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Placebo effect in manual therapy trials on back pain patients: a systematic review and pair-wise meta-analysis

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Title	Placebo effect in manual therapy trials on back pain patients: a systematic review and pair-wise meta-analysis
Author's name	Carolina Lavazza (0000-0002-9907-6819), Margherita Galli (0000-0003-4050-3131), A Abenavoli (0000-0001-8941-2308), A Maggiani (0000-0002-7980-9405)
Address for each author Separate each part of address with a comma (don't use a separate line for each part) Please include postcodes **Authors' names and positions** Use same style of name as below title Please give one job position for each author, (under the relevant address) on separate line from author's name	Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, Carolina Lavazza associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, Margherita Galli associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, A Abenavoli associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, A Maggiani professor
Corresponding author	Correspondence to: carolina.lavazza@docenti.aimoedu.it

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Acronyms

AE= adverse effects
BP= back pain
CI= confidence intervals
CT= clinical trial
MA = meta-analysis
MCID= minimal clinically important difference
MD=mean difference
MT= Manual Therapies
OMT = osteopathic manipulative treatment
PROs = patient-reported outcomes
RCT= randomised controlled trials
RR= risk ratio
SM= Spinal Manipulation

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ABSTRACT

Objective:
To assess the effects and reliability of placebo in manual therapy (MT) trials in the treatment of back pain (BP) in order to provide methodological guidance for clinical trial development.

Methods and analysis:
Different databases were screened up to 20 August 2020. RCT involving adults affected by BP, acute or chronic, were included.
Hand contact placebo was compared to different MT (physiotherapy, chiropractic, osteopathy, massage, kinesiology and reflexology) and to control. Primary outcomes were BP improvement, placebo reliability and adverse effect (AE). Secondary outcomes were number of dropouts. Dichotomous outcomes were analysed using risk ratio (RR), continuous using mean difference (MD), 95% confidence intervals (CI). The minimal clinically important difference was 30 mm changes in pain score.

Results:
24 trials were included with 2,019 participants. Very low evidence quality suggests clinically insignificant pain improvement in favour of MT compared to placebo (MD 3.86, 95% CI 3.29 to 4.43) and no differences between placebo and control (MD -6.04, 95% CI -16.68 to 4.59).
Placebo reliability shows a high percentage of correct detection by participants (ranged from 46.7% to 83.5%), spinal manipulation being the most recognized technique.
Low quality of evidence suggests that AE and dropout rates were similar between placebo and MT (RR AE=0.84, 95% CI 0.55 to 1.28, RR dropouts= 0.98, 95% CI 0.77 to 1.25). A similar dropout rate in control (RR=0.79, 95% 0.51 to 1.23).

Conclusions:
Comparison of placebo and MT shows a small, clinically meaningless effect in pain improvement. Similar effects were found with control. The heterogeneousness of placebo MT studies and the very low quality of evidence render uncertain these review findings.
Future trials should develop reliable kinds of placebo, similar to active treatment, to ensure participant-blinding and to guarantee proper sample size for the reliable detection of clinically meaningful treatment effects.

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Strengths and limitations of this study

Strengths

This systematic review and pair-wise meta-analysis:

- summarises existing evidence on the effectiveness, reliability and application of hand contact placebo in MT randomised controlled trials;
- gives suggestions for researchers on conducting methodical RCT in MT using a reliable placebo.

Limitation

- This study did not include a comparison with machine provided placebo, its aim focused on hand contact placebo
- Insufficient number of studies were included to conduct a network meta-analysis

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Summary of findings:

1. Placebo compared to Manual Therapies (MT)

Patient or population: back pain
Intervention: Placebo
Comparison: MT

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with MT	**Risk with Placebo**				
Pain improvement assessed with: VAS score Scale from: 0 to 100		MD **3.86 higher** (3.29 higher to 4.43 higher)	-	805 (15 RCTs)	⨁◯◯◯ VERY LOW [a,b]	A small effect, not clinically relevant, in pain improvement was detected in favour of MT. This analysis excluded two trials (one suspected of publication bias, one used a different scale) which increased heterogeneity levels but did not affect overall efficacy meaningfully.
Adverse events assessed with: number of AE occurred	144 per 1.000	**121 per 1.000** (79 to 184)	**RR 0.84** (0.55 to 1.28)	531 (6 RCTs)	⨁⨁◯◯ LOW [a]	Pooled data from 6 studies did not show any difference in AE occurrence between placebo and MT.
Dropouts rate assessed with: number of participants that leaved the study	174 per 1.000	**171 per 1.000** (134 to 218)	**RR 0.98** (0.77 to 1.25)	1238 (11 RCTs)	⨁⨁◯◯ LOW [a]	Pooled data from 11 trials did not show difference in dropout rate between placebo and MT.

2. Placebo compared to Control

Patient or population: back pain
Intervention: Placebo
Comparison: control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with control	**Risk with placebo**				
Pain improvement assessed with: VAS score Scale from: 0 to 100		MD **6.04 lower** (16.68 lower to 4.59 higher)	-	251 (4 RCTs)	⨁◯◯◯ VERY LOW [a,c,d]	Pooled data from four trials, highly inconsistent, showed no differences between placebo and control group in pain improvement.
Dropouts rate assessed with: number of participants that leaved the study	205 per 1.000	**162 per 1.000** (104 to 252)	**RR 0.79** (0.51 to 1.23)	331 (5 RCTs)	⨁◯◯◯ VERY LOW [a,d]	Very low quality of evidence suggests no differences in dropout rate between placebo and control.

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **MD:** Mean difference; **RR:** Risk ratio

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GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. The majority of trials were judged as poor quality according to AHRQ standards.
b. Most of the studies were small trial.
c. Heterogeneity levels at 80%.
d. Number of participants < 400

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Background

In Clinical Trials (CT), placebo is commonly used as control therapy to evaluate clinical effectiveness of the treatments tested. (1) Placebo has been defined as "an inert substance or sham procedure that is provided to research participants with the aim of making it impossible for them, and usually the researchers themselves, to know who is receiving an active or inactive intervention." (2)
In Europe, its use in pharmacological CT has been regulated by CT Regulation No. 536/2014. According to this regulation, placebo must be treated as an Investigatory Medical Product (IMP) and as such it has to follow different standards in order to ensure quality , guarantee patient safety and the reliability of study results. (3)
Regulatory aspects of trials involving Manual Therapies (MT) are very different. Although these types of studies might be influenced by the type of placebo provided, no clear guidelines or regulations have been developed to ensure credibility of trial results and patient safety.
In MT trials, placebo treatment is often provided in different modalities from trial to trial although manual techniques or treatments tested are the same. For instance, placebo treatment is commonly administrated as a light touch in the site of pain or as an active treatment in a different site (4), with no clear criterion. Furthermore, in these studies, placebo reliability has been rarely evaluated. An analysis of its credibility results could help to understand better the participants' point of view, assessing which kind of placebo seems more similar to the active treatment provided.

Placebo effect, also called placebo response, is the reported improvement in symptoms among patients in randomized controlled trials (RCT). Since a placebo has no inherent therapeutic power, it rarely cures the disease but it may contribute to the relief of patients' symptoms such as pain.(5)
Additionally, placebo might be related to an adverse effect called nocebo. It has been estimated that up to 26% of patients in RCTs discontinue placebo due to adverse effects. (6)
It is thought that these psychobiological phenomena may be related to the overall therapeutic context, such as treatment environment, individual patient and clinician factors (e.g. beliefs, desire for symptom changes), as well as the patient's expectations of improvement and prior experiences of the treatment. (7-10)
In pharmacological trials this overall therapeutic context and its influence on placebo response has been widely studied. (8) Less evidence is present for MT trials, where other important characteristics should be considered as part of this therapeutic context such as the tactile interaction between patient and practitioner and clinician beliefs. As a matter of fact, touch might have a positive health effect (11) and placebo might be influenced by the same therapist beliefs which are actively providing the inactive treatment. (12, 13)
Another important factor that has to be taken into account is that RCTs involving MT usually use patient-reported outcomes (PROs) - such as pain - as primary outcomes. Studies suggested that physical placebo treatments might have a greater effect on these types of outcome compared to pharmacological placebo and that this effect might be consequent to the physical contact. (1, 14, 15)
Therefore, a better understanding of placebo response in manual treatment would be fundamental to define the real difference in efficacy between active and inactive treatment, with a better knowledge of the effect of manual contact on PROs such as pain relief and dropouts.

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The role of placebo in MT trials is still very confused and the lack of guidelines allows huge discrepancies in its use in RCTs. A clear definition of placebo effect could improve trial design, implementing studies with a proper power and sample size, defining clinical relevance of MT and giving more reliability to study results.
The aim of this systematic review with pair-wise meta-analyses (MA) is to evaluate the use of placebo in MT trials in order to analyse the effects, possible harm and the reliability of different kinds of sham treatments provided in RCTs involving MT. A systematic review could help to define placebo standards to be applied in CT in order to guarantee methodological quality and patient safety.

Objective

To assess the benefits, potential harm and reliability of placebo in manual therapy (MT) randomized controlled trials in the treatment of back pain (BP) in order to provide methodological guidance for clinical trial development.

Methods

This systematic review and meta-analysis was performed following the Preferred Reporting Items for Systematic Reviews (PRISMA)(16).
The protocol registration was performed in PROSPERO (http://www.crd.york.ac.uk/PROSPERO/) and review registration number is ***CRD42020198301.***

Criteria for considering studies for this review

Only randomised controlled studies (RCTs) were included in this review. Quasi-randomised trials in which allocation was not strictly random (e.g. date of birth or toss of a coin) were excluded. No restrictions were applied to language or setting.
Studies were considered eligible if they included adult participants with acute or chronic back pain including coccyx, lumbar, dorsal and cervical. Trials where pain is related to muscular conditions, articular disorders (such as osteoarthritis) or spinal disc herniation were included.
Trials where musculoskeletal diseases were secondary to other pathologies (e.g. amyotrophic lateral sclerosis, fibromyalgia etc.) were excluded.
Trials where pain was related to fracture, surgery, dysmenorrhoea, post-partum or pregnancy, headache or dizziness were excluded.
This review involved all types of placebo that include **hand contact**, studies where placebo was provided by machines (such as inactive ultrasound) were excluded.
All trials that involved hand contact placebo as light touch or a manual treatment in a different site were included.
Placebo was compared to other manual therapies such as: physiotherapy, chiropractic, osteopathy, massage, kinesiology and reflexology and to control.
Physiotherapeutic exercises were included in the analysis only if associated with manual treatment.

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The use of active co-interventions such as oral NSAIDs or other active treatments was accepted if used in all trial arms. Trials with more than two arms of intervention were included, but only data of interested arms were extracted.

Outcomes

Primary outcomes were pain intensity on a validated scale, reliability of placebo and adverse effect. Secondary outcomes were number of dropouts.
Whenever the meta-analysis could not be performed, a narrative summary of the outcomes have been provided. Outcomes were divided into short (≤2 months), medium (≤4 months) and long-term (≥6 months). Data were extracted and analysed based on the time closest to these intervals.

Information sources

Search strategy (***Appendix 1***) was adapted to the different databased by an experienced information specialist.
RCTs were identified in different databases (up to 20 August 2020): MEDLINE, Embase, CINAHL, SPORTDiscus, PEDro, World Health Organization Clinical Trials Registration Platform , Index to Chiropractic Literature, Cochrane central register of controlled trials (CENTRAL), Clinical trials registry and metaRegister of Controlled Trials (mRCT).
Researchers of unpublished trials, but completed and registered, were contacted by *CL* to obtain data.

The search in PROSPERO, in the Cochrane Library and in PubMed (clinical queries) was performed to evaluate the presence of on-going or recently completed systematic reviews. Guidelines from different organizations (e.g. National Council for Osteopathic Research etc.) were reviewed and references from relevant publication were analysed.

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Data collection and analysis

Searches results were screened by two independent reviewers who identified all the potentially eligible trials based on title and abstract. Full-texts of all the selected articles were screened firstly for inclusion. If full-text was not available, or the trial was completed but not published, *CL* contacted the authors in order to obtain the information needed or the document delivery service of the 3Bi Biella library.
Uncertainty about the inclusion of a study were discussed by the two reviewers. If no agreement was reached by the two reviewers a third reviewer (*AM*) was asked for their opinion.
The selection process was recorded and reported through a PRISMA flow diagram.

Data extraction and management

Data extraction was performed by two reviewers with a tested pre-defined form. Data extracted were related to settings, type of study, participants characteristics (such as localization and duration of pain, pain score at baseline, previous similar treatment), interventions, outcomes used in the meta-analysis and other relevant data such as difference in placebo and active treatment or funding. (***Appendix 2***)

Risk of bias in individual studies

Bias risk was assessed by *CL* and agreed by *MG* using the Cochrane Risk of bias (CRB) tool (27). This tool was used to assess selection bias, performance bias, attrition bias, reporting bias and other biases.
Each possible risk was evaluated as “high”, “medium” or “low” by *CL* and a revision of the judgments was performed by *MG*. RevMan 5.3.5 was used for the graphic representation of each risk. The CRB tool results were then converted to AHRQ Standards to assess the quality of the study (Good, Fair, and Poor). Trials were judged as good quality when bias risk was judged as low, studies with fair quality were trials where at least one criteria was high risk, poor quality studies instead were trials with two or more criteria with high or unclear risk.

Assessment of reporting biases

Funnel plots were created to explore reporting bias, whenever more than 10 studies were included in the meta-analysis. Furthermore, for each study, an analysis of possible conflicts of interest and funding sources was performed.

Summary measures

Dichotomous outcomes, such as adverse events (occurred or not), were analysed using risk ratio (RR) with 95% confidence intervals (CI).
Continuous outcomes, such as back pain on VAS scale, were evaluated using mean difference (MD) between placebo and the MT/control group with 95% CI and the standard deviation (SD). The minimal clinically important difference (MCID) between pre- and post-treatment was taken as 30 mm changes in 100 mm pain score. (17-19) These values were used for the interpretation of the clinical significance of the findings.

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Placebo reliability was reported with a percentage of patients guessing correctly the treatment allocation.
In this review the unit of analysis was the participant.

Assessment of heterogeneity

The presence of heterogeneity was assessed with a visual inspection of the forest plots and through an inconsistency level test (I^2).
Cochrane Handbook was used for threshold interpretation: heterogeneity was considered as unimportant for value of I^2 between 0% and 40%,, as moderate for values between 30% and 60% , as substantial for values between 50% an 90% and considerable for values between 75% to 100%. (20)

Synthesis of results

Meta-analysis of pain score, AE and dropout rates were performed using RevMan 5.3.5 whenever possible. The meta-analyses compared all kinds of placebo with all types of manual therapies and to control. Random-effect model was used when a substantial inconsistency was present (I^2= 50-90%). (20) When considerable heterogeneity was present (I^2>75%) and could not be explained by clinical or methodological diversity, the results have been presented narratively.
The statistical significance of measured effects was determined evaluating the p-value and 95% CI.

Additional analyses

Different subgroup analyses were planned in the protocol such as on placebo type provided (applied locally or in different sites from pain), type of manual technique tested (single or multiple techniques) and localization of back pain. However, due to the small number of studies included in this review, only a few subgroup analyses were conducted on follow-up periods.

Sensitivity analysis was conducted for the primary outcomes to assess the effects of skewed and imputed data on the effect measure. These analyses are reported as appendices.

Summarizing results and assessing the quality of the evidence

The quality of evidence for each outcome was evaluated with the GRADE approach by two independent authors and any disagreement was discussed. The quality for each effect measure was judged as high, moderate, low or very low (21). The GRADE approach was used to assess the quality of the key outcomes. The software GRADEpro (https://gradepro.org) was used to import data from RevMan 5.3.5 and to create “summary of findings tables”.
The following outcomes were chosen to be presented: pain scores at short-term, AE and dropouts.

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Patient and Public Involvement

There was no involvement of patients or public during the outline of this project.

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Results

PRISMA 2009 Flow Diagram

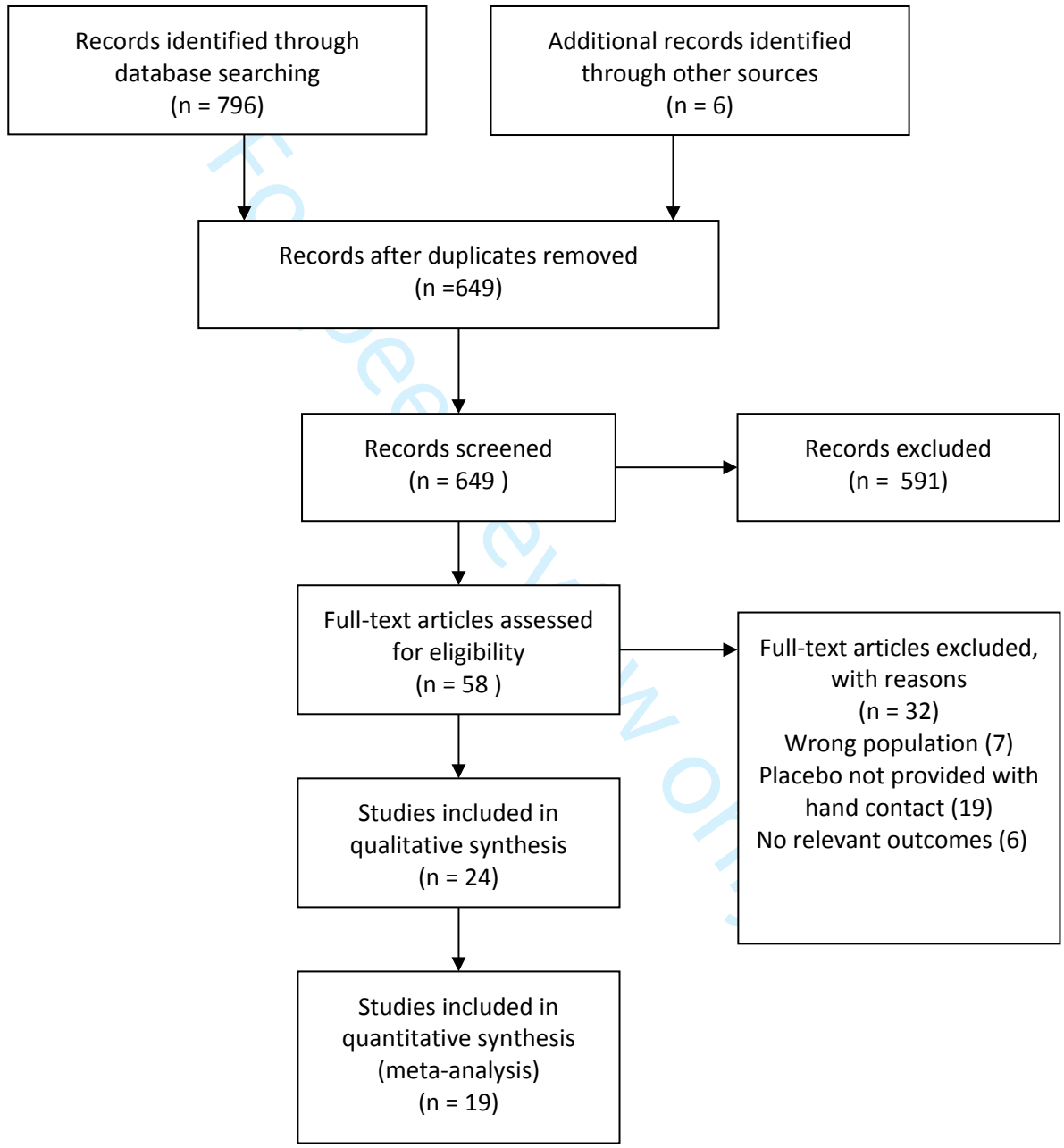

Figure 1: *PRISMA flow diagram*

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Included studies

All 24 studies included in this review were RCT. One study had a 2x2 factorial design, (22) eight studies had multiple arms. (23-30) Only arms involving the interested treatments were included in analyses.
Most of the studies were conducted in physical therapy clinics, in 13 different countries. Three trials did not report where their were conducted. (27, 31, 32)
Eight trials were conducted in Europe , (25, 26, 28, 33-37) five in the United States, (22, 23, 29, 38, 39) three studies in Brazil, (40-42) one in UK, (24) Egypt, (30) Japan (43) and Australia. (44)
No ongoing or unpublished trials were found.

Population

The included trials randomized a total of 2,019 participants, the majority of studies were small with a median of 50 participants and a range from 15 to 455.
Most trials included middle aged patients (mean 39,9 range from 18 to 73) with a mean BMI of 21,7 kg/m^2.
The majority of studies included both genders, with a percentage of male that ranged from 19% to 80% and a percentage of women that ranged from 20% to 82%. Two trials included only male, (36, 42) one study included only female participants. (40)

16 trials enrolled participants with low back pain (LBP), nine included participants with cervical pain (CP).
The majority of trials (N=15) included participants with unspecified cause of back pain. Disk herniation was considered in three trials,(25, 28, 42) other three studies included participants with mechanical pain (described as pain exacerbated by movement). (23, 24, 39).
Duration of symptoms were unassessed in eight trials, most of the studies included participants with chronic pain (N=9), some included participants with both acute and chronic pain.

Participants with experience of the tested treatment were included in 8 trials (22, 27, 29, 30, 33, 35, 40, 41) and excluded in four. (24, 34, 37, 39) Remaining studies did not provide this information.

Interventions

Interventions deferred for number of sessions and number of techniques applied. Most of the trials used a single therapy session (N=11) with a single technique performed (N=8).
Trials with different therapy sessions ranged from 5 (23, 24, 28) to 20 (25) sessions once a week.

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Placebo

Placebo was provided with a hand contact on the area of pain in 19 studies, five studies provided placebo in a different area from where the pain was located. (25, 33, 41, 43, 44)
In trials providing spinal manipulation, as inactive treatment the majority of authors used the similar placement of hands on participants without any force applied. (38-40, 42)
Two trials used a placebo with similar forces applied in different directions. (23, 30)
one trial did not specify the inactive manipulation applied(27).
In trials that provided multiple techniques in the same treatment session (such as osteopathic treatment, spinal mobilization and physiotherapy) the placebo was administrated with different techniques that mimed active treatments using light touch or light tractions.
Only one trial compared one single placebo technique with both single active technique and multiple treatment techniques. In this case only data of the first arm were extracted. (35)

Active and controls treatments

Different active treatments were provided:

- Physiotherapy (2 trials, 288 participants)
- Spinal manipulation (SM)/chiropractic (7 studies, 567 participants)
- Osteopathy (5 trials, 645 participants)
- Kinesiology (one trial, 58 participants)
- Articular mobilizations (5 trials, 325 participants)
- Muscular release (4 trials, 136 participants)

Five trials with multiple arms compared placebo to control group (343 participants).

