Manipulative Therapy for Lower Extremity Conditions: Expansion of Literature Review

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Abstract

Objective: The purpose of this study was to conduct a systematic review on manipulative therapy for lower extremity conditions and expand on a previously published literature review.

Methods: The Scientific Commission of the Council on Chiropractic Guidelines and Practice Parameters (CCGPP) was charged with developing literature syntheses, organized by anatomical region, to evaluate and report on the evidence base for chiropractic care. This article is the outcome of this charge. As part of the CCGPP process, preliminary drafts of these articles were posted on the CCGPP Web site www.ccgpp.org (2006-8) to allow for an open process and the broadest possible mechanism for stakeholder input. The Cumulative Index to Nursing and Allied Health Literature; PubMed; Manual, Alternative, and Natural Therapy Index System; Science Direct; and Index to Chiropractic Literature were searched from December 2006 to February 2008. Search terms included *chiropractic*, *osteopathic*, *orthopedic*, or *physical therapy* and MeSH terms for each region. Inclusion criteria required a diagnosis and manipulative therapy (mobilization and manipulation grades I-V) with or without adjunctive care. Exclusion criteria were pain referred from spinal sites (without diagnosis), referral for surgery, and conditions contraindicated for manipulative therapy. Clinical trials were assessed using a modified Scottish Intercollegiate Guidelines Network ranking system.

Results: Of the total 389 citations captured, 39 were determined to be relevant. There is a level of C or limited evidence for manipulative therapy combined with multimodal or exercise therapy for hip osteoarthritis. There is a level of B or fair evidence for manipulative therapy of the knee and/or full kinetic chain, and of the ankle and/or foot, combined with multimodal or exercise therapy for knee osteoarthritis, patellofemoral pain syndrome, and ankle inversion sprain. There is also a level of C or limited evidence for manipulative therapy of the ankle and/or foot combined with multimodal or exercise therapy for plantar fasciitis, metatarsalgia, and hallux limitus/rigidus. There is also a level of I or insufficient evidence for manipulative therapy of the ankle and/or foot combined with multimodal or exercise therapy for hallux abducto valgus.

Conclusions: There are a growing number of peer-reviewed studies of manipulative therapy for lower extremity disorders. (J Manipulative Physiol Ther 2009;32:53-71)

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

In 2006, Hoskins et al[1] published the first extensive review of chiropractic treatment of lower extremity conditions. Building upon these efforts and using similar methodology and structure, the present study represents an expanded and updated systematic review. While acknowledging the earlier study, the conclusions in this article are solely those of

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the included Council on Chiropractic Guidelines and Practice Parameters (CCGPP) subcommittee authors.[1]

In the Hoskins et al review, *chiropractic treatment* was operationally defined as some form, technique, or procedure using applied manipulative therapy (manipulation, mobilization, and/or other manual or functional procedures) with and without adjunctive treatment. For the purposes of this updated and expanded literature review, *chiropractic* has been replaced by the term *manipulative therapy* to facilitate inclusion of all literature from accessible peer-reviewed sources.[2] Although the public generally associates chiropractic primarily with the treatment of back pain, only a minority of practitioners perceive themselves solely as spine specialists.[3] The data demonstrate that most chiropractors, based upon their professional training, routinely diagnose and treat extremity conditions. It is of importance to the chiropractic profession to elevate the awareness of the general public, government, third-party payers, as well as other stakeholders regarding the training and competency of chiropractors to care for extremity conditions. Although chiropractors can easily document the use of *manipulative therapy* (with and without adjunctive treatment) for lower extremity neuromusculoskeletal problems and disorders for 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 axial and appendicular neuromusculoskeletal system.[1,4-9] Depending upon the source, upper and lower extremity problems have been reported to account for up to 20% of all of chiropractic care, with lower extremity pain and injury specifically accounting for up to 10% of common chiropractic practice and with most practitioners using extremity manipulative therapy based upon location, methodology, training, and philosophy.[3,4,10-15] This contrasts to treatment of nonmusculoskeletal conditions such as chest, abdominal pain, and wellness (5.3%, 3.7%, and 8.0%, respectively).[3,4] 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.[3] Indeed, chiropractic academic curriculums are 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] Certainly, based upon academic training, the current chiropractic graduate is well qualified to manage disorders.

Further exemplifying the chiropractic profession's contribution as the forerunner to extremity care, in a recent 2004 trial of high-velocity, low-amplitude (HVLA) axial elongation thrust manipulation of the hip conducted to determine efficacy in treatment of hip osteoarthritis (including grade 4 radiographic degeneration with severe pain and stiffness), HVLA manipulative therapy was superior to a hip exercise protocol.[16,17] This trial used the most common, and possibly oldest, chiropractic manipulative procedure used for hip disorders and osteoarthritis over the last century, further supporting previous, preliminary studies and reports completed on and before 2004.[18-21] This trial suggests 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 for whom exercise alone is not effective.[22-29] Although publications on manipulative therapy in the treatment of peripheral disorders have recently exploded, much more study is required.[1,30-33] 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 disciplines to work collaboratively in the search for improved clinical methods for the treatment of patients with lower extremity conditions.[16,21,34,35]

In the presence of a rapidly expanding number of research studies as well as growing attention on the usefulness, utilization, and treatment of peripheral disorders through manipulative therapy, the authors believed that it would be helpful to broadly revisit this topic. The purpose of this study is to review the quantity, quality, and types of lower extremity manipulative therapy research published and to rank, grade, and present the characteristics, thus providing a more general, complete, and updated review.[1,33,36]

Methods

In conjunction with the CCGPP and with input from included authors, an expanded update of the Hoskins et al[1] 2006 review was undertaken with a search of the literature conducted using the Cumulative Index to Nursing and Allied Health Literature; PubMed; Manual, Alternative, and Natural Therapy Index System; Science Direct; and Index to Chiropractic Literature from December 2006 to February 2008. Limits were set to English language, with abstract, and human studies. 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, these included *hip injuries*, *hip dislocation*, and *hip joint*. For the knee, these included the terms *knee dislocation*, *knee injuries*, *knee joint*, *collateral*, *meniscus*, and *patellofemoral*. For the ankle, these included *ankle injuries*, *tarsal bones*, and *ankle joint lateral ligament*. For the foot, the terms were *foot bones*, *foot injuries*, *foot joint*, and *interphalangeal*. Finally, for the ankle, the terms were *ankle injuries*, *tarsal bones*, and *ankle joint lateral ligament*. In addition to the literature previously reviewed,[1] a further 389 citations were captured from the 4 regions searched: 33 hip, 86 knee, 249 ankle, and 21 foot, respectively.

