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THE EFFECT OF EXERCISE INTERVENTIONS ON GESTATIONAL DIABETES: A SYSTEMATIC REVIEW

EGZERSİZ MÜDAHALELERİNİN GESTASYONEL DİYABET ÜZERİNDEKİ ETKİSİ: SİSTEMATİK DERLEME

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ABSTRACT

Objective: Gestational diabetes mellitus (GDM) is the most common metabolic disease occurring during pregnancy and it has been observed that GDM rates have increased significantly worldwide in the last 20 years. It has been reported that being physically active during pregnancy is beneficial for the fetus and mother, and that exercise can be effective in preventing possible complications associated with GDM. The purpose of this systematic review is to evaluate the effects of exercise interventions on glycemic index, gestational age, obstetric and neonatal outcomes in gestational diabetes. This study was prepared according to the PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) guideline.

Materials and Methods: Articles to be included in the study; articles between 2012-2022 were searched in Web of Science, Cochrane Library, PUBMED, Scopus and Science Direct electronic databases. In the scans, the terms "gestational diabetes", "exercise" and "combined exercise", "pregnancy" or "pregnant" and "diabetes" and "exercise", and "gestational diabetes" and "exercise" and MeSH terms the keywords were used and clinical studies were filtered out.

Results: Nine randomized controlled studies with 1228 pregnant women with GDM were included in the review. As a result of the compiled randomized controlled studies, it was found that the exercise intervention in pregnant women diagnosed with GDM changed the fasting blood glucose level between 0.3-1.2 mmol and the 2-hour postprandial blood glucose level between 0.2-0.5 mmol, so exercise was an effective factor on fasting and postprandial blood sugar levels.

Conclusion: This systematic review suggests that women diagnosed with GDM can improve their physical activity motivation during pregnancy and in the prevention of complications that may arise due to glycemic management, insulin use, blood sugar level, maternal and neonatal glucose intolerance with exercise intervention. Interventions should aim to follow-up participants postpartum to understand the long-term benefits of antenatal exercise intervention.

Keywords: Blood Sugar, Diabetes, Exercise, Gestational.

ÖZET

Amaç: Gestasyonel diabetes mellitus (GDM) gebelik sırasında ortaya çıkan en yaygın metabolik hastalıktır ve son 20 yılda GDM oranlarının dünya genelinde önemli ölçüde arttığı gözlenmektedir. Hamilelik döneminde fiziksel olarak aktif olmanın fetüs ve anne için faydalı olduğu ve egzersizin GDM ile ilişkili görülebilecek olası komplikasyonları engellemede etkili olabileceği bildirilmiştir. Bu sistematik derlemenin amacı, gestasyonel diyabette egzersiz müdahalelerinin glisemik indeks, gebelik dönemi, obstetrik ve neonatal sonuçlar üzerindeki etkilerini değerlendirmektir. Bu çalışma, PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) kılavuzuna göre hazırlanmıştır.

Materyal ve Metot: Çalışma kapsamına alınacak makaleler; Web of Science, Cochrane Library, PUBMED, Scopus ve Science Direct elektronik veri tabanlarında 2012-2022 yılları arasındaki makaleler taranmıştır. Taramalarda "gestational diabetes", "exercise" ve "combined exercise", ''pregnancy'' or ''pregnant'' ve ''diabetes'' ve ''exercise'' MeSH terimleri ile "gestasyonel diyabet" ve "egzersiz" ve "kombine egzersiz", ''hamilelik'' ya da ''hamile'' ve ''diyabet'' ve ''egzersiz'' anahtar kelimeleri kullanılmış olup, klinik çalışmalar filtrelenmiştir.

Bulgular: Derlemeye 1228 GDM'li hamile kadın ile 9 randomize kontrollü çalışma dahil edilmiştir. Derlenen randomize kontrollü çalışmaların sonucunda, GDM tanısı almış gebelerde egzersiz müdahalesinin açlık kan şekeri seviyesinin 0.3-1.2 mmol, 2 saatlik tokluk kan şekeri seviyesinin de 0.2-0.5 mmol arasında değiştiği dolayısıyla egzersizin açlık ve tokluk kan şekeri seviyesi üzerinde etkili bir faktör olduğu bulunmuştur**.**

Sonuç: Bu sistematik derleme, GDM tanısı almış kadınların egzersiz müdahalesi ile glisemik yönetimi, insülin kullanımı, kan şekeri seviyesi, maternal ve neonatal dönemde glikoz intoleransına bağlı ortaya çıkabilecek komplikasyonların önlenmesinde ve gebelik döneminde fiziksel aktivite motivasyonunu iyileştirebileceğini önermektedir. Müdahaleler, doğum öncesi egzersiz müdahalesinin uzun vadeli faydalarını anlamak için doğum sonrası katılımcıları takip etmeyi amaçlamalıdır.

