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Pilates exercise and blood test in pregnancy: a systematic review and meta-analysis

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ABSTRACT

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.

Keywords: blood test, meta-analysis, pilates exercise, pregnancy women.
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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 pregnancy[3], 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 syncytiotrophoblast, 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 probably delivered to the placenta by low-density lipoprotein, followed by endocytosis. A study with data from four-vessel sampling at cesarean section indicates that high-density lipoprotein releases cholesterol from the placenta to the fetal circulation. High maternal concentrations of triglycerides, cholesterol, low-density lipoprotein, and high-density lipoprotein are found to be associated with several pregnancy complications, such as pregnancy-related hypertension, pre-eclampsia, preterm birth, gestational diabetes (GDM), and fetal overgrowth. The most consistent associations seem to be present for triglycerides.[9]

Throughout the developmental phases, the immune system also alters.[10] Pregnancy 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,

and CRP is often tested as a proxy for infection.[11] The amount of adipose tissue may affect the hepatic production of CRP via increasing IL-6 release.[12] Furthermore, it has been suggested that CRP rises in conjunction with BMI throughout pregnancy[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.[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).

Data analysis

The statistical study was carried out using Comprehensive Meta-study software. At a p-value <.5 level, the significance level was taken into account. The standard deviation of the mean difference, hedges, and mean difference were computed if the data were continuous. Conversely, the dichotomous data's standard deviation in mean and 95% confidence interval were provided. Lastly, the chi-square test and the I-square test (I2) were used to evaluate the heterogeneity. If the I2 value was greater than 50% and the p-value of the chi-square was less than 0.1, the data are heterogeneous. The examination of the heterogeneous data was conducted using the random effects model, whereas the analysis of the homogeneous data was conducted using the fixed effect model.

RESULTS

The study's place of origin varied, with one from Egypt, one from Brazil, one from Iran, and one from Korea. All of the studies were written in English (Table 1). The total analyzed data was of 160 pregnant women, whose mean age was 28.27 ± 5.16 years. The data on pregnancy-related information is heterogeneous, with the gestational time ranging from the 16th to the 28th week of gestation and most of the samples being primiparous (Table 2).

Several instruments were used for the assessment, among which were : Pelvic Stabilization Muscle Strength Test: Hip Flexion (HF), Hip Abduction (HA), Hip Extension (HE), Body Composition Test: Body Weight, Total Body Water, Intracellular Water, Extracelullar Water, Body Fat Mass, Percent Body Fat, Skeletal Muscle Mass (SMM), Blood Test: 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), 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 = 17%) (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 high-density lipoprotein (CI95%: 1.278 - 0.201; I2: 17%). A fixed effect model was used due to the data homogeneity (p = .29, I2= 17%) (Figure 4). The control group was superior to the pilates exercise group in the 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 5).

Table 1. Characterization of studies referential data

Reference	Place of origin	Language
Hyun AH *et al.* (2020)	Egypt	English
Nascimento GRS *et al.* (2021)	Brazil	English
Ghandali NY *et al.* (2021)	Iran	English
Kim HB *et al.* (2022)	Korea	English

Table 2. Characterization of studies samples

Reference	Sample size and age	Information regarding gestation
Hyun AH *et al.* (2020)[15]	Total : 16 Included : 16 PG : 9 (31.78 ± 4.68) CG : 7 (32.00 ± 3.46)	Gestational time : 16th to 24th week Number of pregnancies : all primiparous
Nascimento GRS *et al.* (2021)[16]	Total : 33 Included : 25 PG : 13 (36.0 ± 11.5) CG : 12 (33.5 ± 11.2)	Gestational time : 20th to 28th week Number of pregnancies : all primiparous
Ghandali NY *et al.* (2021)[17]	Total : 110 Included : 103 PG : 51 (25.16 ± 4.41) CG : 52 (23.81 ± 4.30)	Gestational time : 26th to 28th week Number of pregnancies : all primiparous
Kim HB *et al.* (2022)[18]	Total : 16 Included : 16 PG : 8 (39.71 ± 2.01) CG : 8 (38.14 ± 1.39)	Gestational time : 24th to 28th week Number of pregnancies : all primiparous

