INTRODUCTION

Pregnancy and childbirth are important events for every woman. During this period, women experience considerable changes in the skeletal, circulatory, and reproductive systems.¹ Meanwhile, changes in body composition during pregnancy are natural such as uncontrolled weight gain to cause hyperlipidemia, chronic fatigue, low back pain, and depression due to obesity.² In this regard, the American College of Obstetricians and Gynecologists (ACOG) recommends consulting a physiotherapist to improve physical and emotional health in pregnancy³, which can be achieved with physical exercises.⁴ Physical exercises are proven to increase one’s quality of life.⁵

Pilates exercise is advocated for alleviating the discomforts of pregnancy and assisting in strength and endurance for labor and birth. However, this review found no evidence to improve perinatal outcomes in these situations. The American College of Sports Medicine and the Centers for Disease Control and Prevention recommended that women should moderately exercise for thirty minutes or more daily in the absence of medical or obstetric complications.⁶ Evidence-based practice is needed to verify the benefits of pilates as a form of exercise for pregnancy and birthing outcomes.⁷

Triglycerides are hydrolyzed by lipases on the maternal side of the sincytiotrophoblast, and free fatty acids are released and taken up by the placenta.⁸ Cholesterol is essential for placental and fetal growth, maturation, and steroid hormone synthesis. The fetus uses maternal cholesterol transferred across the placenta, and cholesterol is transferred from its synthesis later in pregnancy. Cholesterol is pro-inflammatory throughout the first trimester in order to aid with blastocyst implantation. Fetal growth occurs throughout the second trimester, which is marked by an anti-inflammatory Th2 milieu. Nascency requires a shift to a pro-inflammatory Th1 response, which occurs during the third trimester. Pregnancy-related infections are not uncommon,

Background: While most women perceive pregnancy to be a happy time, there are physiological, anatomical, biochemical, and psychological changes that can occur during this period. Pilates exercise is making strength and endurance for labor and birth. In this sense, this study’s purpose was to systematically review the literature on the implication of pilates exercise on blood tests in pregnant women.

Methods: Three databases were searched in order to find pertinent publications published up until December 31, 2023. Independently, paired reviewers went through the articles and took data from every study that was included. A meta-analysis was carried out to evaluate how pilates affected the blood test. To investigate heterogeneity, subgroup, and sensitivity analyses were carried out.

Results: Ultimately, the meta-analysis containing 32 pregnant women included 4 studies totaling 160 pregnant women. The results of the study demonstrated a significant difference in the levels of total triglycerides (CI95%: -1.627 - -0.104; I²: 16%), total cholesterol (CI95%: -2.210 - 0.027; I²: 17%), and low-density lipoprotein (CI95%: -2.887 - 0.004; I²: 16%) between the pilates exercise group and the control group. The results of the research indicated that the high-density lipoprotein (CI95%: 1.278 - 0.201; I²: 17%) and C-reactive protein (CI95%: -0.556 - 0.579; I²: 18%) levels in the pilates exercise group were considerably lower than those in the control group.

Conclusion: We found that pilates exercises are perfect for placenta growth. It can also reduce anxiety and improve physical condition in pregnant women. Therefore, further research and evaluation in clinical trials are needed.
and CRP is often tested as a proxy for infection.\textsuperscript{11} The amount of adipose tissue may affect the hepatic production of CRP via increasing IL-6 release.\textsuperscript{12} Furthermore, it has been suggested that CRP rises in conjunction with BMI throughout pregnancy\textsuperscript{13}; this is consistent with our data, which shows some modest associations between CRP levels and BMI in the first and second trimesters.

Therefore, the objective of the present study was to systematically review the literature on the effect of pilates exercise and blood tests during pregnancy.

METHODS

Literature study
The Preferred Reporting Items for Systematic Reviews and Meta-analysis updates and the OSF handbook's standards were followed in the design of this work, which is structured as a systematic review and meta-analysis.

Literature search and data collection
Using the following search phrases, the study was conducted from December 2016 to December 2023: [Pilates Exercise AND Pregnancy OR Pregnant OR Gestational Age OR Obstetric AND Blood Test]. Additionally, the following databases were used for the research: PubMed, BMC, and Scopus.

Studies selection and eligibility criteria
Every study that satisfied the requirements was taken into account, including pilot studies, randomized controlled trials (RCTs), and pretest-posttest control group designs; population: ladies expecting; Pilates exercise as an intervention; Control is the comparator. Results: a blood test. The EndNote application was used to eliminate the duplicates once the search was complete. Relevance screening was done on the whole texts, abstracts, and titles. Moreover, the references in the included research were updated to identify any missing pertinent papers.

