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MATERNAL-FETAL MEDICINE

Efficacy of birthing ball exercises to reduce labor pain and cesarean rates: an updated meta-analysis of randomized controlled trials

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Abstract

Purpose This updated systematic review and meta-analysis aims to evaluate the impact of a birthing ball (BB) exercises on low-risk parturients during labor, offering a more comprehensive understanding through a larger sample size, robust analysis, and focus on relevant endpoints that were underexplored in previous studies due to limited data.

Methods We searched PubMed, Embase, Scopus, and Cochrane Central for randomized controlled trials (RCTs) comparing BB (also named Swiss ball) exercises with no intervention or standard care in parturients undergoing low-risk labor. Risk ratios (RR) and mean differences (MD) were calculated using a random-effects model. I^2 heterogeneity was assessed. All statistical analyses were performed using Review Manager 5.4.

Results We included 10 RCTs with 1,008 parturients, 51.2% of whom were assigned to BB exercises. In the pooled analysis, the BB group showed significantly lower cesarean section rates (MD 0.55, $p = 0.007$, $I^2 = 32\%$), reduced pain scores at 4 and 8 cm dilation by approximately 20% ($p < 0.001$), and a reduction of over two hours in the duration of the first stage of labor (MD -130.12 min, $p < 0.001$). There were no significant differences between groups in the duration of the second stage of labor ($p = 0.090$) and in the incidence of instrumental delivery, amniotomy, labor induction, oxytocin use, or epidural analgesia.

Conclusions BB exercises significantly reduced cesarean section rates, alleviated labor pain, and shortened the first stage of labor, supporting their use as a safe and effective non-pharmacological intervention in low-risk labor management.

Keywords Parturition · Labor pain · Cesarean section · First Labor stage · Exercise therapy

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Introduction

Labor, as the culmination of pregnancy, requires specialized care that addresses the social, physiological, anatomical, and emotional needs of the pregnant individual [1]. Prioritizing comfort throughout labor is crucial, with supportive methods playing a key role from the prodromal to the expulsive stages [2, 3]. While complete pain elimination is unattainable, various non-pharmacological techniques can significantly reduce pain and improve the maternal labor experience. These approaches are increasingly valued for promoting patient autonomy and minimizing unnecessary interventions [3–5].

The birthing ball (BB), also referred to as Swiss ball, is a versatile tool used during labor to enhance comfort and facilitate movements like bouncing, rocking, and pelvic rotations, helping parturients manage labor more effectively [6]. Originally introduced as a therapeutic tool in the 1950s by English physiotherapist Mary Quinton for children with cerebral palsy, its applications were expanded after 1958 by Dr. Susanne Klein-Vogelbach in Switzerland for postural training and orthopedic rehabilitation in adults. By the 1980s, the ball was incorporated into obstetric care in maternity hospitals in Germany to support labor progression [7–9]. Data on the effectiveness of BB exercises has emerged in recent years, revealing benefits such as stimulating dilation, promoting fetal positioning, enhancing uterine contractions, improving maternal–fetal circulation, reducing lower back pain, and relaxing perineal muscles [10–12]. Additionally, it provides distraction, reducing anxiety and promoting relaxation, which helps laboring women manage pain and maintain a sense of control [13, 14]. By integrating BB into labor practices, healthcare workers aim to improve the overall childbirth experience and assist in providing a more efficient and comfortable labor process [6].

