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Review Article

Non-pharmaceutical treatments to relieve pain or reduce opioid analgesic intake and improve quality of life after total hip replacement: a meta analysis

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Abstract: To reduce pain after total hip replacement (THR), researchers are interested in drug-free interventions. However, there is still a lack of consensus on their prevention efficacy. We performed a meta-analysis to evaluate the use of nonpharmaceutical interventions for postoperative pain management after THR. We searched the Cochrane Library, MEDLINE, EMBASE, Web of Science, PEDRO, and ClinicalTrials.gov databases for articles published between and 1991 and 2020. The main outcome measures were postoperative pain, opioid consumption, and quality of life (QoL). In total, 1,942 patients were studied. We found moderate evidence indicating postoperative pain relief measured by the Western Ontario and McMaster Universities Arthritis Index Scale, with mean differences (MDs) of -0.28 (95% confidence interval [CI], -0.49 to -0.07; P=0.01; I^2=0%) within three months, -0.19 (95% CI, -0.40 to 0.02; P=0.07; I^2=0%) between 3-6 months, and -0.13 (95% CI, -0.35 to 0.08; P=0.21; I^2=0%) between 6-12 months. Additionally, we found that acupuncture therapy could reduce opioid analgesic consumption (MD, -0.98; 95% CI, -1.18 to -0.79; fentanyl [mg/h]; P<0.01; I^2=72.2%) and significantly improve pain relief with an MD of 0.90 (95% CI, 0.47 to 1.33; P<0.01; I^2=0%) measured using the visual analog scale. Electrotherapy slightly improved perceived pain with an MD of 0.22 (95% CI, -0.27 to 0.70; P=0.37; I^2=0%). Moreover, moderate evidence has shown that preoperative exercises improve QoL. This meta-analysis suggested that continuous passive motion did not improve pain or QoL. Postoperative exercise was associated with pain relief and improved QoL. Acupuncture therapy after THR has been shown to reduce opioid analgesic consumption.

Keywords: Non-pharmaceutical interventions, pain relieve, opioid consumption, quality of life, total hip replacement, meta-analysis

Introduction

Total hip replacement (THR) is a common surgical procedure that has increased worldwide over the last decades. In China, the average annual growth rate of hip and knee replacement surgeries reached 19.96% between 2012 and 2019. In 2020, the number of hip and knee replacement surgeries in China exceeded 500,000 [1, 2]. However, the procedure is associated with moderate to severe postoperative pain, which may impede mobilization, postpone rehabilitation, and increase duration of hospital stay [3]. Insufficient treatment of postoperative acute pain cannot only result in chronic pain but also cause complications, such as hospital-acquired pneumonia, poor wound healing, delay postoperative recovery, and increase the economic burden on patients [4]. Effective treatment for postoperative pain is of great significance to promote early recovery [5].

Opioid analgesics are currently mainstream drugs for treating postoperative pain [6, 7]. They work by inhibiting the pain center in the central nervous system. However, previous research showed that physicians generally do not follow the evidence-based prescription guidelines when using opioid analgesics, which may lead to opioid abuse, addiction, misuse, and opioid-related adverse effects [8]. Therefore, in recent years, reducing the consumption of opioids while ensuring best analgesic effect has been a need in the field of postoperative pain management.

It has been reported that patients requiring THR will reach 3.48 million in 2030, which is an increase of 673% according to the global epidemiological survey data [9, 10]. Total hip replacement refers to a cost-effective orthopedic surgery that replaces a diseased joint with artificial joint prostheses. Total hip replacement is most commonly used in improving joint dysfunction, such as femoral neck fracture, femoral head necrosis, and hip arthritis. It is helpful in relieving pain and enhancing capacity of the hip; this has benefitted patients with end-stage hip osteoarthritis [11, 12]. However, the use of opioid epidemic and prescription opioids indiscriminately results in concern about the management strategy for pain after THR [13]. According to a recent study, nearly half of the research participants had persistent pain within 1 year after THR [14]. There is concern about postoperative pain management that a single operation like arthroplasty can result in long term opioid abuse. Under such circumstances, non-pharmaceutical therapies have gradually been used for postoperative pain after THR to replace the use of opioid analgesics. Research has focused on the efficacy of acupuncture, auricular acupuncture, and other alternative treatments to find a better strategy for treating postoperative pain after THR [15, 16].

We conducted a review to estimate the ability of general non-pharmaceutical therapies for postoperative pain management after THR. Data were collected from randomized clinical trials (RCTs) about postoperative pain, including existing pain metrics and quality of life. Analysis of an alternative pain management could help physicians find an appropriate pain treatment strategy that decrease opioid consumption after THR.

Materials and methods

Analyses were performed under the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [17] and International Prospective Register of Systematic Reviews (PROSPERO) guidelines [18].

Search strategy

Databases: We searched online databases, such as EMBASE (OVID), MEDLINE (PubMed), Web of Science, Cochrane Database of Systematic Reviews, clinicaltrials.gov, and Physiotherapy Evidence (PEDRO database) in a scholarly clinical setting to find related articles published between 1991-2020. To discover more papers, we searched through the citations of chosen review papers, original works, and books. We did a manual search of journals, significant conference proceedings, professional organization webpages, national hip replacement registrations, and policy clearing houses for further publications. The search scheme was implemented using the snowball technique [19].

Search criteria: With the exception of limitation to English language, we did not set time or publication status constraints on the study in order to be as thorough as feasible in this literature review. We found two papers published in Chinese. Nevertheless, there were no translation services available to add them. In each database, we used a given search string: (postoperative pain OR postoperative pain* OR postoperative pain) AND (total hip replacement OR total hip* OR total hip arthroplasty OR THA). The use of asterisks helped to shorten words, which means that any item following the asterisks will be studied. We employed a mix of keywords and indexed phrases to get the maximum sensitivity.

Inclusion criteria: In this study, the major search goal was to find the following problems. The inclusion criteria in this study followed the principles of PICO (population, interventions, comparisons, outcomes): (P) patients underwent primary THR; (I) non-pharmaceutical interventions for postoperative pain management; (C) other non-pharmaceutical interventions or without treatment (along with regular analgesic treatment); and (O) pain alleviation after surgery, opioid consumption, and quality of life.

Exclusion criteria: Duplicate published studies; unrelated studies, such as case reports, reviews, or meta-analyses; studies not available in full text in the database; studies without outcome data available for analysis.

Study selection

Design: Postoperative pain management is mostly hierarchical, involving non-pharmaceutical treatments. Therefore, research was chosen that compared non-pharmaceutical interventions to regular pharmacological therapy. The analysis was limited to adults undergoing main operative treatments.

Outcomes of interest: Three individuals (W.P.S., Y.J.H., and L.L.L.) independently examined the entire papers by scanning portions or abstracts to decide whether the papers satisfy the inclusion standards. Any disagreement was resolved by consensus and dialogue between the individuals. We define postoperative pain alleviation as the mean difference (MD) in grades on the visual analog scale (VAS), or the Western Ontario and McMaster Universities Arthritis Index Scale (WOMAC). Opioid analgesic intake was assessed in sessions of average distinction in fentanyl intake in milligrams per hour. Quality of life was defined as the average distinction in grades in the Medical Outcomes Study Short-Form 36 (SF-36).

Intervention: We put a limit on our focal point to normally known postoperative pain treatments. These involved continuous passive motion (CPM), preoperative workout, hydrotherapy, acupuncture, electrotherapy, and postoperative exercise.

Continuous passive motion comprises using an extraneous machine to offer steady motion to the hip, employing a predetermined range of motion (ROM). Motions theoretically help to scale ROM up, while enhancing pain management at the same time [20].

Preoperative workout (or pre-rehabilitation) includes terms that are used before operation. It allows easy coping with the forcible tension that is related to surgery duration and assists postoperative recovery [21].