Anahtar Kelimeler: Diyabet, Egzersiz, Gebelik, Kan Şekeri

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INTRODUCTION

Gestational diabetes mellitus (GDM) is the most common metabolic disease occurring during pregnancy, and rates of GDM have increased significantly worldwide in the last 20 years (Colberg et al. 2013; Lawrence, 2011). Pregnancy is associated with insulin resistance and hyperinsulinemia, which may predispose some women to develop diabetes, which can lead to GDM (Mack and Tomich, 2017). GDM is defined as "glucose intolerance or hyperglycemia (high blood sugar concentration) that did not exist before pregnancy, onset or first noticed during pregnancy", which usually resolves at birth, and is one of the most common complications of pregnancy (World Health Organization [WHO], 1999). Diagnosis is usually made after an oral glucose tolerance test (OGTT) and OGTT applied to pregnant women is applied at 20-28 weeks of pregnancy, 50 or 100 g OGTT is performed after measuring the fasting blood glucose level of the pregnant (5). After 1 hour, the blood glucose level of the pregnant woman is measured again and the value gives information about the gestational diabetes status of the pregnant, the reference range of this value is between 120-180 mg/dl (American College of Obstetricians and Gynecologists [ACOG], 2013). According to White's obstetric classification, GDM is divided into two classes as A1 and A2; GDM class A1 is diagnosed when fasting plasma glucose is less than 105 mg/dL and 2-hour postprandial blood glucose is less than 120 mg/dL and can be controlled with medical nutrition therapy alone wheras GDM class A2 is defined when fasting plasma glucose is greater than 105 mg/dL and 2-hour postprandial blood glucose is greater than 120 mg/dL; it may be necessary to lower blood sugar using insulin along with medical nutrition therapy and appropriate exercise (American Diabetes Association [ADA], 2011). Management of GDM aims to reduce fasting or postprandial plasma glucose below 95 mg/dl and 2-hour postprandial blood glucose below 120 mg/dl and insulin use, medical nutrition therapy, and exercise are accepted as standard guidelines for glycemic control in pregnant women with GDM (Ballas et al. 2012; ADA,2012).

Unmodifiable risk factors associated with a diagnosis of GDM; Having a macrosomic baby with a birth weight of 4000 grams or more, diagnosed with GDM in previous pregnancies, advanced maternal age, polycystic ovarian syndrome or a history of having a first-degree relative with type 2 diabetes (Petry, 2010; Chamberlain et al., 2013; Cypryk et al., 2008)); modifiable risk factors can be listed as overweight, obesity, sedentary lifestyle and excessive weight gain during pregnancy (Kim et al.,2010; Chasan-Taber et al., 2008; Hedderson et al., 2010). GDM adversely affects both the mother's and the baby's health, and increased glucose intolerance, delayed intellectual development, diabetes, and obesity may be seen in the babies of mothers who had gestational diabetes during pregnancy (Setji et al., 2005). It is seen that maternal hypertension and preeclampsia rates and interventions for delivery such as cesarean section increase in women with GDM, and the risk of developing gestational diabetes, prediabetes (impaired glucose tolerance and impaired fasting glucose) and type 2 diabetes in the future is quite high, so, pregnant women with gestational diabetes should regularly check their blood glucose levels (Crowther et al., 2012; Kim et al., 2007). The frequency of measuring blood glucose levels of pregnant women varies according to the type of diabetes, the content of the insulin drug they use, the intensity of the complications seen, and the presence of additional chronic diseases (Odabasi et al., 2006).

It is known that behavioral and lifestyle factors as well as genetics have an effect on the development of diabetes (Wing et al., 2001). There is evidence that healthy lifestyle behaviors such as being at an ideal weight, eating healthy, exercising regularly and not smoking prevent the development of gestational diabetes (Zhang et al., 2014). It is stated that bad lifestyle behaviors increase the risk of GDM, while healthy lifestyle behaviors reduce the risk of GDM. In addition to the interventions for diabetes treatment, it is necessary for pregnant women with gestational diabetes to gain healthy lifestyle behaviors (Kim et al., 2007). Healthy lifestyle practices are protective against the negative consequences of GDM in the mother and newborn. The American Diabetes Association (ADA) expressed the importance of lifestyle practices in the treatment of diabetes in its 2014 clinical guideline recommendations. In this regard, the importance of medical nutrition therapy and physical activity was emphasized (ADA, 2012).