Pharmacological interventions, when used appropriately, are effective in reducing adverse outcomes such as maternal and neonatal mortality, postpartum hemorrhage, and the need for cesarean sections [15]. For example, oxytocin is recommended for active management of the third stage of labor to prevent postpartum hemorrhage [16], while epidural anesthesia remains an effective option for pain relief [17]. However, it is well-documented that the routine use of pharmacological interventions in low-risk labors may lead to unintended adverse maternal and neonatal outcomes [17, 18]. Recognizing these complexities, WHO recommends minimizing unnecessary interventions and prioritizing practices that support physiological labor processes, such as delayed cord clamping, skin-to-skin contact, and mobility during labor [16, 19, 20]. Non-pharmacological approaches, such as the BB, are valued for enhancing maternal comfort, supporting mobility, and promoting labor progression while reducing the need for medical interventions, especially in early labor [11]. While the ball can offer modest pain relief, its impact on key outcomes like mode of delivery and severe maternal morbidity is less clear, with previous meta-analyses highlighting limitations due to small sample sizes and methodological heterogeneity [11, 21]. A 2015 review involving 220 childbearing women found improved pain relief with BBs but did not assess other outcomes [21]. A 2021 review of 533 parturients also confirmed significant pain reduction during active labor, though it found no substantial differences in labor duration or cesarean section rates [11]. By incorporating an updated sample size and more recent data, this study aims to provide a deeper understanding of the maternal effects of BB use during low-risk labor. The research is guided by the following question: "What are the maternal effects of BB exercises on mode of delivery, pain relief, and labor outcomes during low-risk labor, compared to routine care or no intervention?".

Methods

We registered the protocol for this systematic review and meta-analysis with the International Prospective Register of Systematic Reviews (PROSPERO), under the identifier CRD42024572918, on August 4, 2024. There were no major deviations from the protocol, except for specific adjustments to the secondary outcomes analyzed due to data availability; however, these adjustments remained within the scope of maternal outcomes. Our procedures for data registration, conducting the meta-analysis, and reporting follow the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions and adhere to PRISMA standards [22, 23].

Eligibility criteria

This meta-analysis included studies that met the following criteria: (1) randomized controlled trials (RCTs); (2) comparing BB exercises with no intervention or routine care; (3) involving parturients undergoing low-risk labor at term; and (4) reporting maternal obstetric outcomes. Routine care was defined as standard hospital procedures provided to the control group, without structured or supervised non-pharmacological interventions such as hydrotherapy, music therapy, or massage. Studies were excluded if they had overlapping patient cohorts from the same institution and time period, combined BB exercises with other structured non-pharmacological pain management techniques, or were limited to conference abstracts or non-peer-reviewed studies. When data were incomplete, we attempted to contact the original study authors. There were no restrictions on publication date or language.

Search strategy and data extraction

The study selection process followed the inclusion and exclusion criteria established based on the PICO framework (Population, Intervention, Comparison, and Outcome). Since the criteria were clearly defined, all reviewers were trained on them to ensure consistency and accuracy during the selection process. This approach helped maintain a standardized and reliable process without the need for a pilot test.

We performed a systematic search of PubMed, Embase, Scopus and the Cochrane Central Register of Controlled Trials for eligible RCTs up to June 29, 2024. The search terms used were ("birth ball" OR "birth balls" OR "birthing ball" OR "birthing balls" OR "exercise ball" OR "exercise balls" OR "swiss ball" OR "swiss balls") AND (delivery OR childbirth OR birth OR labor OR labour OR parturient). The same search strategy was applied across all databases, combining MeSH terms for standardized indexing with free-text keywords to capture studies not yet indexed or using varied terminology.

Three authors, M.T., M.S., and L.C., conducted the search independently, using Zotero for reference management and to deduplicate records. Study triage and selection were performed in blind mode using Rayyan by two authors, M.T. and L.C. Disagreements, mainly regarding study eligibility, were resolved through discussion and consensus among the reviewers. The references of all included studies were also examined for additional relevant studies.

Data extraction was performed independently by three authors, L.N., M.A., and S.B., using a standardized Excel form. All reported maternal outcomes, as well as sample, baseline, and intervention data, were extracted. After collecting all data on the form, it was double-checked by a different author for accuracy. When necessary, data were standardized to the same units of measure to ensure consistency and were ultimately triple-checked to confirm the results. No pilot test for data extraction was conducted, as the form was clearly defined in advance; however, discrepancies in data extraction were resolved through discussion and consensus with the fourth and fifth authors, M.T. and A.P.

Outcomes

The primary endpoints of interest included: (1) the incidence of cesarean sections; (2) pain scores at 4 cm and 8 cm dilation; and (3) the duration of the first and second stages of labor, measured in minutes. The incidence of instrumental delivery, amniotomy, induction of labor, and use of oxytocin and epidural analgesia represented secondary outcomes. A meta-analysis was conducted whenever at least three RCTs provided data for an outcome.