The active treatment was generally applied in the area of pain, some trials used techniques additionally in other areas. Just one trial using reflexology provided both active and inactive manipulation in a different zone. (37)

Characteristics of practitioner who administrated treatments were provided by 16 trials. Most of the trials involved physiotherapists (N=8), generally defined physical therapists (N=4), osteopaths (N=3) and students (N=1). Only seven studies provided information on years of practice experience of physicians involved that ranged from 6 to 17 years. (28, 31, 33-35, 38, 40, 42). Information of their gender was provided only in three trials. (24, 28, 35)

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Table 1: summary of main characteristics of included studies

Study ID	N° of participants	Symptoms duration	Pain localization	Technique tested *(site of application)*	Type of placebo	Other arms	Follow-up
Antonilos-Campillo PJ 2014	40	Not reported	Cervical	Soft-tissue *(cervical region)*	Soft mobilization of lower limbs	None	No follow-up (outcomes collected after the intervention)
Bialosky J 2014	110	> 4 months	Lumbar	Spinal Manipulation (SM) *(lumbar spine)*	Ineffective force applied on lumbar spine	Control group	2 weeks
Cleland JA 2005	36	>2 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	No follow-up (outcomes collected after the intervention)
Eardley S 2013	58	> 3 years	Lumbar	Kinesiology *(spine)*	Protocol of ineffective techniques in the site of pain	Control group	7 weeks
Erdogmus S 2007	120	≥ 1.4 weeks	Lumbar	Physiotherapy *(spine)*	Neck massage	Control group	1.5 years
Hall T 2004	24	Not reported	Lumbar	BLR technique *(lower limbs)*	Soft-tissue manipulation of the foot	None	24 hours
Haller H 2016	54	> 7 months	Cervical	Cranio-sacral therapy *(head)*	Ineffective touch of head	None	3 months
Hansen F 1993	168	≥ 18 days	Lumbar	Physiotherapy *(lumbar spine and abdomen)*	Intermittent traction of the spine	Intensive back muscle training	1 year
Hidalgo B 2015	32	Not reported	Lumbar	Articular mobilization *(lumbar spine)*	Ineffective mobilization forces applied on lumbar spine	None	2 weeks
Hoiriis K 2004	156	≥ 2,3 weeks	Lumbar	SM *(spine)*	Ineffective force applied on spine	Medical treatment	4 weeks
Klein R 2003	61	>1 month and <5 years	Cervical	Strain-counterstain techniques (*cervical spine*)	Ineffective force applied on cervical spine	None	No follow-up (outcomes collected after the intervention)
Kogure A 2015	179	> 12 months and < 10 years	Lumbar	AKA-H *(sacro-iliac joint)*	Ineffective force applied on sacro-iliac joint	None	6 months
Krekoukias G 2017	50	Not reported	Lumbar	Articular mobilization techniques *(lumbar spine)*	Hand contact with lumbar skin placement without any movement	Exercise plus TENS	5 weeks
Lascurain-Aguirrebena I 2018	40	Not reported	Cervical	Articular mobilization *(Cervical spine)*	Ineffective force applied on cervical spine	None	No follow-up (outcomes collected after the intervention)
Licciardone J 2003	91	≥ 3 months	Lumbar	Osteopathic manual treatment (OMT) *(all body)*	Protocol of light touch techniques similar to OMT	Control group	6 months

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					applied to all body		
Licciardone J 2013	455	≥ 3 months	Lumbar	Osteopathic manual treatment (OMT) – *(all body)*	Protocol of light touch techniques similar to OMT applied to all body	None	8 weeks
Pires FP 2015	32	> 3 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	72 hours
Quinn F 2008	15	Not reported	Lumbar	Reflexology *(foot)*	Foot massage with less pressure and in different reflex point (not related to the spine)	None	18 weeks
Selkow M 2009	20	1-6 weeks	Lumbar	Muscular energy technique *(anterior superior iliac spine and lower limbs)*	Practitioner hand positioned as active treatment but participant rested for 30 seconds without any active contraction	None	24 hours
Senna MK 2011	93	≥ 13 months	Lumbar	SM *(lumbar spine)*	Ineffective force applied on lumbar spine	Maintained SM	10 months
Sillevis R 2010	100	≥ 23 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	No follow-up (outcomes collected after the intervention)
Silva A 2019	28	>3 months	Cervical	Osteopathic visceral treatment *(abdomen)*	Hand contact on umbilical region without any movement	None	7 days
Veira-Pellez F 2014	40	Not reported	Lumbar	SM *(lumbar/sacral spine)*	Ineffective force applied on lumbar/sacral joints	None	No follow-up (outcomes collected after the intervention)
Younes M 2017	17	< 3 months	Lumbar	OMT *(all spine)*	Placebo mimed active treatment with an ineffective force applied.	None	7 days

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Risk of bias in included studies

Figure 2 shows risks of bias judged by two authors.
Blinding of participants and assessors will be described due to the nature of this review.
According to AHRQ standards of CRB tool, (45) the majority of trials were judged with poor quality (N=22). Good quality was conferred on only two studies. (34, 43)
The random sequence and allocation concealment were adequately reported in 71% and 63% of trials respectively.
The lack of blinding of participants was the most common bias and was judged as high risk in 38% of studies, while 38% were considered as unclear risk.
The reasons for this judgment were mainly related to trials involving spinal manipulations. These studies used a technique which can be easily recognized by patients as active treatment for the popping sound emitted by joints. Additionally, these trials involved participants who could have already received this type of treatment, making the masking of technique almost impossible.
Blinding of outcomes was evaluated mainly as unclear risk in 46% of trials. Only two trials reported the strategies adopted to guarantee assessor blinding. (26, 30)
Incomplete outcome data was the least common bias risk with 80% of trials judged as low risk.
Reporting bias was evaluated unclear in 55% of trials where registration number and trial protocol were not reported or found.
Other bias occurred was generally considered at high risk for baseline differences of the population in 30% of trials.

Figure 2: *Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.*

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Effects of intervention

Placebo versus other manual therapies

Pain

The following outcomes on back pain are presented with a 100 mm visual analogue scale, 0 to 100; higher scores refer to worse pain. Trials using a 10mm scales were converted to 100mm scores.

The comparison between placebo and MT was performed in 17 studies. One trial used a different scale and data were obtained with a conversion formula.(25) Data from seven studies could not be extracted.
The meta-analysis at short-term showed substantial heterogeneity levels using a random-effects model. To further investigate inconsistency levels, a sensitivity analysis excluding two trials was performed. One trial used a different validated scale, (25) while the other was suspected of publication bias (28). This thought was verified with a funnel plot, which showed an asymmetric distribution with the inclusion of these two studies (***Appendix 3***). This sensitivity analysis did not influence overall effectiveness results but inconsistency levels decreased considerably at short-term. It can be deducted that a possible cause of heterogeneity was found (***Full analysis in appendix 4***)

The sensitivity analysis using a fixed-model at short-term showed a slight difference, not clinically meaningful, between placebo and MT in favour of MT on pain outcome (MD 3.86, 95%CI 3.29 to 4.43, 805 participants, I^2=42%, p<0.0001,very low quality of evidence downgraded two levels for very serious risk of bias and imprecision). **(Figure 3)**

Figure 3: *Forest plot of comparison Placebo versus MT in back pain outcome at short-term.*

Comparisons between placebo and MT at medium and long-term could not be performed due to substantial levels of heterogeneity found using a random-effects model. The heterogeneity levels were not explainable by clinical or methodological diversities within trials (medium-term I^2=91% P<0.0001, long-term I^2=81% P=0.005) (***Appendix 4.1***)

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Reliability of placebo

Reliability of placebo was evaluated in five trials; one did not report the results. (28)
Patients were asked to assess if they understood their treatment allocations. Due to the type of data extracted (percentage of correct guessing) meta-analysis was not performed and results are reported descriptively.
Two trials compared placebo with SM, these trials showed a correct perception of treatment allocation that ranged from 63.5% (23) to 83.5%. (27) In this last study patients were considered eligible if they already received SM.
One trial compared placebo to an articular mobilization technique. 54.5% participants correctly guessed treatment allocation. (44)
Participants of one study that compared placebo to reflexology had the lowest perception of the correct detection of allocation (46.7%). Participants in this trials were naïve to the type of treatment tested. (37)

Dropouts

Pooled data from 11 trials at the last follow-up suggested no difference in dropouts rate between placebo and MT at the end of the trials(105/612 compared to 109/626; RR 0.98, 95% CI 0.77 to 1.25 ; 1238 participants, I^2=0%, P=0.90; low quality of evidence downgraded two levels for high risk of bias). ***(Figure 4)***

Figure 4: *Forest plot of comparison Placebo versus MT in number of dropouts outcome*

Adverse effects

Adverse effects were generally under-reported, six trials were included in the meta-analysis.(24-26, 34, 35, 43)
Two trials reported AE overall occurrence without specified event rates in the groups. (22, 30).
AE were predominantly minor and lasted for two/three days after treatment, in the majority of trials transient worse pain, tiredness, muscle weakness and transient headache were reported.(24, 34, 35, 43)
Senna M 2011 reported the most common AE were local discomfort and tiredness but no serious complications were noted. (30)
Haller H 2016 reported two patients dropping out from the trial for recurrent headache after treatments, both Haller H and Klein R 2013 reported dizziness of one patient.
Licciardone J 2013 reported 27% of patients with AE, 2% had serious AE not related to study interventions. (22)

Overall results showed no clear difference in AE occurrence between placebo and MT (32/267 compared to 38/264; RR 0.84, 95% CI 0.55 to 1.28; 531 participants, I^2=26%, P=0.42; low quality of evidence downgraded two levels for inconsistency). ***(Figure 5)*** Senna and Licciardone were excluded from analysis because they did not provide separate data for each group.

Figure 5: *Forest plot of comparison Placebo versus MT in number of adverse events outcome at short-term*

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Placebo versus control

Pain

Five studies compared placebo to control, four were included in random-effect meta-analysis at short-term. (23-25, 27) Data from one trial could not be extracted. (29)
Pooled data showed the presence of significant heterogeneity, therefore results are reported narratively: three trials showed no difference between placebo and control on pain outcome, while Eardley S. 2013 showed an effect in favour of placebo (pooled data from 4 trials: MD -6.04, 95%CI from -16.68 to 4.59, 252 participants, I^2= 80%, P=0.27). The exclusion of Erdogmus S 2013 (that used a different scale) did not affect the results of effectiveness but decreased levels of heterogeneity (MD -9.72, 95%CI -19.94 to 0.51, $I^{2=}$ 69%, P=0.12) (***Appendix 5***)

Dropouts

No differences were showed in the fixed-effect meta-analysis on dropout rate between placebo and control in five trials (27/165 compared to 34/166; RR 0.79, 95% CI 0.51 to 1.23 ; 331 participants, I^2=0%, P=0.30; very low quality of evidence downgraded two levels for very serious risk of bias and imprecision). ***(Figure 6)***

Figure 6: *Forest plot of comparison Placebo versus MT in number of dropouts outcome*

Adverse effects

Of the six studies reporting AE, only two compared placebo and control.
One, Eardley S 2013, did not evaluate the AE occurred in control group while Erdogmus C 2007 reported that 10/40 in the control group and 11/40 in placebo group turned to other therapies for complains.

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Discussion

In the treatment of back pain very low quality of evidence suggests a slight improvement of pain, not clinically meaningful, in favour of MT at short-term. Substantial levels of heterogeneity within the four studies analysed, showed no differences between placebo and control in pain reduction.
Reliability of placebo was reported in four trials that compared placebo to MT, with high percentage of correct detection of treatment allocations by participants.
AE were generally under-reported, with a similar rate of occurrence between placebo and MT accompanying low levels of heterogeneity. Only one study reported AE in control group with no significant difference from placebo.

SM techniques were the treatment most evaluated (N=7). These techniques are highly recognizable by patients for a popping sound emitted by the column during their performance. (46) The fact that participants enrolled in these trials were eligible despite having already received SM, threatens the validity of blinding. This thought is strengthened by the high percentage of participants who recognized treatment allocation in this kind of trial (from 63.5% to 83.5%)(23, 27).
Additionally, five trials applied placebo treatment in a different site compared to pain and active treatment. This might have had important influences on study results.
Reliability placebo seemed not to be related to dropouts rate, although both these data were reported only in two trials. Bialosky J and Hoiriis K showed high percentages of correct treatment allocation detection by participants but dropout rate between placebo and MT group did not differ. These results seem to be in conflict, nevertheless, participants could have wanted to remain in the trial for several other reasons such as settings or being evaluated by an expert clinician free. This possibility is reinforced by the fact that a similar dropout rate was reached in the comparison placebo versus control. These data suggest that dropout rate might not be a dependable outcome for assessing reliability of placebo.

This review included generally small trials. Only 14 of 24 studies performed a sample size calculation but just two of these considered MCID in this computation. The MCID is the measure of smallest change of PROs that patients perceive as important, beneficial or harmful. MCID is useful for clinicians to interpret the findings of trials and apply them in clinical practice and to their decision-making. (47)An adequate sample size calculation, using MCID especially in trials with PROs, is fundamental to assess the number of participants needed to detect clinically relevant treatment effects. Oversized trials, which expose too many people to unnecessary therapies, or underpowered trials, which may not achieve significant results, should be avoided. (48-50)

Our results are similar to other reviews findings, notwithstanding that these reviews did not consider the difference between kinds of placebo provided (hand contact or machines) and evaluated the effect of a singular type of MT (such as SM or OMT) compared to placebo. (51, 52)

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Limitations

This review aimed to compare different kinds of placebo with different kinds of MT and control. The nature of this comparison needed an NMA, but this analysis could not be performed due to the small number of trials using hand contact placebo. The decision to include only this kind of sham therapy was mainly due to the intention of analysing the effect of manual interaction between practitioner and patients, which is suspected of leading to an amplified placebo effect.(11) Additionally, the use of machine placebo trials in the same meta-analysis could have increased diversity within trials included due to the possible enhanced presence of biases such as performance and consequently detection ones.

Although the population differed - some trials analysed cervical, others lumbar pain with different aetiologies and different symptoms duration - this factor did not affect the meta-analysis performed, as highlighted by the low heterogeneity found in the primary outcome. As already suggested by other authors,(1) placebo effect might be influenced by chronic pain, nevertheless, in this review, this analysis could not be performed due to the range of pain duration in trials included (from acute to chronic in the same trial).

Data concerning settings and operators were insufficient to evaluate the influence of these two factors on placebo response. Experience of practitioners was considered in data extraction but insufficient information was provided by authors to draw any hypothesis.
Another limit was in not considering non-objective outcomes as primary outcome for meta-analysis. Nevertheless, most of the trials included did not evaluate an objective outcome and the few studies which analysed this type of outcome used different kinds of scales not easily comparable in a meta-analysis
Pair-wise comparison on pain outcome between placebo and MT showed slightly higher effects of MT in trials where blinding was ensured. A linear regression analysis was planned to assess the impact of blinding on meta-analysis results. Due to the small number of trials, this analysis could not be performed. This trend follows what has been already suggested by other studies. (53) However trials with bigger sample size are needed to assess a real correlation between these two factors.

Implications for practice and research

There is very low quality of evidence that placebo compared to MT might be less effective and equally safe in the treatment of patients affected by back pain. Future studies should improve their methodological properties to ensure patients safety and to guarantee reliability of study results.
Researchers should pay particular attention to sample size calculation using the MCID. This difference is fundamental both for research and patients. MCID indicates patients' values and preferences and can help clinicians improve interpretation and promote the understanding of the importance of intervention effects in RCTs.
Trials should also implement strategies to guarantee patients and assessors blinding, for example avoiding the inclusion of participants who already received the active treatment. Plans to avoid performance bias, such as giving similar treatment with similar localization have to be implemented. Moreover, the evaluation of the reliability of blinding should be considered as, at least, secondary outcome.

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Future researches should also evaluate the real effects of placebo comparing it both with active treatment and to control groups. Only with this kind of design the real placebo effect in MT could be defined.
Trials should also focus on including participants with similar characteristics such as duration of symptoms (acute or chronic pain).

The majority of studies included in this review used a single technique treatment (N=11), however the clinical relevance of demonstrating the effectiveness of a singular technique is not clear. In a clinical context, most manual treatments usually involve different kinds of techniques in the same treatment session, so trials that evaluate the effectiveness of a type of treatment should include a routine of techniques in order to be more similar to clinical approaches.
Studies should also consider using objectives end points, not patient-reported or observer-reported, with a longer period of follow-up.

Conclusions

This review aimed to evaluate placebo effect in MT trials. Although MT showed higher efficacy than placebo, these findings were not clinically meaningful and the very low quality of the included studies might undermine the reliability of this reviews' results.

The use of placebo and its application in MT study is very controversial. Future trials should focus on developing a reliable kind of placebo, similar to the active treatment, to ensure participants blinding and to guarantee a proper sample size for the detection of reliable, clinically relevant, treatment effects.

Contributors:
CL conceived the idea of this review and designed the study with the contribution of *MG* who also helped in literature search and in the interpretation of study findings. *CL* and *MG* revised studies, performed data extraction and analysis and wrote this review.
AA and *AM* provided clinical and technical support, reviewed the manuscript and helped in publication and with the clinical interpretation of study findings.
CL is the guarantor of this paper. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Data sharing: Details of the characteristics of the included studies and data extracted are available from the corresponding author at carolina.lavazza@docenti.aimoedu.it.

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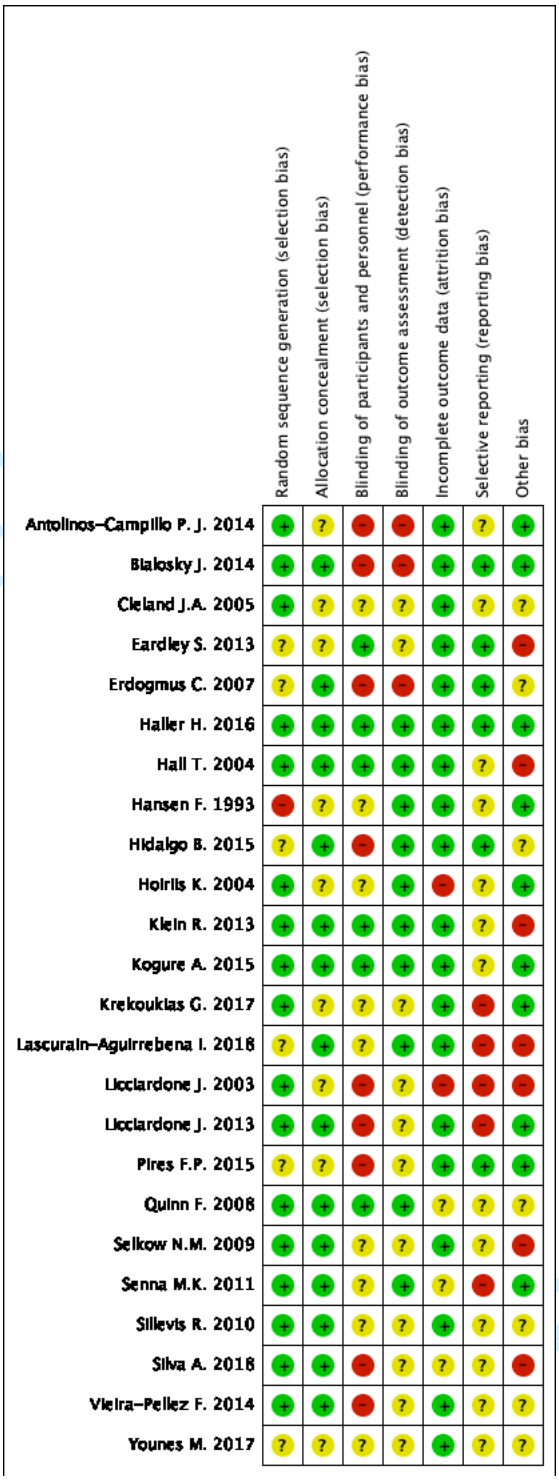

Figure 2: *Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.*

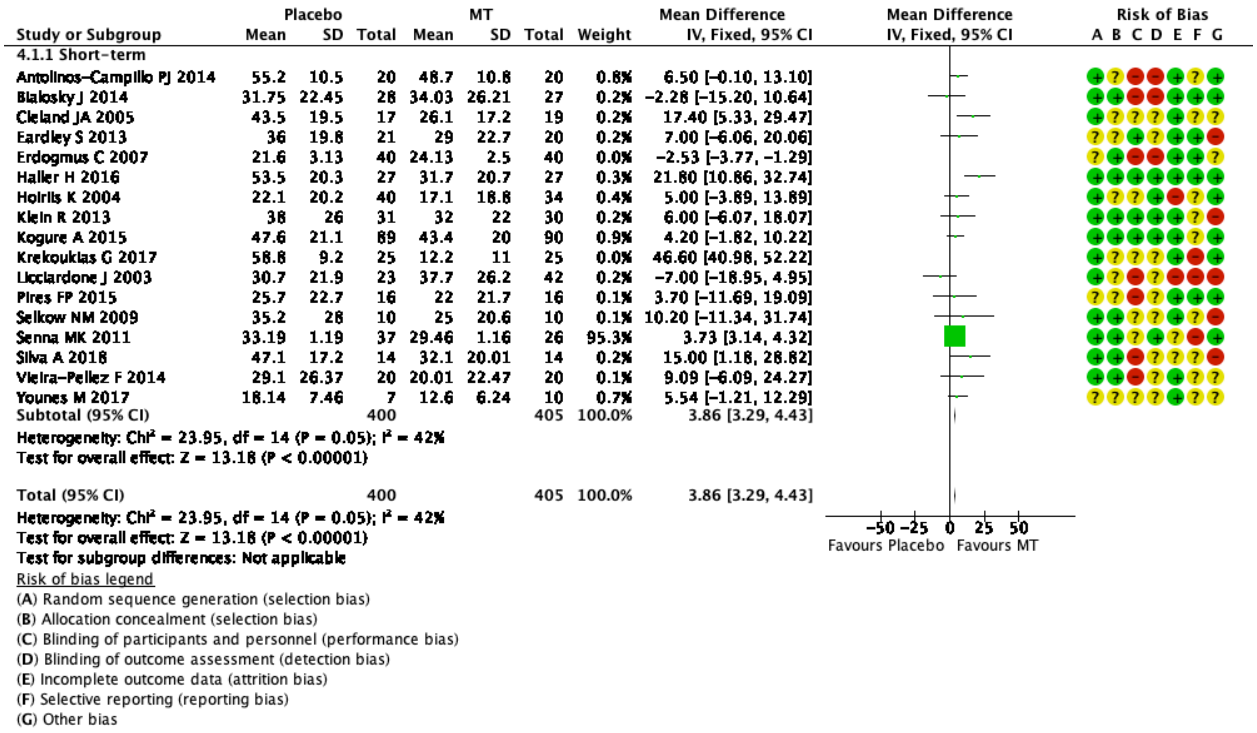

Figure 3: *Forest plot of comparison Placebo versus MT in back pain outcome at short-term.*

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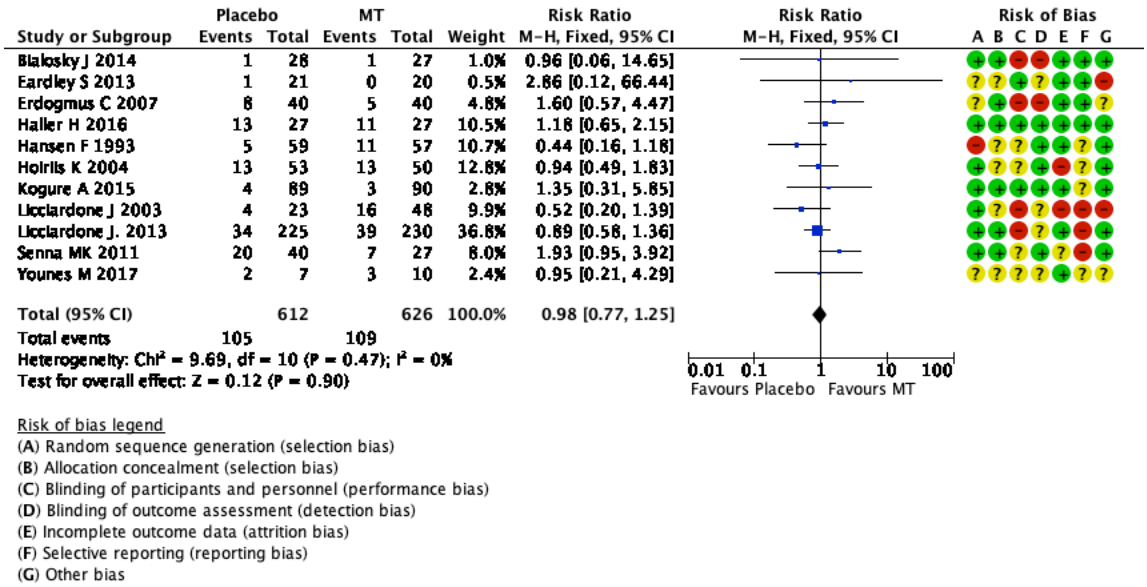

Figure 4: *Forest plot of comparison Placebo versus MT in number of dropouts outcome*

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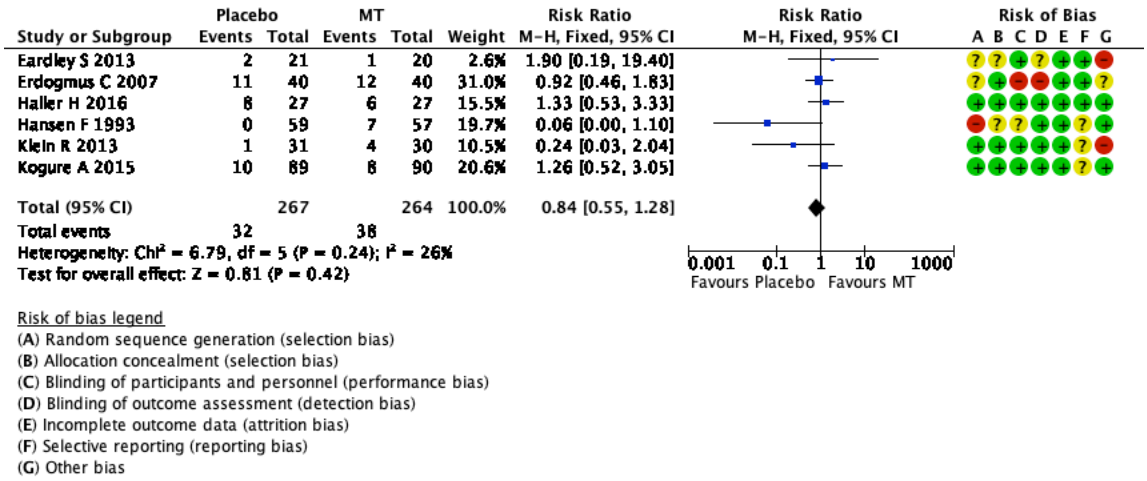

Figure 5: *Forest plot of comparison Placebo versus MT in number of adverse events outcome at short-term*

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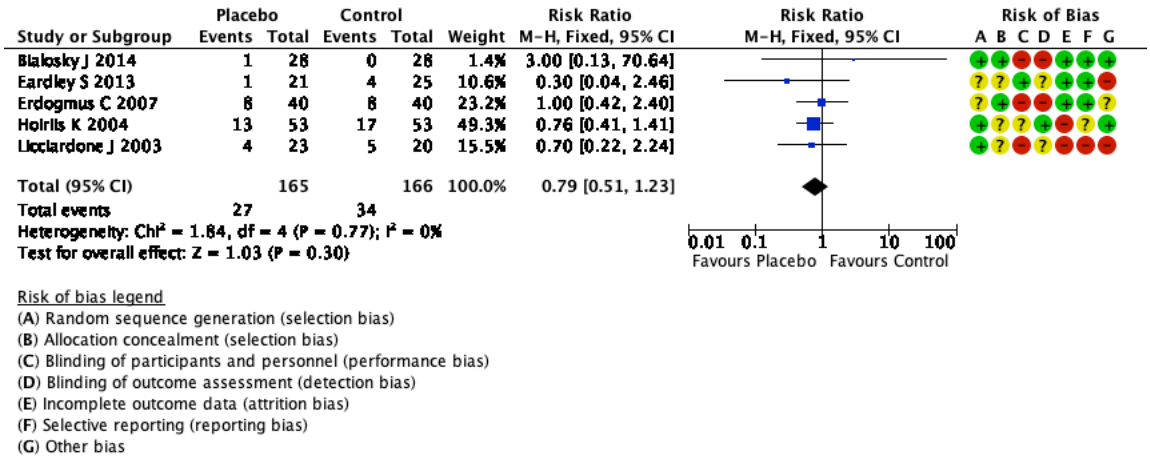

Figure 6: *Forest plot of comparison Placebo versus MT in number of dropouts outcome*

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Appendix 1: search strategy

Medline

1. Mesh descriptor: [Back Pain] explode all trees
2. dorsalgia/
3. backache
4.(neck OR cervical) adj1 pain → Mesh
5. exp Brachial Plexus Neuropaties
6. exp Lumbar Plexus Neuropaties
7. Neck Pain/
8. neckache
9. Torticollis/
10. whiplash.mp
11. cervicodynia.mp
12. spondylitis/ OR spondylosis/ OR spondylolysis/ OR spondylolysthesis
13.(lumbar OR dorsal OR neck OR cervical OR sciatica) adj2 (pain OR ache)
14. (lumbar OR dorsal OR neck OR cervical) adj2 (discitis OR disc adj 1 herniation OR disc adj1 herniation)
15. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14
16. (PLACEBO* or MOCK* or SHAM* or FAKE* or VEHICLE* or DUMM* or ATTENTION* CONTROL* or PSEUDO* TREAT* or UN?SPECIFIC* or NON?SPECIFIC* OR simulat$ treatment OR inert agent)
17. Chiropractic/
18. Manipulation, Chiropractic/
19. chiropract$.tw.
20. (manual adj2 therap$).mp
21. spinal manipulation.mp. or Manipulation, Spinal/
22. osteopath$.tw.
23. Osteopathic Medicine/
24. Physical Therapy Modalities/ or “Physical Therapy (Specialty)”/ or physical therap$.tw. or physiotherap$.tw.
25. myotherapy.mp
26. shiatsu.mp
27.exp Therapeutic Touch/
28. exp Massage/
29. (neuromuscular adj therapy).mp
30. 17 OR 18 OR 19 OR 20 OR OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29
31. pain
32. range of motion
33. ROM
34. 31 OR 32 OR 33
35. Clinical Trial/
36. Randomized Controlled Trial/
37. controlled clinical trial/
38. exp RANDOMIZATION/
39. PLACEBO/
40. (random$ adj2 allocat$).tw.
41. single blind$.tw.

