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Is Prenatal Aquatic Exercise Associated with Maternal and Neonatal Outcomes? A Systematic Review and Meta-Analysis

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Abstrak:
Pendahuluan: *Aquatic exercise* semakin direkomendasikan selama kehamilan karena memiliki dampak musculoskeletal yang rendah dan berpontensi memberikan manfaat untuk ibu. Namun, bukti mengenai efek terhadap ibu dan bayi masih bervariasi. Penelitian ini bertujuan untuk mengevaluasi pengaruh intervensi *aquatic exercise* pada *maternal* dan *neonatal outcome* melalui tinjauan sistematis dan meta-analisis pada *randomized controlled trial*. **Metode:** Pencarian dilakukan secara sistematis pada database Scopus, PubMed, dan ScienceDirect untuk mengidentifikasi seluruh studi RCTs yang diterbitkan hingga bulan Januari 2026 dan melibatkan *aquatic exercise* selama kehamilan. Hasil termasuk *neonatal outcomes* (berat lahir dan skor APGAR pada 1 dan 5 menit) dan *maternal outcomes* (cara persalinan, durasi persalinan, dan nyeri persalinan). Model efek acak digunakan, dan heterogenitas dinilai menggunakan statistik I^2. **Hasil:** Sebelas studi RCTs yang melibatkan 2.261 peserta disertakan. Tidak ada perbedaan signifikan yang diamati pada berat lahir (MD = 45,25 g; 95% CI: -7,00 - 97,50) atau skor APGAR pada 1 dan 5 menit antar kelompok. Demikian pula, tidak ada perbedaan yang signifikan yang ditemukan dalam metode persalinan pervaginam (RR = 0,99; 95% CI: 0,93–1,05) atau durasi persalinan (MD = -46,45 menit; 95% CI: -102,84 hingga 9,94). Namun, *aquatic exercise* dikaitkan dengan pengurangan nyeri persalinan yang signifikan (MD = -0,40; 95% CI: -0,67 hingga -0,13). **Kesimpulan:** Prenatal *aquatic exercise* tidak menunjukkan perbedaan signifikan pada luaran neonatal dan sebagian besar luaran maternal, namun dikaitkan dengan penurunan nyeri persalinan dalam derajat kecil. Intervensi ini berpotensi menjadi strategi non-farmakologis untuk meningkatkan kenyamanan ibu selama persalinan.
Kata kunci: *Aquatic exercise; kehamilan; maternal outcomes; neonatal outcomes*

Abstract:
Introduction: Aquatic exercise is increasingly recommended during pregnancy due to its low musculoskeletal impact and potential maternal benefits. However, evidence regarding its effects on maternal and neonatal outcomes remains inconclusive. This study aims to evaluate the association effect of prenatal aquatic exercise interventions during the perinatal period including prenatal aquatic exercise, mixed exercise programs, and hydrotherapy during labor on neonatal and maternal outcomes through a systematic review and meta-analysis specific randomized controlled trials. **Methods:** A systematic search of Scopus, PubMed, and ScienceDirect was conducted to identify all RCTs published until January 2026 and involving aquatic exercise during pregnancy. Outcomes included neonatal outcomes (birth weight and APGAR scores at 1 and 5 minutes) and maternal outcomes (mode of delivery, labor duration, and labor pain). A random-effects model was used, and heterogeneity was assessed using the I^2 statistic. **Results:** Eleven randomized controlled trials involving 2,261 participants were included. No significant differences were observed in birth weight (MD = 45.25 g; 95% CI: −7.00 to 97.50) or APGAR scores at 1 and 5 minutes between groups. Similarly, no significant differences were found in vaginal delivery rates (RR = 0.99; 95% CI: 0.93–1.05) or labor duration (MD = −46.45 minutes; 95% CI: −102.84 to 9.94). However, aquatic exercise was associated with a significant reduction in labor pain (MD = −0.40; 95% CI: −0.67 to −0.13). **Conclusion:** Prenatal aquatic exercise shows no significant differences in neonatal and most maternal outcomes but is associated with a small reduction in labor pain. It may serve as a non-pharmacological approach to improve maternal comfort during labor.
Keywords: Aquatic exercise; maternal outcomes; neonatal outcomes; pregnancy

1. Introduction

Physical activity during pregnancy has been widely recommended as part of antenatal care because of its benefits in improving maternal health, including weight control, improved cardiovascular fitness, as well as a reduced risk of complications such gestational diabetes and hypertension (1–3). However, physical limitations experienced during pregnancy, such as increased body weight and musculoskeletal discomfort, are often obstacles in the implementation of ground-based exercises. In this context, aquatic exercise emerged as a potential alternative, as the hydrostatic and buoyancy pressure properties of water can reduce the load on the musculoskeletal system as well as improve circulation and comfort during physical activity (4,5). In addition, this exercise can also improve pregnant women's quality of life physically and mentally, including reducing the risk of postpartum depression and improving glucose tolerance (6,7). Aquatic exercise is also associated with good fetal outcomes, such as an increase in the baby's birth length without negative effects on birth weight or APGAR scores (7).

Although the general benefits of engaging in physical activity while pregnant have been extensively reported, the information about the particular impacts of aquatic exercise during pregnancy and its effect of maternal and neonatal outcomes is still inconsistent. Some studies show that aquatic exercise can help control maternal weight gain and improve physical fitness (5), and potentially increase comfort during childbirth through reduced pain (5,8). However, its effect on broader clinical outcomes, such as delivery methods, duration of delivery, as well as neonatal indicators such as birth weight and APGAR scores, still showed varying outcomes between studies (9,10). Furthermore, concerns related to the safety of physical activity during pregnancy on fetal welfare are still a consideration in clinical practice, particularly related to potential disruptions to fetal growth and neonatal adaptation (2,11).

These systematic reviews that comprehensively evaluate the effects of prenatal aquatic exercise on simultaneous maternal and neonatal outcomes are limited, especially those focusing on labor outcomes and newborn conditions. Therefore, this study aims to evaluate the effects of aquatic-based interventions during the perinatal period including prenatal aquatic exercise, mixed exercise programs, and hydrotherapy during labor on neonatal and maternal outcomes through a systematic review and meta-analysis specific randomized controlled trials. By integrating the existing evidence, the study is expected to provide a stronger scientific basis regarding the safety and potential clinical benefits of aquatic exercise during pregnancy.