Water's unique characteristics are used by hydrotherapy to promote rehabilitative attempts through improving looseness, reducing pain, making it easier to balance, and enhancing strength. Benefits have been shown by hydrotherapy in musculoskeletal disorder therapy, involving osteoarthritis and rheumatoid arthritis [22].

Electrotherapy decreases pain and enhances the role by using power. Transcutaneous electric nerve stimulation and neuromuscular electrical stimulation are included by these modalities [23].

Acupuncture is a traditional Chinese medical approach, requiring needle insertion at detailed acupoints on patients to relieve pain. The mechanism of acupuncture analgesia is its impact on the nervous system, especially its long- and short-term impact, resulting in changes in hormones and neurotransmitters [24].

Postoperative exercises involve sessions performed by patients after THR, which include standard exercises with interactive education, strength training, gait training, ergometer cycling, and functional exercises. These rehabilitation programs support considerable ameliorations in interference and pain severity in patients and optimize these patients' roles by enabling an early return to everyday living movements [25].

Study quality assessment

L.M.Y. and Z.J.Y. independently evaluated the risk of bias [26]. Disagreement was decided by consensus and consultation between one another. Y.J.H., R.Y.Z. and X.F.S. independently evaluated the quality of the body of evidence for the different results considered by the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) approach [27].

Data analysis and synthesis

W.P.S., L.L.L., and Z.J.Y. retrieved the data from included papers independently. Central results were collected by applying a standardized form. Country, number of participants, publication year, intervention, age, gender, research design, period of intervention, statistical method, postoperative pain, opioid analgesic intake, quality of life, and outline of the outcomes were included by these variables.

The outcomes were standardized by our physicians through changing results that were on a numeric rating scale to a 10-point VAS and pain metrics of the WOMAC scale for the pain

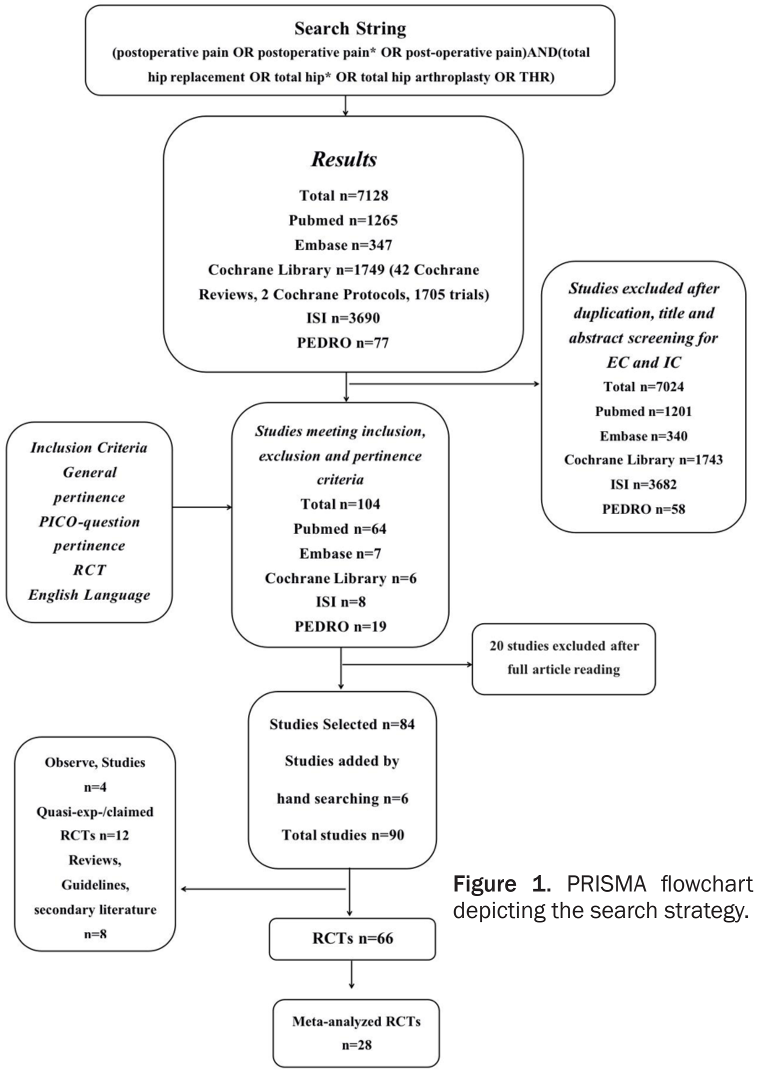

Figure 1. PRISMA flowchart depicting the search strategy.

grades. Where conceivable, the outcomes were separated. We changed data in other forms (for example, interquartile range, median, and mean [confidence interval]) to means (SDs) [26]. For those data not shown in papers, we mailed the authors for the original data; however, there was no response. Data were normalized for pain relief, opioid analgesic intake, and quality of life. Finally, all data about opioid analgesic intake were changed to milligrams per hour.

The evidence-based tables were evaluated by our clinical specialist (interventions, participants, results, and implementations), and heterogeneity was evaluated to decide whether the research qualified to execute a meta-analysis [28]. When suitable to pool the outcomes, we applied weighted mean differences (MDs) for uninterrupted data, employing the equivalent standardized MDs for uninterrupted results by employing dissimilar scales. We pooled both sets of summary statistics by involving research from distinct time dots.

We tested statistical heterogeneity to decide whether it was suitable to merge the research. Heterogeneity was graphically examined, depicting the variability in result estimations due to heterogeneity instead of sampling error (chance). The I^2 statistic was supposed to be bigger than half to be considered heterogeneous. If P≥0.05 and I^2≤50%, the fixed-effect model was used for meta-analysis; if P<0.05 and I^2>50%, the random-effects model was used for meta-analysis. Data were analyzed using Stata (version 16.0).

Results

Search findings

We included 7,128 studies, of which 90 (84 were from selection and 6 were artificially added one by one, as well as by snowball searching) were suitable for study. This meta-analysis followed the flow diagram of PRISMA, which is shown in **Figure 1**. We pulled the data out from 28 RCTs in the 66 RCTs without deletion, as shown in **Figure 1**. The covered research was published between 1991-2020.

Study characteristics

As shown in **Table 1**, a total of 1,942 samples were studied in the 28 RCTs. The 28 RCTs were based on three results (pain alleviation, opioid analgesic intake, and quality of life, involving dissimilar measures and types) and six interventions were categorized, involving three in the CPM group (three on pain and two on life quality), seven in the exercise group (five on pain and two on quality of life), two in the hydro-

Table 1. Characteristics of randomized clinical trials of nonpharmacological postoperative pain and quality of life management after total hip replacement