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42. double blind$.tw.
43. placebo$.tw.
44. 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43
45. animals/
46. humans/
47. 46 NOT 45
48. 15 AND 16 AND 30 AND 44 AND 47

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Appendix 2: data extraction form

Methods	**Trial Design** **Settings**
Participants	**Total number of participants:** **Age**: **Gender(M/F):** **BMI:** **Activity:** **Duration of the symptoms:** **Location of pain (**one-sided, double-sided, central, cervical, dorsal or lumbar)**:** **Cause of pain:** (e.g. disc herniation, contractures, aspecific pain) **Previous experience of the treatment provided:** Y/N/ N/A **Inclusion and exclusion Criteria:** **VAS:** **Practitioner characteristics**: (years of experience, gender)
Interventions	**Placebo:** **Comparator:**
Outcomes	**Outcomes used in the meta-analysis:** **Length of follow-up:**
Notes	**Difference between Placebo and active treatment:** **Placebo check for reliability:**

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	Adverse event: **Lost to follow-up:** **Funding source:**

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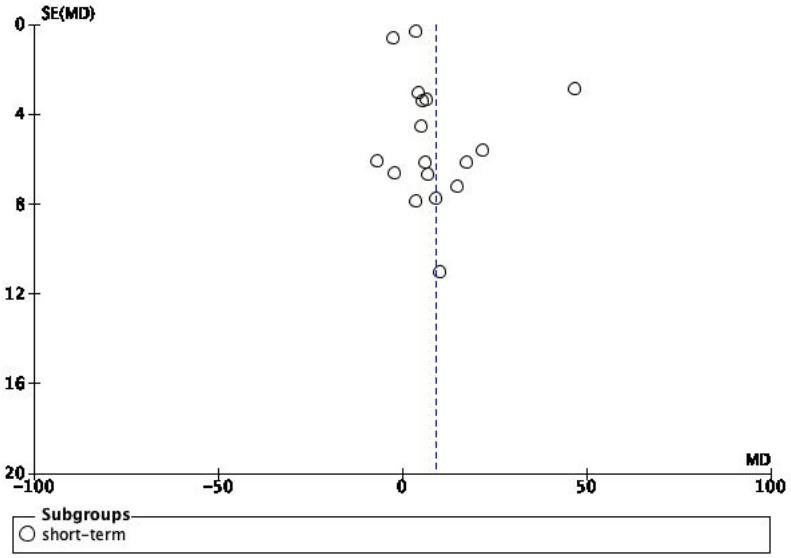
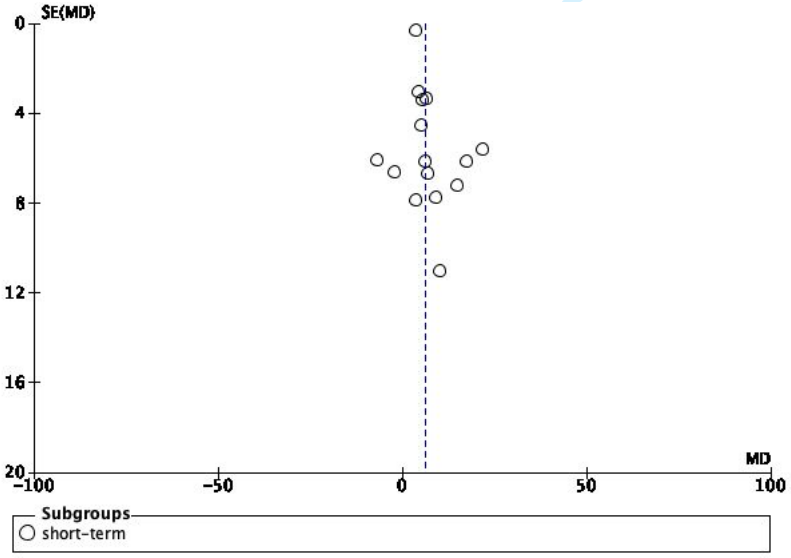
Appendix 3: funnel plot of pain outcome with the inclusion (A) and with the exclusion (B) of two studies of Erdogmus C and Krekoukias G.

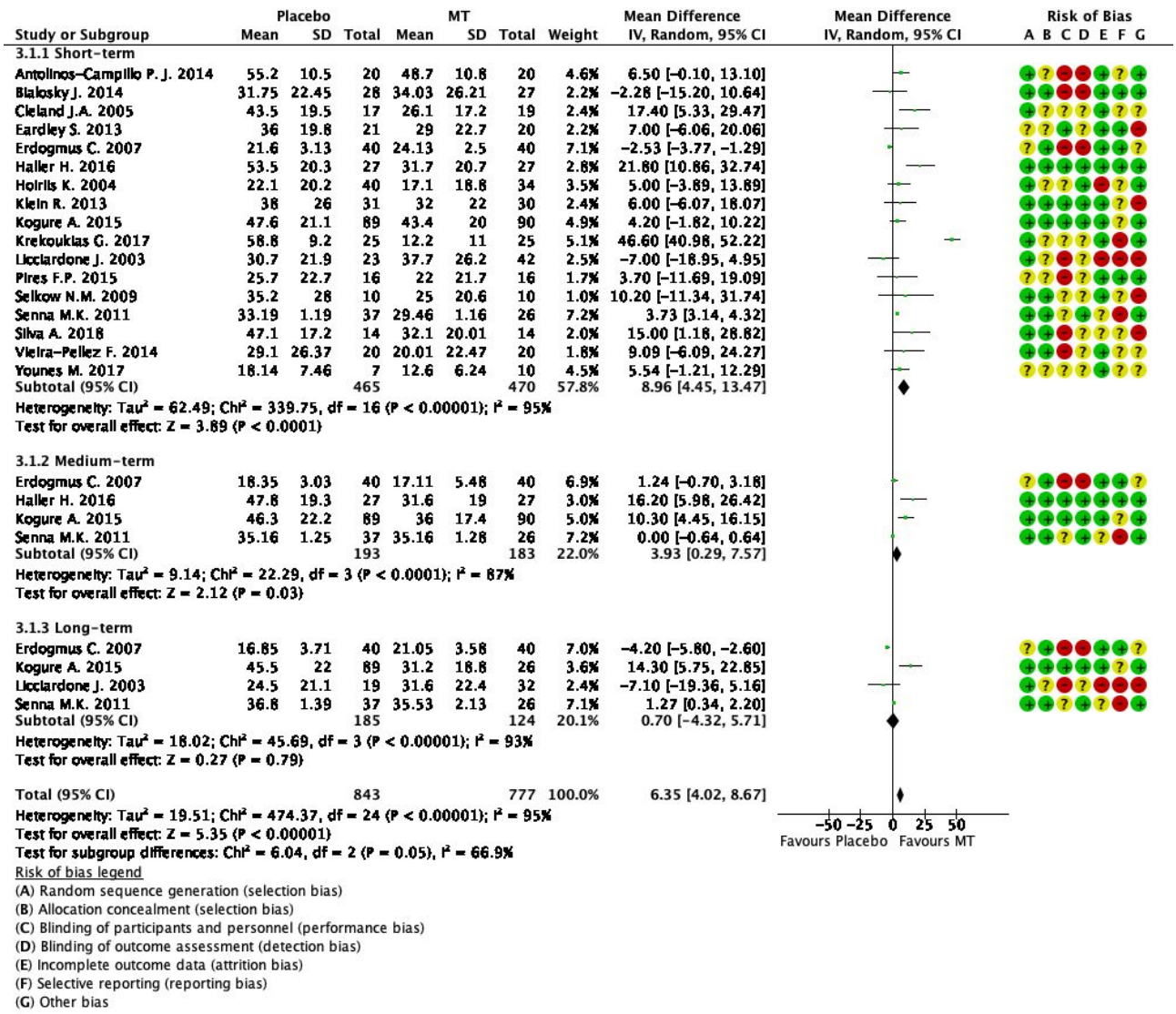
(A)



(B)

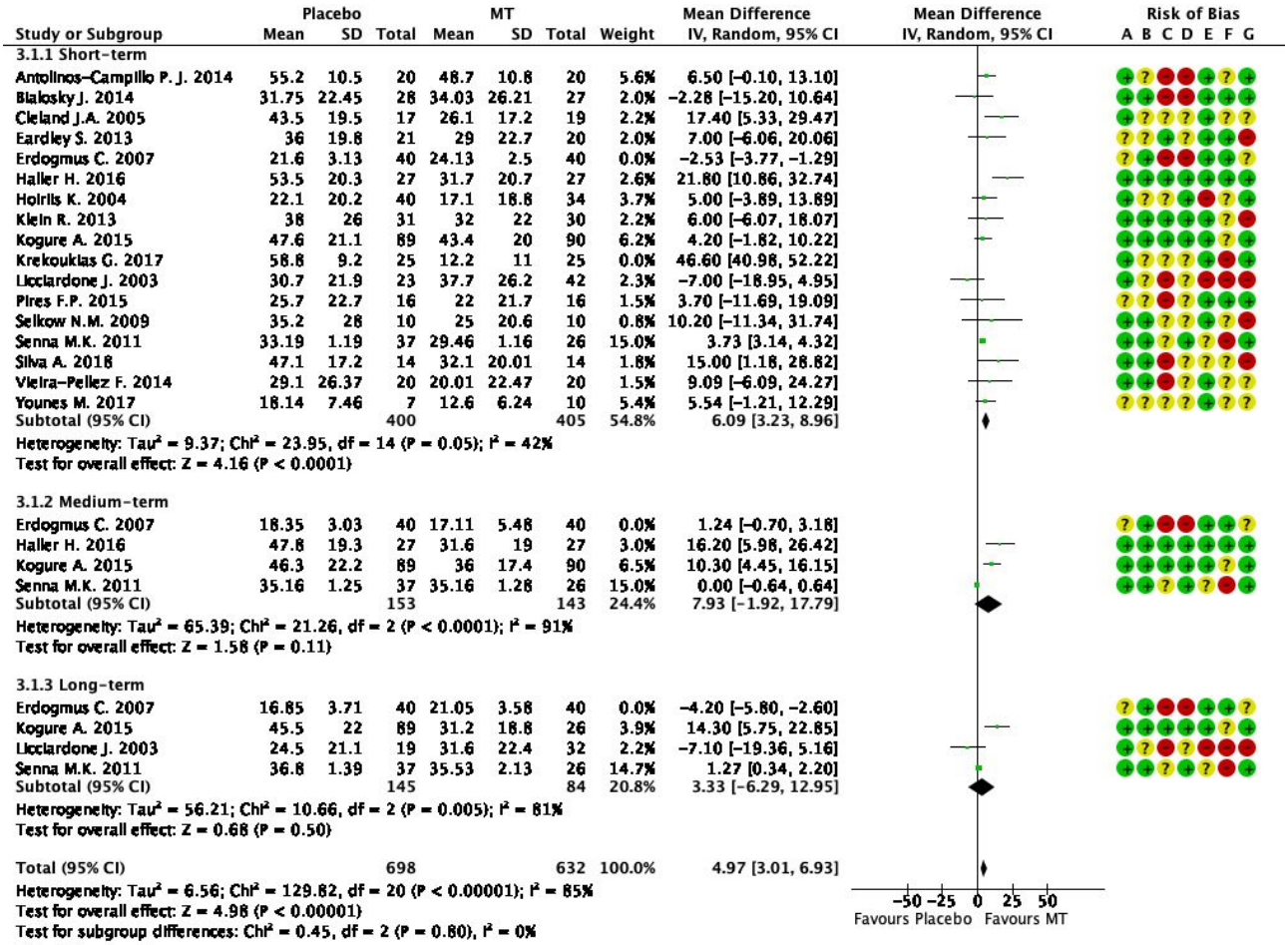


Appendix 4: forest plot of comparison pain outcome placebo vs manual therapies with the inclusion of two trials (Erdogmus C and Krekoukias G) at short, medium and long-term.

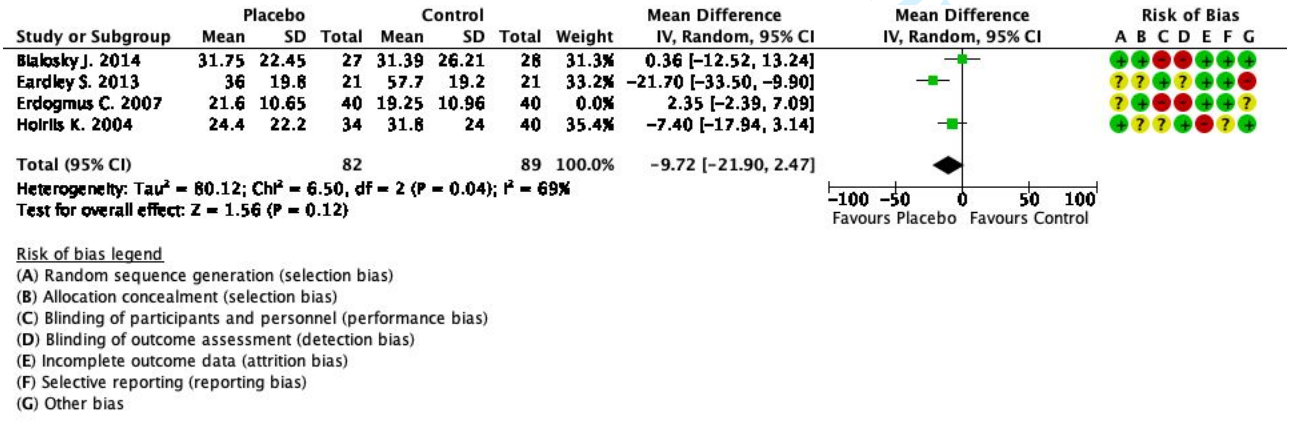


only

Appendix 4.1: Sensitivity analysis with the exclusion of Ergogmus C and Krekoukias G at short, medium and long-term



Appendix 5: forest plot of comparison Placebo versus control in back pain outcome at short-term with exclusion of Erdogmus C 2007 trial



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Page 5
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Pages 9-10
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Page 10
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Pages 6 and 10
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Pages 10-11
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Page 11
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Page 12
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Page 12
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Page 12-13
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Page 12
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Pages 12-13

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PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (I^2) for each meta-analysis.	Page 13

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Pages 12-13
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Page 13
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Page 15
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Pages 16-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Page 20, figure 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Pages 21-23
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Pages 7-8
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Pages 20-figures 2,3,4,5,6
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Appendices 4-6
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Pages 7-8, 24
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Page 25
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Page 26
FUNDING			

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PRISMA 2009 Checklist

Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Page 2

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

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Primary Subject Heading:	Complementary medicine
Secondary Subject Heading:	Research methods
Keywords:	COMPLEMENTARY MEDICINE, STATISTICS & RESEARCH METHODS, Back pain < ORTHOPAEDIC & TRAUMA SURGERY

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Author's name	Carolina Lavazza (0000-0002-9907-6819), Margherita Galli (0000-0003-4050-3131), A Abenavoli (0000-0001-8941-2308), A Maggiani (0000-0002-7980-9405)
Address for each author Separate each part of address with a comma (don't use a separate line for each part) Please include postcodes **Authors' names and positions** Use same style of name as below title Please give one job position for each author, (under the relevant address) on separate line from author's name	Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, Carolina Lavazza associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, Margherita Galli associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, A Abenavoli associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, A Maggiani professor
Corresponding author	Correspondence to: carolina.lavazza@docenti.aimoedu.it

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Ethical approval: not required.

Transparency: The manuscript's guarantor affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Funding: None.

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Competing interests: No funding were provided for this project and authors did not received support from any organisation for the submitted work. Authors have no financial relationships with any organisations that might have an interest in this project and have no other relationships or activities that could appear to have influenced this review.

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Acronyms

AE= adverse effects
BP= back pain
CI= confidence intervals
CRB= Cochrane risk of bias
CT= clinical trial
MA = meta-analysis
MCID= minimal clinically important difference
MD=mean difference
MT= manual therapies
OMT = osteopathic manipulative treatment
PROs = patient-reported outcomes
RCT= randomised controlled trials
RR= risk ratio
SM= spinal manipulation
ST= sham treatment

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ABSTRACT

Objective:
To assess the effects and reliability of sham procedures in manual therapy (MT) trials in the treatment of back pain (BP) in order to provide methodological guidance for clinical trial development.

Design: systematic review and meta-analysis

Methods and analysis:
Different databases were screened up to 20 August 2020. RCT involving adults affected by BP (cervical and lumbar), acute or chronic, were included.
Hand contact sham treatment (ST) was compared to different MT (physiotherapy, chiropractic, osteopathy, massage, kinesiology and reflexology) and to control. Primary outcomes were BP improvement, success of blinding and adverse effect (AE). Secondary outcomes were number of dropouts. Dichotomous outcomes were analysed using risk ratio (RR), continuous using mean difference (MD), 95% confidence intervals (CI). The minimal clinically important difference was 30 mm changes in pain score.

Results:
24 trials were included with 2,019 participants. Very low evidence quality suggests clinically insignificant pain improvement in favour of MT compared to ST (MD 3.86, 95% CI 3.29 to 4.43) and no differences between ST and control (MD -6.04, 95% CI -16.68 to 4.59).
ST reliability shows a high percentage of correct detection by participants (ranged from 46.7% to 83.5%), spinal manipulation being the most recognized technique.
Low quality of evidence suggests that AE and dropout rates were similar between ST and MT (RR AE=0.84, 95% CI 0.55 to 1.28, RR dropouts= 0.98, 95% CI 0.77 to 1.25). A similar dropout rate in control (RR=0.79, 95% 0.51 to 1.23).

Conclusions:
Comparison of ST and MT shows a small, clinically meaningless effect in pain improvement. Similar effects were found with control. The heterogeneousness of sham MT studies and the very low quality of evidence render uncertain these review findings.
Future trials should develop reliable kinds of ST, similar to active treatment, to ensure participant-blinding and to guarantee proper sample size for the reliable detection of clinically meaningful treatment effects.

PROSPERO register: CRD42020198301
https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=198301

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Strengths and limitations of this study

Strengths

This systematic review and pair-wise meta-analysis:

- summarises existing evidence on the effectiveness, reliability and application of hand contact sham treatment in MT randomised controlled trials;
- gives suggestions for researchers on conducting methodical RCT in MT using a reliable sham procedure.

Limitation

- This study did not include a comparison with machine provided placebo, its aim focused on hand contact sham treatment
- Insufficient number of studies were included to conduct a network meta-analysis

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Background

In Clinical Trials (CT), placebo is commonly used as a control therapy to evaluate clinical effectiveness of the treatments tested. (1) Placebo has been defined as "an inert substance or sham procedure that is provided to research participants with the aim of making it impossible for them, and usually the researchers themselves, to know who is receiving an active or inactive intervention." (2)
In Europe, its use in pharmacological CT has been regulated by CT Regulation No. 536/2014. According to this regulation, placebo must be treated as an Investigatory Medical Product (IMP) and as such it has to follow different standards in order to ensure quality , guarantee patient safety and the reliability of study results.(3)
Regulatory aspects of trials involving Manual Therapies (MT) are very different. Although such studies might be influenced by the type of placebo provided, no clear guidelines or regulations have been developed to ensure the credibility of trial results and patient safety.
MT is a clinical approach used by different physical therapists and involves hands-on techniques to manipulate, mobilise and massage the body tissues. This type of therapy can help to relieve pain and stiffness, promote relaxation of soft-tissues, enhancing blood supply to tissues and increase mobility of joint structures. (4)
In MT trials, placebo treatment is often provided in different modalities from trial to trial although the manual techniques or treatments tested are the same. For instance, placebo treatment is commonly administrated as a light touch in the site of pain or as an active treatment in a different site (5), with no clear criterion. Such light touch might in fact have a health effect and there is no evidence as to its ineffectiveness. Touch itself could have a positive outcome on health (6) and active treatments could have an analgesic reflex on pain even if administered anywhere in the body.(7)

Placebo effect, also called placebo response, is the reported improvement in symptoms among patients that occurs as a result of the placebo administration. Since a placebo has no inherent therapeutic power, it rarely cures the disease but it may contribute to the relief of patients' symptoms such as pain.(8) Additionally, placebo might be related to an adverse effect called nocebo. It has been estimated that up to 26% of patients in randomized control trials (RCTs) discontinue placebo due to adverse effects.(9)
It is thought that these psychobiological phenomena may be related to the overall therapeutic context, such as treatment environment, individual patient and clinician factors (e.g. beliefs, desire for symptom changes), as well as the patient's expectations of improvement and prior experiences of the treatment. (10-13)
In pharmacological trials this overall therapeutic context and its influence on placebo response has been widely studied. (11) Less evidence is present for MT trials, where other important characteristics should be considered as part of this therapeutic context such as the tactile interaction between patient and practitioner and clinician beliefs. (14, 15) Pharmacological trials avoid the influence of clinicians' beliefs by using a placebo that ensures both patients and clinicians blinding to treatment allocation, but, in MT trials, the blinding of clinicians is almost impossible to achieve. The best alternative in this type of trial is the use of a sham treatment that mimics the active treatment and aims to ensure at least the blinding of participants.

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Another important factor that has to be taken into account is that RCTs involving MT usually use patient-reported outcomes (PROs) - such as pain - as primary outcomes. Studies suggested that physical placebo treatments might have a greater effect on these types of outcome compared to pharmacological placebo and that this effect might be a consequence of physical contact.
Moreover, especially when subjective PROs outcomes are used, the lack of clinician blinding could also increase the possibility of performance bias. (14)
Therefore, a better understanding of placebo procedures in manual treatment would be fundamental to define the real difference in efficacy between manual and sham treatment, with a better knowledge of the effect of manual contact on PROs such as pain relief and dropouts.

The role of placebo – referred to as sham therapy in this review - in MT trials is still very confused and the lack of guidelines allows huge discrepancies in its use in RCTs. Additionally, the reliability of sham procedures in MT trials has been rarely evaluated.
A clear definition of placebo effect could improve trial design, implementing studies with a proper power and sample size, defining clinical relevance of MT and giving more reliability to study results.
The aim of this systematic review with pair-wise meta-analyses (MA) is to evaluate the use of placebo in MT trials in order to analyse the effects, possible harm and the reliability of different kinds of sham treatments provided in RCTs involving MT. A systematic review could help to define placebo standards to be applied in CT in order to guarantee methodological quality and patient safety.

Objective
To assess the benefits, potential harm and reliability of sham treatment in manual therapy (MT) randomized controlled trials in the treatment of back pain (BP) both cervical and lumbar in order to provide methodological guidance for clinical trial development.