After the abstracts were reviewed, the literature was placed into 3 broad categories. Category 1 included randomized controlled or clinical trials (RCTs) with manipulative therapy (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) randomized controlled trials (RCT) that indicate these studies were *placebo* controlled; (2) randomized clinical trials (RCT^) that denote a comparative study (treatment vs treatment; usually with evidence superior to placebo); (3) controlled or clinical trials (CTs) that are generally pseudo- or nonrandomized (with systematic assignment or purposive allocation) containing a range of controlled variables, diagnosis, manipulative therapy vs placebo, comparative treatment, or both; and (4) studies that are prospective and measurable and that generally include valid and reliable outcome measures with appropriate statistical analyses.

Category 2 included case series (≥3 patients per study). For case series, the co-chairs of the CCGPP Scientific Commission developed a checklist modified from other instruments. Category 3 included case studies (≤2 patients), but studies not included in the previous review. Inclusion criteria required diagnosis and some variety or mode of manipulative therapy. Articles were excluded when (1) pain was referred from spinal sites (without 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 to manipulative therapy (rheumatoid arthritis, fracture, ligament tear with instability, etc), (4) a red-flag diagnosis was identified, or (5) there was a diagnosis absent a description of management or intervention. In the current review, osteopathic, physical therapy, and other types of medical literature were 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.

Abstraction of data was completed by 3 independent authors using predetermined criteria. Articles were retrieved as hard copy, PDF, or electronic format from the Cleveland Chiropractic College library or from associated library collections. All relevant clinical trials were assessed, reviewed, and ranked using a modified adaptation of the Scottish Intercollegiate Guidelines Network (SIGN) ranking system (instead of the Physiotherapy Evidence Database or "PEDro" scale used in the previous review).[37-40] General use of SIGN is in conformity to CCGPP systematic reviews. When documenting treatment, standardized terminology was used; therefore, the term *manipulative therapy* indicated any of the following: (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 manipulative therapy procedures.[2,41-43]

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

One methodological difference between this and the Hoskins et al 2006 review grew out of CCGPP concerns with the disproportionately inflexible weighting structure represented by singular SIGN components that makes the application to burgeoning areas of historically, weakly supported research, such as 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, with any noncomputerized randomization completely rejected. The literature supports the appropriateness of the *restricted* use of manual and mechanical randomization methods, particularly in small samples.[44-47] In addition, SIGN's overemphasis and weighting of a few scale components, excluding all other methodological considerations, are inconsistent with other validated, widely accepted systems such as JADAD or PEDro where randomization and intention to treat analyses (ITAs) are considered as *one* of a number of important methodological concerns, assigning decreased weight, depressing, not rejecting, overall trial quality.[47,48]

In accordance with these above-stated concerns, controlled and clinical trials were ranked using a modified Liddle et al[39] revision of the SIGN scale.[1,37,38] Whereas the SIGN RCT checklist rates studies as high quality (+), low quality (−), or neutral (n), the *modified* Liddle et al SIGN scale (Fig 1) 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 and with high risk for bias.[37,38]

The SIGN revisions of Liddle et al have undergone rigorous development and validation procedures, part of a hierarchy of studies widely accepted as reliable.[39,40] 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.[38-40]

Some of the trials cited in this expanded review (principally smaller studies) used earlier, noncomputerized randomization procedures then in wide use by various researchers at institutions such as Durban University of Technology in Durban, South Africa, and the University of Surrey in Guilford, England, where much of the pioneering work in lower extremity manipulation research originated. These randomization procedures were accomplished using equal numbers of obscured and folded sheets of paper (eg, 15 or 30 marked A, 15 or 30 marked B), thoroughly mixed to ensure discontinuity, placed in and blindly extracted from a container. At each subject randomization time point, containers were held such that all folded slips were

Fig 1. *SIGN checklist rating (Liddle et al).*[37-39]

Rating	Explanation
++	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

Fig 2. *Summary of grading of strength of evidence.*[66,67]

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

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

Grade C: limited evidence from studies/reviews.
- Studies with substantial uncertainty due to design flaws or adequacy of sample size.
- Limited number of studies; weak design for answering the question addressed.

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

masked; and a slip was drawn out randomly allocating treatment. This older procedure, long used in medicine before accessible, affordable computerized randomization, remains acceptable for samples of N less than or equal to 60 ($n \leq 30$ per group).[44-46] Consequently, this review's use of a modified SIGN ranking means manual and mechanical randomization procedures were given decreased methodological weight, indicating lesser quality, but not rejected.[47,48]

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 this has been determined to be neither economically feasible, practical, scientific, nor ethical.[46] With these considerations in mind, this study includes nonrandomized, systematically assigned, controlled or clinical trials (CT) as well as the addition of unlisted or new case series and studies excluded by previous criteria and added in ranked and updated case series and studies sections. In addition, studies using systematic assignment, no longer considered validly randomized, have been included in this review because they frequently used or contain significant innovative methodological controls, concepts, and insights. Such studies, evaluated by the authors as equal to retrospective case series, have been previously treated as if they constitute no evidence at all, discarded as worthless; and incorrectly excluded from the evidence-based hierarchy.[37,44-49]

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 (PP) or ITA as well as disagreement and lack of consensus or standards regarding blinding and blind assessment, there are sufficient justification and rational for inclusion of these RCTs and CTs.[1,16,32,50-61]