2. Method

2.1 Study Design

The methodology for conducting this review was developed prior to starting and follows the Preferred Report Items for Systematic Reviews and Meta Analyses 2020 (PRISMA) guidelines. Additionally, the review protocol was prospectively registered in PROSPERO (International Prospective Register of Systematic Reviews) under registration number CRD420261351953.

2.2 Search Strategy and Screening Procedures

A systematic literature search was performed to investigate how aquatic exercise during pregnancy impacts both maternal and neonatal outcomes. Three databases including PubMed, Scopus, and ScienceDirect were searched from database inception until January 2026. The search strategy integrated keywords related to pregnancy, aquatic exercise, and randomized trials. The search string detail for each database is shown in Table 1.

Table 1. Search String Detail

No.	Source	Search String	Time Frame
1.	PubMed	("Pregnancy"[Mesh] OR pregnancy[tiab] OR pregnant[tiab]) AND ("Exercise"[Mesh] OR "Exercise Therapy"[Mesh] OR "Hydrotherapy"[Mesh] OR "aquatic exercise"[tiab] OR "water exercise"[tiab] OR "aquatic physical activity"[tiab] OR "water-based exercise"[tiab] OR hydrotherapy[tiab]) AND ("Labor, Obstetric"[Mesh] OR "Delivery, Obstetric"[Mesh] OR "Pregnancy Outcome"[Mesh] OR "Maternal Health"[Mesh] OR "labor outcome"[tiab] OR "labour outcome"[tiab] OR "maternal outcome"[tiab] OR "birth outcome"[tiab])	All time until January 2026
2.	Scopus	TITLE-ABS-KEY (pregnan* OR prenatal OR antenatal) AND TITLE-ABS-KEY (aquatic OR "water-based" OR water OR pool OR hydro) AND TITLE-ABS-KEY ("gestational weight gain" OR "maternal weight gain" OR "birth weight") AND TITLE-ABS-KEY (random* OR trial)	All time until January 2026
3.	ScienceDirect	("pregnancy" OR "pregnant") AND ("aquatic exercise" OR "water exercise" OR "aquatic physical activity" OR "water therapy") AND ("labour outcome" OR "maternal outcome")	All time until January 2026

2.3 Eligibility Criteria

Studies were included for inclusion criteria if the following: participants were pregnant women; interventions in the form of physical exercise in water or aquatic-based physical activity during pregnancy; the research design is a randomized controlled trial (RCT); and a comparison group is routine antenatal care or non-aquatic physical exercise. Studies that qualify should present at least one of the following results: infant birth weight, first or fifth minute APGAR score, duration of labour, labour pain, or vaginal delivery. The included interventions encompassed a range of aquatic-based approaches, including structured prenatal aquatic exercise programs, mixed land–aquatic exercise interventions, and hydrotherapy applied during labor. These variations were considered eligible as they represent different modalities of aquatic-based physical activity across the perinatal period. Studies are excluded if they are non-randomized studies, review articles, conference abstracts, or do not evaluate aquatic exercise interventions during pregnancy.

2.4 Selection Process

Three researchers independently conducted a title and abstract screening of all articles found. Articles that have the potential to meet the criteria are then checked in full-text articles. Differences of opinion between researchers are clarified through discussion or by involving a fourth researcher.

2.5 Meta-analysis

Review Manager (RevMan) software was used to measure meta-analysis. The mean difference (MD) with 95% confidence interval was used to analyse continuous outcomes such the APGAR score, birth weight, length of labour,

and labour discomfort. A risk ratio (RR) with a 95% confidence interval was used to analyse categorical outcomes, such as vaginal delivery. To account for differences between the investigations, a model with random effects was used, and I^2 statistics were used to assess the results.

2.6 Quality Assessment

Two separate researchers evaluated the quality of the included study technique using the Cochrane Handbook Risk of Bias 2 (RoB2) for Systematic Review of Intervention. Sequence generation, allocation concealment, participant blinding, outcome assessment blinding, insufficient outcome data, selective reporting, and other possible sources of bias are all included in this evaluation tool. Each item's bias risk is divided into three groups: low, high, and unclear risk.

3. Results

A total of 257 entries were found, comprising 54 from ScienceDirect, 167 from Scopus, and 36 from PubMed. 236 articles were left for title and abstract screening after duplicates were eliminated. 206 entries were eliminated at this phase, comprising 148 research and 58 review articles that were eliminated due to their title and abstract relevancy. Two reports were not obtained out of the thirty full-text articles that were searched for. The eligibility of 28 full-text publications was evaluated. In the end, only 11 randomized controlled trials satisfied the eligibility requirements and were incorporated into the meta-analysis and systematic review **(Figure 1).**

