Effectiveness of High-Intensity Interval Training during pregnancy in the management of preeclampsia: a systematic review

Efectividad del entrenamiento de alta intensidad por intervalos durante el embarazo, en el manejo de la preeclampsia: una revisión sistemática

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Abstract

Introduction: Preeclampsia is one of the most common and serious complications during pregnancy, with significant maternal and fetal consequences. Physical exercise has been proposed as a preventive strategy, but evidence on the effects of high-intensity interval training (HIIT) during pregnancy remains limited.
Objective: To evaluate the effectiveness of HIIT during pregnancy on preeclampsia and other outcomes related to maternal physical and mental health.
Methods: A systematic review was conducted following the PRISMA guidelines. Randomized controlled trials evaluating HIIT interventions in pregnant women beyond 20 weeks of gestation were included. Searches were conducted in MEDLINE, Web of Science, and Scopus until April 2024. Risk of bias was assessed using the RoB 2 tool.
Results: Four studies with a total of 185 participants were included. Findings suggest that HIIT may improve or maintain maximal oxygen consumption (VO2 max), mental health, and functional capacity without reported adverse effects. No negative impact on glycemic response or blood pressure was observed.
Conclusion: HIIT during pregnancy appears to be a safe and potentially effective intervention to enhance cardiorespiratory and psychological health. However, current evidence is still limited and of moderate quality; more rigorous studies with larger sample sizes are needed.

Keywords

HIIT; physical exercise; preeclampsia; pregnancy.

Resumen

Introducción: La preeclampsia es una de las complicaciones más comunes y peligrosas durante el embarazo, con importantes consecuencias maternas y fetales. El ejercicio físico ha sido propuesto como una estrategia preventiva, pero existe escasa evidencia sobre el efecto del entrenamiento por intervalos de alta intensidad (HIIT) durante la gestación.
Objetivo: Evaluar la efectividad del entrenamiento HIIT durante el embarazo sobre la preeclampsia y otros desenlaces relacionados con la salud física y mental materna.
Métodos: Se realizó una revisión sistemática conforme a la guía PRISMA. Se incluyeron ensayos controlados aleatorizados que evaluaran la intervención HIIT en mujeres embarazadas con más de 20 semanas de gestación. La búsqueda se realizó en las bases de datos MEDLINE, Web of Science y Scopus hasta abril de 2024. Se utilizó la herramienta RoB 2 para evaluar el riesgo de sesgo.
Resultados: Se incluyeron cuatro estudios con un total de 185 participantes. Los hallazgos indican que el HIIT puede mejorar o mantener el consumo máximo de oxígeno (VO2 máx), la salud mental y la capacidad funcional sin efectos adversos reportados. No se observaron efectos negativos en la respuesta glucémica ni en la presión arterial.
Conclusión: El HIIT durante el embarazo parece ser una intervención segura y potencialmente efectiva para mejorar la salud cardiorrespiratoria y psicológica. Sin embargo, la evidencia aún es limitada y de moderada calidad, por lo que se requieren estudios con mayor rigor metodológico y tamaño muestral.

Palabras clave

Ejercicio físico; embarazo; HIIT; preeclampsia.

Introduction

Human pregnancy typically lasts an average of 265 days, with full-term gestation defined as occurring between 37 (259 days) and 42 weeks (294 days), calculated from the first day of the last menstrual period (López Araque et al., 2015). During this time, the maternal body undergoes major anatomical and physiological changes that affect nearly all systems, including the cardiovascular, endocrine, respiratory, gastrointestinal, hematological, musculoskeletal, and neurological systems (Serdán Ruiz et al., 2023).

Maintaining optimal maternal health throughout pregnancy is critical to prevent gestational complications such as hypertension, gestational diabetes, and preeclampsia (American College of Obstetricians and Gynecologists [ACOG], 2020). One of the proposed strategies to enhance maternal health is physical activity—particularly high-intensity interval training (HIIT), which has gained increasing attention in recent years.

HIIT involves repeated short bouts of vigorous exercise—ranging from 85% to 250% of VO_2 max—interspersed with brief recovery periods at 20%–40% of VO_2 max (Batacan et al., 2017; Gibala et al., 2012). This modality has been shown to produce significant benefits in cardiovascular function, mitochondrial activity, glycemic and lipid metabolism, and body composition in both general and clinical populations (Wilczyńska et al., 2024).

