Systematic Review and Meta-Analysis

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Effects of electroacupuncture on obesity

A systematic review and meta-analysis

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Abstract

Background: This systematic review and meta-analysis evaluated the efficacy of electroacupuncture for the treatment of obesity.

Methods: We searched 8 electronic databases for articles published between 2005 and 2021, including only randomized controlled trials (RCTs) in the review. The intervention groups received either electroacupuncture alone or electroacupuncture with standard care, whereas the control groups received sham electroacupuncture, standard care, or no treatment. The primary outcome was the body mass index (BMI), and the secondary outcomes were the body weight (BW), waist circumference (WC), hip circumference, waist-to-hip ratio (WHR), body fat mass, body fat percentage, and adverse effects. Continuous outcome data are presented as mean differences (MDs) with 95% confidence intervals (CIs).

Results: This systematic review and meta-analysis included 13 RCTs involving 779 participants. Results revealed that the BMI (MD: −0.98; 95% CI: −1.35 to −0.61), BW (MD: −1.89; 95% CI: −2.97 to −0.80), WC (MD: −2.67; 95% CI: −4.52 to −0.82), and WHR (MD: −0.03; 95% CI: −0.06 to −0.01) were significantly improved in the intervention groups compared with those in the control groups. Adverse effects were reported in 5 studies. The most commonly used acupoint in the abdomen was ST25, whereas the most commonly used acupoints in other regions were ST36 and SP6 for the treatment of obesity. ST25 was the most commonly used acupoint connected by electroacupuncture.

Conclusion: This systematic review and meta-analysis suggested that electroacupuncture is an effective and safe therapy for simple obesity. To increase the reliability of this study, further detailed, long-term studies should be conducted on the effects of electroacupuncture on obesity.

Abbreviations: BFM = body fat mass, BFP = body fat percentage, BMI = body mass index, BW = body weight, CI = confidence interval, HC = hip circumference, MD = mean difference, RCT = randomized controlled trial, WC = waist circumference, WHR = waist-to-hip ratio.

Keywords: electroacupuncture, meta-analysis, obesity, systematic review

1. Introduction

Obesity is a chronic metabolic problem that has a negative impact on the quality of life and health.[1] The prevalence of obesity and overweight continues to increase regardless of sex or geographic location and has doubled since 1980.[2] Lack of physical activity, technological advances, and excessive food consumption have been reported as factors contributing to the increase in the prevalence of obesity.[3] Obesity is associated with decreased life expectancy[4,5] and an increased risk of various diseases, such as cardiovascular diseases,[6] diabetes,[7] cancer,[8] and depression.[9]

As obesity is recognized as a problem with significant health risks, various treatment methods have been investigated to address it. The first and most important factors to consider in obesity treatment are lifestyle changes, including dietary

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The study protocol is registered in the Open Science Framework (DOI 10.17605/OSF.IO/YU5XR; https://osf.io/yu5xr).

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control, physical exercise, and behavioral therapy. These methods continue to be developed through various studies.[10] If lifestyle changes are ineffective, drugs or surgery should be considered. However, drug therapy has adverse effects, including gastrointestinal, mental, or cardiovascular problems,[11] and surgical treatment, such as laparoscopic or open surgery, is also associated with adverse effects.[12] Therefore, drugs and surgical treatments are administered based on strict criteria. Although the number of patients with obesity is increasing, there are limitations to existing treatments.[13] Consequently, there is growing interest in safe and effective treatment methods with minimal adverse effects.

Acupuncture is a major treatment method used in traditional Korean medicine. Acupuncture is widely used in clinical practice in Korea and other countries due to its economic viability, safety, and minimal adverse effects.[14] Electroacupuncture is a type of acupuncture that delivers electrical stimulation to the body through acupuncture needles. Compared with acupuncture, electroacupuncture has been shown to enhance stimulation at acupoints through electrical stimulation.[15] Electroacupuncture shares the same advantages as acupuncture in terms of safety and effectiveness, with few adverse effects.[16,17] There have been many studies on the anti-obesity effects of electroacupuncture,[18–20] which is widely used for obesity treatment in clinical practice.

We conducted a systematic review and meta-analysis of the efficacy of electroacupuncture on obesity treatment. Previously, only one systematic review and meta-analysis was conducted on the effects of electroacupuncture on obesity.[21] However, that study included studies published only until October 2019 and specifically analyzed studies comparing the effects of electroacupuncture with those of other traditional Korean medicine treatments. Therefore, in the present systematic review and meta-analysis, we included more recent studies and analyzed data from additional databases in different countries. We excluded studies that compared electroacupuncture with other traditional Korean medicine treatments to provide a more accurate analysis of the effects of electroacupuncture on obesity.

2. Methods

2.1. Study registration

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[22] This protocol is registered in the Open Science Framework (https://osf.io/yu5xr).

2.2. Eligibility criteria for study selection

2.2.1. Study types. Only randomized controlled trials (RCTs) were analyzed to generate high-quality evidence. Animal studies and quasi-RCTs were excluded. The language was not restricted in the selection process.

2.2.2. Participants. We included patients diagnosed with simple obesity, with no restrictions on age, sex, or race.

2.2.3. Interventions. Studies that used electroacupuncture to treat simple obesity as an experimental group were included. Studies that combined electroacupuncture with standard care, including physical exercise, dietary control, and dietary education, were also included. Patients who received electroacupuncture combined with other treatments, such as moxibustion, cupping, or catgut embedding therapies, were excluded. The control group included patients who received sham electroacupuncture, standard care, or no treatment. In sham electroacupuncture, the wire of the electroacupuncture device is connected to the body, but there is no electrical stimulation.

2.2.4. Types of outcome measures. The body mass index (BMI) was used as the primary outcome. The body weight (BW), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), body fat mass (BFM), and body fat percentage (BFP) were used as secondary outcomes, in addition to the analysis of adverse effects.

2.3. Search strategy

The following 8 electronic databases were searched from their inception to December 2021 for this review: MEDLINE/PubMed, EMBASE, Cochrane Central Register of Controlled Trials, 3 Korean databases (Oriental Medicine Advanced Searching Integrated System, ScienceON, and KoreaMed), one Japanese database (Citation Information by the National Institute of Informatics), and one Chinese database (Chinese National Knowledge Infrastructure). Table 1 presents the search strategy for MEDLINE/PubMed. For a wider review of the related articles, the reference lists of the included articles were scanned. Offline articles were manually searched.

2.4. Data collection and analysis

2.4.1. Study selection. According to search guidelines, 2 independent researchers individually searched electronic databases and other resources. The titles, abstracts, and full texts of the articles were reviewed. Differences between the results of the 2 researchers were resolved through discussion with a third researcher. A third researcher made a final decision.

2.4.2. Data extraction and management. Two independent researchers organized the data into an Excel spreadsheet (Microsoft Corp., Redmond, WA), including the authors' names, publication year, study design, number of participants in each group, details of the experimental and control groups, duration and frequency of treatment, outcome measures, and adverse effects. If the Excel spreadsheets of the 2 researchers did not match, a third researcher made a final decision.

2.4.3. Assessment of the risk of bias. The risk-of-bias tool developed by the Cochrane Collaboration group was used to assess the risk of bias.[23] The domains of bias included random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. Each domain was evaluated by 2 independent researchers using 3 categories: high, low, and unclear risks. If the assessment of the risk of bias between the 2 researchers differed, a third researcher made the final decision.

Table 1

Search strategy for PubMed.

("obes*"[All Fields] OR "weight gain*"[All Fields] OR "weight loss"[All Fields] OR "body mass ind*"[All Fields] OR "adipos*"[All Fields] OR "overweight"[MeSH Terms] OR "overweight"[All Fields] OR "overweighted"[All Fields] OR "overweightness"[All Fields] OR "overweights"[All Fields] OR "over weight"[All Fields] OR "overload syndrome*"[All Fields] OR "overeat*"[All Fields] OR "over eat*"[All Fields] OR "overfeed*"[All Fields] OR "over feed*"[All Fields] OR "weight cycling"[All Fields] OR "weight reduc*"[All Fields] OR "weight los*"[All Fields] OR "weight maint*"[All Fields] OR "weight decreas*"[All Fields] OR "weight chang*"[All Fields]) AND ("electroacupuncture"[MeSH Terms] OR "electroacupuncture"[Text Word] OR "electro-acupuncture"[Text Word] OR "electric acupuncture"[Text Word]) AND ("randomized controlled trial"[All Fields] OR "controlled clinical trial"[All Fields] OR "random*"[All Fields] OR "controlled"[All Fields] OR "placebo"[All Fields] OR "trial"[All Fields])

2.4.4. Assessment of the effect of treatment. For continuous outcome data, mean differences (MDs) with 95% confidence intervals (CIs) were used.

