REVIEW ARTICLE

Efficacy of non-pharmacological interventions for labor pain reduction: A systematic review and meta-analysis

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Abstract

Labor pain is often managed with pharmacological interventions, which can lead to several adverse effects for mothers and neonates. Consequently, non-pharmacological interventions are gaining attention as safer alternatives for pain relief during labor. This systematic review aimed to assess the effectiveness of non-pharmacological methods in reducing labor pain. A comprehensive search was conducted in PubMed, Scopus, Web of Science, and Cochrane Library databases up to September 2024. Only randomized controlled trials (RCTs) evaluating non-pharmacological interventions for labor pain relief were included, with pain intensity during cervical dilatation as the primary outcome. Data synthesis was performed using RevMan (V5.3). Seventy-seven RCTs involving 8,805 pregnant women were analyzed. The results indicated that non-pharmacological methods significantly reduced pain at 3-4 cm cervical dilatation compared to control groups (M.D. = -1.63, 95% C.I. [-2.05 to -1.21], P < 0.0001). Notably, subgroup analysis showed that body acupressure (M.D. = -2.08, 95% C.I. [-2.76 to -1.40], P < 0.0001) and foot reflexology (M.D. = -2.48, 95% C.I. [-2.84 to -2.13], P < 0.0001) were particularly effective. High heterogeneity ($I^2 > 90\%$) was noted, partly reflecting differences in intervention types, protocols, and participant characteristics. Overall, non-pharmacological interventions provided substantial relief in labor pain compared to standard care, suggesting their potential utility in obstetric practice. Further large-scale studies are warranted to confirm these findings. *(Afr J Reprod Health 2025; 29 [10]: 207-228).*

Keywords: Non-pharmacological interventions; acupressure; aromatherapy; Labor; pain; pregnancy; systematic review; meta-analysis

Résumé

La douleur du travail est souvent prise en charge par des interventions pharmacologiques, ce qui peut entraîner plusieurs effets indésirables pour la mère et le nouveau-né. Par conséquent, les interventions non pharmacologiques suscitent un intérêt croissant en tant qu'alternatives plus sûres pour soulager la douleur pendant le travail. Cette revue systématique visait à évaluer l'efficacité des méthodes non pharmacologiques pour réduire la douleur du travail. Une recherche exhaustive a été menée dans les bases de données PubMed, Scopus, Web of Science et Cochrane Library jusqu'en septembre 2024. Seuls les essais contrôlés randomisés (ECR) évaluant les interventions non pharmacologiques pour soulager la douleur du travail ont été inclus, l'intensité de la douleur pendant la dilatation cervicale étant le critère d'évaluation principal. La synthèse des données a été réalisée à l'aide de RevMan (V5.3). Soixante-dix-sept ECR portant sur 8 805 femmes enceintes ont été analysés. Les résultats ont indiqué que les méthodes non pharmacologiques réduisaient significativement la douleur à une dilatation cervicale de 3 à 4 cm par rapport aux groupes témoins (DM = -1,63, IC à 95 % [-2,05 à -1,21], P < 0,0001). L'analyse de sous-groupes a notamment montré que l'acupression corporelle (DM = -2,08, IC à 95 % [-2,76 à -1,40], p < 0,0001) et la réflexologie plantaire (DM = -2,48, IC à 95 % [-2,84 à -2,13], p < 0,0001) étaient particulièrement efficaces. Une forte hétérogénéité ($I^2 > 90$ %) a été constatée, reflétant en partie les différences entre les types d'intervention, les protocoles et les caractéristiques des participantes. Globalement, les interventions non pharmacologiques ont considérablement soulagé les douleurs du travail par rapport aux soins standard, ce qui suggère leur utilité potentielle en obstétrique. D'autres études à grande échelle sont nécessaires pour confirmer ces résultats. *(Afr J Reprod Health 2025; 29 [10]: 207-228).*

Mots-clés: Interventions non pharmacologiques ; acupression ; aromathérapie ; travail ; douleur ; grossesse ; revue systématique ; méta-analyse.

Introduction

Labor is generally considered one of the happiest life events for every woman. It is a natural physiological process and often progresses without the need for any medical intervention.[1,2] Despite its natural occurrence, several physiological factors, such as uterine contractions and psychological factors, encompassing fear and anxiety, along with cultural practices and acquired knowledge of labor, can exacerbate the intensity of pain experienced during labor.[3,4,5] Sever labor pain can eventually disrupt the mother's emotional and mental health and adversely influence maternal and fetal physiology, involving elevated cardiac output, heightened pulmonary ventilation, and prolonged labor, necessitating obstetric interventions.[6]

Additionally, Lee *et al*. found that pregnant women identified severe pain as the predominant factor causing fear of delivery.[7] Also, the heightened severity of labor pain with the linked mother fear can adversely decrease the desire for vaginal delivery and increase the rates of caesarean section deliveries.[8] Owing to the dangerous effects of labor pain on the fetus, mother, and delivery outcomes, ensuring safe and effective pain control is essential.

Pharmacological interventions are often employed for labor pain management; however, they show several side effects for both the mother and fetus.[9] A previously published systematic review highlighted that inhaled pain medications during labor are linked to various side effects involving nausea, vomiting, and dizziness. They also concluded that epidural analgesia may result in hypotension, fever, urinary retention, and fetal distress.[10] Hence, many women favor non-medical approaches encompassing massage, Lamaze, yoga, aromatherapy, and birth ball for relief of labor pain. These non-pharmacologic techniques effectively mitigate labor pain and provide multiple benefits, such as having no side effects for the mother or fetus, not disrupting the labor process, and having no risk for allergic reactions.[11-13]. Therefore, our systematic review objective is to evaluate the role of non-pharmacological interventions in managing labor pain.

Methods

We conducted our study based on the rules declared in the Cochrane Handbook and adhered to the PRISMA statement guidelines during the study reporting process.[14,15]

Selection criteria

All randomized controlled trials (RCTs) that satisfied our predetermined selection criteria were included. The population was pregnant women at the labor stage. The intervention was any non-pharmacological intervention applied during the first stage of labor. The control group consisted of routine care or other non-pharmacological interventions. The primary sole outcome was post-intervention or change pain measured when cervical dilatation was estimated at 3-4, 5-6, 7-8, or 9-10 cm. We excluded observational studies, conference abstracts, protocols, and studies in which intervention was not applied during the first stage of labor. 12 studies excluded from meta-analysis due to insufficient quantitative data or incompatible outcome measures.

Literature search and screening

A comprehensive search of the literature was executed in four databases, including PubMed, Scopus, Web of Science, and Cochrane Library, from inception until September 2024. Our search strategy contained a mixture of strings related to non-pharmacological interventions such as birth ball, massage, heat and cold application, and pregnancy, including pregnant, pregnant women, and labor. In-depth information concerning each database's search strategy is outlined in supplementary Table 2.

After searching the four databases, the retrieved articles were evaluated using two-phase approaches. First, the titles and abstracts of the gathered reports were evaluated using the Rayyan website.[16] Second, the full text of the articles that resulted was screened based on our predetermined inclusion criteria. Duplicate reports were eliminated using Endnote (Clarivate Analytics, PA, USA).

Data extraction

Utilizing an Excel collection sheet, we collected the subsequent items: study arms, site, trial registration, age, study period, parity, need to oxytocin, study technique, APGAR score, baseline pain score, education, occupation, economic status, inclusion criteria, primary endpoints, and conclusion.

Quality evaluation

The Cochrane risk of bias one tool (ROB 1) was utilized to evaluate the quality of RCTs.[17] ROB 1 tool assesses the risk of bias regarding several domains encompassing the random sequence generation, allocation concealment, blinding of patients and investigators, blinding of the outcome assessment, incomplete outcome data, selection of the reported results and other sources of bias.

Data synthesis

Continuous outcomes were analyzed as mean difference (M.D.) and its 95% Confidence interval (C.I.) utilizing a random-effect meta-analysis model. A p-value < 0.05 was interpretated as significant outcome. Significant heterogeneity was identified when the I-square was more than 50% or the chi-square was less than 0.1. We also grouped the analysis based on the type of non-pharmacological intervention utilized. Finally, the funnel plot was constructed to examine any potential publication bias. All the data analyses were conducted employing RevMan (V5.3).

Results

Literature search

Our initial electronic search retrieved 32437 records. 6510 of them were eliminated as duplicate studies, resulting in 25927 articles entering the first screening phase. 25633 articles were eliminated in this phase, leaving a total of 294 articles eligible for the second screening stage. Consequently, 77 articles were involved in our investigation, as shown in **Figure 1.**

Characteristics of the included studies

Seventy-seven studies, with a total of 8805 women, were finally encompassed in our investigation; 65 studies were involved in the meta-analysis.[2,8,12,18-21,91] The included studies were performed in various geographical regions, with 40 studies conducted in Asia, 24 in Europe, and 13 in America. Multiple non-pharmacological approaches have been utilized in our research, mainly acupressure, acupuncture, aromatherapy, ball exercise, expressive touching, hot-pack application, warm shower bath, massage, music, and others. Our study included a mixture of nulliparae and primipara women, with a mean age of 24.85, ranging from 16 to 36.71 years. The education levels varied across studies, ranging from illiteracy to high school and university stages. The primary endpoint of most studies was pain measured by the Visual Analogue Scale (VAS). In-depth information regarding the summary and baseline characteristics are presented in supplementary Table 1.

Quality assessment

Based on the ROB 1 tool, 46 studies revealed a low risk of bias regarding the random sequence generation, 18 showed a high risk of bias, and 12 showed an unclear risk of bias.