Methods

This systematic review and meta-analysis was performed following the Preferred Reporting Items for Systematic Reviews (PRISMA)(16).
The protocol registration was performed in PROSPERO (http://www.crd.york.ac.uk/PROSPERO/) and review registration number is ***CRD42020198301.***

Criteria for considering studies for this review

Only randomised controlled studies (RCTs) were included in this review. Quasi-randomised trials in which allocation was not strictly random (e.g. date of birth or toss of a coin) were excluded. No restrictions were applied to language or setting.
Studies were considered eligible if they included adult participants with acute or chronic back pain including coccyx, lumbar, dorsal and cervical. Trials where pain is related to muscular conditions, articular disorders (such as osteoarthritis) or spinal disc herniation were included. Trials where musculoskeletal diseases were secondary to other pathologies (e.g. amyotrophic lateral sclerosis, fibromyalgia etc.) were excluded.

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Trials where pain was related to fracture, surgery, dysmenorrhoea, post-partum or pregnancy, headache or dizziness were excluded.
This review involved all types of placebo that include **hand contact** provided by all kinds of physical therapists. Studies where placebo was provided by machines (such as inactive ultrasound) were excluded.
All trials that involved hand contact ST as light touch or a manual treatment in a different site were included.
ST was compared to other manual therapies such as: physiotherapy, chiropractic, osteopathy, massage, kinesiology and reflexology and to control.
To assess if touch itself could have a positive health effect, ST was also compared to control.
Physiotherapeutic exercises were included in the analysis only if associated with manual treatment.
The use of active co-interventions such as oral NSAIDs or other active treatments was accepted if used in all trial arms. Trials with more than two arms of intervention were included, but only data of interested arms were extracted.

Outcomes

Primary outcomes were pain intensity on a validated scale, success of blinding of and adverse effect. Secondary outcomes were number of dropouts.
Whenever the meta-analysis could not be performed, a narrative summary of the outcomes have been provided. Outcomes were divided into short (≤2 months), medium (≤4 months) and long-term (≥6 months). Data were extracted and analysed based on the time closest to these intervals.

Information sources

Search strategy (***Appendix 1***) was adapted to the different databased by an experienced information specialist.
RCTs were identified in different databases (up to 20 August 2020): MEDLINE, Embase, CINAHL, SPORTDiscus, PEDro, World Health Organization Clinical Trials Registration Platform , Index to Chiropractic Literature, Cochrane central register of controlled trials (CENTRAL), Clinical trials registry and metaRegister of Controlled Trials (mRCT).
Researchers of unpublished trials, but completed and registered, were contacted by *CL* to obtain data.

The search in PROSPERO, in the Cochrane Library and in PubMed (clinical queries) was performed to evaluate the presence of on-going or recently completed systematic reviews.
Guidelines from different organizations (e.g. National Council for Osteopathic Research etc.) were reviewed and references from relevant publication were analysed.

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Data collection and analysis

Searches results were screened by two independent reviewers who identified all the potentially eligible trials based on title and abstract. Full-texts of all the selected articles were screened firstly for inclusion. If full-text was not available, or the trial was completed but not published, *CL* contacted the authors in order to obtain the information needed or the document delivery service of the 3Bi Biella library.
Uncertainty about the inclusion of a study were discussed by the two reviewers. If no agreement was reached by the two reviewers a third reviewer (*AM*) was asked for their opinion.
The selection process was recorded and reported through a PRISMA flow diagram.

Data extraction and management

Data extraction was performed by two reviewers with a tested pre-defined form. Data extracted were related to settings, type of study, participants characteristics (such as localization and duration of pain, pain score at baseline, previous similar treatment), interventions, outcomes used in the meta-analysis and other relevant data such as difference in ST and active treatment or funding. (***Appendix 2***)

Risk of bias in individual studies

Bias risk was assessed by *CL* and agreed by *MG* using the Cochrane Risk of bias (CRB) tool (27). This tool was used to assess selection bias, performance bias, attrition bias, reporting bias and other biases.
Each possible risk was evaluated as “high”, “medium” or “low” by *CL* and a revision of the judgments was performed by *MG*. RevMan 5.3.5 was used for the graphic representation of each risk. The CRB tool results were then converted to AHRQ Standards to assess the quality of the study (Good, Fair, and Poor). Trials were judged as good quality when bias risk was judged as low, studies with fair quality were trials where at least one criterion was high risk, poor quality studies instead were trials with two or more criteria with high or unclear risk.

Assessment of reporting biases

Funnel plots were created to explore reporting bias, whenever more than 10 studies were included in the meta-analysis. Furthermore, for each study, an analysis of possible conflicts of interest and funding sources was performed.

Summary measures

Dichotomous outcomes, such as adverse events (occurred or not), were analysed using risk ratio (RR) with 95% confidence intervals (CI).
Continuous outcomes, such as back pain on VAS scale, were evaluated using mean difference (MD) between ST and the MT/control group with 95% CI and the standard deviation (SD).
The minimal clinically important difference (MCID) between pre- and post-treatment was taken as 30 mm changes in 100 mm pain score. (17-19)These values were used for the interpretation of the clinical significance of the findings.

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Success of blinding was reported with a percentage of patients guessing correctly the treatment allocation.
In this review the unit of analysis was the participant.

Assessment of heterogeneity

The presence of heterogeneity was assessed with a visual inspection of the forest plots and through an inconsistency level test (I^2).
Cochrane Handbook was used for threshold interpretation: heterogeneity was considered as unimportant for value of I^2 between 0% and 40%,, as moderate for values between 30% and 60% , as substantial for values between 50% an 90% and considerable for values between 75% to 100%. (20)

Synthesis of results

Meta-analysis of pain score, AE and dropout rates were performed using RevMan 5.3.5 whenever possible. The meta-analyses compared all kinds of ST with all types of manual therapies and to control. Random-effect model was used when a substantial inconsistency was present (I^2= 50-90%). (20) When considerable heterogeneity was present (I^2>75%) and could not be explained by clinical or methodological diversity, the results have been presented narratively.
The statistical significance of measured effects was determined evaluating the p-value and 95% CI.

Additional analyses

Different subgroup analyses were planned in the protocol such as on ST type provided (applied locally or in different sites from pain), type of manual technique tested (single or multiple techniques) and localization of back pain. However, due to the small number of studies included in this review, only a few subgroup analyses were conducted on follow-up periods.

Sensitivity analysis was conducted for the primary outcomes to assess the effects of skewed and imputed data on the effect measure. These analyses are reported as appendices.

Summarizing results and assessing the quality of the evidence

The quality of evidence for each outcome was evaluated with the GRADE approach by two independent authors and any disagreement was discussed. The quality for each effect measure was judged as high, moderate, low or very low.(21) The GRADE approach was used to assess the quality of the key outcomes. The software GRADEpro (https://gradepro.org) was used to import data from RevMan 5.3.5 and to create “summary of findings tables”.
The following outcomes were chosen to be presented: pain scores at short-term, AE and dropouts.

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Patient and Public Involvement

There was no involvement of patients or public during the outline of this project. The differences noted between therapies tested on primary pain outcome were those clinically meaningful to patients.

Results

Figure 1: *PRISMA flow diagram*

Included studies

Table 1 shows a summary of main characteristics of included studies.
24 studies were included in this review (***Figure 1***), one study had a 2x2 factorial design, (22) eight studies had multiple arms. (23-30)Most of the studies were conducted in physical therapy clinics, in 13 different countries. Three trials did not report in which clinical setting their were conducted. (27, 31, 32)
Eight trials were conducted in Europe ,(25, 26, 28, 33-37) five in the United States,(22, 23, 29, 38, 39) three studies in Brazil,(40-42) one in UK, (24) Egypt, (30) Japan (43) and Australia. (44)
No ongoing or unpublished trials were found.

Population

The included trials randomized a total of 2,019 participants, the majority of studies (N=18) were small with a median of 50 participants and a range from 15 to 455.
Most trials included middle aged patients (mean 39,9 range from 18 to 73) with a mean BMI of 21,7 kg/m^2.
The majority of studies included both genders, with a percentage of male that ranged from 19% to 80%. Two trials included only male, (36, 42) one study included only female participants. (40)

16 trials enrolled participants with low back pain (LBP), nine included participants with cervical pain (CP).
The majority of trials (N=18) included participants with unspecified cause of back pain. Disk herniation was considered in three trials. (25, 28, 42)
Duration of symptoms were unassessed in eight trials, most of the studies included participants with chronic pain (N=9), some included participants with both acute and chronic pain.

Participants with experience of the tested treatment were included in 8 trials(22, 27, 29, 30, 33, 35, 40, 41) and excluded in four. (24, 34, 37, 39) Remaining studies did not provide this information.

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Interventions

Interventions deferred for number of sessions and number of techniques applied. Generally the trials used a single therapy session (N=11) with a single technique performed (N=8).
Trials with different therapy sessions ranged from 5(23, 24, 28) to 20 (25) sessions once a week.

Sham treatment

ST was provided with a hand contact on the area of pain in 19 studies, five studies provided ST in a different area from where the pain was located. (25, 33, 41, 43, 44)
In trials providing spinal manipulation, as inactive treatment the majority of authors used the similar placement of hands on participants without any force applied. (38-40, 42)
Two trials used a ST with similar forces applied in different directions. (23, 30)
one trial did not specify the inactive manipulation applied. (27)
In trials that provided multiple techniques in the same treatment session (such as osteopathic treatment, spinal mobilization and physiotherapy) the ST was administrated with different techniques that mimed active treatments using light touch or light tractions.
Only one trial compared one single sham technique with both single active technique and multiple treatment techniques. In this case only data of the first arm were extracted. (35)

Manual and controls treatments

Different manual treatments were provided:

- Physiotherapy (2 trials, 288 participants)
- Spinal manipulation (SM)/chiropractic (7 studies, 567 participants)
- Osteopathy (5 trials, 645 participants)
- Kinesiology (one trial, 58 participants)
- Articular mobilizations (5 trials, 325 participants)
- Muscular release (4 trials, 136 participants)

Five trials with multiple arms compared ST to control group (343 participants).

The manual treatment was generally applied in the area of pain, some trials used techniques additionally in other areas. Just one trial using reflexology provided both manual therapy and sham in a different zone. (37)

Characteristics of practitioner who administrated treatments were provided by 16 trials. Most of the trials involved physiotherapists (N=8), physical therapists (N=4), osteopaths (N=3) and students (N=1). Only seven studies provided information on years of practice experience of physicians involved that ranged from 6 to 17 years. (28, 31, 33-35, 38, 40, 42) The gender of practitioners was indicated in only three trials.(24, 28, 35)

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Table 1: summary of main characteristics of included studies

Study ID	N° of participants	Symptoms duration	Pain localization	Technique tested *(site of application)*	Type of sham procedure	Other arms	Follow-up
Antonilos-Campillo PJ 2014	40	Not reported	Cervical	Soft-tissue *(cervical region)*	Soft mobilization of lower limbs	None	No follow-up (outcomes collected after the intervention)
Bialosky J 2014	110	> 4 months	Lumbar	Spinal Manipulation (SM) *(lumbar spine)*	Ineffective force applied on lumbar spine	Control group	2 weeks
Cleland JA 2005	36	>2 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	No follow-up (outcomes collected after the intervention)
Eardley S 2013	58	> 3 years	Lumbar	Kinesiology *(spine)*	Protocol of ineffective techniques in the site of pain	Control group	7 weeks
Erdogmus S 2007	120	≥ 1.4 weeks	Lumbar	Physiotherapy *(spine)*	Neck massage	Control group	1.5 years
Hall T 2004	24	Not reported	Lumbar	BLR technique *(lower limbs)*	Soft-tissue manipulation of the foot	None	24 hours
Haller H 2016	54	> 7 months	Cervical	Cranio-sacral therapy *(head)*	Ineffective touch of head	None	3 months
Hansen F 1993	168	≥ 18 days	Lumbar	Physiotherapy *(lumbar spine and abdomen)*	Intermittent traction of the spine	Intensive back muscle training	1 year
Hidalgo B 2015	32	Not reported	Lumbar	Articular mobilization *(lumbar spine)*	Ineffective mobilization forces applied on lumbar spine	None	2 weeks
Hoiriis K 2004	156	≥ 2,3 weeks	Lumbar	SM *(spine)*	Ineffective force applied on spine	Medical treatment	4 weeks
Klein R 2003	61	>1 month and <5 years	Cervical	Strain-counterstain techniques (*cervical spine*)	Ineffective force applied on cervical spine	None	No follow-up (outcomes collected after the intervention)
Kogure A 2015	179	> 12 months and < 10 years	Lumbar	AKA-H *(sacro-iliac joint)*	Ineffective force applied on sacro-iliac joint	None	6 months
Krekoukias G 2017	50	Not reported	Lumbar	Articular mobilization techniques *(lumbar spine)*	Hand contact with lumbar skin placement without any movement	Exercise plus TENS	5 weeks
Lascurain-Aguirrebena I 2018	40	Not reported	Cervical	Articular mobilization *(Cervical spine)*	Ineffective force applied on cervical spine	None	No follow-up (outcomes collected after the intervention)
Licciardone J 2003	91	≥ 3 months	Lumbar	Osteopathic manual treatment (OMT) *(all body)*	Protocol of light touch techniques similar to OMT	Control group	6 months

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					applied to all body		
Licciardone J 2013	455	≥ 3 months	Lumbar	Osteopathic manual treatment (OMT) – *(all body)*	Protocol of light touch techniques similar to OMT applied to all body	None	8 weeks
Pires FP 2015	32	> 3 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	72 hours
Quinn F 2008	15	Not reported	Lumbar	Reflexology *(foot)*	Foot massage with less pressure and in different reflex point (not related to the spine)	None	18 weeks
Selkow M 2009	20	1-6 weeks	Lumbar	Muscular energy technique *(anterior superior iliac spine and lower limbs)*	Practitioner hand positioned as active treatment but participant rested for 30 seconds without any active contraction	None	24 hours
Senna MK 2011	93	≥ 13 months	Lumbar	SM *(lumbar spine)*	Ineffective force applied on lumbar spine	Maintained SM	10 months
Sillevis R 2010	100	≥ 23 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	No follow-up (outcomes collected after the intervention)
Silva A 2019	28	>3 months	Cervical	Osteopathic visceral treatment *(abdomen)*	Hand contact on umbilical region without any movement	None	7 days
Veira-Pellez F 2014	40	Not reported	Lumbar	SM *(lumbar/sacral spine)*	Ineffective force applied on lumbar/sacral joints	None	No follow-up (outcomes collected after the intervention)
Younes M 2017	17	< 3 months	Lumbar	OMT *(all spine)*	Placebo mimed active treatment with an ineffective force applied.	None	7 days

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Risk of bias in included studies

Figure 2 shows risks of bias.
Blinding of participants and assessors will be described due to the nature of this review.
According to AHRQ standards of CRB tool, (21) the majority of trials were judged with poor quality (N=22). Good quality was conferred on only two studies. (34, 43)
The random sequence and allocation concealment were adequately reported in 71% and 63% of trials respectively.
The lack of blinding of participants was the most common bias and was judged as high risk in 38% of studies, while 38% were considered as unclear risk.
The reasons for this judgment were mainly related to trials involving spinal manipulations. These studies used a technique which can be easily recognized by patients as active treatment for the popping sound emitted by joints. Additionally, these trials involved participants who could have already received this type of treatment, making the masking of technique almost impossible.
Blinding of outcomes was evaluated mainly as unclear risk in 46% of trials. Only two trials reported the strategies adopted to guarantee assessor blinding. (26, 30)
Incomplete outcome data was the least common bias risk with 80% of trials judged as low risk.
Reporting bias was evaluated unclear in 55% of trials where registration number and trial protocol were not reported or found.
Other bias occurred was generally considered at high risk for baseline differences of the population in 30% of trials.

Figure 2: *Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.*

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Effects of intervention

Table 2 summaries treatment effects and GRADE quality of the evidence for all comparisons.

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Table 2: summary of findings of treatment effects and certainty of the evidence (GRADE) included for all comparisons.

1. Sham treatment (ST) compared to Manual Therapies (MT)

Patient or population: back pain
Intervention: ST
Comparison: MT

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with MT	**Risk with ST**				
Pain improvement assessed with: VAS score Scale from: 0 to 100		MD **3.86 higher** (3.29 higher to 4.43 lower)	-	805 (15 RCTs)	⨁◯◯◯ VERY LOW [a,b]	A small effect, not clinically relevant, in pain improvement was detected in favour of MT. This analysis excluded two trials (one suspected of publication bias, one used a different scale) which increased heterogeneity levels but did not affect overall efficacy meaningfully.
Adverse events assessed with: number of AE occurred	144 per 1.000	**121 per 1.000** (79 to 184)	**RR 0.84** (0.55 to 1.28)	531 (6 RCTs)	⨁⨁◯◯ LOW [a]	Pooled data from 6 studies did not show any difference in AE occurrence between ST and MT.
Dropouts rate assessed with: number of participants that leaved the study	174 per 1.000	**171 per 1.000** (134 to 218)	**RR 0.98** (0.77 to 1.25)	1238 (11 RCTs)	⨁⨁◯◯ LOW [a]	Pooled data from 11 trials did not show difference in dropout rate between ST and MT.

2. ST compared to Control

Patient or population: back pain
Intervention: ST
Comparison: control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with control	**Risk with ST**				
Pain improvement assessed with: VAS score Scale from: 0 to 100		MD **6.04 lower** (16.68 lower to 4.59 higher)	-	251 (4 RCTs)	⨁◯◯◯ VERY LOW [a,c,d]	Pooled data from four trials, highly inconsistent, showed no differences between ST and control group in pain improvement.
Dropouts rate assessed with: number of participants that leaved the study	205 per 1.000	**162 per 1.000** (104 to 252)	**RR 0.79** (0.51 to 1.23)	331 (5 RCTs)	⨁◯◯◯ VERY LOW [a,d]	Very low quality of evidence suggests no differences in dropout rate between ST and control.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **MD:** Mean difference; **RR:** Risk ratio

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GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. The majority of trials were judged as poor quality according to AHRQ standards.
b. Most of the studies were small trial.
c. Heterogeneity levels at 80%.
d. Number of participants < 400

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Sham treatment versus other manual therapies

Pain

The following outcomes on back pain are presented with a 100 mm visual analogue scale, 0 to 100; higher scores refer to worse pain. Trials using a 10mm scales were converted to 100mm scores.

The comparison between ST and MT was performed in 17 studies. One trial used a different scale and data were obtained with a conversion formula.(25) Data from seven studies could not be extracted.
The meta-analysis at short-term showed substantial heterogeneity levels using a random-effects model. To further investigate inconsistency levels, a sensitivity analysis excluding two trials was performed. One trial used a different validated scale, (25) while the other was suspected of publication bias.(28) This thought was verified with a funnel plot, which showed an asymmetric distribution with the inclusion of these two studies (***Appendix 3***). This sensitivity analysis did not influence overall effectiveness results but inconsistency levels decreased considerably at short-term. It can be deducted that a possible cause of heterogeneity was found (***Full analysis in appendix 4***).

The sensitivity analysis using a fixed-model at short-term showed a slight difference, not clinically meaningful, between ST and MT in favour of MT on pain outcome (MD 3.86, 95%CI 3.29 to 4.43, 805 participants, I^2=42%, p<0.0001,very low quality of evidence downgraded two levels for very serious risk of bias and imprecision) **(Figure 3).**

Figure 3: *Forest plot of comparison ST versus MT in back pain outcome at short-term.*

Comparisons between ST and MT at medium and long-term could not be performed due to substantial levels of heterogeneity found using a random-effects model. The heterogeneity levels were not explainable by clinical or methodological diversities within trials (medium-term I^2=91% P<0.0001, long-term I^2=81% P=0.005) (***Appendix 4.1***).

Success of blinding

Success of blinding was evaluated in five trials; one did not report the results. (28)
Patients were asked to assess if they understood their treatment allocations. Due to the type of data extracted (percentage of correct guessing) meta-analysis was not performed and results are reported descriptively.
Two trials compared ST with SM, these trials showed a correct perception of treatment allocation that ranged from 63.5% (23) to 83.5%. (27) In this last study patients were considered eligible if they already received SM.
One trial compared ST to an articular mobilization technique. 54.5% participants correctly guessed treatment allocation. (44)

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Participants of one study that compared ST to reflexology had the lowest perception of the correct detection of allocation (46.7%). Participants in this trials were naïve to the type of treatment tested. (37)

Dropouts

Pooled data from 11 trials at the last follow-up suggested no difference in dropouts rate between ST and MT at the end of the trials(105/612 compared to 109/626; RR 0.98, 95% CI 0.77 to 1.25 ; 1238 participants, I^2=0%, P=0.90; low quality of evidence downgraded two levels for high risk of bias) ***(Figure 4)***.

Figure 4: *Forest plot of comparison ST versus MT in number of dropouts outcome*

Adverse effects

Adverse effects were generally under-reported, six trials were included in the meta-analysis.(24-26, 34, 35, 43)
Two trials reported AE overall occurrence without specified event rates in the groups.(22, 30)
AE were predominantly minor and lasted for two/three days after treatment, in the majority of trials transient worse pain, tiredness, muscle weakness and transient headache were reported.(24, 34, 35, 43)
Senna M 2011 reported the most common AE were local discomfort and tiredness but no serious complications were noted. (30)
Haller H 2016 reported two patients dropping out from the trial for recurrent headache after treatments, both Haller H and Klein R 2013 reported dizziness of one patient.
Licciardone J 2013 reported 27% of patients with AE, 2% had serious AE not related to study interventions. (22)

Overall results showed no clear difference in AE occurrence between ST and MT (32/267 compared to 38/264; RR 0.84, 95% CI 0.55 to 1.28; 531 participants, I^2=26%, P=0.42; low quality of evidence downgraded two levels for inconsistency) ***(Figure 5)***.Senna and Licciardone were excluded from analysis because they did not provide separate data for each group.

Figure 5: *Forest plot of comparison ST versus MT in number of adverse events outcome at short-term*

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Sham treatment versus control

Pain

Five studies compared ST to control, four were included in random-effect meta-analysis at short-term. (23-25, 27) Data from one trial could not be extracted. (29)
Pooled data showed the presence of significant heterogeneity, therefore results are reported narratively: three trials showed no difference between ST and control on pain outcome, while Eardley S. 2013 showed an effect in favour of ST (pooled data from 4 trials: MD -6.04, 95%CI from -16.68 to 4.59, 252 participants, I^2= 80%, P=0.27). The exclusion of Erdogmus S 2013 (that used a different scale) did not affect the results of effectiveness but decreased levels of heterogeneity (MD -9.72, 95%CI -19.94 to 0.51, $I^{2=}$ 69%, P=0.12) (***Appendix 5***).

Dropouts

No differences were showed in the fixed-effect meta-analysis on dropout rate between ST and control in five trials (27/165 compared to 34/166; RR 0.79, 95% CI 0.51 to 1.23 ; 331 participants, I^2=0%, P=0.30; very low quality of evidence downgraded two levels for very serious risk of bias and imprecision) ***(Figure 6)*** .

Figure 6: *Forest plot of comparison ST versus control in number of dropouts outcome*

Adverse effects

Of the five studies comparing ST and control, only two reported AE.
One, Eardley S 2013, did not evaluate the AE occurred in control group while Erdogmus C 2007 reported that 10/40 in the control group and 11/40 in ST group turned to other therapies for complains.

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Discussion

Results show a small, not clinically meaningful effect in favour of MT for short-term pain relief compared with sham treatment. However, the quality of evidence is very low, indicating that the true effect is probably markedly different from the estimated effect. Substantial levels of heterogeneity within the four studies analysed, showed no differences between sham treatment and control in pain reduction

Success of blinding was reported in four trials that compared sham treatment to MT, with high percentage of correct detection of treatment allocations by participants.

AE were generally under-reported, with a similar rate of occurrence between sham and MT accompanying low levels of heterogeneity. Only one study reported AE in control group with no significant difference from ST.

The performance bias was the bias that recurred most with a possible or unclear presence of lack of participants blinding in 76% of the studies included in this review.

SM techniques were the treatment most evaluated (N=7). These techniques are highly recognizable by patients for a popping sound emitted by the column during their performance.(45)The fact that participants enrolled in these trials were eligible despite having already received SM, threatens the validity of blinding. This thought is strengthened by the high percentage of participants who recognized treatment allocation in this kind of trial (from 63.5% to 83.5%). (23, 27) Additionally, five trials applied sham treatment in a different site compared to pain and active treatment. This might have had important influences on sham therapy reliability and consequently to study results.

Reliability of sham therapy seemed not to be related to dropouts rate, although both these data were reported only in two trials. Bialosky J and Hoiriis K showed high percentages of correct treatment allocation detection by participants but dropout rate between sham and MT group did not differ. These results seem to be in conflict, nevertheless, participants could have wanted to remain in the trial for several other reasons such as settings or being evaluated by an expert clinician free. This possibility is reinforced by the fact that a similar dropout rate was reached in the comparison sham versus control. These data suggest that dropout rate might not be a dependable outcome for assessing reliability of sham therapy. The majority of trials judged as at high or unclear risk of performance bias used a single technique evaluating its effects on pain soon after its performance, or its effect after different sessions. Single techniques were generally more difficult to mask, negatively affecting the validity of blinding of participants. Moreover, it should be asked what result can be achieved with the application of a single technique in a single therapeutic session and if the possible changes detected could be clinically meaningful and long-lasting for the enrolled patients.

