did stop ups 12× for 1.5 min; if possible, the step height was increased. "Permissible exercise" done more than 30 min without causing pain. RT ROM. first sat and stretched legs, the moved KJ from middle of flexion to end of extension range and maintained the extension 3 s with a 3-s break; repeated 2.5 min. Repeated but moving	Significant difference ($P \leq .05$) for both MT and RT groups at 8 wk (but descriptively greater in the MT group) for 1.↑ Strength of the quadriceps posttreatment Significant difference ($P \leq .05$) for MT group at 8 wk for 2. ↑ Kinesthetic positional sense degrees proprioception 3. Functional difference for 10-m walk speed, timed step up, and timed chair sit (see article for details)	Power not calculated No blinding ITT not reported	+

				into extension (see article for details). MT (used RT program + MT). MT, axial traction in flexion and extension 2× each for 30 s then extension mobilization 2× 30 s and flexion mobilization 2× 30 s and distal or inferior gliding of patella 2× 30 s (at different points KJ ROM (see article for details) 24 Txs at 3/wk for 8 wk Lequense Index for Knee OA used (scores of 7-14 required at baseline)		
Fish et al[108]	RCT^	Knee OA Average duration of KOA Sxs >3.4 years	n = 60 Age, 40-75 y Mean age, 62 y RT group 1 n = 20 Topical capsaicin only Mean age, 62 y MT group 2 n = 20 Mean age, 60 y Group 3 n = 20 MT + capsaicin combined Mean age, 63 y	Group 1, capsaicin only massaged in 3-4× per day. Tx for 3 wk vs Group 2, MT of knee only mobilization: careful graded/slowly increased physiologic mob knee to ↑ flex, ext, patellar mob; + axial elongation thrust technique (all gradually up to 4++ or with axial elongation up to HVLA thrust) Primarily using Maitland techniques; but other ↓ accessory motions occasionally treated similarly; primarily used Maitland 1999 technique (see article for details) 6 Txs over 3 wk vs group 3 MT + capsaicin combined: MT of knee = mobilization: careful graded/slowly increased physiologic mob knee to ↑ flex, ext, patellar mob; + axial elongation	No difference between Txs. However, capsaicin is better than placebo therefore and mob alone and mob alone + capsaicin were equivalent; but not definitive (a type II error possible) due to small sample size. Significant within-group improvement in 2 groups for WOMAC at 1-wk FU mob and mob + capsaicin but not for capsaicin alone. (Friedman ANOVA; $P = .000$). Noteworthy is group 3 mob + capsaicin had an overall WOMAC decrease of 42.3%. Flexion ROM was significant for mob and mob + capsaicin at 1-wk FU ($P < .05$) with a median ↑ of 5° for mob + capsaicin. NRS 101 pain scale changes were statistically significant at the final 1-wk FU (1 mo), with a ↓ of 8.45 points in the group 1 or capsaicin ($P = .049$), a ↓ of 14.0 points in group 2 mob ($P = .000$), and statistically and clinically significant with a ↓ of	Calculated full power at n = 128 Power low n = 60 (small sample size) Single blind: participant ITT insufficiently addressed Drop out: 13 PT (2 side effects others various reasons), 2 placebo	–

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
				thrust technique (all gradually up to 4++ or with axial elongation up to HVLA thrust) Primarily using Maitland techniques (see article for details). 6 Txs over 3 wk. Early forced or forceful end ROM (at end range into accessory motion) of knee flexion or extension not allowed (see article for details) Capsaicin previously demonstrated superior to placebo for OA Outcomes: baseline, 3-wk and 1-wk FU Groups 2 and 3 2×/day for 3 wk (6 Txs)	22.0 points in group 3 mob + capsaicin (P = .000). There was a significant change in the SFMPQ for mob and a significant and clinically meaningful decrease for the SFMPQ (↓ 5.5 points) for the mob + capsaicin. Capsaicin was not significant for intragroup SFMPQ at 1-wk FU. Mild after Tx side effects for all groups (3 in group 1, 3 in group 2, and 4 in group 3: 2 left due to capsaicin irritation and 2 left from after Tx soreness in mob and mob + capsaicin).		
Pollard et al[109]	RCT	Knee OA Required duration of KOA Sxs ≥1 y	n = 43 Age, 47-70 y Mean age, 62 y MT group 1 (or MIMG protocol) n = 26 Mean age, 56.5 y Sham/placebo group 2 n = 17 Mean age, 59.6 y Physical contact at knee with sham modality	Group 1 MT MT of knee: using the MIMG knee protocol 1. Myofascial (patellar) mobilization technique: careful graded mob/subject seated patellar fixed, subject extends knee until just below pain 10× (with or without thrust at any point; see article for details); + axial elongation thrust technique (with added internal or external rotation when indicated) vs group 2 placebo/sham Palmer hand placed near position for treatment of knee (without force) followed by interferential modality set at zero. 6 Txs at 3/wk over 2 wk	MT group 1 Tx appeared to be a superior Tx compared with group 2 placebo Tx for knee OA but may not be generalized and may be considered a pilot or feasibility study However, as a feasibility study conducting statistical analysis, there was an apparent significant difference between Txs in favor of MT group 1 for VAS pain (1.1 cm on a 100-mm scale, difference $P \leq .05$) Also, apparently significant in favor of MT group 1 for the overall functional scale (11 questions using VAS: Did Tx help you? Pain/discomfort improved? Mobility improved? Tx painful? Activities improved? Has knee Tx improved mob in hip? Should this Tx be used? How effective	Power not calculated Power low n = 43 (small sample size) Single blind ITT adequate	+

				FU: immediate	was Tx to ↓ pain and ↑ function? All $P < .05$ except for has knee Tx improved mob in hip? $P > .05$. However, low power and small sample size could = type 1 error etc		
Collins et al[114]	RCT^	PFPS	n = 179 Age, 18-40 y Mean age, 29.3 y 100♀ n = 40 per group (n = 44 for 10% drop out)	4 groups: PT (+MT or patellar mobilization) only (multimodal Crossley et al PT protocol = progressive strengthening and retraining with EMG, taping, education, and home exercise, see article) Foot orthotics and PT (+MT), fit for comfort (slightly heat or wedge modifiable Vasyli, ethylene vinyl acetate orthotics) Foot Orthosis (OTC Vasyli Orthotics International) only, flat foot not assessed or required. Flat inserts (control) fit to shoes (ethylene vinyl acetate), control, no arch etc 6 Txs over 6 wk then self-management FU: 6, 12, and 52 wk	Recommendation: Use orthotics or PT (+MT) or PT (+MT) + orthotics to shorten symptoms of PFPS in the short term. Long term at 1 year no difference; but note that 80% improved in this study at 1 year compared with a 4-year FU of only 50% in another study (see article) Significant for 3 treatments (orthotics, PT + MT, and PT + MT + orthotics) at 6 and 12 wk, except for orthotics vs flat inserts at 6 wk by 19.8% or $P = .01$ with NNT 4: Significantly in favor of orthotics and PT (+MT) or the PT + MT + orthotics groups For GROC (Likert scale) vs flat inserts But no statistical difference for GROC (Likert) between orthotics vs PT (+MT) or PT (+MT) + orthotics Significant for VAS (worst only), AKPS, and Functional Index Scale Side effects particularly from orthotics without or with PT (72%), tape (tape 40%), and PT (41%) etc, mostly mild and resolved.	Full power and sample (calculated for VAS usual 15-mm change) 80% at 0.01 Blinding: adequate Blind assessor ITT adequate No statistical difference between 3 "real" treatments Orthotics, PT (+MT), PT (+MT) + orthotics at 6 and 12 wk, but all have within-group significant changes. At long-term 1-year FU, no difference between all treatments, and all had significant VAS worst pain severity >20-mm decrease.	++
Brantingham et al[115]	RCT^ A feasibility study carrying out all components of an RCT	PFPS	n = 31 Age, 18-45 y Mean age group A, 27.9 y Group B, 30.7 y	2 groups Group A MT of the local KJs (mobilization of patella and mobilization or manipulation of local KJs with soft tissue	Recommendation: Feasibility of RCT is possible Small sample size does not allow extrapolation of intergroup findings (there was no difference	Low power due to small sample size. Sample size for full power at 80% calculated for the AKPS Blinding adequate:	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
				(instrument assisted soft tissue mobilization hereafter simply ST) and an exercise protocol: progressive strengthening and retraining with education and home exercise. Group B received FKC or MT (as above) to the local knee but also MT (mob or manipulation) to the lumbosacral, SI, and all other lower extremity joints if indicated. Also received same ST and exercise protocol 6 Txs over 2-6 wk, then self management FU: 6 and 8 wk	between groups for any outcome measure), but within-group findings can be reported. AKPS (reported MCID 8 points), VAS (reported MCID 1.5 cm), and the PSS (a dichotomous "discharged" [no longer needs treatment] or "referred," feels the need for more treatment). Significant within-group change; $P \leq .05$ for both treatments, for the AKPS (groups A and B at the sixth treatment) +9.5 points and +6.1 points at 6 wk and +13.23 + 13.1 points at the 2-mo FU, respectively. Significant for VAS for group A treatment; $P \leq .05$ for VAS at sixth treatment VAS usual ↓ 1 cm and for group B at the 2-mo FU. VAS worst significant for group B; $P \leq 0{,}05$ VAS ↓ 1.5 cm decreased; significant for both groups for VAS worst at sixth treatment and 2-mo FU; all $P \leq .05$ with A ↓ 1.95, B ↓ 1.91 and at the 2 mo A ↓ 2.04 and B 2.73 cm, respectively. Side effects for a few patients in each group to either exercise or MT; mild and all resolved, no serious adverse reactions 64% were "discharged" (no need for further care) in group A and 73% "discharged" in group B.	Blind assessor ITT inadequate	