Source	Country	No. of Participants in Per-Protocol Analysis	Intervention	Age, Mean (SD) or Median (Range), y	Female, %
Continuous passive motion (CPM)					
Benjamin et al, 2012	Germany	36	Treatment group (T): CPM plus standardized exercise	64.9 (7.5)	12
			Control group (C): Standardized exercise	64.7 (9)	12
Beaupre et al, 2014	Canada	21	T: CPM plus physical therapy	51.7 (8.3)	7
			C: Physical therapy	55.9 (9.9)	3
Winther et al, 2018	Norway	60	T: CPM	61 (35-77)	17
			C: Standardized exercise	66 (44-83)	15
Electrotherapy					
Lan et al, 2012	China	60	T: Transcutaneous electrical nerve stimulation on acupoints	76 (6)	16
			C: Sham treatment	75 (5)	17
Castellano et al, 2016	United States	29	T: Neuromuscular electrical stimulation	57.55	9
			C: Standard rehabilitation	58 (4)	10
Preoperative exercise					
Hoogeboom et al, 2010	The Netherlands	62	T: Six week of workout two day per week before surgery	77 (3)	7
			C: No intervention	75 (5)	7
Vukomanović et al, 2008	Serbia	45	T: Preoperative education and physical therapy before surgery	60.1 (11)	14
			C: No intervention	56.2 (18.5)	16
Rooks et al, 2006	United States	63	T: Six week of water and land-based exercise two day per week before surgery	65 (11)	20
			C: Education intervention	59 (7)	16
Villadsen et al, 2013	Denmark	84	T: Eight week of water and land-based exercise two day per week before surgery	68.7 (8.4)	22
			C: No intervention	68.6 (7.1)	21
Berge et al, 2004	United Kingdom	40	T: Six week of pain management program two day per week before surgery	71.6 (6)	12
			C: Standardized exercise	71 (6.1)	15
Cavill et al, 2016	Australia	23	T: Four week of pain management program two day per week before surgery	63.9 (11.7)	6
			C: No intervention	64.9 (9.9)	6
Gocen et al, 2004	Turkey	59	T: Two week of exercise training program three day per week before surgery	46.9 (11.5)	13
			C: No intervention	55.5 (14.4)	8
Hydrotherapy					
Giaquinto et al, 2010	Italy	64	T: Hydrotherapy plus Passive joint motion	70.1 (8.5)	21
			C: Passive joint motion	70.6 (8.4)	26
Liebs et al, 2012	Germany.	280	T: Early Aquatic Therapy	66.7 (10.3)	NA
			C: Late Aquatic Therapy	69.1 (9.8)	NA

Acupuncture					
Usichenko et al, 2005	Germany	54	T: Auricular acupuncture	68 (10)	17
			C: Sham treatment	66 (11)	13
Wetzel et al, 2011	Germany	120	T: Auricular acupuncture	66 (10)	34
			C: Sham treatment	67 (8)	36
Lan et al, 2012	China	60	T: Transcutaneous electrical nerve stimulation on acupoints	76 (6)	16
			C: Sham treatment	75 (5)	17
Haslam et al, 2015	United Kingdom	28	T: Auricular acupuncture	66 (39-77)	13
			C: Standardized exercise	68 (57-77)	8
White et al, 2003	United Kingdom	37	T: Acupuncture	65.8 (8.3)	10
			C: Sham treatment	64.4 (12.7)	13
Postoperative Exercise					
Saw et al, 2016	South Africa	74	T: Standardized exercises plus Interactive education	60.7 (5.54)	60
			C: Standardized exercises		
Marchisio et al, 2020	Brazil	48	T: Accelerated Gait Training plus Standard exercise	64.62 (9.79)	10
			C: Standard exercise	64.68 (11.07)	12
Coulter et al, 2017	Australian	98	T: Outpatient rehabilitation program	66 (57-88)	36
			C: Perform rehabilitation independently	63 (53-86)	21
Galea et al, 2008	Australian	23	T: Supervised center-based exercise	68.6 (9.7)	8
			C: Unsupervised home-based exercise	6.6 (7.9)	8
Liebs et al, 2010	Germany	203	T: Ergometer Cycling	67.2 (10.3)	61
			C: No Ergometer Cycling	67.2 (8.5)	65
Monaghan et al, 2016	Ireland	63	T: Functional exercise	68 (8)	11
			C: No functional exercise	69 (9)	8
Monticone et al, 2014	Italy	100	T: Task-oriented exercises	69.5 (7.5)	32
			C: Open chain kinetic exercises	68.8 (8.1)	28
Siggeirsdottir et al, 2005	Iceland	50	T: Preoperative education program and postoperative home-based rehabilitation	69 (52-81)	14
			C: Conventional treatment	66 (28-86)	12
Steinhilber et al, 2012	Germany	36	T: An eight-week progressive home-based strengthening exercise program plus weekly institutional exercise therapy	65 (8)	12
			C: Weekly institutional exercise therapy	65 (9)	12

Abbreviations: C, control group; CPM, continuous passive motion; NA, not available; T, treatment group.

Table 2. The major significance of the meta-analysis is summed up for two pain scales, for one type of analgesic results, as well as for one type of the evaluation for quality of life

Variable	No. of Studies	No. of Participants	Effect Estimate (confidence interval)	I^2 Heterogeneity, %	GRADE
Pain Relief on the WOMAC					
Postoperative Exercise	6	1017	-0.20 (-0.32, -0.02)	0	Moderate
<3 months	3	349	-0.28 (-0.49, -0.07)	0	
3-6 months	3	337	-0.19 (-0.40, 0.02)	0	
6-12 months	3	331	-0.13 (-0.35, 0.08)	0	
Continuous passive motion (CPM)	3	154	0.24 (-0.07, 0.58)	61.7	Very Low
4-6 months	2	81	0.32 (-0.13, 0.76)	72.2	
12 months	2	73	0.17 (-0.27, 0.62)	75.2	
Hydrotherapy	2	344	-0.40 (-0.62, -0.19)	75.6	Low
Pain Relief on the VAS					
Postoperative Exercise	3	199	-0.78 (-1.13, -0.43)	76.4	Low
Preoperative exercise	5	229	-0.64 (-0.94, -0.34)	42.5	Very Low
Acupuncture	2	114	0.90 (0.47, 1.33)	0	Low
Electrical stimulation	2	89	0.22 (-0.27, 0.70)	0	Low
SF-36					
Postoperative Exercise	4	845	0.29 (0.16, 0.42)	1.7	Moderate
<3 months	2	301	0.33 (0.10, 0.55)	61.8	
3-6 months	2	288	0.23 (0.00, 0.46)	51.6	
6-12 months	2	256	0.31 (0.08, 0.54)	0	
CPM	2	57	0.31 (-0.28, 0.90)	80.2	Very Low
Preoperative exercise	2	147	0.69 (0.34, 1.04)	0	Low
Fentanyl demand					
Acupuncture	3	454	-0.98 (-1.18, -0.79)	72.2	Low

therapy group (two on pain), two studies in the electrotherapy group (two on pain), five in the acupuncture group (two on pain and three on analgesics), and nine in the postoperative exercise group (nine on pain and four on quality of life).

Quality assessment

All research was evaluated for risk bias. The different scope of interventions we tested was reflected by the methodologic heterogeneity. We found that the highest bias in research was due to unsuitable or lost masking over the study (21 of 28 RCTs). In some papers [29, 30], masking was fully reached. In some cases, high risks of bias were found for chosen results [31-34]. A high risk of bias exists in a similar way because of unsuitable or missing random sequencing methods in one study [31]. Finally, none of the groups demonstrated high risk of bias for incomplete result data. No considerable differences were proven. The GRADE quality of evidence is shown particularly in **Table 2**.

Publication bias

Publication bias was tested using funnel plots. In the funnel plots, the scattered dots of each study were distributed on both sides of the plot and were relatively symmetrical. Most of the scattered dots were located in the upper part of the plot, suggesting that the outcome indicators were less likely to have publication bias or were affected by small sample effects.

Interventions

The central findings are summed up in **Table 2**. There were two types of pain scales, one type was for analgesic results, and another type was for the evaluation for quality of life. **Figures 2** and **3** demonstrate the meta-analyses, which reported statistically meaningful outcomes.