Values expressed as mean ± standard deviation; PG: pilates group; CG: comparison/ control group

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.[19]

Pilates is a type of exercise that is founded on six principles: breathing, centralization, precision, rhythm, and whole body involvement.[20] Pilates is an intentional kind of exercise that encourages

Table 3. Characterization of the evaluation tools, study design, intervention protocols and studies outcomes

Reference	Evaluation tools	Study design	Intervention	Comparison/ Control Group	Outcome
Hyun AH *et al.* (2020)[15]	Pelvic stabilization muscle strength test: hip flexion (HF), hip abduction (HA), hip extension (HE). Body composition: 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).	Pretest-Posttest Control Group Design	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 scissors, donkey kick	No exercise	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) ↑ Control : HA : ↓ Extracellular water : ↓

Reference	Evaluation tools	Study design	Intervention	Comparison/ Control Group	Outcome
Nascimento GRS *et al.* (2021)[16]	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)	Pretest-Posttest Control Group Design	Week 1 – 12 : spine stretch, spine twist, saw, mermaid, chest expansion, shoulder bridge, side kick – front and back, leg – small circles, scissors, and leg adduction	Conventional treatment	Pilates exercise: Urinary Incontinence ↓, Sexual Function ↑, Pain ↓. Control : Urinary Incontinence ↑, Sexual Function ↓, Pain ↑,
Ghandali NY *et al.* (2021)[17]	Borg Rating of Perceived Exertion (RPE), Visual Analog Scale (VAS), and Mackey Childbirth Satisfaction Rating Scale.	Randomised controlled trials (RCT)	No specified	No exercise	Pilates exercise: Pain ↓, Duration childbirth ↓, RPE - Control: Pain ↓, Duration childbirth ↓, RPE ↑
Kim HB et al. (2022)[18]	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)	A randomized controlled experiment with pilot study	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, kneeing push-up, leg side up. Weeks 7–8 : Half-lunge twist, squat, low impact down dog, leg side kick, lunges, deep breathing	No exercise	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) ↑

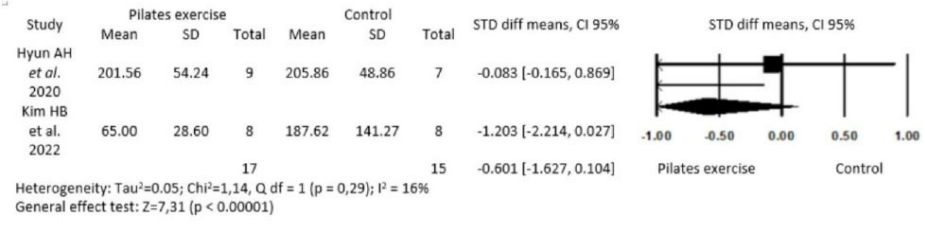

Figure 1. Comparison between the pilates exercise versus control regarding blood test by the total triglycerides (TG).

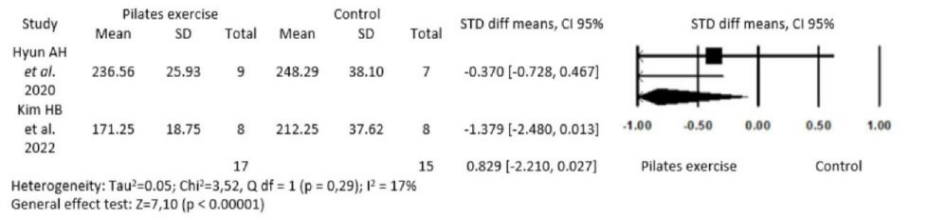

Figure 2. Comparison between the pilates exercise versus control regarding blood test by the total cholesterol (TC).

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.