Statistical analysis

Risk ratios (RR) were estimated using the inverse variance (IV) method for binary outcomes, presenting the effect size with 95% confidence intervals (CI). For continuous outcomes, mean differences (MD) with 95% CI were used. P-values below 0.05 were considered statistically significant. To address possible clinical and methodological differences among studies, we used the restricted maximum-likelihood estimator and a DerSimonian and Laird random-effects model. We assessed heterogeneity through the Cochran Q-test and I^2 statistics. Classified as follows: 0% to 40% may be insignificant; 30% to 60% indicates moderate heterogeneity; 50% to 90% suggests substantial heterogeneity; and 75% to 100% represents considerable heterogeneity. All statistical analyses were performed using Review Manager version 5.4.

Quality and sensitivity assessment

As our study included only RCTs, the risk of bias was assessed using version 2 of the Cochrane Risk of Bias assessment tool (RoB 2) [24]. This assessment was carried out by two authors, M.T. and L.N., and any discrepancies were resolved through discussion. We conducted sensitivity analyses by employing a manual leave-one-out method and by excluding studies with a high risk of bias across all outcomes.

Results

The systematic search yielded 367 items, of which 209 were duplicates and 73 were deemed unrelated based on their titles or abstracts. After meticulously examining the remaining 18 publications, 10 RCTs [25–34] were chosen for inclusion in this meta-analysis (Fig. 1). Of the studies assessed for eligibility, one was excluded for not including low-risk parturients as the population of interest, one for not reporting any maternal outcomes of interest, and four for unpublished clinical trials. Other exclusions included one trial protocol and one conference abstract.

The present study included 1008 childbearing women, of which 516 (51.2%) were randomly assigned to receive the BB exercises. The BB interventions varied across studies in terms of timing, duration, and protocols. Most interventions began during active labor, typically at 4 cm dilation, while a few started earlier, during the latent phase or at hospital admission. Exercise durations ranged from 20 to 30 min, with some studies specifying variable lengths and others leaving it unspecified. The protocols typically involved

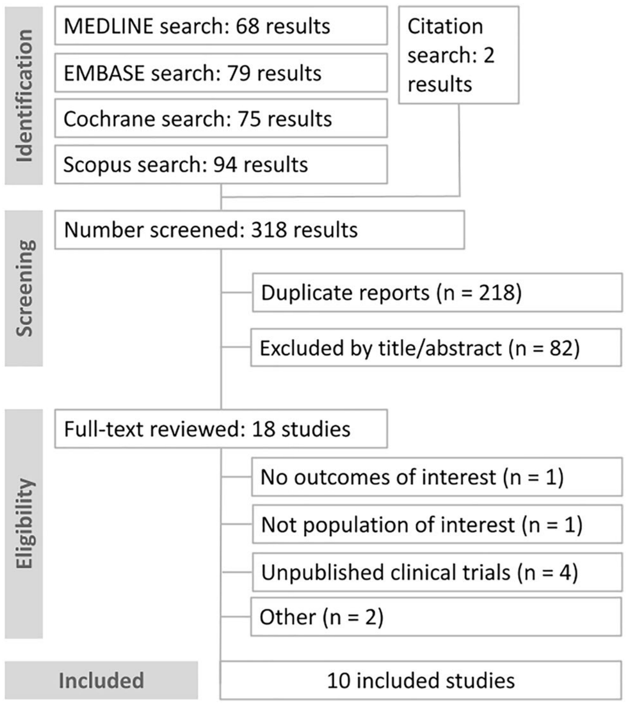

Fig. 1 PRISMA flowchart for study search and inclusion

supervised pelvic movements, such as rocking, rotations, and circular hip motions. While some studies included video-guided instructions prior to labor, most focused exclusively on in-hospital exercises. The exercises were typically limited to a single session during labor, though a few studies also included repeated sessions in the weeks leading up to delivery. Table 1 summarizes these variations along with the baseline characteristics of each study. Table 2 provides a concise overview of our key findings.

