The Effectiveness of Physiotherapy in the Management of Temporomandibular Disorders: A Systematic Review and Meta-analysis

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Aims: To analyze the methodologic quality, summarize the findings, and perform a meta-analysis of the results from randomized controlled trials that assessed the effects of physiotherapy management of temporomandibular disorders. **Methods:** A literature review was performed using the electronic databases PubMed, Science Direct, and EBSCO. Each article was independently assessed by two investigators using the Physiotherapy Evidence Database (PEDro), Jadad scales, and the Cochrane Risk of Bias tool. A meta-analysis was conducted by using the DerSimonian-Laird random-effects method to obtain summary estimates of the standardized mean differences (SMD) and the corresponding 95% confidence intervals (95% CI). Between-study heterogeneity was computed and publication bias was assessed. **Results:** Seven articles met the inclusion criteria and were used in the analysis, corresponding to nine estimates of SMD. The meta-analysis showed that for pain reduction, the summary SMD favored physiotherapy (SMD = −0.63; 95% CI: −0.95 to −0.31; number of studies = 8; I^2 = 0.0%), while for active range of movement (ROM) the differences between the intervention and control groups were not statistically significant (SMD = 0.33; 95% CI: −0.07 to 0.72; number of studies = 9; I^2 = 61.9%). **Conclusion:** Physiotherapy seems to lead to decreased pain and may improve active ROM. However, the results are not definitive and further studies and meta-analyses are needed before these results can be considered fully generalizable. *J Oral Facial Pain Headache 2016;30:210–220. doi: 10.11607/ofph.1661*

Keywords: *mandibular function, pain, RCT*

Temporomandibular disorders (TMD) consist of a group of pathologies affecting the masticatory muscles, the temporomandibular joint (TMJ) and associated structures, or both.[1,2] The etiology of TMD is not clear,[3,4] but these disorders are the most common chronic orofacial pain conditions with prevalence studies demonstrating that TMD can affect from 10 to 25% of the population.[5,6] The presence of persistent pain is the main reason that TMD patients seek medical aid.[4] Other signs and symptoms usually manifested by TMD sufferers are impaired range of mandibular movement, joint sounds, and muscle and joint tenderness as well as head and neck pain.[7] This variety of signs and symptoms reveals the complexity of the condition, which has a multitude of risk factors.[8]

Currently, TMD may be managed by a combination of physiotherapy, splint therapy, orthodontics, pharmacotherapy, counseling, and surgery, among others.[9–13] Noninvasive treatments tend to be the first option for approximately 85 to 90% of TMD patients.[12] In the case of physiotherapy, two systematic reviews performed in 2006[14,15] concluded that the studies reviewed had methodologic problems that affected any possible conclusions about the effectiveness of physiotherapy in treating TMD. Since then, new studies[16–18] attempting to overcome these problems have been conducted, but the effectiveness of physiotherapy interventions in the management of TMD is still unclear. Thus, the aim of this systematic review was to analyze the methodologic quality, summarize the findings, and perform a meta-analysis of the results from randomized controlled trials (RCTs) that assessed the effects of physiotherapy management of TMD.

Materials and Methods

Data Sources

The following electronic databases were searched from their inceptions up to August 2014: PubMed, EBSCO, and Science Direct. The search expression used was built according to medical subject headings (MeSH) terms [("craniomandibular disorders" OR "temporomandibular disorders" OR "orofacial pain" OR "temporomandibular joint dysfunction") AND (physiotherapy OR "physical therapy" OR rehabilitation OR exercises OR "manual therapy")] and restricted to articles published in English, Portuguese, French, or Spanish. In addition, a manual search for further relevant articles in the references of all the included studies was performed.

Study Selection

Types of Studies. This systematic review included RCTs that assessed the effects of physiotherapy treatment regardless of blinding.

Types of Participants. The review included studies with subjects diagnosed with TMD by any specified diagnostic criteria regardless of their age, gender, or race. Studies evaluating patients with TMD found to be caused by psychogenic, neurologic, or metabolic disorders were excluded, as well as those with patients who had undergone TMJ surgery.

Types of Interventions. Interventions performed by therapists and within the scope of physiotherapy practice (ie, manual therapy, dry needling, exercise therapy) were included. Studies with nonphysiotherapy interventions, acupuncture, solely home-physical therapy or electrical modalities, and interventions involving passive range of movement (ROM) devices were excluded, along with studies with mixed treatments (physiotherapy combined with other forms of treatment).

Outcome Measures

Studies were not included in the analysis if they did not assess at least one of the following outcomes: pain and/or mandibular function.