2.4.5. Management of missing data. If necessary data were missing from the selected articles, the corresponding author was contacted. If data could not be obtained, the data were excluded from the analysis.

2.4.6. Data synthesis. Review Manager software version 5.4 (Cochrane Collaboration, London, UK) was used to synthesize the extracted data. Statistical heterogeneity among the included studies was assessed using the Higgins I^2 test. As this review included studies from various countries without restrictions on age, sex, or race, a random-effects model was used to account for heterogeneity. The potential publication bias was assessed using funnel plots.

2.4.7. Subgroup analysis. Subgroup analysis was applied to explore the heterogeneity or compare differences in effectiveness based on the type of experimental group to make more detailed judgments.

2.4.8. Evidence certainty. Grading of Recommendations Assessment, Development and Evaluation (GRADE) online software was used for assessing the certainty of evidence.

2.4.9. Ethics statement. As this was a systematic review and meta-analysis, ethical approval was not required.

3. Results

3.1. Study selection

A total of 1178 articles published until December 2021 were searched from 8 electronic databases: MEDLINE/PubMed (n = 141), EMBASE (n = 531), Cochrane Central Register of Controlled Trials (n = 114), OASIS (n = 6), ScienceON (n = 199), KoreaMed (n = 1), CINII (n = 2), and CNKI (n = 184). Of these, 297 duplicate studies were excluded. The titles and abstracts of the remaining 881 articles were analyzed. Animal studies (n = 325), non-RCT studies (n = 175), studies not related to simple obesity (n = 199), studies with inappropriate interventions (n = 92), and studies with inappropriate comparisons (n = 56) were excluded. The remaining 34 articles were analyzed through the full text; non-RCT studies (n = 4), studies not related to simple obesity (n = 1), studies with inappropriate intervention (n = 1), studies with inappropriate outcome measures (n = 3), studies with inappropriate comparisons (n = 8), and studies with unclear full texts (n = 4) were excluded, resulting in a final selection of 13 studies. The detailed process of the search and study selection is shown in Figure 1.

3.2. Study characteristics

The 13 selected studies[24–36] were analyzed based on the authors' names, publication year, study design, number of participants in each group, details of the experimental and control groups, duration and frequency of treatment, outcome measures, and adverse effects (Table 2).

The selected studies were published between 2005 and 2021, with 8 studies written in English and 5 in Chinese. There was one crossover study,[25] in which Group A received electroacupuncture for 6 weeks, followed by 1 week of rest, and, then, 6 weeks of standard care; Group B received 6 weeks of standard care, followed by 1 week of rest, and, then, 6 weeks of electroacupuncture. The results of electroacupuncture and standard care in each group were combined to analyze the results. Another study,[27] which was conducted by dividing the participants into the electroacupuncture, sham electroacupuncture, and no-treatment groups, analyzed the results of comparing the effects of electroacupuncture with those of sham electroacupuncture as well as the results of the comparison of the effects of electroacupuncture with those of no treatment.

A total of 779 participants were analyzed in the final selected studies, and the number of participants in each study ranged from 23 to 91. In the experimental group, the data of 396 participants were analyzed, with 8 and 5 studies performing electroacupuncture and a combination of electroacupuncture and standard care, respectively. In the control group, the data of 383 participants were analyzed, with sham electroacupuncture, standard care, and no treatment performed in 5, 6, and 3 studies, respectively. Sham electroacupuncture was performed using non-acupoints and connecting electroacupuncture wires without electrical stimulation. The details of sham electroacupuncture in studies are presented in Table 3. Standard care included physical exercise, dietary control, and dietary education, which could be applied in daily life. The treatment duration ranged from 4 to 24 weeks and the treatment frequency ranged from 2 to 5 times per week.

The outcome measures in the studies included BMI, BW, WC, HC, WHR, BFM, and BDP, with 11, 11, 10, 4, 5, 2, and 5 studies utilizing each measure, respectively. Adverse effects were reported in 5 studies.

In the selected 13 studies, the main acupoints used in obesity treatment, including acupoints connected by electroacupuncture, were analyzed (Table 4). The main acupoints were located in the abdomen (20 acupoints) and other regions (14 acupoints). In the abdomen, ST25 was the most commonly used acupoint in 10 of the 13 studies. CV12, CV6, and both CV9 and SP15 were used in 9, 7, and 6 out of 13 studies, respectively. In the other regions, ST36 and SP6 were the most commonly used acupoints and were used in 7 out of 13 studies. LI4 was used in 6 studies and both LI11 and ST40 were used in 5 of the 13 studies. ST25 was the most commonly used acupoint connected by electroacupuncture and was used in 8 out of 13 studies. CV6 and SP15 were used in 4 out of 13 studies.

3.3. Assessment of the risk of bias

The results of the risk of bias assessment, represented using Cochrane Review Manager software version 5.4 program are shown in Figures 2 and 3.

3.3.1. Random sequence generation. Nine studies that reported the details of random sequence generation, such as random number tables or computer randomization, were evaluated as having a "low" risk of bias. Four studies were evaluated as having an "unclear" risk of bias because there was no detailed description of random sequence generation.

3.3.2. Allocation concealment. Two studies that conducted allocation concealment, such as storing allocation sequences in opaque and sealed envelopes or using computer programs to generate random codes and having a third party keep them, were evaluated as having a "low" risk of bias. Eleven studies were evaluated as having an "unclear" risk of bias because there was no detailed description of allocation concealment.

3.3.3. Blinding of participants and personnel. All 13 studies were evaluated as having a "high" risk of bias because it was impossible to blind them owing to the nature of the electroacupuncture treatment process.

3.3.4. Blinding of outcome assessment. Two studies were evaluated as having a "low" risk of bias because the third party assessing the outcomes was blinded to the allocation. Eleven studies were evaluated as having an "unclear" risk of bias because there was no detailed mention of blinding in the outcome assessment.

3.3.5. Incomplete outcome data. Ten studies were evaluated as having a "low" risk of bias because they did not have missing data or provided a valid explanation for the occurrence

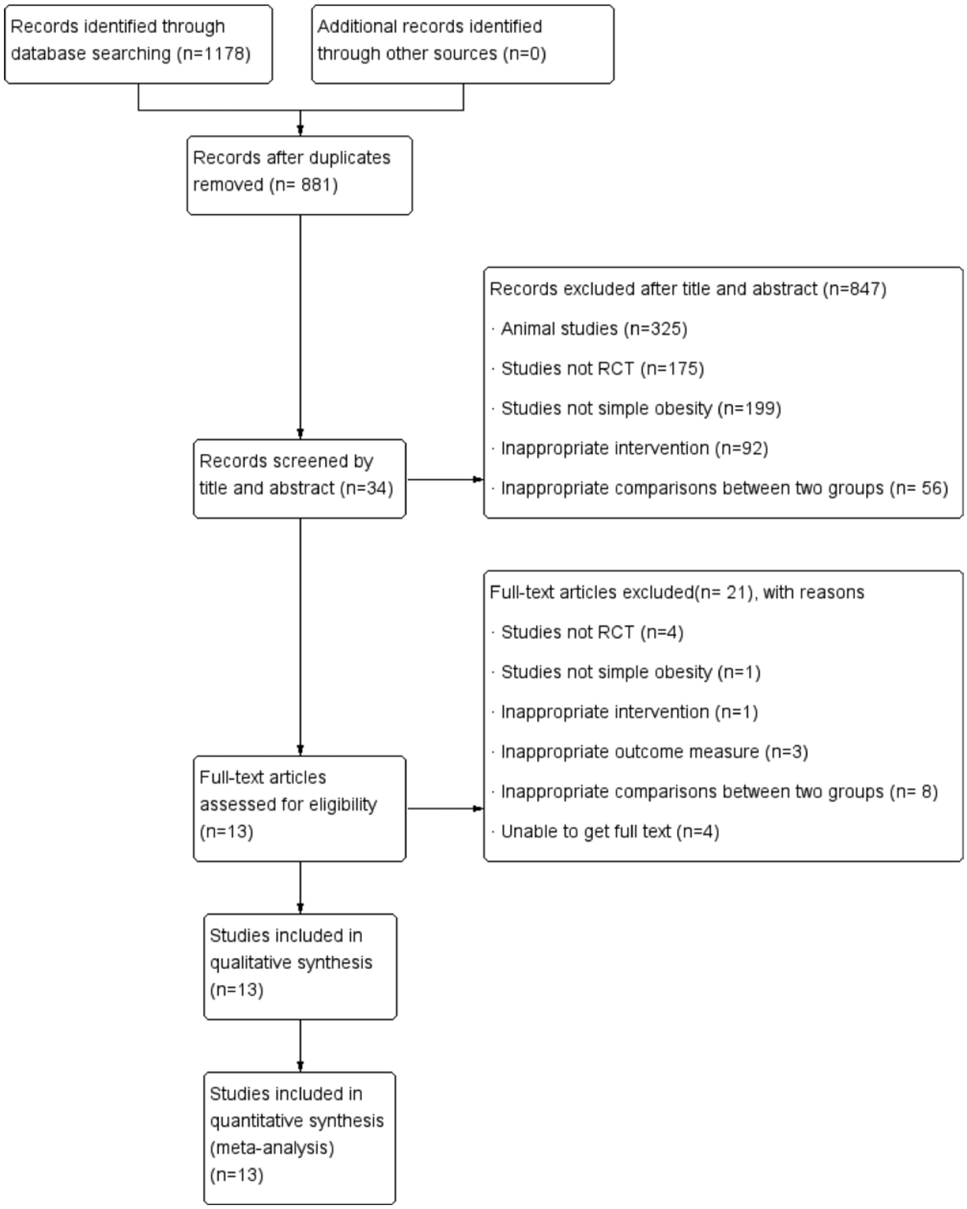

Figure 1. Flow diagram of the systematic review.

of missing data. Three studies were evaluated as having an "unclear" risk of bias because there was no detailed mention of the reasons for the missing data.