Quality assessment

Among the included studies, seven demonstrated overall moderate concerns regarding the risk of bias (Fig. 2), mostly due to the impossibility of blinding the assessment process (domain 2) and inconsistencies in intervention protocols and reporting of results (domain 5). Three studies were flagged for high risk of bias.

Incidence of cesarean section

Cesarean section events were significantly less frequent in the BB group when pooling data from seven included RCTs [26–32], as detailed in Fig. 3.

Heterogeneity was classified as "may be insignificant" ($I^2 = 32\%$). The binary nature of this endpoint contributed to minimal methodological and clinical heterogeneity in reporting across studies.

In the sensitivity analysis using a leave-one-out approach, statistical significance for the incidence of cesarean sections was lost when either Delgado 2024 [26] or Mylod 2024 [32] was excluded, resulting in *p*-values of 0.07 and 0.08, respectively. However, upon excluding studies with a high risk of bias, the results for cesarean section incidence remained consistent with the initial analysis, as shown in Fig. 4.

Pain scores

Pain scores were defined by using a VAS at 0–10 cm [29, 33, 34] or 0–100 mm [27] scales, representing methodological heterogeneity in data reporting. All results were converted to a 0–10 cm scale to improve clarity and facilitate the interpretation of data.

Across two distinct measured intervals (at 4 and 8 cm dilation), we found a statistically significant reduction in pain scores in favor of the BB group. These results show a consistent decrease in pain score of nearly 20% at both 4 (Table 2) and 8 cm dilation (Fig. 5). By evaluating two steady intervals based on the parturients' clinical presentation (dilation measurements), clinical heterogeneity was minimal in the reporting of the outcomes.

The statistical heterogeneity for pain scores at 4 cm dilation was classified as moderate or possibly insignificant, with an I^2 value of 38%. However, for pain scores at 8 cm dilation, there was higher statistical heterogeneity ($I^2 = 65\%$). The sensitivity analysis for pain scores showed that excluding any single study did not significantly impact the overall results for both 4 cm and 8 cm dilation intervals. Additionally, excluding studies with a high risk of bias did not affect the outcome for pain at 8 cm dilation, as no high-risk studies were included in that analysis (Fig. 5). Pain scores at 4 cm dilation were not included in the exclusion analysis due to the limited number of studies.

Duration of first and second stages of labor

The definitions of the first stage of labor varied slightly across the studies: from the active phase of labor to full dilation [25, 30]; from 4 cm [27, 31] or 5 cm [26] to 10 cm of dilation with effective contractions; or it was left unspecified [29], indicating both methodological and clinical heterogeneity across studies.

The BB group demonstrated a statistically significant decrease in the duration of the first stage of labor, reduced by more than two hours (MD of −130.12 min, $p < 0.001$, Table 2, Supplementary Fig. 1). I^2 results suggested substantial heterogeneity (84%).

The second stage of labor was defined as the time until the baby's head came out after the dilatation [25–27, 29–31]. The duration of the second stage of labor, however, showed no statistical difference between groups ($p = 0.090$, Table 2).