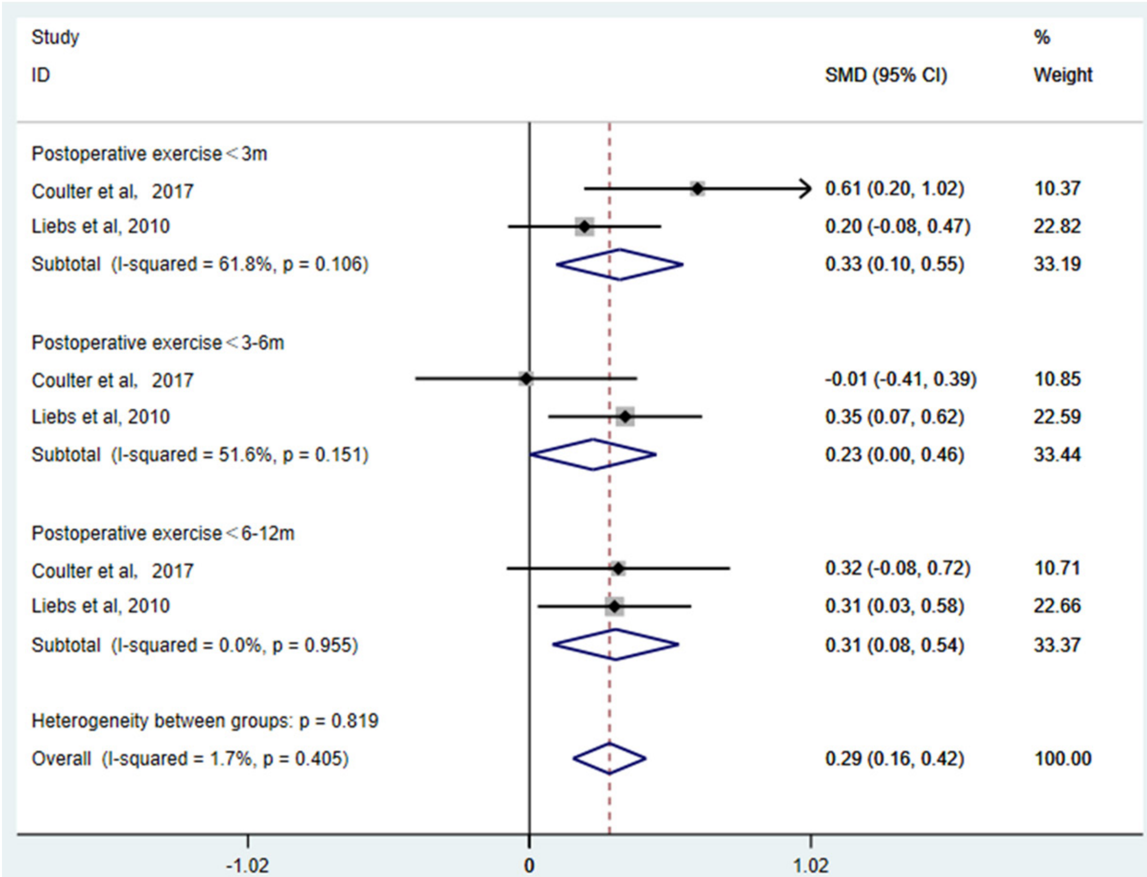

Figure 2. Forest plot of individual and pooled weighted mean differences in pain with the Western Ontario and McMaster Universities Arthritis Index Scale of postoperative exercises using the inverse variance method.

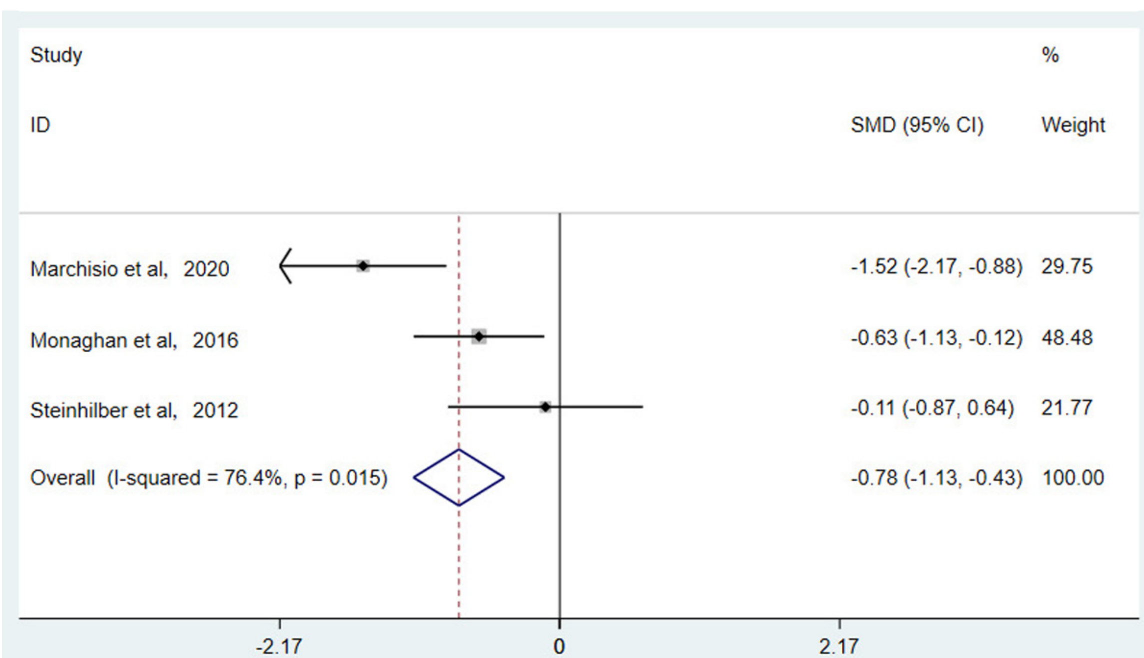

Figure 3. Forest plot of individual as well as pooled weighted mean differences in visual analog scale of postoperative exercises using the inverse variance method.

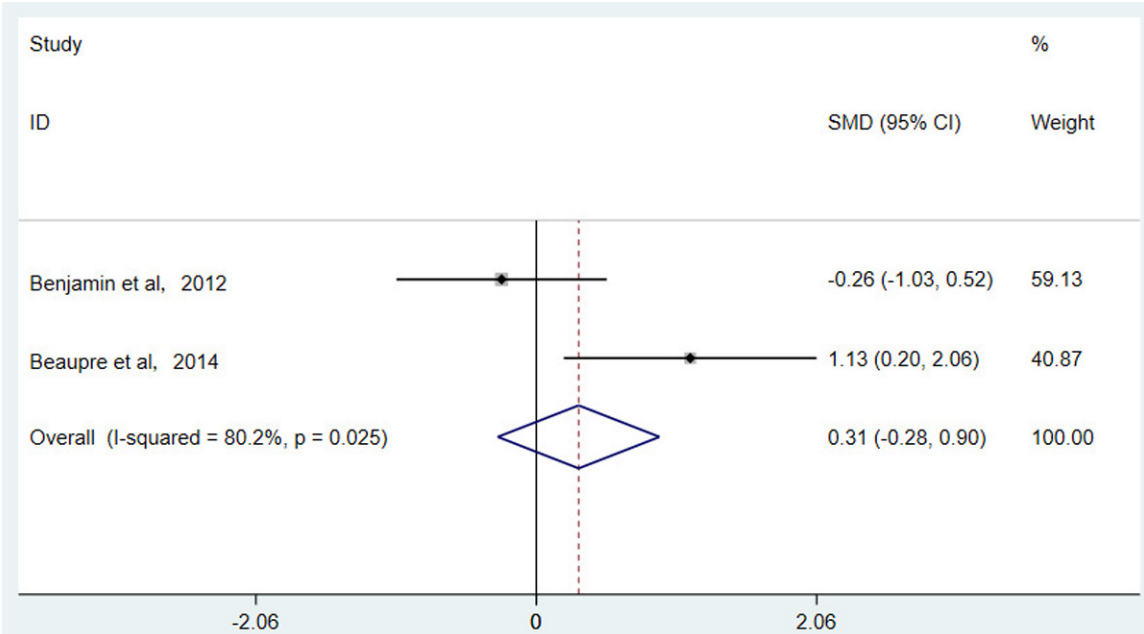

Figure 4. Forest plot of individual and pooled weighted mean differences in pain with the Western Ontario and McMaster Universities Arthritis Index Scale of continue passive motion using the inverse variance method.