This review included generally small trials. Only 14 of 24 studies performed a sample size calculation but just two of these considered MCID in this computation. The MCID is the measure of smallest change of PROs that patients perceive as important, beneficial or harmful. MCID is useful for clinicians to interpret the findings of trials and apply them in clinical practice and to their decision-making. (46) An adequate sample size calculation, using MCID especially in trials with PROs, is fundamental to assess the number of participants needed to detect clinically relevant treatment effects. Oversized trials, which expose too many people to unnecessary therapies, or underpowered trials, which may not achieve significant results, should be avoided. (47-49)

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Our results are similar to other reviews findings, notwithstanding that these reviews did not consider the difference between kinds of ST provided (hand contact or machines) and evaluated the effect of a singular type of MT (such as SM or OMT) compared to sham treatment.(50, 51)

Limitations

This review aimed to compare different kinds of sham therapy with different kinds of MT and control. The nature of this comparison needed an NMA, but this analysis could not be performed due to the small number of trials using hand contact ST. The decision to include only this kind of sham therapy was mainly due to the intention of analysing the effect of manual interaction between practitioner and patients, which is suspected of leading to an amplified placebo effect. (52) Additionally, the use of machine placebo trials in the same meta-analysis could have increased diversity within trials included due to the possible enhanced presence of biases such as performance and consequently detection ones.

Although the population differed - some trials analysed cervical, others lumbar pain with different aetiologies and different symptoms duration - this factor did not affect the meta-analysis performed, as highlighted by the low heterogeneity found in the primary outcome. As already suggested by other authors, (1) placebo effect might be influenced by chronic pain, nevertheless, in this review, this analysis could not be performed due to the range of pain duration in trials included (from acute to chronic in the same trial).

Data concerning settings and operators were insufficient to evaluate the influence of these two factors on sham therapy response. Experience of practitioners was considered in data extraction but insufficient information was provided by authors to draw any hypothesis. Another limit was in not considering non-objective outcomes as primary outcome for meta-analysis. Nevertheless, most of the trials included did not evaluate an objective outcome and the few studies which analysed this type of outcome used different kinds of scales not easily comparable in a meta-analysis.
Pair-wise comparison on pain outcome between sham and MT showed slightly higher effects of MT in trials where blinding was ensured. A linear regression analysis was planned to assess the impact of blinding on meta-analysis results. Due to the small number of trials, this analysis could not be performed. This trend follows what has been already suggested by other studies. (53) However trials with bigger sample size are needed to assess a real correlation between these two factors.

Another limit of this study is that risk of bias was assessed by one author (CL) and agreed by another (MG). This aspect could have improved if both authors worked independently on bias risk assessment and then discussed any discrepancy.

Implications for practice and research

There is very low quality of evidence that sham compared to MT might be less effective and equally safe in the treatment of patients affected by back pain. Future studies should address

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meaningful research question and improve their methodological properties to ensure patients safety and to guarantee reliability of study results

Researchers should pay particular attention to sample size calculation using the MCID. This difference is fundamental both for research and patients. MCID indicates patients' values and preferences and can help clinicians improve interpretation and promote the understanding of the importance of intervention effects in RCTs.
Although in MT trials a true placebo is difficult to achieve, trials should also implement strategies to guarantee patients and assessors blinding, for example avoiding the inclusion of participants who already received the active treatment. Plans to avoid performance bias, such as giving similar treatment with similar localization have to be implemented.
Moreover, the evaluation of the success of blinding should be considered as, at least, secondary outcome.
Future researches should also evaluate the real effects of ST comparing it both with active treatment and to control groups. Only with this kind of design the real placebo effect in MT could be defined.

Trials should also focus on including participants with similar characteristics such as duration of symptoms (acute or chronic pain).
The majority of studies included in this review used a single technique treatment (N=11), however the clinical relevance of demonstrating the effectiveness of a singular technique is not clear. In a clinical context, most manual treatments usually involve different kinds of techniques in the same treatment session, so trials that evaluate the effectiveness of a type of treatment should include a routine of techniques in order to be more similar to clinical approaches.
Studies should also consider using objective end points, not patient-reported or observer-reported, with a longer period of follow-up. All these design implementations might not have a great impact on the demonstration of effectiveness of MT in BP, nevertheless, addressing meaningful researches questions, closer to the therapeutic context, could probably help to assess the real clinical effects of sham and MT.

Conclusions

This review aimed to evaluate ST effect in MT trials. Although MT showed higher efficacy than ST, these findings were not clinically meaningful and the very low quality of the included studies might undermine the reliability of this reviews' results.

The use of ST and its application in MT study is very controversial. Future trials should focus on developing a reliable kind of sham procedure similar to the active treatment, to ensure participants blinding and to guarantee a proper sample size for the detection of reliable, clinically relevant, treatment effects.

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Contributors:
CL conceived the idea of this review and designed the study with the contribution of *MG* who also helped in literature search and in the interpretation of study findings. *CL* and *MG* revised studies, performed data extraction and analysis and wrote this review.
AA and *AM* provided clinical and technical support, reviewed the manuscript and helped in publication and with the clinical interpretation of study findings.
CL is the guarantor of this paper. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.
Patients and public were not involved in this project.

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Data sharing: Details of the characteristics of the included studies and data extracted are available from the corresponding author at carolina.lavazza@docenti.aimoedu.it.

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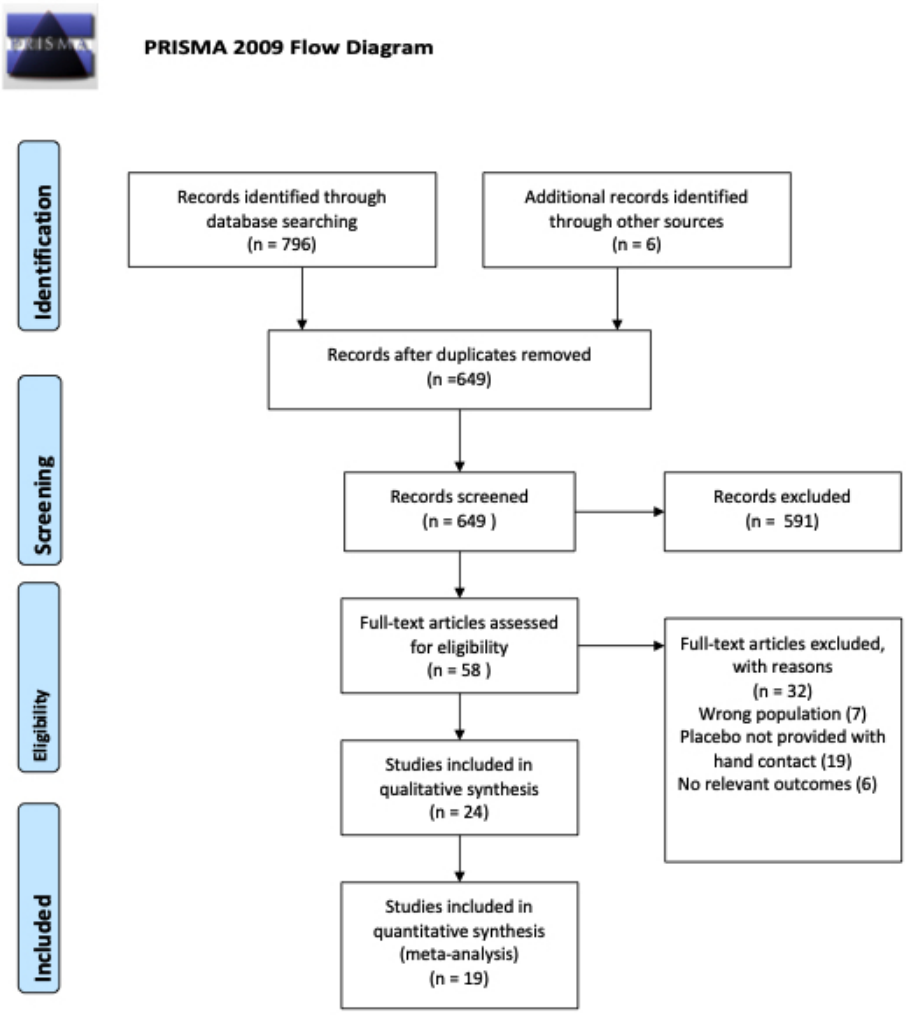

Figure 1: PRISMA flow diagram

48x56mm (298 x 300 DPI)

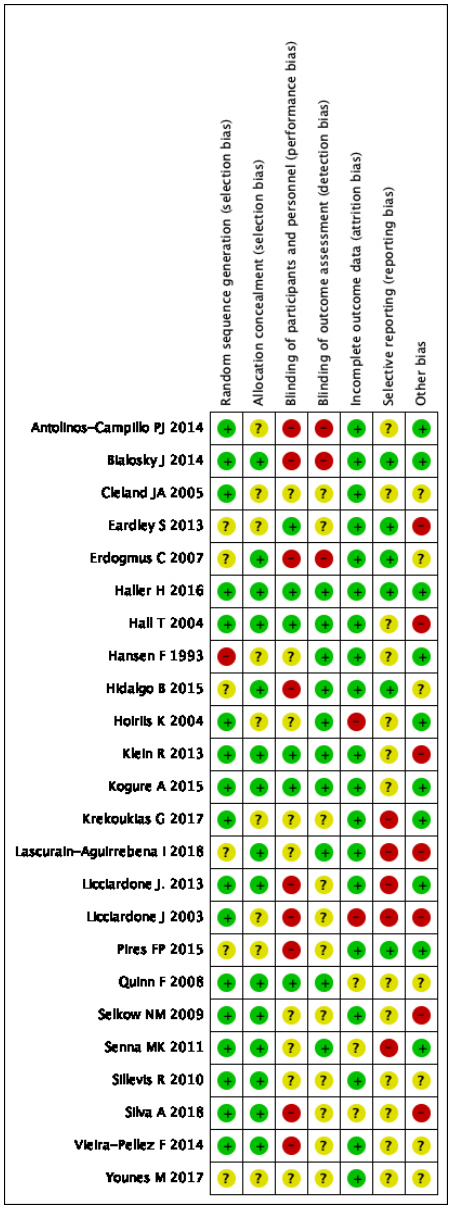

Figure 2: Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.

34x93mm (298 x 299 DPI)

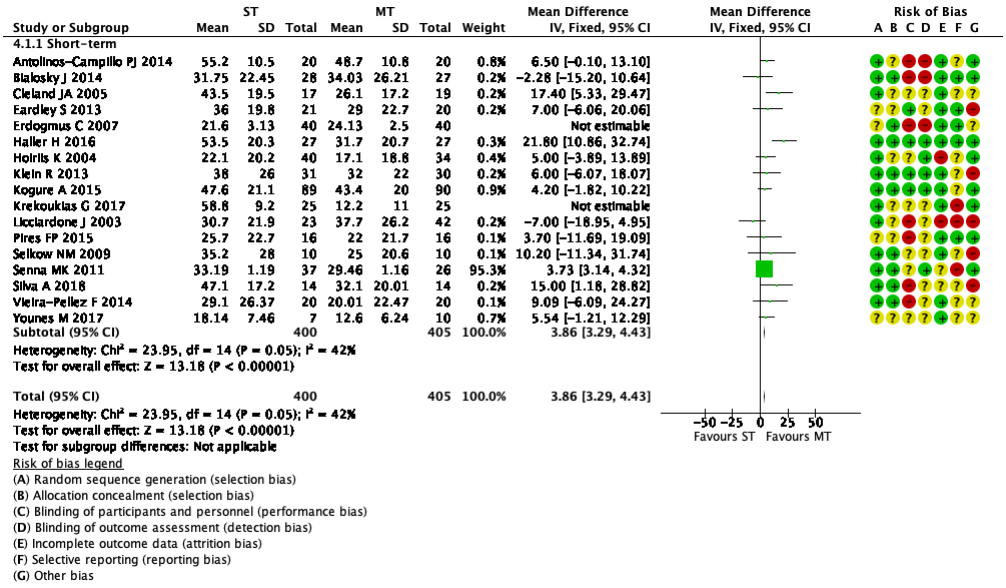

Figure 3: Forest plot of comparison ST versus MT in back pain outcome at short-term.

84x50mm (300 x 298 DPI)

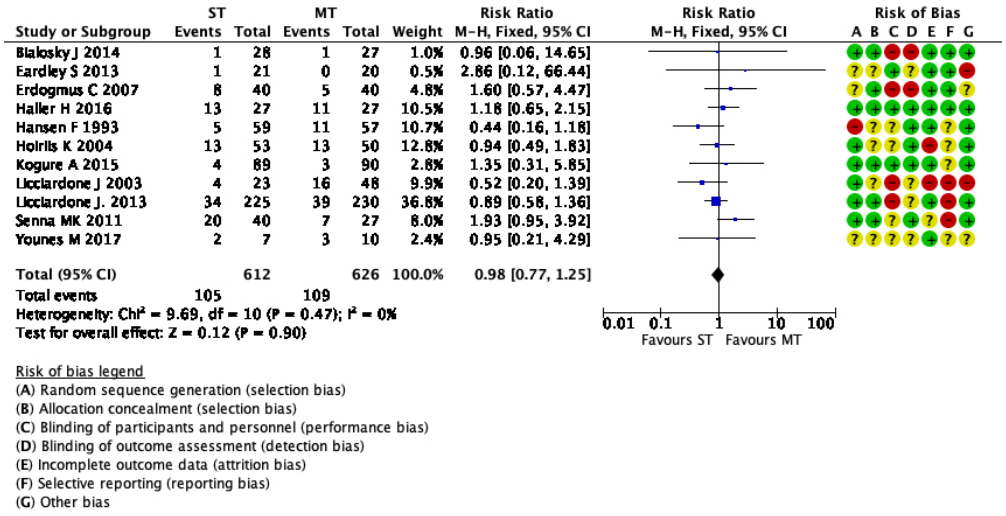

Figure 4: Forest plot of comparison ST versus MT in number of dropouts outcome

72x38mm (299 x 299 DPI)

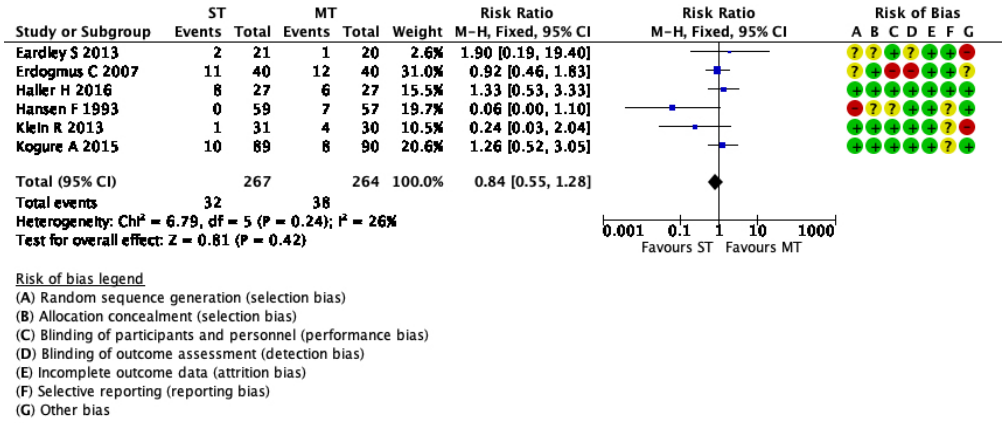

Figure 5: Forest plot of comparison ST versus MT in number of adverse events outcome at short-term

72x31mm (299 x 298 DPI)

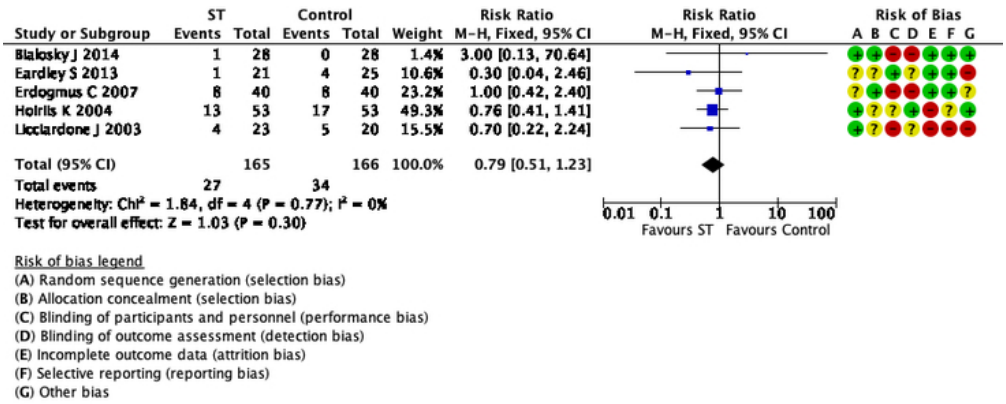

Figure 6: Forest plot of comparison ST versus control in number of dropouts outcome

61x25mm (300 x 300 DPI)

Appendix 1: search strategy

Medline

1. Mesh descriptor: [Back Pain] explode all trees
2. dorsalgia/
3. backache
4.(neck OR cervical) adj1 pain → Mesh
5. exp Brachial Plexus Neuropaties
6. exp Lumbar Plexus Neuropaties
7. Neck Pain/
8. neckache
9. Torticollis/
10. whiplash.mp
11. cervicodynia.mp
12. spondylitis/ OR spondylosis/ OR spondylolysis/ OR spondylolysthesis
13.(lumbar OR dorsal OR neck OR cervical OR sciatica) adj2 (pain OR ache)
14. (lumbar OR dorsal OR neck OR cervical) adj2 (discitis OR disc adj 1 herniation OR disc adj1 herniation)
15. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14
16. (PLACEBO* or MOCK* or SHAM* or FAKE* or VEHICLE* or DUMM* or ATTENTION* CONTROL* or PSEUDO* TREAT* or UN?SPECIFIC* or NON?SPECIFIC* OR simulat$ treatment OR inert agent)
17. Chiropractic/
18. Manipulation, Chiropractic/
19. chiropract$.tw.
20. (manual adj2 therap$).mp
21. spinal manipulation.mp. or Manipulation, Spinal/
22. osteopath$.tw.
23. Osteopathic Medicine/
24. Physical Therapy Modalities/ or “Physical Therapy (Specialty)”/ or physical therap$.tw. or physiotherap$.tw.
25. myotherapy.mp
26. shiatsu.mp
27.exp Therapeutic Touch/
28. exp Massage/
29. (neuromuscular adj therapy).mp
30. 17 OR 18 OR 19 OR 20 OR OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29
31. pain
32. range of motion
33. ROM
34. 31 OR 32 OR 33
35. Clinical Trial/
36. Randomized Controlled Trial/
37. controlled clinical trial/
38. exp RANDOMIZATION/
39. PLACEBO/
40. (random$ adj2 allocat$).tw.
41. single blind$.tw.

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42. double blind$.tw.
43. placebo$.tw.
44. 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43
45. animals/
46. humans/
47. 46 NOT 45
48. 15 AND 16 AND 30 AND 44 AND 47

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Appendix 2: data extraction form

Methods	**Trial Design** **Settings**
Participants	**Total number of participants:** **Age**: **Gender(M/F):** **BMI:** **Activity:** **Duration of the symptoms:** **Location of pain (**one-sided, double-sided, central, cervical, dorsal or lumbar)**:** **Cause of pain:** (e.g. disc herniation, contractures, aspecific pain) **Previous experience of the treatment provided:** Y/N/ N/A **Inclusion and exclusion Criteria:** **VAS:** **Practitioner characteristics**: (years of experience, gender)
Interventions	**Placebo:** **Comparator:**
Outcomes	**Outcomes used in the meta-analysis:** **Length of follow-up:**
Notes	**Difference between Placebo and active treatment:** **Placebo check for reliability:** **Adverse event:**

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	Lost to follow-up: **Funding source:**

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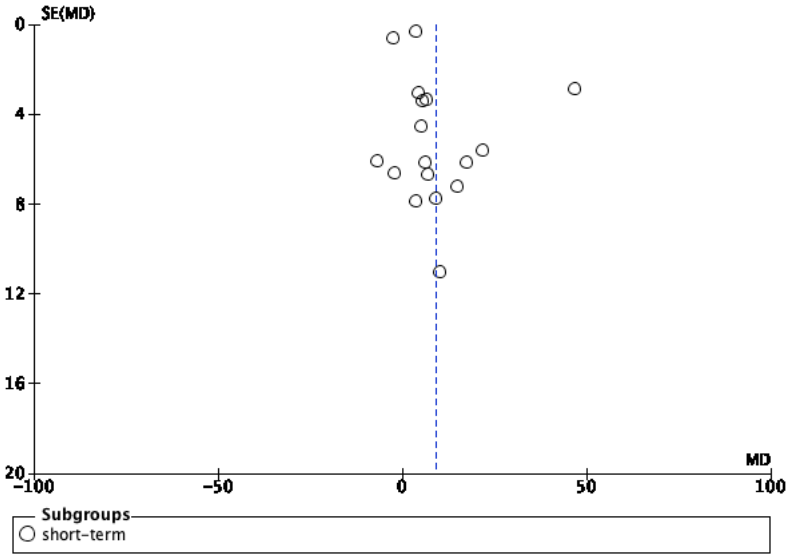
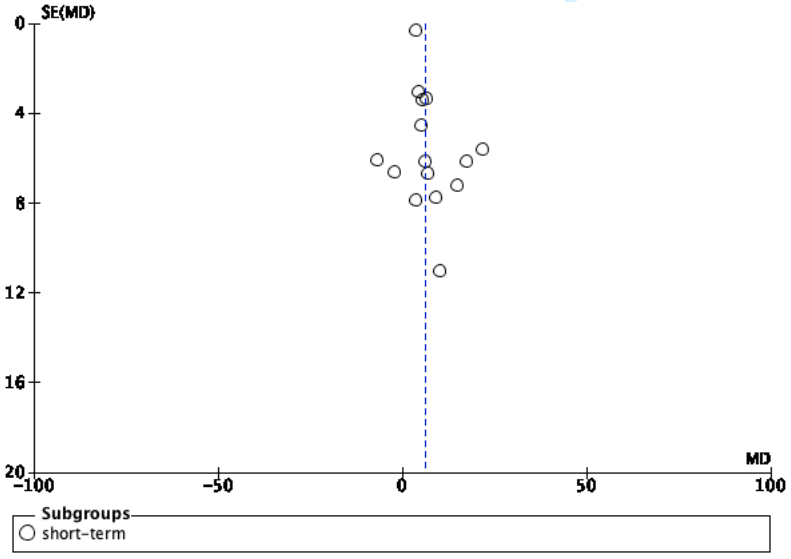
Appendix 3: funnel plot of pain outcome with the inclusion (A) and with the exclusion (B) of two studies of Erdogmus C and Krekoukias G.