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 ITA. However, the retrospective requirement of ITA levied on all previous studies can discount evidence that should be considered on some level of the hierarchical ladder.[46,56,57] Furthermore, in many studies with ITA, it is evident that many authors have serious objections to ITA being a sole arbiter of a valid or legitimate trial (SIGN rejects studies that do not use ITA).[62-65] Hollis and Campbell[62] point out that 52% of medical trials fail or do a poor or an inadequate job with ITA. In a recent systematic review of 249 trials, Gravel et al[63] pointed out that randomization was used only 77% of the time and ITA only 23% of the time, with ITA in general done poorly or incorrectly, or unclearly explained. Porta et al[64] caution that ITA or PP analysis is flawed to such an extent that it is inappropriate to base conclusions of a controlled trial on single report of either ITA or the PP approach alone. Baron et al[65] found that, out of 54 trials, full ITA analysis was done correctly in these studies only 7.4% of the time. For this reason, like randomization, it is important to use a ranking methodology that balances rigor with reason to yield the best evidence possible from the literature. Therefore, in this review, the absence of ITA results in a lower study rating. Furthermore, if essentially all subjects that began the trial complete the trial, ITA was rated as adequate.[46,62-65]

The initial step of using the modified Liddle et al SIGN 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*

Table 1. *Evidence table of manipulative therapy for lower extremity disorders*

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
Hip								
Hoeksma et al[16]	RCT^ (see § below)	Hip osteoarthritis	N = 109	HVLA axial elongation hip manipulation with stretch vs exercise	9 Txs/5 wk	Significant in favor of man therapy: primary, 2nd outcome measures (Likert scale): self report % improvement, and Harris hip score, VAS, ROM	Adequate power, adequate blinding	++
			Age, 60-85 y Mean age, 71.5 y		5 wk 17 wk 29 wk FU	No serious but minor ↑ adverse effects: 3 left man group, 2 exercise	Int to tx covered	
Brantingham et al[21]	CT¥ systematic assignment randomized 1st patient (then A, B, etc) Blind assessor/ 1 unblinded	Hip osteoarthritis	N = 8 Average age, 69.8y	HVLA axial elongation and other manipulations and mob of hip joint vs placebo	6 Txs/3 wk 7 wk 1 wk FU 2 Withdrew (N = 10)	Significant effect size for man ther: WOMAC, NRS vs placebo ROM, Fabere unchanged in tx group No adverse effects. 1 excluded, got PT. 1 sham left—pain to high	Cohen *d* Large effect size changes	+
Level of evidence for manipulative therapy for hip osteoarthritis		Average no. of txs: 7.5 over 3-5 wk Range, 6 to 9 (2 trials)				1 High-quality trial, 1 low-quality trial	Grade of evidence: C (man ther of the hip combined with multimodal or exercise therapy)	
Knee								
Deyle et al[54]	RCT	Knee osteoarthritis	N = 83 Mean age, 61 y	Manipulative therapy of knee and full kinetic chain SI-foot vs placebo = nontherapeutic ultrasound Knee man: mob knee ↑ flex, ext, patellar mob (gradually up to 4++ or thrust)	8 Txs/4 wk 4 wk 8 wk 1 y	Significant in favor of man therapy: 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 Int to tx covered	++
Deyle et al[71]	RCT^	Knee osteoarthritis	N = 134 Mean age, 63 y	Man therapy of knee and full kinetic chain-SI to foot vs home exercise Knee man: mob knee ↑ flex, ext, patellar mob	8 Txs/4 wk 4 wk 8 wk 1 y	Significant in favor of man therapy at 4, 8 wk with WOMAC 52% to exercise 26%. 1-year FU both significantly improved but man ↑ satisfaction, ↓ meds	Adequate power Int to tx well covered	++

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
				(gradually up to 4++ or thrust)				
Tucker et al[72]	RCT^	Knee osteoarthritis	N = 63	CMT to the knee (HVLA) vs meloxicam 1×/d for 3 wk	8 Txs/3 wk	No difference between txs	No patients left man ther group	+
	Assessor not blind		Mean age, 59.3 y	Knee man: long axis, A-P, P-A and patellar mob NSAID previously superior to placebo		Significant improvement both: NRS, VAS, PSFS. 3 left trial: NSAID adverse effects: nausea, diarrhea, allergic		
Moss et al[29]	RCT	Knee osteoarthritis	N = 38	Supine A-P mobilization of tibia on femur within subjects repeated measures vs placebo (holding position) vs no contact	1 Tx	Significant ↓ in pain (=↑ in algometry) and ↑ speed in "up and go" (from chair)	Adequate power	+
	Allocated to 3 txs		Adults ≥40		Immediate postintervention		Adequate blinding	
	Assessor, patients blind				No drop outs		Int to tx adequate	
Bennell et al[28]	RCT	Knee osteoarthritis	N = 140	PT program: knee taping, exercise, ST, *thoracic spine mobilization* vs placebo	PT and placebo tx:	No significant difference between groups	Power adequate	+
	Double blind		Age, 68.6 y		8 Txs 1×/wk for 4 wk then 1×/ 2 wk for 8 wk (8 txs)	Significant outcome for PT at 24 wk for VAS pain, global improvement (2 areas) out of 12 assessments (VAS pain and activity, WOMAC, KPS, SF-36, *AQoL*, quad strength, step test)	In to tx good Poor design and internal validity: *thoracic spine manipulation?* Nonstandard No man therapy for knee/LE	
					13 dropped out PT (2 side effects others various reasons) 2 in placebo			
Level of evidence for manipulative therapy for knee osteoarthritis		Average no. of txs: 6.25 (range, 1-8 txs) over 4 wk (range, 1 tx to 8 wk; 2 with 1-y FU)				2 High-quality trials, 3 mod-quality trials	Grade of evidence: B (man ther of the knee and/or full kinetic chain combined with multimodal or exercise therapy)	
Hillerman et al[75]	CT Allocation by presentation: PFPS, or PFPS + SI joint dysfnx	PFPS and quadriceps inhibition/ weakness	N = 20 Age, 18-40 y = PFPS with and without SI	SI manipulation vs knee axial elongation manipulation	1 Tx Immediate FU No loss of patients.	Significant ↑ in intragroup knee extensor strength by Cybex after SI manipulation	Int to tx adequate	−

Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
Drover et al[76]	CT Not randomized Focus: effect on knee extensors	PFPS (AKPS)	N = 9 Mean age, 25.7 y	ART technique for knee vs testing normal contra lateral leg	1 Tx Immediate FU No loss of patients	No Significant change for all measures: 1. Knee extension strength Biodex. 2. mm inhibition: interpolated twitch torque technique	Int to tx adequate	−
Crossley et al[53]	RCT Double blind	PFPS	N = 71 Age ≤40 y	PT (patellar mobilization tape, exercise, stretch, soft tissue) vs placebo (detuned ultrasound, tape, gel)	6 Txs over 6 wk 6 wk 3-mo FU PT group 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 Int to tx reported	++
Suter et al[77]	RCT Double blind	PFPS (AKPS)	N = 25 Mean age, 34 y	HVLA sacroiliac manipulation only for PFPS vs control–no adjustment Both measured for muscle inhibition , EMG and mm strength in quadriceps	1 Tx Immediate post tx follow-up No loss of patients	Pre tx baseline Significant decrease in MI by 7.5% using interpolated twitch torque technique Nonsignificant ↑ in quad mm strength Cybex and EMG	Int to tx adequate SI relieves PFPS knee pain	++
Rowlands and Brantingham[78]	RCT Single blind	PFPS	N = 30 Ave age, >18 y Some dropouts; not noted	Mob of patella vs placebo (detuned ultrasound)	8 Txs/4 wk 1-mo FU 2-mo study	Significant in favor of mob: ↓ pain with algometry and ↓ pain with McGill vs placebo	McGill % intergroup change very large mob vs placebo >80% power; (McGill correlates well 0-100 scales). Algometry <power	+
Stakes et al[79]	RCT^ Single blind (see § below)	PFPS	N = 60 Mean age, 30.5 y	Patellar mob vs patellar mob and HVLA sacroiliac or L/S adjustment	6 Txs over 4 wk 8 dropouts: 2 per group transport problems. No adverse effects. 2 per group lost to follow-up. Subjects replaced.	No difference between groups. Power not calculated; inter-group statistics must be viewed with caution. Significant intragroup change for both groups: NRS, PFJE, SFMPQ, PSFS, and algometry	For both groups, magnitude of changes in NRS and PFJE scales % -appear statistically and clinically meaningful.	+

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Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
Taylor and Brantingham[80]	RCT (see § below)	PFPS	N = 12	Patellar mob vs patellar mob + home exercise	8 Txs over 4 wk	Descriptive statistics suggest both txs helpful.	Int to tx adequate	+
	Blind assessor No unblinding		Mean age, 30.17 y		1-wk follow-up. 5 wk No adverse effects All patients finished tx.	Nonparametric intragroup significant for NRS, SFMPQ, ALG, and PSFS		
Level of evidence for manipulative therapy for patellofemoral pain syndrome (aka anterior knee pain syndrome)		Average no. txs: 4.43 txs (2 trials 6 txs, 2-8 txs; range 1-8 txs) over 4-8 wk (range 1 tx to 3-mo FU).				2 High-quality, 2 moderate, 2 low-quality trials	Grade of evidence: B (man ther of the knee and/or full kinetic chain combined with multimodal or exercise therapy)	
Ankle								
Pellow and Brantingham[81]	RCT	Ankle sprain	N = 30	Manipulation ankle axial elongation (HVLA) vs detuned ultrasound (placebo)	8 Txs (or til sx free)/4 wk 1-mo FU	Significant for man ther for SFMPQ, functional improvement, at 8th tx, and for SFMPQ, functional, ROM 1-mo FU vs placebo	Power adequate for intragroup No intention to treat	+
	Single blind	Subacute and chronic Grade I and II >5 d	Mean age, 24.9 y		2 mo			
Green et al[55]	RCT^	Ankle sprain	N = 41	RICE and tape and A-P talus mob vs control (RICE and tape)	≤6 Txs/2 wk	Significant for man ther for ↑ ROM, ↓ pain, ↑ gait.	Adequate blinding	+
	Blind assessor	Acute (72 h)	Mean age, 25.5 y		No adverse effects. No dropouts.	Faster recovery, activity with mob	Intention to tx adequate	
Coetzer et al[82]	RCT^ §	Ankle sprain	N = 30	Both groups received (for ethical and methodological reasons) standard care = RICE.	6 Txs/2 wk with 1-mo FU	No significant difference between groups except 6th tx ↑ ROM in favor man ther; and blind assessor detected ↓ restricted motion in joints in man ther group at FU.	Power generally low	+
	Retrospective 2nd author: appropriate randomization, adequately described in article. (see § Coetzer et al 2001)	Acute ≤24 h		Man ther: HVLA ankle manipulation-axial elongation and subtalar joint eversion vs NSAID (piroxicam)	NSAIDS	All groups had significant intragroup improvement: ALG (↓ pain), goniometer (↑ ROM), NRS (↓ pain), athletic limitation ↑ function) and SFMPQ (↓ pain)	Otherwise, essentially equal effects	
	Blind assessor for motion palpation				40 mg 2 d, 20 mg 5 d With 1-mo FU			

Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
Eisenhart et al[32]	RCT^	Ankle Sprain	N = 55	Standard care (RICE + NSAIDS) vs	1 Tx pre and post measures in ER. 1-wk FU	Significant for man ther post 1st tx for ↓ swelling, ↓ VAS.	Int to tx performed	+
	Single blind	Acute grade I and II <24 h	Mean age, 30.5 y, >18	standard care + osteopathic manipulative therapy (combination of HVLA, functional and ST	Loss of patients n = 15	1-wk FU: significant for man ther ↑ ROM dorsiflexion		
Collins et al[83]	RCT	Ankle sprain	N = 16	Mobilization with movement vs placebo	1 Tx pre and post	Man ther significant for ROM ↑ dorsiflexion	2 left trial, 1 had increased pain.	+
	Double blind	Subacute grade II	Mean age, 28.5 y	(sham) or control (holding position only)	All txs Dropouts discussed 2 left trial, 1 ↑ pain.	No change in PPT (algometry) or TPT (thermal pressure threshold)	Int to tx not reported	
Vicenzino et al[84]	RCT	Ankle sprain	N = 16	1. MWM wt bearing post talar glide (PTG) and dorsiflexion ROM (DF)	1 Tx	Significant for man ther ↑ PTG° and DF° weight bearing and non-wb MWM	Int to tx adequate	++
	Random to 3 txs Double blind	Chronic recurrent <20 mm dorsiflexion in injured ankle inclusion	Mean age, 19.8 y	2. Ditto but non–wt bearing 3. Control–position held	Immediate post tx FU No loss of patients	Large effect sizes PTG, Mod effect ↑ dorsiflex vs control		
Lopez-Rodriguez et al[85]	RCT Single blind	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 Immediate post tx or post placebo No loss of patients	Significant for man ther ↑ in proprioception with stabilometry and baropodometry vs placebo	Int to tx adequate	+
Kohne et al[86]	RCT^ (see § below)	Ankle sprain	N = 30	Manipulation ankle axial elongation (HVLA)	6 Txs/4 wk	Significant for group 1 (6 txs) for ↑ proprioception and ↑ dorsiflexion ROM:		+
	Baseline characteristics and statistics essentially equal (Kohne, E dissertation)	Chronic recurrent grade I and II	Mean age, 31.7 y	Group 1, 6 txs vs group 2 (control), 1 tx	1-wk FU vs 1 tx A "few" sensed ↑ "instability" in group 1 (Kohne dissertation)	ROM: strapped inclinometer ankle moved only by patient-↓ bias		
Level of evidence for manipulative		Average txs: 3.75 txs				1 High-quality, 5 moderate,	Grade of evidence: B	

(*continued on next page*)

Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
therapy for ankle inversion sprain		(3 trials-6 txs; 1-8 txs; 4-1 tx; range 1- 8 txs) over 2-8 wk				2 low-quality trials	(man ther for ankle sprain with multimodal or exercise therapy)	
Foot Plantar fasciitis								
Dimou et al[88]	RCT^	Plantar fasciitis	N = 20	Foot and ankle adjusting + stretching vs orthotics	8 Txs/5 wk	Significant ↓ pain between groups in NRS at 4 wk in favor of man ther and stretching	Int to treat adequate	+
	Randomization (see § below) and blind assessor	Chronic >7 wk	Mean age, 42.4 y		1-mo follow-up 2 mo All patients completed treatment	Significant (intragroup) for both txs (but not different) at 9 wk for ↓ 1st step pain, ↓ heel pain at rest and algometry	Low power No adverse effects	
Level of evidence for manipulative therapy for plantar fasciitis		Average txs: 8 txs over 5 wk				1 Moderate-quality trial	Grade of evidence: C (man ther for plantar fasciitis with stretch/ and or multimodal/ exercise therapy)	
Metatarsalgia Petersen et al[90]	CT¥	Metatarsalgia (common or mechanical)	N = 40	Man ther of foot and ankle (mob, HVLA: especially	8 Txs/4 wk	Significant in favor for man ther vs placebo for: SFMPQ, NRS, FFI and ALG.		–
	Systematic assignment (1st patient randomized)		Mean age, 49.5 y	intermetatarsal glide, 1st MTPJ, etc) vs placebo (detuned ultrasound)	4 dropouts, not clear which groups; none from adverse effects (family, business problems, etc).	Note: placebo patients started with higher level of pain.		
Govender et al[91]	RCT Single blind (see § below)	Morton neuroma (aka Morton 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 All 20 finished trial. No dropouts. Adverse effects not reported.	Significantly in favor for man ther: NRS and algometry vs placebo	Power adequate Int to tx adequate	+
Level of evidence for manipulative therapy for metatarsalgia		Average txs: 7.5 txs over 3-4 wks. 1 trial, 8 txs; 1, 6 txs.				1 Moderate-quality trial 1 Poor-quality trial	Grade of evidence: C (man ther for metatarsalgia with/and without multimodal	

Table 1. (*continued*)

Author	Study type	Condition	Participants	Intervention/ control	Follow-up	Results/outcomes	Grade (below)	Rating
							therapy)	
Hallux limitus/rigidus								
Shamus et al[93]	RCT^	Hallux limitus	N = 20	Man ther of hallux and or/ hallux and sesamoids + different physical therapy protocols:	12 Txs/4 wk	Significant in favor of experimental tx for: ↑ ROM, ↑ strength, ↓ VAS, faster return of ROM and function	Single blind (blind patients)	+
			Mean age, 32.8 y	Comparative tx: modalities, hallux mob, exercise) vs experimental tx (same) + *sesamoid mob, hallux flex strengthening, and gait retraining*	No dropouts 2 Patients discharged at 10 visits (with relief)		Int to Tx adequate	
Level of evidence for manipulative therapy for hallux limitus/rigidus		12 Tx/4 wk				1 Moderate-quality trial	Grade of evidence: C (man ther for hallux limitus/ rigidus with multimodal therapy)	
Hallux abducto valgus (HAV or bunion)								
Brantingham et al[96]	RCT Single blind	HAV (painful HAV)	N = 60 Ave age, 50.1 y	Man ther 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/3 wk 1-wk follow-up 7 wk total Dropouts not reported/ unclear No reported adverse effects.	Significant in favor for man therapy for ↓ NRS, ↓ pain, disability, ↑ function with HAL and FFI vs placebo		+
Level of evidence for manipulative therapy for hallux abducto valgus/bunion		6 Txs/3 wk				1 Moderate-quality trial (no other known trials, case series, or case studies)	Grade of evidence: I (man ther for hallux abducto valgus)	

The SIGN checklist rating (++, +, −) and a summary of grading strength of evidence (A, B, C, and I) are in Figures 1 and 2. *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); *CT¥*, controlled or clinical trial with systematic assignment (*pseudo*randomization) or nonrandomization, but with inclusion, exclusion, controlled, independent, and dependent variables vs placebo and/or comparative treatment.