HIIT during pregnancy has been shown to be safe and potentially beneficial, provided that the intensity does not exceed approximately 90% of maximum heart rate, as reported in recent studies (Wowdzia et al., 2023). Intensity values up to 250% of VO_2max correspond to extreme sprint interval training (SIT) protocols that are not recommended for pregnant populations. Reported benefits include improved maternal cardiovascular fitness, better weight control, and reduced risk of gestational complications such as diabetes and preeclampsia (Yu et al., 2022; Wilczyńska et al., 2022). Despite these benefits, a substantial proportion of pregnant women do not meet the recommended guidelines of 150–300 minutes per week of moderate-intensity aerobic activity, as confirmed by a recent scoping review of international physical activity guidelines during pregnancy (Hayman et al., 2023). This highlights the need for safe and effective interventions. This systematic review aims to evaluate the effectiveness of HIIT in reducing preeclampsia incidence and in improving maternal physical and mental health outcomes.

Interestingly, HIIT may offer a practical alternative that increases adherence, as several studies indicate that pregnant women enjoy HIIT more and perceive it as more effective compared to traditional aerobic training (Nascimento et al., 2022; Wilczyńska et al., 2022). Moreover, acute fetal and maternal cardiovascular responses to HIIT appear comparable to those of moderate-intensity continuous training, suggesting safety for both mother and fetus (Wowdzia et al., 2022).

However, while several randomized controlled trials have explored the effects of HIIT during pregnancy, no systematic reviews have yet synthesized the evidence regarding its specific impact on preeclampsia prevention or management. Given the growing prevalence and burden of preeclampsia globally, and the limited adherence to traditional exercise guidelines during pregnancy, this review aims to evaluate the effectiveness of high-intensity interval training in pregnant women, compared to those not engaging in such training, in reducing the risk or severity of preeclampsia.

Method

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021). The protocol was prospectively registered in the International Prospective Register of Systematic Reviews (October 2024) (PROSPERO; ID: CRD42024593402).

Eligibility Criteria

Types of Studies

We included randomized controlled trials (RCTs), with no restrictions on language or publication date. Both published and unpublished studies were eligible, provided that the full text was available.

Types of Participants

We included studies involving adult pregnant women (≥18 years of age) with singleton pregnancies beyond 20 weeks of gestation. Women with pre-existing risk factors for preeclampsia or other comorbidities such as gestational hypertension and controlled diabetes were included.

Types of Interventions

Eligible interventions consisted of structured high-intensity interval training (HIIT) programs. HIIT was defined as repeated bouts of exercise performed at intensities ranging from 80–95% of maximum heart rate (HRmax), or 85–95% of VO_2max, interspersed with periods of either passive rest or active recovery at 40–50% of HRmax.

Types of Outcome Measures

Primary outcome: Incidence of preeclampsia

Secondary outcomes: Gestational diabetes control, quality of life, and psychological well-being

Search Strategy

Relevant trials were identified by systematically searching the following electronic databases up to April 2024:

MEDLINE (via PubMed)

Web of Science

Scopus

The search strategy was developed using relevant Medical Subject Headings (MeSH) and text words related to pregnancy and high-intensity interval training. The following Boolean search string was used:

#1 Pregnan*

#2 "High-Intensity Interval Training" OR "High-Intensity Interval Trainings" OR "Interval Training, High-Intensity" OR "Interval Trainings, High-Intensity" OR "Training, High-Intensity Interval" OR "Trainings, High-Intensity Intermittent Exercise" OR "Exercise, High-Intensity Intermittent" OR "Exercises, High-Intensity Intermittent" OR "High-Intensity Intermittent Exercises" OR "Sprint Interval Training" OR "Sprint Interval Trainings"

#1 AND #2

Data Management

Covidence software (free version) was used to remove duplicate records. The remaining entries were then imported into Rayyan (an open-access tool) for screening. All references were stored and organized using Zotero reference management software. Furthermore, one duplicate record was manually identified and removed, resulting in a single duplicate exclusion.

Study Selection and Screening

Two reviewers independently screened all titles and abstracts retrieved through the search. After duplicate removal, the remaining records underwent full-text screening to determine eligibility. Discrepancies were resolved through discussion, and if consensus could not be reached, a third reviewer was consulted.