3.3.6. Selective reporting. All 13 studies were evaluated as having an "unclear" risk of bias because there was no mention of the protocol or preplanning.

3.3.7. Other bias. All 13 studies were evaluated as having an "unclear" risk of bias because no information was available to evaluate other risks of bias.

3.4. Certainty of evidence

The certainty of evidence ranged from very low to moderate (Table 5).

3.5. Missing data

As there were no missing data in the process of data extraction, there was no need to contact the corresponding author of the included studies.

3.6. Synthesis of results

The meta-analysis was conducted according to the BMI, BW, WC, HC, WHR, BFM, and BFP, with adverse reactions also analyzed. A meta-analysis was conducted by analyzing the effects on the experimental group that received electroacupuncture or electroacupuncture combined with standard care with those of the control group that received sham electroacupuncture, standard care, and no treatment. When separating the studies that compared all 3 groups (i.e., electroacupuncture, sham electroacupuncture, and no treatment groups), we found that the experimental group received electroacupuncture and electroacupuncture combined with standard care in 9 and 5 studies, respectively. The control groups in the studies, in which the experimental group received electroacupuncture alone, received electroacupuncture, standard care, and no treatment. Moreover, the control group in the studies, in which the experimental group received electroacupuncture combined with standard care, was set to standard care.

3.6.1. BMI. When analyzing 12 studies, the experimental group showed a significant improvement in the BMI compared to that

Table 2

Characteristics of the included studies.

Study	Country	Sample size (E/C)	Intervention group	Control group	Duration	Frequency	Outcomes	Results	Adverse events (n)
Hsu[23] (2005_1)	Taiwan	43 (22/21)	EA	NT	6 wk	Twice a week	1) BMI 2) BW 3) WC 4) HC	1) E > C, $P < .05$ 2) E > C, $P < .01$ 3) E > C. $P < .01$ 4) E > C, $P > .05$	Mild bleeding (2) Abdominal discomfort (1)
Hsu[24] (2005_2) *Crossover study	Taiwan	Group A: 24 Group B: 22	EA	SC	6 wk 1 wk washout	Twice a week	1) BMI 2) BW 3) WC	1) E > C, $P < .01$ 2) E > C, $P < .01$ 3) E > C, $P < .01$	Mild bleeding (1) Abdominal discomfort (1)
Li[25] (2005)	China	68 (35/33)	EA + SC	SC	4 wk	3 times a week	1) BW 2) WC 3) HC 4) WHR 5) BFM 6) BFP	1) E > C, $P < .01$ 2) E > C, $P < .01$ 3) E > C, $P < .01$ 4) E > C, $P < .01$ 5) E > C, $P < .01$ 6) E > C, $P < .01$	NR
Chung_sham[26] (2010)	South Korea	23 (12/11)	EA	Sham EA	5 wk	Twice a week	1) BMI 2) BW 3) WC 4) WHR 5) BFP	1) E > C, $P > .05$ 2) E > C, $P > .05$ 3) E > C, $P < .01$ 4) E > C, $P < .01$ 5) E < C, $P > .05$	Mild bruise (6) Abdominal discomfort (3)
Chung_NT[26] (2010)	South Korea	24 (12/12)	EA	NT	5 wk	Twice a week	1) BMI 2) BW 3) WC 4) WHR 5) BFP	1) E > C, $P > .05$ 2) E > C, $P > .05$ 3) E > C, $P < .01$ 4) E > C, $P < .01$ 5) E > C, $P > .05$	Mild bruise (6) Abdominal discomfort (3)
Lin[27] (2010)	Taiwan	41 (20/21)	EA	NT	12 wk	Twice a week	1) BW 2) WC 3) HC 4) BFP	1) E > C, $P < .01$ 2) E > C, $P < .01$ 3) E > C, $P < .05$ 4) E > C, $P < .05$	NR
Zhang[28] (2011)	China	52 (26/26)	EA + SC	SC	8 wk	Every other day	1) BMI 2) BW 3) BFP	1) E > C, $P < .05$ 2) E > C, $P < .05$ 3) E > C, $P < .05$	NR
Zhang[29] (2012)	China	30 (15/15)	EA	Sham EA	4 wk	5 times a week	1) BMI 2) WHR 3) BFP	1) E > C, $P < .05$ 2) E > C, $P < .05$ 3) E > C, $P < .05$	Mild bleeding (1)
Darbandi[30] (2013)	Iran	86 (42/44)	EA	Sham EA	6 wk	Twice a week	1) BMI 2) BW 3) BFM	1) E > C, $P > .05$ 2) E > C, $P > .05$ 3) E > C, $P > .05$	NR
Zhang[31] (2015)	China	60 (32/28)	EA + SC	SC	24 wk	Every other day	1) BMI 2) WC	1) E > C, $P < .05$ 2) E > C, $P < .05$	NR
Zheng[32] (2018)	China	64 (32/32)	EA + SC	SC	8 wk	Every other day	1) BMI 2) BW 3) WC	1) E > C, $P < .05$ 2) E > C, $P < .05$ 3) E > C, $P < .05$	NR
Sheng[33] (2020)	China	73 (37/36)	EA + SC	SC	8 wk	3 times a week	1) BMI 2) BW 3) WC 4) HC 5) WHR	1) E > C, $P > .05$ 2) E > C, $P > .05$ 3) E > C, $P < .01$ 4) E > C, $P > .05$ 5) E > C, $P < .01$	NR
Ren[34] (2020)	China	32 (17/15)	EA	Sham EA	6–8 wk	3 times a week	1) BMI 2) BW 3) WC	1) E > C, $P < .05$ 2) E > C, $P < .05$ 3) E > C, $P > .05$	NR
Kim[35] (2021)	South Korea	91 (48/43)	EA	Sham EA	6 wk	Twice a week	1) BMI 2) BW 3) WC 4) WHR	1) E > C, $P > .05$ 2) E > C, $P > .05$ 3) E < C, $P > .05$ 4) E < C, $P > .05$	Mild bruise (1) Headache (1) Tremor of finger (1)

BFM = body fat mass, BFP = body fat percentage, BMI = body mass index, BW = body weight, C = control group, E = experimental group, EA = electroacupuncture, HC = hip circumference, NT = no treatment, NR = not reported, SC = standard care, WC = waist circumference, WHR = waist-to-hip ratio.

of the control group, with low heterogeneity (MD: −0.98; 95% CI: −1.35 to −0.61).

Moreover, the electroacupuncture alone group showed a significant improvement in the BMI compared with that of the control group, with low heterogeneity (MD: −0.77; 95% CI: −1.36 to −0.18).

The experimental group that received electroacupuncture combined with standard care showed a significant improvement in the BMI compared with that of the control group, with low heterogeneity (MD: −1.06; 95% CI: −1.60 to −0.51) (Fig. 4).

3.6.2. BW. When analyzing 12 studies, the experimental group showed a significant improvement in the BW compared to that of the control group, with low heterogeneity (MD: −1.89; 95% CI: −2.97 to −0.80).

When comparing the experimental group that received electroacupuncture alone to the control group, there was low heterogeneity and no significant effect of electroacupuncture alone on BW improvement compared with the corresponding in the control group (MD: −1.31; 95% CI: −2.78 to 0.17).

The BW in the experimental group that received electroacupuncture combined with standard care showed a significant improvement compared with that in the control group, with low heterogeneity (MD: −2.45; 95% CI: −4.13 to −0.76) (Fig. 5).

3.6.3. WC. When analyzing 11 studies, the experimental group showed a significant improvement in WC compared to that in the control group, with moderate heterogeneity (MD: −2.67; 95% CI: −4.52 to −0.82).

Table 3

Details of sham electroacupuncture.