Table 2. *A summary of research on the hip: case series*[37-39]

Author	Diagnosis	Treatment/management	Reported outcome
MacDonald et al[68]	HOA	Man ther of hip (grade IV and V) + exercise for (HOA) 5 treatments (over 2-5 wk)	HHS for disability. 6 Patients: median improvement ↑ 25 points (clm change = ↑ 4 points).
	N = 7 Median age, 62 y	1. HVLA axial elongation 2. Various hip manipulation and mobilization techniques from multiple sources/textbooks 3. Hip, knee, and trunk exercises for hip OA	1 Patient (no HHS scale) but instead Global Rating of Change Scale: " a great deal better" 7 Patients mean NPRS (↓ 5 points on 0-10 scale; clm 1.5-2 points) Goniometry: global ↑ ROM 82° Conclusion: all ↓ pain, ↑ ROM

Case series were assessed using the checklist for case series. *HOA*, Hip osteoarthritis; *HHS*, Harris hip scale; *clm*, clinically meaningful.

Table 3. *A summary of research on the knee: case series*

Author	Diagnosis	Treatment/management	Reported outcome
Cliborne et al[73]	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)?	Man ther of hip (grade III and IV Maitland techniques) 1 Treatment–immediate post test 1 Group intragroup pre-post test	NPRS ↓ and all clinical tests less painful (except hip flexion) in mobilization group posttest $P < .05$ All clinical tests more + in KOA patients compared with normal asymptomatic, and less painful in symptomatic post test, except Faber)
Currier et al[74]	KOA N = 60 (51-79 y) CPR: study to determine which KOA variables (patients) respond to hip mob and the validity of tests to predict outcome. 5 variables: 1. Hip/groin pain or parathesia 2. Anterior thigh pain 3. Knee flexion <122° 4. Hip internal rotation <17° 5. Pain with hip distraction	Man the of hip (Maitland grade IV) + exercise 4 Treatments Immediate and 48 h post test. 1 Group intragroup pre-post test	Global Rating of Change Scale ↑ 3.27 points (clinically meaningful) NPRS, WOMAC, PSFS post test 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*

For case series, the co-chairs of the CCGPP Scientific Commission developed a checklist modified from other instruments. *KOA*, Knee osteoarthritis; *CPR*, clinical prediction rule.

Clinical Practice Guidelines[66,67] (Fig 2). The "considered judgment on quality of evidence" was applied to all reviewed materials, including case series and studies from the previous review, and assessed per the grading recommendations as listed in Figure 2.[1,38,66,67]

Results

Of 389 citations identified, 39 were determined to be relevant and supplementary to the clinical or controlled trials previously found by Hoskins et al. Of the 39 studies, 8 pertained to conditions effecting the knee; 1, the hip; 7, the ankle; and 2, the foot. These studies were assessed. The case series and studies previously incorporated in 2006 have not been cited in this investigation; therefore, readers are referred to that review. However, 13 case series and studies excluded and/or not previously reported in a single source are included: 3 regarding the hip, 2 regarding the knee, 2 regarding the ankle, and 6 regarding the foot.

Evidence

There is a level of C or limited evidence for manipulative therapy combined with multimodal or exercise therapy of the hip for hip osteoarthritis.[1,16,21,68-70] There is a level of B or fair evidence for manipulative therapy of the knee and/or full kinetic chain combined with multimodal or exercise therapy for knee osteoarthritis.[1,28,29,54,71-74] There is a level of B or fair evidence for manipulative therapy of the knee and/or full kinetic chain combined with multimodal or exercise therapy for patellofemoral pain syndrome.[1,53,75-80] There is a level of B or fair evidence for manipulative therapy of the ankle and/

Table 4. *A summary of research on the ankle and foot: case series*

Author	Diagnosis	Treatment/management	Reported outcome
Dananberg et al[87]	AE	Man ther + exercise (1 treatment manipulation and mobilization)	Gravity goniometer strapped on and used only by patient (to ↓ bias): active ROM, patient pulling strap under foot, etc.
	N = 22	1 Group immediate pre-post test	Mean ↑ ankle dorsiflexion ROM 4.9° (left), 5.5° (right) *t* tests at 99% confidence level $P < .001$
	(= Abnormal loss of ankle dorsiflexion ROM ↓ less than 10° from neutral)	1. P-A HVLA manipulation to proximal fibular head	Reports soreness in some ≤2 d but none later
	2nd diagnosis along with AE: a. Plantar fasciitis b. Acute chronic ankle sprain strain c. Achilles tendonitis d. Neuroma e. Metatarsalgia	2. Traction (mob) ankle/mortice: axial elongation with HVLA A-P talar thrust 3. Then active dorsi/plantarflexion ROM movement of ankle by patient	States better than stretch alone
Dananberg[50]	AE	Man ther + various treatments per condition: RICE, taping, exercise (inversion sprain), casting (Kohler) orthotics (hallux limitus)	3-wk follow-up for all
	N = 3 With: 1. Inversion sprain–chronic (and had big toe pain too) 2. Kohler (osteochodrosis of the navicular with pain) 3. Hallux limitus (1st MTPJ stiffness and pain) All patients had AE + additional diagnosis	1. Same as 2000 study plus: 2. Manipulation of the 1st metatarsocuneiform joint for 1st MTPJ for ↓ big toe pain.	Descriptive outcomes. Ankle sprain (and big toe pain) 1 Treatment resolved condition. ↑ ROM Kohler disease—a few treatments quickly resolved navicular pain. Antalgia resolved. Hallux limitus. A few treatments ↓ pain ↑ ROM of big toe.
Jennings and Davies[51]	Cuboid syndrome: unresolved lateral ankle/cuboid pain N = 7 Mean age, 21. 1 y a. 2nd to inversion Ankle sprain All college athletes and/or sports injuries	Man ther–HVLA "cuboid-whip" manipulation Different patients received additional treatments: tape, stretch, orthotics, modalities. 5 Had 1 manipulation 2 Had 2 manipulations	VAS pre and post (pre average VAS 2.85 and posttreatment VAS 0) Improvements post tx: also in ↓ cuboid tenderness, MTJ mobility, antalgic gait and inability to do single hop
Wyatt[52]	Plantar fasciitis (recalcitrant lateral plantar pain, postfasciotomy–referred by podiatric surgeon for chiropractic after full postsurgical healing and 4-6 wk of NSAIDS, shoe padding, and rest) 15 Patients Mean age, 46.4 y None lost to FU	Man ther + 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 VRS 3 Moderate relief (50-90%) 1 No change 9 Had minor adverse effects to man ther that resolved