Data Extraction and Quality Assessment

Two independent reviewers (P.M.; P.T.) screened the titles and abstracts of retrieved articles to determine their eligibility according to the criteria listed above. Quality assessment was performed using the Cochrane Risk of Bias tool,[19] the Physiotherapy Evidence Database (PEDro) scale,[20] and the 5-point Jadad scale.[21] The Cochrane Risk of Bias tool assesses six domains: *(1)* selection bias (random sequence generation, allocation concealment); *(2)* performance bias (blinding of participants and personnel); *(3)* detection bias (blinding of outcome assessment); *(4)* attrition bias (incomplete outcome data); *(5)* reporting bias (selective reporting); and *(6)* other bias. The PEDro scale was developed to rate the methodologic quality of trials and includes 11 items. While the first item evaluates external validity and is not used to calculate the PEDro score, the following 8 items deal with a trial's internal validity, and the last 2 items are relevant to the trial's statistical reporting. The PEDro score ranges from 0 (poor quality) to 10 (high quality). The 5-point Jadad scale has been previously validated[21] and focuses on three dimensions of internal validity: quality of randomization, double-blinding, and withdrawals. The score ranges from 0 (poor quality) to 5 (high quality). A trial scoring at least 3 out of 5 is considered to be of strong quality while scores lower than 3 indicate poor quality.

When discrepancies occurred between reviewers on whether the study should be included in the review, the reasons for disagreement were analyzed, the trial report was consulted, and a consensus was achieved. The procedure was the same regarding data extraction.

Meta-analysis

The standardized mean difference (SMD) of each individual study was calculated by determining the difference between the mean outcomes of the intervention's effectiveness and, in the control group, dividing by the pooled standard deviation. If data were not in a form suitable for quantitative pooling, trial authors were contacted for additional information. When necessary, transformations were performed by using the method described by Hozo et al in order to pool data.[22] Summary SMDs and the corresponding 95% confidence intervals (95% CI) were computed with STATA, version 11.2, using the DerSimonian-Laird random-effects method.[23] Heterogeneity between the studies was quantified by using the I^2 statistic.[24] Visual inspection of the funnel plots and Egger's regression asymmetry tests were used to assess publication bias.[25] A P value of $< .05$ was considered to reflect statistical significance.

Results

The search identified 3,243 potentially relevant studies, 3,218 of which were excluded after screening the titles and/or abstracts. After the full-text reading, only seven studies fulfilled all inclusion criteria and were used in the qualitative and quantitative analysis (Fig 1). For the quantitative analysis, the intervention group in the study by Carmeli et al[26] was divided into two subgroups (B1 [pain-dominant patients] and B2 [impaired ROM–dominant patients]) and one of the studies by Kalamir et al[17] had two intervention groups

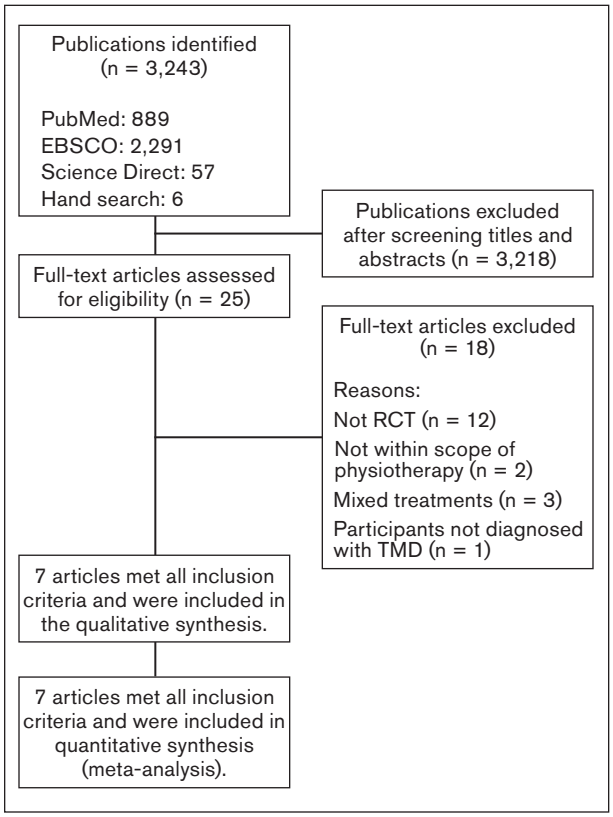

Fig 1 PRISMA flowchart of study selection process.

(intraoral myofascial therapy [IMT] and intraoral myofascial therapy plus education and self-care [IMT + ESC]); these data were analyzed independently.

A total of 329 patients were included in these studies (mean sample size: 47 participants). The main data are summarized in Table 1.

Diagnosis

In six of the seven studies, the TMD diagnostic method used was the Research Diagnostic Criteria for TMD (RDC/TMD);[16,17,27–30] the seventh study (Carmeli et al[26]) made the diagnosis according to the patients' medical history, radiographs, and medical and dental examinations. All subjects in the study by Carmeli et al[26] were diagnosed as having anterior displaced discs. In the studies classified according to the RDC/TMD, one study had patients diagnosed within groups IIb and IIc (disc displacement with and without limitations of mouth opening, respectively),[27] four had group I (muscle disorder) patients,[16,17,28,29] and the study by Tuncer et al[30] had patients from groups I (muscle disorders) and IIa (disc displacement with reduction). The duration of TMD was generally more than 12 weeks (chronic TMD), although this parameter was not described in two studies[17,29] and one study described the duration being from several weeks to years without quantifying the period.[27]

Groups at Baseline

Except for the study by Carmeli et al,[26] all studies reported the baseline comparisons of TMD symptoms. The comparisons showed similarities between groups in three of the studies.[27,28,30] The baseline measurements by Craane et al[16] showed that the intervention group had significantly higher pressure pain threshold (PPT) levels for the affected masseter muscle and temporalis compared with the control group. Differences between groups at baseline were also found in both studies by Kalamir et al; in the first[17] the intervention group had a greater opening range and in the second[29] the intervention group had a greater opening range in addition to higher average pain scores.