Quality assessment
Randomized controlled trials that were part of experiments have been assessed by the OSF risk of bias tool. This tool's domains include the following ones: Selection bias detection and other biases; arm allocation; blinding of participants and investigators; evaluation of results and blinding of outcomes; and population randomization. There are three levels of bias risk in judgment: high, low, and unclear. Additionally, the pilot study's risk of bias was evaluated using the QUADAS-C methodology. Nineteen questions covering question, statement, index test, patient selection, reference standard, flow, and timing were included in the instrument. Not only that, but someone also developed a technique (the QUADAS-C tool) to assess the pilot study's quality.\textsuperscript{14}

Data extraction
The data was extracted into Excel sheets. The extracted data contained the following items: Summary characteristics including reference, evaluation tools, study design, intervention, comparison/ control group, and outcomes; Characterization of the study referential data including reference, place of origin, and language; Characterization of studies sample data including reference, sample size and age, information regarding gestation; Outcomes including: Blood Test (triglycerides (TG), total cholesterol (TC), High-Density Lipoprotein (HDL), Low-Density Lipoprotein (LDL), C-Reactive Protein (CRP), Aspartate Aminotransferase (AST), The International Consultation on Incontinence Questionnaire (ICIQ-SF), The Hospital Anxiety and Depression Scale, The Female Sexual Function Index (FSFI), The Nordic Musculoskeletal Questionnaire (NMQ), Borg Rating Randomised Perceived Exertion (RPE), Visual Analog Scale (VAS), Mackey Childbirth Satisfaction Rating Scale, Edinburgh Postnatal Depression Scale (EPDS), Pittsburgh Sleep Quality Index (PSQI), Perceived Stress Scale (PSS), Pelvic Stabilization Muscle Strength Test, Body Composition, Blood Test: Insulin and Serotonin (Table 3).

Four studies applied the pilates exercise modality with the help of accessories, and two applied pilates exercise exclusively. The frequency varied between one and two times weekly, between 8-12 weeks, totaling 12, 16, and 24 sessions. Pilates exercise showed superiority over control interventions in all analyzed outcomes in all studies (Table 3).

According to the meta-analysis, the pilates exercise group was superior to the control group in the blood test as measured by the total triglycerides (CI 95%; -1.627 - -0.104; I2: 16%). The pooled
results were homogeneous (p = .29, I2 = 16%, fix effect model) (Figure 1). The pilates exercise group was superior to the control group in the blood test as measured by the total cholesterol (CI 95%: -2.210 - 0.027; I2: 17%). The pooled estimate was homogeneous (p = .29, I2 = 16%, fixed effect model) (Figure 2). The pilates exercise group was superior to the control group in a blood test as measured by the low-density lipoprotein (CI95%: -2.887 - 0.004; I2: 16%). The analyzed data were homogeneous (p = .29, I2 = 16%, fixed effect model) (Figure 3). The control group was superior to the pilates exercise group in a blood test as measured by the C-reactive protein (CI95%: -0.556 - 0.579; I2: 18%). The pooled results were homogeneous (p = .29, I2 = 18%) (Figure 4).

**DISCUSSION**

The goal of physiotherapy care is to facilitate a healthy pregnancy and delivery by creating the best possible conditions. Unfortunately, though, one of the main problems that women face during labor is pain related to pregnancy. In addition, the women have uncontrollable skeletal, reproductive, and circulatory alterations throughout pregnancy. Weight gain, hyperlipidemia, back discomfort, and obesity-related depression are the results of these alterations. Prolonged labor and delivery also lead to a number of problems, such as hypoxia, uterine atony, and fetal exhaustion. Pilates is a type of exercise that is founded on six principles: breathing, centralization, precision, rhythm, and whole body involvement. Pilates is an intentional kind of exercise that encourages

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample size and age</th>
<th>Information regarding pretest - posttest design</th>
<th>Intervention</th>
<th>Comparison/Control Group</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyun AH et al. (2020)</td>
<td>Total: 16</td>
<td>Group: PG = 9 (31.78 ± 4.68); CG = 7 (32.00 ± 3.46)</td>
<td>Week 1 - 6: Torso twist, cat cow, kneeling half, push-up, lying one-leg circles, one leg side kick, pelvic stretch. Week 7 - 12: spine stretch, double arm circles, half roll down and up, one leg side rotation, lying leg scissor, donkey kick</td>
<td>No exercise</td>
<td>Pilates exercise: HF †, HA †, HE †, Body weight †, total body water †, intracellular water †, extracellular water †, body fat mass †, percent body fat †, skeletal muscle mass (SMM) †, Blood test: total triglycerides (TG) †, total cholesterol (TC) †, high density lipoprotein (HDL) †, low density lipoprotein (LDL) †, creatine kinase (CK) †, lactate dehydrogenase (LDH) †, C-reactive protein (CRP) †, aspartate aminotransferase (AST) †</td>
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Physical Therapy Journal of Indonesia 2024; 5(1): 71-76; DOI: 10.51559/ptji.v5i1.193