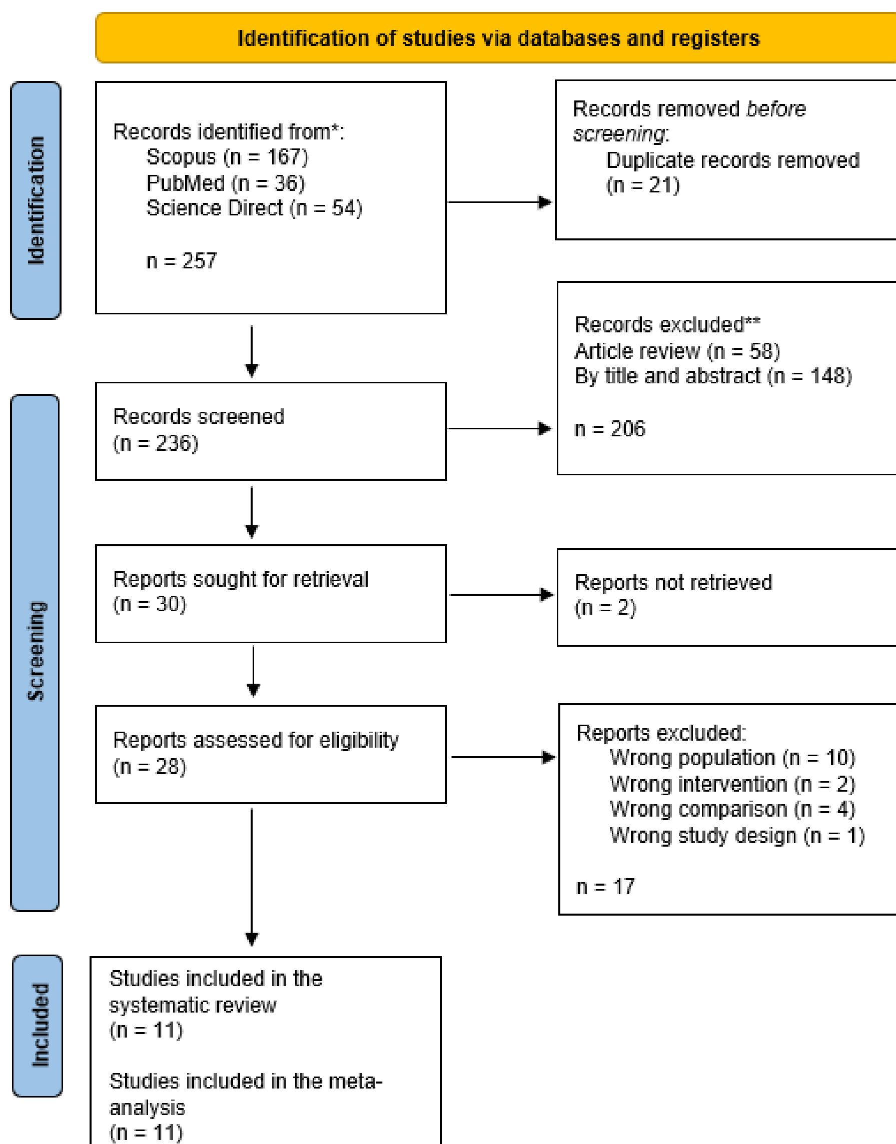


Figure 1. PRISMA flow diagram

3.1 Description of Included Studies in Review

Table 2. Characteristics of included studies

Author, Year	Participants	Sample Size	Intervention	Comparison	Outcomes
Cambaz et al., 2025 (12)	Pregnant women at 37–42 weeks of gestation	80	Hydrotherapy during labour	Routine hospital care	Labour time, labour pain, and gestation weeks
Carrascosa et al., 2021 (13)	Low-risk pregnant women	294	Moderate-intensity aquatic aerobic exercise	Usual antenatal care	Birth weight, APGAR score, labour time, labour pain, gestation weeks, and method of delivery
Navas et al., 2021 (14)	Low-risk pregnant women	259	Aquatic aerobic exercise	Usual antenatal care	Birth weight, APGAR score, labour pain, gestation weeks
Baciuk et al., 2008 (15)	Low-risk pregnant women	71	Water aerobic exercise	Usual antenatal care	Birth weight, labour time, gestation weeks, and method of delivery
Barakat et al., 2017 (16)	Healthy pregnant women	461	Land-based or aquatic exercise	Usual antenatal care	Maternal weight, birth weight, and gestation weeks
Bacchi et al., 2017 (17)	Healthy pregnant women	111	Aquatic exercise during pregnancy	Usual antenatal care	Maternal weight, birth weight, APGAR score, and gestation weeks
Backhausen et al., 2017 (10)	Healthy pregnant women	516	water exercise twice	Usual antenatal care	Birth weight, gestation weeks, and method of delivery
Rodríguez-Blanque et al., 2019 (18)	Healthy pregnant women	129	SWEP aquatic exercise program	Usual antenatal care	Birth weight and gestation weeks
Rodríguez-Blanque et al., 2019 (19)	Healthy pregnant women	140	SWEP aquatic exercise program	Usual antenatal care	Labour time
Rodríguez-Blanque et al., 2020 (20)	Healthy pregnant women	129	SWEP aquatic exercise program	Usual antenatal care	Method of delivery
Cavalcante et al., 2009 (9)	Low-risk pregnant women	71	Water aerobic exercise	Usual antenatal care	Birth weight and method of delivery

The eleven included studies involved a total of 2,261 pregnant women, sample sizes ranging 71 - 516 participants **(Table 2).** Most studies involved healthy or low-risk pregnant women, although one study evaluated the use of hydrotherapy during childbirth in women with a gestational of 37–42 weeks (12). The interventions used in most studies were physical exercise programs in the aquatic during pregnancy, including moderate-intensity aquatic aerobic exercise (13,14,17), aquatic-based aerobics programs (9,15), as well as structured exercise programs such as SWEP (Study Water Exercise Pregnant) (20). Some studies have also compared aquatic exercise with land-based exercise or routine antenatal care (10,16).

The most commonly reported outcomes in the included studies were infant birth weight and gestational age at delivery, followed by Apgar score, duration of delivery, and labour pain. In addition, several studies have also evaluated the method of delivery, especially vaginal delivery (9,15,17). Notably, the included studies demonstrated heterogeneity in the intervention including type and timing. While most studies evaluated structured aquatic exercise programs during pregnancy, some included mixed exercise interventions (land-based and aquatic), and one study assessed hydrotherapy applied during labor. This variation reflects differences in both the nature and timing of exposure, which may contribute to variability in observed outcomes.

3.2 Quality Assessment

The quality of the methods used in the selected studies was assessed with the Cochrane Risk of Bias tool, which assesses potential bias across several domains including allocation concealment, sequence generation, blinding, incomplete outcome data, selective reporting, and other sources of bias. This tool is widely recommended for evaluating randomized controlled trials (RCTs) in systematic reviews because it allows a structured appraisal of internal validity and methodological transparency. In this review, eleven studies investigating aquatic-based or aquatic exercise interventions during pregnancy were assessed using this framework (9,10,12–20). Overall, the quality of methods that used in all of included studies was considered moderate to high, as most domains demonstrated a predominance of low risk of bias. This finding reflects the fact that the majority of studies employed randomized designs with clearly defined intervention protocols and comparable baseline characteristics between groups, which are essential features for ensuring the validity of intervention trials in maternal health research.