Assessed outcomes and synthesis of evidence for pain relief

We found that evidence property was of temperate certainty or interventions (**Table 2**), and these were examined by depressed certainty for pain amelioration altogether. Nine pain relief studies with meta-analysis (N=1017) proposed a considerable amelioration with postoperative physical exercise, MDs of -0.28 (95% confidence interval [CI], -0.49 to -0.07; P=0.01; I^2=0%) on the WOMAC scale within three months, -0.19 (95% CI, -0.40-0.02; P=0.07; I^2=0%) between 3-6 month, and -0.13 (95% CI, -0.35-0.08; P=0.21; I^2=0%) between 6-12 month (**Figure 2**) with MDs of -0.78 (95% CI, -1.13 to -0.43; P=0.01; I^2=76.4%) on the VAS (**Figure 3**). Three pain relief studies with meta-analysis (N=154) showed no considerable amelioration in treated vs. control groups with CPM (**Figure 4**), and the MDs were 0.32 (95% CI, -0.13-0.76; P=0.16; I^2=72.2%) on the WOMAC scale between 4-6 month and 0.17 (95% CI, -0.27-0.62; P=0.44; I^2=75.2%) on the WOMAC scale for 12 months. Two pain relief studies with meta-analysis (N=114) showed a meaningful amelioration in treated groups compared to control groups using acupuncture, and the MD was 0.90 (95% CI, 0.47-1.33; P<0.01; I^2=0%) on the VAS (**Figure 5**). Two pain relief studies with meta-analysis (N=344) showed a meaningful amelioration in treated groups compared to control groups with hydrotherapy, and the MD was -0.40 (95% CI, -0.62 to -0.19; P<0.01; I^2=75.6%) on the WOMAC scale (**Figure 6**). Five pain relief studies with meta-analysis (N=229) showed a meaningful amelioration in treated groups compared to control groups with preoperative workout, and the MD was -0.64 (95% CI, -0.94 to -0.34; P<0.01; I^2=42.5%) on the VAS scale (**Figure 7**). Two pain relief studies with meta-analysis (N=89) showed no meaningful amelioration in treated groups compared to control groups with electrical stimulation, and the MD was 0.22 (95% CI, -0.27-0.70; P=0.37; I^2=0%) on the VAS scale (**Figure 8**).

We carried out sensitivity subgroup analyses to address potential overestimation deprived from the research design. No significant contrasts were obtained.

SF-36 total score: Meta-analysis of four quality of life studies (N=845) showed a meaningful amelioration in treated groups compared to control groups using postoperative exercise, and the MDs were 0.33 (95% CI, 0.10-0.55;

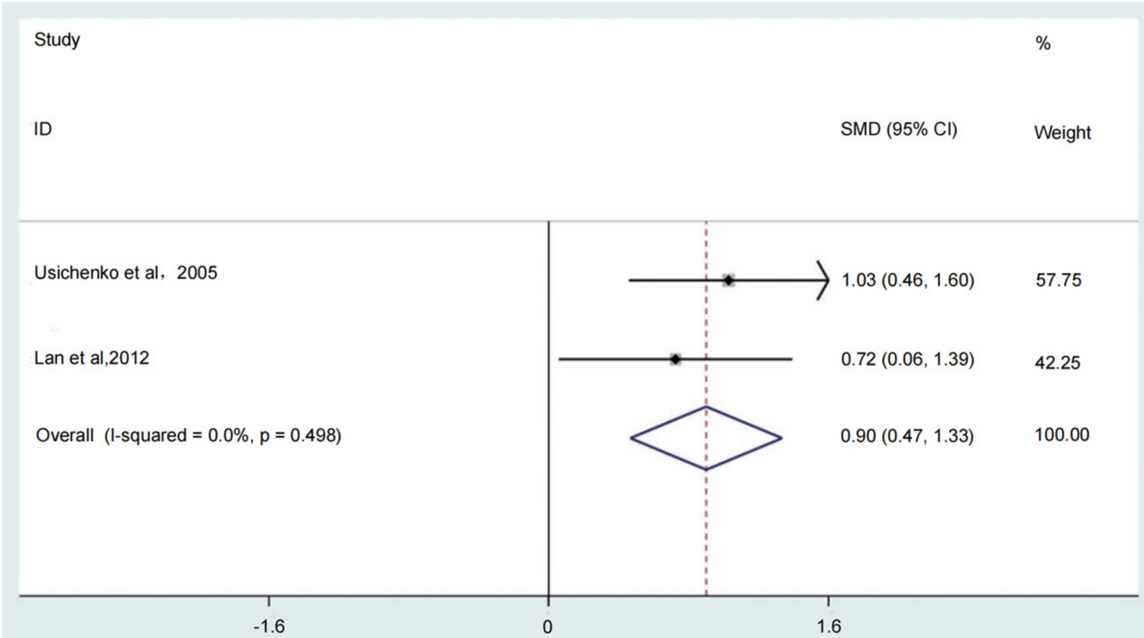

Figure 5. Forest plot of individual as well as pooled weighted mean differences in visual analog scale of acupuncture therapy using the inverse variance method.

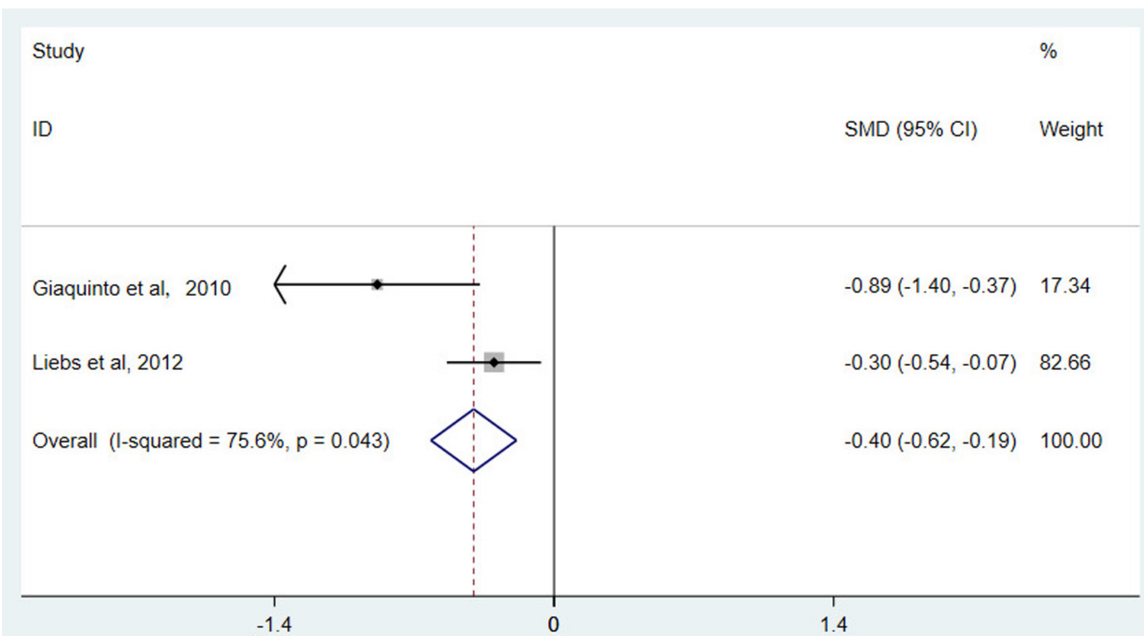

Figure 6. Forest plot of individual and pooled weighted mean differences in pain with the Western Ontario and McMaster Universities Arthritis Index Scale of hydrotherapy using the inverse variance method.