Study	Acupoints	Penetration	Electrical stimulation
Chung[26] (2010)	Non-acupoints	Superficial penetration	The wire of electroacupuncture device is connected to the body, but no electrical stimulation.
Zhang[29] (2012)	Non-acupoints	Superficial penetration	The wire of electroacupuncture device is connected to the body, but no electrical stimulation.
Darbandi[30] (2013)	Non-acupoints	Superficial penetration	The wire of electroacupuncture device is connected to the body, but no electrical stimulation.
Ren[34] (2020)	Non-acupoints	Superficial penetration	The wire of electroacupuncture device is connected to the body, but no electrical stimulation.
Kim[35] (2021)	Abdomen: non-acupoints Other regions: acupoints	Abdomen: same depth of penetration Other regions: non-penetration	The wire of electroacupuncture device is connected to the body, but no electrical stimulation.

Table 4

Acupoints selected for the treatment of obesity in the studies.

Study	Main acupoints (abdomen)	Main acupoints (other regions)	Acupoints connected by electroacupuncture
Hsu[23] (2005_1)	CV6, CV9, ST28, KI14	ST26, ST40, SP6	CV6, CV9, ST28, KI14
Hsu[24] (2005_2)	CV6, CV9, ST28, KI14	ST26, ST40, SP6	CV6, CV9, ST28, KI14
Li[25] (2005)	CV6, CV12, ST20, ST25, SP15, KI16, KI20, GB26	None	CV6, CV12, ST20, ST25, SP15, KI16, KI20, GB26
Chung[26] (2010)	CV6, CV12, ST25, SP14, SP15	LI4, LI11, ST36, ST44	CV6, CV12, LI4, LI11, ST25, ST36, ST44, SP14, SP15
Lin[27] (2010)	None	ST36, SP6	ST36, SP6
Zhang[28] (2011)	CV6, CV9, CV12, ST25, SP15, GB26	ST36, ST40, SP9, TE6	Four acupoints selected for each treatment
Zhang[29] (2012)	CV12, ST25	ST36, SP6	CV12, ST25, ST36, SP6
Darbandi[30] (2013)	CV4, CV9, CV12, ST25, GB28	SP6	Four acupoints selected for each treatment
Zhang[31] (2015)	CV7, CV9, ST24, ST25, ST26	LI11, ST36, ST44, TE6	CV7, CV9, ST25
Zheng[32] (2018)	CV9, CV12, ST25, ST28, SP15, GB26	LI11, ST36, ST40, SP6, SP9, TE6	ST25, SP15
Sheng[33] (2020)	CV4, CV6, CV12, ST25, SP14, SP15, GB26	BL20, BL23, BL25	ST25, SP14, SP15, GB26
Ren[34] (2020)	CV10, CV12, ST21, ST24, ST25, ST26, ST27, SP14, SP15	LI4, LI11, ST37, ST39, ST40, ST44, TE6	ST21, ST25, ST37, ST44
Kim[35] (2021)	CV6, CV12, ST25, ST28	LI4, LI11, ST36, SP6	ST25, ST28

When comparing the experimental group that received electroacupuncture alone to the control group, there was high heterogeneity and no significant effect of electroacupuncture alone on WC improvement compared with that in the control group (MD: –2.49; 95% CI: –5.53 to 0.54).

The WC was significantly improved in the experimental group that received electroacupuncture combined with standard care compared to that in the control group, with moderate heterogeneity (MD: –2.97; 95% CI: –4.96 to –0.99) (Fig. 6).

3.6.4. HC. In 4 studies, the HC did not show a significant improvement in the experimental group compared to that in the control group, with low heterogeneity (MD: –1.02; 95% CI: –2.55 to 0.51).

Moreover, there was moderate heterogeneity and no significant effect of electroacupuncture alone on HC improvement compared with the corresponding in the control group (MD: –0.87; 95% CI: –5.21 to 3.48).

When comparing the experimental group that received electroacupuncture combined with standard care to the control group, electroacupuncture combined with standard care did not show a significant improvement in HC compared with the corresponding in the control group, with moderate heterogeneity (MD: –0.94; 95% CI: –2.79 to 0.92) (Fig. 7).

3.6.5. WHR. In 6 analyzed studies, the experimental group showed a significant improvement in the WHR compared with the corresponding in the control group, with moderate heterogeneity (MD: –0.03; 95% CI: –0.06 to –0.01).

The experimental group that received electroacupuncture alone showed a significant improvement in the WHR compared with that in the control group, with high heterogeneity (MD: –0.04; 95% CI: –0.08 to –0.01).

Further, the experimental group that received electroacupuncture combined with standard care did not show a significant improvement in the WHR compared with that in the control group, with moderate heterogeneity (MD: –0.02; 95% CI: –0.05 to 0.00) (Fig. 8).

3.6.6. BFM. In 2 studies, the experimental group did not show a significant improvement in the BFM compared to that in the control group, with low heterogeneity (MD: –0.95; 95% CI: –2.78 to 0.88) (Fig. 9).

3.6.7. BFP. In 6 studies, the experimental group did not show a significant improvement in the BFP compared to that in the control group, with high heterogeneity (MD: –0.30' 95% CI: –2.84 to 2.25).

When comparing the effects on the experimental group that received electroacupuncture alone to those of the control group, there was moderate heterogeneity and no significant effect of electroacupuncture alone on BFP improvement compared with that in the control group (MD: –0.85; 95% CI: –4.79 to 3.09).

Finally, the experimental group that received electroacupuncture combined with standard care did not show a significant improvement in the BFP compared with that in the control group, with low heterogeneity (MD: 0.90; 95% CI: –0.70 to 2.49) (Fig. 10).

3.7. Publication bias

Publication bias was analyzed for studies using the BMI, BW, or WC as outcome measures. The analysis was performed using a funnel plot (Figs. 11–13). They showed a relatively asymmetrical distribution, indicating that the risk of publication bias was not low.

3.8. Adverse effects

In 5 studies, 18 adverse effects were reported. After electroacupuncture treatment in the experimental group, 4 cases of mild bleeding, 5 cases of abdominal discomfort, 7 cases of mild

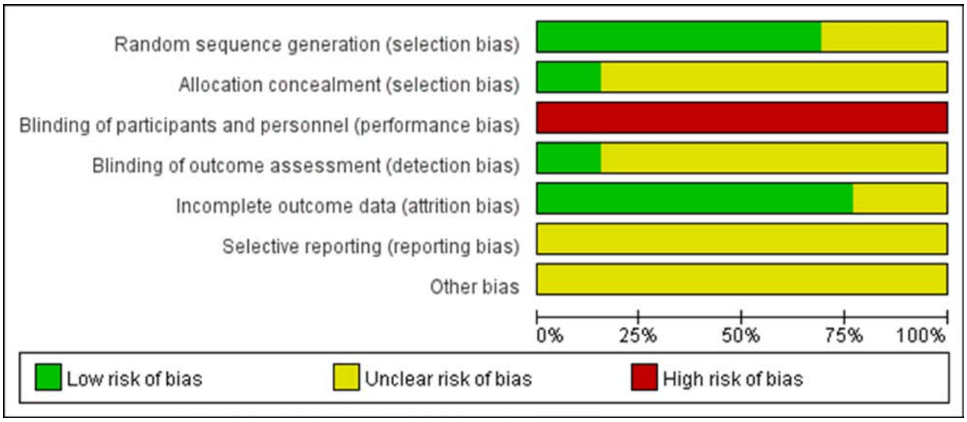

Figure 2. Risk of bias graph.

bruising, one case of headache, and one case of finger tremor were observed. Among the 18 adverse effects, no serious adverse effects were reported and no participants withdrew from the study owing to adverse effects.

4. Discussion

In this review, we aimed to evaluate the efficacy of electroacupuncture for the treatment of obesity. Obesity increases the risk of metabolic, cardiovascular, and musculoskeletal disorders, Alzheimer's disease, depression, and cancer, leading to decreased life expectancy and increased social costs.[37] Despite these risks, the prevalence of obesity continues to increase.[38] However, there is currently no safe drug treatment for obesity, and surgical treatment has adverse effects.[39] Therefore, research on traditional Korean medicine for the treatment of obesity is crucial. Electroacupuncture is widely used in Korean medicine clinics because of its effectiveness and low adverse effects. It has been found to promote fat metabolism and reduce appetite by activating the sympathetic nervous system.[40] In this study, a systematic literature review and meta-analysis were conducted to confirm the therapeutic effect of electroacupuncture on obesity and to establish evidence.

After conducting a search of 8 electronic databases, 13 randomized controlled trials evaluating the effects of electroacupuncture on obesity were analyzed. Eight and five studies compared the outcomes of the experimental groups that received electroacupuncture and electroacupuncture combined with standard care, respectively with those of the control groups. In 5, one, 3, and 5 studies, respectively, the outcomes of the experimental groups that received electroacupuncture with sham electroacupuncture, electroacupuncture with standard care, electroacupuncture with no treatment, and electroacupuncture combined with standard care, were compared with those of the group that received standard care.