Table 1 Baseline characteristics of the included studies

Author, year	Country	Total of patients	Mean age (years ± SD)	Parity status	Site of intv	Intv resources	Intv start timing	Intv duration	Intervention protocol
Aslantas, 2023	Turkey	120	22.9 ± 2.9	Primiparous	Hospital	Swiss ball	From 4 cm dilation	NI	Supervised 7-movement ball exercises
Delgado, 2024	Brazil	200	26.0 ± 3.0	Mixed	Hospital	Swiss ball	From 5 cm dilation	Variable	Supervised but unstrict pelvic exercises
Delgado-Garcia, 2012	Spain	55	27.7 ± 5.7	Nulliparous	Hospital	Swiss ball	During labor	At least 20 min	Supervised pelvic rocking and rotation movements
Gallo, 2014	Brazil	40	19.0 ± 4.0	Nulliparous	Hospital	Swiss ball	From 4 cm dilation	30 min	Supervised pelvic mobility exercises
Gau, 2011	Taiwan	87	30.1 ± 3.4	Mixed	Home and Hospital	Swiss ball, Booklet, Video	From 4 cm dilation	Variable	Participants had video-guided instructions at home 6–8 weeks prior to labor. At the hospital, supervised free ball exercises
Lopes, 2003	Brazil	34	18.9 ± 4.3	Primiparous	Hospital	Swiss ball	From 4 cm dilation	Active phase of labor	Guided unstrict ball exercises
Mathew, 2012	India	60	NI	Nulliparous	Hospital	Swiss ball	From 1 cm dilation	Until 3 cm dilation	Exercises with circular hip motion
Mylod, 2024	UK	294	NI	Mixed	Home	Swiss ball, Video	Latent stage of labor	Variable	Video-instructed ball exercises
Shirazi, 2019	Iran	174	32.2 ± 3.9	Mixed	Home and Hospital	Swiss ball, Training class	From hospital admission in labor	Variable	Participants had unsupervised exercises at home of 20 min, 3 × a week, 6–8 weeks prior to labor. At the hospital, supervised free ball exercises
Taavoni, 2011	Iran	60	24.8 ± 3.3	Primiparous	Hospital	Swiss ball	From 4–8 cm dilation	At least 30 min	Guided exercises with circular hip motion

[#]SD = standard deviation

[@]Intv = intervention

*UK = United Kingdom

– NI = no information

Table 2 Overview of results

Outcome	Number of studies	Number of patients	MD†/RR‡	CI♥	*p*-value	Favoring
Incidence of Cesarean Section	7	748	0.55‡	0.35 to 0.85	$p=0.007$	BB#
Pain score at 4 cm dilation	3	213	−2.04 cm†	−2.60 to −1.48 cm	$p<0.001$	BB#
Pain score at 8 cm dilation	3	229	−2.01 cm†	−2.62 to −1.40 cm	$p<0.001$	BB#
Duration of the first stage of labor	6	532	−130.12 min†	−194.28 to −65.96 min	$p<0.001$	BB#
Duration of the second stage of labor	6	532	−16.50 min†	−35.76 to 2.76 min	$p=0.090$	ND@
Incidence of instrumental delivery	5	672	0.78‡	0.44 to 1.38	$p=0.400$	ND@
Incidence of amniotomy	3	383	1.01‡	0.82 to 1.25	$p=0.940$	ND@
Incidence of induction of labor	3	436	1.15‡	0.90 to 1.48	$p=0.270$	ND@
Oxytocin use	4	583	0.97‡	0.88 to 1.06	$p=0.480$	ND@
Epidural analgesia use	4	636	0.79‡	0.56 to 1.11	$p=0.170$	ND@