$P<0.01$; $I^2=61.8\%$) on the SF-36 scale within three months, 0.23 (95% CI, 0.00-0.46; $P=0.04$; $I^2=51.6\%$) on the SF-36 scale between 3-6 months, and 0.31 (95% CI, 0.08-0.54; $P<0.01$; $I^2=0\%$) on the SF-36 scale between 6-12 months (**Figure 9**). Meta-analysis of two quality of life papers (N=57) showed no meaningful amelioration in treated groups compared

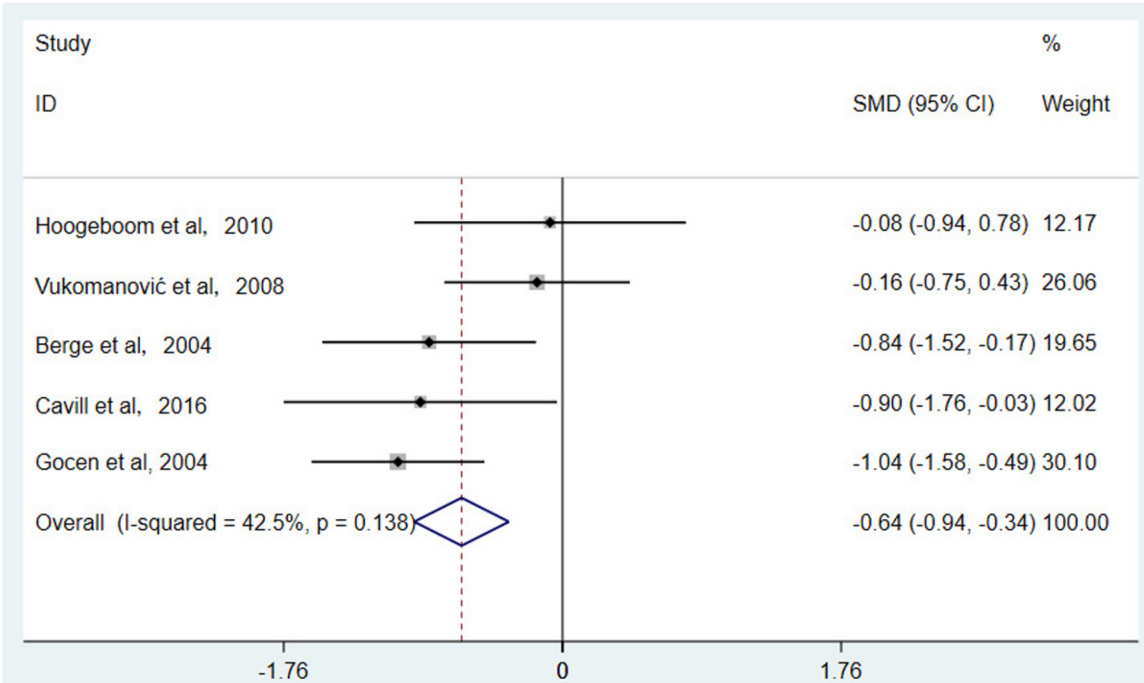

Figure 7. Forest plot of individual as well as pooled weighted mean differences in visual analog scale of preoperative exercises using the inverse variance method.

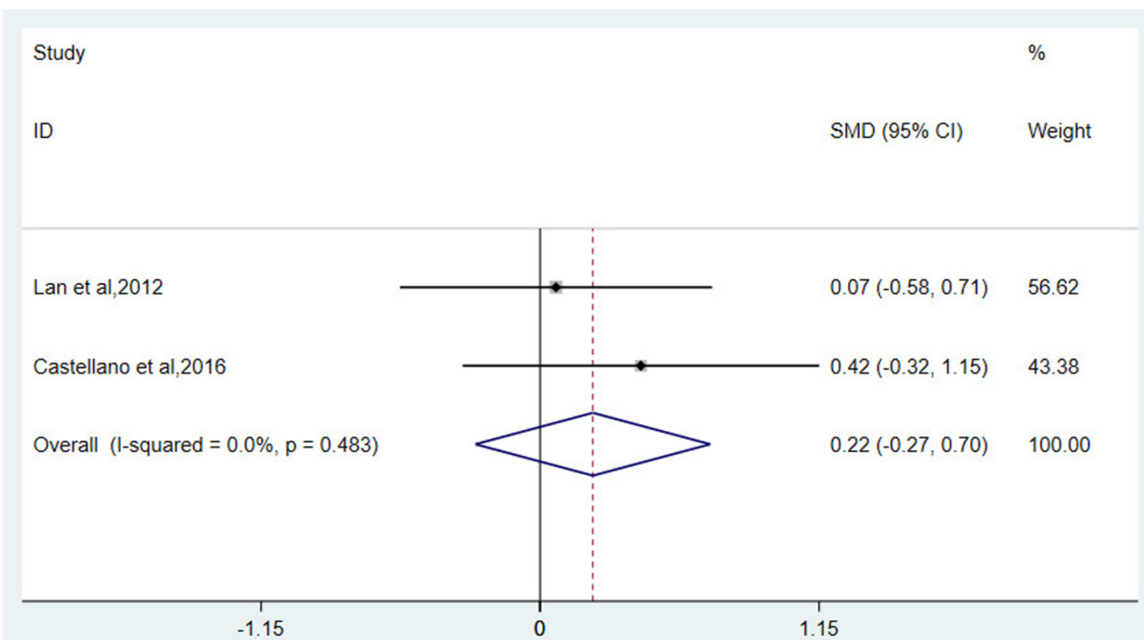

Figure 8. Forest plot of individual as well as pooled weighted mean differences in visual analog scale of electrotherapy using the inverse variance method.

to control groups using CPM, and the MD was 0.31 (95% CI, -0.28-0.90; *P*=0.30; I^2=80.2%) on the SF-36 scale (**Figure 10**). Analysis of two quality of life studies (N=147) showed a meaningful amelioration in treated groups compared to control groups with preoperative workout, and the MD was 0.69 (95% CI, 0.34-1.04; *P*<0.01; I^2=0%) on the SF-36 scale (**Figure 11**).

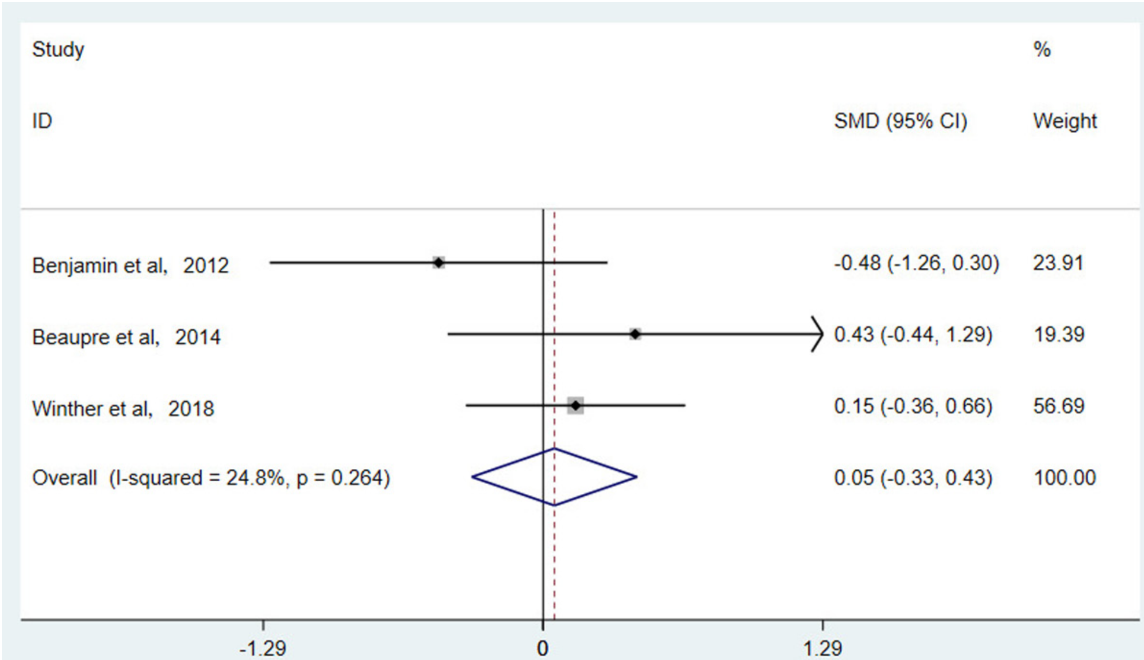

Figure 9. Forest plot of individual and pooled weighted mean differences with the Medical Outcomes Study Short-Form 36 of continue passive motion using the inverse variance method.