In the selected 13 studies, the main acupoints used for obesity treatment were 20 acupoints located in the abdomen and 14 in other regions. Most studies have acupoints located in the abdomen as the main acupoints. Among the abdominal acupoints, ST25 was the most commonly used, appearing in 10 of the 13 studies. Among the other regions, SP6 and ST36 were the most commonly used. ST25 is the most commonly used acupoint for electroacupuncture.

Our findings showed that the experimental group had a significant improvement in the primary outcome measure, BMI, compared to the control group. Additionally, significant improvements were observed in BW, WC, and WHR. However, there were no significant improvements in HC, BFM, or BFP.

In the experimental group, the subgroups were divided into those receiving electroacupuncture alone and electroacupuncture combined with standard care. The results showed that electroacupuncture alone significantly improved the BMI and WHR compared to the corresponding in the control group. However, no significant improvements were observed in the BW, WC, HC, or BFP. Electroacupuncture combined with standard care significantly improved the BMI, BW, and WC. However, there were no significant improvements in the HC, WHR, or BFP. A subgroup analysis for BFM was not conducted because there was only one study in each experimental group.

The BMI, the primary outcome, is an important indicator for evaluating obesity treatment because it is used to diagnose obesity and analyze the risk of cardiovascular diseases, diabetes, and other diseases.[41] Additionally, it is widely used in public health policy decision-making and is useful for assessing health issues.[42] In the results of this study, there was a significant improvement in the BMI in the experimental group compared to those in the control group, and in the subgroup analysis, both electroacupuncture alone and electroacupuncture combined with standard care were also effective in improving the BMI. Therefore, it can be inferred that electroacupuncture can be effectively utilized in obesity treatment.

Various adverse effects were observed in the participants who received electroacupuncture in this study. Mild bleeding, abdominal discomfort, mild bruising, headache, and finger tremors were observed after electroacupuncture treatment. However, no significant adverse reactions were reported, and no participants withdrew from the study because of adverse effects. Furthermore, in studies where electroacupuncture was used for the treatment of other diseases, adverse effects were minimal and no significant adverse reactions were reported.[42–44] Thus, it can be inferred that electroacupuncture can be safely used.

There are many traditional Korean medicine treatments for obesity in addition to electroacupuncture. A meta-analysis of the effects of acupuncture on obesity, which included normal acupuncture, laser acupuncture, and ear acupuncture, reported that acupuncture therapy was more effective for treating obesity than sham acupuncture, placebo acupuncture, or no treatment. The outcome measures were the BMI, BW, WC, WHR, and BFM. Acupuncture therapy, including body, laser, and ear acupuncture, significantly affects the BMI, BW, WC, and BFM improvement.[45] A meta-analysis compared the effects of ear acupuncture and ear acupuncture combined with those of standard care with sham ear acupuncture, placebo ear acupuncture, no treatment, standard care alone, and placebo ear acupuncture combined with standard care. The study used the BW as the outcome measure, and the results showed that ear acupuncture combined with standard care had a significant effect on improving the BW compared with other treatments.[46] A meta-analysis of the effects of herbal medicine on obesity showed that herbal medicine was more effective than a placebo herbal medicine or

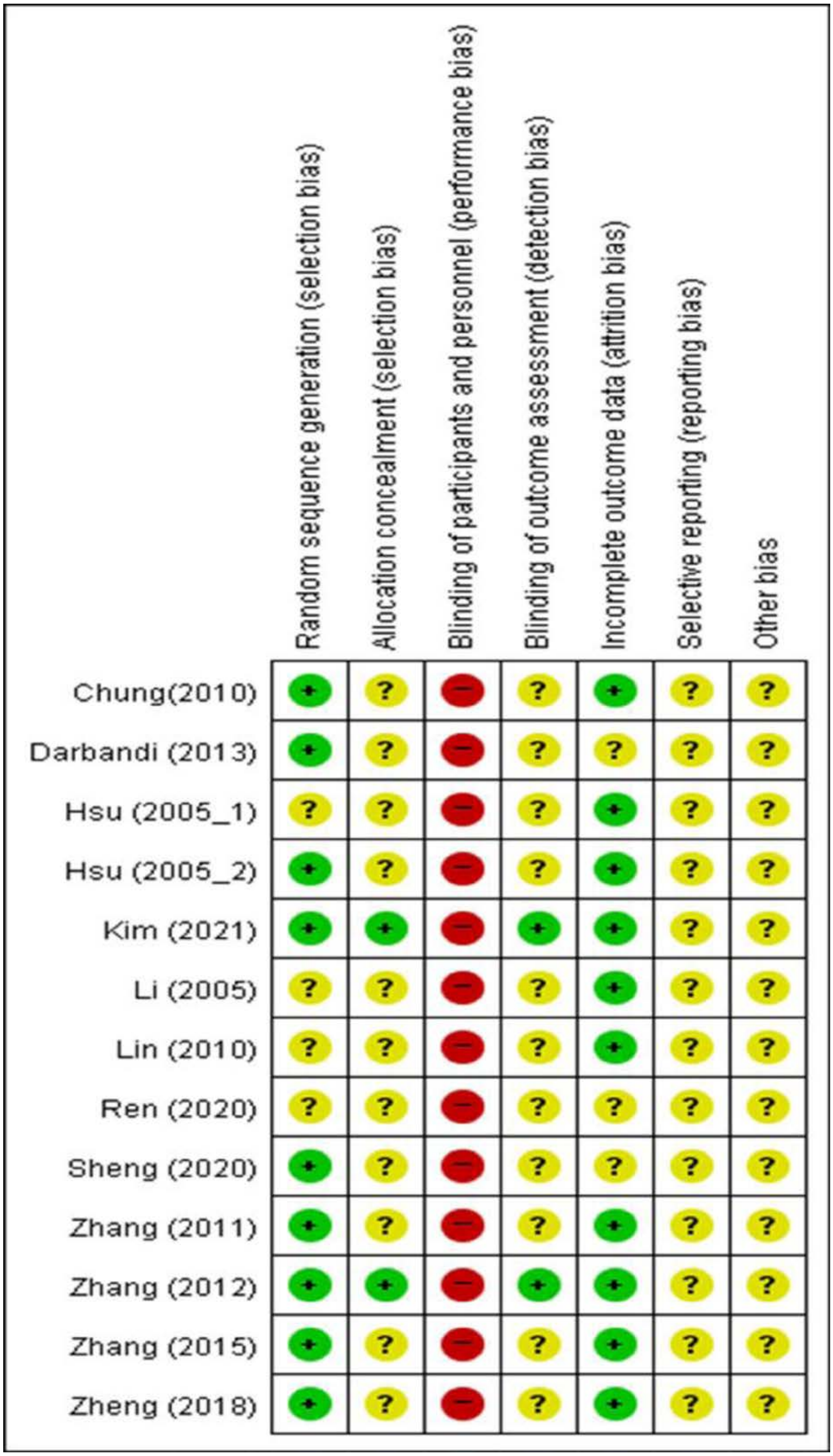

Figure 3. Summary of risk of bias.

no treatment in treating obesity. This study used the BMI and BW as outcome measures and reported that herbal medicine significantly improved BMI and BW.[47] Therefore, as traditional Korean medicine is significantly effective in treating obesity, combining other traditional Korean medicine treatments with electroacupuncture may be more effective in treating obesity. If further studies on combined treatments of electroacupuncture and other traditional Korean medicine treatments are conducted, the traditional Korean medicine treatments for obesity can be systematically established.

However, this systematic review and meta-analysis had several limitations. All included studies had a small sample size of < 100 people, which may have affected the quality and accuracy of the results. Moreover, many studies with a high

Table 5

Certainty assessment.

	Certainty assessment						No. of participants		Effect	
Outcomes	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Experimental group	Control group	Absolute (95% CI)	Certainty
BMI	Randomized trials	Serious*	Not serious	Not serious	Not serious	None	341	329	MD 0.98 lower (1.35 lower to 0.61 lower)	⊕⊕⊕○ Moderate
BW	Randomized trials	Serious*	Not serious	Not serious	Not serious	None	349	340	MD 1.89 lower (2.97 lower to 0.80 lower)	⊕⊕⊕○ Moderate
WC	Randomized trials	Serious*	Serious†	Not serious	Not serious	None	313	298	MD 2.67 lower (4.52 lower to 0.82 lower)	⊕⊕○○ Low
HC	Randomized trials	Serious*	Not serious	Not serious	Serious‡	None	114	111	MD 1.02 lower (2.55 lower to 0.51 higher)	⊕⊕○○ Low
WHR	Randomized trials	Serious*	Serious†	Not serious	Serious‡	None	159	150	MD 0.03 lower (0.06 lower to 0.01 lower)	⊕○○○ Very low
BFM	Randomized trials	Serious*	Not serious	Not serious	Serious‡	None	77	77	MD 0.95 lower (2.78 lower to 0.88 higher)	⊕⊕○○ Low
BFP	Randomized trials	Serious*	Serious†	Not serious	Serious‡	None	120	118	MD 0.30 lower (2.84 lower to 2.25 higher)	⊕○○○ Very low

BFM = body fat mass, BFP = body fat percentage, BMI = body mass index, BW = body weight, CI = confidence interval, HC = hip circumference, MD = mean difference, WC = waist circumference, WHR = waist-to-hip ratio.