**Reference**

**Evaluation tools**

**Study design**

**Intervention**

**Comparison/Control Group**

**Outcome**

<table>
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<tr>
<td>Kim HB et al. (2022)</td>
<td>Body composition test, Blood test (total triglycerides (TG), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), C-reactive protein (CRP), insulin, serotonin, Edinburgh Postnatal Depression Scale (EPDS), Pittsburgh sleep quality index (PSQI), Perceived Stress Scale (PSS)</td>
<td>A randomized controlled experiment with pilot study</td>
<td>Week 1-3: Half squat, cat cow, donkey kick, bridge, clam, spine rotation, arm circle, leg circles. Weeks 4–6: Half-saw, half-lunges, hip hinge, side lateral raise, kneeling push-up, leg side up. Weeks 7–8: Half-lunge twist, squat, low impact down dog, leg side kick, lunges, deep breathing</td>
<td>No exercise</td>
<td>Pilates exercise: Body composition test ↓, Blood test (total triglycerides (TG) ↓, total cholesterol (TC) ↓, high density lipoprotein (HDL) ↓, low density lipoprotein (LDL) ↓, C-reactive protein (CRP) ↓, insulin, serotonin ↑, Edinburgh Postnatal Depression Scale (EPDS) ↓, Pittsburgh sleep quality index (PSQI) ↓, Perceived Stress Scale (PSS) ↓. Control: Perceived Stress Scale (PSS) ↑.</td>
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**Figure 1.** Comparison between the pilates exercise versus control regarding blood test by the total triglycerides (TG).

**Figure 2.** Comparison between the pilates exercise versus control regarding blood test by the total cholesterol (TC).

awareness of muscle recruitment, body movement, and body shape. According to Joseph Pilates, this series of corrective exercises stabilizes the posture muscles during dynamic movement, increases mental vigor, and encourages voluntary or effective posture. Pilates can be done using equipment that provides resistance to stabilize and build deep muscle groups, or it can be done on a mat utilizing the weight of the body.16

The analysis showed that pilates exercises nourish the placenta and shape the immune system in pregnant women and infants. Pilates also plays a vital role in total triglycerides, total cholesterol, and low-density lipoprotein during pregnancy and the placenta. However, pilates exercise has no significant effect on blood, namely high-density lipoprotein and C-reactive protein. Although the results did not fully meet our expectations, the data found were of great pilates exercise relevance since the sample included pregnant women.

The analysis showed that pilates exercises nourish the placenta and shape the immune system in pregnant women and infants. Pilates also plays a vital role in total triglycerides, total cholesterol, and...
A thorough systematic review and meta-analysis have never before been conducted to examine the impact of pilates exercise on blood tests during pregnancy. There are a lot of similar research and patients, which makes it feasible to draw as valid and trustworthy a conclusion as possible. However, the study had certain shortcomings. First, there were only a few experimental research journals that addressed pregnant women with pilates exercises in laboratory-based examinations. Second, the sample size of pregnant women in this study was considered small, so the findings cannot be generalized to other populations. Third, there was a lack of in-depth discussion on the effects of exercise and control groups on whether the pilates exercise program proved more beneficial in pregnancy and childbirth than other exercises. Fourth, as researchers consider that many complex factors, such as hormonal status, environmental factors, etc., affect the immune system and influence the effects of exercise, we should mention the lack of a control group as one of the study's limitations. Hence, further studies with a larger control group and sample size are needed.

CONCLUSION

Our research findings suggest that pilates exercise can affect changes in total triglycerides, total cholesterol, and low-density lipoprotein, which may indicate a resetting of the placenta and possible enhancement of immune system responsiveness. On the other hand, the effects of pilates exercise can significantly upregulate immunity, which may also be beneficial in maintaining appropriate adaptive immune function and physical condition in pregnant women and the baby-to-be.

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ETHICAL CONSIDERATION

This study was not required inform consent or approval from the institutional board since using published articles data.

CONFLICT OF INTEREST

There is no conflict of interest with the study's participants, according to the author.

FUNDING

No funding from any institution declared.

AUTHOR CONTRIBUTIONS

AQ concepted the study design, searched literature, analyzed data, and drafted manuscript; RZU and DAP searched literature, analyzed data, and reviewed manuscript.

REFERENCES

1. Long G., Haoning M., Ping Y., Mingheng T. Asymmetry in Paraspinal Muscles as a Predictor of the Development of Pregnancy-Related Low

Figure 3. Comparison between the pilates exercise versus control regarding blood test by the low density lipoprotein (LDL).

Figure 4. Comparison between the pilates exercise versus control regarding blood test by the high density lipoprotein (HDL).

Figure 5. Comparison between the pilates exercise versus control regarding blood test by the C-Reactive Protein (CRP)