Data Extraction

Two reviewers independently extracted data using a standardized extraction form. Inconsistencies were resolved by consensus; if disagreement persisted, a third reviewer adjudicated. Data extraction included variables such as participant demographics, intervention duration and frequency, adherence rates, and numerical health outcomes related to the intervention.

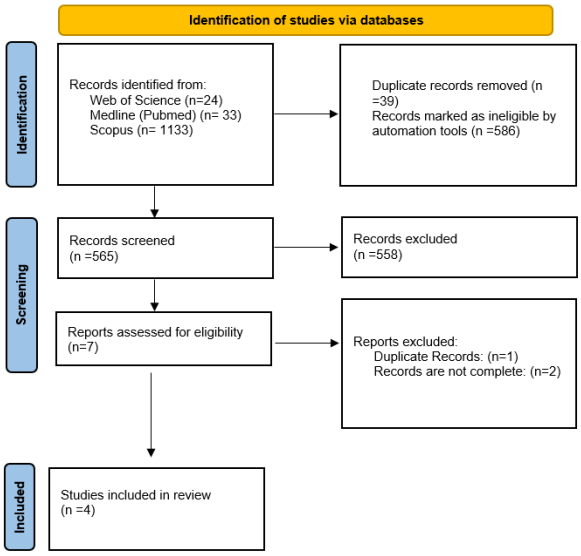
Risk of Bias Assessment

Risk of bias was independently assessed by two reviewers using the Cochrane Risk-of-Bias 2 (RoB 2) tool for randomized trials (Cochrane, 2023). The process was later reviewed with two additional authors (C.F. and M.N.). The following domains were evaluated: (1) bias arising from the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in outcome measurement; and (5) bias in selection of the reported results.

Results

The literature search resulted in 1190 records. After duplication, 565 records. During title and abstract screening, we excluded 558 clearly irrelevant records. We proceeded to retrieve the full-text reports for 7 records. Of these, we excluded 3 studies for reasons summarized in figure 1.

Figure 1. Flow diagram of literature search and selection process.



Characteristics of the Included Studies

The characteristics of the included studies are summarized in Table 1. A total of 185 pregnant female participants were involved. The average age was 31.4 years, with a mean gestational age of 23.4 weeks at the time of the interventions. The studies were conducted in controlled environments, including the Laboratory of Physical Effort and Sport Genetics at the University of Physical Education and Sport in Gdańsk (Poland), as well as a private laboratory at the University of Alberta or via online sessions through webcam (Canada).

In total, 103 participants underwent high-intensity interval training (HIIT), which consisted of three structured phases: warm-up, main workout, and cool-down. All sessions were supervised by professionals with expertise in physical activity and maternal health.

Regarding the comparators, 70 participants received an educational program (EDU), and 12 participants engaged in moderate-intensity continuous training (MICT).

The most frequently assessed outcome across studies was maximal oxygen consumption (VO_2max), followed by mental health and quality of life parameters (Wilczyńska et al., 2024; Wowdzia et al., 2022, 2023; Yu et al., 2022).

The four reviewed studies consistently employed structured exercise protocols with similar frequency and duration. Typically, pregnant women participated in three sessions weekly, each session lasting approximately 60 minutes. These sessions incorporated a warm-up of about 7 to 10 minutes, followed by high-intensity intervals lasting between 15 to 20 minutes, complemented by resistance and neuromotor

exercises, and concluding with a cool-down phase lasting up to 15 minutes. Each program was tailored individually regarding exercise intensity, aiming for around 85–90% of the maximal heart rate during work intervals, with interval durations between 30 and 60 seconds and matched rest intervals. For example, Wilczyska et al. (2024) conducted an 8-week intervention with online supervised sessions three times per week lasting 60 minutes each. Yu et al. (2022) similarly prescribed thrice-weekly sessions of 60 minutes including warm-up and rest intervals. Wilczyska et al. (2022) also used an online format with additional educational components once weekly over 8 weeks. In contrast, Wowdzia et al. (2022) investigated acute effects of a single 19-minute HIIT session composed of ten 1-minute high-intensity intervals with 1-minute active recovery.