*High or unclear risk of bias in blinding.

†High or moderate heterogeneity.

‡Small sample size.

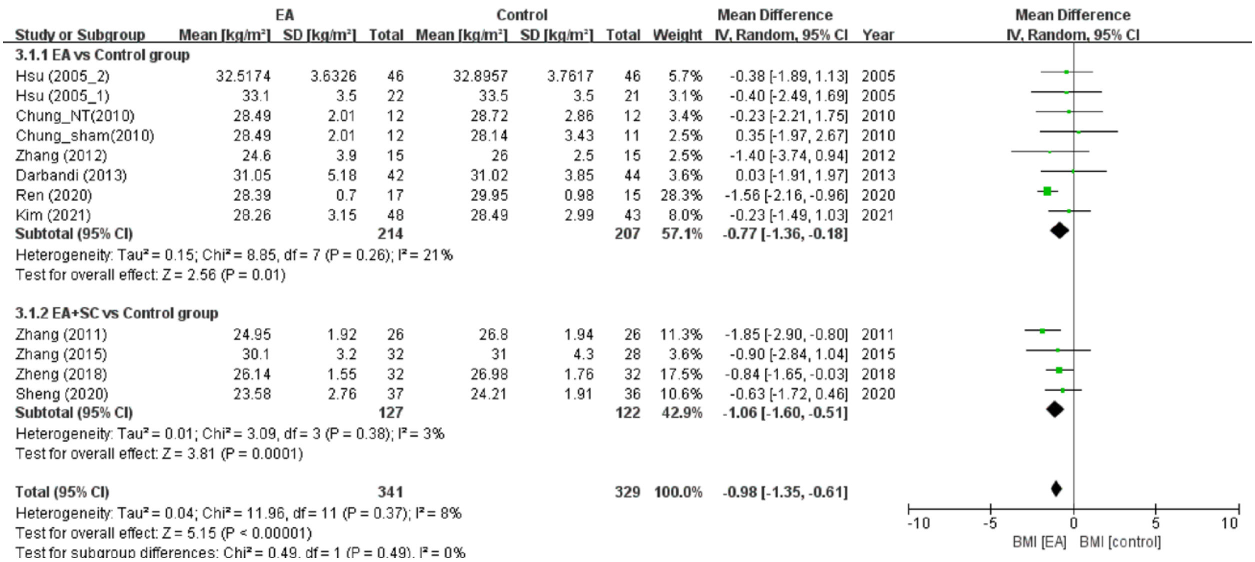

Figure 4. Forest plot for BMI. BMI = body mass index.

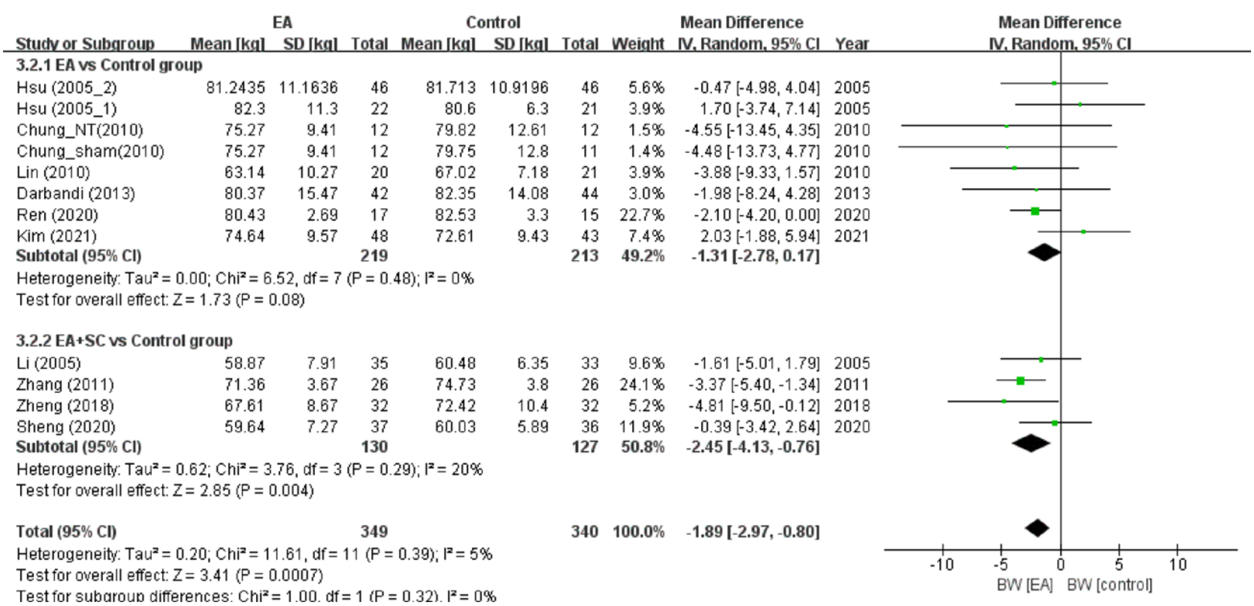

Figure 5. Forest plot for BW. BW = body weight.

risk of bias were included. Specifically, in all 13 studies, owing to the nature of the electroacupuncture process as a treatment, in which the experimental and control groups' treatment methods differed, blinding the participants and researchers was impossible, resulting in a high risk of bias. While it is true that electroacupuncture is a treatment that the researcher must perform directly and is difficult to blind, further studies should be conducted to reduce the risk of other biases to minimize the total bias of the study. In addition, most studies included in this review were conducted in Asia, including Korea, Taiwan, and China. Although obesity is a disease with increasing prevalence worldwide, the included studies were limited to Asia, making it difficult to represent the global population. There was also a limitation in the measurement tools used to assess the results, as the focus was only on anthropometric measurements, such as the BMI, BW, WC, HC, WHR, BFM, and BFP. In patients with obesity, changes in parameters, such as the blood glucose and lipid levels in blood tests, can also be observed in addition to anthropometric measurements; however, the effects of electroacupuncture on these parameters were not evaluated in this study. There was also a limitation in how the control groups were established for each experimental group. Of the 13 studies included in this review, some compared the outcomes after performing electroacupuncture with sham electroacupuncture, electroacupuncture with standard care, electroacupuncture with no treatment, and electroacupuncture combined with standard care with those of standard care. However, to our knowledge, no studies have compared the effects of electroacupuncture combined with standard care with those of no treatment; thus, there were limitations to more diverse comparisons. There were also limitations related to the characteristics of the obesity treatment. The studies included in this review had treatment durations of 4 to 24 weeks. However, obesity is a chronic disease that requires long-term and sustained treatment. Therefore, it is suggested that if electroacupuncture treatment had been received over a longer period, improvements could have been made in HC, BFM, and BFP, which were not found to have significant

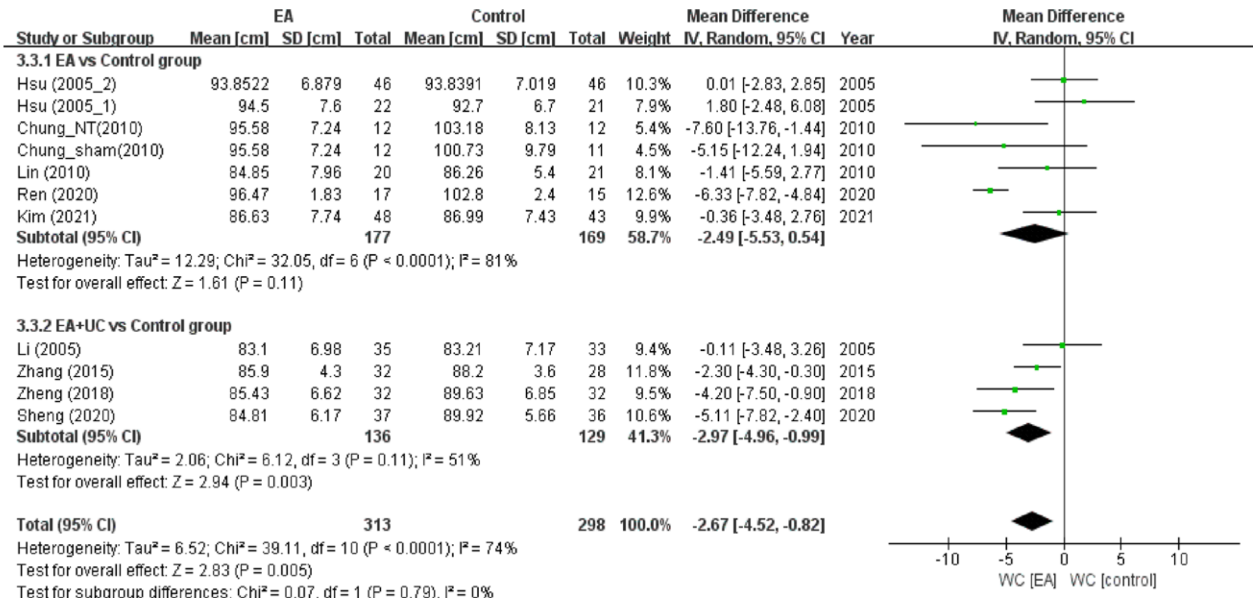

Figure 6. Forest plot for WC. WC = waist circumference.