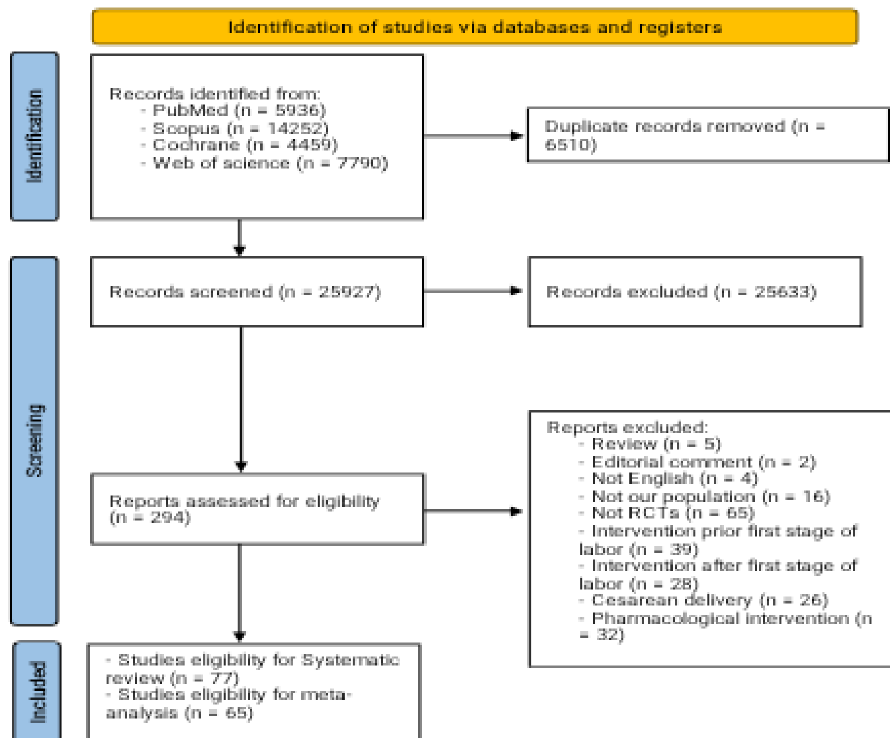


Figure 1: PRISMA Flow chart

Regarding the allocation concealment domain, 49 studies exhibited a low risk of bias, 17 showed a high risk, and 10 revealed an unclear risk of bias. More details regarding the other domains risk of bias are illustrated in Figure 2.

Outcomes

Postintervention pain (3-4 cm)

Our pooled analysis based on pooling 35 studies with a total of 3553 women showed significantly lower postintervention pain with the non-pharmacological interventions relative to the control group (M.D. = -1.63, 95% C.I. [-2.05 to -1.21], P < 0.00001) with associated significant heterogeneity ($I^2 = 96\%$, p < 0.00001), as illustrated in Figure 3. Moreover, the subgroup analysis based on the type of non-pharmacological approach exhibited that body acupressure (M.D. = -2.08, 95% C.I. [-2.76 to -1.40], P< 0.00001), foot reflexology (M.D.= -2.48, 95% C.I. [-2.84 to -2.13], P< 0.00001), and hand acupressure (M.D. = -2.69, 95% C.I. [-3.51 to -1.88], P < 0.00001) were notably linked to lower postintervention pain when compared to the control group, as presented in Figure 3.

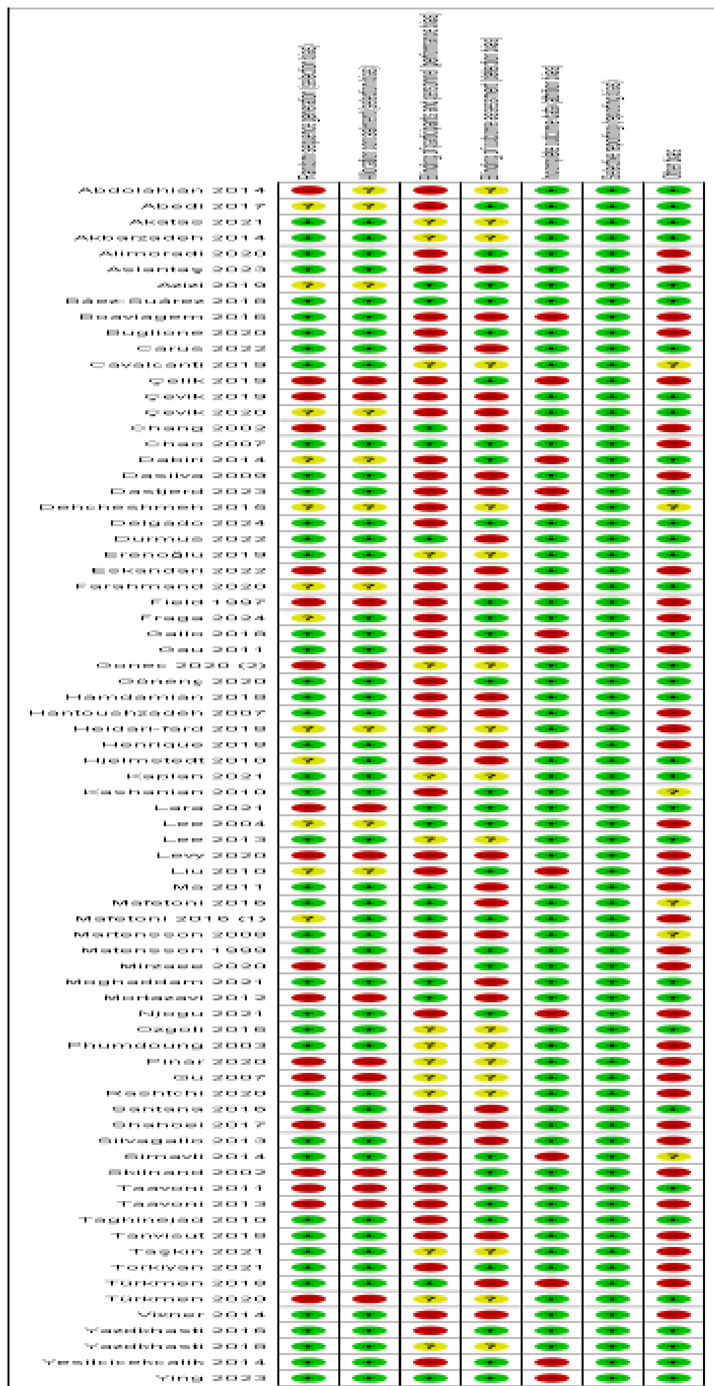


Figure 2: Quality assessment of the included RCTs by Rob tool

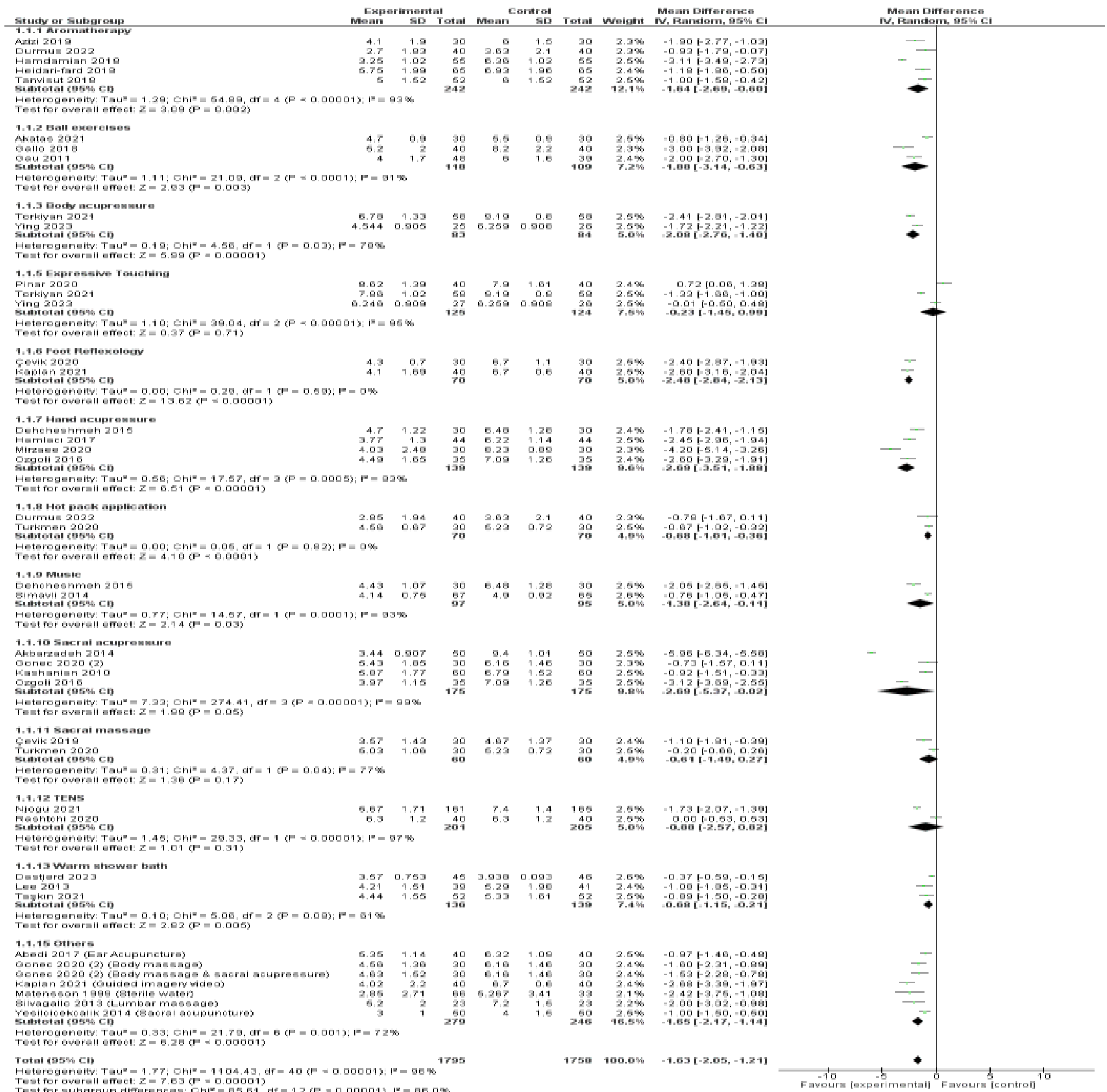
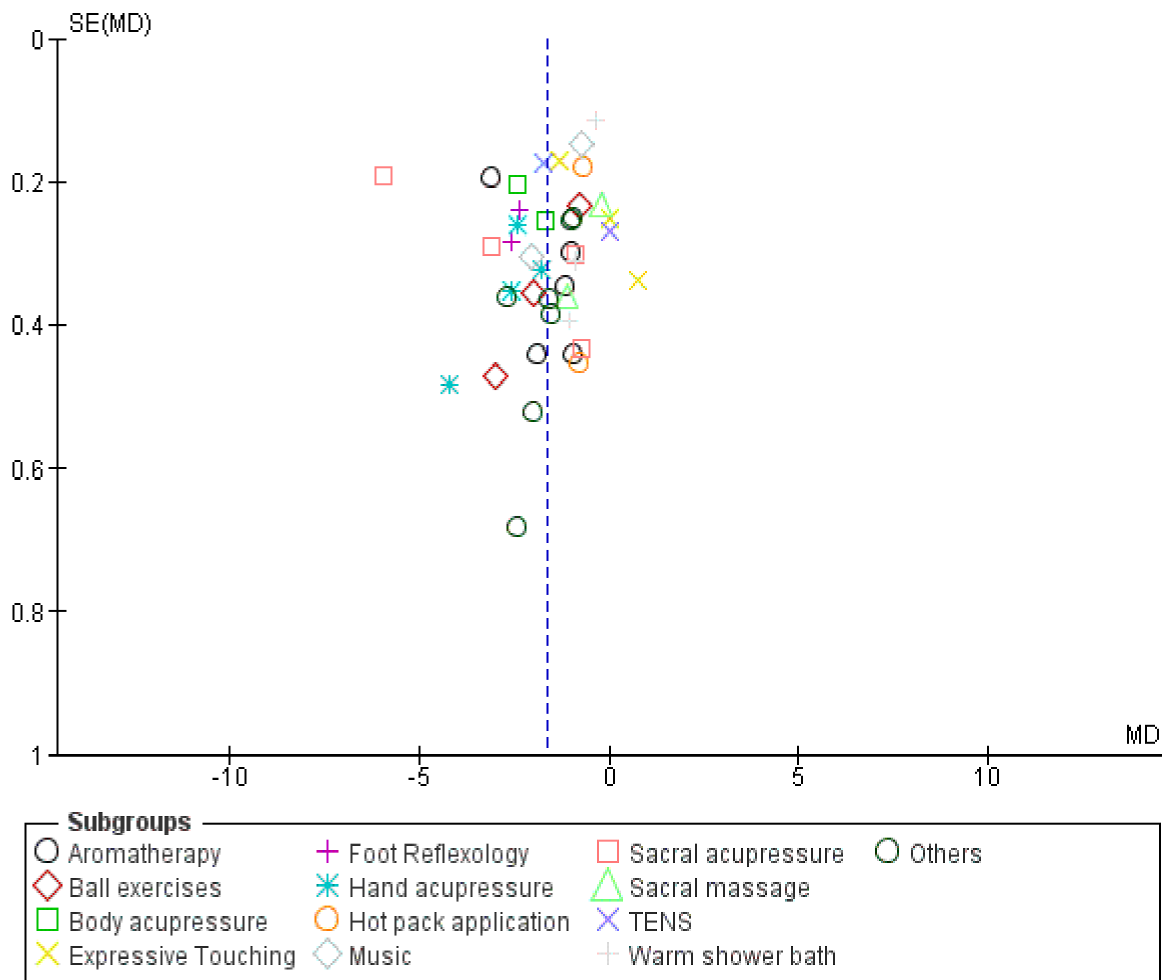