van den Dolder and Roberts[116]	RCT MT only	PFPS	n = 38 Group A n = 21 Mean age, 55 y Group B n = 17 Mean age, 52 y	2 groups Experimental (MT treatment) group A: therapeutic massage (transverse frictions with knee fully extended and flexed), patellar mobilization (tilt mob and sustained L-M glide while knee is flexed and extended) per Cyriax technique (1984). No other treatment given such as exercise or stretch. Control (waiting list) group B: no treatment 6 Txs over 2 wk FU: 2 wk	Full power but still a small sample size Patellofemoral PFPSQ (reported MCID, 20 mm). Active knee ROM in flexion and extension, the step test, and a patient satisfaction (Likert) scale (from very dissatisfied to very satisfied) Significant in favor of the Tx group at sixth treatment for the PFPSQ for knee flexion (↑10°) and for the step test (↑ of 5 steps in 60 s); all P <.05 Otherwise not significantly different. Descriptively for the Likert scale In the Tx group, 29% very satisfied, 61% somewhat satisfied, and 9% very dissatisfied	Fully powered Adequate blinding: Blind assessor ITT adequate Sample size for full power at 80% calculated for a 20-mm MCID change in the PFPSQ, n = 19 per group or n = 38.	++
Hains and Hains[117]	RCT^ Crossover study	PFPS Anterior knee pain >3 mo	n = 38 Age, 18-50 y Group 1 (Tx), n=27 Mean age, 25.3 y Group 2 (sham Tx) n = 11 Mean age, 25 y	MT, soft tissue Tx, postpatella grinding test (a form of mobilization), and trigger point location both used to find the trigger point (then myofascial or trigger point ischemic; then application of Tx to located point [per Travel J, 1992] around patellar/at local knee involvement (see article for details of Tx) vs sham/placebo Tx, trigger point ischemic compression at the hip area 15 Tx at 3/wk over 5 wk Wash out period then sham group received local knee trigger point/myofascial Tx	VAS and the PGT Significant and clinically meaningful in favor for all subjects treated by local knee trigger point/myofascial treatment for VAS both ↓ >2 cm; all $P \leq .05$ vs sham Significant ↓ in favor for all subjects Tx with knee trigger point/myofascial Tx with a decrease in PGT; all $P \leq .05$ vs sham Experimental significance maintained up to 6 mo No significant change for sham Tx	Fully powered statement (but post hoc tests) Adequate blinding: Double/assessors participants Adequate ITT	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
Hillerman et al[118]	CT Allocation by presentation: PFPS or PFPS + SI joint dysfunctional	PFPS and quadriceps inhibition/weakness	n = 20 Age, 18-40 y (difficult to recruit sample), PFPS with and without SI	SI manipulation vs knee axial elongation manipulation 1 Tx with immediate FU	Significant ↑ in intragroup knee extensor strength by Cybex after SI manipulation	ITT adequate No loss of participants	−
Drover et al[119]	CT Not randomized Focus: effect on knee extensors	PFPS (AKPS)	n = 9 Mean age, 25.7 y	ART technique for knee (vastus muscle etc) vs testing normal contralateral leg 1 Tx with immediate FU	No significant change for all measures: 1. Knee extension strength Biodex (Biodex Medical Systems, Shirley, NY). 2. muscle inhibition: interpolated twitch torque technique	ITT adequate No loss of participants	−
Crossley et al[72]	RCT Double blind	PFPS	n = 71 Age, ≤40y	PT (patellar mobilization tape, exercise, stretch, soft tissue) vs placebo (detuned ultrasound, tape, gel) 6 Txs over 6 wk FU: 3 mo for PT only	Significantly in favor of PT group VAS, AKPS, step ups. No serious adverse effects; side effects: soreness in 2 in PT and in placebo	Adequate power Adequate blinding Double blind ITT reported	++
Suter et al[120]	RCT	PFPS (AKPS)	n = 25 Mean age, 34 y	HVLA SI manipulation only for PFPS vs control, no adjustment Both measured for MI, EMG, and muscle strength in quadriceps 1 Tx with immediate FU	Pre-Tx baseline Significant decrease in MI by 7.5% using interpolated twitch torque technique (nonsignificant ↑ in quad muscle strength Cybex [Cybex Norm, Testing & Rehabilitation system; Lumex Inc, New York, NY] and EMG)	Double blind ITT adequate SI relieves PFPS knee pain No loss of participants	++
Rowlands and Brantingham[121]	RCT	PFPS	n = 30 Mean age, >18 y Some drop outs, not noted	Mob of patella vs placebo (detuned ultrasound) 8 Tx over 4 wk FU: 1 mo	Significant in favor of mob: ↓ pain with ALG and ↓ pain with McGill vs placebo	McGill % intergroup change very large mob vs placebo >80% power (McGill correlates well 0-100 scales). ALG <power Single blind	+
Stakes et al[157]	RCT^ (see § below)	PFPS	n = 60 Mean age, 30.5 y	Patellar mob vs patellar mob and HVLA SI or L/S adjustment 6 Txs over 4 wk	No difference between groups Power not calculated; intergroup statistics must be viewed with caution. Significant intragroup change	Single blind For both groups, magnitude of changes in NRS and PFJE scales % appear statistically and clinically meaningful	+

					for both groups: NRS, PFJE, SFMPQ, PSFS, and ALG	8 drop outs: 2 per group transport problems No side effects 2 per group lost to FU. Subjects replaced	
Taylor and Brantingham[158]	RCT (see § below) Blind assessor No unblinding	PFPS	n = 12 Mean age, 30.17 y	Patellar mob vs patellar mob + home exercise 8 Tx over 4 wk FU: 1 wk	Descriptive statistics suggests that both Txs are helpful. Nonparametric intragroup significant for NRS, SFMPQ, ALG, and PSFS	ITT adequate No side effects No loss of participants	+
Ankle							
Pellow and Brantingham[123]	RCT	Ankle sprain Subacute and chronic Grade I and II >5 d	n = 30 Mean age, 24.9 y	Manipulation ankle axial elongation (HVLA) vs detuned ultrasound (placebo) 8 Txs over 4 wk or until Sx free FU: 1 mo	Significant for MT for SFMPQ, functional improvement, at eighth Tx, and for SFMPQ, functional, ROM 1-mo FU vs placebo	Power adequate for intragroup No ITT Single blind	+
Green et al[74]	RCT^	Ankle sprain Acute 72 h	n = 41 Mean age, 25.5 y	RICE and tape and A-P talus mob vs control (RICE and tape) ≤6 Tx over 2 wk	Significant for MT for ↑ ROM, ↓ pain, ↑ gait. Faster recovery, activity with mob	Adequate blinding Blind assessor ITT adequate No adverse effects No drop outs	+
Coetzer et al[124]	RCT^ § Retrospective second author: appropriate randomization, adequately described in the article (see § Coetzer et al 2001).	Ankle sprain Acute ≤24 h	n = 30	Both groups received (for ethical and methodological reasons) SC = RICE. MT: HVLA ankle manipulation—axial elongation and subtalar joint eversion vs NSAID (Piroxicam) 6 Txs over 2 wk with 1-mo FU NSAIDS, 40 mg for 2 d and 20 mg for 5 d with 1-mo FU	No significant difference between groups except sixth Tx ↑ ROM in favor MT; blind assessor detected ↓ restricted motion in joints in MT group at FU All groups had significant intragroup improvement: ALG (↓ pain), goniometer (↑ ROM), NRS (↓ pain), athletic limitation (↑ function), and SFMPQ (↓ pain)	Power generally low Otherwise essentially equal effects Blind assessor for motion palpation	+
Eisenhart et al[38]	RCT^	Ankle sprain Acute Grade I and II <24 h	n = 55 Mean age, 30.5 y	SC (RICE + NSAIDS) vs SC + OMT (combination of HVLA, functional, and ST) 1 Tx with premeasures and postmeasures in ER FU: 1 wk	Significant for MT after first Tx for ↓ swelling, ↓ VAS. 1 wk/FU: Significant for MT ↑ ROM DF	ITT performed Single blind Loss 15 participants to FU	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
Collins et al[125]	RCT Double blind	Ankle sprain Subacute Grade II	n = 16 Mean age, 28.5 y	MWM vs placebo (sham) or control (holding position only) 1 Tx with premeasures and postmeasures	MT significant for ROM ↑ DF No change in PPT (ALG) or TPT	2 left trial, 1 had increased pain. ITT not reported	+
Vicenzino et al[135]	RCT Random to 3 Txs Double blind	Ankle sprain Chronic recurrent <20-mm DF in injured ankle inclusion	n = 16 Mean age, 19.8 y	1. MWM weight-bearing PTG and DF ROM 2. Ditto but nonweight bearing 3. Control, position held 1 Tx with after FU	Significant for MT ↑ PTG° and DF° weight-bearing and non–weight-bearing MWM Large effect sizes PTG Moderate effect ↑ dorsiflex vs control	ITT adequate No loss of participants	++
Lopez-Rodriguez et al[126]	RCT	Ankle sprain Grade II >5 d	n = 52 Mean age, 22.5 y	Manipulation ankle axial elongation (HVLA) and supine HVLA A-P talar thrust vs placebo (holding position) 1 Tx with after FU	Significant for MT ↑ in proprioception with stabiliometry and baropodometry vs placebo	ITT adequate No loss of participants Single blind	+
Kohne et al[127]	RCT^ (see § below) Baseline characteristics and statistics essentially equal (see Kohne, E dissertation)	Ankle sprain Chronic recurrent Grade I and II or AIS	n = 30 Mean age, 31.7 y	Manipulation ankle axial elongation (HVLA) Group 1: 6 Txs over 4 wk Group 2: 1 Tx FU: 1 wk	Significant for group 1 (6 Txs) for ↑ proprioception and ↑ DF ROM: ROM: strapped inclinometer—kinesthetic proprioception significant postmanipulation compared with control (° relocation of position in space) ankle moved only by participant ↓ bias	A "few" sensed ↑ "instability" in group 1 (per Kohne dissertation)	+
Joseph et al[128]	RCT^ No blinding reported HVLA manipulation grade 5 vs mobilization grades III and IV (ME technique) All subjects who began completed treatment in same groups (except 1 subject replaced and data management not reported)	Ankle sprain AIS (chronic recurrent inversion sprain grades I and II)	n = 40 n = 20 Mean age Group 1, 30.5 y Group 2, 28.4 y	Group 1: Manipulation, HVLA thrust grade 5 ankle axial elongation. Group 2: Mobilization = ME technique per Greenman (1996) = PIR with stretch; a form of mobilization: ankle is held at end point of restricted end physiologic and accessory DF ROM and at end of the restricted anterior to posterior talar	NRS, 101 for pain (0, 100 mm); OLST eyes open and closed for proprioception/balance; FES; SFMPS; ROM: DF and PF No significant difference between groups at 3 wk for all outcome measures (after 6 Txs); all MANOVA, $P > .05$. Both groups significant within-group change at 6 Txs for all outcome measures; all $P \leq .05$, and clinically meaningful differences for pain (NRS, 101), OLST, and DF ROM Within-group (paired t test): Significant and clinically	Power low ITT inadequate No significant adverse reactions or side effects reported. Loss of 1 patient reported (not clear what was done with data) and replaced; otherwise, all that began trial ended trial in same groups.	+