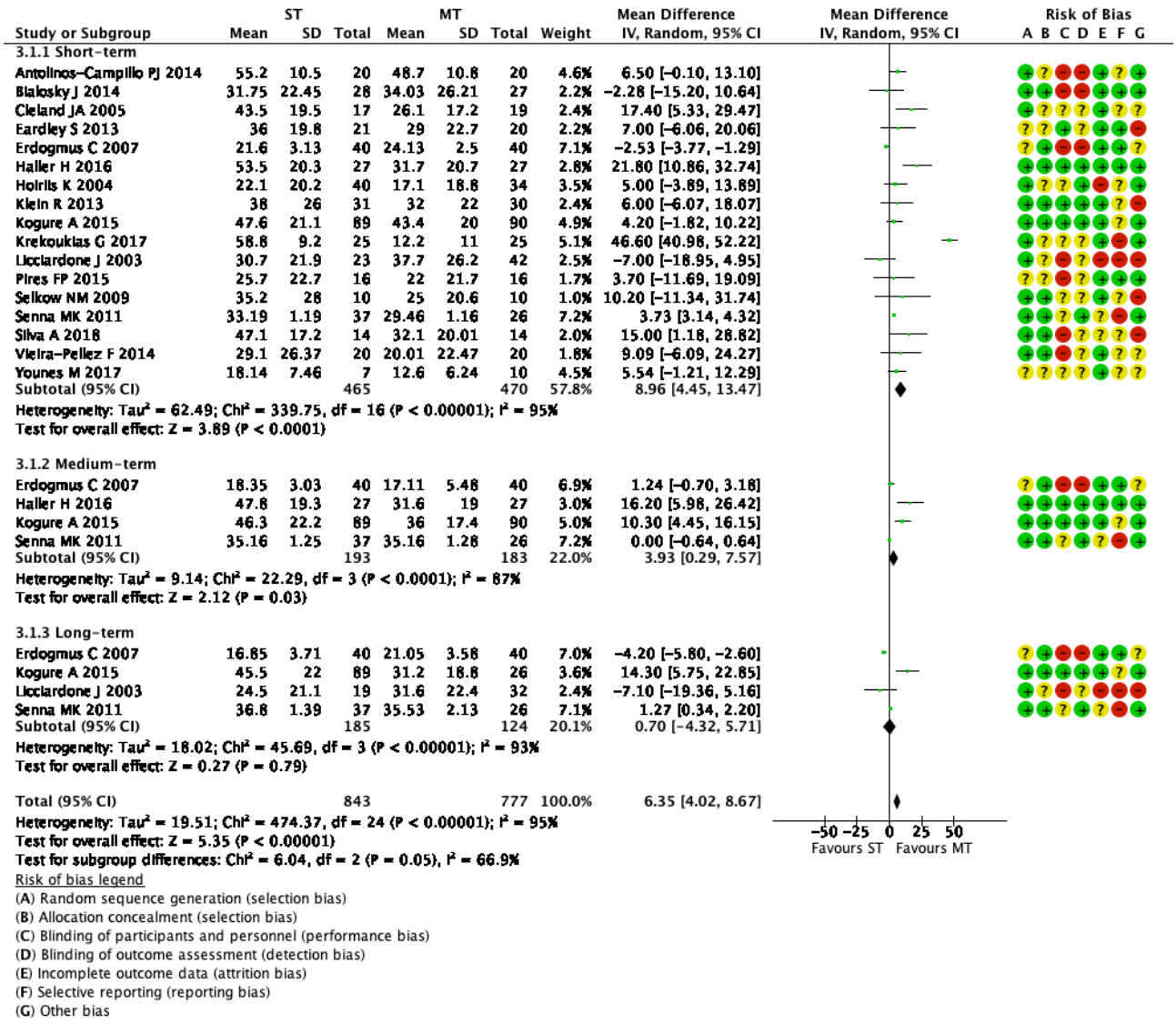
(A)



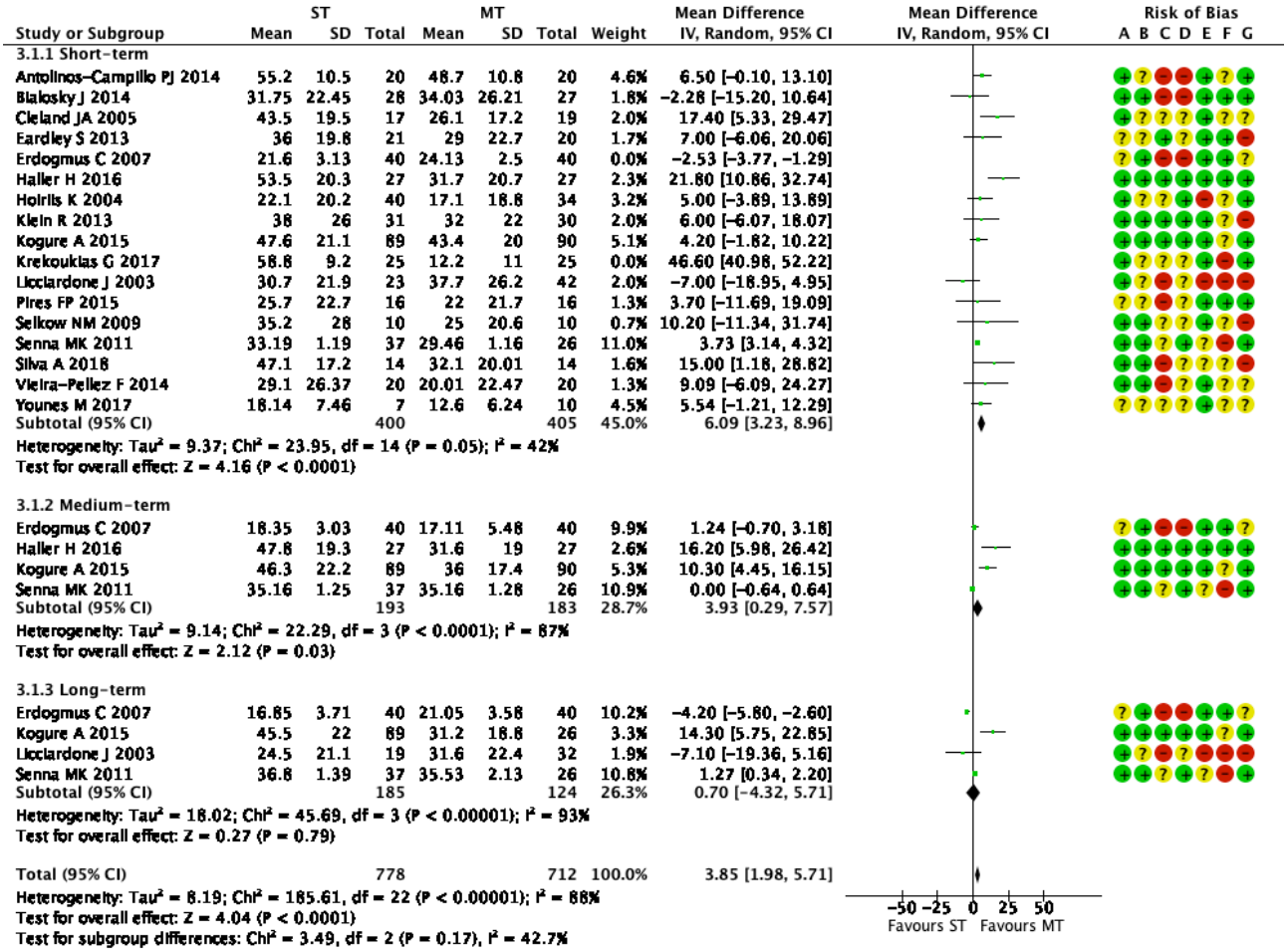
(B)



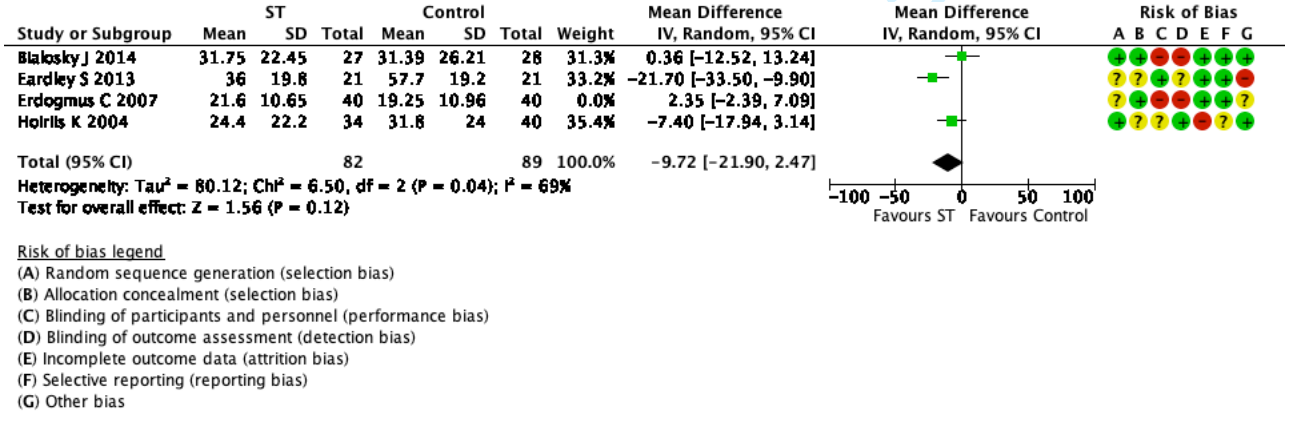
Appendix 4: forest plot of comparison pain outcome sham treatment vs manual therapies with the inclusion of two trials (Erdogmus C and Krekoukias G) at short, medium and long-term.



Appendix 4.1: Sensitivity analysis with the exclusion of Ergogmus C and Krekoukias G at short, medium and long-term



Appendix 5: forest plot of comparison ST versus control in back pain outcome at short-term with exclusion of Erdogmus C 2007 trial



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Page 5
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Pages 9-10
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Page 10
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Pages 6 and 10
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Pages 10-11
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Page 11
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Page 12
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Page 12
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Page 12-13
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Page 12
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Pages 12-13

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PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Page 13

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Pages 12-13
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Page 13
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Page 15
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Pages 16-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Page 20, figure 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Pages 21-23
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Pages 7-8
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Pages 20-figures 2,3,4,5,6
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Appendices 4-6
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Pages 7-8, 24
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Page 25
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Page 26
FUNDING			

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PRISMA 2009 Checklist

Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Page 2

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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Sham treatment effects in manual therapy trials on back pain patients: a systematic review and pair-wise meta-analysis

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Title	Sham treatment effects in manual therapy trials on back pain patients: a systematic review and pair-wise meta-analysis
Author's name	Carolina Lavazza (0000-0002-9907-6819), Margherita Galli (0000-0003-4050-3131), A Abenavoli (0000-0001-8941-2308), A Maggiani (0000-0002-7980-9405)
Address for each author Separate each part of address with a comma (don't use a separate line for each part) Please include postcodes **Authors' names and positions** Use same style of name as below title Please give one job position for each author, (under the relevant address) on separate line from author's name	Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, Carolina Lavazza associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, Margherita Galli associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, A Abenavoli associate professor, Department of Research AIMO institute, Piazzale Santuario 7, 21047 Saronno, Italy, A Maggiani professor
Corresponding author	Correspondence to: carolina.lavazza@docenti.aimoedu.it

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Acronyms

AE = adverse effects
BP = back pain
CI = confidence intervals
CRB = Cochrane risk of bias
CT = clinical trial
MA = meta-analysis
MCID = minimal clinically important difference
MD = mean difference
MT = manual therapies
OMT = osteopathic manipulative treatment
PROs = patient-reported outcomes
RCT= randomised controlled trial
RR = risk ratio
SM = spinal manipulation
ST = sham treatment

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ABSTRACT

Objective:
To assess the effects and reliability of sham procedures in manual therapy (MT) trials in the treatment of back pain (BP) in order to provide methodological guidance for clinical trial development.

Design: systematic review and meta-analysis

Methods and analysis:
Different databases were screened up to 20 August 2020. Randomized controlled trials (RCTs) involving adults affected by BP (cervical and lumbar), acute or chronic, were included.
Hand contact sham treatment (ST) was compared to different MT (physiotherapy, chiropractic, osteopathy, massage, kinesiology and reflexology) and to no treatment. Primary outcomes were BP improvement, success of blinding and adverse effect (AE). Secondary outcomes were number of dropouts. Dichotomous outcomes were analysed using risk ratio (RR), continuous using mean difference (MD), 95% confidence intervals (CI). The minimal clinically important difference was 30 mm changes in pain score.

Results:
24 trials were included involving 2,019 participants. Very low evidence quality suggests clinically insignificant pain improvement in favour of MT compared to ST (MD 3.86, 95% CI 3.29 to 4.43) and no differences between ST and no treatment (MD -6.04, 95% CI -16.68 to 4.59).
ST reliability shows a high percentage of correct detection by participants (ranged from 46.7% to 83.5%), spinal manipulation being the most recognized technique.
Low quality of evidence suggests that AE and dropout rates were similar between ST and MT (RR AE=0.84, 95% CI 0.55 to 1.28, RR dropouts= 0.98, 95% CI 0.77 to 1.25). A similar dropout rate was reported for no treatment (RR=0.79, 95% 0.51 to 1.23).

Conclusions:
MT does not seem to have clinically relevant effect compared to ST. Similar effects were found with no treatment. The heterogeneousness of sham MT studies and the very low quality of evidence render uncertain these review findings.
Future trials should develop reliable kinds of ST, similar to active treatment, to ensure participant-blinding and to guarantee a proper sample size for the reliable detection of clinically meaningful treatment effects.

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Strengths and limitations of this study

Strengths

This systematic review and pair-wise meta-analysis:

- summarises existing evidence on the effect, reliability and application of hand contact ST in MT RCTs;
- gives suggestions for researchers on conducting methodical RCT in MT using a reliable sham procedure.

Limitation

- Settings and practitioner influences on ST effects were not analysed due to lack of data;
- The number of studies included was insufficient to assess the impact of lack of blinding on ST effects.

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Background

In Clinical Trials (CT), a placebo is commonly used as a control therapy to evaluate the clinical effectiveness of the treatments tested. (1) Placebo has been defined as "an inert substance or sham procedure that is provided to research participants with the aim of making it impossible for them, and usually the researchers themselves, to know who is receiving an active or inactive intervention." (2) Placebo interventions are methodological tools used to treat participants in the study arm and the control arm in exactly the same way, except that the study group receives an active substance and the control group does not.
In Europe, its use in pharmacological CT has been regulated by CT Regulation No. 536/2014. According to this regulation, placebo must be treated as an Investigatory Medical Product (IMP) and as such it has to meet certain standards in order to ensure quality , guarantee patient safety and the reliability of the study results. (3)
The regulatory aspects of trials involving Manual Therapies (MT) are very different. Although such studies might be influenced by the type of placebo provided, no clear guidelines or regulations have been developed to ensure the credibility of trial results and patient safety.
MT is a clinical approach used by different physical therapists and involves hands-on techniques to manipulate, mobilise and massage the body tissues. This type of therapy can help relieve pain and stiffness, promote relaxation of soft-tissues, enhance blood supply to tissues and increase mobility of joint structures. (4)
In MT trials, placebo treatment is often provided in different modalities from trial to trial although the manual techniques or treatments tested are the same. A true placebo does not exist for MT and testing the effectiveness of MT requires a sham intervention. For instance, sham treatment (ST) is commonly administrated as a light touch in the site of pain or as an active treatment in a different site, (5) with no clear criterion. Such light touch might in fact have a health effect and there is no evidence as to its ineffectiveness. Touch itself could have a positive outcome on health (6) and active treatments could have an analgesic reflex on pain even if administered elsewhere in the body. (7)

Placebo effect, also called placebo response, is the reported improvement in symptoms among patients that occurs as a result of the placebo administration. Since a placebo has no inherent therapeutic power, it cannot cure the disease but it may contribute to the relief of patients' symptoms such as pain. (8) Additionally, placebo might be related to an adverse effect called nocebo. It has been estimated that up to 26% of patients in randomized control trials (RCTs) discontinue placebo due to adverse effects (AE). (9)
It is thought that these psychobiological phenomena may be related to the overall therapeutic context, such as treatment environment, individual patient and clinician factors (e.g. beliefs, desire for symptom changes), as well as the patient's expectations of improvement and prior experiences of the treatment. (10-13)
In pharmacological trials this overall therapeutic context and its influence on placebo response has been widely studied. (11) Less evidence is present for MT trials, where the tactile interaction could be considered as an important characteristic of this therapeutic context. (14, 15) Pharmacological trials avoid the influence of clinicians' beliefs by using a placebo that ensures both patient and clinician blinding to treatment allocation, but, in MT trials, the blinding of clinicians is impossible to achieve. The best alternative in this type of trial is the use of a ST that mimics the active treatment and aims at blinding of participants.

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Another important factor that has to be taken into account is that RCTs involving MT usually use patient-reported outcomes (PROs) - such as pain - as primary outcomes. Studies suggested that physical placebo treatments might have a greater effect on these types of outcome compared to pharmacological placebo and that this effect might be a consequence of physical contact. (1, 16, 17)
Moreover, especially when subjective PROs outcomes are used, the absence of clinician blinding could also increase the possibility of performance bias. (14)
Therefore, a better understanding of sham procedures in manual treatment would be fundamental to define the real difference in efficacy between manual and sham treatment, with a better knowledge of the effect of manual contact on PROs such as pain relief and dropouts.

The role of placebo – referred to as sham therapy in this review - in MT trials is still very confused and the lack of guidelines allows huge discrepancies in its use in RCTs. Additionally, the reliability of sham procedures in MT trials has been rarely evaluated.
A clear definition of placebo effect could improve trial design, implementing studies with a proper power and sample size, defining clinical relevance of MT and giving more reliability to study results.
The aim of this systematic review with pair-wise meta-analyses is to evaluate the use of ST in MT trials in order to analyse the effects, possible harm and the reliability of different kinds of sham procedures provided in RCTs involving MT. A systematic review could help to define sham treatment standards to be applied in CT in order to guarantee methodological quality and patient safety.

Objective
To assess the benefits, potential harm and reliability of ST in MT RCTs in the treatment of back pain - both cervical and lumbar - in order to provide methodological guidance for clinical trial development.

Methods

This systematic review and meta-analysis was performed following the Preferred Reporting Items for Systematic Reviews (PRISMA). (18)
The protocol registration was performed in PROSPERO (http://www.crd.york.ac.uk/PROSPERO/) and review registration number is ***CRD42020198301.***

Criteria for considering studies for this review

Only RCTs were included in this review. Quasi-randomised trials in which allocation was not strictly random (e.g. date of birth or toss of a coin) were excluded. No restrictions were applied to language or setting.
Studies were considered eligible if they included adult participants with acute or chronic back pain including coccyx, lumbar, dorsal and cervical. Trials where pain was related to muscular conditions, articular disorders (such as osteoarthritis) or spinal disc herniation were included. Trials where musculoskeletal diseases were secondary to other pathologies (e.g. amyotrophic lateral sclerosis, fibromyalgia etc.) were excluded.

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Trials where pain was related to fracture, surgery, dysmenorrhoea, post-partum or pregnancy, headache or dizziness were excluded.
This review involved all types of ST that include **hand contact** provided by all kinds of physical therapists. Studies where ST was provided by machines (such as inactive ultrasound) were excluded. This choice was based on the fact that many MT used detuned ultrasound as control. This type of sham was not considered adequate for MT trials where active treatment is provided by hand contact. Therefore, these studies were excluded.
All trials that involved hand contact ST as light touch or a manual treatment in a different site were included.
ST was compared to other MT provided by any type of health care provider such as: physiotherapist, chiropractor, osteopath, massage therapist, kinesiologist and reflexologist.
To assess if touch itself could have a positive health effect, ST was also compared to no treatment. Physiotherapeutic exercises were included in the analysis only if associated with manual treatment.
The use of active co-interventions such as oral NSAIDs or other active treatments was accepted if used in all trial arms. Trials with more than two arms of intervention were included, but only data from interested arms were extracted.

Outcomes

Primary outcomes were pain intensity on a validated scale, success in the blinding of participants and AE. Secondary outcomes were number of dropouts.
Whenever the meta-analysis could not be performed, a narrative summary of the outcomes has been provided. Outcomes were divided into short (≤2 months), medium (≤4 months) and long-term (≥6 months). Data were extracted and analysed based on the time closest to these intervals.

Information sources

Search strategy (***Appendix 1***) was adapted to the different databases by an experienced information specialist.
RCTs were identified in different databases (up to 20 August 2020): MEDLINE, Embase, CINAHL, SPORTDiscus, PEDro, World Health Organization Clinical Trials Registration Platform, Index to Chiropractic Literature, Cochrane central register of controlled trials (CENTRAL), Clinical trials registry and metaRegister of Controlled Trials (mRCT).
Researchers of unpublished trials, but completed and registered, were contacted by *CL* to obtain data.

The search in PROSPERO, in the Cochrane Library and in PubMed (clinical queries) was performed to evaluate the presence of on-going or recently completed systematic reviews. Guidelines from different organisations (e.g. National Council for Osteopathic Research etc.) were reviewed and references from relevant publication were analysed.

Data collection and analysis

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Search results were screened by two independent reviewers who identified all the potentially eligible trials based on title and abstract. Full-texts of all the selected articles were screened firstly for inclusion. If full-text was not available, or the trial was completed but not published, *CL* contacted the authors in order to obtain the information needed or used the document delivery service of the 3Bi Biella library.
Uncertainty about the inclusion of a study was discussed by the two reviewers. If no agreement was reached by the two reviewers a third reviewer (*AM*) was asked for their opinion.
The selection process was recorded and reported through a PRISMA flow diagram.

Data extraction and management

Data extraction was performed by two reviewers with a tested pre-defined form. Data extracted were related to settings, type of study, participants characteristics (such as localization and duration of pain, pain score at baseline, previous similar treatment), interventions, outcomes used in the meta-analysis and other relevant data such as difference in ST and active treatment or funding. (***Appendix 2***)

Risk of bias in individual studies

Bias risk was assessed by *CL* and agreed by *MG* using the Cochrane Risk of bias (CRB) tool. (19) This tool was used to assess selection bias, performance bias, attrition bias, reporting bias and other biases.
Each possible risk was evaluated as “high”, “medium” or “low” by *CL* and a revision of the judgments was performed by *MG*. RevMan 5.3.5 was used for the graphic representation of each risk. The CRB tool results were then converted to AHRQ Standards to assess the quality of the study (Good, Fair, and Poor). Trials were judged as good quality when bias risk was judged as low, studies with fair quality were trials where at least one criterion was high risk, while poor quality studies were trials with two or more criteria with high or unclear risk.

Assessment of reporting biases

Funnel plots were created to explore reporting bias, whenever more than 10 studies were included in the meta-analysis. Furthermore, for each study, an analysis of possible conflicts of interest and funding sources was performed.

Summary measures

Dichotomous outcomes, such as AE (occurred or not), were analysed using risk ratio (RR) with 95% confidence intervals (CI).
Continuous outcomes, such as back pain on VAS scale, were evaluated using mean difference (MD) between ST and the MT/no treatment group with 95% CI and the standard deviation (SD). The minimal clinically important difference (MCID) between pre- and post-treatment was taken as 30 mm changes in 100 mm pain score. (20-22) These values were used for the interpretation of the clinical significance of the findings.
Success of blinding was reported with a percentage of patients guessing correctly the treatment allocation.

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In this review the unit of analysis was the participant.

Assessment of heterogeneity

The presence of heterogeneity was assessed with a visual inspection of the forest plots and through an inconsistency level test (I^2).
Cochrane Handbook was used for threshold interpretation: heterogeneity was considered as unimportant for values of I^2 between 0% and 40%, as moderate for values between 30% and 60%, as substantial for values between 50% and 90%, and considerable for values between 75% to 100%. (23)

Synthesis of results

Meta-analysis of pain score, AE and dropout rates were performed using RevMan 5.3.5 whenever possible. The meta-analyses compared all kinds of ST with all types of MT and to no treatment. Random-effect model was used when a substantial inconsistency was present (I^2= 50-90%). (20) When considerable heterogeneity was present (I^2>75%) and could not be explained by clinical or methodological diversity, the results have been presented narratively. The statistical significance of measured effects was determined evaluating the p-value and 95% CI.

Additional analyses

Different subgroup analyses were planned in the protocol such as on ST type provided (applied locally or in different sites from pain), type of manual technique tested (single or multiple techniques) and localization of back pain. However, due to the small number of studies included in this review, only a few subgroup analyses were conducted on follow-up periods. Sensitivity analysis was conducted for the primary outcomes to assess the effects of skewed and imputed data on the effect measure. These analyses are reported as appendices.

Summarizing results and assessing the quality of the evidence

The quality of evidence for each outcome was evaluated with the GRADE approach by two independent authors and any disagreement was discussed. The quality for each effect measure was judged as high, moderate, low or very low. (19) The GRADE approach was used to assess the quality of the key outcomes. The software GRADEpro (https://gradepro.org) was used to import data from RevMan 5.3.5 and to create “summary of findings tables”.
The following outcomes were chosen to be presented: pain scores at short-term, AE and dropouts.

Patient and Public Involvement

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There was no involvement of patients or public during the outline of this project. The differences noted between therapies tested on primary pain outcome were those clinically meaningful to patients.

Results

Figure 1: *PRISMA flow diagram*

Included studies

Table 1 shows a summary of the main characteristics of included studies.
24 studies were included in this review (***Figure 1***), one study had a 2x2 factorial design, (24) eight studies had multiple arms. (25-32) Most of the studies were conducted in physical therapy clinics, in 13 different countries. Three trials did not report in which clinical setting they were conducted. (29, 33, 34)
Eight trials were conducted in Europe, (27, 28, 30, 35-39) five in the United States, (24, 25, 31, 40, 41) three studies in Brazil, (42-44) one in the UK, (26) Egypt, (32) Japan (45) and Australia. (46)
No ongoing or unpublished trials were found.

Population

The included trials randomized a total of 2,019 participants, the majority of studies (N=18) were small with a median of 50 participants and a range from 15 to 455.
Most trials included middle aged patients (mean 39.9 range from 18 to 73) with a mean BMI of 21.7 kg/m^2.
The majority of studies included both genders, with a percentage of male that ranged from 19% to 80%. Two trials included only male, (38, 44) one study included only female participants. (42)

16 trials enrolled participants with low back pain (LBP), eight included participants with cervical pain (CP). (26, 33, 35-37, 40-42)
The majority of trials (N=18) included participants with unspecified cause of back pain. Disk herniation was considered in three trials. (27, 30, 44)
Duration of symptoms were unassessed in eight trials, nine studies included participants with chronic pain, some included participants with both acute and chronic pain.

Participants with experience of the tested treatment were included in eight trials (24, 29, 31, 32, 35, 37, 42, 43) and excluded in four. (26, 36, 39, 41) The remaining studies did not provide this information.

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Interventions

Interventions deferred for number of sessions and number of techniques applied. Eleven trials used a single therapy session with a single technique performed in eight of those trials. Trials with different therapy sessions ranged from five (25, 26, 30) to 20 (27) sessions once a week.