#BB = birthing ball

@ND = no difference

♥CI = confidence interval

†MD = mean difference

‡RR = risk ratio

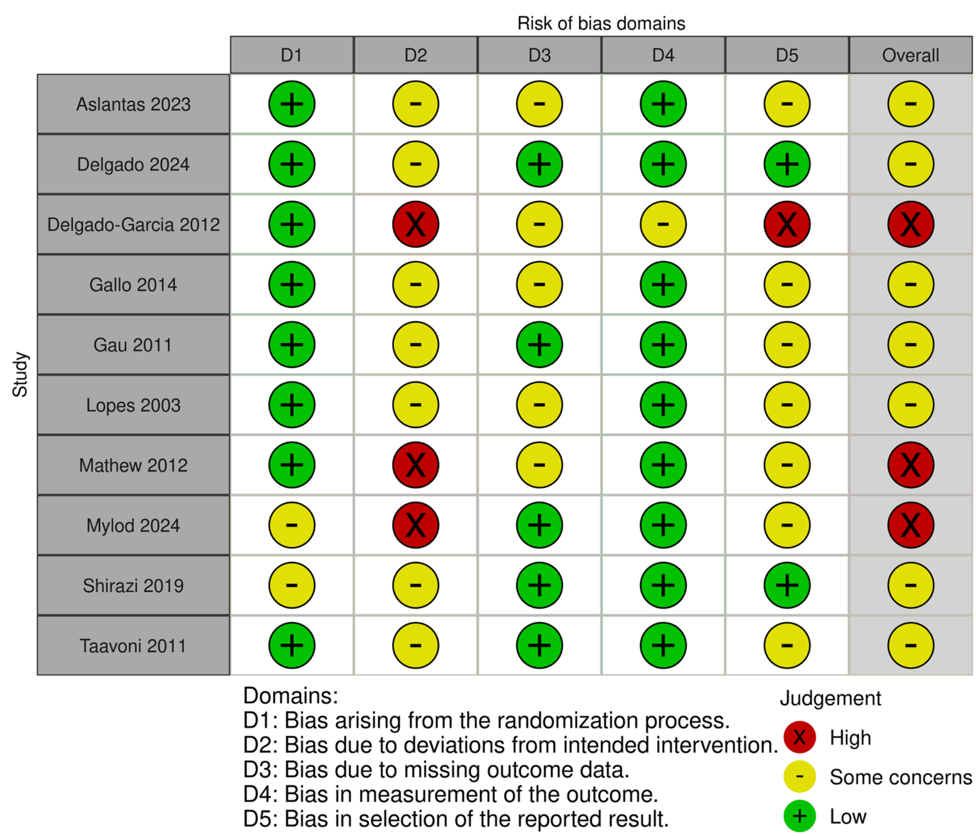

Fig. 2 Summarized risk of bias assessment of the 10 included trials using the Rob 2 tool

Sensitivity analysis for both endpoints demonstrated that excluding individual studies by the leave-one-out approach did not significantly alter the results. Upon excluding high-risk-of-bias studies, results remained consistent for both the first (MD of −131.60 min, $p<0.001$, I^2 72%, 4

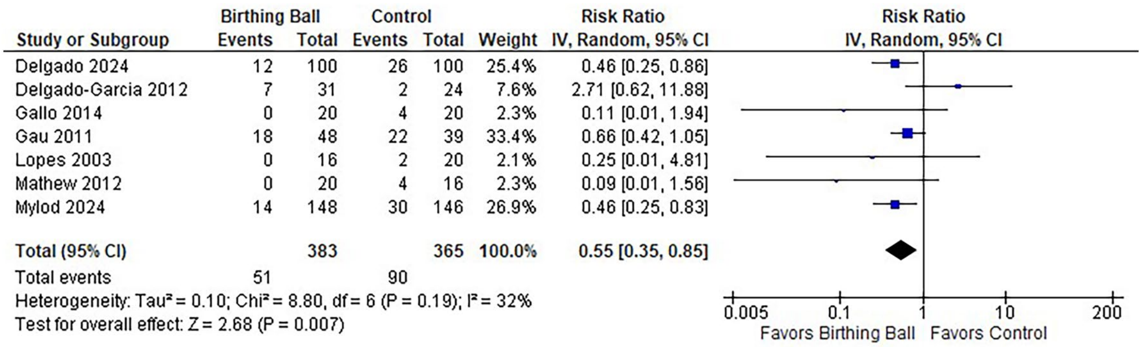

Fig. 3 Pooled analysis of the incidence of cesarean sections favored the birthing ball group. *MD* Mean Difference; *CI* Confidence Interval; *IV* Inverse Variance

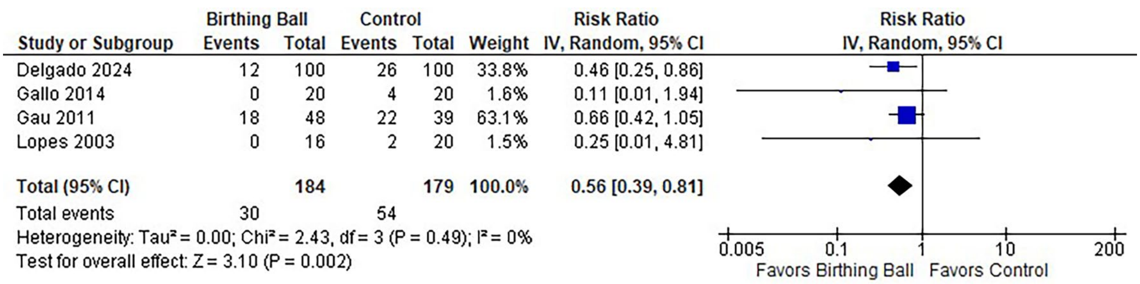

Fig. 4 Pooled analysis of the incidence of cesarean sections, excluding studies with a high risk of bias, favored the birthing ball. *MD* Mean Difference; *CI* Confidence Interval; *IV* Inverse Variance