				movement (restricted posterior talar movement); held 5 s then further DF and posterior force against the talus and held 10 s; repeated 5× 6 Tx at 2/wk for 3 wk	meaningful for either form of MT for: ↑ in proprioception (OLST) eyes closed; both P = .000. Manipulation OLST ↑ by 10.45 s and ME (mob + stretch) ↑ by 10.05 s; the NRS at Sixth visit; significant and clinically meaningful for a ↓ in NRS, 101 for pain both >37 and 39.6 mm manipulation and mob (ME), respectively; also for ↑ in ROM or DF 9.8° and 7.7° manipulation and mob (ME), respectively (see article for details)		
Yeo and Wright[129]	RCT Apparent randomized, placebo-controlled trial using a within-group random allocation to 1 of 3 "procedures" randomized to 3 different procedures/Txs	Ankle sprain Subacute inversion or lateral ankle sprain grade II (from 2-10 weeks before treatment).	n = 13 (n = 13 × 3 = 39 evaluations 48 h apart) Mean age, 29.5 y (20-49 y) Mean duration of pain/injury, 5 wk. W persistent pain and decrease DF by 20%	Group 1: Mobilization of the talus on the distal tibia A-P (using Maitland's technique 1991), 1 min of oscillation with a 30-s rest between 3 applications in the "long sitting position"—for all 3 groups (see text or article). Enough force was used to cause a gliding motion of the talus but not to produce pain (grade III to probably grade IV) Group 2: Mobilization of the talus on the distal tibia A-P once (to end of "available range" then held/sustained for the same period as the experimental (or group 1 Tx). Group 3: Participant was placed in the same position, but there was no contact between therapist and patient for the same period. All received the group 1 experimental or "real" Maitland MT treatment once. 3 different treatments	Significant in favor of group 1 ROM (↑ for ankle DF of 9.6 mm; P = .000) compared with placebo and no contact control. Significant in favor of group 1 for PPT ↑ 17.8% compared with placebo and no contact control, $P \leq .000$ and .002, respectively). VAS was slightly decreased in group 1 but not significantly different from the other groups (all $P > .05$) There was no significant difference between groups for the ankle functional score (all $P > .05$).	Power low (small sample size) ITT complete Double blinding subject and assessors; no significant adverse reactions or side effects reported. ROM: DF measured using the "lunge" weight-bearing technique AFS per Kikkonen (1994) included 9 items: 3 subjective questions measurement of DF ROM (used above), joint laxity, functional tests of walking downstairs, heel and toe raising, and the OLST. Pain was measured with PPT (digital algometry) and a 10-cm VAS. Note: normal opposite ankle also measured.	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
				randomly allocated each 48 h apart. All had preblind measurement and postblind measurement blindly taken.			
Reid et al[130]	RCT With crossover design (both groups randomly received Tx or sham and data recorded pre and post) See article MWM per Mulligan 1995	Ankle sprain Chronic, average >3-mo duration with majority >12 mo or AIS Study design was to test for a change in ROM (DF)	n = 23 Group 1, n=11 Mean age, 24 y Group 2, n=12 Mean age, 26 y	Group 1: MWM—subject standing and flexes knee and leans forward (the "lunge" method) inducing ankle DF while practitioner with supported web contact pushes A-P on talus as the DF occurs; a belt is around the practitioner's trunk and looped around post. Distal tibia—and the practitioner leans back as she pushes A-P on the talus as DF occurs. vs placebo/sham Tx (ankle and foot grasped with a splint keeping ankle in neutral and flexion and extension of knee; see article) All received the group 1 experimental MWM Tx once and the placebo/sham Tx once. Washout period between MWM and sham was 7 d.	Significant in favor of group 1 ROM after 1 MWM Tx (↑ 4.5 mm ankle DF of $P = .019$, paired t test) compared with placebo/sham and no contact control. Small change but only 1 Tx	Power low ITT complete Double blind: assessors and participants No significant adverse reactions or side effects reported.	+
Grindstaff et al[131]	RCT Randomly assigned to 3 groups Study to detect post-HVLA manipulation changes (H-reflex and M-response measurements for CAI [also known as AIS]) Used surface electromyography	Ankle sprain (H-reflex and M-response measurements of muscle activation) post-HVLA manipulation for AIS Used surface electromyography (the MP150; BIOPAC Systems, Inc) from proximal or distal	n = 43 Group 1, n=15 Mean age, 25.2 y Group 2, n = 15 Mean age, 27.5 y Group 3, n= 13 Mean age, 23.8 y	Group 1: proximal tibiofibular HVLA manipulation to improve anterior glide of the fibula. The proximal fibula grasped and associated soft tissue pulled laterally; the knee was fully flexed and then the externally rotated distal leg was suddenly forced into further end	No significant difference for the fibularis longus; all (ANOVA, all $P < .05$) Significant difference (with ANOVA) in favor of the soleus H/M ratio (and activation of the oleus muscle) at all postintervention periods compared with the other Tx and the control ($P < .05$) except at the 20-min postintervention.	Power low ITT complete No significant adverse reactions or side effects reported.	+

	(the MP150; BIOPAC Systems, Inc, Santa Barbara, CA) from proximal or distal tibiofibular joint manipulation in ankle musculature activation in patients with CAI	tibiofibular joint manipulation in ankle musculature activation in patients with CAI		feel/end ROM flexion with the heel pushed toward buttock and if cavitated stopped if not repeated again with or without cavitation (see article). Group 2: distal tibiofibular HVLA manipulation to improve posterior glide of fibula, or an A-P palmer contact is placed on lateral distal tibiofibula joint—at the distal fibula; the other had wraps around opposite side and after A-P motion is removed, an A-P thrust at the distal fibula is delivered (as above). Group 3 (control): no treatment 1 Tx was delivered and the H-reflex and M response EMG MP150 results obtained after each of the 2 Txs or no treatment. There was a premeasurement and measurements taken immediately after at 10, 20, and 30 min post-HVLA manipulations	Activation of muscle may facilitate a weak or inhibited muscle, allowing a window for rehabilitation.		
Lubbe et al[132]	RCT^	AIS: chronic recurrent inversion sprain Average, previously 4-6 sprains	n = 33 Age range, 18-45 y Group 1 Mean age, 25.5 y Chronicity, 192 wk Group 2 Mean age, 25.7 y Chronicity, 336 wk	Group 1: Manipulation: rehabilitation (rehabilitation identical for both groups) Manipulation: HVLA grade 5 to (ankle and foot) ankle, subtalar, and/or tarsal joints (1 up to 3 joints per session) Group 2: Rehabilitation only: peroneal muscle strengthening: with elastic band 3 × 12 repetitions to mild fatigue.	Significant ANOVA between groups in favor of group 1 for VAS (↓ ≥30 mm), ALG (↑ 1.4 kg), and motion palpation (after last treatment ↓ in "fixations" or decreased accessory motions); all $P \leq .05$ Significant within-group ANOVA change for all outcome measures for groups 1 and 2 for VAS, FADI (both ↑ 15 points), and BBS (both group 1 ↑ 12.7 points and group 2 ↑ 10.7 points); all $P \leq .05$	Power low ITT complete Blind assessor No significant adverse reactions or side effects reported.	++