Figure 3: Forest plot of post-intervention pain (at 3-4 cm)



Supplementary Figure 1: Funnel plot of publication bias for post-intervention pain (at 3-4 cm) outcomes

The funnel plot was constructed, and upon examination, an asymmetrical pattern was noticed, suggesting a potential publication bias, as shown in **Supplementary Figure 1.**

Postintervention pain (5-6 cm)

Based on an analysis of 33 studies with a total of 3494 women, the non-pharmacological interventions exhibited significantly lower postintervention labor pain relative to the control group (M.D. = -1.66, 95% C.I. [-2.01 to -1.31], P< 0.001) with a pooled significant heterogeneity (I^2 = 94%, p < 0.00001), as presented in ***Figure 4.*** The subgroup analysis demonstrated lower postintervention labor pain with aromatherapy (M.D. = -2.24, 95% C.I. [-3.18 to -1.31], P< 0.00001), ball exercises (M.D. = -1.58, 95% C.I. [-2.04 to -1.12], P< 0.00001), and hand acupressure (M.D. = -2.58, 95% C.I. [-3.19 to -1.97], P< .00001) than the control group, as illustrated in **Figure 4.**

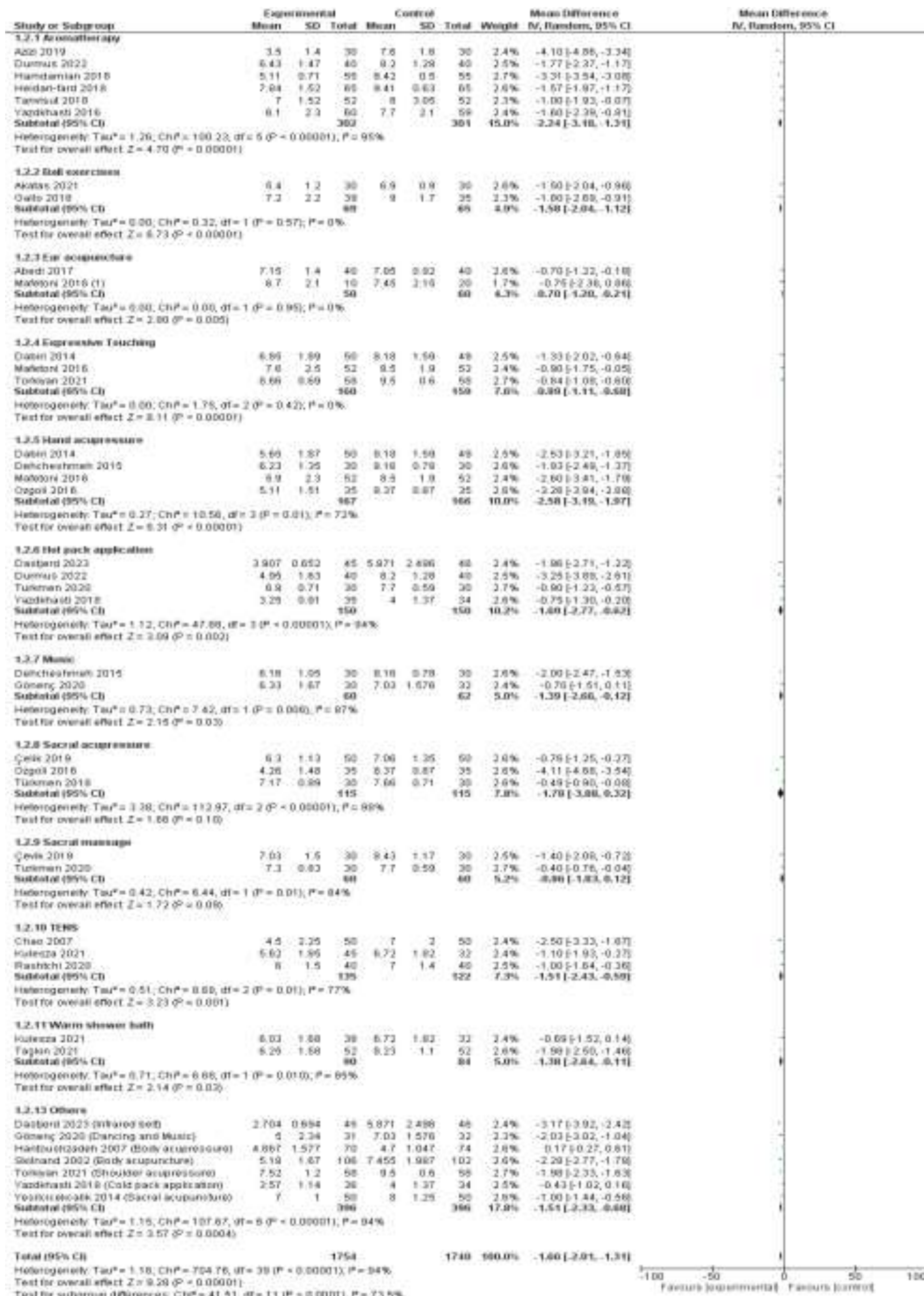


Figure 4: Forest plot of post-intervention pain (at 5-6 cm)