Description of Interventions

The duration of total treatment ranged from 1 day to 6 weeks (mean = 5 weeks). Of the included studies, one used a single treatment to test immediate effects of dry needling,[28] three studies performed a 5-week protocol (one with 15 treatments[26] and two with 10 treatments[17,29]), one performed a 4-week protocol (12 treatments),[30] and two had an intervention period of 6 weeks which was comprised of nine treatment sessions.[16,27] Two trials evaluated manual therapy with additional exercise,[26,27] three trials assessed manual therapy combined with home physical therapy,[16,17,30] one trial studied the effect of manual therapy alone,[29] and one trial studied the effect of dry needling.[28]

Manual mobilization and active exercises were compared with an individually designed polyethylene soft occlusal repositioning splint[26] and with a control group.[27] The participants who underwent manual therapy combined with home physical therapy were compared with a control group,[16] a wait-list control group, and two groups of participants who underwent manual therapy alone[17] or home physical therapy alone.[30] Manual therapy alone was compared with ESC[29] and the study by Fernández-Carnero et al[28] compared the effect of dry needling on active trigger points with a sham intervention.

Adverse Events

Only three studies stated that there were no adverse events.[17,29,30] The others failed to mention either the presence or absence of adverse events.

Methodologic Quality

The methodologic quality of the included studies varied. Figure 2 represents the data from the Cochrane Risk of Bias tool analysis. When assessed with the Jadad scale, six of the seven studies were shown to have strong methodologic quality (score higher than 3). Those six studies also had PEDro scores of strong quality (scores higher than 7).[16,17,27–30]

Outcomes

The seven studies utilized nine different outcome measures. The outcome measures found in the studies were visual analog scale (VAS), pain physiopathology instrument scale, 11-point graded chronic pain scale (CPS), 10-cm numeric pain rating scale (NPRS), McGill Pain Questionnaire (MPQ), PPT, mandibular function impairment questionnaire (MFIQ), 7-point global reporting of changes, and jaw opening (interincisal distance).

Pain. The included studies used different instruments to assess pain. All seven studies used "at rest" or "current" to describe the pain. Other measures included pain "with stress" (chewing),[30] "upon maximal active opening" and "upon clenching,"[17,29] and also the "worst" and the "lowest" levels of pain experienced in the preceding 24 hours.[28]

All studies evaluated pain at baseline and after the total treatment protocol, and some also at 3 weeks after baseline (during the treament protocol),[16,27] 6 weeks posttreatment,[16,27] 20 weeks posttreatment,[16,27] 24 weeks posttreatment,[17] 46 weeks posttreatment,[16,27] and 1 year posttreatment.[17]

VAS for Pain Intensity at Rest. Three studies assessed pain intensity through a VAS.[16,27,30] One study showed that physiotherapy resulted in significant pain reduction ($P < .01$)[30] while the studies by Craane et al[16,27] found no significant differences between the physiotherapy and control groups ($P > .05$).

MPQ. Two studies assessed pain by using the MPQ[16,27] and both found no significant differences between the physiotherapy and control groups ($P > .05$).

PPT. Three studies assessed the participants' PPTs over the masseter muscle[16,27,28]; two of these studies found no significant differences between groups ($P > .05$)[16,27] while the study by Fernández-Carnero et al[28] found greater improvements in the intervention group (dry needling) when compared with the control group (sham) ($P < .001$).

Other Pain Measurements. Other pain measurements included the pain physiopathology instrument, which showed that physiotherapy was significantly better than splint therapy in reducing pain ($P < .05$).[26] The studies by Kalamir et al[17,29] utilized an 11-point graded CPS and found a significant difference between the IMT and ESC groups that favored the IMT group ($P < .001$), although this difference was not clinically significant.[29] A significant difference between the treatment groups (IMT and IMT + ESC) and control group was also found with the 1-year assessment showing significantly lower pain scores in the IMT + ESC group when compared with both the IMT group and the control group.[17] The study by Fernández-Carnero et al[28] used a 10-cm NPRS and showed significant differences favoring the intervention (dry needling) when compared with the sham group ($P < .001$).