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
				Proprioception exercise using the Bosu ball: subject stood and balanced on ball for 10 min per session. Both groups initially taught rehabilitation at clinic, then at home; groups 1 and 2 at FUs could repeat rehab at clinic if needed to assure it is correctly being done; otherwise, all did exercise at home (with diary). 6 Tx at 1-3/wk for 3-5 wk Outcomes after third and sixth visit	Greater and more complete and faster recovery in group 1		
Foot							
Plantar fasciitis							
Dimou et al[136]	RCT^ Randomization; see § below	Plantar fasciitis "Plantar heel pain" Chronic >7 wk	n = 20 Mean age, 42.4 y	Group 1: foot and ankle adjusting + stretching vs group 2: orthotics (custom made for each individual by a licensed podiatrist) 8 Txs over 5 wk FU: 1 mo	Significant ↓ pain between groups in NRS at 4 wk in favor of group 1: MT of the foot and ankle and stretching Significant (intragroup) for both Txs (but not different) at 9 wk for ↓ first step pain, ↓ heel pain at rest, and ALG	ITT adequate Low power No side effects Blind assessor All participants Completed treatment	+
Cleland et al[137]	RCT	Plantar heel pain Commonly diagnosed as "plantar fasciitis" in the past	n = 60 Mean age, 48.4 y Group 1, n = 30 Mean age, 47.4 y Group 2, n = 30 Mean age, 49.5 y 3 drop outs in both groups; both group 1 did not return for various reasons; at the 6-mo FU, 2 in both groups did not return FU questionnaires, so both n = 27, or n = 54 finished all Tx	Group 1: EPAX vs group 2: MTEX EPAX: All exercises 3× daily for 4 wk. Iontophoresis w desamethasone for heel pain/plantar fascia (PF). In addition, ultrasound at 1.5 W/cm^2 at 100 Hz for 5 min (before iontophoresis) and cryotherapy. Stretching techniques for soleus and gastrocnemius and PF and intrinsic foot muscle strengthening. Ice at PF 15 min after	Significant and clinically superior in favor of the MTEX group 2 for: the LEFS (0-80 scale higher is best) with a reported MCID of 9 points. LEFS at 4 wk MTEX + 13.5 points more P =.001 At 6-mo FU MTEX + 9.9 points P =.027 Also used the FAAM (0-84 score higher is best) with a reported MCID of 8 points FAAM at 4 wk MTEX + 13.3 points more; P =.004 At 6-mo FU MTEX + 13.6 points; P =.012 NPRS at 4 wk MTEX = ↓ 1.5 points; P =.008	Full power ITT adequate No significant adverse reactions or side effects reported.	++

				exercise and advised to avoid ADL that aggravated symptoms. MTEX: 5-min aggressive ST mob at triceps surae and insertion of PF at medial tubercle and rear foot eversion mobilization. Also for restricted physiologic and accessory motion such as ankle DF (from restricted A-P talocrural motion or restricted axial distraction manipulation; also, other FKC MT to the hip joint and other lower extremity joints as indicated such as the knee, patellofemoral joint, the prox fib-tib joints, etc [see article for details]). Plus all subjects were instructed to do self-mobilization of the ST joint into eversion and manual ST mob of the plantar fascia at home along with gastrocnemius and soleus stretches identical to the EPAX group. 6 Txs over 4 wk Outcomes: at 4 wk (end of care) and FU: 6 mo	Not significantly different at 6-mo FU NNT: 4 for the MTEX, which is reported as to effective treatment		
Metatarsalgia							
Petersen et al[140]	CT ¥ Systematic assignment (first patient randomized)	Metatarsalgia (common or mechanical)	n = 40 Mean age, 49.5 y	MT of foot and ankle (mob, HVLA: especially intermetatarsal glide, first MTPJ, etc) vs placebo (detuned ultrasound) 8 Txs over 4 wk	Significant in favor of MT vs placebo for SFMPQ, NRS, FFI, and ALG. Note: placebo patients started with higher level of pain.	4 drop outs Not clear which groups None from side effects (family, business problems, etc).	–

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
Govender et al[141]	RCT (see § below)	Morton's neuroma aka Morton's metatarsalgia	n = 40 Mean age, 51 y	Adjustive therapy (mob and HVLA) for foot and ankle vs placebo (detuned ultrasound) 6 Txs over 3 wk	Significantly in favor for MT: NRS and ALG vs placebo	Power adequate Single blind ITT adequate No loss of subjects No side effects reported	+
Decreased proprioception, balance, and function from foot and ankle injury, decreased ROM, and/or joint dysfunction							
Lopez-Rodriguez et al[126]	RCT	Ankle sprain Grade II >5 d	n = 52 Mean age, 22.5 y	Manipulation ankle axial elongation (HVLA) and supine HVLA A-P talar thrust vs placebo/control (holding position) 1 Tx with immediate post-FU	Significant for MT ↑ in proprioception with stabiliometry and baropodometry vs placebo	See above Single blind No loss of participants	+
Vaillant et al[148]	RCT Placebo controlled crossover trial	Foot and ankle joint dysfunction and plantar myofascial dysfunction Vellas (1997) ↓ OLST is a significant factor in predicting injurious falls Muir (2010) OLST also found to be a significant risk factor for falls Kemoun 2002 ↓ ankle DF = ↑ fall risk	n = 28 Mean age, 78.8 y (SD, 8.5); range, 65-95 y Group 1 (MMP), 14 Group 2 (PP), 13	Group 1: MMP or massage and mobilization protocol: massage to plantar aspect of the foot using friction, static, glide, and pressure focus on sole of foot. Mobilization: DF and plantar flexion of talocrural joints, eversion/inversion of subtalar joints, A-P glide, torsion, flex, and ext of midtarsal joints, A-P glide, and rotation of tarsometatarsal joints of intermetatarsal joints and plantar and PF and ext of the MTP and interphalangeal joints. All Tx 3×/foot for 20 min vs group 2: PP—3 demagnetized magnets placed in region of the fifth metatarsals for 20 min. Both groups have a washout period of 1 wk	Significant between groups in favor of MMP (n = 27) for the OLST and increased speed in performing the timed up and go test; both P <.01 compared with PP or placebo. Not different for the lateral reach test. 1. ↑ OLST time and 2. ↑ speed in performing TUG test	See above Single blind No side effects reported 1 drop out due to loss of interest; otherwise, all that started ended trial.	+

				and then crossed over to the other Tx randomized 1 Tx with premeasurement and postmeasurement.			
Kohne et al[127] See above: ankle sprain	RCT^	AIS, chronic recurrent inversion sprain	n = 30	Manipulation ankle axial elongation (HVLA) Group 1: 6 Txs over 4 wk Group 2 (control): 1 Tx with FU	Significant for group 1 (6 Txs) for ↑ proprioception: ROM kinesthetic proprioception significant postmanipulation compared with control (° relocation of position in space) strapped inclinometer ankle moved by participant ↓ bias	See above	+
Joseph et al[128]	RCT^ HVLA manipulation grade 5 vs mobilization grades III and IV (ME technique)	Ankle sprain AIS, chronic recurrent inversion sprain grades I and II	n = 40 Mean age Group 1, 30.5 y Group 2, 28.4 y	Group 1: Manipulation, HVLA thrust grade 5 ankle axial elongation Group 2: Mobilization, ME technique per Greenman (1996)—PIR with stretch, a form of mobilization: ankle is held at end point of restricted end physiologic and accessory DF ROM and at end of the restricted anterior to posterior talar movement (restricted posterior talar movement), held 5 s then further DF and posterior force against the talus, and held 10 s. Repeated 5× 6 Tx at 2/wk for 3 wk	NRS,101 for pain (0, 100 mm); OLST eyes open and closed for proprioception/balance, FES, SFMPS, ROM: DF and PF No significant difference between groups at 3 wk for all outcome measures (after 6 Txs); all MANOVA $P > .05$. Both groups have significant within-group change at 6 Txs for all outcome measures; all $P \leq .05$, and clinically meaningful differences for pain (NRS, 101), OLST, and DF ROM within group (paired *t* test): Significant and clinically meaningful for either form of MT for: ↑ in proprioception (OLST) eyes closed; both $P = .000$. Manipulation OLST ↑ by 10.45 s and ME (mob + stretch) ↑ by 10.05 s, the NRS at sixth visit; significant and clinically meaningful for a ↓ in NRS, 101 for pain both >37 and 39.6 mm manipulation and mob (ME),	See above Blinding: none Loss of 1 patient reported (not clear what was done with data) and replaced; otherwise, all who began trial ended trial in same groups All subjects who began completed treatment in same groups (except 1 subject, replaced, and data management not reported)	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/control	Results/outcomes	Particulars	Modified Liddle et al*
					respectively; also for ↑ in ROM or DF 9.8° and 7.7° manipulation and mobilization (ME), respectively (see article for details)		
Hallux limitus/rigidus							
Shamus et al[143]	RCT^	Hallux limitus	n = 20 Mean age, 32.8	MT of hallux and or/hallux and sesamoids + different physical therapy protocols: Comparative Tx: modalities, hallux mob, exercise vs experimental Tx (same) + sesamoid mob, hallux flex strengthening, and gait retraining 12 Txs over 4 wk	Significant in favor of experimental Tx for: ↑ ROM, ↑ strength, ↓ VAS, faster return of ROM, and function	Single blind: Blind participants ITT adequate No drop outs 2 patients discharged at 10 visits (with relief)	+
HAV (or bunion)							
Brantingham et al[146]	RCT	HAV (painful HAV)	n = 60 Mean age, 50.1	MT of hallux, foot and ankle (with a progressive protocol of mobilization to HVLA manipulation of the hallux) vs placebo (PT modality: nontherapeutic action potential therapy) 6 Txs over 3 wk FU: 1 wk	Significant in favor for MT for ↓ NRS, ↓pain, disability, ↑ function with HAL and FFI vs placebo	Single blind Drop outs not reported/unclear No reported side effects	+

du Plessis et al[147]	RCT^	HAV (mild to moderate painful HAV—rule out severe deformity, RA, diabetes, etc)	n = 30 Age range, 25 -65 y Mean age, 42 y	Group 1 MT of hallux (or first MTPJ), foot, and ankle joints (with a progressive protocol of mobilization to HVLA manipulation of the hallux). See article for details. vs Night splint MT: 4 Tx over 2 wk FU: 1 and 4 wk Night splints worn during sleep (holds great toe in an adducted position) for 3 wk Graded mobilization protocol is an attempt to protect against aggravation or side effects (obtain paper)	Both groups had significant within-group change for VAS and FFI and DF ROM at the 1-wk FU, etc (see article). However, no significant between group differences (ANCOVA, $P > .05$) for all outcome measures at the end of care or the 1-wk FU. Significantly in favor (for between groups) for the MT group for a ↓ in pain (VAS) and significant and clinically meaningful ↓ in FFI and ↑ ROM in DF of hallux at the 1-m FU. This suggests that the night splint regressed to the mean but the MT treatment effects persisted at the 1-mo FU.	Power adequate ITT adequate No adverse reactions of side effects reported	++