(*continued on next page*)

Table 4. (*continued*)

Author	Diagnosis	Treatment/management	Reported outcome
Solan et al[94]	Hallux rigidus grades I-III (refers to radiographic findings)	1 Man ther under anesthesia with steroid injection of the 1st MTPJ.	*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.
	N = 37	1 Manipulation of hallux (manipulative technique not fully described)	Grade I = 6 mo of relief
	Mean age, 52.3 y	1-y follow-up	Grade II = 3 mo of relief
	2 Lost to follow-up	No additional treatment: additional manipulation, exercise, stretch, medication, etc.	Grade III = minimal to no relief.
	1-y follow-up 29 available		12 Grade I, 4 went to surgery
			18 Grade II, 12 went to surgery
			5 Grade 3, all 3 went to surgery
			Conclusion: manipulation acceptable for grade I, limited for grade II, not indicated grade III

For case series, the co-chairs of the CCGPP Scientific Commission developed a checklist modified from other instruments. *AE*, Ankle equinus.

or foot combined with multimodal or exercise therapy for ankle inversion sprain.[1,32,50,51,55,81-87] There is a level of C or limited evidence for manipulative therapy of the ankle and/or foot combined with multimodal or exercise therapy for plantar fasciitis.[1,52,87-89] There is a level of C or limited evidence for manipulative therapy of the ankle and/or foot combined with multimodal or exercise therapy for metatarsalgia.[1,87,90-92] There is a level of C or limited evidence for manipulative therapy of the ankle and/or foot combined with multimodal or exercise therapy for hallux limitus/rigidus.[1,50,93-95] There is a level of I or insufficient evidence for manipulative therapy of the ankle and/or foot combined with multimodal or exercise therapy for hallux abducto valgus/bunion (Table 1).[1,96] Tables 2 to 5 summarize additional case series and studies and will be commented upon in the discussion section.

Discussion

This literature review revealed new, recent, and previously noncited (secondary to limitations previously discussed) publications regarding manipulative treatment, for the most part with, but also without, adjunctive therapy (frequently exercise and/or rehabilitation and soft-tissue therapy, secondarily, in conjunction with modalities, NSAIDS, etc) for lower extremity conditions. There is an increase of limited and fair evidence for use of manipulative therapy in the treatment of a number of common lower extremity disorders since the Hoskins et al[1] 2006 review. Within this new evidence, there exist several studies representing higher-level evidence with case studies/series of increasing quality continuing to proliferate. Also worth noting are the highly rated trials that have been included recently into systematic reviews for treatments of hip and knee osteoarthritis, patellofemoral pain syndrome, and inversion sprain. Interestingly, these competing systematic reviews that use a variety of methodologies reach opposite conclusions as to whether there is support or not for the same treatment. One surprising example of just such a finding is exercise for acute inversion sprain.[33,36,97-99] Overall, when reviewing the increasing quantity and quality of included trials, manipulative therapy for lower extremity disorders appears to be of value and is fundamentally safe. The trials and studies used numerous outcome measures, most with minimally general and some with a condition-specific validity and reliability, such as the following: primary patient report of improvement, algometry, visual analogue (VAS) and numerical rating pain (NPRS) scales, the short-form McGill pain questionnaire, Cybex isokinetic muscle testing, goniometry, anterior knee pain scale, Harris hip scale, Western Ontario and McMasters arthritis index (WOMAC), hallux metatarsophalangeal interphalangeal index, foot function Index, interpolated twitch and electromyography (EMG), and functional tests like "first step heel pain," "step-ups," "get up and go," gait analysis, stabilometry, baropodometry, and orthopedic tests.

The literature suggests sustained interest in the application of manipulative therapy for lower extremity conditions conveying the impression that the examination and usefulness of manipulative therapy procedures for lower extremity disorders have barely begun. There are studies for hip osteoarthritis, knee osteoarthritis, patellofemoral pain syndrome, ankle sprain, plantar fasciitis, metatarsalgia, Morton neuroma, hallux limitus, and hallux valgus; and case studies assessing hip manipulative therapy with exercise for hip osteoarthritis, knee manipulative therapy for hip osteoarthritis, the effect of hip manipulative therapy for knee osteoarthritis, ankle and/or foot manipulative therapy for treatment of ankle equinus, metatarsalgia, Achilles tendonitis, plantar fasciitis, Morton metatarsalgia, hallux manipulation and injection for treatment of hallux rigidus, and foot and ankle manipulative therapy for cuboid syndrome secondary to lateral ankle sprains; and other and various