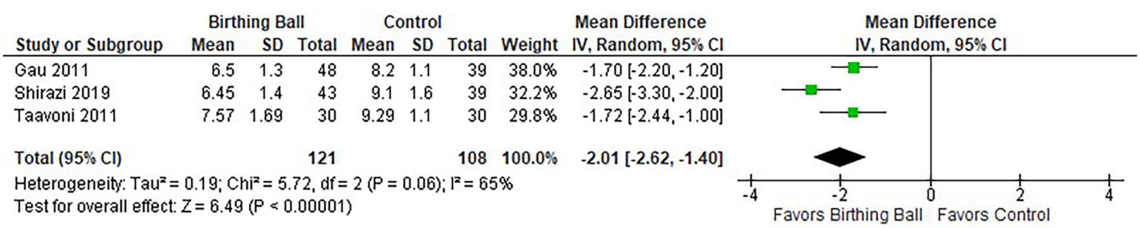

Fig. 5 Pain score assessment at 8 cm dilation favored birthing ball. *MD* Mean Difference; *CI* Confidence Interval; *IV* Inverse Variance

RCTs) and second (MD of −18.98 min, $p = 0.15$, I^2 97%, 4 RCTs) stages of labor.

Incidence of obstetric interventions

In our analysis, there was no statistically significant difference in the incidence of instrumental delivery ($p = 0.40$), amniotomy ($p = 0.94$), induction of labor ($p = 0.27$), as well as the need for oxytocin ($p = 0.48$) and epidural analgesia ($p = 0.17$) between groups, as detailed in Table 2. The binary classification of these outcomes helped minimize both methodological and clinical heterogeneity in data reporting across studies.

The sensitivity analyses for the incidence of obstetric interventions revealed no significant differences between groups when individual studies were excluded. Due to the limited number of studies, these outcomes were not assessed in sensitivity analyses excluding high-risk-of-bias studies.

Discussion

Our meta-analysis provides evidence supporting the efficacy of BB exercises in improving maternal outcomes during labor. Through a comprehensive systematic review of 10 RCTs, involving 1,008 childbearing women, we have demonstrated significant benefits associated with the clinical use of BB exercises in (1) incidence of cesarean delivery, (2) labor pain, and (3) duration of the first stage of labor.

First, our analysis revealed a statistically significant reduction in the incidence of cesarean sections among parturients exposed to BB exercises. This effect had not been conclusively demonstrated in previous meta-analyses [7, 11], where only one study specifically examined cesarean rates [11]. That study included four trials with a high risk of bias and reported an RR of 0.90 (95%CI 0.27 to 3.03, 4RCTs). The observed reduction in cesarean sections in our study, supported by our larger sample size and sensitivity analysis, likely stems from the benefits of widening the pelvic outlet, which can shorten labor duration—a key factor since failure in labor progression is a common indication for cesarean delivery [6, 7, 35]. Reducing cesarean rates is a critical priority in obstetric care, not only because cesarean sections have shown to carry a three-to-five-fold higher maternal mortality rate compared to vaginal deliveries [21, 36] but also because they are a significant risk factor for postpartum hemorrhage and placenta accreta spectrum disorders in future pregnancies [37–39]. The decreased need for cesarean sections with the BB highlights its potential as an effective, low-cost intervention to reduce obstetric complications and improve maternal outcomes [7].

Effective management of labor pain is a critical component of obstetric care and an important concern for expectant mothers [21]. Our analysis showed a consistent and significant reduction in pain scores at both 4 cm and 8 cm cervical dilation among women using BBs. The nearly 20% decrease in pain scores underscores the analgesic benefits of BB exercises, which can enhance the overall childbirth experience and reduce the need for pharmacological interventions. Though the clinical impact of a 2-point drop on a VAS is unclear, it's reasonable to believe that even slight pain relief during labor could positively affect the maternal experience. Studies show that fear of labor pain can lead to a higher demand for cesarean sections, and persistent severe pain may impact women's decisions about delivery methods in future pregnancies [40, 41].