ADL, activities of daily living; *AFS*, ankle functional scale; *AIS*, ankle instability syndrome; *AKPS*, Anterior Knee Pain Scale; *ALG*, algometry; *ANCOVA*, analysis of covariance; *ANOVA*, analysis of variance; *A-P*, antero-posterior; *AQoL*, health-related quality of life measure; *ART*, active release therapy; *BBS*, Berg Balance Scale; *CMT*, chiropractic manipulative treatment; *CT ¥*, controlled or clinical trial with systematic assignment (pseudorandomization) or no randomization but with inclusion, exclusion, controlled, independent, and dependent variables vs placebo and/or comparative treatment; *DF*, dorsiflexion; *EMG*, electromyogram; *EPAX*, electrophysical agents and exercise; *ER*, emergency room; *ext*, extension; *FAAM*, foot and ankle ability measure; *FES*, functional evaluation scale; *FFI*, Foot Function Index; *FKC*, full kinetic chain; *flex*, flexion; *FU*, follow-up; *GROC*, Global Rating of Change; *HAL*, Hallux-Metatarsophalangeal-Interphalangeal Scale; *HAV*, hallux abducto valgus; *HHS*, Harris Hip Scale; *KJ*, knee joint; *KOA*, knee osteoarthritis; *KPS*, knee pain scale; *LEFS*, Lower Extremity Functional Scale; *L-M*, lateral-medial; *man*, manipulation; *MANOVA*, multivariate analysis of variance; *MCID*, minimal clinically important difference; *ME*, muscle energy; *meds*, medications; *MI*, muscle inhibition; *MIMG*, Macquarie Injury Management Group Knee Protocol; *MMP*, massage and mobilization protocol; *mob*, mobilization; *MTEX*, manual therapy and exercise; *MTP*, metatarsophalangeal; *MTPJ*, metatarsophalangeal joint; *MWM*, mobilization with movement; *NNT*, number needed to treat; *NPRS*, Numerical Pain Rating Scale; *NRS*, Numerical Rating Scale; *NSAID*, nonsteroidal anti-inflammatory drug; *OLST*, one-leg-standing test; *OMT*, osteopathic MT; *OTE*, Overall Effectiveness Scale; *P-A*, postero-anterior; *PF*, plantarflexion; *PFPSQ*, Pain Severity Questionnaire; *PGT*, Patellar Grinding Test; *PIR*, postisometric relaxation; *PP*, placebo protocol; *PPT*, pressure pain threshold; *PSFS*, Patient Specific Function Scale; *PSS*, Patient Satisfaction Scale; *PT*, physical therapy; *PTG*, post talar glide. *RICE*, rest-ice-compression-elevation; *RT*, resistive therapy; *SC*, standard care; *SF-36*, Short Form-36 Health Survey; *SFMPQ*, Short-Form McGill Pain Questionnaire; *SFMPS*, Short-Form McGill Pain Scale; *SI*, sacroiliac; *ST*, soft tissue; *Sx*, symptoms; *TFL*, tensor fascia lata; *TFM*, transverse friction massage; *TPT*, thermal pressure threshold; *TUG*, timed up and go test; *Tx*, treatment; *US*, usual care; *VAS*, Visual Analog Scale.

§ *RCT*, randomized controlled trial (treatment vs placebo); *RCT^*, randomized clinical trial (treatment vs another treatment, usually comparative treatment demonstrated superior to placebo or standard care).

Table 2. *Level of evidence for MT*

Condition	Treatment no.	Quality	Grade of evidence *
Hip OA	Average: 6 over 3-5 wk Range, 6-9	2 high 2 moderate 2 low	B for MT of the hip combined with multimodal or exercise therapy for short-term relief C for intermediate and long-term relief
Knee OA	Average: 10 over 6 wk Range, 1-24 1-y follow-up	2 high 6 moderate 1 low	B for MT of the knee and/or full kinetic chain combined with multimodal or exercise therapy for short-term relief C for intermediate and long-term relief
Patellofemoral pain syndrome, also known as anterior knee pain syndrome	Average: 6.37 over 4-8 wk Range, 1-8 Range, 1 Tx to 1-y follow-up	2 high 5 moderate 2 low	B for MT of the knee and/or full kinetic chain combined with multimodal or exercise therapy for short-term relief C for intermediate and long-term relief
Ankle inversion sprain	Average: 3.25 Range, 1-8 over 2-8 wk	1 high 10 moderate 2 low	B for MT for ankle sprain with multimodal or exercise therapy for short-term relief C for intermediate relief
Plantar fasciitis (fasciopathy)/heel pain	Average: 7 over 5 wk	1 high 1 moderate	B for MT for plantar fasciitis with multimodal/exercise therapy for short-term relief C for intermediate relief
Metatarsalgia	Average: 7.5 over 3-4 wk	1 moderate 1 poor	C for MT for metatarsalgia with and without multimodal therapy No change, no new studies found
Decreased proprioception, balance, and function from foot and ankle injury, decreased ROM, and/or joint dysfunction	Average: 3.5 Range, 1-6	4 moderate	C for MT for improving ankle and foot proprioception/balance with multimodal/exercise therapy for short-term relief
Hallux limitus/rigidus	12 over 4 wk	1 moderate	C for MT for hallux limitus/rigidus with multimodal therapy for short-term relief; otherwise, no change
Hallux abducto valgus/bunion	Average: 5	2 moderate	I for MT for hallux abducto valgus for short-term relief

* Refer to Figure 2 for definitions.

observational, clinical, and basic science research, case series, and reports.

Discussion

This literature review revealed new, recent, and previously uncited (secondary to limitations previously discussed) peer-reviewed articles and publications regarding manipulative treatment. For the most part these studies included adjunctive therapy (frequently exercise and/or rehabilitation and soft tissue therapy, secondarily, in conjunction with modalities, NSAIDS, etc) for lower extremity conditions. Since the earlier reviews,[1,2] along with broader inclusion parameters, there is a clear increase of fair and limited evidence for use of MT in the treatment of several common lower extremity disorders. Notably, within this new evidence, there exist several studies representing very high and higher level RCT evidence with SGPPDs, case studies, and reports of increasing quality continuing to proliferate. Also worth noting is that the highly and lesser rated trials included in this analysis have recently been included in systematic reviews for treatments of hip and knee OA, patellofemoral pain syndrome, and inversion sprain.[39,40,43,88] However, in this proliferation of competing, systematic reviews, using similar and/or a variety of methodologies, some reach opposite conclusions as to whether to support or not support the same treatment. One surprising example of just such a finding is exercise for acute inversion sprain.[39,89-91] Nevertheless, overall, when appraising the increasing quantity and quality of included trials, MT for lower extremity disorders appears to be of value and, like spinal MT, fundamentally safe. The trials and studies used numerous outcome measures, most with minimally general, and some with a condition-specific validity and reliability. Some of the measures used were primary patient reports of improvement (using Likert, overall therapy effectiveness, and other scales), and algometry, Visual Analog Scale, Numerical Pain Rating Scale, and the Short-form McGill Pain Questionnaire. In addition, Cybex isokinetic muscle testing; Goniometry; the Anterior Knee Pain Scale; Harris Hip Scale; the WOMAC; the Hallux Metatarsophalangeal Interphalangeal Index; the Foot Function Index; One Leg Standing Test; Interpolated Twitch and EMG; and functional tests such as "First Step Heel Pain," "Step-Ups," "Get Up and Go," Gait Analysis, Stabiliometry, and Baropodometry as well as orthopedic tests were used.

Intention-to-treat analysis can be a useful tool in interpreting study data. For example, when data from subjects who drop out of a study secondary to adverse effects are excluded, this certainly constitutes a potential bias in interpreting findings that would benefit from the addition of ITT. However, Hollis and Campbell[81] point out that 52% of medical trials fail to do ITT or do a poor or an inadequate job with ITT. In a systematic review of 249 trials, Gravel et al[82] pointed out that randomization was used only