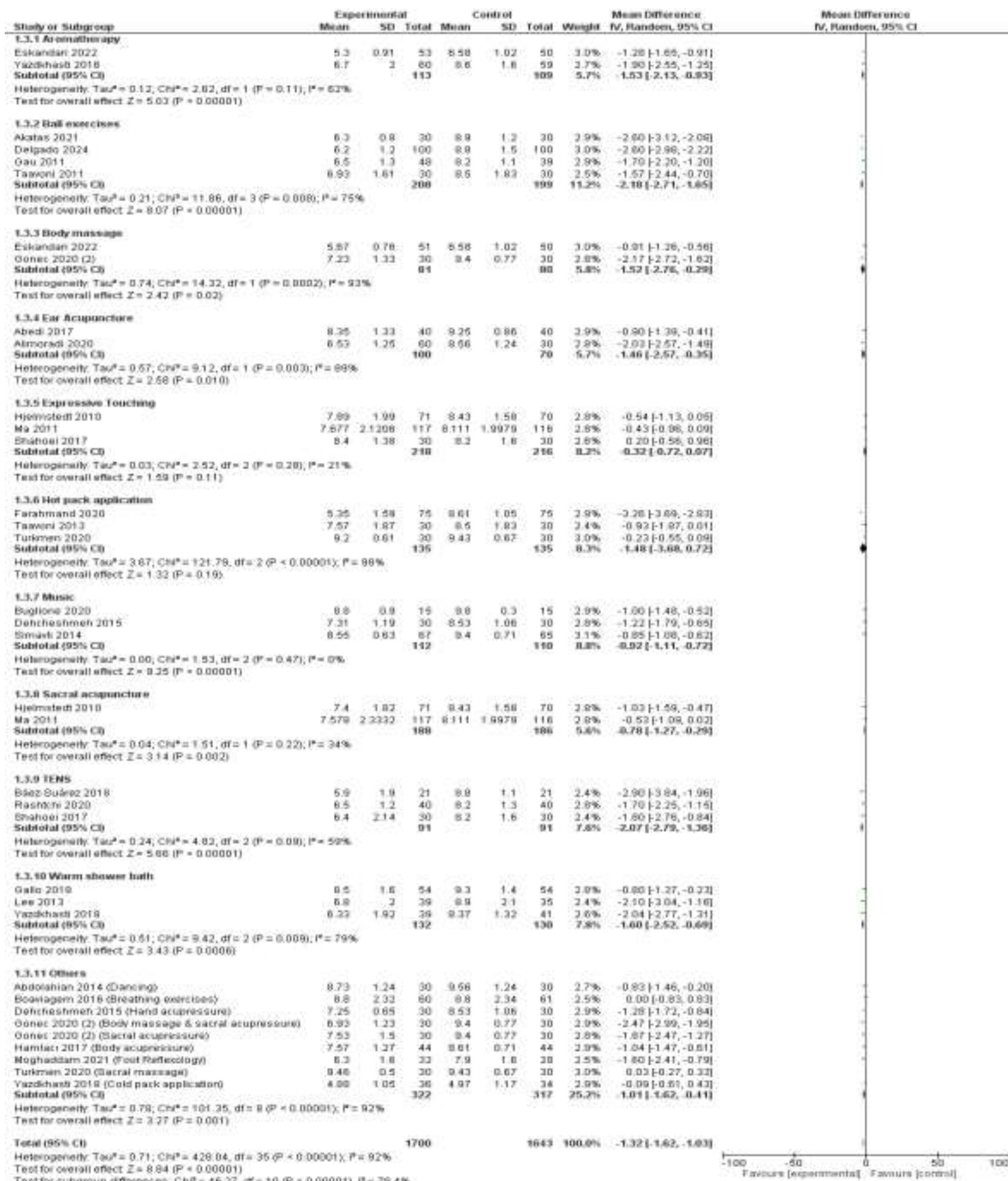


Figure 5: Forest plot of post-intervention pain (at 7-8 cm)

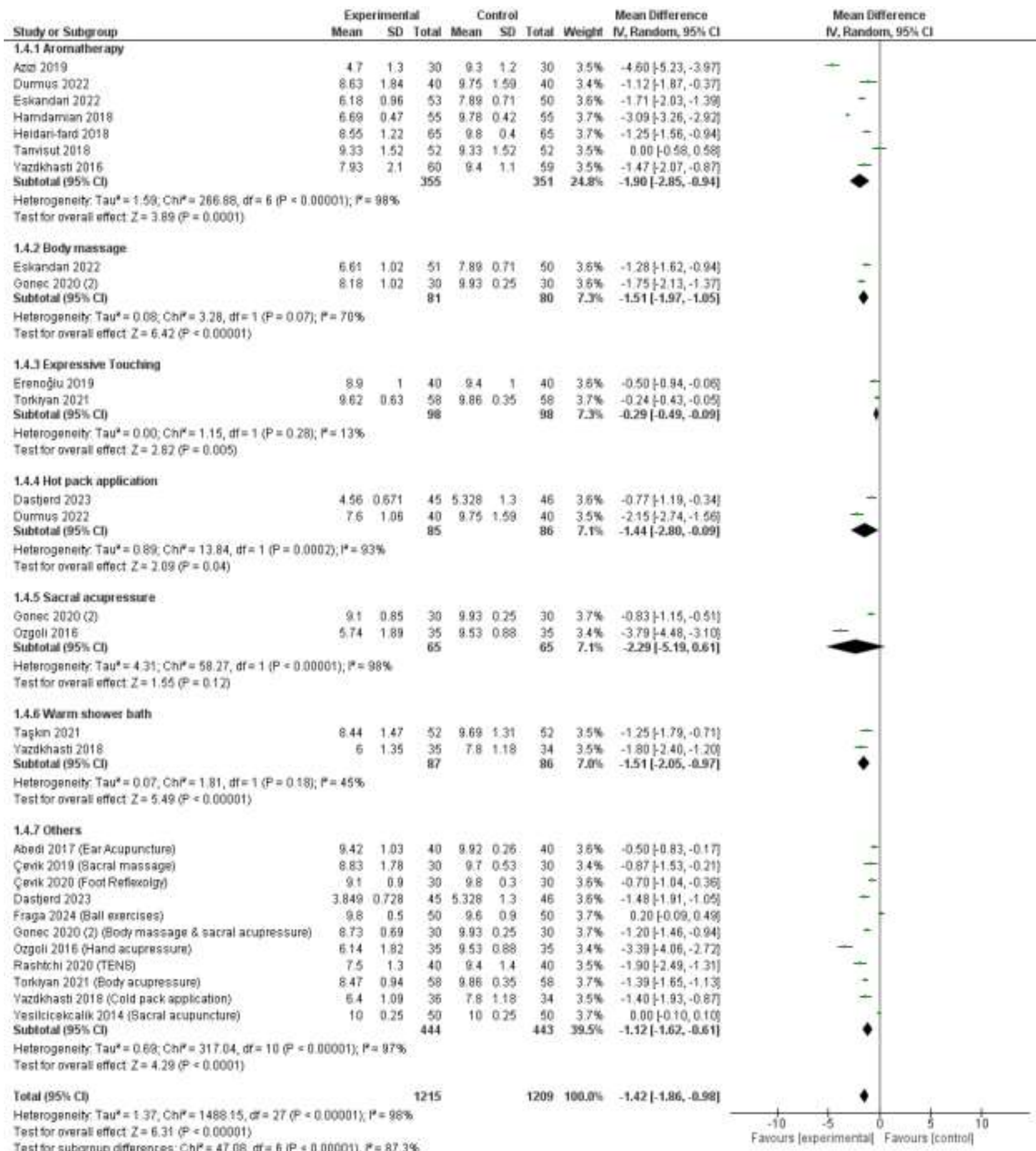


Figure 6: Forest plot of post-intervention pain (at 9-10 cm)

Postintervention pain (7-8 cm)

Thirty-two studies reported the postintervention labor pain at a cervical dilatation estimated at 7-8 cm. The pooled analysis demonstrated a notably lower postintervention pain with the non-pharmacological strategies compared to the control group with a pooled M.D. of -1.32 (95% C.I. [-1.62 to -1.03], P < 0.0001) with pooled significant heterogeneous studies ($I^2 = 92\%$, p < 0.00001), as shown in Figure 5. Particularly, ball exercises (M.D.= -2.18, 95% C.I. [-2.71 to -1.65], P< 0.00001) and TENS (M.D.=-2.07, 95% C.I. [-2.79 to -1.36], P< 0.0001) were strongly linked to lower postintervention labor pain compared to the control group, as shown in Figure 5.

Postintervention pain (9-10 cm)

The pooled M.D. showed that the non-pharmacological strategies were significantly related to a lower postintervention labor pain than the control group (M.D. = -1.42, 95% C.I. [-1.86 to -0.98],P<0.00001) with linked significant heterogeneity ($I^2 = 98\%$, p < 0.00001), as shown in Figure 6. Furthermore, the subgroup analysis strongly favored body massage (M.D. = -1.51, 95% C.I.[-1.97 to -1.05], P< 0.00001) and warm shower path (M.D.=-1.51, 95%C.I.[-2.05 to -0.97],P< 0.0001) in reducing the postintervention labor pain relative to the control group, as illustrated in Figure6

Change in pain from baseline

Change in pain (3-4 cm)

A pooled analysis of 31 studies gathering a total of 2983 patients revealed that non-pharmacological interventions significantly reduce labor pain compared to the control group (M.D. = -1.88, 95% C.I. [-2.44 to -1.33], P < 0.0001). Pooled results exhibited a notable heterogeneity ($I^2 = 99\%$, p < 0.00001), as presented in Figure 7. The subgroup analysis according to the type of non-pharmacological intervention showed significantly lower labor pain values with aromatherapy (M.D. = -1.76, 95% C.I. [-2.51 to -1.02], P < 0.0001), body acupressure (M.D. = -2.26, 95% C.I. [-3.34 to -1.18], P < 0.0001), and TENS (M.D. = -2.04, 95% C.I. [-2.87 to -1.21], P < 0.0001) relative to the control group, as illustrated in Figure 7.

Change in pain (5-6 cm)