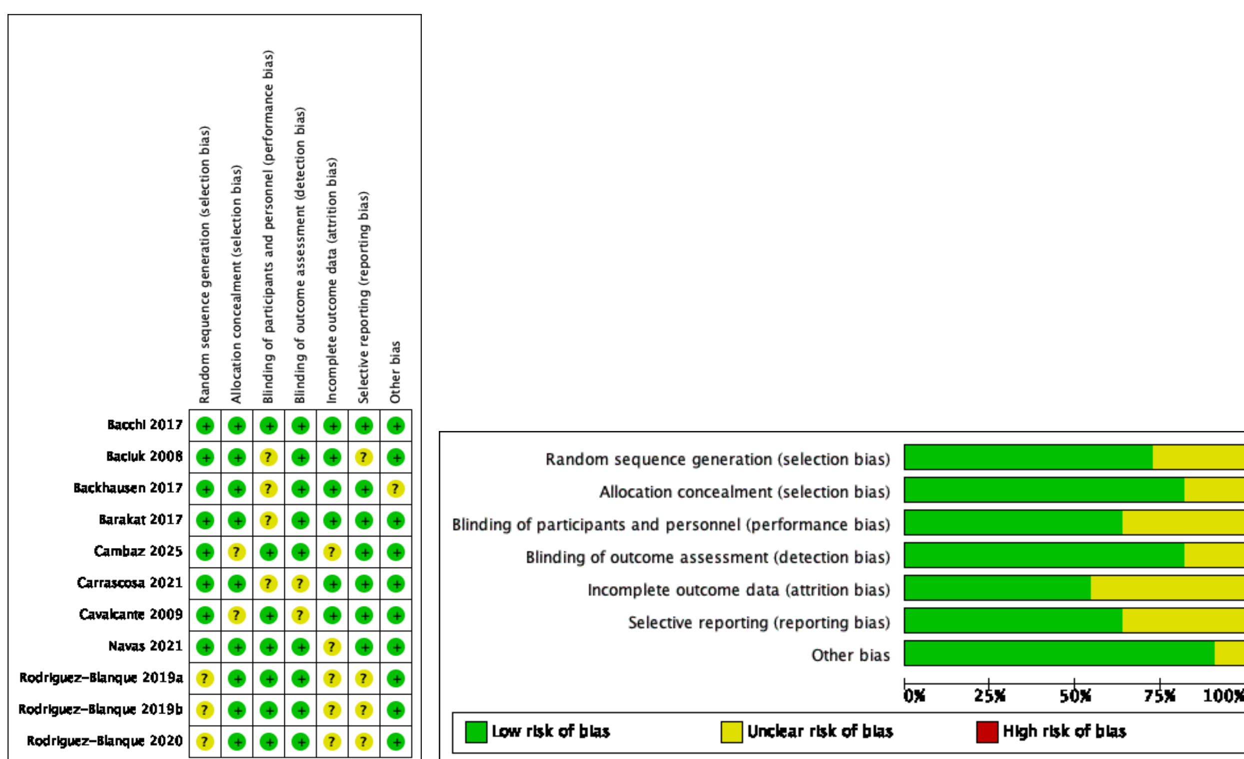


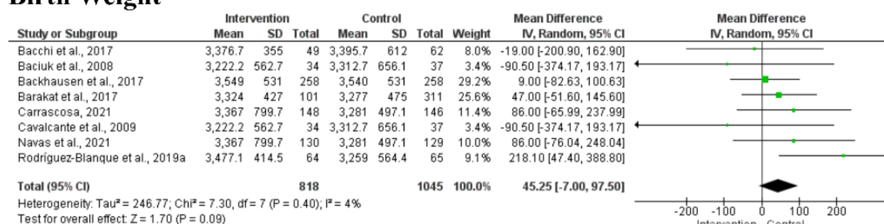
Figure 2. Risk of bias assessment of the included studies using the Cochrane Risk of Bias-2 (RoB-2) tool.
The summary and graph illustrate the proportion and distribution of low and unclear risk across domains for the eleven randomized controlled trials included.

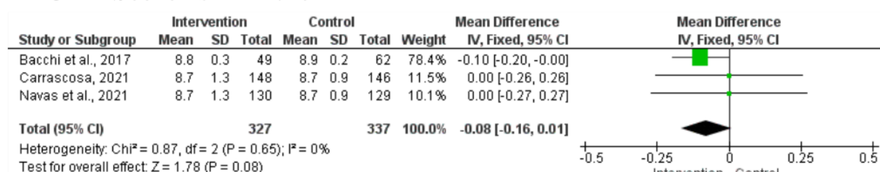
The Risk of Bias graph indicates that the domains of random sequence generation and allocation concealment were predominantly rated as low risk across the included studies, suggesting that most trials applied adequate randomization procedures to minimize selection bias. For example, studies such as (17), (10), and (14) explicitly reported the use of computer-generated randomization methods and controlled allocation procedures, that strengthens the internal validity of their findings. Similarly, the domain of incomplete outcome data showed largely low risk, reflecting relatively low attrition rates and balanced follow-up between intervention and control groups (12,13). Nevertheless, some domains demonstrated unclear risk, particularly those related to blinding of

participants and personnel. This limitation is inherent to exercise-based interventions, where populations are typically aware of the intervention they receive, making blinding difficult to implement in practice (9,18). Despite this constraint, most outcomes evaluated in these trials such as birth outcomes, neonatal parameters, and clinical measurements were obtained from medical records or objective clinical assessments, which reduces the likelihood that lack of blinding substantially influenced outcome measurement.

The Risk of Bias summary further highlights variations in methodological reporting across individual studies while still indicating an overall acceptable level of quality. Several studies, including (17), (16), and (14) demonstrated consistently low risk across most domains, reflecting robust trial design, transparent reporting, and clear outcome measurement procedures. In contrast, some studies displayed unclear risk in specific domains, mainly due to insufficient reporting of allocation procedures or blinding strategies rather than clear methodological (15,19). Earlier trials such as (9,15) were more likely to present incomplete methodological descriptions, which is common in older clinical trials published before the widespread adoption of CONSORT reporting guidelines. Overall, no study demonstrated a consistently high risk of bias across domains, suggesting that the body of evidence included in this review is methodologically reliable, with the main limitations related to reporting transparency and the practical challenges of implementing blinding in physical activity interventions during pregnancy.