Table 5. *A summary of research on the hip/foot: case studies (descriptive)*

Author	Diagnosis	Treatment/management	Reported outcome
Whipple et al[70]	1. Acetabular anterosuperior labral tear	Man ther 1 treatment	Began VAS 7/10 with pain abducting when dancing.
	2. Instability (↑ ext. rot.)	1. Cyriax technique (variation on technique for loose bodies):	After treatment VAS 0/10
	3. Nonspecific hip pain	a. Axial elongation traction of the hip with	With abduction
	1 Patient	b. 5 Mobilizations from 30°-75° abduction	a. No pain on scour test
	1 Patient with symptoms for 1 mo. 14-y–old ballet dancer	1 Visit	b. ↑ External rotation persisted
	A. Overstretch.		1-wk follow-up no symptoms
	B. Weight-bearing flexed/extended twist of hip dancing		6-mo follow-up; 1 incidence of "giving way" otherwise no symptoms
	C. Painful click with abduction		
Pollard et al[69]	1. Acetabular anterosuperior labral tear (arthroscopically confirmed)	Man ther and mobilization (using multimodal and "MIMG" protocol–see article)	Patient 1 ↓ hip pain 70%. Some pain with weight bearing and rotation of hip
	2 Patients	Patient 1: 10 visits/2 mo	↓ CMLBP 80%-90%
	1. 45-y–old woman. Prolonged housecleaning 3 wk earlier (with 10 y of chronic mechanical LBP).	Patient 2: 14 visits/21/2 mo	Patient 2 initially ↓ hip pain 30%, at 3- and 6-mo follow-up 0% (no) hip pain. Painless click
	2. 15-y–old swimmer with 3 wk of knee and groin pain	a. Hip long axis traction with HVLA variations	Hip ROM still partially ↓
		b. Other hip manipulations and mobilizations	Surgical consult, but surgeon ` recommends against at this time.
		c. PNF, exercise, SMT, knee manipulative therapy, and activity modifications	10-14 Visits
Costa and Dyson et al[89]	Plantar fasciitis	Man ther + multimodal ther:	Treatment began VAS 7/10 morning pain and 4/10 usual pain all day
	1 Patient. 15-y–old girl. Soccer injury. Knee and groin pain.	a. Manipulation and mobilization	After 6 wk of treatment, resolution of symptoms 0/10
	Symptoms for 1 y even after treatment by GP and podiatrist–minimal help.	b. Iontophoresis (acetic acid), orthotics, ice, tape, myofascial, exercise, stretch and activity changes, and therapy, etc. 3×/wk for 2 wk then 2×/wk for 2 wk or 10 total treatments	10 Visits
Brantingham et al[95]	Hallux rigidus (grade I)	Man ther + multimodal ther:	NPRS 6/10
	1 Patient	(All grades I-V)	LEFI 22% (0-100, 100 worst), hallux dorsiflexion ROM 45°
	31-y–old male professional golfer	a. Hallux, ankle/foot, sesamoid mob and manip	Final visit
	Big toe pain and stiffness for 7 mo	d. Exercise therapy and stretching	NPRS 1-2/10
		e. Ultrasound	LEFI 2%
		Quick relief after a few txs	Hallux dorsiflexion ROM 84°
		17 Visits/10 mo	
Cashley[92]	Plantar digital neuritis (Morton metatarsalgia)	Man ther	Descriptive
	Aka Morton neuroma	Patient 1: 4 txs plantarflexion HVLA manipulation at the MTPJs	Patient 1 pain free by 4 wk.
	2 Patients	Patient 2: 3 txs over 6 wk	Follow-up at 14 mo still pain and symptom free
	Patient 1. 25 y old. Symptoms 3 mo after soccer.		Patient 2 pain free after 3 treatments.
	Patient 2. 63 y old. Symptoms 1 y. Steroid injections/orthotics with minimal relief.		Follow-up at 8 mo still pain and symptom free

LEFI, Lower extremity functional index.

additional case studies demonstrating the momentum, growing interest, and publication in this area. The present studies of manipulative therapy for lower extremity disorders appear to parallel the results and overall beneficial outcomes per spinal research.[100-102] It may be useful to investigate the most effective methods of manipulation/mobilization for every joint in the human body, 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, joint mobilization/manipulation appears to be universally indicated for lower limb joints as a therapeutic trial, in combination with other reasonable evidence-influenced conservative approaches, and for all common neuromusculoskeletal joint conditions, particularly where joint hypomobility is suspected as contributory. Common indications for the use of manipulative therapy, characterized by various definitions such as joint dysfunction, subluxation, or as a result of a clinical prediction rule, include (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, and (5) pain on stressing and/or overstressing/provoking (in any or all planes) a joint.[2,72,73,83,103,104]

Doctors of chiropractic are highly trained practitioners in HVLA thrusting techniques; but the profession has also used low-velocity, high- or low-amplitude mobilization techniques throughout the last century; and a myriad of mobilization techniques is well represented and used within the profession and these studies.[1,2,8,79,80,91] Most manipulative therapy applied to extremity disorders is delivered as multimodal therapy, blending exercise, soft tissue treatment, modalities, or multiple extremity joint and/or combined spinal and extremity joint manipulative therapy, and is usually condition and patient specific.[1,16,54,73,74,79,80] It appears that manipulative therapy with stretch is superior to either therapy alone in increasing range of motion (ROM), a possible solution to a previous conundrum of reductionistic interventional study.[16,21,71,72] Further research should address issues of safety, clinical predictors of efficacy and effectiveness, clarification of scope, and other similar issues.

Limitations

One limitation of this review is that 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 diagnosis (eg, measuring ROM), RCTs using immediate rehabilitative postsurgical manipulative therapy of an extremity, conference proceedings, red-flag conditions, or conditions that required referral were excluded.[1,105-108] Unfortunately, this means that interesting and informative studies such as an RCT of osteopathic manipulative treatment immediately after knee and/or hip arthroplasty, a study on manipulative management of foot pain due to an os peroneum and accessory navicular bone, or use of spinal manipulative therapy 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 not included.[52,108-111] Future reviewers may want to consider including immediate (or rehabilitative) postsurgical manipulative therapy management.

Conclusion

There is a growing number of peer-reviewed, published studies of manipulative therapy for lower extremity disorders. Larger, methodologically improved, and well-funded randomized controlled and clinical trials, as well as observational, clinical, and basic science research, case series, and studies, are both needed and merited. Interdisciplinary collaboration should be encouraged and supported as well. Finally, the basic overarching model of similarity of indications for and beneficial effect/responsiveness of patients to manipulative therapies for joint conditions throughout the human body merits further attention.

Practical Applications

- There is fair evidence for manipulative therapy of the knee and/or full kinetic chain, and of the ankle and/or foot, combined with multimodal or exercise therapy for knee osteoarthritis, patellofemoral pain syndrome, and ankle inversion sprain.
- There is limited evidence for manipulative therapy combined with multimodal or exercise therapy for hip osteoarthritis.

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