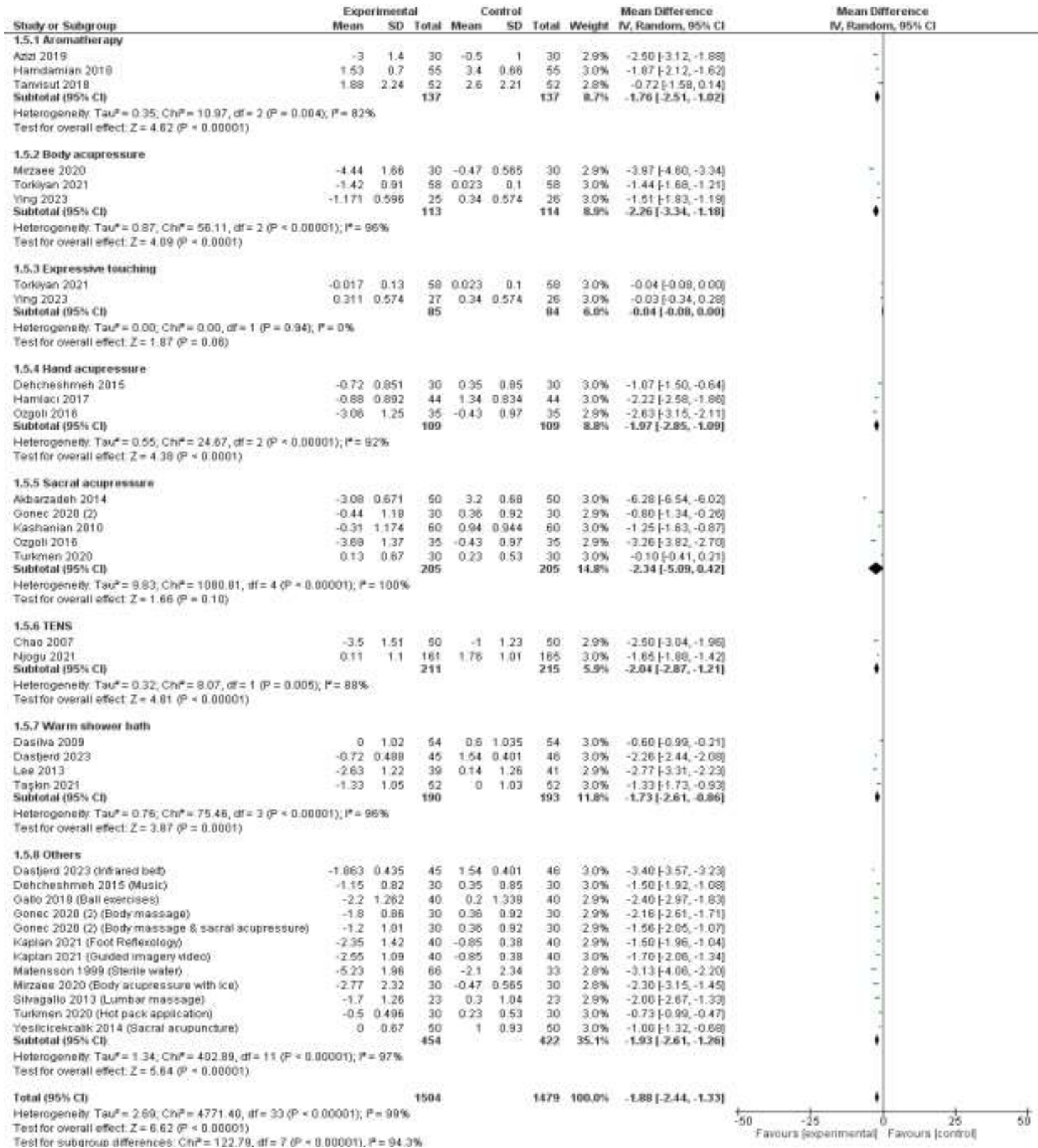
Our pooled analysis notably favored the non-pharmacological interventions in reducing the labor pain than the control group with a pooled M.D. of -1.72 (95% C.I. [-2.11 to -1.32], P < 0.0001), with pooled heterogeneous studies ($I^2 = 94\%$, p < 0.00001), as illustrated in Figure 8. Additionally, the subgroup analysis showed significantly lower labor pain values with aromatherapy (M.D. = -2.49, 95% C.I. [-3.66 to -1.31], P < 0.0001) and hand acupressure (M.D. = -2.60, 95% CI [-3.26 to -1.94], P < 0.00001) compared to the control group, as illustrated in Figure 8.

Change in pain (7-8 cm)

The pooled M.D. significantly favored the non-pharmacological interventions in reducing the labor pain compared to the control group (M.D. = -1.46, 95% C.I. [-1.96 to -0.95], P < 0.00001) with associated notable heterogeneity ($I^2 = 97\%$, p < 0.00001), as shown in **Supplementary Figure 2.** Furthermore, the subgroup analysis exhibited a significant reduction in labor pain with aromatherapy (M.D. = -2.39, 95% C.I. [-2.72 to -2.07], P < 0.00001) and ball exercises (M.D. = -2.47, 95% C.I. [-2.74 to -2.21], P < 0.00001) relative to the control group, as detailed in Supplementary Figure 2.

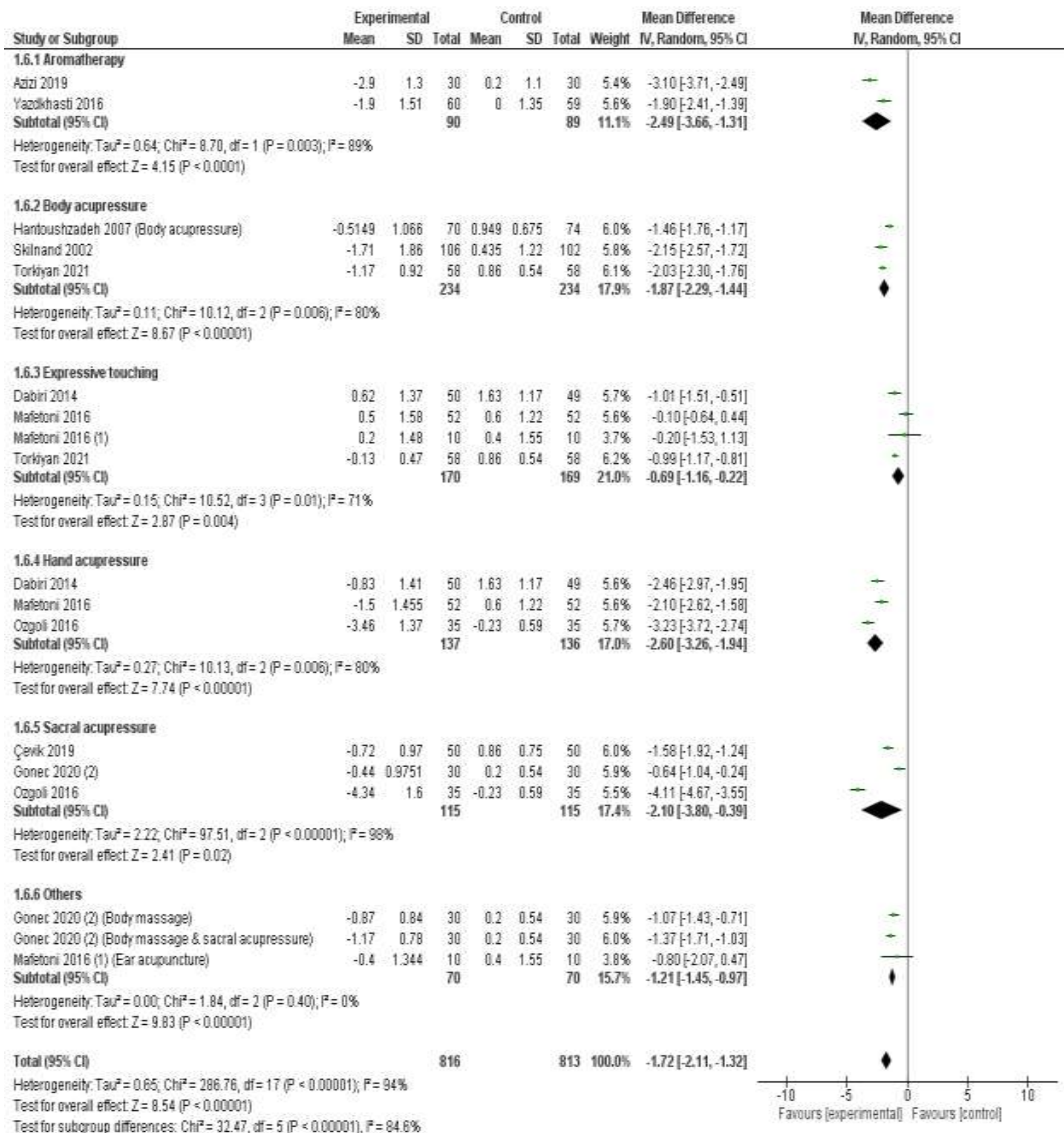
Change in pain (9-10 cm)

Our pooled analysis showed significantly lower labor pain levels with non-pharmacological interventions than the control group (M.D. = -1.1, 95% C.I. [-1.55 to -0.66], P < 0.00001), with linked significant heterogeneity ($I^2 = 97\%$, p < 0.00001), as shown in Supplementary Figure 3.