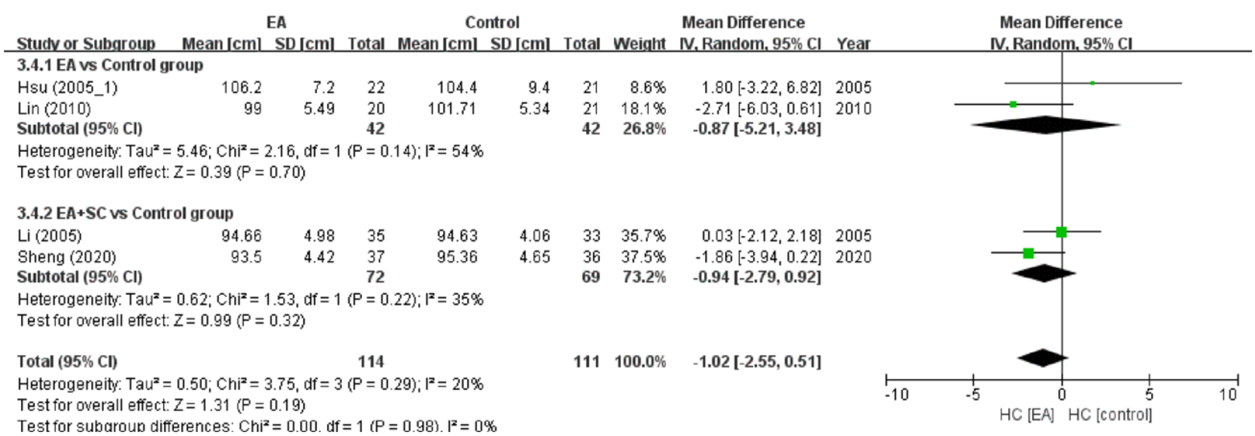

Figure 7. Forest plot for HC. HC = hip circumference.

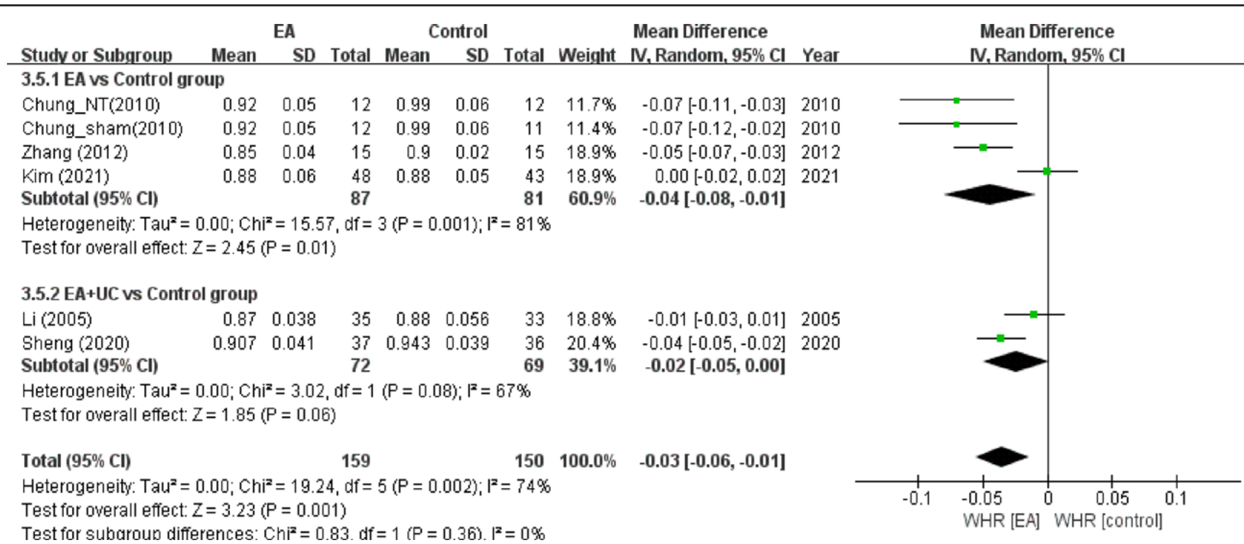

Figure 8. Forest plot for WHR. WHR = waist-to-hip ratio.

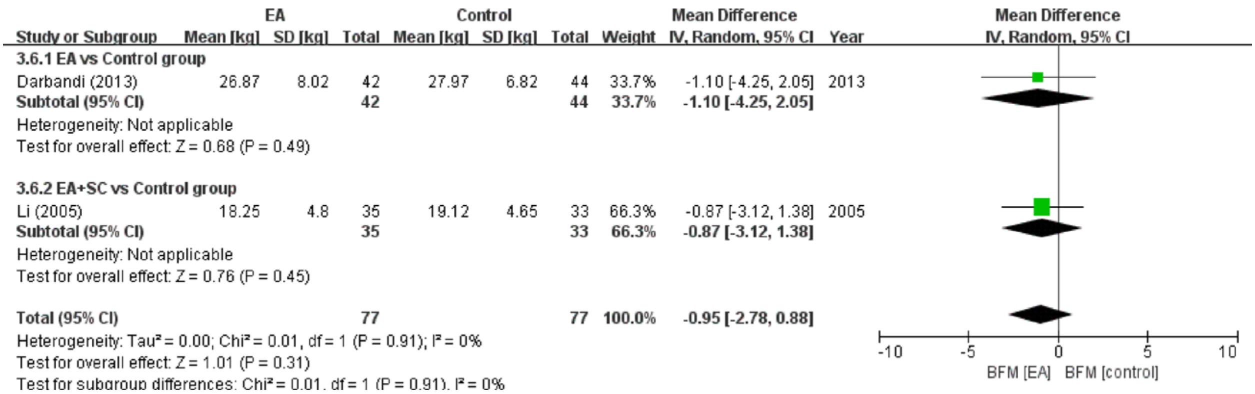

Figure 9. Forest plot for BFM. BFM = body fat mass.

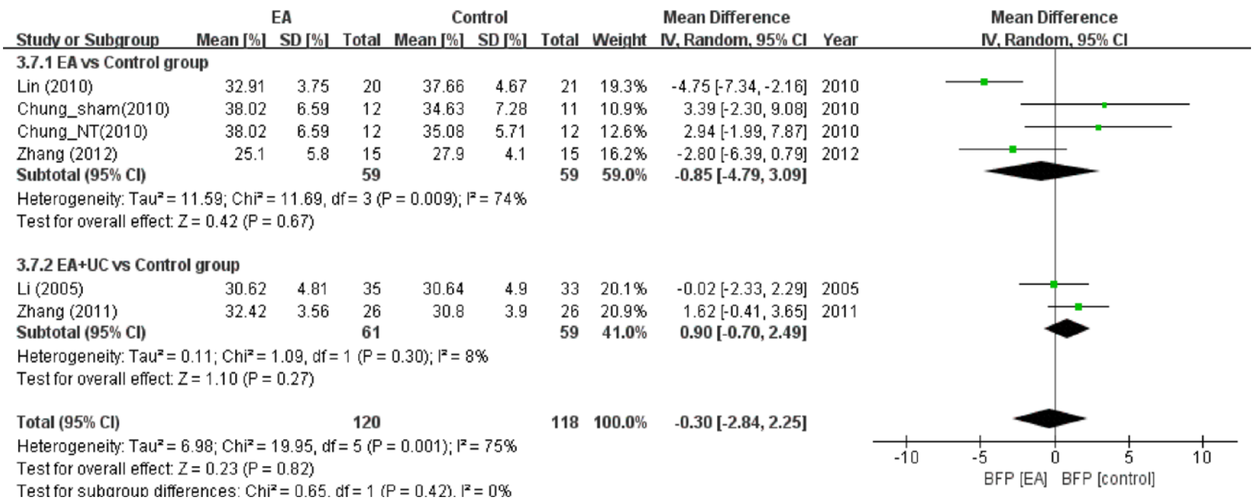

Figure 10. Forest plot for BFP. BFP = body fat percentage.