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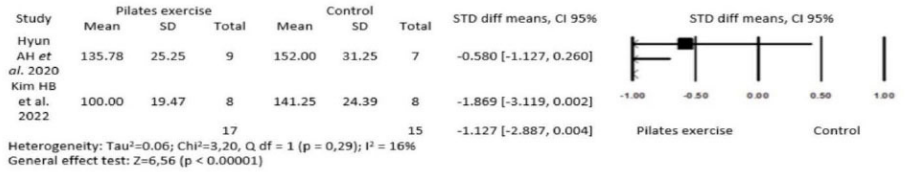

Figure 3. Comparison between the pilates exercise versus control regarding blood test by the low density lipoprotein (LDL).

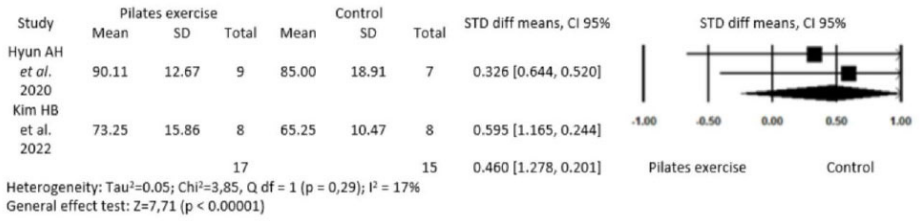

Figure 4. Comparison between the pilates exercise versus control regarding blood test by the high density lipoprotein (HDL).

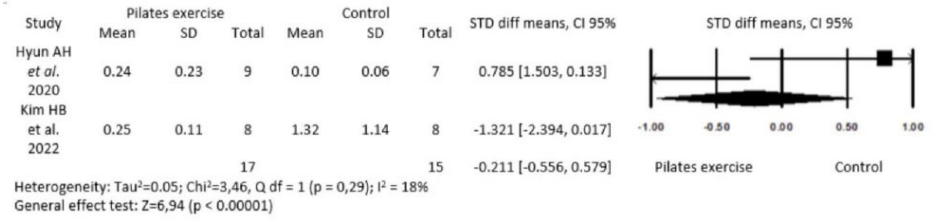

Figure 5. Comparison between the pilates exercise versus control regarding blood test by the C-Reactive Protein (CRP)

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 pregnancy women.

About C-reactive protein, other researchers stated that one of the advantages of the control group was a decrease in C-reactive protein levels, consequently reducing inflammatory conditions and associated body weight.[21] To date, only a few studies have verified the effect of pilates exercises on C-reactive protein.[12] However, the results of both control groups showed a significant decrease after twelve weeks of intervention, although C-reactive protein concentrations indicated a possible absence of inflammatory processes in the pilates exercise group. Furthermore, glucose values such as HDL showed similar results to C-reactive protein. Pilates exercise has not significantly reduced systemic inflammation, which would reduce insulin resistance in pregnant women and fetuses.[22]

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.

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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., Mingsheng T. Asymmetry in Paraspinal Muscles as a Predictor of the Development of Pregnancy-Related Low