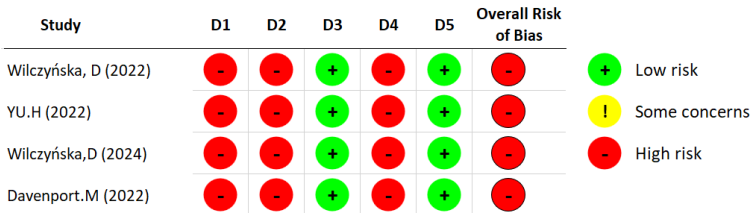
Table 1. Characteristics of Included Studies

Study	Characteristics of Participants	Intervention Group	Objectives	Outcomes
Wilczyńska, D. et al. (2024)	Country: Poland Population: 38 Caucasian women in singleton pregnancy without complications Age: 31.11 ± 4.03 years Gestational weeks: 21.82 ± 4.30	Intervention group: 22 women Control group: 16 women	To assess the impact of HIIT on cortisol levels, whether these are associated with symptoms of depression, fear of childbirth, mental and physical health, as well as exercise capacity in pregnant women.	Primary outcomes: • Fear of childbirth (Fear of Childbirth Scale questionnaire) • Depressive symptoms (Beck Depression Inventory-I) • VO_2max (progressive maximal exercise test on cycle ergometer) • Hair cortisol levels (DetectX cortisol ELISA kit)
Wilczyńska, D. et al. (2022)	Country: Poland Population: 54 Caucasian women in uncomplicated singleton pregnancies Age: 32 ± 4 years Gestational weeks: 22 ± 4	Intervention group: 34 women Control group: 20 women	To assess changes in depressive symptoms, fear of childbirth, fear of Covid-19, and quality of life after an 8-week supervised online HIIT program, compared to an educational program.	Primary outcomes: • Fear of childbirth (Fear of Childbirth Scale questionnaire) • Depressive symptoms (Beck Depression Inventory-I) • VO_2max (progressive maximal exercise test on cycle ergometer)
Davenport, M. et al. (2022)	Country: Canada Population: 24 normoglycemic women with single pregnancy Age: 31.5 ± 4.1 years Gestational weeks: 27.8 ± 4.7	Intervention group: 12 women Control group: 34 women	To assess the glycemic response to an acute session of HIIT (10 one-minute intervals ≥90% HR maximal interspersed with one minute of active recovery) versus MICT (30 minutes at 64-76% HR maximal) during pregnancy.	Primary outcome: • Glycemic response (flash glucose monitor; interstitial glucose)
Yu, H. et al. (2022)	Country: Poland Population: 69 Caucasian women with singleton pregnancy without complications Age: 31 ± 4 years Gestational weeks: 22 ± 5	Intervention group: 35 women Control group: 34 women	To evaluate the effects of an 8-week online HIIT program on parameters related to anaerobic threshold (AT), body weight, and body composition in pregnant women.	Primary outcomes: • VO_2max (progressive maximal exercise test on cycle ergometer with respiratory gas analyzer) • Maternal heart rate • Systolic blood pressure • Maternal weight (bioelectrical impedance analysis, InBody 720) • Body mass index (weight in kg/height in m^2)

Risk of Bias of Included Studies

Figure 2 presents the individual risk of bias assessments for the included studies. Two studies were rated as having a high risk of bias, while the remaining studies were classified as having "some concerns," according to the Cochrane risk-of-bias tool for randomized trials (RoB 2) (Higgins et al., 2022).

Figure 2. The Cochrane risk-of-bias tool for randomized trials (RoB 2).



Abbreviations: D1, Randomization process; D2, Deviations from intended interventions; D3, Missing outcome data; D4, Outcome measurement; D5, Selection of the reported result 3.3 Outcomes

Outcomes

None of the included studies reported the primary outcome, preeclampsia

Maximal Oxygen Consumption

Three of the four included studies evaluated changes in maximal oxygen consumption (VO_2max) using a graded maximal exercise test on a cycle ergometer with electronically regulated load and a stationary respiratory gas analyzer (Yu et al., 2022; Wowdzia et al., 2022; Wilczyńska et al., 2024). In the study by Wilczyńska et al. (2024), VO_2max was assessed at two time points: no significant difference was found at time 1, but time 2 showed a significant change only in the education group (EDU). In the study by Wowdzia et al. (2022), no significant differences were observed between groups at baseline; however, in the second assessment, the EDU group exhibited a significant reduction in VO_2max pre- and post-intervention, while the HIIT group showed no significant change. In contrast, the study by Yu et al. (2022) assessed changes in anaerobic threshold (VO_2/AT) after eight weeks and found significantly higher values in the HIIT group, whereas the EDU group experienced a significant decrease.