In the Canadian Diabetes Association (CDA) 2008 clinical practice guidelines, in the postpartum follow-up of women with GDM; advocates that they should maintain healthy lifestyle practices, lose appropriate weight, breastfeed and have their blood glucose levels measured (Canadian Diabetes Association [CDA], 2008). The American Society of Gynecology and Obstetrics (ACOG) stated in 2009 that it would be appropriate for women with GDM to be screened with Fasting Plasma

Glucose and OGTT in the postpartum period (ACOG, 2009). It is recommended that healthy lifestyle behaviors should be started before pregnancy, should be continued throughout pregnancy, and should be continued after birth to prevent diabetes (Turkish Endocrinology and Metabolism Association,2020). It is thought that physical activity plays a major role in glucose homeostasis by directly or indirectly affecting insulin sensitivity through various mechanisms. Physical activity is recommended for like all diabetic patients as well as pregnant women for prevention and treatment purposes. During pregnancy, the effects of physical activity on the digestive system, the effects on the circulatory system, the effect on weight control, the effect on endurance and increasing muscle strength are quite high (Rönö et al., 2014. It is known that being physically active during pregnancy is beneficial for the fetus and the mother and contributes to the development of aerobic capacity for the mother in the future, reduction of musculoskeletal pain, prevention of urinary incontinence, control of weight gain during pregnancy, and reduction of the risk of development of depression and it is thought that exercise during pregnancy may be effective in preventing possible complications related to GDM) (Petry, 2010). Dangerous indications for terminating physical activity during pregnancy; vaginal bleeding, dyspnea, dizziness, headache, chest pain, muscle weakness, foot pain or swelling, leakage of amniotic fluid, decreased fetal movements (Wang and Yang, 2016). In recent years, low and moderate aerobic and resistance exercises such as yoga, pilates, walking, cycling have been recommended for pregnant women and it is desirable to prevent these risks and possible pathologies that pregnant women are exposed to (Chamberlain et al., 2013). With this systematic review, it was aimed to evaluate the effect of exercise interventions in women diagnosed with GDM during pregnancy. The following questions were identified for this systematic review:

1. Is there an effect of exercise intervention in gestational diabetes?
2. Does exercise intervention have an effect on blood glucose level, gestational age, maternal and neonatal outcomes in gestational diabetes?

MATERIALS AND METHODS

This study was prepared according to the PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) guideline, which is preferred for systematic review and meta-analysis studies and used to guide the authors (Moher et al., 2015).

Search strategy

Articles to be included in the study; It has been searched in electronic databases of Web of Science, Cochrane Library, PUBMED, Scopus and Science Direct. In the scans, the terms “gestational diabetes”, “exercise” and “combined exercise”, “pregnancy” or “pregnant” and “diabetes” and “exercise”, and “gestational diabetes” and “exercise” and MeSH terms keywords “combined exercise”, “pregnancy” or “pregnant” and “diabetes” and “exercise” were used, clinical studies were filtered out (n=1427). Repetitive studies (duplications) were determined with the EndNote 20 program. The titles and summary of the studies were reviewed by the researchers, and 9 studies were included in the systematic review as shown in figure 1.

Selection Criteria for the Study

Inclusion criteria

Inclusion criteria in the systematic review were defined according to PICOS (P: Population, I: Interventions, C: Comparisons, O: Outcomes, S: Study designs) (Centre for Reviews and Dissemination [CRD], 2009):

Participants: Participants are pregnant women with gestational diabetes. There is no restriction on age, socio-economic status or ethnicity.

Interventions: Exercise as an intervention was the basis of studies in which pregnant women with gestational diabetes were taken as a model.

Comparison groups: Studies with interventional and control groups of women with gestational diabetes were included.

Results: Studies evaluating the effects of exercise interventions on gestational diabetes were included.