3.3 Meta-Analysis





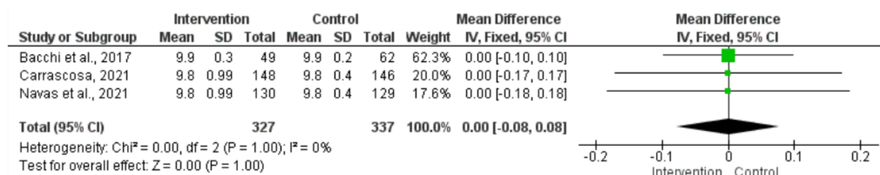
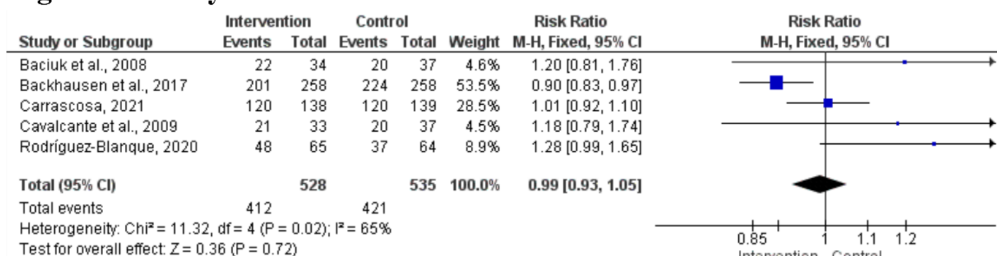


Figure 3. Forest plot of neonatal outcomes

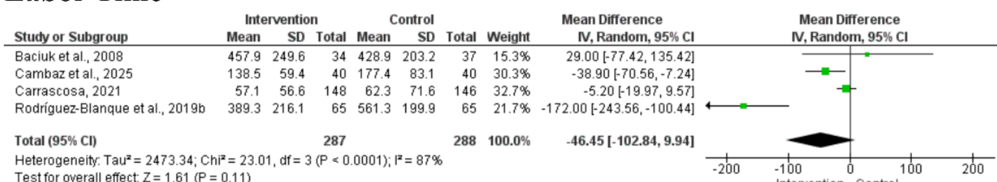
Neonatal outcomes included birth weight and APGAR scores at the first and fifth minutes after birth **(Figure 3).** The pooled analysis demonstrated that neonatal outcomes were generally comparable between women who participated in prenatal aquatic exercise and those in the control group. For birth weight, six studies contributed to the meta-analysis, and the pooled estimate showed no meaningful difference between groups (MD = 45.25 g; 95% CI: −7.00 to 97.50; p = 0.09), with low heterogeneity observed across studies (I^2 = 4%).

Similarly, three studies reported APGAR scores at the first minute, and the pooled analysis indicated similar scores between the intervention and control groups (MD = −0.08; 95% CI: −0.16 to 0.01; p = 0.08), with no heterogeneity detected (I^2 = 0%). Three studies also evaluated APGAR scores at the fifth minute, showing consistent findings across studies, with no meaningful difference between groups (MD = 0.00; 95% CI: −0.08 to 0.08; p = 1.00; I^2 = 0%).

Vaginal Delivery Rates



Labor Time



Labor Pain

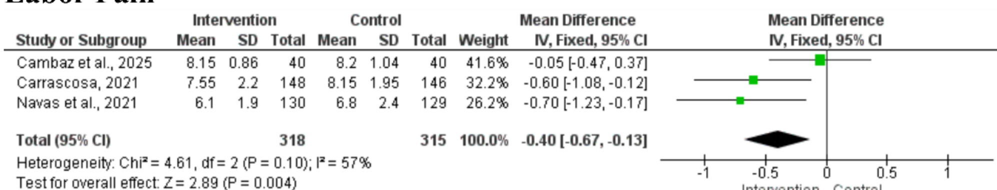


Figure 4. Forest plot of maternal outcomes

Maternal outcomes included mode of delivery, labour duration, and labour pain **(Figure 4)**. Five studies examined vaginal delivery rates, and the pooled analysis indicated that the likelihood of vaginal delivery was similar between pregnant women who participated in aquatic exercise and those receiving usual antenatal care (RR = 0.99; 95% CI: 0.93–1.05; p = 0.72). Moderate heterogeneity was observed among studies (I^2 = 65%).

Four studies assessed labour duration, and the pooled results suggested that labour duration tended to be shorter in the aquatic exercise group, although the difference did not reach significance in statistical analysis value (MD = −46.45 minutes; 95% CI: −102.84 to 9.94; p = 0.11). Labour pain was evaluated in three studies including 318 participants in the aquatic exercise group and 315 in the control group. The pooled analysis showed that prenatal aquatic exercise was associated with significantly lower labour pain intensity compared with usual antenatal care (MD = −0.40; 95% CI: −0.67 to −0.13; p = 0.004). Moderate heterogeneity was observed across studies (I^2 = 57%).

4. Discussion

This study found there were two main groups of outcomes analyzed, neonatal outcomes and maternal outcomes. Overall, the findings of this study show that aquatic exercise during pregnancy is a safe form of physical activity, as it does not have a negative impact on the baby's condition, while potentially providing benefits to the mother during the delivery process.

In neonatal outcomes, a combined analysis showed that there was no significant difference in birth weight or APGAR score at the first and fifth minutes between the control group and intervention group. These findings indicate that aquatic exercise during pregnancy does not interfere with fetal growth or neonatal adaptation immediately after birth. These results are consistent with previous studies, in which (17) reported that aquatic exercise can help control maternal weight without affecting the baby's birth weight, as well as (15) who showed no adverse effects on neonatal outcomes. In addition, (13) assert that disorders in the fetus are more often caused by other clinical factors such as respiratory disorders, sepsis, or hypothyroidism, which are not directly related to exercise interventions during pregnancy.

Previous study are also in line with these findings (9) which showed that aquatic-based physical activity during pregnancy did not increase the risk of perinatal complications nor significant changes in birth weight. The consistency of results between studies, demonstrated by relatively low heterogeneity values across multiple outcomes, reinforces the reliability of these findings. Given that birth weight and APGAR scores are key indicators

of neonatal health, the lack of differences between groups suggests that participation in aquatic exercise during pregnancy does not harm the well-being of the newborn. This is also supported by previous meta-analyses (21–23) reported that aquatic-based interventions during pregnancy and childbirth did not increase the risk of serious neonatal complications.