Maternal Heart Rate

Two studies evaluated heart rate responses (Yu et al., 2022; Wowdzia et al., 2023). One of them used a progressive maximal exercise test on a cycle ergometer, showing that post-intervention heart rate at the anaerobic threshold (HR/AT) was significantly higher in the HIIT group compared to the EDU group (Yu et al., 2022). The other study continuously monitored heart rate with a POLAR H10 device during training sessions, reporting that participants in the HIIT group reached above 90% of their maximum heart rate, with the highest recorded at 97% (Wowdzia et al., 2023).

Blood Pressure

One study assessed blood pressure values and anaerobic threshold parameters using a graded maximal exercise test and an electronic BP monitor (Yu et al., 2022). Baseline values did not differ significantly between HIIT and EDU groups. However, after eight weeks of intervention, the HIIT group showed statistically significant improvements.

Glycemic Response

Glycemic response was evaluated in one study using a flash glucose monitoring system (Abbott Diabetes Care Inc.) placed on the left triceps for seven consecutive days (Wowdzia et al., 2022). Glucose trend reports were analyzed with Freestyle Libre Pro desktop software. Results indicated no significant differences between HIIT and EDU groups in interstitial glucose levels before and after exercise. However, fewer participants experienced post-exercise hypoglycemia in the HIIT group compared to the moderate-intensity continuous training (MICT) group.

Mental Health and Quality of Life

One study assessed stress levels using hair cortisol concentrations measured by ELISA with the DetectX cortisol immunoassay kit (Wilczyńska et al., 2024). Cortisol levels significantly increased in the HIIT group and decreased in the EDU group, with no adverse effects on fear of childbirth or psychophysical condition during pregnancy.

Two studies evaluated depressive symptoms using the Beck Depression Inventory-II (BDI-II), showing no significant differences between groups at either measurement timepoint (Wilczyńska et al., 2024; Wilczyńska et al., 2022). Fear of childbirth was assessed with the Fear of Childbirth Scale, revealing significant changes only in the EDU group between the first and second assessments.

Health-related quality of life was measured using the 12-item Short Form Health Survey (SF-12). No significant changes were observed in physical health scores between groups or timepoints. However, mental health scores significantly improved in the HIIT group, while no changes were found in the EDU group (Wilczyńska et al., 2024).

Discussion

This systematic review identified four studies that evaluated the effectiveness of high-intensity interval training (HIIT) during pregnancy by assessing changes in serum parameters, physiological evaluations, and health-related questionnaires.

One of the most significant findings was that parameters related to the anaerobic threshold either improved or remained stable after an 8-week HIIT intervention, despite the progression of pregnancy and associated weight gain. In contrast, participants in the education (EDU) group demonstrated significantly lower VO_2max values after 8 weeks (Wilczyńska et al., 2024). Another study found no between-group differences in maternal glycemic responses to acute exercise; however, fewer participants experienced post-exercise hypoglycemia in the HIIT group compared to the moderate-intensity continuous training (MICT) group (Wowdzia et al., 2022).

One study reported that HIIT stimulated cortisol production but did not negatively affect fear of childbirth or psychophysical well-being during pregnancy (Wilczyńska et al., 2024). On the contrary, a significant improvement in mental health was observed exclusively in the HIIT group (Wilczyńska et al., 2024). Another study found significant reductions in depression symptoms, fear of childbirth, and mental health composite scores (BDI-II, Fear of Childbirth Scale, and MCS) in both the EDU and HIIT groups following the intervention (Wilczyńska et al., 2022).

The included studies demonstrated that maternal cortisol levels increased following HIIT interventions. Based on current literature, such as Wilczyńska et al. (2024), this hormonal increase appears to reflect an adaptive physiological response to exercise-related stress rather than signaling adverse health effects for mother or fetus. Nonetheless, it remains essential to monitor long-term outcomes to elucidate any potential risks.