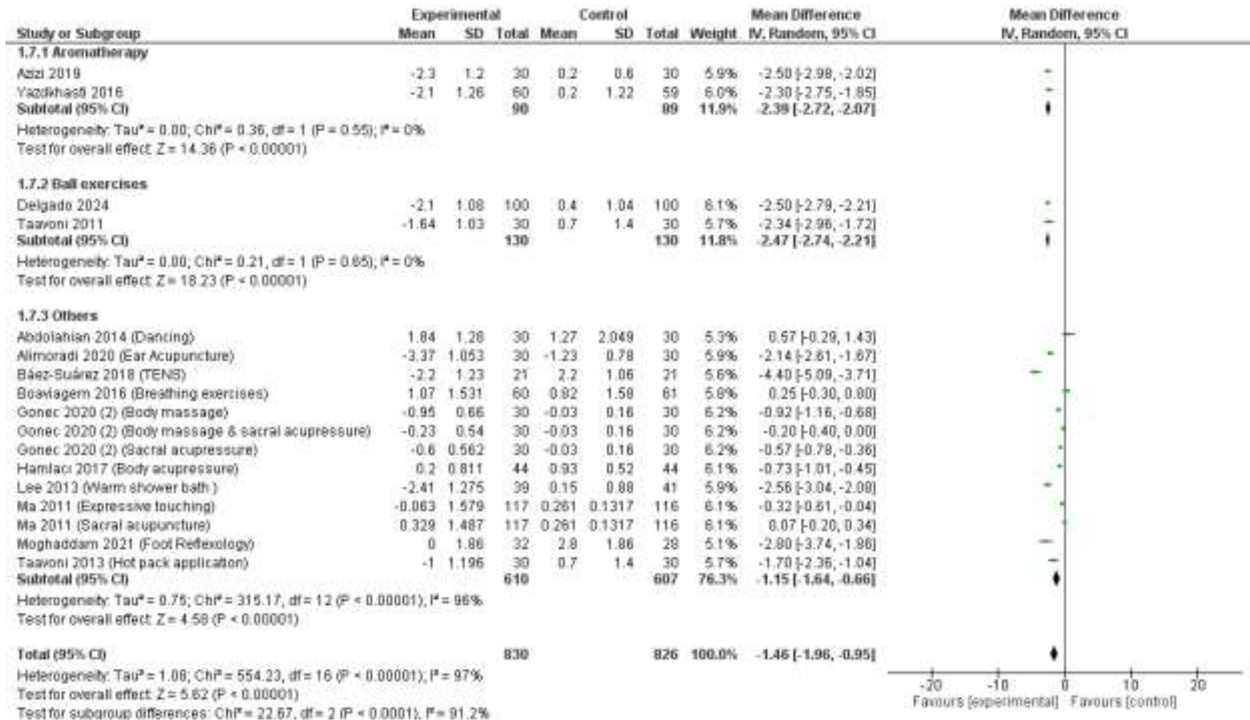
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
1.5.1 Aromatherapy								
Azizi 2019	-3	1.4	30	-0.5	1	30	2.9%	-2.50 [-3.12, -1.88]
Hamdamian 2018	1.53	0.7	55	3.4	0.66	55	3.0%	-1.87 [-2.12, -1.62]
Tanvisut 2018	1.88	2.24	52	2.6	2.21	52	2.8%	-0.72 [-1.58, 0.14]
Subtotal (95% CI)			**137**			**137**	**8.7%**	**-1.76 [-2.51, -1.02]**
Heterogeneity: Tau^2 = 0.35; Chi^2 = 10.97, df = 2 (P = 0.004); I^2 = 82%								
Test for overall effect: Z = 4.62 (P < 0.00001)								
1.5.2 Body acupressure								
Mirzaee 2020	-4.44	1.66	30	-0.47	0.565	30	2.9%	-3.97 [-4.60, -3.34]
Torkiyan 2021	-1.42	0.91	58	0.023	0.1	58	3.0%	-1.44 [-1.68, -1.21]
Ying 2023	-1.171	0.596	25	0.34	0.574	26	3.0%	-1.51 [-1.83, -1.19]
Subtotal (95% CI)			**113**			**114**	**8.9%**	**-2.26 [-3.34, -1.18]**
Heterogeneity: Tau^2 = 0.87; Chi^2 = 56.11, df = 2 (P < 0.00001); I^2 = 96%								
Test for overall effect: Z = 4.09 (P < 0.0001)								
1.5.3 Expressive touching								
Torkiyan 2021	-0.017	0.13	58	0.023	0.1	58	3.0%	-0.04 [-0.08, 0.00]
Ying 2023	0.311	0.574	27	0.34	0.574	26	3.0%	-0.03 [-0.34, 0.28]
Subtotal (95% CI)			**85**			**84**	**6.0%**	**-0.04 [-0.08, 0.00]**
Heterogeneity: Tau^2 = 0.00; Chi^2 = 0.00, df = 1 (P = 0.94); I^2 = 0%								
Test for overall effect: Z = 1.87 (P = 0.06)								
1.5.4 Hand acupressure								
Dehcheshmeh 2015	-0.72	0.851	30	0.35	0.85	30	3.0%	-1.07 [-1.50, -0.64]
Hamlaci 2017	-0.88	0.892	44	1.34	0.834	44	3.0%	-2.22 [-2.58, -1.86]
Ozgoli 2016	-3.06	1.25	35	-0.43	0.97	35	2.9%	-2.63 [-3.15, -2.11]
Subtotal (95% CI)			**109**			**109**	**8.8%**	**-1.97 [-2.85, -1.09]**
Heterogeneity: Tau^2 = 0.55; Chi^2 = 24.67, df = 2 (P < 0.00001); I^2 = 92%								
Test for overall effect: Z = 4.38 (P < 0.0001)								
1.5.5 Sacral acupressure								
Akbarzadeh 2014	-3.08	0.671	50	3.2	0.68	50	3.0%	-6.28 [-6.54, -6.02]
Gonec 2020 (2)	-0.44	1.18	30	0.36	0.92	30	2.9%	-0.80 [-1.34, -0.26]
Kashanian 2010	-0.31	1.174	60	0.94	0.944	60	3.0%	-1.25 [-1.63, -0.87]
Ozgoli 2016	-3.69	1.37	35	-0.43	0.97	35	2.9%	-3.26 [-3.82, -2.70]
Turkmen 2020	0.13	0.67	30	0.23	0.53	30	3.0%	-0.10 [-0.41, 0.21]
Subtotal (95% CI)			**205**			**205**	**14.8%**	**-2.34 [-5.09, 0.42]**
Heterogeneity: Tau^2 = 9.83; Chi^2 = 1080.81, df = 4 (P < 0.00001); I^2 = 100%								
Test for overall effect: Z = 1.66 (P = 0.10)								
1.5.6 TENS								
Chao 2007	-3.5	1.51	50	-1	1.23	50	2.9%	-2.50 [-3.04, -1.96]
Njogu 2021	0.11	1.1	161	1.76	1.01	165	3.0%	-1.65 [-1.88, -1.42]
Subtotal (95% CI)			**211**			**215**	**5.9%**	**-2.04 [-2.87, -1.21]**
Heterogeneity: Tau^2 = 0.32; Chi^2 = 8.07, df = 1 (P = 0.005); I^2 = 88%								
Test for overall effect: Z = 4.81 (P < 0.00001)								
1.5.7 Warm shower bath								
Dasilva 2009	0	1.02	54	0.6	1.035	54	3.0%	-0.60 [-0.99, -0.21]
Dastjerd 2023	-0.72	0.488	45	1.54	0.401	46	3.0%	-2.26 [-2.44, -2.08]
Lee 2013	-2.63	1.22	39	0.14	1.26	41	2.9%	-2.77 [-3.31, -2.23]
Taşkın 2021	-1.33	1.05	52	0	1.03	52	3.0%	-1.33 [-1.73, -0.93]
Subtotal (95% CI)			**190**			**193**	**11.8%**	**-1.73 [-2.61, -0.86]**
Heterogeneity: Tau^2 = 0.76; Chi^2 = 75.46, df = 3 (P < 0.00001); I^2 = 96%								
Test for overall effect: Z = 3.87 (P = 0.0001)								
1.5.8 Others								
Dastjerd 2023 (Infrared belt)	-1.863	0.435	45	1.54	0.401	46	3.0%	-3.40 [-3.57, -3.23]
Dehcheshmeh 2015 (Music)	-1.15	0.82	30	0.35	0.85	30	3.0%	-1.50 [-1.92, -1.08]
Gallo 2018 (Ball exercises)	-2.2	1.262	40	0.2	1.338	40	2.9%	-2.40 [-2.97, -1.83]
Gonec 2020 (2) (Body massage)	-1.8	0.86	30	0.36	0.92	30	2.9%	-2.16 [-2.61, -1.71]
Gonec 2020 (2) (Body massage & sacral acupressure)	-1.2	1.01	30	0.36	0.92	30	2.9%	-1.56 [-2.05, -1.07]
Kaplan 2021 (Foot Reflexology)	-2.35	1.42	40	-0.85	0.38	40	2.9%	-1.50 [-1.96, -1.04]
Kaplan 2021 (Guided imagery video)	-2.55	1.09	40	-0.85	0.38	40	3.0%	-1.70 [-2.06, -1.34]
Matensson 1999 (Sterile water)	-5.23	1.98	66	-2.1	2.34	33	2.8%	-3.13 [-4.06, -2.20]
Mirzaee 2020 (Body acupressure with ice)	-2.77	2.32	30	-0.47	0.565	30	2.8%	-2.30 [-3.15, -1.45]
Silvagallo 2013 (Lumbar massage)	-1.7	1.26	23	0.3	1.04	23	2.9%	-2.00 [-2.67, -1.33]
Turkmen 2020 (Hot pack application)	-0.5	0.496	30	0.23	0.53	30	3.0%	-0.73 [-0.99, -0.47]
Yesilcicekcalik 2014 (Sacral acupuncture)	0	0.67	50	1	0.93	50	3.0%	-1.00 [-1.32, -0.68]
Subtotal (95% CI)			**454**			**422**	**35.1%**	**-1.93 [-2.61, -1.26]**
Heterogeneity: Tau^2 = 1.34; Chi^2 = 402.89, df = 11 (P < 0.00001); I^2 = 97%								
Test for overall effect: Z = 5.64 (P < 0.00001)								
Total (95% CI)			**1504**			**1479**	**100.0%**	**-1.88 [-2.44, -1.33]**
Heterogeneity: Tau^2 = 2.69; Chi^2 = 4771.40, df = 33 (P < 0.00001); I^2 = 99%								
Test for overall effect: Z = 6.62 (P < 0.00001)								
Test for subgroup differences: Chi^2 = 122.79, df = 7 (P < 0.00001), I^2 = 94.3%								

Figure 7: Forest plot of change in pain (at 3-4 cm)