However, despite the reduction in pain scores, there was no significant reduction in the use of epidural analgesia. Several factors may contribute to this discrepancy. First, pain perception and the decision to use epidural analgesia are influenced by a variety of individual factors, including psychological aspects, previous birth experiences, and the overall labor environment [42, 43]. Additionally, while BBs may alleviate pain to some degree, they may not provide sufficient pain relief for women with more intense or prolonged labor [11]. Further investigation is needed to explore how the use of BBs interacts with other pain management strategies and whether combining approaches could yield more significant reductions in epidural use.

Our analysis found no statistically significant differences between the BB and control groups in terms of the incidence of other common obstetric interventions as instrumental deliveries, amniotomy, induction of labor, and the need for oxytocin. This finding is supported by previous evidence [11].

Additionally, we found a reduction in the duration of the first stage of labor by approximately 130 min in the BB group compared to the control. This finding suggests that BB exercises may facilitate labor progression, potentially by enhancing pelvic mobility and maternal comfort [6, 7]. However, it is notable that the duration of the second stage of labor did not differ significantly between the groups. This result is supported by previous studies [11], indicating that while BBs may expedite the early stages of labor, their effect on the later stages remains inconclusive. A more holistic, woman-centered approach to labor management, which considers a range of interventions and individual patient factors, is essential for understanding the complex dynamics of labor progression and its outcomes [20, 44, 45]. Further investigation into the combined effects of various interventions is needed to clarify their impact on the different stages of labor.

Maternal satisfaction and childbirth experience are key factors in assessing the overall effectiveness of labor interventions. Although some studies in our review assessed these outcomes [26, 31, 32] the data were too heterogeneous to allow formal pooling. Nonetheless, the BB should be viewed as one of several strategies to promote maternal mobility and encourage upright positions during labor. These practices are widely recognized for their positive effects on both maternal and neonatal outcomes, including improved labor progression and enhanced comfort [46–48]. As part of a comprehensive approach to labor management, the BB can contribute to a more favorable birth experience but should be used alongside other evidence-based interventions tailored to the individual needs of each woman.

Limitations

This meta-analysis has limitations that should be acknowledged. Variability in intervention protocols and outcome definitions across the included studies posed methodological challenges and likely contributed to heterogeneity. For example, differences in the BB exercise protocols, such as timing, duration, and the inclusion of pre-labor exercises, added to this variability. Despite standardizing outcomes and addressing clinical differences, substantial heterogeneity persisted in some outcomes.

Although sensitivity analyses demonstrated that removing individual studies did not substantially alter most outcomes, the statistical significance of the incidence of cesarean sections was sensitive to the exclusion of certain studies, highlighting the need for cautious interpretation of this result.

Quality assessment further identified moderate concerns regarding the risk of bias in several studies, mainly due to challenges in blinding the assessment process and inconsistencies in intervention protocols and reporting practices. Three studies were identified as having a high risk of bias, potentially affecting the reliability of specific outcomes. To mitigate this concern, sensitivity analyses were conducted by excluding these high-risk studies. Notably, the incidence of cesarean sections remained consistent with the initial analysis, preserving statistical significance in favor of the BB.

Given these methodological limitations and variations across protocols, the findings should be interpreted with caution. Future research should prioritize standardized designs and reporting frameworks to improve data comparability and strengthen the evidence base in this field.

Conclusion

Our meta-analysis provides evidence that BB exercises are a valuable tool in labor management, offering significant reductions in cesarean section rates, alleviating labor pain, and shortening the first stage of labor. These findings advocate for the broader implementation of BB exercises in clinical practice as a safe non-pharmacological intervention to enhance maternal outcomes during labor. Future research should focus on elucidating the mechanisms underlying these benefits and exploring the potential impacts on long-term maternal and neonatal health.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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