Sham treatment

ST was provided by a hand contact on the area of pain in 19 studies, and five studies provided ST in a different area from where the pain was located. (27, 35, 43, 45, 46)
In trials providing spinal manipulation, as inactive treatment the majority of authors used the similar placement of hands on participants without any force applied. (40-42, 44) Two trials used a ST with similar forces applied in different directions. (25, 32) One trial did not specify the inactive manipulation applied. (29)
In trials that provided multiple techniques in the same treatment session (such as osteopathic treatment, spinal mobilization and physiotherapy) the ST was administrated with different techniques that mimed active treatments using light touch or light tractions.
Only one trial compared one single sham technique with both single active technique and multiple treatment techniques. In this case only data of the first arm were extracted. (37)

Manual and controls treatments

Different manual treatments were provided:

- Spinal manipulation (SM)/chiropractic (7 studies, 567 participants)
- Osteopathy (5 trials, 645 participants)
- Kinesiology (one trial, 58 participants)
- Articular mobilizations (6 trials, 445 participants)
- Muscular release (5 trials, 304 participants)

Four trials with multiple arms compared ST to no intervention (379 participants) (25-27, 31) and one to muscle relaxant group (156 participants). (29)
The manual treatment was generally applied in the area of pain, some trials used techniques additionally in other areas. Just one trial using reflexology provided both manual therapy and sham in a different zone. (39)

Characteristics of the practitioner who administrated treatments were provided by 16 trials. Trials involved physiotherapists (N=8), physical therapists (N=4), osteopaths (N=3) and osteopathic students (N=1). Only seven studies provided information on years of practice experience of the physicians involved ranging from six to 17 years. (30, 33, 35-37, 40, 42, 44)
The gender of practitioners was indicated in only three trials.(26, 30, 37)

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Table 1: summary of main characteristics of included studies

Study ID	N° of participants	Symptoms duration	Pain localization	Technique tested *(site of application)*	Type of sham procedure	Other arms	Follow-up
Antonilos-Campillo PJ 2014	40	Not reported	Cervical	Soft-tissue *(cervical region)*	Soft mobilization of lower limbs	None	No follow-up (outcomes collected after the intervention)
Bialosky J 2014	110	> 4 months	Lumbar	Spinal Manipulation (SM) *(lumbar spine)*	Ineffective force applied on lumbar spine	No treatment group	2 weeks
Cleland JA 2005	36	>2 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	No follow-up (outcomes collected after the intervention)
Eardley S 2013	58	> 3 years	Lumbar	Kinesiology *(spine)*	Protocol of ineffective techniques in the site of pain	No treatment group	7 weeks
Erdogmus S 2007	120	$\geq$ 1.4 weeks	Lumbar	Physiotherapy *(Exercises of the spine and articular mobilisation techniques)*	Neck massage	No treatment group	1.5 years
Hall T 2004	24	Not reported	Lumbar	BLR technique *(lower limbs)*	Soft-tissue manipulation of the foot	None	24 hours
Haller H 2016	54	> 7 months	Cervical	Cranio-sacral therapy *(head)*	Ineffective touch of head	None	3 months
Hansen F 1993	168	$\geq$ 18 days	Lumbar	Physiotherapy *(exercises of lumbar spine and abdomen, soft-tissues techniques)*	Intermittent traction of the spine	Intensive back muscle training	1 year
Hidalgo B 2015	32	Not reported	Lumbar	Articular mobilization *(lumbar spine)*	Ineffective mobilization forces applied on lumbar spine	None	2 weeks
Hoiriis K 2004	156	$\geq$ 2,3 weeks	Lumbar	SM *(spine)*	Ineffective force applied on spine	Medical treatment	4 weeks
Klein R 2003	61	>1 month and <5 years	Cervical	Strain-counterstain techniques (*cervical spine*)	Ineffective force applied on cervical spine	None	No follow-up (outcomes collected after the intervention)
Kogure A 2015	179	> 12 months and < 10 years	Lumbar	AKA-H *(sacro-iliac joint)*	Ineffective force applied on sacro-iliac joint	None	6 months
Krekoukias G 2017	50	Not reported	Lumbar	Articular mobilization techniques *(lumbar spine)*	Hand contact with lumbar skin placement without any movement	Exercise plus TENS	5 weeks

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Lascurain-Aguirrebena I 2018	40	Not reported	Cervical	Articular mobilization *(Cervical spine)*	Ineffective force applied on cervical spine	None	No follow-up (outcomes collected after the intervention)
Licciardone J 2003	91	≥ 3 months	Lumbar	Osteopathic manual treatment (OMT) *(all body)*	Protocol of light touch techniques similar to OMT applied to all body	No treatment group	6 months
Licciardone J 2013	455	≥ 3 months	Lumbar	Osteopathic manual treatment (OMT) – *(all body)*	Protocol of light touch techniques similar to OMT applied to all body	None	8 weeks
Pires FP 2015	32	> 3 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	72 hours
Quinn F 2008	15	Not reported	Lumbar	Reflexology *(foot)*	Foot massage with less pressure and in different reflex point (not related to the spine)	None	18 weeks
Selkow M 2009	20	1-6 weeks	Lumbar	Muscular energy technique *(anterior superior iliac spine and lower limbs)*	Practitioner hand positioned as active treatment, but participant rested for 30 seconds without any active contraction	None	24 hours
Senna MK 2011	93	≥ 13 months	Lumbar	SM *(lumbar spine)*	Ineffective force applied on lumbar spine	Maintained SM	10 months
Sillevis R 2010	100	≥ 23 months	Cervical	SM *(thoracic spine)*	Ineffective force applied on thoracic spine	None	No follow-up (outcomes collected after the intervention)
Silva A 2019	28	>3 months	Cervical	Osteopathic visceral treatment *(abdomen)*	Hand contact on umbilical region without any movement	None	7 days
Veira-Pellez F 2014	40	Not reported	Lumbar	SM *(lumbar/sacral spine)*	Ineffective force applied on lumbar/sacral joints	None	No follow-up (outcomes collected after the intervention)
Younes M 2017	17	< 3 months	Lumbar	OMT *(all spine)*	Placebo mimed active treatment with an ineffective force applied.	None	7 days

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Risk of bias in included studies

Figure 2 shows risks of bias.
Blinding of participants and assessors will be described due to the nature of this review.
According to AHRQ standards of CRB tool, (19) the majority of trials were judged as poor quality (N=22). Good quality was conferred on only two studies. (36, 45)
The random sequence and allocation concealment were adequately reported in 71% and 63% of trials respectively.
The lack of blinding of participants was the most common bias and was judged as high risk in 38% of studies, while 38% were considered as unclear risk.
The reasons for this judgment were mainly related to trials involving spinal manipulations. These studies used a technique which can be easily recognized by patients as active treatment for the popping sound emitted by joints. Additionally, these trials involved participants who could have already received this type of treatment, making the masking of technique almost impossible.
Blinding of outcomes was evaluated mainly as unclear risk in 46% of trials. Only two trials reported the strategies adopted to guarantee assessor blinding. (28, 32)
Incomplete outcome data was the least common bias risk with 80% of trials judged as low risk.
Reporting bias was evaluated as unclear in 55% of trials where registration number and trial protocol were not reported or found.
Other bias occurred was generally considered as high risk for baseline differences of the population in 30% of trials.

Figure 2: *Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.*

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Effects of intervention

Table 2 summaries treatment effects and GRADE quality of the evidence for all comparisons.

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Table 2: summary of findings of treatment effects and certainty of the evidence (GRADE) included for all comparisons.

1. Sham treatment (ST) compared to Manual Therapies (MT)

Patient or population: back pain
Intervention: ST
Comparison: MT

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with MT	**Risk with ST**				
Pain improvement assessed with: VAS score Scale from: 0 to 100		MD **3.86 higher** (3.29 lower to 4.43 higher)	-	805 (15 RCTs)	⨁◯◯◯ VERY LOW [a,b]	A small effect, not clinically relevant, in pain improvement was detected in favour of MT. This analysis excluded two trials (one suspected of publication bias, one used a different scale) which increased heterogeneity levels but did not affect overall efficacy meaningfully.
Adverse events assessed with: number of AE occurred	144 per 1.000	**121 per 1.000** (79 to 184)	**RR 0.84** (0.55 to 1.28)	531 (6 RCTs)	⨁⨁◯◯ LOW [a]	Pooled data from 6 studies did not show any difference in AE occurrence between ST and MT.
Dropouts rate assessed with: number of participants that leaved the study	174 per 1.000	**171 per 1.000** (134 to 218)	**RR 0.98** (0.77 to 1.25)	1238 (11 RCTs)	⨁⨁◯◯ LOW [a]	Pooled data from 11 trials did not show difference in dropout rate between ST and MT.

2. ST compared to no treatment

Patient or population: back pain
Intervention: ST
Comparison: No treatment

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no treatment	**Risk with ST**				
Pain improvement assessed with: VAS score Scale from: 0 to 100		MD **5.84 lower** (20.46 lower to 8.78 higher)	-	177 (3 RCTs)	⨁◯◯◯ VERY LOW [a,c,d]	Pooled data from three trials, highly inconsistent, showed no differences between ST and no treatment group in pain improvement.
Dropouts rate assessed with: number of participants that leaved the study	150 per 1.000	**123 per 1.000** (65 to 233)	**RR 0.82** (0.43 to 1.55)	225 (4 RCTs)	⨁◯◯◯ VERY LOW [a,d]	Very low quality of evidence suggests no differences in dropout rate between ST and no treatment.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **MD:** Mean difference; **RR:** Risk ratio

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GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. The majority of trials were judged as poor quality according to AHRQ standards.
b. Most of the studies were small trial.
c. Heterogeneity levels at 80%.
d. Number of participants < 400

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Sham treatment versus other manual therapies

Pain

The following outcomes on back pain are presented with a 100 mm visual analogue scale, 0 to 100; higher scores refer to worse pain. Trials using a 10mm scales were converted to 100mm scores.
The comparison between ST and MT was performed in 17 studies. One trial used a different scale and data were obtained with a conversion formula. (27) Data from seven studies could not be extracted.
The meta-analysis at short-term showed substantial heterogeneity levels using a random-effects model. To further investigate inconsistency levels, a sensitivity analysis excluding two trials was performed. One trial used a different validated scale, (25) while the other was suspected of publication bias. (30) This thought was verified with a funnel plot, which showed an asymmetric distribution with the inclusion of these two studies (***Appendix 3***). This sensitivity analysis did not influence overall effectiveness results, but inconsistency levels decreased considerably at short-term. It can be deducted that a possible cause of heterogeneity was found (***Full analysis in appendix 4***).

The sensitivity analysis using a fixed-model at short-term showed a slight difference, not clinically meaningful, between ST and MT in favour of MT on pain outcome (MD 3.86, 95%CI 3.29 to 4.43, 805 participants, I^2=42%, p<0.0001,very low quality of evidence downgraded two levels for very serious risk of bias and imprecision) **(Figure 3).**

Figure 3: *Forest plot of comparison ST versus MT in back pain outcome at short-term.*

Comparisons between ST and MT at medium and long-term could not be performed due to substantial levels of heterogeneity found using a random-effects model. The heterogeneity levels were not explainable by clinical or methodological diversities within trials (medium-term I^2=91% P<0.0001, long-term I^2=81% P=0.005) (***Appendix 4.1***).

Success of blinding

Success of blinding was evaluated in five trials; one did not report the results. (30)
Patients were asked to assess if they understood their treatment allocations. Due to the type of data extracted (percentage of correct guessing) meta-analysis was not performed and results are reported descriptively.
Two trials compared ST with SM, these trials showed a correct perception of treatment allocation that ranged from 63.5% (25) to 83.5%. (29) In this last study patients were considered eligible if they had already received SM.
One trial compared ST to an articular mobilization technique. 54.5% participants correctly guessed the treatment allocation. (46)
Participants of one study that compared ST to reflexology had the lowest percentage of correct detection of allocation (46.7%). Participants in this trials did not know about the type of treatment tested. (39)

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Dropouts

Pooled data from 11 trials at the last follow-up suggested no difference in dropouts rate between ST and MT at the end of the trials (105/612 compared to 109/626; RR 0.98, 95% CI 0.77 to 1.25; 1238 participants, I^2=0%, P=0.90; low quality of evidence downgraded two levels for high risk of bias) ***(Figure 4)***.

Figure 4: *Forest plot of comparison ST versus MT in number of dropouts outcome*

Adverse effects

AE were generally under-reported, six trials were included in the meta-analysis. (26-28, 36, 37, 45)
Two trials reported AE overall occurrence without specified event rates in the groups.(24, 32)
AE were predominantly minor and lasted for two/three days after treatment, in the majority of trials transient worse pain, tiredness, muscle weakness and transient headache were reported. (26, 36, 37, 45)
Senna M 2011 reported the most common AE were local discomfort and tiredness but no serious complications were noted. (32)
Haller H 2016 reported two patients dropping out from the trial for recurrent headache after treatments, both Haller H and Klein R 2013 reported dizziness of one patient. (36, 37)
Licciardone J 2013 reported 27% of patients with AE, 2% had serious AE not related to study interventions. (24)

Overall results showed no clear difference in AE occurrence between ST and MT (32/267 compared to 38/264; RR 0.84, 95% CI 0.55 to 1.28; 531 participants, I^2=26%, P=0.42; low quality of evidence downgraded two levels for inconsistency) ***(Figure 5)***.Senna and Licciardone were excluded from analysis because they did not provide separate data for each group.

Figure 5: *Forest plot of comparison ST versus MT in number of adverse events outcome at short-term*

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Sham versus no treatment

Pain

Four studies compared ST to no intervention, three were included in random-effect meta-analysis at short-term. (25-27, 29) Data from one trial could not be extracted. (31)
Pooled data showed the presence of significant heterogeneity, therefore results are reported narratively: two trials showed no difference between ST and no treatment on pain outcome, while Eardley S. 2013 showed an effect in favour of ST (pooled data from 3 trials: MD -5.84, 95% CI from -20.46 to 8.78, 252 participants, I^2= 85%, P=0.43). The exclusion of Erdogmus S 2013 (that used a different scale) did not affect the results of effectiveness neither decreased levels of heterogeneity (MD -10.83, 95% CI -32.44 to 10.79, $I^{2=}$ 84%, P=0.33) (***Appendix 5***).

Dropouts

No differences were shown in the fixed-effect meta-analysis on dropout rate between ST and no intervention in four trials (14/112 compared to 17/113; RR 0.82, 95% CI 0.43 to 1.55; 225 participants, I^2=0%, P=0.54; very low quality of evidence downgraded two levels for very serious risk of bias and imprecision) ***(Figure 6)*** .

Figure 6: *Forest plot of comparison ST versus no treatment in number of dropouts outcome*

Adverse effects

Of the four studies comparing ST to no intervention, only two reported AE.
One, Eardley S 2013, did not evaluate AE occurred in the no treatment group while Erdogmus C 2007 reported that 10/40 in the no intervention group and 11/40 in ST group turned to other therapies for complains.

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Discussion

Results show a small, not clinically meaningful effect in favour of MT for short-term pain relief compared with ST. However, the quality of evidence is very low, suggesting that the true effect may be different from the estimated effect. Substantial levels of heterogeneity within the four studies analysed, showed no differences between ST and no treatment in pain reduction. Success of blinding was reported in four trials that compared ST to MT, with a high percentage of correct detection of treatment allocations by participants.
AE were generally under-reported, with a similar rate of occurrence between sham and MT accompanying low levels of heterogeneity. Only one study reported AE in its no treatment group with no significant difference from ST.

SM techniques were the treatment most evaluated (N=7). These techniques are highly recognizable by patients for a popping sound emitted by the column during their performance. (47) The fact that participants enrolled in these trials were eligible despite having already received SM, threatens the validity of blinding. This thought is strengthened by the high percentage of participants who recognized treatment allocation in this kind of trial (from 63.5% to 83.5%). (25, 29) Additionally, five trials applied ST in a different site compared to pain and active treatment. This might have had important influences on sham therapy reliability and consequently to study results.
Lack of blinding seemed not to be related to dropouts rate, although both these data were reported only in two trials. Bialosky J and Hoiriis K showed high percentages of correct treatment allocation detection by participants but dropout rate between sham and MT group did not differ. (25, 29) These results seem to be in conflict, nevertheless, participants could have wanted to remain in the trial for several other reasons such as the setting or the attraction of being evaluated by an expert clinician free. This possibility is reinforced by the fact that a similar dropout rate was reached in the comparison sham versus no treatment. These data suggest that dropout rate might not be a dependable outcome for assessing reliability of ST.
Another factor that seemed to put blinding validity at risk was the use of a single technique. Single techniques were generally more difficult to mask, negatively affecting the validity of blinding of participants. The majority of trials judged as at high or unclear risk of performance bias used a single technique evaluating its effects on pain soon after its performance, or its effect after different sessions.

When compared to no intervention, ST showed no effect. Only one study of the four included in the meta-analysis showed a statistically significant effect in favour of ST. This study was the only one judged at low risk of performance bias because researches tried to mask ST performing techniques very similar to MT and excluding participants that already received the treatment tested. (26) This trial was the one that showed a marked effect on pain (MD -21.7, 95% CI -33.5 to -9.9, 42 participants). (**Appendix 5**) Other studies included in this comparison, judged at high risk of performance bias, showed no effect of ST. These results suggest that lack of blinding could have had an impact on this comparison.

This review included generally small trials. Only 14 of 24 studies performed a sample size calculation but just two of these considered MCID in this computation. The MCID is the measure of smallest change of PROs that patients perceive as important, beneficial or harmful. MCID is useful for clinicians to interpret the findings of trials and apply them in clinical practice

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and to their decision-making. (48) An adequate sample size calculation, using MCID especially in trials with PROs, is fundamental to assess the number of participants needed to detect clinically relevant treatment effects. Oversized trials, which expose too many people to unnecessary therapies, or underpowered trials, which may not achieve significant results, should be avoided. (49-51)

Comparison with other studies

Similar findings were found in other reviews conducted on LBP. Ruddock JK 2016 included studies where SM was compared to what authors called “an effective ST”, namely a credible sham manipulation that physically mimics the SM. Pooled data from four trials showed a very small and not clinically meaningful effect in favour of MT. (52)
Rubinstein SM 2019 compared SM and mobilisation techniques to recommended, non-recommended therapies and to ST. Their findings showed that 5/47 studies included attempted to blind patients to the assigned intervention by providing a ST. Of these five trials, two were judged at unclear risk of participants blinding. The authors also questioned the need for additional studies on this argument, as during the update of their review they found recent small pragmatic studies with high risk of bias. We agree with Rubinstein SM *et al.* that recent studies included in this review did not show a higher quality of evidence. The development of RCT with similar characteristic will probably not add any proof of evidence on MT and ST effectiveness. (53)

Limitations

This review aimed to compare different kinds of sham therapy with different kinds of MT and no intervention. The nature of this comparison needed an NMA, but this analysis could not be performed due to the small number of trials using hand contact ST. The decision to include only this kind of sham therapy was mainly due to the intention of analysing the effect of manual interaction between practitioner and patients, which is suspected of leading to an amplified placebo effect. (54) Additionally, the use of machine placebo trials in the same meta-analysis could have increased diversity within included trials due to the possible enhanced presence of biases such as performance and consequently detection ones.

Although the population differed - some trials analysed cervical, others lumbar pain with different aetiologies and different symptoms duration - this factor did not affect the meta-analysis performed, as highlighted by the low heterogeneity found in the primary outcome. As already suggested by other authors, (1) placebo effect might be influenced by chronic pain, nevertheless, in this review, this analysis could not be performed due to the range of pain duration in trials included (from acute to chronic in the same trial).

Data concerning settings and operators were insufficient to evaluate the influence of these two factors on sham therapy response. Experience of practitioners was considered in data extraction but insufficient information was provided by authors to draw any hypothesis. Another limit was in not considering non-objective outcomes as primary outcome for meta-analysis. Nevertheless, most of the trials included did not evaluate an objective outcome and the few studies which analysed this type of outcome used different kinds of scales not easily comparable in a meta-analysis.

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Pair-wise comparison on pain outcome between sham and MT showed slightly higher effects of MT in trials where blinding was ensured. A linear regression analysis was planned to assess the impact of blinding on meta-analysis results. Due to the small number of trials, this analysis could not be performed. This trend follows what has been already suggested by other studies. (55) However trials with bigger sample size are needed to assess a real correlation between these two factors.

Another limit of this study is that risk of bias was assessed by one author (CL) and agreed by another (MG). This aspect could have been improved if both authors had worked independently on bias risk assessment and then discussed any discrepancy.

Implications for practitioners

In some clinical contexts, MT could be difficult to apply; for example, some patients may present hyperalgesia to tactile stimuli. Defrin R 2014 suggested that tactile allodynia might be present in 60% of patients with chronic LBP associated with radicular pain. (56)
In this kind of patient the use of MT could be excessively painful, and any MT that triggers pain should be avoided. (57) ST - and therefore a possible placebo effect - could represent a valid alternative to MT in the multi-disciplinary approach to back pain, promoting pain relief without increasing the possibility of AE occurrence.
This thought is strengthened by our findings: ST was found to be equally safe to MT without increasing the risk of AE occurrence when compared to no intervention. Furthermore, when blinding was guaranteed, ST showed a statistically significant effect on pain reduction in chronic LBP patients compared to no treatment.
ST could be seen as an “affective touch”, which it is suggested creates a pleasant therapeutic experience promoting affiliative behaviours and pain improvement. (58, 59)
Nevertheless, due to the low quality of the studies included in this review, further studies are needed to verify the possible role of ST among patients where MT is not well tolerated.

Implications for research

In MT trials a true placebo is impossible to achieve so trials should implement strategies to guarantee patient and assessor blinding, for example avoiding the inclusion of participants who already received the active treatment and avoiding single technique performance which are more difficult to mask. Plans to avoid performance bias, such as giving similar treatment with similar localization have to be implemented.
Moreover, the evaluation of the success of blinding should be considered as, at least, secondary outcome.
Researchers should pay particular attention to sample size calculation using the MCID. This difference is fundamental both for research and patients. MCID indicates patients’ values and preferences and can help clinicians improve interpretation and promote the understanding of the importance of intervention effects in RCTs.

NICE guidelines for LBP suggest the use of MT only as “ a part of a treatment package including exercise, with or without psychological therapy”. (60) Therefore, the development of future CT

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should imitate the real multi-disciplinary clinical context to assess the external validity of future findings.
Future researches should also evaluate the real effects of ST comparing it both with active treatment and with the no intervention groups. Only with this kind of design could the real placebo effect in MT be defined.

Conclusions

This review aimed to evaluate ST effect in MT trials. MT showed higher efficacy than ST, but when blinding was ensured the effects of ST and MT were larger. Nevertheless, these findings were not clinically meaningful and the very low quality of the included studies might undermine the reliability of this reviews' results.

The use of ST and its application in MT study is very controversial. Future trials should focus on developing a reliable kind of sham procedure similar to the active treatment, to ensure participants blinding and to guarantee a proper sample size for the detection of reliable, clinically relevant, treatment effects.

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Contributors:
CL conceived the idea of this review and designed the study with the contribution of *MG* who also helped in literature search and in the interpretation of study findings. *CL* and *MG* revised studies, performed data extraction and analysis and wrote this review.
AA and *AM* provided clinical and technical support, reviewed the manuscript and helped in publication and with the clinical interpretation of study findings.
CL is the guarantor of this paper. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.
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Data sharing: Details of the characteristics of the included studies and data extracted are available from the corresponding author at carolina.lavazza@docenti.aimoedu.it. Extra data can be accessed via the Dryad data repository at http://datadryad.org/ with the doi: 10.5061/dryad.v9s4mw6tb

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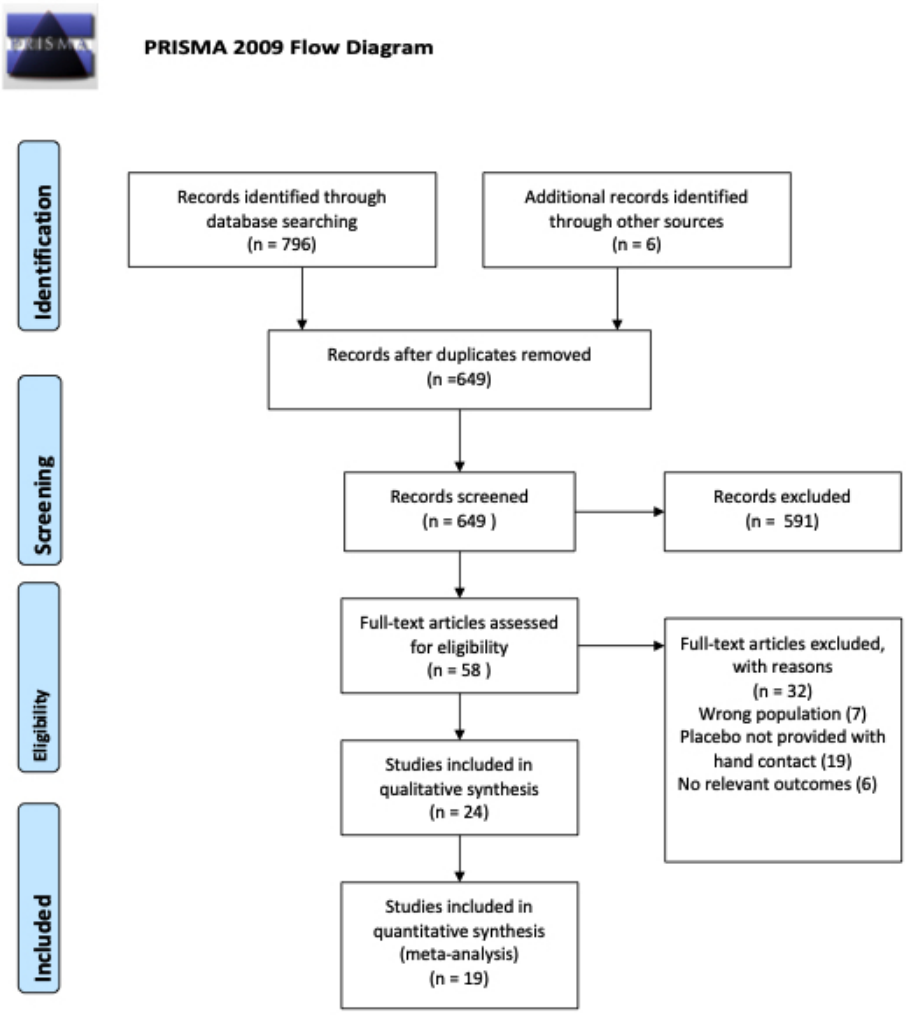

Figure 1: PRISMA flow diagram

48x56mm (298 x 300 DPI)

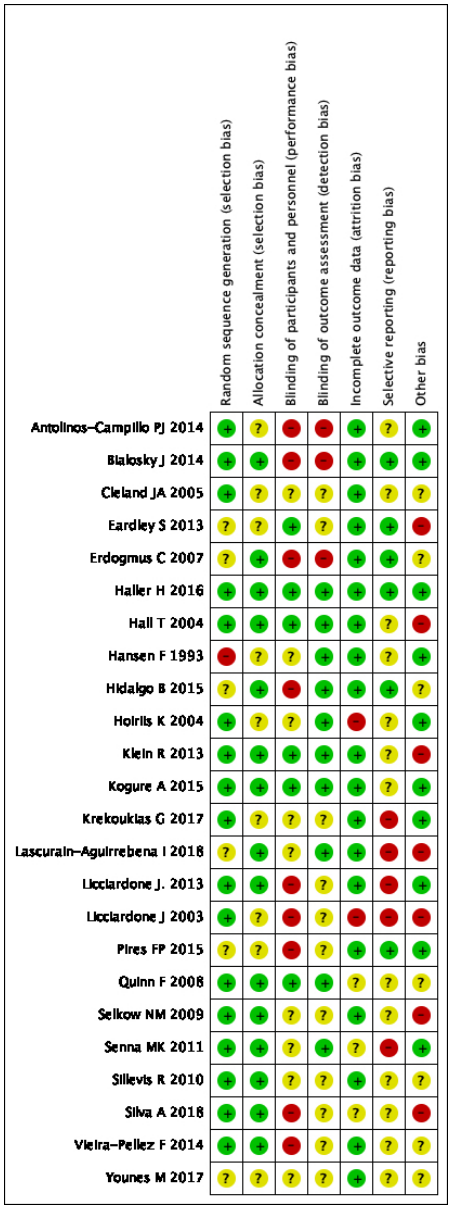

Figure 2: Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.