Physiologically, these findings can be explained by the ability of moderate-intensity aquatic exercise to maintain adequate uteroplacental blood flow. Hydrostatic pressure during immersion in aquatic promotes venous return and stabilizes maternal hemodynamic, so that the supply of oxygen and nutrients to the fetus is maintained (22,24). This mechanism explains why fetal growth parameters, such as birth weight, remain stable even if the mother performs regular physical activity during pregnancy.

At maternal outcomes, the analysis showed that prenatal aquatic exercise did not have a significant effect on the method of delivery, with relatively similar proportions of vaginal delivery between the intervention and control groups (16). These findings are consistent with previous research (13,20) which shows that the method of delivery is more influenced by obstetric factors, such as fetal size, maternal pelvic condition, pregnancy complications, and clinical decisions during childbirth (25,26) compared to exercise interventions during pregnancy.

Nonetheless, the analysis also showed that the duration of labour tended to be shorter in the aquatic exercise group, although it did not reach statistical significance. This trend is in line with the findings of (19), who propose that engaging in physical exercise while pregnant may enhance condition of the mother. Aquatic exercise contributes to increased cardiovascular endurance, muscle strength, and respiratory efficiency, which can potentially support the labour process (16,20). In addition, the relaxing effects of warm aquatic as well as a decrease in gravitational load can help reduce muscle tension and stress, thereby supporting the coordination of uterine contractions (27,28). However, the fairly high heterogeneity indicates variations in measurement methods and intervention characteristics between studies.

Interestingly, the findings of the meta-analysis showed that that engaging in aquatic exercise during pregnancy greatly diminished the level of pain compared to the control group. This finding represents a statistically significant effect observed in this study. This effect is supported by several studies suggesting that aquatic-based therapy can improve maternal comfort during childbirth through reduced pressure on the musculoskeletal system and increased relaxation (29,30). In addition, hydrotherapy is known to stimulate the release of endorphins as the body's natural analgesic, which contributes to a decrease in pain perception. A study by (12) showed that hydrotherapy during childbirth can lower pain levels and improve maternal comfort, while (13) report that participation in aquatic exercise is related to lower use of epidural analgesia.

In addition to the benefits during childbirth, aquatic exercise also provides benefits to the mother's musculoskeletal condition during pregnancy. Research by (10), (31), and (32) shows that regular physical activity can improve muscle flexibility, tolerance to pain, as well as relaxation, which plays a role in reducing musculoskeletal complaints such as low back pain. Similar findings were also reported by (22), (33) and (23) suggesting that aquatic-based exercise can improve maternal well-being and contribute to better pain management during labour.

Mechanistically, this effect can be explained through a combination of physiological factors. The floating ability of aquatic lessens the weight that gravity exerts on joints and muscles, thus allowing physical activity to be performed with lower mechanical stress (34,35). In addition, hydrostatic pressure improves venous circulation and return, which supports maternal hemodynamic stability (36,37). This combination of effects not only increases comfort during pregnancy, but also prepares the mother's body to face the delivery process more optimally.

The absence of statistically significant differences in neonatal outcomes should be interpreted with caution. While these findings suggest that prenatal aquatic exercise does not adversely affect key neonatal indicators, they do not necessarily establish safety in a definitive sense. Rather, the results indicate a lack of evidence of harm within the measured outcomes, which may also reflect insufficient statistical power or variability across studies. It is also important to distinguish between statistical non-significance and clinical equivalence. The lack of observed differences may indicate that aquatic exercise does not provide additional benefit over standard care for certain outcomes, rather than confirming equivalence or superiority.

From a clinical perspective, the findings of this study suggest that prenatal aquatic exercise may be considered as a supportive, non-pharmacological intervention for improving maternal comfort during labour, particularly in terms of pain perception. However, given the modest effect size and the lack of significant impact on delivery mode and labour duration, aquatic exercise should not be expected to alter major obstetric outcomes. Instead, it may be more appropriately recommended as part of a comprehensive antenatal care program aimed at

enhancing maternal well-being rather than modifying clinical delivery endpoints. Clinicians should therefore interpret these findings with an emphasis on patient-centered benefits, particularly for women seeking non-invasive strategies to manage labour discomfort.

Despite the observed reduction in labour pain, no significant effects were found in other maternal and neonatal outcomes. The discrepancy between the reduction in labour pain and the absence of significant effects on other maternal and neonatal outcomes may be explained by differences in the nature and underlying mechanisms of these outcomes. Labour pain is a subjective and multidimensional experience influenced by psychological, neuroendocrine, and environmental factors, which may be more responsive to the relaxing and analgesic effects of aquatic exercise, including reduced gravitational load and increased endorphin release. In contrast, outcomes such as mode of delivery, labour duration, and neonatal parameters are determined by complex physiological and obstetric factors, including fetal characteristics, uterine contractility, pelvic anatomy, and clinical decision-making. These factors are less likely to be substantially modified by exercise interventions alone.

However, several limitations need to be considered when interpreting the results of this study. The number of studies included in the meta-analysis is relatively limited, and there are variations in intervention protocols between studies, including differences in the intensity, frequency, and duration of aquatic exercises. These variations may affect the homogeneity of the results obtained. Also the important limitation of this review is the heterogeneity of the included interventions. The studies encompassed different types of aquatic-based approaches, including prenatal aquatic exercise, mixed exercise programs, and hydrotherapy during labor. These interventions differ not only in their physiological mechanisms but also in their timing (antenatal vs intrapartum), which may influence maternal and neonatal outcomes differently. Future research should aim to conduct subgroup analyses based on intervention type, timing (antenatal versus intrapartum), and outcome measurement methods to better understand the differential effects of specific aquatic-based interventions.

Overall, the findings of this systematic review and meta-analysis indicate that prenatal aquatic exercise appears not to be associated with adverse neonatal outcomes based on the current evidence and may provide a modest reduction in labour pain, potentially improving the maternal experience during labour. Nevertheless, these findings should be interpreted cautiously, as non-significant differences do not establish clinical equivalence or definitive safety and may be influenced by study heterogeneity and limited statistical power.

5. Conclusion

This systematic review and meta-analysis suggest that prenatal aquatic exercise does apear to be associated with adverse outcomes during pregnancy, with no adverse effects on key neonatal outcomes, including birth weight and APGAR scores. Although no significant differences were observed in mode of delivery or labour duration, prenatal aquatic exercise was associated with a significant reduction in labour pain intensity, representing the primary clinically meaningful benefit identified in this analysis.