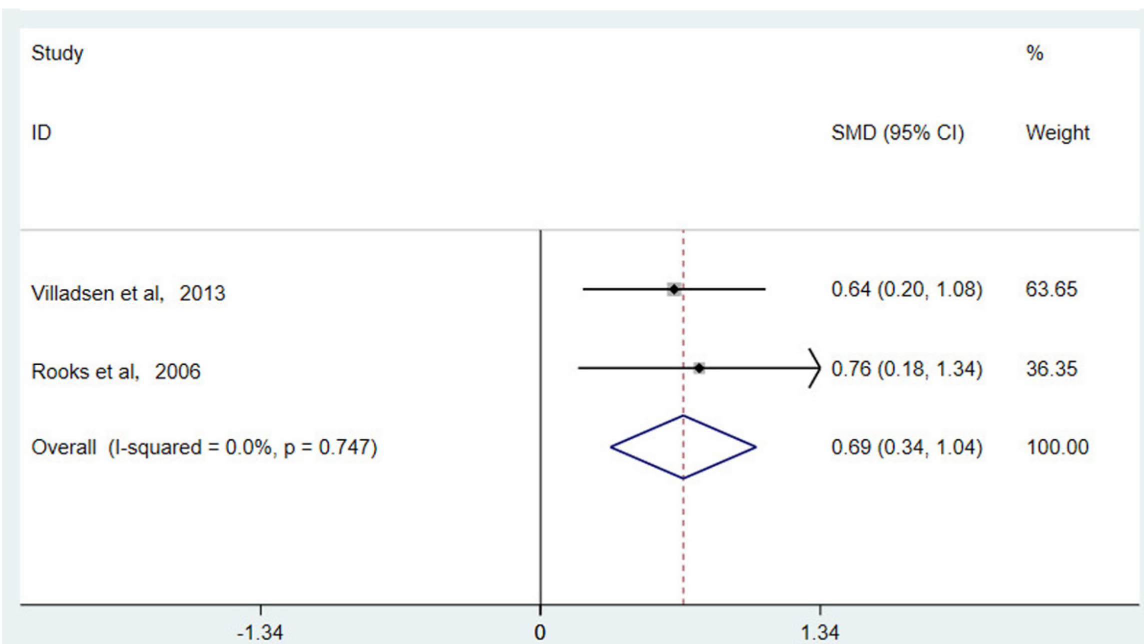

Figure 10. Forest plot of individual and pooled weighted mean differences with the Medical Outcomes Study Short-Form 36 of preoperative exercises using the inverse variance method.

Analgesic consumption: Analysis of three papers (N=454) indicated low certainty evidence that acupuncture reduced fentanyl intake (MD, -0.98; 95% CI, -1.18 to -0.79 fentanyl; $P<0.01$; $I^2=72.2\%$), as shown in **Figure 12**.

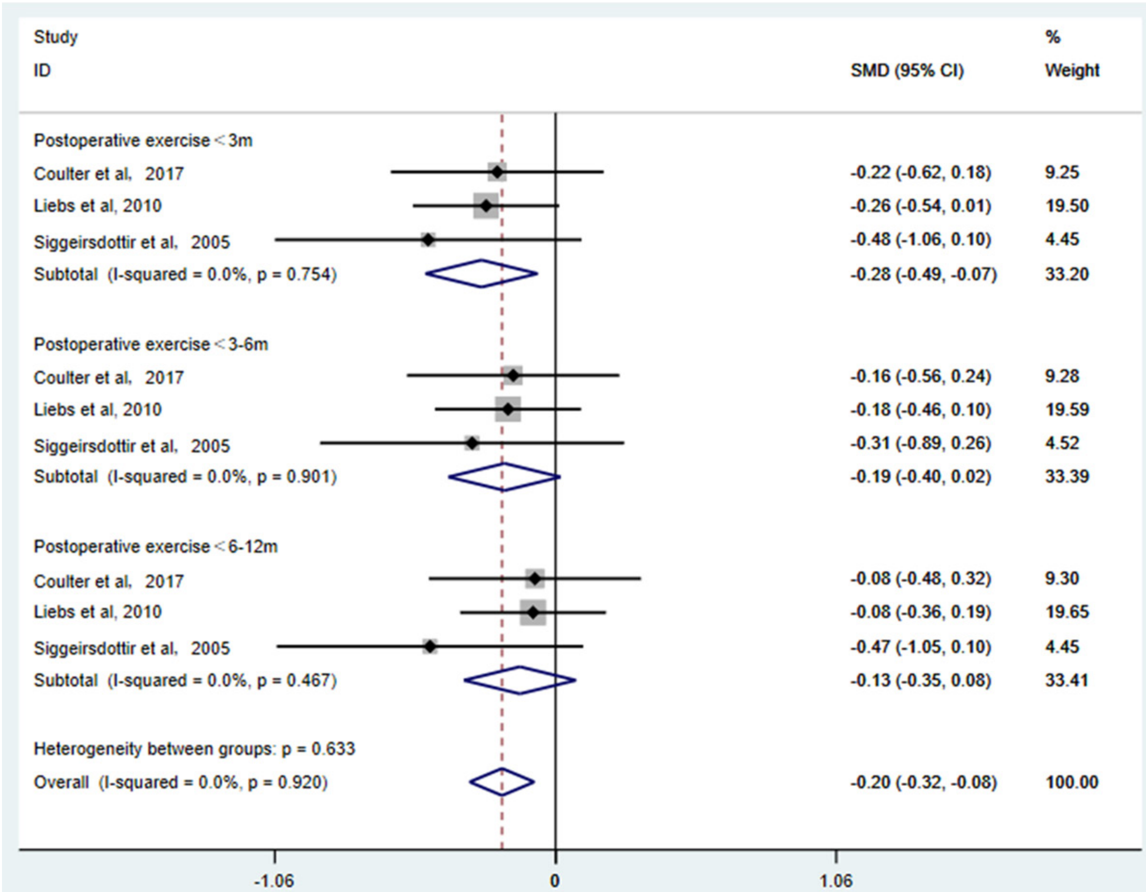

Figure 11. Forest plot of both pooled and individual weighted mean differences with Medical Outcomes Study Short-Form 36 of postoperative exercises using the inverse variance method.