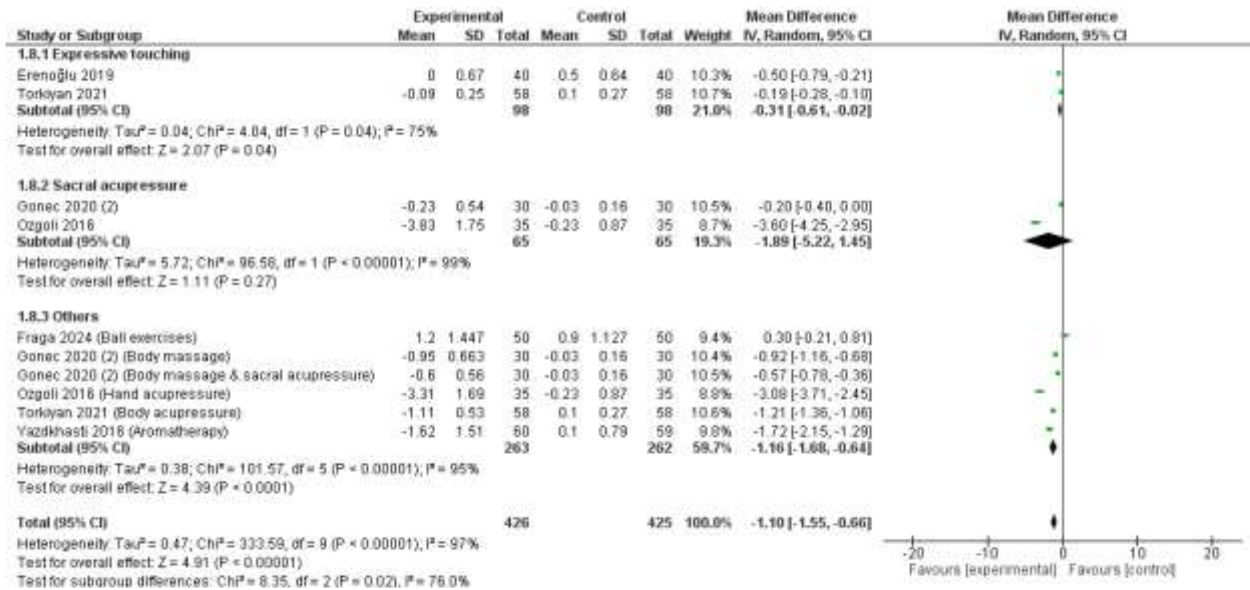
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
1.6.1 Aromatherapy								
Azizi 2019	-2.9	1.3	30	0.2	1.1	30	5.4%	-3.10 [-3.71, -2.49]
Yazdkhasti 2016	-1.9	1.51	60	0	1.35	59	5.6%	-1.90 [-2.41, -1.39]
Subtotal (95% CI)			**90**			**89**	**11.1%**	**-2.49 [-3.66, -1.31]**
Heterogeneity: Tau² = 0.64; Chi² = 8.70, df = 1 (P = 0.003); I² = 89%								
Test for overall effect: Z = 4.15 (P < 0.0001)								
1.6.2 Body acupressure								
Hantoushzadeh 2007 (Body acupressure)	-0.5149	1.066	70	0.949	0.675	74	6.0%	-1.46 [-1.76, -1.17]
Skilnand 2002	-1.71	1.86	106	0.435	1.22	102	5.8%	-2.15 [-2.57, -1.72]
Torkiyan 2021	-1.17	0.92	58	0.86	0.54	58	6.1%	-2.03 [-2.30, -1.76]
Subtotal (95% CI)			**234**			**234**	**17.9%**	**-1.87 [-2.29, -1.44]**
Heterogeneity: Tau² = 0.11; Chi² = 10.12, df = 2 (P = 0.006); I² = 80%								
Test for overall effect: Z = 8.67 (P < 0.00001)								
1.6.3 Expressive touching								
Dabiri 2014	0.62	1.37	50	1.63	1.17	49	5.7%	-1.01 [-1.51, -0.51]
Mafetoni 2016	0.5	1.58	52	0.6	1.22	52	5.6%	-0.10 [-0.64, 0.44]
Mafetoni 2016 (1)	0.2	1.48	10	0.4	1.55	10	3.7%	-0.20 [-1.53, 1.13]
Torkiyan 2021	-0.13	0.47	58	0.86	0.54	58	6.2%	-0.99 [-1.17, -0.81]
Subtotal (95% CI)			**170**			**169**	**21.0%**	**-0.69 [-1.16, -0.22]**
Heterogeneity: Tau² = 0.15; Chi² = 10.52, df = 3 (P = 0.01); I² = 71%								
Test for overall effect: Z = 2.87 (P = 0.004)								
1.6.4 Hand acupressure								
Dabiri 2014	-0.83	1.41	50	1.63	1.17	49	5.6%	-2.46 [-2.97, -1.95]
Mafetoni 2016	-1.5	1.455	52	0.6	1.22	52	5.6%	-2.10 [-2.62, -1.58]
Ozgoli 2016	-3.46	1.37	35	-0.23	0.59	35	5.7%	-3.23 [-3.72, -2.74]
Subtotal (95% CI)			**137**			**136**	**17.0%**	**-2.60 [-3.26, -1.94]**
Heterogeneity: Tau² = 0.27; Chi² = 10.13, df = 2 (P = 0.006); I² = 80%								
Test for overall effect: Z = 7.74 (P < 0.00001)								
1.6.5 Sacral acupressure								
Çevik 2019	-0.72	0.97	50	0.86	0.75	50	6.0%	-1.58 [-1.92, -1.24]
Gonec 2020 (2)	-0.44	0.9751	30	0.2	0.54	30	5.9%	-0.64 [-1.04, -0.24]
Ozgoli 2016	-4.34	1.6	35	-0.23	0.59	35	5.5%	-4.11 [-4.67, -3.55]
Subtotal (95% CI)			**115**			**115**	**17.4%**	**-2.10 [-3.80, -0.39]**
Heterogeneity: Tau² = 2.22; Chi² = 97.51, df = 2 (P < 0.00001); I² = 98%								
Test for overall effect: Z = 2.41 (P = 0.02)								
1.6.6 Others								
Gonec 2020 (2) (Body massage)	-0.87	0.84	30	0.2	0.54	30	5.9%	-1.07 [-1.43, -0.71]
Gonec 2020 (2) (Body massage & sacral acupressure)	-1.17	0.78	30	0.2	0.54	30	6.0%	-1.37 [-1.71, -1.03]
Mafetoni 2016 (1) (Ear acupuncture)	-0.4	1.344	10	0.4	1.55	10	3.8%	-0.80 [-2.07, 0.47]
Subtotal (95% CI)			**70**			**70**	**15.7%**	**-1.21 [-1.45, -0.97]**
Heterogeneity: Tau² = 0.00; Chi² = 1.84, df = 2 (P = 0.40); I² = 0%								
Test for overall effect: Z = 9.83 (P < 0.00001)								
Total (95% CI)			**816**			**813**	**100.0%**	**-1.72 [-2.11, -1.32]**
Heterogeneity: Tau² = 0.65; Chi² = 286.76, df = 17 (P < 0.00001); I² = 94%								
Test for overall effect: Z = 8.54 (P < 0.00001)								
Test for subgroup differences: Chi² = 32.47, df = 5 (P < 0.00001), I² = 84.6%								

Figure 8: Forest plot of change in pain (at 5-6 cm)



Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
1.7.1 Aromatherapy								
Azizi 2019	-2.3	1.2	30	0.2	0.6	30	5.9%	-2.50 [-2.98, -2.02]
Yazdkhasti 2016	-2.1	1.26	60	0.2	1.22	59	6.0%	-2.30 [-2.75, -1.85]
Subtotal (95% CI)			**90**			**89**	**11.9%**	**-2.39 [-2.72, -2.07]**
Heterogeneity: Tau^2 = 0.00; Chi^2 = 0.36, df = 1 (P = 0.55); I^2 = 0%								
Test for overall effect: Z = 14.36 (P < 0.00001)								
1.7.2 Ball exercises								
Delgado 2024	-2.1	1.08	100	0.4	1.04	100	6.1%	-2.50 [-2.79, -2.21]
Taavoni 2011	-1.64	1.03	30	0.7	1.4	30	5.7%	-2.34 [-2.96, -1.72]
Subtotal (95% CI)			**130**			**130**	**11.8%**	**-2.47 [-2.74, -2.21]**
Heterogeneity: Tau^2 = 0.00; Chi^2 = 0.21, df = 1 (P = 0.65); I^2 = 0%								
Test for overall effect: Z = 18.23 (P < 0.00001)								
1.7.3 Others								
Abdolahian 2014 (Dancing)	1.84	1.28	30	1.27	2.049	30	5.3%	0.57 [-0.29, 1.43]
Alimoradi 2020 (Ear Acupuncture)	-3.37	1.053	30	-1.23	0.78	30	5.9%	-2.14 [-2.61, -1.67]
Báez-Suárez 2018 (TENS)	-2.2	1.23	21	2.2	1.06	21	5.6%	-4.40 [-5.09, -3.71]
Boaviagem 2016 (Breathing exercises)	1.07	1.531	60	0.82	1.58	61	5.8%	0.25 [-0.30, 0.80]
Gonec 2020 (2) (Body massage)	-0.95	0.66	30	-0.03	0.16	30	6.2%	-0.92 [-1.16, -0.68]
Gonec 2020 (2) (Body massage & sacral acupressure)	-0.23	0.54	30	-0.03	0.16	30	6.2%	-0.20 [-0.40, 0.00]
Gonec 2020 (2) (Sacral acupressure)	-0.6	0.562	30	-0.03	0.16	30	6.2%	-0.57 [-0.78, -0.36]
Hamlaci 2017 (Body acupressure)	0.2	0.811	44	0.93	0.52	44	6.1%	-0.73 [-1.01, -0.45]
Lee 2013 (Warm shower bath)	-2.41	1.275	39	0.15	0.88	41	5.9%	-2.56 [-3.04, -2.08]
Ma 2011 (Expressive touching)	-0.063	1.579	117	0.261	0.1317	116	6.1%	-0.32 [-0.61, -0.04]
Ma 2011 (Sacral acupuncture)	0.329	1.487	117	0.261	0.1317	116	6.1%	0.07 [-0.20, 0.34]
Moghaddam 2021 (Foot Reflexology)	0	1.86	32	2.8	1.86	28	5.1%	-2.80 [-3.74, -1.86]
Taavoni 2013 (Hot pack application)	-1	1.196	30	0.7	1.4	30	5.7%	-1.70 [-2.36, -1.04]
Subtotal (95% CI)			**610**			**607**	**76.3%**	**-1.15 [-1.64, -0.66]**
Heterogeneity: Tau^2 = 0.75; Chi^2 = 315.17, df = 12 (P < 0.00001); I^2 = 96%								
Test for overall effect: Z = 4.58 (P < 0.00001)								
Total (95% CI)			**830**			**826**	**100.0%**	**-1.46 [-1.96, -0.95]**
Heterogeneity: Tau^2 = 1.08; Chi^2 = 554.23, df = 16 (P < 0.00001); I^2 = 97%								
Test for overall effect: Z = 5.62 (P < 0.00001)								
Test for subgroup differences: Chi^2 = 22.67, df = 2 (P < 0.0001), I^2 = 91.2%								

Supplementary Figure 2: Forest plot of change in pain (at 7-8 cm)



Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
1.8.1 Expressive touching								
Erenoğlu 2019	0	0.67	40	0.5	0.64	40	10.3%	-0.50 [-0.79, -0.21]
Torkiyan 2021	-0.09	0.25	58	0.1	0.27	58	10.7%	-0.19 [-0.28, -0.10]
Subtotal (95% CI)			**98**			**98**	**21.0%**	**-0.31 [-0.61, -0.02]**
Heterogeneity: Tau^2 = 0.04; Chi^2 = 4.04, df = 1 (P = 0.04); I^2 = 75%								
Test for overall effect: Z = 2.07 (P = 0.04)								
1.8.2 Sacral acupressure								
Gonec 2020 (2)	-0.23	0.54	30	-0.03	0.16	30	10.5%	-0.20 [-0.40, 0.00]
Ozgoli 2016	-3.83	1.75	35	-0.23	0.87	35	8.7%	-3.60 [-4.25, -2.95]
Subtotal (95% CI)			**65**			**65**	**19.3%**	**-1.89 [-5.22, 1.45]**
Heterogeneity: Tau^2 = 5.72; Chi^2 = 96.58, df = 1 (P < 0.00001); I^2 = 99%								
Test for overall effect: Z = 1.11 (P = 0.27)								
1.8.3 Others								
Fraga 2024 (Ball exercises)	1.2	1.447	50	0.9	1.127	50	9.4%	0.30 [-0.21, 0.81]
Gonec 2020 (2) (Body massage)	-0.95	0.663	30	-0.03	0.16	30	10.4%	-0.92 [-1.16, -0.68]
Gonec 2020 (2) (Body massage & sacral acupressure)	-0.6	0.56	30	-0.03	0.16	30	10.5%	-0.57 [-0.78, -0.36]
Ozgoli 2016 (Hand acupressure)	-3.31	1.69	35	-0.23	0.87	35	8.8%	-3.08 [-3.71, -2.45]
Torkiyan 2021 (Body acupressure)	-1.11	0.53	58	0.1	0.27	58	10.6%	-1.21 [-1.36, -1.06]
Yazdkhasti 2016 (Aromatherapy)	-1.62	1.51	60	0.1	0.79	59	9.8%	-1.72 [-2.15, -1.29]
Subtotal (95% CI)			**263**			**262**	**59.7%**	**-1.16 [-1.68, -0.64]**
Heterogeneity: Tau^2 = 0.38; Chi^2 = 101.57, df = 5 (P < 0.00001); I^2 = 95%								
Test for overall effect: Z = 4.39 (P < 0.0001)								
Total (95% CI)			**426**			**425**	**100.0%**	**-1.10 [-1.55, -0.66]**
Heterogeneity: Tau^2 = 0.47; Chi^2 = 333.59, df = 9 (P < 0.00001); I^2 = 97%								
Test for overall effect: Z = 4.91 (P < 0.00001)								
Test for subgroup differences: Chi^2 = 8.35, df = 2 (P = 0.02), I^2 = 76.0%								

Supplementary Figure 3: Forest plot of change in pain (at 9-10 cm)

Notably, expressive touching significantly reduced labor pain compared to the control group (M.D. = -0.31, 95% C.I. [-0.61 to -0.02], P = 0.04), as illustrated in Supplementary Figure 3.

Discussion

This study represents the most comprehensive and updated evidence regarding the role of non-pharmacological interventions in decreasing labor pain, with a total of 77 studies encompassing 8805 pregnant women. Our pooled analysis showed that non-pharmacological interventions were effective in reducing labor pain across different cervical dilatation stages with either pooling postoperative or change pain. Body acupressure and foot reflexology notably showed significant efficacy in reducing labor pain when pooling postintervention pain at 3-4 cm of cervical dilatation. Furthermore, TENS and ball exercise exhibited lower labor pain based on pooling the postintervention pain at 7-8 cm. Body massage significantly reduced the labor pain when measuring the postintervention pain at 9-10 cm. Based on pooling the change pain at 3-4 cm or 5-6 cm, aromatherapy, body acupressure, and hand acupressure showed notable efficacy in mitigating labor pain. Expressive touching demonstrated lower labor pain levels relative to the control group based on pooling the change pain at 9-10 cm of cervical dilatation.

In recent years, clinicians and researchers have acknowledged the need to employ safe and effective pain relief strategies that do not interfere with the labor process, maintain maternal consciousness, and preserve her natural straining reflex and other physiological functions. Notably, these complications are often observed with pharmacological interventions.[92] As a result, a significant number of women favor non-pharmacological methods to alleviate labor pain.[11]

According to traditional Chinese medicine, acupressure, a non-invasive and non-pharmacological approach, has been shown to reduce labor pain.[66,93] In their prospective control trial, Torkian and his colleagues randomized 174 pregnant women undergoing the first stage of labor into three groups: GB21 acupressure cohort, sham cohort, and control cohort.[85] They measured the degree of labor pain at three different stages of cervical dilatations, including 4-5 cm, 6-7 cm, and 8-10 cm. They found that the GB21 acupressure was associated with significantly lower labor pain compared to either sham or control groups at the three cervical dilatation phases, which is aligned with our pooled analysis. Moreover, they reported a notable difference in satisfaction between the three groups, with the acupressure group showing notably higher satisfaction levels. Similarly, Mirzaee et al. conducted a randomized controlled trial in 90 pregnant women, evaluating the role of LI-4 acupressure in mitigating labor pain.[70] They also found substantially lower pain levels in the LI-4 acupressure group relative to the control.

A possible explanation for the efficacy of acupressure in reducing labor pain is that this method works based on the gate control theory, wherein techniques such as messaging, scratching, or burning active fibers transmit impulses to the spinal cord. Sustained stimulation to these fibers can effectively block pain signals. Furthermore, applying needles, heat, or pressure to acupressure points promotes endorphin release.[42]

Aromatherapy, known as the science of utilizing highly concentrated essential oils or plant essences to benefit from their therapeutic effects, is widely used for reducing pain, anxiety, and fear. [94] Fragrances of essential oil have been shown to induce several positive psychological effects, encompassing stress reduction and improved relaxation and alertness state of the brain.[95] Consequently, these effects may contribute to favorable labor outcomes, as stress can adversely affect the labor process by increasing the pain intensity and delaying effective labor.[96,97] In the

same context, our pooled analysis concluded that aromatherapy has a beneficial role in decreasing labor pain. This was aligned with a randomized study conducted by Tanvisut and his colleagues on 104 pregnant women to assess the role of aromatherapy in managing labor pain.[83]

They found notably lower labor pain scores with aromatherapy compared to the control group in both latent and active phases of labor.

Additionally, ball exercises exhibited a significant role in reducing labor pain based on our pooled analysis. This was aligned with the study by Delgado *et al.*, who found significantly lower pain scores with active pelvic movements using a Swiss ball compared to the control group.[46] Swiss ball exercises focusing on pelvic biomechanics can affect physiological pain mechanisms, reduce the nociceptive response, and help reduce labor pain during contractions.[98,99]

TENS, identified as a non-pharmacological and non-invasive method, has been widely employed for the relief of chronic pain, such as back pain and rheumatic pain. The FDA approved TENS for application in controlling surgical and traumatic pain.[100] Our study proved its efficacy in mitigating labor pain across several cervical dilatation stages. This was supported by Rashtchi *et al.*, who also found significantly lower pain scores during labor when utilizing the TENS in a cohort of 40 pregnant women.[75] This can be explained by the fact that the electrical impulses induced by TENS could decrease the pain signals transmitted to the spinal cord and brain.[101]

Reflexology, a newly emerged non-drug approach, is a therapeutic technique involving hand and foot massage, which induces electrochemical signals by stimulating the nerve points with particular approaches. Targeted pressure on particular reflex points on the foot sole facilitates the breakdown of calcium crystals and uric acid stored in nerve terminals. Also, this pressure could open the closed nerve pathways and enhance the blood flow across the body.[102,103] Our primary analysis reported a notable benefit of foot reflexology in reducing labor pain relative to the control group. Similarly, Kaplan et al. reported significantly lower VAS pain scores with foot reflexology compared to the control group.[61] They also found higher birth satisfaction and lower delivery duration among women treated by foot reflexology than among women managed by routine care. The gate control theory could justify the observed reduction in labor pain with foot reflexology. The gate control theory proposes that adequate or excessive sensory stimulation makes the brainstem close the gate and inhibit the transmission of pain signals.[61] We suggested that foot reflexology decreases labor pain by heightening the sensory stimulation through the skin.

Our study also found a notable benefit for massage and music in reducing labor pain compared to the control group. In the same context, Dehcheshmeh et al. found substantially lower pain scores in Iranian women who had undergone massage or music therapy during labor compared to women who received routine care.[45]

Our study has several strengths points. First, to our most updated knowledge, our study represents the most updated and comprehensive evidence regarding the efficacy of non-pharmacological interventions in reducing labor pain for pregnant women. Second, the diverse populations with different non-pharmacological interventions support the generalizability of our findings to the whole population. Third, we restricted the studies in our systematic review to only RCTs to give strong evidence and avoid potential selection bias.

Multiple limitations are also noticed in our study. First, the heterogeneity observed within almost all the outcomes could limit our findings. The lack of differences in applying non-pharmacological methods across the studies and the

diverse population characteristics could explain this heterogeneity. Second, many included studies have small samples, so further large RCTs are recommended for better clarification of the role of non-pharmacological strategies in mitigating labor pain. Third, our study only focused on assessing short-term pain relief without evaluating the procedure's long-term outcomes or potential adverse effects.

Our study highlights the clinical understanding of the different non-pharmacological interventions and their role in pain relief without any side effects, as observed with the medical interventions. Additionally, our study supports using particular non-pharmacological methods according to the stage of labor, which in turn encourages personalized care. For example, foot reflexology and acupressure showed strong efficacy in the earlier stages of cervical dilatation, while ball exercises and TENS exhibited more significant effectiveness in the later stages.

Future searches should focus on addressing our study limitations. The observed significant heterogeneity between studies emphasizes the need for a high standardization level in employing different non-pharmacological interventions. Moreover, future researchers should pay more attention to studying long-term pain relief and the potential side effects of these procedures.

Conclusion

Our study represents the most updated and comprehensive evidence supporting the efficacy of non-pharmacological strategies in mitigating labor pain in pregnant women. Our subgroup analysis showed that approaches such as acupressure, aromatherapy, TENS, and massage notably decrease labor pain across different phases of cervical dilatation. Further, large-scale randomized controlled trials are recommended to support our findings.

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Conflict of interest

The authors confirm that there are no conflicts of interest associated with this research.

Availability of data

The data utilized and analyzed during this study can be provided by the corresponding author upon reasonable request.

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