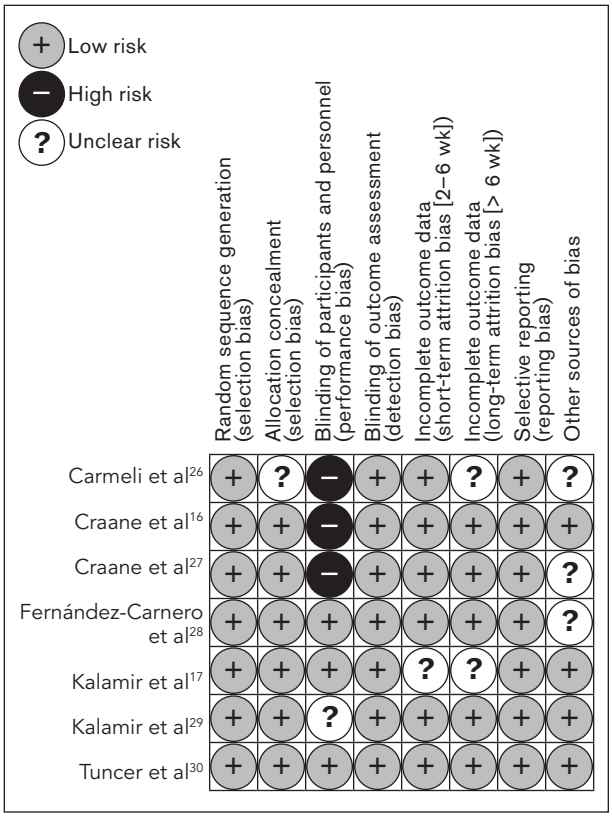

Fig 2 Risk of bias summary.

Meta-analysis Regarding Pain at Rest. Figure 3 represents the meta-analysis of pain at rest in all the included studies except for the study by Fernández-Carnero et al,[28] as their outcome measure was through PPT, a very different instrument whose data could not be grouped with the rest of the data.

The summary SMD showed that globally, there was a statistically significant improvement favoring intervention (SMD = −0.63; 95% confidence intervals [CI]: −0.95 to −0.31). The I^2 result showed no heterogeneity between studies.

When a sensitivity analysis was performed restricting the analysis to studies that presented the same diagnostic criteria, the estimated summary remained similar (SMD = 0.59; CI: −0.98 to −0.21; number of studies = 6; I^2 = 20.5%).

Figure 4 represents the funnel plot concerning the publication bias for pain at rest. Egger's regression asymmetry test shows no evidence of publication bias ($P = .264$).

Mandibular Function. Mandibular function was assessed through the MFIQ,[16,27] passive jaw opening,[16,27] and also by maximum active jaw opening in all included studies.

Table 1 Data Extracted from the Included Studies

Study ID	Objective	Method/ study design	No. of participants	Diagnoses	Interventions	Outcome measures: Outcome	Outcome measures: Scale/Instrument
Carmeli et al[26] (2001)	To compare the results of two treatment protocols (mobilization with active exercises and soft repositioning splint) for the management of ADTMD syndrome.	RCT	36	ADTMD	G1: Soft flat plane occlusal repositioning splint (n = 18) G2: Manual mobilization and active exercises (n = 18)	1. Active ROM of mouth opening 2. Pain	1. Fabric measuring tape 2. PPI scale
Craane et al[27] (2012)	To investigate the effect of physical therapy on pain and mandibular function in patients with ADD-R of the TMJ in a randomized controlled trial.	RCT	49	TMD (IIb and IIc according to RDC/TMD)	G1: Physical therapy (n = 23) G2: Control (n = 26)	1. Pain 2. Mandibular function 3. MMOa 4. MMOp	1. MPQ, VAS, and PPT 2. MFIQ 3. Interincisal distance at MMO (plastic ruler, mm) 4. Interincisal distance at mouth opening (plastic ruler, mm)
Craane et al[16] (2012)	To investigate the effect of physical therapy on pain and mandibular function in patients with masticatory muscle pain (with RDC-TMD Axis I, Ia, or Ib diagnosis) using a randomized and controlled design.	RCT (single-blind, randomized, controlled trial with a 1-year follow-up)	53	TMD (I, Ia, or Ib according to RDC/TMD)	G1: Treatment (n = 26) G2: Control (n = 27)	1. Pain 2. Mandibular function 3. MMOa 4. MMOp	1. MPQ, VAS, and PPT 2. MFIQ 3. Interincisal distance at MMO (plastic ruler, in mm) 4. Interincisal distance at mouth opening (plastic ruler, in mm)
Kalamir et al[17] (2012)	To investigate whether IMT and IMT + ESC treatments are superior to no treatment and to investigate whether IMT + ESC is superior to IMT over the course of 1 year.	RCT	93	Chronic myogenous TMD (according to RDC/TMD)	G1: Control (n = 31) G2: IMT (n = 31) G3: IMT + ESC (n = 31)	1. Pain (at rest, upon MMOa, upon clenching) 2. Interincisal range of opening 3. Global reporting of changes	1. 11-point GCPS 2. Vernier calipers (in mm) 3. 7-point global reporting of changes
Kalamir et al[29] (2013)	To compare the short-term effects of ESC to those of IMT on pain and opening ROM in participants with chronic myogenous TMD.	RCT	46	Myogenous TMD (according to RDC/TMD)	G1: ESC (n = 22) G2: IMT (n = 23)	1. Jaw pain at rest 2. Jaw pain upon MMOa 3. Jaw pain upon clenching 4. Maximal voluntary interincisal opening range (in mm)	1, 2, and 3: 11-point NPRS 4. N/A
Tuncer et al[30] (2013)	To compare the short-term effectiveness of MT + HPT and HPT alone.	RCT	40	TMD, (I, IIa according to RDC/TMD)	G1: HPT (n = 20) G2: MT + HPT (n = 20)	1. Pain intensity at rest 2. Pain intensity with stress 3. Pain-free MMO	1. VAS 2. VAS 3. Measured the interincisal distance (in mm)
Fernández-Carnero et al[28] (2010)	To investigate the effects of dry needling over active trigger points in the masseter muscle in patients with TMD.	RCT, crossover	12	TMD, myofascial pain (according to RDC/TMD)	G1: Deep dry needling (n = 12) G2: Placebo (n = 12)	1. Pain intensity (current, worst, lowest) 2. Pain-free MMO	1. 10-cm NPRS, PPT 2. The distance between the upper and lower central dental incisors (in mm).