Table 3. *A summary of research on the hip: case series and SGPPDs*

Author	Diagnosis	Treatment/management	Reported outcome
MacDonald et al[99]	HOA n = 7 Median age, 62 y	MT of hip and exercise for (HOA) 5 treatments (over 2-5 wk) Mobilization and manipulation (grades IV and V) 1. HVLA axial elongation 2. Various additional hip manipulation and mobilization techniques from multiple sources/textbooks 3. Hip, knee, and trunk exercises for HOA	HHS (for disability) 6 patients: median improvement ↑ 25 points (clinically meaningful [*clm*] change ↑ 4 points). 1 patient (no HHS scale) but instead did Global Rating of Change Scale: "a great deal better" 7 patients mean NPRS (↓ 5 points on 0-10 scale; 1.5-2 points *clm*) Goniometry: Global ↑ ROM 82° Conclusion: All ↓ pain, ↑ ROM
Brantingham et al[100]	HOA SGPPD n = 18 Age range, 40-85 y Blind assessment: Assessors did not know which group these study and/or group in various HOA trials these subjects were in. Assessors did not know if they were receiving full kinetic chain or local hip Tx.	9 Txs over 5 wk and a 3-mo FU Subjects received preadjustive stretches of the iliopsoas, rectus femoris, tensor fascia latae, sartorius, long adductors, and short adductors. Stretches were followed by a HVLA long-axis manipulation thrust or traction of the hip with a sudden HVLA "pull" on the involved hip. If it was determined that hip flexion was still restricted or not improved, then the HVLA hip manipulation was repeated after adding slight internal rotation and/or abduction to produce a more "close packed" hip joint position. Maximum no. of hip manipulations per treatment session allowed was 5. Postadjustive, active-assisted stretches were conducted such as hip flexion, hip adduction, or a piriformis stretch. No Tx or a formal home exercise program was prescribed after the 3-mo FU except general advice as to how to increase activities and exercise safely. Increased activity was encouraged. Valid and reliable outcome measures: OTE, WOMAC, and HHS (see next column) Plus ROM	Within-group clinical and statistically and clinically significant for the (Kolmogorov-Smirnov test for OTE and WOMAC demonstrated normally distributed data, also used χ^2, paired *t* test, and Friedman ANOVA tests): OTE (a globally rated patient satisfaction and improvement outcome measure) χ^2 OTE at ninth Tx = ↑ 85.2% improvement; $P = .005$ (MCID estimated at an ↑ of 30%) OTE at 3-mo FU = ↑ 77.8% improvement; $P = .02$ WOMAC (*t* test) WOMAC at ninth Tx = ↑ 58.6% improvement; $P = .000$ (MCID estimated at an ↑ of 20%-25%) WOMAC at 3-mo FU = ↑ 50.1% improvement; $P = .000$ HHS HHS at ninth Tx = ↑ 13.6 points improvement; $P = .000$ (MCID estimated at an ↑ of 4 points) HHS at 3-mo FU = ↑ 11.6 points improvement; $P = .001$ ROM The total increase in the global ROM was +11.89° ($P < .05$). ROM increased in flexion, extension, and internal rotation—significantly at the 3-mo FU (internal rotation +5.4°; $P = .037$).
Brantingham et al[101]	HOA SGPPD n = 27 Age range, 40-85 y Age range, 40-85 y Blind assessment: Assessors did not know which group these study and/or group in various HOA trials these subjects were in. Assessors did not know if they were receiving full kinetic chain or local hip Tx.	9 Txs/5 wk and a 3-mo FU Subjects received preadjustive stretches of the iliopsoas, rectus femoris, tensor fascia latae, sartorius, long adductors, and short adductors. Stretches were followed by a HVLA long-axis manipulation thrust or traction of the hip with a sudden HVLA "pull" on the involved hip. If it was determined that hip flexion was still restricted or not improved, then the HVLA hip manipulation was repeated after adding slight internal rotation and/or abduction to produce a more "close packed" hip joint position. Maximum no. of hip manipulations per treatment session allowed was 5. Postadjustive, active-assisted stretches were conducted such as hip flexion, hip adduction, or a	Within-group clinical and statistically and clinically significant for the (Kolmogorov-Smirnov test for OTE and WOMAC demonstrated normally distributed data, also used χ^2, paired *t* test, and Friedman ANOVA tests): OTE (a globally rated patient satisfaction and improvement outcome measure) χ^2 OTE at ninth Tx = ↑ 83.3% improvement; $P = .005$ (MCID estimated at an ↑ of 30%) OTE at 3-mo FU = ↑ 78.0% improvement; $P = .02$. WOMAC (*t* test) WOMAC at ninth Tx = ↑ 63.9% improvement; $P = .000$ (MCID estimated at an ↑ of 20%-25%) WOMAC at 3-mo FU = ↑ 47.0% improvement; $P = .016$

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Table 3. (*continued*)

Author	Diagnosis	Treatment/management	Reported outcome
		piriformis stretch. No Tx or a formal home exercise program was prescribed after the 3-mo FU except general advice as to how to increase activities and exercise safely. Increased activity was encouraged. Valid and reliable outcome measures: OTE, WOMAC, and HHS (see next column) Plus ROM	HHS HHS at ninth Tx = ↑ 12.2 points improvement; $P = .001$ (MCID estimated at an ↑ of 4 points) HHS at 3-mo FU = ↑ 11.8 points improvement; $P = .007$ Global overall ROM increased 23.58°. Flexion, extension, and internal rotation all increased significantly at the 3-mo FU; all $P \leq .05$ significantly at the 3-mo FU. This was supported by Friedman ANOVA; $P = .008$.
de Luca et al[102]	HOA Case series n = 4 HOA n = 4 Average age, 59.5 y (SD, ±6.7)	9 Txs/5 wk Each subject received preadjustive stretches of the iliopsoas, rectus femoris, tensor fascia latae, sartorius, long adductors, and short adductors. Stretches were followed by HVLA long-axis hip thrust (or traction with a sudden pull) of the involved hip. The hip manipulation was repeated up to a maximum of 5 times (after adding slight internal rotation and/or abduction to make a more closed packed hip joint position) if flexion ROM was still restricted or not improved. Postadjustive, active-assisted stretches were conducted in hip flexion, hip adduction, piriformis stretch, and/or the Patrick-Fabere position. No Tx or a formal home exercise program was prescribed except general advice to safely increase activities and exercise. Increased activity was encouraged. Outcome measures: a valid and reliable measure: WOMAC Secondary outcome measure: ROM Adverse events: none. Side effects: mild posttreatment soreness after the first 1-2 treatments, which resolved in all patients.	WOMAC WOMAC at ninth Tx = average improvement of overall 69% ↓ in WOMAC scores for the 4 cases (of 2400 mm maximum worst). A mean group reduction of 382.5 mm (SD, ±115.8) All 4 subjects also had large decreases in hip pain, disability, and stiffness as well as an overall increase of 15° ↑ in flexion; all appear to be greater than a minimally clinical important change (see de Luca et al 2010 article). In addition, there was a mean group ↑ in hip ROM: internal rotation (51.7%; mean, 7.3°; SD, ±6.2°), adduction (26.7%; mean, 5.3°; SD, ±5.0°), abduction (21.1%; mean, 6.8°; SD, ±5.4°), flexion (15.3%; mean, 15°; SD, ±4.8°), and external rotation (8.5%; mean, 8.5°; SD, ±6.0°).

HOA, hip OA.

77% of the time; ITT, only 23% of the time, with ITT in general done poorly, incorrectly, or unclearly explained, whereas Furlan et al,[85] in a massive meta-analysis of RCTs assessing chronic low back pain, found only 34.7% with adequate ITT, whereas Rubenstein et al[86] found serious ITT deficiencies in 73% (19/26) of RCTs assessed in a 2011 meta-analyses. Porta et al[83] caution that ITT or per protocol analysis (PP) is so often flawed and flawed to such an extent that it is wrong to base conclusions of a controlled trial on single report of either ITT or the PP approach alone. Baron et al[84] found that, of 54 trials, full ITT analysis was done correctly in these studies only 7.4% of the time. Furthermore, most diagnoses and their respective treatments or management even now have no RCTs undergirding them (nor ITT analysis) to guide practitioners, and diagnosis and management are still determined by expert consensus.[60,64,92,93] Consequently, in this review, absence of ITT resulted in modification of ranking and a lower rating of the study rather than exclusion.

The literature suggests vigorous and sustained interest in the application of peripheral or extremity MT for lower extremity conditions; the effectiveness of MT procedures, particularly in conjunction with rehabilitation (such as exercise therapy and advice) for some common lower extremity disorders, is cautiously supported by this review; questions of effectiveness, especially cost-effectiveness, need to be undertaken.[94-96]

This review cites earlier[1,2] but new or previously undetected MT studies for hip OA and disorders,[23,97-104] knee OA and disorders,[105-113] patellofemoral pain syndrome,[114-122] ankle sprain disorders,[69,123-135] plantar fasciitis and/or heel pain,[133,136-139] metatarsalgia,[140] Morton

Table 4. *A summary of research on the knee: case series*

Author	Diagnosis	Treatment/management	Reported outcome
Cliborne et al[110]	KOA n = 22 with KOA (mean age, 61 y) n = 17 normal and asymptomatic (age, 64 y) Does hip mobilization ↓ pain and ↑ ROM in KOA. What hip tests, etc + in both groups (Faber, hip ROM, Scour test, etc)	MT of hip 1 treatment, immediate posttest 1 group intragroup pre-post test Hip mobilization grades III and IV Maitland techniques	NPRS ↓ and all clinical tests less painful (except hip flexion) in mobilization group posttest; $P < .05$ All clinical tests more + in patients with KOA compared with normal asymptomatic and less painful in symptomatic posttest, except Faber
Currier et al[111]	KOA n = 60 (51-79 y) CPR study to determine patients with KOA who respond to hip mob and validity of tests to predict outcome. 5 variables: 1. Hip/groin pain or paresthesia 2. Anterior thigh pain 3. Knee flexion <122° 4. Hip internal rotation <17° 5. Pain with hip distraction	MT of hip + exercise 4 treatments Immediate and 48-h posttest. 1 group intragroup pre-post test Maitland mobilizations grade IV Maitland techniques	Global Rating of Change Scale ↑ 3.27 points (clinically meaningful) NPRS, WOMAC, PSFS posttest intragroup changes, all statistically and clinically meaningful; $P < .05$ CPR in symptomatic KOA If +2 CPRs 97% at 48-h follow-up (LR, 5.1) If +1 CPR 68% at 48 h Conclusion: CPR may improve examination and treatment of KOA.
Bozkurt et al[112]	Nonspecific diagnosis of lateral knee pain secondary to PTFJ as evaluated with specific radiographs and MRI including degenerative changes, effusion and local tendon pathology (biceps), and ligamentous pathology LCL n = 32 (38 knees) Mean age, 27.2 y	Manipulation of the proximal tibiofibular joint Strengthening and stretching of local muscles.	Follow-up at 12-36 mo (mean, 28 mo) after treatment protocol 28/38 knees reported complete resolution of symptoms at follow-up. No change in 5 patients Poor description of treatment protocol Conclusion: PTFJ pathologies should be kept in mind in the evaluation of patients with lateral knee pain. MRI examination provides useful information.
Brantingham et al[113]	Meniscus tear Confirmed with MRI in 4 patients n = 5 Case series study to determine the effectiveness of MT and exercises management on 5 patients with a clinical diagnosis of meniscus lesion Rx frequency ≤6	Diversified MT of the knee-Genu circumduction extension mobilization High-velocity, low-amplitude thrust—axial elongation thrust Exercises: isometric quadriceps setting, isotonic knee extension, and shallow eccentric bilateral squats. Case series	4/5 patients reported a reduction in VAS with an increase in knee ROM 1 patient reported worsening of symptoms LEFS improvement in 3 patients Orthopedic tests specific for meniscus lesions less painful 1-mo follow-up Conclusion: This case series reports on chiropractic treatment of meniscal injury using traditional diversified MT and rehabilitative exercise. Chiropractic care appeared helpful in 4 of 5 patients.
Iverson et al[122]	PFPS n = 50 Mean age, 24.5 y Prospective cohort predictive validity study to determine which patients with a diagnosis of PFPS have a positive and immediate response to lumbopelvic manipulation Rx frequency: 1 visit Each subject performed 3 typically pain producing functional activities and were immediately given a lumbopelvic manipulation. Treatment success was considered if there was a >50% reduction in pain levels on a global rating of change	Supine lumbopelvic manipulation to the symptomatic side	At baseline, NPRS was used to establish pain levels after each functional test Global rating of change pain questionnaire Procedure was considered successful in 22 (45%) of subjects Mean NPRS improvement in the success group was 80% ± 17%, Clinical prediction rule for success Side-to-side difference in internal rotation >14° Ankle dorsiflexion knee flexed >16° Navicular drop >3 mm No self-reported stiffness with sitting >20 min