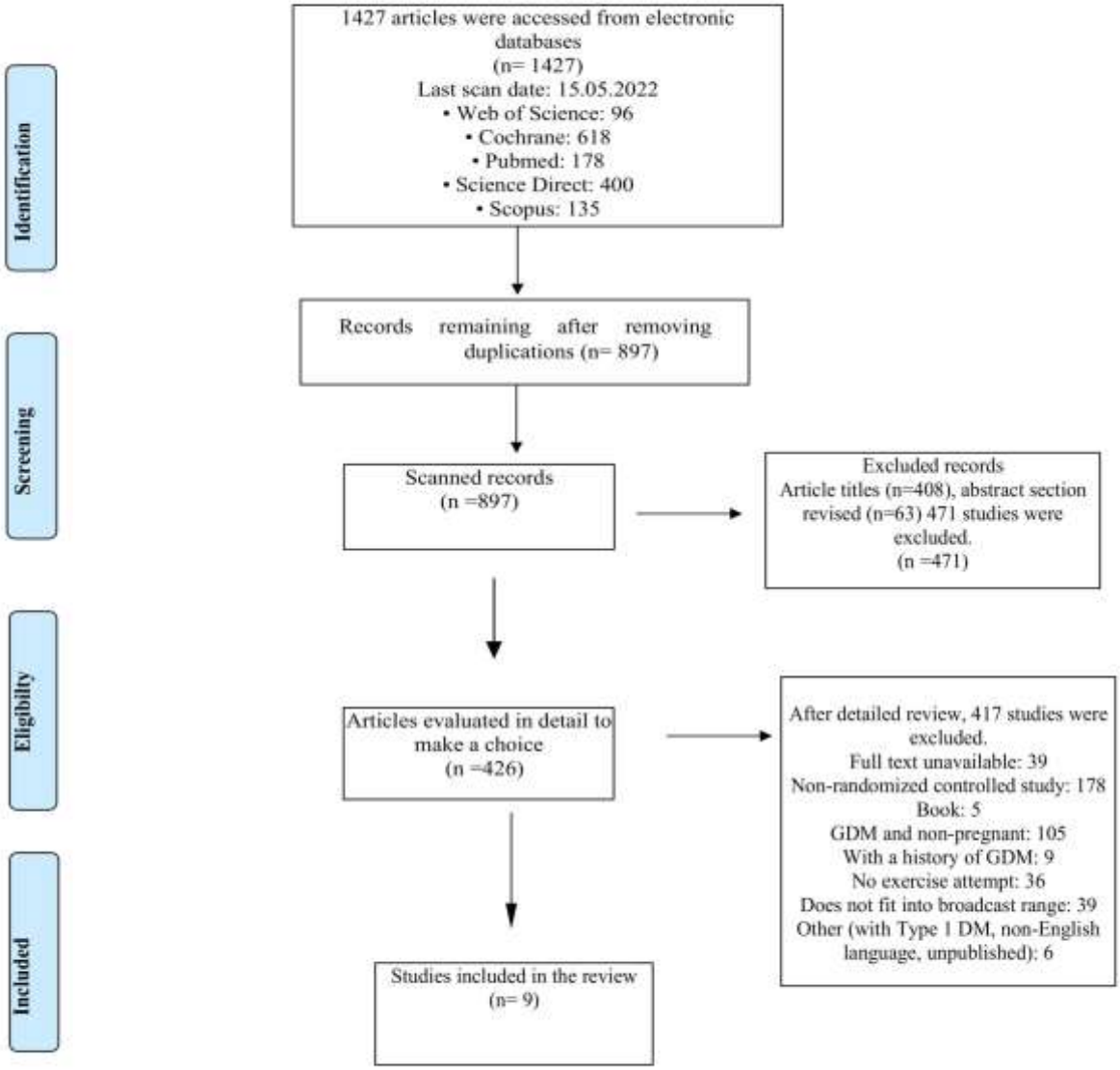
Study designs: Appropriate Randomized Controlled Studies (RCTs) were selected to reach studies with a high level of evidence. The studies included in the systematic review were RCTs, and

those whose full text was available in English, and those published between 2012 and 2022 were included.

Exclusion criteria

Case-control, cohort, quasi-experimental studies, systematic reviews and meta-analysis studies were not included in the systematic review. Studies whose consisted of pregnant women with Type 1 and Type 2 diabetes were excluded.

Figure 1: Characteristics of studies included in the review, PRISMA flow chart



Selection of Studies

In the first stage, articles between 2012-2022 were searched by entering keywords in databases (Web of Science, Cochrane Library, PUBMED, Scopus and Science Direct). The articles reached in different databases were transferred to the EndNote 20 program and repetitive studies were deleted. Studies were recorded and selected by two independent researchers over the EndNote 20 program according to the inclusion criteria for a quality evaluation. Two researchers reviewed the titles and abstracts of the articles and independently read all abstracts and classified them as either excluded or potentially included. When the abstracts are relevant to the purpose of the review, the entire article was read. The full texts of 426 studies were examined in detail by two researchers. In case of any disagreement between the researchers during these procedures, the third researcher was asked, and a consensus was reached with reference to

the inclusion criteria. The researchers included 9 articles after reading and rigorously applying the inclusion criteria. The selection process of the studies is given in figure 1 in detail in line with the PRISMA flowchart along with the numerical data.