ADTMD = anterior displaced temporomandibular disc syndrome; ADD-R = anterior disc displacement without reduction; IMT = intraoral myofascial therapy; ESC = education and self care; MT = manual therapy; HPT = home physical therapy; ROM = range of movement; MMOa = maximal active mouth opening; MMOp = maximal passive mouth opening; PPI = pain physiopathology instrument; MPQ = McGill pain questionnaire; VAS = visual analog scale; PPT = pressure pain threshold; MFIQ = mandibular function impairment questionnaire; GCPS = graded chronic pain scale; NPRS = numeric pain rating scale.

Results	Authors' conclusion	Methodologic quality PEDro	Jadad
Manual mobilization and exercises demonstrated a significant decrease in total average pain level ($P < .05$) for the patients in G2; occlusal splints did not demonstrate a significant decrease ($P > .05$) in G1. Concerning active ROM of mouth opening, no significant increase was found in G1 ($P > .05$), but a significant increase was found in G2 ($P < .05$). The comparison between groups showed that G2 was significantly better than G1 in reducing pain ($P < .05$). No results on the comparison between groups concerning ROM.	Manual mobilization and active exercises are more effective for treatment of pain and ROM deficits associated with ADTMD than soft repositioning occlusal splint therapy.	5	1
No differences between groups at baseline. All pain variables decreased and all function variables increased significantly over time for both groups. The interaction between time and treatment group was not significant.	Physical therapy had no significant additional effect in patients with ADD-R.	8	3
At baseline there were no significant differences between groups, except in PPT levels for the affected masseter and temporalis muscles, which were significantly higher in the treatment group. Both groups improved significantly over time for VAS pain intensity, PPT, function by MMOa and MMOp, and by MFIQ ($P < .05$), but no significant differences between groups was found.	These findings indicate that independent of the treatment provided, all participants improved over time. There was no specific therapeutic effect of physical therapy on MMO.	7	3
At baseline there were no significant differences between groups except for opening ROM, which was greater in both treatment groups. Both treatment groups had significantly lower pain scores than the control group after baseline. By the 1-year assessment, the IMT + ESC group had significantly lower pain scores than the IMT group, which was not apparent at the 6-week or 6-month assessment. Global reporting of changes showed significant differences in change in scores between the groups, with the IMT + ESC group showing the best scores at 1 year. In both treatment groups, outcomes remained significantly different from the control group even at 1 year.	IMT + ESC can be safely used and may be superior to no treatment as well as IMT alone at 1 year.	8	5
Results for the pain scores (at rest, maximal opening, and clenching) indicated statistically significant differences between groups ($P < .001$); however, this difference was not clinically significant. Results for opening range showed that the difference between groups was not significant ($P = .416$), although the difference intragroup was significant in both ESC and IMT groups ($P = .025$ and .032, respectively).	IMT showed significantly lower mean pain scores when compared with ESC, and there were significantly higher odds of IMT achieving a 2 or more point decrease in pain scores in myogenous TMD sufferers. Both treatments indicated positive effects over time; however, the short duration of the trial suggests that the results should be interpreted with caution.	7	5
VAS scores (for pain at rest and pain with stress) significantly decreased in both groups over time ($P < .01$). Time*treatment effect as well as treatment effect were significant only for pain with stress in the MT + HPT group ($P < .01$). On the VAS, mean change scores for pain at rest were 34.6% on HPT and 59.2% on MT + HPT, and for pain with stress there was a decrease of 35.7% in the HPT group and 91.3% in the MT + HPT group ($P < .01$) Pain-free MMO significantly increased in both groups ($P < .01$). Time* treatment effect had a greater increase in the MT + HPT group compared with the HPT group ($P = .009$).	In the short term, MT in conjunction with HPT is more effective than HPT alone for the treatment of TMD, particularly with regard to decreasing pain and increasing pain-free mouth opening.	10	5
The ANOVA detected a significant interaction between intervention and time for PPT for PPT levels in the masseter muscle ($P < .001$) and in the condyle ($P < .001$) and pain-free MMO ($P < .001$). Subjects showed greater improvements in all the outcomes when receiving the deep dry needling compared with the sham dry needling ($P < .001$).	The application of dry needling into active trigger points in the masseter muscle induced significant increases in PPT levels and MMO when compared to sham dry needling in patients with myofascial TMD.	8	4