(*continued on next page*)

Table 4. (*continued*)

Author	Diagnosis	Treatment/management	Reported outcome
			Squatting reported as most painful activity Conclusion: A CPR was developed to predict an immediate successful response to lumbopelvic manipulation in patients with PFPS. The most robust predictor of success to spinal manipulation being in patients with PFPS being a side-to-side difference in hip internal rotation ROM of >14°. The clinical prediction rule developed in this study may help clinicians identify patients with PFPS who will respond successfully to lumbopelvic manipulation.

CPR, Clinical Prediction Rule; *KOA*, knee OA; *LCL*, lateral collateral ligament; *LEFS*, Lower Extremity Functional Scale; *MRI*, magnetic resonance imaging; *NPRS*, Numerical Pain Rating Scale; *PFPS*, patellofemoral pain syndrome; *PSFS*, Patient Specific Function Scale; *PTFJ*, proximal tibiofibular pathology; *Rx*, prescription or prescribed treatment.

metatarsalgia/neuroma,[141,142] hallux rigidus/limitus,[69,143-145] and hallux valgus.[146,147] A new and expanding category has been added in this review: (*a*) decreased proprioception, balance, and function from foot and/or ankle injury or from decreased range of motion (ROM), myofascial, and/or joint dysfunction and injuries.[126-128,148-150] These investigations included single-group pretest-posttest studies, case series, and reports for assessing hip MT (with exercise) for hip OA, knee MT for hip OA, and the effect of hip MT for knee OA. Also reported on were ankle and/or foot MT for treatment of ankle equinus, metatarsalgia, Achilles tendonitis, plantar fasciitis, Morton metatarsalgia, and hallux manipulation and injection for treatment of hallux rigidus, foot and ankle MT for "cuboid syndrome" secondary to lateral ankle sprains, and other and various additional case reports demonstrating the momentum, growing interest, and publication in this area.

In effect, the present studies of MT for lower extremity disorders appear to parallel the results and overall beneficial outcomes per spinal research.[151,152] However, in an attempt to be clearer in regard to what is known and unknown and to increase accuracy in prognosis, split levels of evidence have been used for the first time. For example, in this study, MT for hip OA was given a level of B or fair evidence for MT combined with multimodal or exercise therapy in the short term and a level of C or limited evidence for MT combined with multimodal or exercise therapy in long-term treatment for hip OA. Although it will be useful to thoroughly investigate the most effective methods of manipulation/mobilization for each and every joint in the human body, at this point, based upon the combined level of evidence of the benefit of mobilization/manipulation for the axial and appendicular system as well as safety, one could tentatively posit that, in the presence of mechanical joint dysfunction and other applicable signs and symptoms, joint mobilization/manipulation appears to be universally indicated as a therapeutic trial, in combination with other reasonable evidence-influenced conservative approaches, for all joint conditions, particularly where joint hypomobility is suspected as contributory. Common indications for the use of a MT (characterized by various definitions such as joint dysfunction, subluxation, or as a result of decreased function particularly with associated stiffness and pain and/or per a clinical prediction rule) are (1) diagnosis of a painful neuromusculoskeletal joint disorder, (2) pain in or from palpation of bony joint surfaces, (3) pain in or from palpation of joint soft tissues, (4) decreased or altered range or quality of motion, (5) pain on stressing and/or overstressing/overprovoking (in any or all planes) a joint.[3,111-153]

When a single treatment (mobilization of the hallux for hallux rigidus) produces relief for months, it would seem reasonable that additional MT extremity treatments may give a longer period of relief, and as needed (occasional "maintenance"), treatment may, for some select patients, continue to give a higher level of relief.[143,152,153] Treatment dosage, use of "as-needed or maintenance care" to sustain higher benefits from the initial treatments, and related cost-effectiveness issues for MT for lower extremity disorders (as for spinal disorders) remain unresolved and issues that must be addressed in future research.[86,154-156]

Although DCs are highly trained in and most known for the application of HVLA thrusting techniques, the profession has also incorporated low-velocity, high- or low-amplitude mobilization techniques throughout the last century. This is well characterized by the myriad of mobilization techniques used within the profession and represented by these studies.[1,3,9,140,157,158] As noted, most MT applied to extremity disorders is delivered as multimodal therapy, blending exercise, soft tissue treatment, modalities,

Table 5. *A summary of research on the ankle: case series*

Author	Diagnosis	Treatment/management	Reported outcome
Dananberg et al[133]	Ankle equinus (decrease abnormal loss of ankle dorsiflexion ROM ↓ <10° from neutral) Give examples of secondary diagnoses associated with ankle equinus and helped in case series: a. plantar fasciitis b. acute chronic ankle sprain strain c. Achilles tendonitis d. neuroma e. metatarsalgia	MT + exercise (1 treatment manipulation and mobilization) n = 22 1 group immediate pre-post test 1. P-A HVLA manipulation to proximal fibular head 2. Traction (mob) of ankle/mortice in axial elongation followed by HVLA A-P talar thrust 3. Then active dorsi and plantarflexion ROM movement of ankle by patient	Gravity goniometer strapped on and used only by patient: active ROM, patient pulling strap under foot, etc. Mean ↑ ankle dorsiflexion ROM 4.9° (left), 5.5° (right) *t* tests at 99% confidence level; $P < .001$ Reports soreness in some ≤2 d but none later States better than stretch alone
Dananberg[69]	Ankle equinus With: 1. Inversion sprain, chronic (and had big toe pain too) 2. Kohlers (osteochodrosis of the navicular with pain) 3. Hallux limitus (first MTPJ stiffness and pain) All patients had ankle equinus + additional diagnosis.	MT combined with various treatments per condition: RICE, taping, exercise (inversion sprain), casting (Kohlers) orthotics (hallux limitus) n = 3 1. P-A HVLA manipulation to proximal fibular head 2. Traction (mob) of ankle/mortice in axial elongation followed by HVLA A-P talar thrust 3. Manipulation of the first metatarsocuneiform joint for first MTPJ for big toe pain.	3-wk follow-up for all. Descriptive outcomes. Ankle sprain (and big toe pain) 1 treatment resolved condition. ↑ ROM Kohler 's disease—a few treatments: quickly resolved navicular pain. Antalgia resolved. Hallux limitus. A few treatments ↓ pain ↑ ROM of big toe.
Jennings and Davies[70]	Cuboid syndrome: unresolved lateral ankle/cuboid pain n = 7; mean age, 21.1 y a. Second to inversion ankle sprain All college athletes and/or sports injuries	MT—HVLA "cuboid-whip" manipulation Different patients received various different additional treatments: tape, stretching, orthotics, cuboid pad, and modalities. 5 patients had 1 manipulation 2 patients had 2 manipulations	VAS before and after (pre average VAS, 2.85, and posttreatment VAS, 0) Improvements post-Tx: also in ↓ cuboid tenderness, MTJ mobility, antalgic gait, and in ability to do single hop

or multiple extremity joint and/or combined spinal and extremity joint MT (treatment of the kinetic chain), either condition and/or patient specific.[1,21,73,101,102,155,156] In fact, it would appear that MT with stretch may be superior to either therapy alone in common extremity disorders for increasing ROM.[21,27,159,160]