Evaluation of the Quality of Evidence

Selected studies were independently by the researchers analyzed and evaluated for their methodological quality. The methodological quality of the studies was assessed using the PEDro scale (Maher et al., 2003). The PEDro scale aims to evaluate four key methodological aspects of a study, such as random processing, blanking technique, group comparison, and data analysis process. Verhagen et al. (Verhagen et al., 1998) PEDro scale developed by; such as specified eligibility criteria (this item is not used to calculate the PEDro score), randomization, covert location, reference comparability, study blind participants, blind therapists, blind raters, appropriate follow-up, intent-to-treat analysis, group-to-group comparisons, point estimates, and variability like is a 11-item scale and based on Delphi list. According to PEDro, Randomized Controlled Studies are graded from 1 to 10, with higher scores indicating higher methodological quality. According to this; 4 are considered "poor," 4 to 5 are "moderate," 6 to 8 are "good," and 9 to 10 are "excellent'' (Cashin et al., 2020). Test quality assessment in the PEDro database was performed separately by two researchers, and consensus was reached by consulting a third researcher in any disagreement. The following criteria were used to evaluate the quality of the method: A PEDro score of less than 5 indicates low quality and a PEDro score of 5 or higher indicates high quality (Smith et al., 2006) (Table 1).

Data Analysis

A standard data summary form was developed for the analysis of the data. In the process of selecting the data, the studies were selected by independent researchers and recorded in the form, and the studies included in the consensus were transferred to a new form. In the form of data analysis; the authors of the study, year and purpose, sample size, age and gestational week of the participants, intervention interventions, findings and results of the study were included.

Ethical Aspect of the Study

In the study, ethical permission was not required as the research articles included in the sample were obtained from accessible electronic databases and search engines. All stages of the study were carried out in accordance with the principles in the Declaration of Helsinki.

RESULTS

From electronic databases; A total of 1427 records were reached, including Web of Science (96), Cochrane (618), Pubmed (178), Science Direct (400), Scopus (135). After eliminating duplications, 897 records remained. While analyzing the article titles (408) and abstract sections (63), 471 records were extracted. Remaining of the 426 records, the full text could not be accessed (39), not randomized controlled (178), with a book chapter (5), including GDM and non-pregnant participants (105), with a history of GDM (9), no exercise attempt (36), year of publication Records that did not fit the range (39), did not fit the language, and were not published (6) were excluded. Nine randomized controlled trials that met the inclusion criteria for the purpose of the study were included in the review (Figure 1).

Features of the Study

In this review, the results of 9 articles involving 1228 pregnant women with GDM are presented in detail in Table 2. The sample size varies between 19-510 individuals. The studies included in the review were published between 2012 and 2022. The mean age of the pregnant women participating in the studies was the lowest 28.75±3.93 and the highest 35.92±5.24, the earliest gestational week is 20, and the latest is 36 weeks of gestation.

Types of intervention applied to the experimental group; low-medium-high intensity aerobic and resistance exercises, breathing, stretching, stabilization, pelvic floor exercises, yoga movements and practice times vary. Aerobic exercises; outdoor walking, bicycle ergometer, treadmill, and resistance exercises consisted of upper and lower extremity resistance exercises. Considering the duration of the sessions, it is stated that it is between 15-70 minutes depending on the exercise intensities, and it is commonly three sessions a week. In some of the studies in Table 2, only exercise was given to the

intervention group, while in some studies weight management, diet, exercise training were combined with exercise.

The studies included in the review looked at the effects of exercise interventions on glycemic index, gestational age, obstetric and neonatal outcomes in gestational diabetes.

Results Regarding Blood Sugar Levels of Exercise Interventions in Gestational Diabetes

In studies examining the effect of exercise intervention on blood sugar levels in pregnant women diagnosed with GDM; Pre- and post-intervention blood glucose levels of moderate-high-intensity aerobic exercises (treadmill, cycling, postprandial interval walking, yoga, breathing, stretching, stabilization and pelvic floor exercises), resistance exercises (lower and upper extremities) and face-to-face exercises in pregnant women It has been found to reduce fasting and postprandial blood sugar levels when compared (Andersen et al.,2021;Wu et al.,2021;Xie et al.,2022;Yaping et al.,2021;Downs et al.,2017;Qazi et al.2020; Youngwanichsetha et al.,2014).

Results of Pregnancy Period, Obstetric and Neonatal Outcomes of Exercise Interventions in Gestational Diabetes

In studies examining the effect of exercise intervention on pregnancy outcomes in pregnant women diagnosed with GDM; It has been reported that moderate-intensity aerobic and resistant exercises performed regularly during this period reduce the risk of newborns with macrosomia and cesarean delivery, and the mother's weight gain is lower (Wu et al.,2021; Halse et al., 2015; Barakat et al.,2013). Studies have shown that moderate-intensity exercise intervention in the 2nd and 3rd trimesters of pregnancy does not reduce the risk of developing GDM (Barakat et al.,2013) and it has been stated that home-based exercise program has no negative effects on maternal and neonatal pregnancy outcomes in pregnant women diagnosed with GDM (Halse et al.,2015). In another study, no difference was observed in insulin use rates between groups after aerobic and resistance exercise interventions (Barakat et al.,2013). In conclusion, studies have shown that exercise interventions have an effect on gestational diabetes in pregnant women diagnosed with GDM.