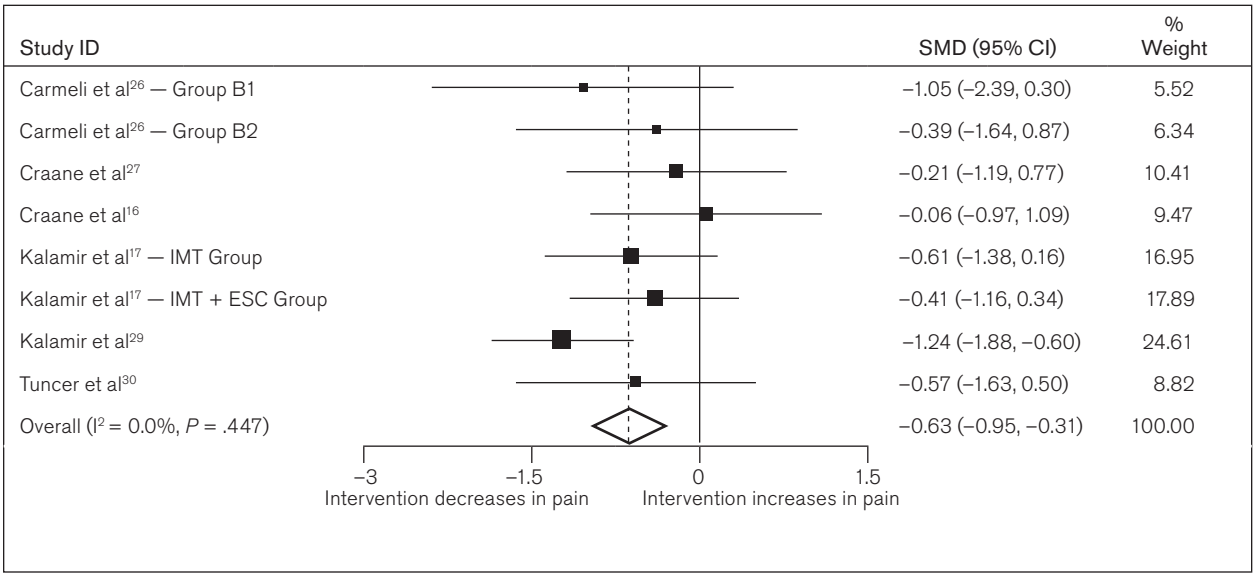

Fig 3 Forest plot of pain at rest.

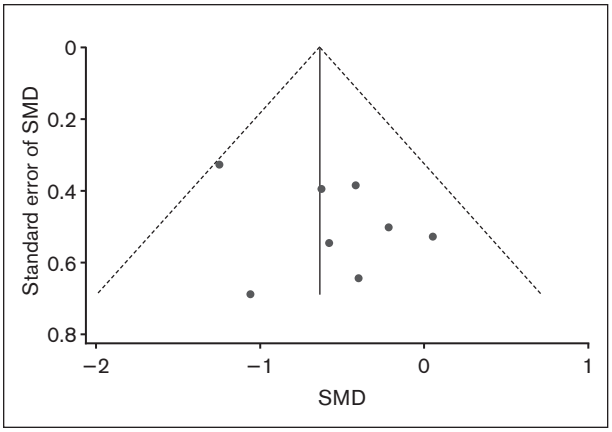

Fig 4 Funnel plot of publication bias for pain at rest. SMD = standardized mean difference.

MFIQ. Two studies assessed mandibular function by using the MFIQ and found no significant differences between the physiotherapy and control groups ($P > .05$).[16,27]

Passive Jaw Opening. Two studies assessed passive jaw opening and found no differences between the physiotherapy and control groups ($P > .05$).[16,27]

Active Jaw Opening. All seven studies assessed maximum active jaw opening. In the study by Carmeli et al,[26] results showed a significant increase in the experimental group ($P < .05$) while the control group failed to demonstrate a significant difference ($P > .05$). Notwithstanding, the results of the comparison between ROM data from the different groups were not found and could not be included in the analysis. Three studies found no differences between the physiotherapy and control groups ($P > .05$).[16,27,29] The study by Tuncer et al[30] revealed that pain-free mouth opening significantly increased in both experimental groups ($P < .01$), and that the time*treatment effect was greater for the experimental group (physiotherapy + home physical therapy) than for the control group (home physical therapy) ($P = .009$). Fernández-Carnero et al[28] also reported a greater improvement in the experimental group (dry needling) when compared with the sham group ($P < .001$), as did Kalamir et al,[17] who found the intervention was superior to the control group even after 1 year ($P < .001$).

Meta-analysis of Active ROM. Figure 5 represents the meta-analysis of active ROM data in all the included studies. The summary SMD shows that globally there was an improvement favoring intervention, although the differences found were not significant (SMD = 0.33; 95% CI: −0.07 to 0.72). The I^2 result revealed moderate heterogeneity between the studies.

When a sensitivity analysis was performed restricting the analysis to studies that presented the same diagnostic criteria, the estimated summary remained (SMD = 0.38; 95% CI: −0.08, 0.85; number of studies = 7; $I^2 = 70.1\%$).

Figure 6 represents the funnel plot of publication bias for active ROM. Egger's regression asymmetry test shows no evidence of publication bias ($P = .575$).