These findings indicate that aquatic exercise may improve the maternal experience during labour, particularly in terms of pain reduction, and may serve as a non-pharmacological approach to pain management in obstetric care. Nevertheless, the absence of significant differences in several outcomes do not establish clinical equivalence or definitive safety, and may reflect variability across studies as well as limited statistical power. Therefore, further well-designed randomized controlled trials with standardized intervention protocols and appropriate subgroup analyses are needed to confirm these findings and to better define clinical recommendations.

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References

1. Heljezović Š, Lučovnik M, Verdenik I, Šćepanović D. Association between regular physical activity during pregnancy and perinatal outcomes: A population-based cohort study. European Journal of Obstetrics & Gynecology and Reproductive Biology: X. 2025 Jun;26:100380. https://doi.org/10.1016/j.eurox.2025.100380

2. Gascoigne EL, Webster CM, Honart AW, Wang P, Smith-Ryan A, Manuck TA. Physical activity and pregnancy outcomes: an expert review. American Journal of Obstetrics & Gynecology MFM. 2023 Jan;5(1):100758. https://doi.org/10.1016/j.ajogmf.2022.100758
3. Taliento C, Piccolotti I, Sabattini A, Tormen M, Cappadona R, Greco P, et al. Effect of Physical Activity during Pregnancy on the Risk of Hypertension Disorders and Gestational Diabetes: Evidence Generated by New RCTs and Systematic Reviews. JCM. 2024 Apr 11;13(8):2198. https://doi.org/10.3390/jcm13082198
4. Ayubi N, Putri DRS, Syafawi A, Aljunaid M, Ming JW, Lesmana HS, et al. Water Aerobic Exercise Improves Mother's Quality of Life During Pregnancy: A Systematic Review. Teor metod fiz vihov. 2024 Jun 30;24(3):486–93. https://doi.org/10.17309/tmfv.2024.3.19
5. Cancela-Carral JM, Blanco B, López-Rodríguez A. Therapeutic Aquatic Exercise in Pregnancy: A Systematic Review and Meta-Analysis. JCM. 2022 Jan 19;11(3):501. https://doi.org/10.3390/jcm11030501
6. Parveen A, Yadav D, Khera Bose A, Joshi D. EFFECT OF MODERATE INTENSITY AQUATIC PHYSICAL EXERCISES DURING PREGNANCY ON POSTPARTUM DEPRESSION: A SYSTEMATIC REVIEW. ijsr. 2025 Mar 1;8–11. https://doi.org/10.36106/ijsr/2300478
7. Zhao K, Xu J, Zhao J, Chen R, Wang Y, Ye X, et al. Influence of prenatal aquatic activities on fetal outcomes and maternal physical and mental outcomes: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2024 Oct 25;24(1):701. https://doi.org/10.1186/s12884-024-06870-9
8. Cilar Budler L, Budler M. Physical activity during pregnancy: a systematic review for the assessment of current evidence with future recommendations. BMC Sports Sci Med Rehabil. 2022 Jul 16;14(1):133. https://doi.org/10.1186/s13102-022-00524-z
9. Cavalcante SR, Cecatti JG, Pereira RI, Baciuk EP, Bernardo AL, Silveira C. Water aerobics II: maternal body composition and perinatal outcomes after a program for low risk pregnant women. Reprod Health. 2009 Dec;6(1):1. https://doi.org/10.1186/1742-4755-6-1
10. Backhausen MG, Tabor A, Albert H, Rosthøj S, Damm P, Hegaard HK. The effects of an unsupervised water exercise program on low back pain and sick leave among healthy pregnant women – A randomised controlled trial. Zhang Q, editor. PLoS ONE. 2017 Sep 6;12(9):e0182114. https://doi.org/10.1371/journal.pone.0182114
11. Davenport MH, Hayman M. Physical activity during pregnancy: Essential steps for maternal and fetal health. Obstet Med. 2022 Sep;15(3):149–50. https://doi.org/10.1177/1753495X221122540
12. Cambaz Z, Şolt Kırca A. The Effect of Hydrotherapy Application on Pain During Birth and Postpartum Fatigue and Comfort. Evaluation Clinical Practice. 2025 Apr;31(3):e70060. https://doi.org/10.1111/jep.70060
13. Carrascosa MDC, Navas A, Artigues C, Ortas S, Portells E, Soler A, et al. Effect of aerobic water exercise during pregnancy on epidural use and pain: A multi-centre, randomised, controlled trial. Midwifery. 2021 Dec;103:103105. https://doi.org/10.1016/j.midw.2021.103105
14. Navas A, Carrascosa MDC, Artigues C, Ortas S, Portells E, Soler A, et al. Effectiveness of Moderate-Intensity Aerobic Water Exercise during Pregnancy on Quality of Life and Postpartum Depression: A Multi-Center, Randomized Controlled Trial. JCM. 2021 May 30;10(11):2432. https://doi.org/10.3390/jcm10112432
15. Baciuk EP, Pereira RI, Cecatti JG, Braga AF, Cavalcante SR. Water aerobics in pregnancy: cardiovascular response, labor and neonatal outcomes. Reprod Health. 2008 Dec;5(1):10. https://doi.org/10.1186/1742-4755-5-10
16. Barakat R, Perales M, Cordero Y, Bacchi M, Mottola MF. Influence of Land or Water Exercise in Pregnancy on Outcomes: A Cross-sectional Study. Medicine & Science in Sports & Exercise. 2017 Jul;49(7):1397–403. https://doi.org/10.1249/MSS.0000000000001234
17. Bacchi M, Mottola MF, Perales M, Refoyo I, Barakat R. Aquatic Activities During Pregnancy Prevent Excessive Maternal Weight Gain and Preserve Birth Weight: A Randomized Clinical Trial. Am J Health Promot. 2018 Mar;32(3):729–35. https://doi.org/10.1177/0890117117697520
18. Rodríguez-Blanque R, Sanchez-Garcia JC, Sanchez-Lopez AM, Expósito-Ruiz M, Aguilar-Cordero MJ. Randomized Clinical Trial of an Aquatic Physical Exercise Program During Pregnancy. Journal of Obstetric, Gynecologic & Neonatal Nursing. 2019 May;48(3):321–31. https://doi.org/10.1016/j.jogn.2019.02.003
19. Rodríguez-Blanque R, Sánchez-García JC, Sánchez-López AM, Aguilar-Cordero MJ. Physical activity during pregnancy and its influence on delivery time: a randomized clinical trial. PeerJ. 2019 Feb 7;7:e6370. https://doi.org/10.7717/peerj.6370
20. Rodríguez-Blanque R, Aguilar-Cordero MJ, Marín-Jiménez AE, Núñez-Negrillo AM, Sánchez-López AM, Sánchez-García JC. Influence of a Water-Based Exercise Program in the Rate of Spontaneous Birth: A Randomized Clinical Trial. IJERPH. 2020 Jan 28;17(3):795. https://doi.org/10.3390/ijerph17030795
21. Zhao J wei, Tang P jun, Zhou Z tao, Xu G, Li Q, Li K ran, et al. Nrf2 signaling activation by a small molecule activator compound 16 inhibits hydrogen peroxide-induced oxidative injury and death in osteoblasts. Cell Death Discov. 2022 Aug 8;8(1):353. https://doi.org/10.1038/s41420-022-01146-7
22. Burns E, Feeley C, Hall PJ, Vanderlaan J. Systematic review and meta-analysis to examine intrapartum interventions, and maternal and neonatal outcomes following immersion in water during labour and waterbirth. BMJ Open. 2022 Jun;12(7):e056517. https://doi.org/10.1136/bmjopen-2021-056517
23. McKinney JA, Vilchez G, Jowers A, Atchoo A, Lin L, Kaunitz AM, et al. Water birth: a systematic review and meta-analysis of maternal and neonatal outcomes. American Journal of Obstetrics and Gynecology. 2024 Mar;230(3):S961-S979.e33. https://doi.org/10.1016/j.ajog.2023.08.034
24. Sanders J, Barlow C, Brocklehurst P, Cannings-John R, Channon S, Cutter J, et al. Characteristics of Women, Intrapartum Interventions, and Maternal and Neonatal Outcomes Among Users of Intrapartum Water Immersion: The UK POOL Cohort Study. Birth. 2026 Mar;53(1):55–66. https://doi.org/10.1111/birt.12921
25. Abdalla M, Jabak S, Hameed A. Maternal characteristics and induction methodologies as predictors of delivery outcomes: A retrospective analysis of inductions of labor. Intl J Gynecology & Obste. 2026 Mar;172(3):1462–72. https://doi.org/10.1002/ijgo.70491
26. Dong Y, Wang L, Lu Y, Fu Z, Du Y, Wang L. Factors affecting mode of delivery in women of advanced maternal age. BST. 2021 Feb 28;15(1):61–3. https://doi.org/10.5582/bst.2020.03375
27. Gregolis TBL, Santos SDS, Silva IFD, Bessa ARDS. Influence of non-pharmacological methods on duration of labor: a systematic review. Ciênc saúde coletiva. 2024 Jun;29(6):e19032022. https://doi.org/10.1590/1413-81232024296.19032022