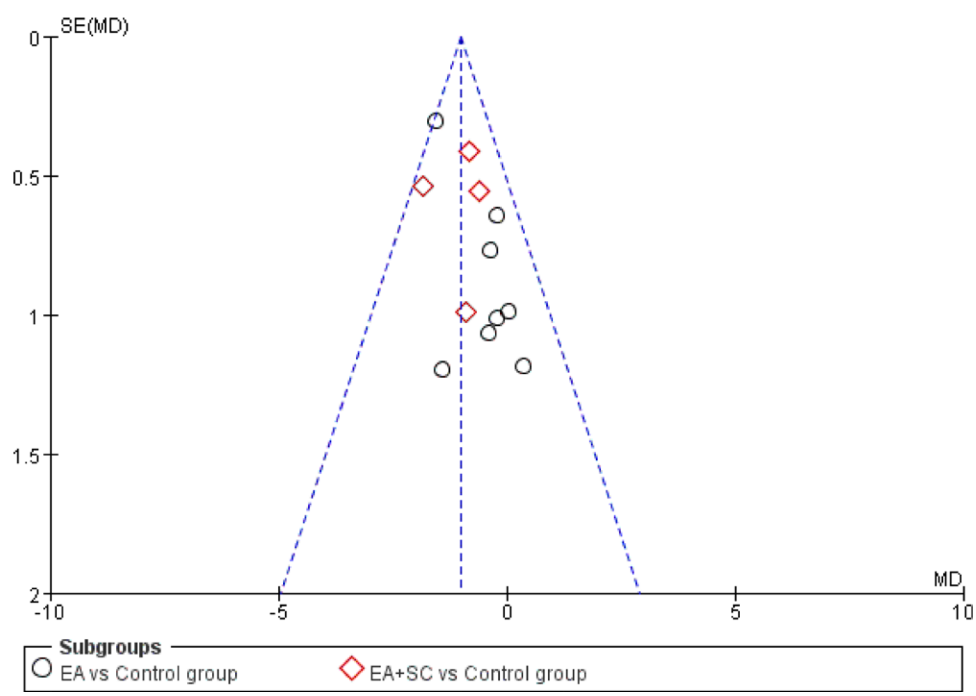

Figure 11. Funnel plot for BMI. BMI = body mass index.

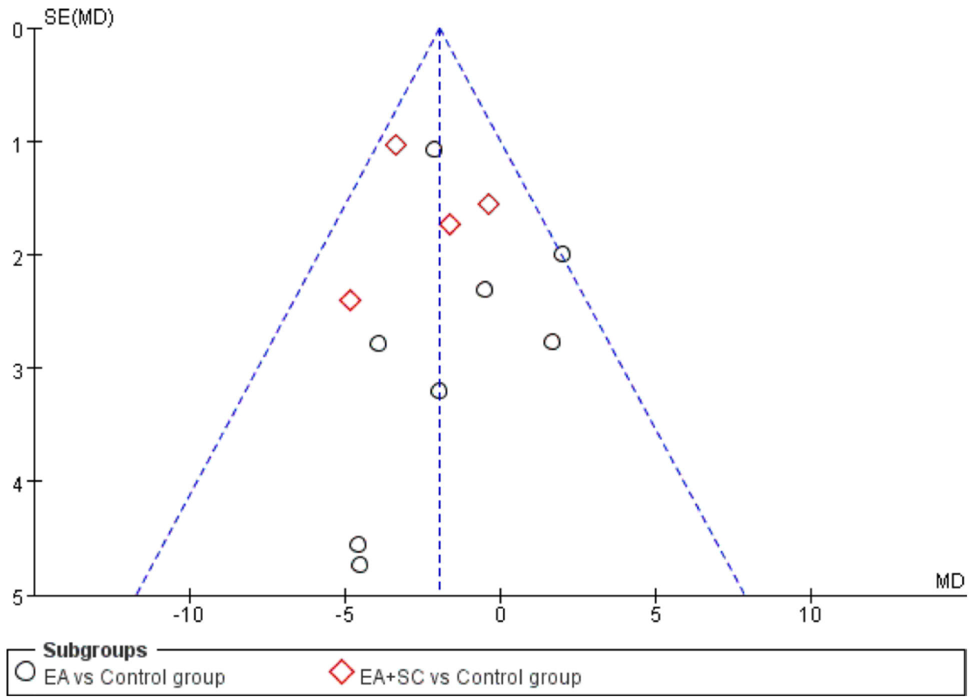

Figure 12. Funnel plot for BW. BW = body weight.

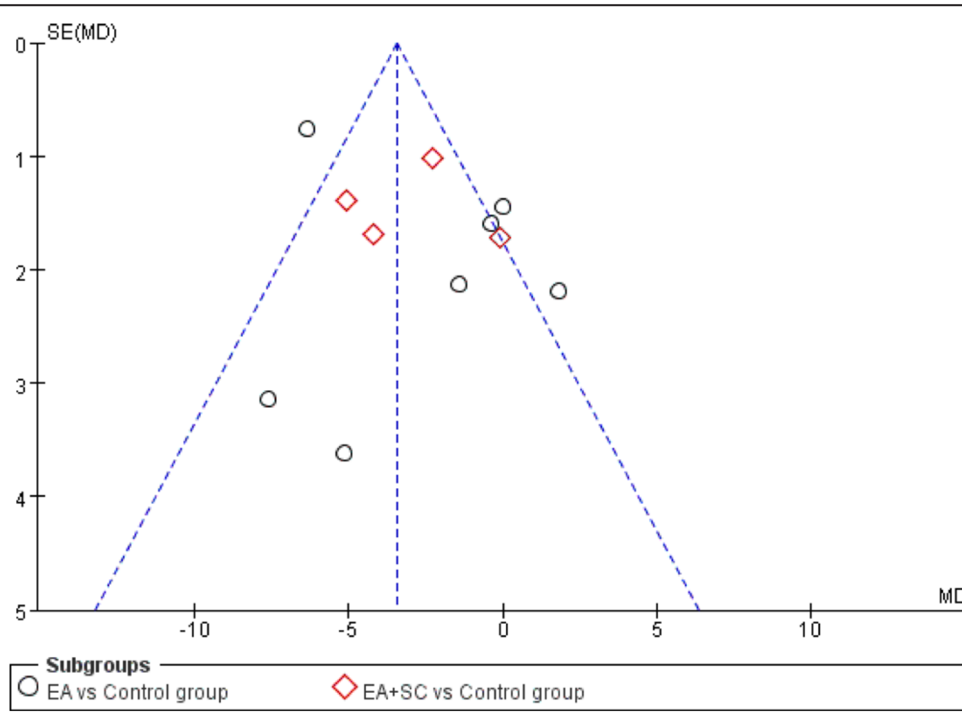

Figure 13. Funnel plot for WC. WC = waist circumference.

effects. Therefore, future studies with longer treatment periods should be conducted. Finally, there was also the limitation that the number of analyzed studies was small in a few outcome measures. The BMI and BW were each analyzed in 11 studies, but the BFM was only analyzed in 2 studies. The WHR and BFP were analyzed in 5 studies each, and the HC was analyzed in 4 studies. Although this study found no significant effects of electroacupuncture on HC, BFM, or BFP, it is suggested that if more studies are conducted and analyzed in the future, electroacupuncture may also be effective in improving the HC, BFM, and BFP.

Based on the results of this systematic review and meta-analysis, electroacupuncture is an effective treatment method for patients with obesity. If more studies are conducted to evaluate the long-term effects of electroacupuncture and the mechanism of action of electroacupuncture in the future, clearer and more reliable treatment options can be developed in traditional Korean medicine clinical practice.

5. Conclusion

In this systematic review and meta-analysis, the effects of electroacupuncture on obesity were analyzed. The results showed that electroacupuncture is a safe and effective treatment for obese patients and has promising benefits in treating obesity. If further studies on the effects of electroacupuncture on obesity are conducted in the future, electroacupuncture may be used more actively in clinical practice.

Author contributions

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Project administration: Mi-Yeon Song, Won-Seok Chung.
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Visualization: Koh-Woon Kim, Hyungsuk Kim, Jae-Heung Cho.
Writing – original draft: Junhyuk Kang, Woo-Chul Shin, Koh-Woon Kim.
Writing – review & editing: Junhyuk Kang, Woo-Chul Shin, Koh-Woon Kim, Sungha Kim, Hyungsuk Kim, Jae-Heung Cho, Mi-Yeon Song, Won-Seok Chung.

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