34x93mm (298 x 299 DPI)

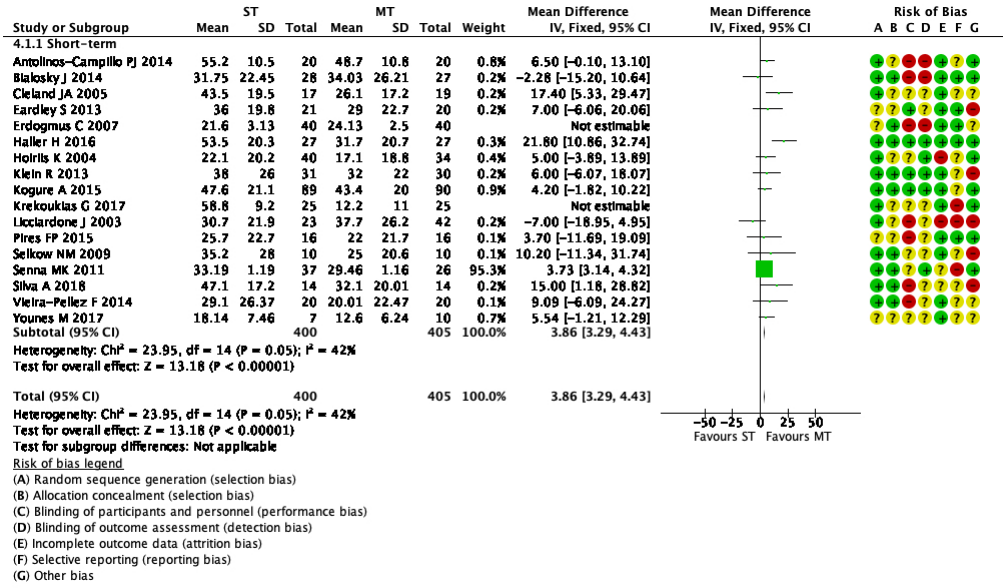

Figure 3: Forest plot of comparison ST versus MT in back pain outcome at short-term.

84x50mm (300 x 298 DPI)

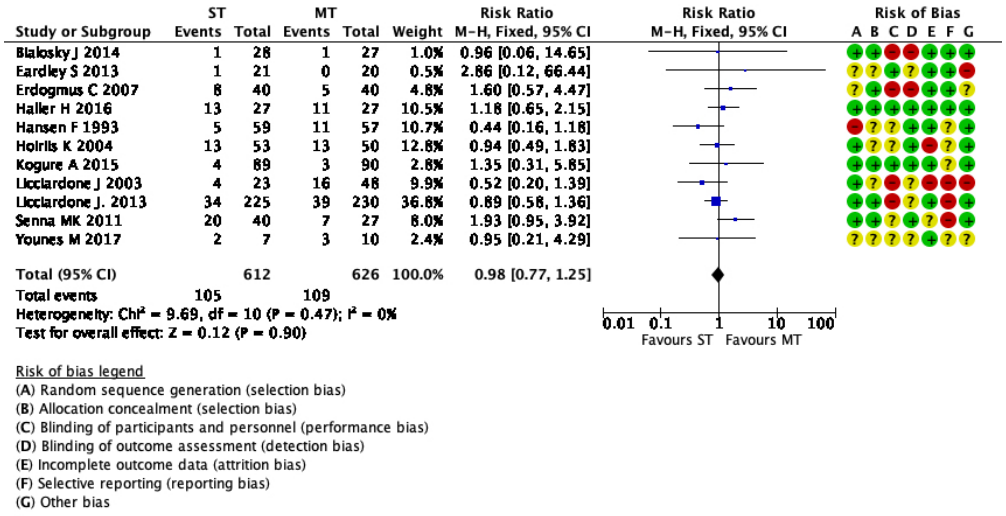

Figure 4: Forest plot of comparison ST versus MT in number of dropouts outcome

72x38mm (299 x 299 DPI)

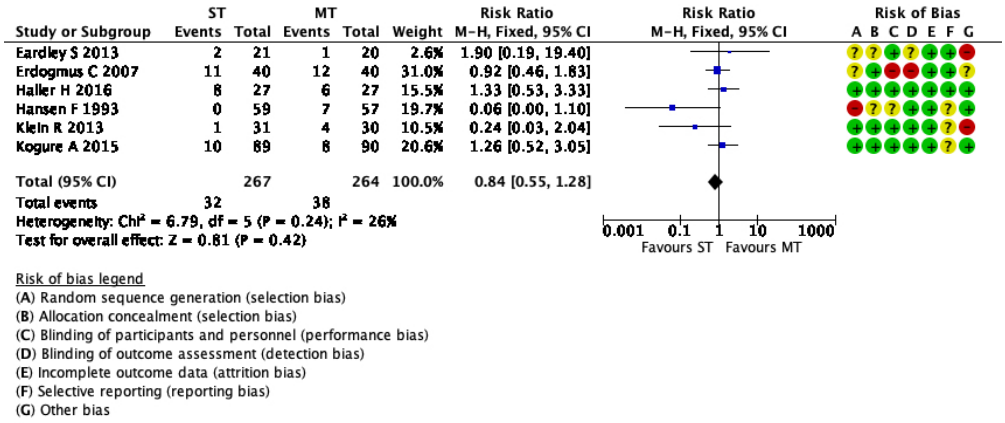

Figure 5: Forest plot of comparison ST versus MT in number of adverse events outcome at short-term

72x31mm (299 x 298 DPI)

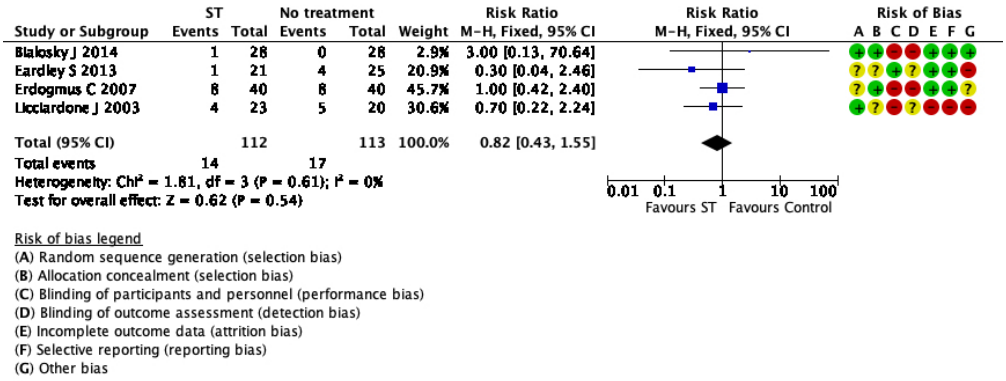

Figure 6: Forest plot of comparison ST versus no treatment in number of dropouts outcome

73x28mm (299 x 299 DPI)

Appendix 1: search strategy

Medline

1. Mesh descriptor: [Back Pain] explode all trees
2. dorsalgia/
3. backache
4.(neck OR cervical) adj1 pain → Mesh
5. exp Brachial Plexus Neuropaties
6. exp Lumbar Plexus Neuropaties
7. Neck Pain/
8. neckache
9. Torticollis/
10. whiplash.mp
11. cervicodynia.mp
12. spondylitis/ OR spondylosis/ OR spondylolysis/ OR spondylolysthesis
13.(lumbar OR dorsal OR neck OR cervical OR sciatica) adj2 (pain OR ache)
14. (lumbar OR dorsal OR neck OR cervical) adj2 (discitis OR disc adj 1 herniation OR disc adj1 herniation)
15. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14
16. (PLACEBO* or MOCK* or SHAM* or FAKE* or VEHICLE* or DUMM* or ATTENTION* CONTROL* or PSEUDO* TREAT* or UN?SPECIFIC* or NON?SPECIFIC* OR simulat$ treatment OR inert agent)
17. Chiropractic/
18. Manipulation, Chiropractic/
19. chiropract$.tw.
20. (manual adj2 therap$).mp
21. spinal manipulation.mp. or Manipulation, Spinal/
22. osteopath$.tw.
23. Osteopathic Medicine/
24. Physical Therapy Modalities/ or “Physical Therapy (Specialty)”/ or physical therap$.tw. or physiotherap$.tw.
25. myotherapy.mp
26. shiatsu.mp
27.exp Therapeutic Touch/
28. exp Massage/
29. (neuromuscular adj therapy).mp
30. 17 OR 18 OR 19 OR 20 OR OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29
31. pain
32. range of motion
33. ROM
34. 31 OR 32 OR 33
35. Clinical Trial/
36. Randomized Controlled Trial/
37. controlled clinical trial/
38. exp RANDOMIZATION/
39. PLACEBO/
40. (random$ adj2 allocat$).tw.
41. single blind$.tw.

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42. double blind$.tw.
43. placebo$.tw.
44. 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43
45. animals/
46. humans/
47. 46 NOT 45
48. 15 AND 16 AND 30 AND 44 AND 47

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Appendix 2: data extraction form

Methods	**Trial Design** **Settings**
Participants	**Total number of participants:** **Age**: **Gender(M/F):** **BMI:** **Activity:** **Duration of the symptoms:** **Location of pain (**one-sided, double-sided, central, cervical, dorsal or lumbar)**:** **Cause of pain:** (e.g. disc herniation, contractures, aspecific pain) **Previous experience of the treatment provided:** Y/N/ N/A **Inclusion and exclusion Criteria:** **VAS:** **Practitioner characteristics**: (years of experience, gender)
Interventions	**Placebo:** **Comparator:**
Outcomes	**Outcomes used in the meta-analysis:** **Length of follow-up:**
Notes	**Difference between Placebo and active treatment:** **Placebo check for reliability:** **Adverse event:**

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	Lost to follow-up: **Funding source:**

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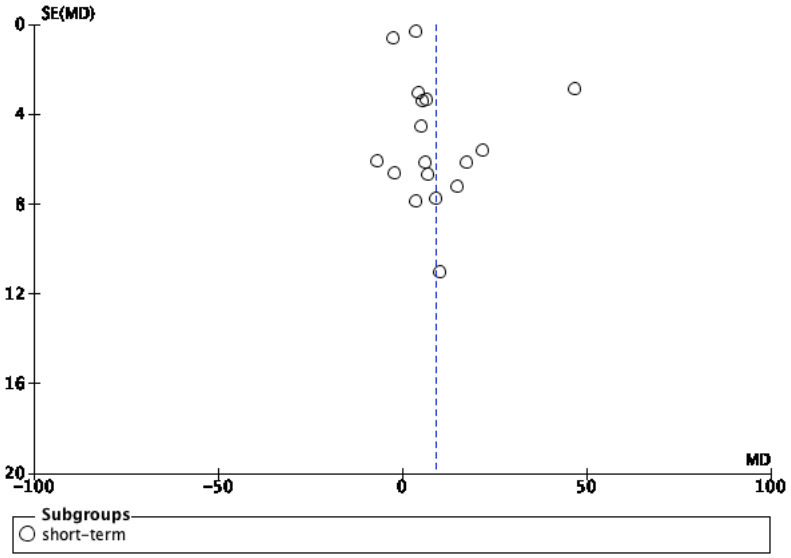
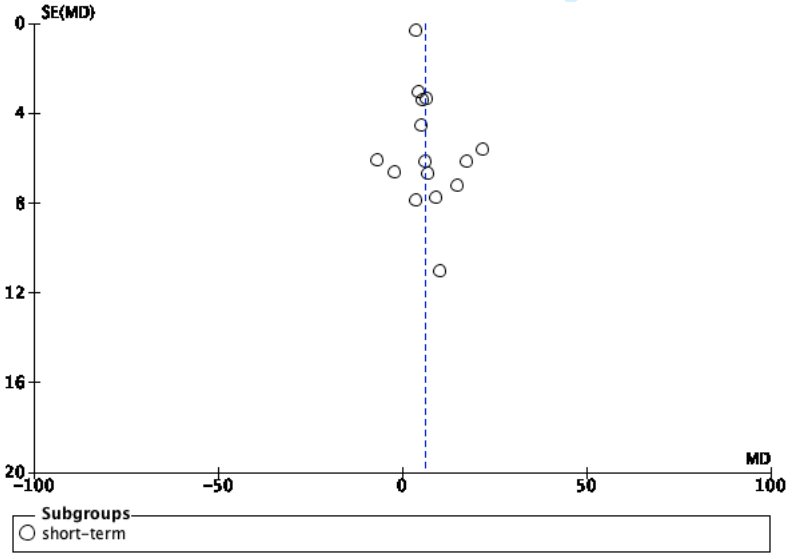
Appendix 3: funnel plot of pain outcome with the inclusion (A) and with the exclusion (B) of two studies of Erdogmus C and Krekoukias G.

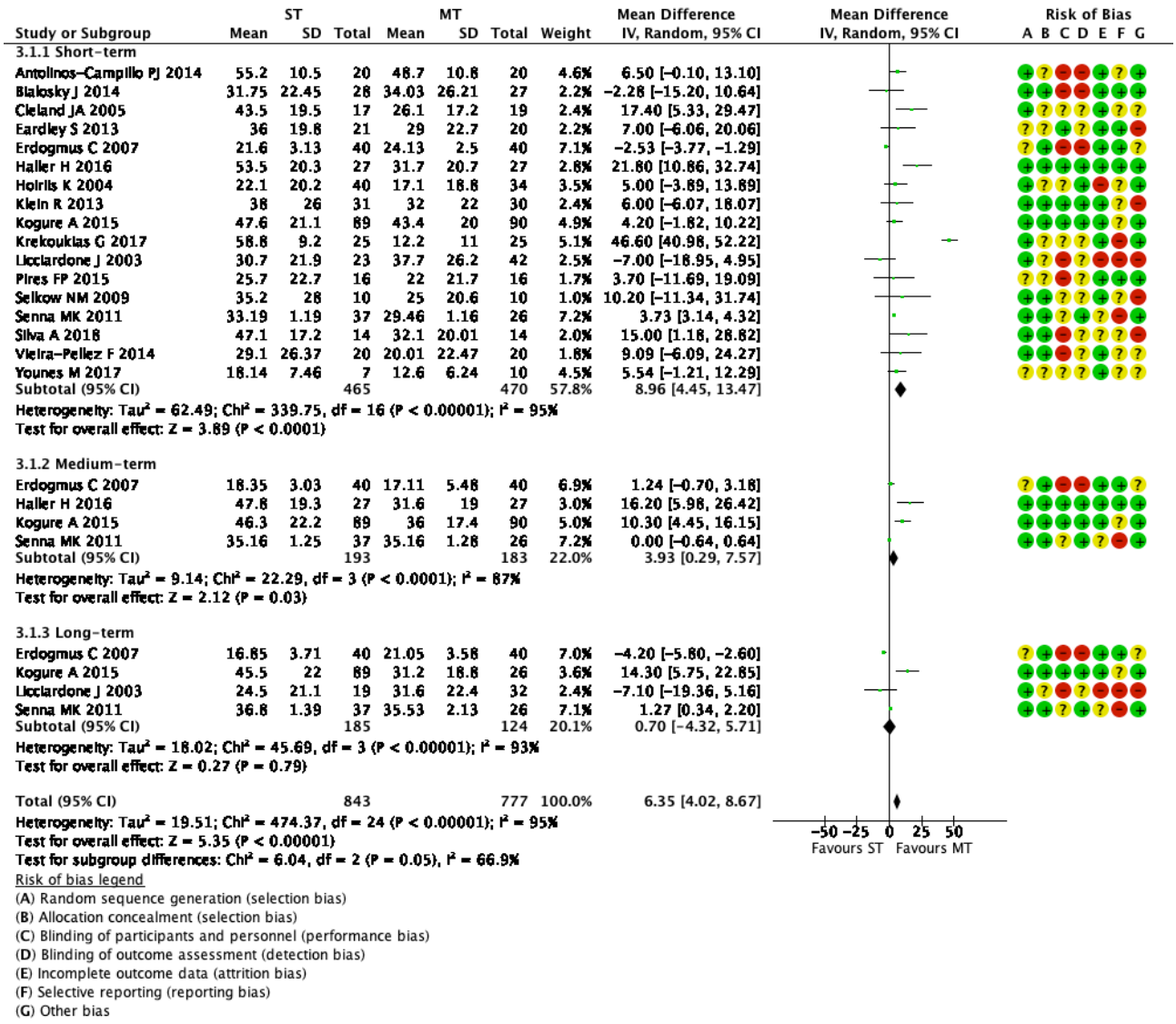
(A)



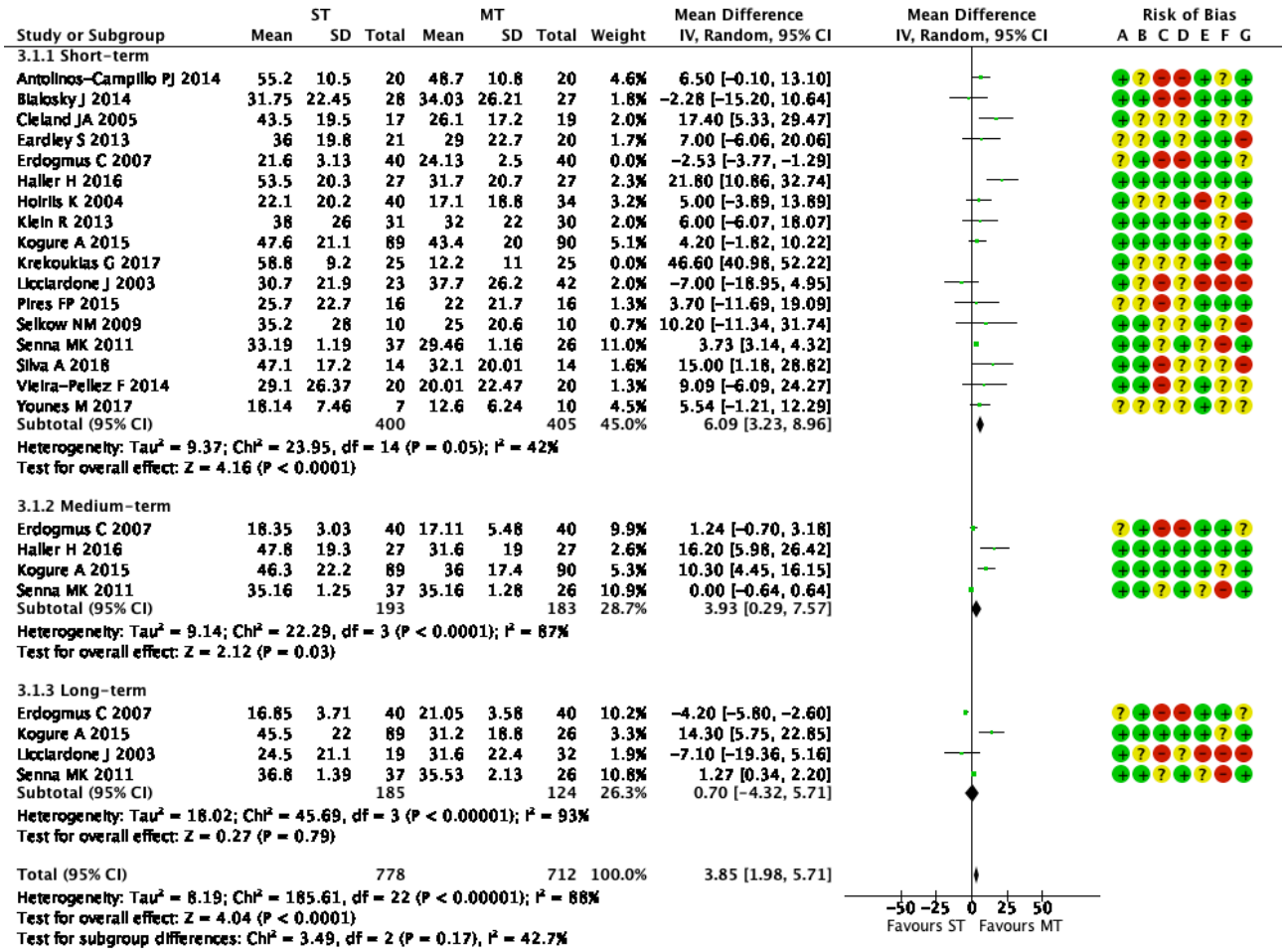
(B)



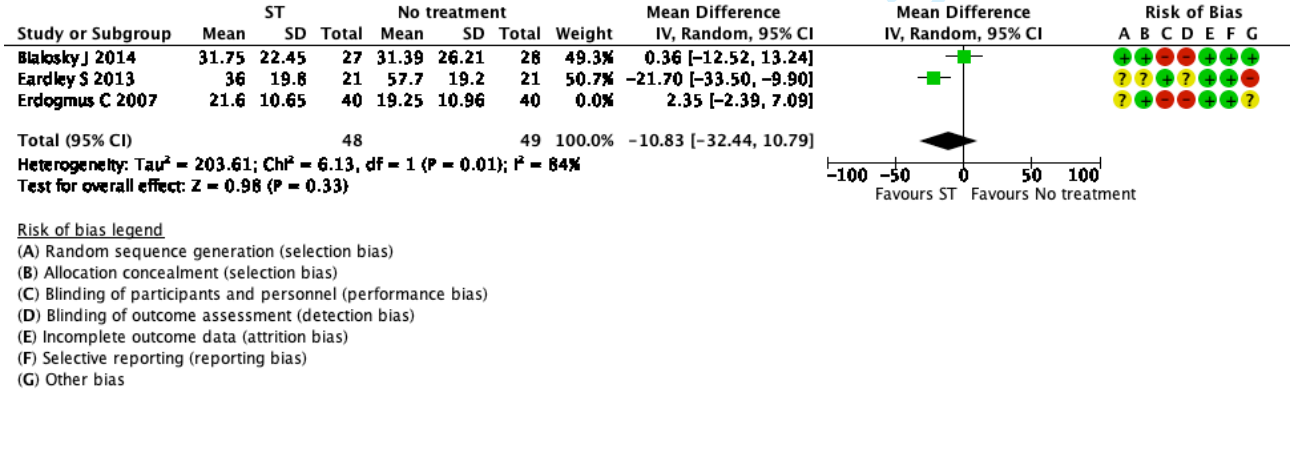
Appendix 4: forest plot of comparison pain outcome sham treatment vs manual therapies with the inclusion of two trials (Erdogmus C and Krekoukias G) at short, medium and long-term.



Appendix 4.1: Sensitivity analysis with the exclusion of Ergogmus C and Krekoukias G at short, medium and long-term



Appendix 5: forest plot of comparison ST versus no treatment in back pain outcome at short-term with exclusion of Erdogmus C 2007 trial



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Page 5
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Pages 9-10
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Page 10
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Pages 6 and 10
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Pages 10-11
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Page 11
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Page 12
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Page 12
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Page 12-13
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Page 12
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Pages 12-13

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PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Page 13

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Pages 12-13
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Page 13
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Page 15
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Pages 16-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Page 20, figure 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Pages 21-23
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Pages 7-8
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Pages 20-figures 2,3,4,5,6
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Appendices 4-6
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Pages 7-8, 24
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Page 25
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Page 26
FUNDING			

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PRISMA 2009 Checklist

Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Page 2

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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