Although one of the primary objectives was to assess the impact of HIIT on preeclampsia incidence, existing data from included studies did not confirm significant reductions. Limitations such as small sample sizes and heterogeneity in intervention protocols may explain these inconclusive findings. Future research should prioritize preeclampsia as a primary outcome to better inform clinical recommendations.

Overall, HIIT appears to produce greater improvements in specific outcomes such as VO_2max and mental health when compared to educational interventions. However, it does not consistently lead to improvements across all indicators, such as glycemic response.

Integrity and Applicability of the Evidence

The studies included in this review were conducted in Poland and Canada, both high-income countries (World Bank, 2023). Interventions were performed in university-affiliated sports science laboratories or remotely via web-based platforms. Most participants were monitored using specialized equipment under the supervision of qualified professionals.

While strict implementation of these protocols in other settings may be challenging, the interventions could be adapted by adjusting intensity and volume parameters to ensure safety. Notably, some participants were not monitored in person, as sessions were conducted online, increasing the accessibility and scalability of HIIT interventions in diverse contexts. These findings suggest that HIIT is a potentially transferable strategy across multiple environments and populations.

Quality of the Evidence

The most critical limitation of this review is the high risk of bias across the included studies (Yu et al., 2022; Wowdzia et al., 2022; Wilczyńska et al., 2022; Wilczyńska et al., 2024). Although all four studies reported randomization, none provided clear details about allocation concealment or baseline comparability between groups, introducing potential selection bias. Due to the nature of the intervention, it was not possible to blind participants or exercise administrators. However, no deviations from intended interventions were noted, and appropriate analytical methods were used to estimate intervention effects.

Attrition rates exceeded 10% in most studies, although dropouts were unrelated to participants' health status. Importantly, outcome measurements were robust and applied equally across groups. Nevertheless, two studies may have been affected by detection bias, as self-reported outcomes could be influenced by awareness of group allocation (Wilczyńska et al., 2022; Wilczyńska et al., 2024).

Possible Biases in the Review Process

The literature search was comprehensive, with no restrictions on language or publication date. However, a potential reporting bias may exist due to unplanned modifications to the search strategy that were made to accommodate time constraints and technical issues. The review process followed Cochrane guidelines: two independent reviewers conducted blinded screening, data extraction, and risk-of-bias assessment, with a third reviewer resolving disagreements. Despite these safeguards, some unpublished studies or grey literature may have been inadvertently excluded.

Conclusions

Implications for Practice

The current body of evidence supports the beneficial role of high-intensity interval training (HIIT) during pregnancy. The reviewed studies indicate that HIIT can significantly enhance women's health and support the physiological progression of a normal pregnancy. Improvements were observed in exercise capacity and cardiometabolic health, with no adverse obstetric or neonatal outcomes reported in low-risk pregnancies (Yu et al., 2022; Wowdzia et al., 2022; Wilczyńska et al., 2022; Wilczyńska et al., 2024). Furthermore, HIIT appears to exert preventive effects on psychological well-being by reducing stress markers and improving mental health status, as measured by validated psychological inventories (Wilczyńska et al., 2024).

Regarding maternal glycemic response, no adverse events were noted following acute HIIT sessions, and the intervention was generally well-tolerated throughout pregnancy (Wowdzia et al., 2022). Despite these promising findings, it is important to interpret the results with caution. The total sample size across studies was relatively small and limited to specific populations, which restricts the generalizability of the findings. Therefore, HIIT during pregnancy cannot yet be universally recommended for all pregnant women without individual medical evaluation and further research validation.

Implications for Research

There is a clear need for additional randomized controlled trials (RCTs) to evaluate the efficacy and safety of HIIT in managing conditions such as preeclampsia and gestational diabetes in uncomplicated pregnancies. Future studies should ensure adequate sample sizes to achieve sufficient statistical power and minimize the risk of type II errors. Moreover, improved methodological rigor is necessary, including transparent reporting of randomization procedures and allocation concealment, to reduce the risk of bias (Cochrane, 2023).

It is also recommended that future research includes more heterogeneous populations, particularly those with varying psychological profiles and mental health conditions, to determine whether HIIT provides universal or subgroup-specific benefits. This could help identify which groups may benefit the most from structured HIIT interventions during pregnancy and guide more personalized exercise recommendations.

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