Limitations

One limitation that is clear from this study is that most lower extremity MT studies assess only short-term treatment outcomes for 3 months or less. This is because most clinical studies are designed/powered to reach the point where a clinically significant difference might first be detected and are not funded generally, to evaluate the maximum period or extent of the benefit. However, more intermediate extremity studies less than 6 months are beginning to be conducted, but long-term studies greater than 6 months are still rare.[21,23,94] As a result, strong assertions about intermediate or long-term outcomes must not be made; however, this is not different from most medical care or usual care, no matter the provider. Thus, there is a need to carry out more, larger, long-term, and methodologically stronger MT trials that also include a cost-effectiveness component.[60,161,162] Another limitation of this systematic review is that, as with all systematic reviews, some studies may have potentially been missed or were omitted for a priori reasons. For example, a study would have been missed if it did not contain the included search terms or key words or was simply not contained within the applicable/normative databases. Studies without a peripheral diagnosis (eg, measuring ROM), RCTs using immediate rehabilitative postsurgical MT of an extremity, conference proceedings, red flag conditions, or conditions that required referral were excluded.[1,163,164] Unfortunately, this means that interesting and informative studies such as an RCT of osteopathic manipulative treatment immediately after knee and/or hip arthroplasty and an RCT of chiropractic MT just before hip arthroplasty manipulative management of foot pain due to an os peroneum and accessory navicular, spinal MT for a hamstring injury (without clear peripheral injury and diagnosis) and chiropractic management of injuries sustained during Brazilian capoeira (art that fuses dance, sport, and martial arts) were unfortunately not included.[71,125-167] Arguably, the RCT of Thorman et al[167] demonstrating statistically significant pain relief and functional improvement for patients with hip OA awaiting arthroplasty and information and data from other studies should have been

Table 6. *A summary of research on the ankle and foot: case series*

Solan et al[144]	Hallux rigidus grades I-III (refers to x-ray findings) n = 37 Mean age, 52.3 y 2 lost to FU 1-y FU, 29 available	1 manipulation under anesthesia with steroid injection of the first MTPJ. 1 manipulation of hallux (manipulative technique not fully described) 1-y FU. No additional treatment: additional manipulation, exercise, stretch, medication, etc.	*Relief* was defined as period free of symptoms, pain and stiffness on walking/using foot and in activities of daily living/function and or making a decision to have surgery. Grade I, 6 mo of relief Grade II, 3 mo of relief Grade III, minimal to no relief. 12 grade I, 4 went to surgery 18 grade II, 12 went to surgery 5 grade 3, all 3 went to surgery Conclusion: manipulation is acceptable for grade I, limited for grade II, and not indicated for grade III.
Whitman et al[134]	Prospective cohort study Inversion lateral ankle sprain n = 85 Mean age, 32 y 2 Rx sessions	Treatment session 1 Thrust manipulation of the rear foot and proximal P-A tibiofibular Nonthrust manipulation A-P talocrural, lateral glide/eversion rear foot technique, and distal tibiofibular technique ROM exercises Treatment session 2 Same techniques at discretion of therapist if there was nonsuccess as perceived by the participant after the first treatment session SGPPD	Outcome variables NPRS (4 at baseline to 1.2) FAAM (33.7-62.1) LEFS (476-676) GROC Participants were deemed as a success to therapy if on the GROC, they rated their recovery as "a very great deal better" or "great deal better" Total success, n = 64 Conclusion: The authors have developed a clinical prediction rule to identify patients with a status of postinversion ankle sprain most likely to benefit rapidly and dramatically from manual therapy and general exercise. All patients reported improvement in their NPRS when compared with baseline, ROM, and subjective patient self-reported functional status Conclusion: A manual physical therapy emonstrated complete pain relief and return to full activities in 4 patients.
Young et al[139]	Plantar heel pain, plantar fasciitis n = 4 Rx frequency, average 2-7 sessions over 8-49 d	Manual physical therapy including talocrural, subtalar mobilization and manipulation, stretches of the gastronomies, soleus muscle, and plantar fascia 1 patient received additional strengthening exercises 2 patients received custom orthotics	
Wyatt[71]	Plantar fasciitis (recalcitrant lateral plantar pain, after fasciotomy—referred by podiatric surgeon for chiropractic after full postsurgical healing and 4-6 weeks of NSAIDS, shoe padding, and rest) 15 patients Mean age, 46.4 y None lost to FU	MT + multimodal a. Manipulation and mobilization of the ankle and foot (including HVLA plantar to dorsal "snap or whip" manipulation). b. Exercise and change or ↓ activity c. 1 Tx/wk for 2-8 visits over 2-8 wk.	Verbal Rating Scale (0-100) Most experienced quick relief 11 experienced significant or 90% relief on Verbal Rating Scale 3 moderate relief (50%-90%) 1 no change 9 had minor side effects to MT, which resolved.

included.[149,150] Future reviewers may want to consider including these studies and immediate or presurgical and/or postsurgical rehabilitative MT management.

Future Research

Further research is needed to include larger trials with improved methodology. Funding is needed for RCTs as

Table 7. *A summary of research on the hip/foot: case reports*

Author	Diagnosis	Treatment/management	Reported outcome
Whipple et al[103]	1. Acetabular anterosuperior labral tear 2. Instability (↑ ext. rot.) 3. Nonspecific hip pain Patient: 14-year-old ballet dancer with symptoms for 1 mo A. overstretch. B. weight-bearing flexed/extended twist of hip dancing C. painful click with abduction	MT 1 treatment 1. Cyriax technique (variation on technique for loose bodies): a. Axial elongation traction of the hip with b. 5 mobilizations from 30°-75° abduction	Began VAS 7/10 with pain abducting when dancing. After treatment, VAS 0/10 with abduction a. no pain on scour test b. ↑ external rotation persisted 1-wk follow-up, no symptoms 6-mo follow-up—1 incidence of "giving way"; otherwise, no symptoms 1 visit
Pollard et al[104]	1. Acetabular anterosuperior labral tear (arthroscopically confirmed) 2 patients 1. 45-year-old woman, prolonged housecleaning 3 wk earlier (with 10 y of chronic mechanical LBP). 2. 15-year-old swimmer with 3 wk of knee and groin pain	MT and mobilization (using multimodal and "MIMG" protocol, see article) Patient 1, 10 visits/2 mo Patient 2, 14 visits/2 1/2 mo a. hip long-axis traction with HVLA variations b. other hip manipulations and mobilizations c. PNF, exercise, SMT, knee MT, and activity modifications	Patient 1, ↓ hip pain 70%. Some pain with weight bearing and rotation of hip ↓ CMLBP 80%-90% Patient 2, initially ↓ hip pain 30%, at 3- and 6-mo follow-up, 0% (no) hip pain. Painless click Hip ROM still partially ↓ Surgical consult—but surgeon recommends against at this time. 10-14 visits
Costa and Dyson et al[138]	Plantar fasciitis Patient: 15-year-old girl. Soccer injury…knee, and groin pain. Symptoms for 1 y even after treated by GP and podiatrist, minimal help.	MT + multimodal therapy: a. manipulation and mobilization b. iontophoresis (acetic acid), orthotics, ice, tape, myofascial, exercise, stretch, and activity changes and therapy, etc. 3×/wk for 2 wk the 2×/wk for 2 wk or 10 total treatments	Treatment began VAS 7/10 morning pain and 4/10 usual pain all day After 6 weeks of treatment, resolution of symptoms 0/10 10 visits
Brantingham et al[145]	Hallux rigidus (grade I) 1 patient 31-year-old male professional golfer Big toe pain and stiffness for 7 mo.	MT + multimodal therapy: (all grades I-V) a. Hallux b. ankle/foot c. sesamoid mobilization and manipulation d. exercise therapy and stretching e. ultrasound Quick relief after a few Txs 17 visits/10 mo	NPRS 6/10 Lower extremity functional index, 22% (0-100, 100 worst) Hallux dorsiflexion ROM, 45° Final visit NPRS 1-2/10 Lower extremity functional index, 2% Hallux dorsiflexion ROM 84°
Cashley[142]	Plantar digital neuritis (Morton metatarsalgia) aka Morton neuroma 2 patients Patient 1, 25 years old; symptoms 3 mo after soccer. Patient 2, 63 years old; 1-y symptoms, steroid injections/orthotics with minimal relief.	MT Patient 1, 4 Txs plantarflexion HVLA manipulation at the MTPJs Patient 2, 3 Txs over 6 wk	Descriptive Patient 1 pain free by 4 wk. Follow-up at 14 mo, still pain and symptom free Patient 2, pain free after 3 treatments. Follow-up at 8 mo, still pain and symptom free

GP, general practitioner; *LBP*, low back pain; *PNF*, proprioreceptive neuromuscular facilitation; *SMT*, spinal manipulative therapy.

well as observational, clinical, and basic science research, case series, and reports. Interdisciplinary collaboration should certainly be encouraged and supported as well. Finally, the overarching observation, borne out of this body of research, of similarity of indications for and beneficial effect/responsiveness of patients to manipulative therapies for joint conditions throughout the human body[135] merits greater recognition and further support across professional, health delivery, research, and policy stakeholders.

Conclusion

There is a level of B (fair evidence) for MT combined with multimodal or exercise therapy for short-term treatment of hip OA and a level of C (limited evidence) for MT combined with multimodal or exercise therapy for long-term treatment of hip OA. There is a level of B for MT of the knee and/or full kinetic chain and of the ankle and/or foot, combined with multimodal or exercise therapy for short-term treatment of knee OA, patellofemoral pain

syndrome, and ankle inversion sprain and a level of C for MT of the knee and/or full kinetic chain and of the ankle and/or foot, combined with multimodal or exercise therapy for long-term treatment of knee OA, patellofemoral pain syndrome, and ankle inversion sprain. There is also a level of B for MT of the ankle and/or foot combined with multimodal or exercise therapy for short-term treatment of plantar fasciitis but a level of C for MT of the ankle and/or foot combined with multimodal or exercise therapy for short-term treatment of metatarsalgia and hallux limitus/rigidus and (for a new category) for loss of foot and/or ankle proprioception and balance. Finally, there is also a level of I (insufficient evidence) for MT of the ankle and/or foot combined with multimodal or exercise therapy for hallux abducto valgus.

Practical Applications

- The purpose of this study is to expand upon a systematic review, documenting the quality, quantity, and type of research conducted on MT for lower extremity conditions.
- In addition to the previous citations used in a 2009 systematic review, an additional 399 citations were accessed.
- Level of evidence was found to range from B to I for the hip through the foot.

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