Other Outcomes Measured. One study assessed the participants' perceptions of improvement through a 7-point global reporting of changes[17] and concluded that there were significant differences in the change in scores between the groups, with the

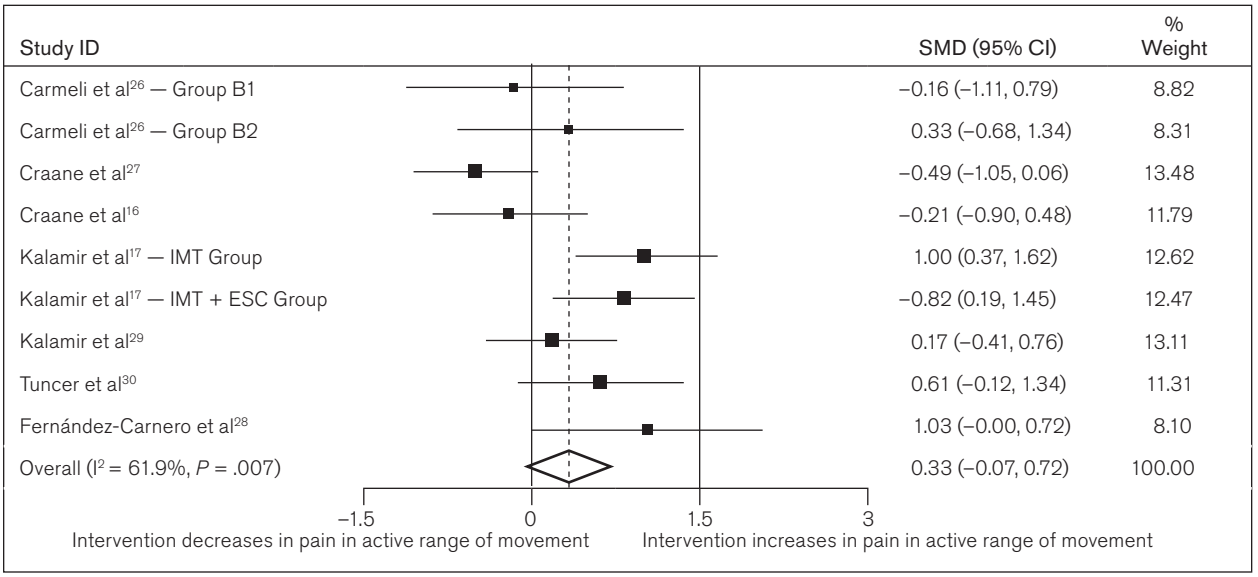

Fig 5 Forest plot of active range of movement.

IMT + ESC group showing the best scores at 1 year compared with the IMT group and the control group.

Discussion

A total of seven RCTs tested the effects of physiotherapy interventions compared with other interventions or control/placebo groups.

The methodologic quality based on the Cochrane Risk of Bias tool and the Jadad and PEDro scales was good, with an overall low risk of bias for all studies, except for the study by Carmeli et al,[26] which had a lower-quality score. All studies used an appropriate sequence generation, which reduced their risk of selection bias. Additionally, six studies employed allocation concealment;[16,17,27–30] however, in the study by Carmeli et al,[26] the risk of selection bias was unclear as the authors included no description of the allocation. Of the seven included studies, only three used double-blinding methods.[17,28,30] In the study by Kalamir et al,[29] there was an unclear risk because the blinding was incomplete, meaning that the participants were not blinded. This is a bias often found in physiotherapy intervention studies due to the difficulties of blinding not only the participant but also the therapist. Future studies should try to find ways to address these problems and assess and report the effectiveness of blinding. Four studies performed power analyses to calculate the required sample size[16,17,27,29] and three of these accounted for possible dropouts,[16,27,29] making these studies less susceptible to type II error.

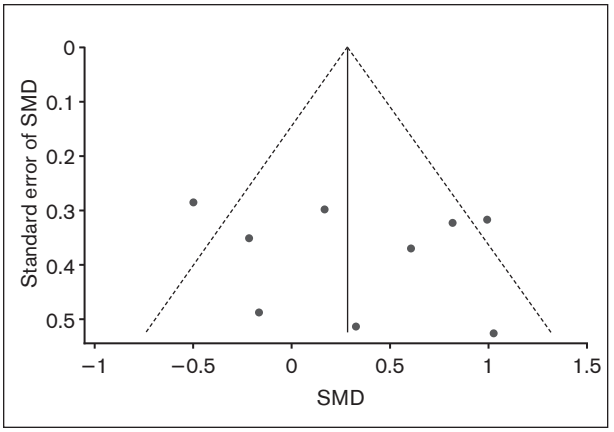

Fig 6 Funnel plot of publication bias for active range of movement. SMD = standardized mean difference.

Almost all the included studies reported details on dropouts,[16,17,27–30] diminishing the possibility of exclusion or attrition bias. Only the study by Carmeli et al[26] had no specific reference to dropouts, although throughout the text it is implicit that there were none. Additionally, the dropout rates of the included studies were very low, ranging from 0%[26,28,30] to 15%.[16] This may be due to the short duration of the trials (the longest trial had the highest dropout rate[16]) and even to the benign nature of the interventions. The dropout rates in the included studies were lower than in similar studies, which reported dropout rates from 15% to 30%.[31,32] Some of the dropout reasons cited were impatience with being on the waiting list,[17] changes in professional and personal life,[16,27,29] illness,[16,27] and insufficient decrease in patient complaints.[16]