DISCUSSION

In this systematic review, in which the effect of exercise interventions on gestational diabetes in pregnant women diagnosed with GDM was investigated, 9 studies were included in the study. The studies in the compilation were conducted between 2012 and 2022 in America, China, Spain, Australia, Thailand and Pakistan. The systematic review made at the end of the fasting blood glucose level of a diagnosis of GDM in pregnant women exercise intervention 0.3-1.2 mmol, 2-hour postprandial blood glucose level of 0.2-0.5 mmol changed between, therefore the fasting and postprandial exercise on blood glucose levels was found to be an effective factor.

The American Association of Gynecology and Obstetrics and the American Diabetes Association (ADA) recommend increasing long-term physical activity and regular exercise as a lifestyle intervention in pregnant women diagnosed with GDM (ACOG,2013; ADA,2015). The details of exercise (modality, time, intensity) are very important during GDM because the diagnosis is between 24-28 weeks of pregnancy and provides an opportunity for 8-10 weeks of intervention before birth (Metzger et al.,2007; Canadian Diabetes Association [CDA],2003). In the studies included in this review (ranging from 20 to 36 weeks), participants' fasting and 2-hour postprandial blood glucose levels in the exercise intervention varied as a product of the different GDM diagnostic criteria used by the study to define a baseline.

The American Society of Sports Medicine (ACSM) and the American Society of Obstetrics and Gynecology (ACOG) recommend that pregnant women without obstetrics or medical problems engage in moderate-intensity physical activity for at least 30 minutes a day, at least three times a week, but preferably five times a week (ACOG, 2002). Again, in line with the guidelines of the ADA, it has been reported that resistance exercises (2 times a week, 2-4 sets and 8-10 repetitions) combined with aerobic exercise are highly effective on blood glucose regulation and are an important factor in lowering blood glucose. In the guide published jointly by the American Diabetes Association and the American College of Sports Medicine in 2010, it was noted that resistance exercises combined with aerobic exercise are the most effective type of exercise in blood glucose regulation (Colberg et al.,2010). In most of the studies in the review, low-moderate-high level aerobic and resistance exercise intervention was applied,

the frequency of these interventions was 2-5 days a week, during 4-8 weeks and in the range of 15-70 minutes, in the intervention groups of the studies, blood glucose levels were measured by pre-test and post-test, as a result of exercise application, significantly decreased fasting plasma glucose and glycosylated hemoglobin (HbA1c) values were observed. It can be thought that exercise has an effect on the decreases in post-tests compared to pre-test blood glucose (Table 2).

Gestational Diabetes is associated with various maternal and fetal complications in the short and long term. The Hyperglycemia and Harmful Pregnancy Outcomes (HAPO) study on the effect of hyperglycemia on pregnancy outcomes confirmed that glucose during pregnancy is associated with an increased risk for macrosomia, cesarean delivery, and neonatal hypoglycaemia rates. The cesarean section rate was found to be around 47% in macrosomic fetuses, which occur especially in cases where glucose control is not provided adequately. It is stated that the worse the control of GDM, the higher the cesarean section rate (ACOG,2000). According to Brody et al., in his study, the incidence of macrosomia in GDM is reported as 16-29%, while this rate is reported as 10% in non-GDM (Brody et al.,2003). GDM treatment has been shown to improve maternal and neonatal outcomes (Landon et al.,2009). In the study conducted by Wang et al. to determine the effect of physical activity in obese pregnants, in the early period of pregnancy (<12 weeks), the experimental group was given an average of 30 minutes of bicycle ergometry 3 days a week, and standard care was given to the control group. Both groups were compared in terms of GDM incidence, weight gain during pregnancy, gestational age, cesarean delivery, hypertensive disorders and macrosomia. The incidence of GDM and weight gain in the second trimester were found to be lower in the experimental group compared to the other group, but no difference was found in terms of gestational age, cesarean delivery, hypertensive disorders and macrosomia (Wang et al.,2016). In a study in the review, after 4 weeks of quantitative moderate-intensity exercise intervention (at least 30 minutes a day, at least 150 minutes a week) in GDM, fasting blood glucose and 2-hour postpartum blood glucose were reduced, and the rate of macrosomia delivery and cesarean section decreased (Wu et al.,2021). In another study included in the review, the risk of having a disease related to GDM, the risk of newborns with GDM-related macrosomia and cesarean delivery in the group given moderate resistance and aerobic exercises in GDM during the second and third trimesters of pregnancy was reduced, the gestational age was similar to the treatment control group and maternal weight gain was found to be lower (Barakat et al.,2013). It is thought that moderate-intensity exercises in women diagnosed with GDM may be beneficial in preventing complications that may occur due to glucose intolerance in the maternal and neonatal period by helping to provide glucose control.