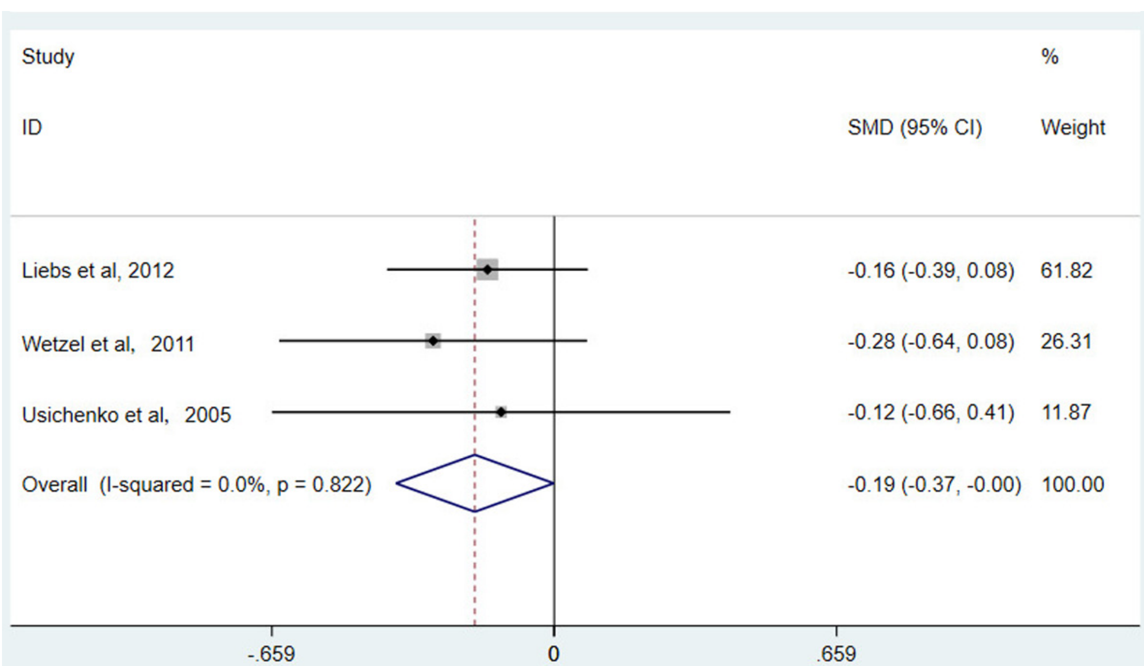

Figure 12. Forest plot of individual as well as pooled weighted mean differences in opioid intake reduction of acupuncture therapy using the inverse variance method.

Conflict of interest of included studies: The funding sources of 11 studies were reported by the authors.

Discussion

We found with moderate certainty that acupuncture reduced opioid analgesic consumption, and caused a significant improvement in pain relief measured by VAS. We also found moderate evidence that postoperative exercises improved quality of life and postoperative pain relief, as measured by the WOMAC scale within three months, between 3-6 months, and between 6-12 months, respectively, but of low certainty as measured by VAS. We found low certainty evidence that electrotherapy enhanced perceived pain on the VAS scale. Moreover, moderate evidence showed that preoperative exercises improved quality of life and low certainty evidence in pain relief. This meta-analysis suggested that CPM could not relieve pain, reduce opioid consumption, or improve quality of life.

In this study, strategies were found for postoperative pain alleviation that focused on the early postoperative stage (first three months). The postoperative interventions included standard exercise, ergometer cycle, and functional exercise. These programs have used strengthening workouts, as well as functional tasks to enhance muscle strength, power duration, and mobility [35-38]. Practice schemes beyond the initial period of postoperative recovery have been shown to decrease leg stiffness and pain, enhance body function, and reduce the risk of accidental falls in THR patients [39, 40]. The use of task-oriented exercises after THR may have added value in reducing pain intensity and improving activities of daily living performance. Pain perception had decreased, which indicated definite interactive impacts of dynamic practices and surgical treatment [41]. However, the long-term efficacy of postoperative exercises was not shown by this meta-analysis. One of the reasons might be outcomes between dose and reaction of postoperative practice therapy, which have seldom been investigated [42, 43] with little evidence or no standard criteria-based suggestions of clinical rehabilitation prescriptions. Subsequently, our results showed that quality of life on the SF-36 scale improved significantly from 0 to 12 months. This implied that even if pain does not improve significantly from three months after surgery, patients can still benefit from postoperative exercises (e.g., standard exercise, ergometer cycle, and functional exercise) with improvement in quality of life.

Additionally, we included studies using acupuncture and auricular acupuncture to analyze their efficacy on THR postoperative pain management. The results suggested that acupuncture therapy was effective in reducing analgesic consumption, resulting in possible profits in this time window. Acupuncture therapy has been proven to stimulate the brain and spinal cord to produce endogenous opioid peptides, which inhibit production of pain-causing substances, thereby enhancing the function of the anti-pain system, and finally relieving pain [44]. Moreover, several studies have discovered that acupuncture provided considerable pain amelioration in patients who had THR on the first two days after surgical operation [45]. However, no significant differences were observed in the efficacy of acupuncture in improving pain measured by VAS in this study, and this illustrated that a larger sample size of RCTs is needed regarding acupuncture for pain relief. In conclusion, acupuncture therapy is more reliable than other non-pharmaceutical therapies due to less risk of bias.

In this study, electrotherapy included transcutaneous electrical nerve stimulation (TENS) and neuromuscular electrical stimulation (NMES). Transcutaneous electrical nerve stimulation is a non-invasive analgesic treatment that activates peripheral nerve fibers with electric pulses, which is effective in relieving pain. With the relief of postoperative pain, TENS also promotes functional recovery and shortens hospital stay; this was verified by research that used TENS intervention in 41 patients with hip extracapsular fracture fixation in the acute phase. The results demonstrated that TENS significantly reduced pain during walking and was helpful for restoring functional gait [46]. Neuromuscular electrical stimulation combines low-frequency current with electromyographic biofeedback therapy to stimulate specific muscles rhythmically, ultimately reducing muscle atrophy and spasms and promoting joint recovery. There has been little research published regarding the use of NMES and TENS for chronic low back pain reduction [47]. Nevertheless, our research finding showed that electrotherapy had little improvement for pain. However, TENS was considered to reduce opioid intake. However, because the research involved for this result was low-quality, more high-quality RCTs on pain amelioration and opioid intake after electrotherapy are required.

Hydrotherapy is applied by physiotherapists for improving pain in patients with knee or hip disorders [48]. We found low certainty evidence that hydrotherapy reduced perceived pain in this meta-analysis. Studies suggested that after hip arthroplasty, the WOMAC subscale of pain at all time points of hydrotherapy after discharge was better and statistically significant [29]. However, no study reported a benefit of hydrotherapy after THR for quality-of-life improvement. Therefore, hydrotherapy could be an alternative intervention to reduce pain for those who cannot engage in land exercises. More research may focus on how hydrotherapy affects quality of life and opioid intake.

Continuous passive motion was at first suggested in postoperative recovery after wound or joint operation, since an animal experiment demonstrated that it counteracted the pathologic phases of joint stiffness [49]. However, recent studies did not reveal the efficacy of CPM in enhancing body function [50], which was a similar result as the RCTs, and it led to conflicting results. We found very low-certainty evidence that CPM showed better pain reduction and quality of life. Continuous passive motion is found to be associated with increased length of hospital stay [51]. Considering the inadequate evidence, the application of CPM is not recommended.

Preoperative exercise, including education and muscle training in this meta-analysis, reflected good efficacy for pain and quality of life improvement, although the quality of included literature showed low certainty. Research suggested that preoperative exercise was able to reduce the risk of postoperative loosening of the prothesis and avoid chronic pain [52]. As a result, rehabilitation after THR should be started before the operation, so that patients can be educated to understand the importance of postoperative rehabilitation. Before the operation, the muscles of the hip joint can be exercised for muscle strength, which is helpful in improving pain and quality of life.

Several limitations were taken into account for interpreting our findings. First, for every result and intervention, we included a small number of studies because of high heterogeneity in timing and interventions. To deal with this problem, studies were pooled from different time intervals to acquire larger sample scales, and subgroup analyses showed similar outcomes overall. Gender and age were not differently distributed. Second, research frequently demonstrated an unclear risk or high risk of bias, resulting in underestimations or overestimations of the published results. We evaluated the evidence using validation tools and took the certainty of evidence into consideration for every outcome. Third, several studies did not meet the requirement of full masking, thereby bringing effects of overestimation in various kinds of meta-analysis conducted.

Conclusion

In this meta-analysis, postoperative exercises were associated with pain relief and quality of life improvement. This can be a first choice for THR pain. Acupuncture or auricular acupuncture after THR were preliminarily proven to reduce opioid analgesic consumption, which is good news in this critical time window, but more RCTs with larger sample sizes are needed before further promotion in clinical use.

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Disclosure of conflict of interest

None.

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