28. Andargie BA, Legas A, W/Sellassie A, Abuhay H, Angaw DA. Effects of physical exercise during pregnancy on delivery outcomes: Systematic review and meta-analysis of randomized controlled trials. Maged AM, editor. PLoS One. 2025 Jul 23;20(7):e0326868. https://doi.org/10.1371/journal.pone.0326868
29. Mellado-García E, Díaz-Rodríguez L, Cortés-Martín J, Sánchez-García JC, Piqueras-Sola B, Prieto Franganillo MM, et al. Hydrotherapy in Pain Management in Pregnant Women: A Meta-Analysis of Randomized Clinical Trials. JCM. 2024 May 31;13(11):3260. https://doi.org/10.3390/jcm13113260
30. K I L, N.P E, Pooja P, Jose J, Verma A, Verma K. Cold Hip Bath Therapy for Labor Pain Management: A Review of Non-Pharmacological Interventions in Women's Health. IJRSI. 2025;XII(VIII):361–7. https://doi.org/10.51244/IJRSI.2025.120800033
31. Rofita D, Halimatusyaadiah S, Murni NNA. The Effect of Prenatal Yoga on Reducing Lower Back Pain in Third-Trimester Pregnancy. JPKI. 2025 Apr 24;20(3):163–70. https://doi.org/10.14710/jpki.20.3.163-170
32. Barbier M, Blanc J, Faust C, Baumstarck K, Ranque-Garnier S, Bretelle F. Standardized Stretching Postural postures to treat low-back pain in pregnancy: the GEMALODO randomized clinical trial. American Journal of Obstetrics & Gynecology MFM. 2023 Oct;5(10):101087. https://doi.org/10.1016/j.ajogmf.2023.101087
33. Carregui-Vilar S, Moya-Artuñedo EM, Chalmeta R, Rocca-Ihenacho L, Collado-Boira EJ. Epidural or water immersion? A prospective cohort study of maternal and neonatal outcomes in a tertiary hospital. Midwifery. 2025 Jul;146:104392. https://doi.org/10.1016/j.midw.2025.104392
34. Norato O, Velez S, Lleshi A, Lam G, Morales M, Udechi G, et al. Elderly Hip Osteoarthritis: A Review of Short-Term Pain Relief Through Non-Weight-Bearing Therapies. JFMK. 2025 Apr 8;10(2):124. https://doi.org/10.3390/jfmk10020124
35. Peng Y, Zou Y, Asakawa T. The glamor of and insights regarding hydrotherapy, from simple immersion to advanced computer-assisted exercises: A narrative review. BST. 2025 Feb 28;19(1):10–30. https://doi.org/10.5582/bst.2024.01356
36. Weenink RP, Wingelaar TT. Commentary: The circulatory effects of increased hydrostatic pressure due to immersion and submersion. Front Physiol. 2022 Oct 18;13:1029393. https://doi.org/10.3389/fphys.2022.1029393
37. Regnard J, Bouhaddi M, Castagna O, Mourot L. Commentary: The Circulatory Effects of Increased Hydrostatic Pressure Due to Immersion and Submersion. Front Physiol. 2022 Jan 27;13:830759. https://doi.org/10.3389/fphys.2022.830759