The amount of physiotherapy treatment (ie, time per session and number of sessions) is an important clinical consideration and is quite variable. This variability is related to the patient's response to the treatment and the treatment technique selected, as there are so many different techniques within the scope of physiotherapy. This variability and the fact that there are several studies in which physiotherapy is performed by medical assistants or is considered to be any exercise or movement of the jaw is the reason why the present systematic review set the inclusion criterion that the treatment must be performed by a therapist and excluded studies that were solely hands-off. Additionally, while performing the review, several studies were found that used the word "exercise" to describe simply opening and closing the mouth. Therefore, the reviewers had a discussion in order to reach a consensus on what this analysis would consider to be physiotherapy; the definition included manual therapy techniques that are often performed not only by physiotherapists but also by chiropractors, osteopaths, and massage therapists, and also included exercise therapy, although studies in which opening or closing the jaw was considered an exercise without further consideration on how the movement was performed were excluded. In order to highlight the effectiveness of physiotherapy interventions unbiased and unmasked by the cumulative effects of other techniques, studies encompassing mixed treatments were excluded. This aspect narrowed the results but allowed a better understanding of the effects of physiotherapy in isolation and of the contribution of physiotherapy interventions in TMD management.

Since pain is one of the clinical signs of TMD and one of the main reasons that patients seek assistance,[2,7,33] this systematic review assessed the effects of physiotherapy interventions on pain and revealed findings that a physiotherapy intervention was significantly better in reducing pain than home physical therapy alone,[30] sham dry needling,[28] soft occlusal splints,[26] waiting-list control,[17] and ESC[29] (although in this last case, despite being statistically significant, the difference was not clinically relevant). It has been suggested that in patients with myogenous TMD, a change in pain of 24.2 mm on a VAS represents a clinically significant change;[34] and changes greater than 24.2 mm in patients with myogenous TMD were seen in the two studies that used a VAS.[16,30] Additionally, Farrar et al[35] found that a 27.9% decrease (or a 1.74-point decrease when assessed with an 11-point NPRS) in pain represents a clinically significant difference in patients with chronic pain; in the included studies that used this scale, the average change scores supported the clinical effectiveness of the intervention in pain.[17,29]

The meta-analysis results on pain at rest showed that a physiotherapy intervention produced a significant reduction in pain at rest. This reduction may be explained by peripheral and central mechanisms.[36] In response to injury, peripheral nociceptors and inflammatory mediators may act together, and manual therapy may directly affect this process.[36] In addition, manual therapy has been shown to trigger mechanical hypoalgesia, changes related to the activation of the sympathetic nervous system, and to the lessening of temporal summation, suggesting mechanisms that involve the periaqueductal gray and the spinal dorsal horn.[36,37] Schmid et al[37] found strong evidence to support the involvement of the central nervous system in mediating the response to manual therapy treatment. Several studies have been performed in order to study the mechanisms underlying manual therapy; however, none of these studies did so with an intervention directed at a TMD population.

The studies included in this review had many different control methods. Pertaining to ROM, physiotherapy was found to be superior to home physical therapy,[30] to sham dry needling,[28] and to the wait-list control group.[17] However, this difference was not found in the remaining studies. ROM did increase from baseline in the remaining studies,[16,27,29] showing a tendency for physiotherapy interventions to improve ROM, but the improvement was not statistically significant.

Each of the studies reported ethical approval of the study, although only three studies reported the absence of adverse events.[17,29,30] The fact that most of the studies did not report adverse events is alarming and should be taken into account in future studies.

Despite the increase in trials regarding the use of physiotherapy in the management of TMD, most of the published trials were not RCTs. Thus, the findings of these studies are less conclusive and generalizable as the risk of bias is much higher. It is therefore important for future RCTs to be performed in order to assess the effectiveness of physiotherapy in the management of TMD. It is also important to standardize assessment of the outcomes. Although almost all the included studies measured pain, ROM, and other mandibular function outcomes as dependent variables, the measurement instruments used were very different. Standardization of the outcome assessment instruments would allow researchers to pool data from multiple studies and to thereby draw consistent conclusions for the efficacious management of TMD. It will also be important to study further the pain mechanisms underlying physiotherapy interventions. In order to do this, investigations should include outcome measures designed to evaluate the multisystem effects of treatment, such as quantitative sensory testing protocols.[37–39]

One of the possible biases in the review process was the chosen definition of physiotherapy. The present researchers intended this definition to reflect the effects of "hands-on" physiotherapy interventions. Consequently, other potential studies with very different interventions may have been missed. However, all the included interventions were within the scope of physiotherapy and therefore reflect the effectiveness of physiotherapy.

Despite the small number of included articles, the meta-analysis assessed articles of high and very high quality and low risk of bias, allowing the reader to reach an evidence-based decision. However, the reader should take into account that the low number of included studies in the meta-analysis does not allow for definitive conclusions and that further studies are needed.

Conclusions

This systematic review and meta-analysis produced evidence that physiotherapy interventions are more effective than other treatment modalities and sham treatment in the management of TMD for pain reduction and that there was a tendency toward improved active ROM. However, these results are not definitive and should be interpreted with caution, mostly due to the small number of included studies and to the variability of the instruments used to assess the outcomes. Therefore, large-scale, high-quality, experimental studies with a standardized treatment protocol are needed to establish whether physiotherapy is effective and has real therapeutic value in the management of TMD.

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