Back and Pelvic Pain: A Prospective Study. Orthop. Surg. 2021;13:2255–2262.
2. Chen H., D'Onofrio G., Hameed F. Role of Exercise Treatment of Low Back Pain in Pregnancy. Curr. Phys. Med. Rehabil. Rep. 2020;8:322–328.
3. Di Liegro C.M., Schiera G., Proia P., Di Liegro I. Physical activity and brain health. Genes. 2020;10:720. doi: 10.3390/genes10090720.
4. Kadir MI, Hardiyanty N, Adliah F. A pilot study of the effect of Otago Exercise Program on Fall Risk and quality of life of older women. Physical Therapy Journal of Indonesia. 2021 May 12;2(1):1–4. doi:10.51559/ptji.v2i1.16
5. Pradnyanini IAM, Adhitya IPGS, Muliarta IM. Lansia Kurang Aktif Memiliki Risiko Jatuh Lebih Tinggi Dibandingkan Lansia Aktif di Denpasar Barat. Open Access Journal. 2019.
6. Sytsma TT, Zimmerman KP, Manning JB, Jenkins SM, Nelson NC, Clark MM, et al. Perceived barriers to exercise in the first trimester of pregnancy. The Journal of Perinatal Education. 2018 Oct;27(4):198–206. doi:10.1891/1058-1243.27.4.198
7. Artal R, O'Toole M. Guidelines of the American College of Obstetricians and Gynecologists for exercise during pregnancy and the postpartum period. Br J Sports Med. 2014;37(1):6-12.
8. Duttaroy AK, Basak S. Maternal fatty acid metabolism in pregnancy and its consequences in the Feto-placental development. Frontiers in Physiology. 2022 Jan 20;12. doi:10.3389/fphys.2021.787848
9. Jain N. The Early Life Education of the Immune System : Moms, Microbes and (missed) Opportunities. Gut Micobes. 2020. doi:10.1080/19490976.2020.1824564.
10. Horne H, et al. Maternal-fetal cholesterol transfer in human term pregnancies. Placenta. 2019;87:23–29.
11. Mor G, Aldo P, Alvero AB. The Unique Immunological and Microbial Aspects of Pregnancy. Nat Rev Immunol (2017) 17(8):469–82. 10.1038/nri.2017.64
12. Maguire PJ, Power KA, O'Higgins AC, Jackson S, Harley R, le Roux CW, et al.. Maternal C-Reactive Protein in Early Pregnancy. Eur J Obstet Gynecol Reprod Biol (2015) 193:79–82.
13. Dockree S, Brook J, James T, Shine B, Impey L, Vatish M. Pregnancy-Specific Reference Intervals for C-Reactive Protein Improve Diagnostic Accuracy for Infection: A Longitudinal Study. Clin Chim Acta (2021) 517:81–5.
14. Yang B, Mallett, Takwoingi Y, Davenport C, Hyde C, Whiting P, Deeks J and Leeflang M. Development of QUADAS-C, a risk of bias tool for comparative diagnostic accuracy studies. OSF. 2018.
15. Hyun AH, Jeon YJ. Effect of Mat Pilates on Body Fluid Composition, Pelvic Stabilization, and Muscle Damage during Pregnancy. Applied Sciences. 2020;9111;1-13.
16. Nascimento GRS, Ferraz VS, Oliveira PMVW, Ayach W, Christofoletti G, Pegorare ABGS. Effect of Pilates exercises on blood glucose, urinary problems, sexual symptoms, pain and anxiety in women with gestational diabetes mellitus. Hum Mov. 2021;22(4):36–45.
17. Ghandali NY, Iravani M, Habibi A, Cheraghian B. The effectiveness of a Pilates exercise program during pregnancy on childbirth outcomes: a randomised controlled clinical trial. BMC Pregnancy and Childbirth. 2021;21(480):1-11
18. Kim HB, Hyun AH. Psychological and Biochemical Effects of an Online Pilates Intervention in Pregnant Women during COVID-19: A Randomized Pilot Study. Int J Environ Res Public Health. 2022 1;19(17):10931.
19. Zaman AY. Obstetric, maternal, and neonatal outcomes after Pilates exercise during pregnancy: A systematic review and meta-analysis. Medicine (Baltimore). 2023;26:102(21):e33688.
20. Canarslan B, Akbayrak T. Assessing the effects of clinical pilates exercises on the strength of abdominal muscles and diastasis recti abdominis in pregnant women. Fiz Rehabil. 2017;28(2):42-3.
21. Kim hJ, KIM J, KIM CS 2014 The effects of pilates exercise on lipid metabolism and inflammatory cytokines mRNA expression in female undergraduates. Journal of Exercise Nutrition and Biochemistry 18(3): 267-275
22. Delevatti RS, Netto N, Heberle I, Bracht CG, Santiago E, Lisboa SDC. Acute and chronic glycemic effects of aerobic training in patients with type 2 diabetes. Revista Brasileira de Atividade Física & Saúde 2018.