In the literature, a wide variety of factors that prevent physical activity during pregnancy have been emphasized, but it has been concluded that the main obstacle is personal barriers. These; lack of motivation and time, fatigue, pregnancy discomforts (nausea, pain and discomfort due to increasing weight gain as pregnancy progresses), and safety concerns for pregnancy and their babies related to the type and intensity of activity were reported less frequently (Cramp et al.,2009; Harrison et al.,2018;Coll et al.,2017). Included in the systematic review was Halse et al. in a study she conducted, the effect of a cycling program applied at home for women diagnosed with GDM on aerobic fitness, weight gain, mobility, maternal attitudes and intentions towards exercise, as well as obstetric and neonatal outcomes was examined. The mother's aerobic fitness and attitudes and intentions towards exercise responded better to the home exercise intervention compared with the control group and a home-based exercise program had no adverse effects on maternal and neonatal pregnancy outcomes (Hlase et al.,2015), in the other, they conducted a physical activity training program to be given face-to-face in women with GDM in order to determine the motivation status, blood sugar levels and insulin initiation status of women, it was found that the group receiving face-to-face physical activity training performed more physical activity and had higher motivation than the group receiving standard care (Downs et al.,2017).

In another systematic review of patients with GDM, Cremona et al. investigated the effect of exercise on insulin sensitivity and blood glucose levels in pregnant women with GDM and compared care and exercise interventions during pregnancy in women with or without GDM risk. Interventions show that insulin therapy, dose and intervals of administration are improved in the groups that exercise (Cremona et al.,2018). In both studies included in the review, it was found that exercise interventions improved the rate of insulin use in women diagnosed with GDM. Exercise increases the activation of skeletal muscles and regulates blood glucose level (Boulinguiez et al.,2017) and we think that the rate of insulin use in women diagnosed with GDM in these studies is improved by this mechanism.

In addition to the aerobic and resistance exercise interventions recommended for GDM control during pregnancy, the evidence continues to increase in the literature showing the benefits of yoga during pregnancy, these widely evaluated evidence for pregnancy include stress, anxiety, depression, pregnancy and labor pain, sleep, and pregnancy outcomes (Babbar and Shyken,2016). In a study, it was reported that yoga exercises increase the use of glucose by muscle cells and therefore improve insulin sensitivity, and also help lower blood sugar by regulating blood circulation (Balaji et al.,2012; Kuntsevich et al.,2010). Taking part in the systematic review, Youngwanichsetha et al., in a study conducted in 2014 in which they examined the effect of mindful eating and yoga exercise on blood sugar levels in pregnant women with GDM, significantly reduced fasting plasma glucose, 2-hour satiety blood sugar and glycosylated hemoglobin values were observed in the intervention group (Youngwanichsetha et al.2014). It is believed that yoga practice has a positive effect on health through the mechanism of humoral and nervous system activity and is beneficial for lowering blood sugar through this mechanism in participants with GDM (Alexander et al.,2008).

CONCLUSION AND RECOMMENDATIONS

This systematic review suggests that women diagnosed with GDM can improve glycemic management during pregnancy, insulin use, blood sugar level, complications that may arise due to glucose intolerance in the maternal and neonatal period, and physical activity motivation during pregnancy with exercise intervention. It has been shown that aerobic exercises reduce the average blood sugar level, insulin usage dose, cesarean delivery risk, glycosylated hemoglobin level, C reactive protein values, and do not have a negative effect on maternal and neonatal outcomes. Resistant exercises and yoga have been shown to have positive effects on fasting and 2-hour postprandial blood sugar. Since our study takes a certain population as the target audience, it is important to understand the mechanisms of the exercises, to make recommendations for women with GDM, to announce the results to large masses and to understand how effective which exercise is on which parameters. It should be known that blood sugar levels being high, even to small degrees have a significant impact on pregnancy and newborn outcomes, as confirmed by the HAPO study, in future studies should focus on absolutely measuring high blood sugar levels in pregnant women. The clinical relevance of the outcome measures used should be considered. Interventions should aim to follow-up participants postpartum to understand the long-term benefits of antenatal exercise intervention.

Conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors Contributions

Plan, design: ŞY, BÜE, ARÖ; **Material, methods and data collection:** ŞY, BÜE, ARÖ; **Data analysis and comments:** ŞY, BÜE, ARÖ**; Writing and corrections:** ŞY, BÜE, ARÖ.

Table 1. Quality Evaluation of the studies included in the systematic review (n=9) with the PEDro Methodology

Reference	Eligibility Criteria *	Random Allocation	Concealed Allocation	Groups Similar at Baseline	Blind Participant	Blind Therapist	Blind Assessor	Follow-Up	Intention to Treat Analysis	Between-Group Comparisons	Point Measure and Variability	PEDro Score Total
Barakat, Ruben, et al.2013.	1	1	1	1	0	0	1	0	0	1	1	6/10
Halse, Rhiannon E., et al. 2015.	1	1	1	1	0	0	0	0	0	1	1	5/10
Yaping, Xie, et al.2021	1	1	1	1	0	0	0	1	0	1	1	6/10
Andersen, Mette B., et al. 2021.	1	1	0	1	0	0	0	1	1	1	1	6/10
Wu, Yingying, et al.2021	1	1	1	1	0	0	0	1	0	1	1	6/10
Youngwanichsetha, et al. 2014	1	1	1	1	0	0	0	1	1	1	1	7/10
Qazi, et al. 2020.	0	1	1	1	0	0	0	0	0	1	1	5/10
Yaping, Xie, et al.2021(b)	1	1	1	1	1	0	0	1	0	1	1	7/10
Downs, Danielle Symons, et al.2017.	1	1	1	1	0	0	0	1	0	1	1	6/10

* This item is not used to calculate the PEDro score total.

Table 2. Details of Randomized Controlled Trials Included in The Systematic Review

Reference	Aim	Participants (N)	Mean age ± Standard Deviation (Median/ Range)	Gestational age (week)	Intervention type	p	Results	Pedro Scale
Andersen, Mette B., et al. 2021.	Investigation of the effect of 20-minute intermittent walking after a meal on glycemic control and glycemic variability in pregnant women diagnosed with GDM.	19 with GDM 1 person knee pain 2 people found it difficult 2 people withdrew from the study due to pelvic floor pain. n:14 (one person did not complete) n:13 people analyzed.	32.4± 5.4	30-35 week gestations are included	-All participants received 4 days of intervention each with a 3-day break in between. -20 minutes postprandial interval walking 30-40 minutes after breakfast, lunch and dinner (completion no later than 60 minutes after the start of each meal) -Interval walking, alternating 3 minute slow and fast interval	Average glucose over 24-hour periods (mmol/L) day 1 (p:0.00) day 2 (p:0.01) day 3 (p:0.00) day 4 (p:0.11) Average daytime glucose (mmol/L) (6:00 AM - 22 PM) day 1 (p:0.00) day 2 (p:0.00) day 3 (p:0.00) day 4 (p:0.11)	It has been stated that 20-minute postprandial interval walking in women with GDM reduces the average daytime glucose profiles compared to the control period.	6/10
Halse, Rhiannon E., et al. 2015.	To determine the effect of a home cycling program on aerobic fitness, weight gain, mobility, attitude and maternal intentions towards exercise and obstetric and neonatal outcomes for women with a recent GDM diagnosis.	40 women with GDM Exercise group (n:20) Control group (n:20)	Control group: 32±3 Exercise group: 34± 5	26-30 weeks of gestation are included.	In addition to unsupervised exercise sessions two days a week, the exercise group received supervised home-based exercise sessions three days a week. Each session, 5 minutes of low intensity (55-65% HRmax); Warm-up on the cycle ergometer, followed by a 65%-75% HRmax conditioning period and intervals of 15 to 60 sec bouts of higher intensity (75%-85% HRmax), lastly lower intensity (55%-65% HRmax) for recovery. (6 weeks)	There were no differences between groups in terms of maternal weight gain or obstetric and neonatal outcomes (p > 0.05). Mother's aerobic fitness and attitudes and intentions towards exercise were better than the control group (p<0.05).	A 6 ± 1 week home-based exercise program initiated after the diagnosis of GDM can improve aerobic fitness and attitudes and intentions towards exercise with no adverse effects on maternal and neonatal pregnancy outcomes.	5/10

Wu, Yingying, et al.2021	To explore the application of a diversified and quantitative management model of exercise intervention in GDM.	150 women with GDM 12 participants did not continue the study. Exercise group (n:68) Control group (n:70)	Control group: 28.77 ±4.01 Exercise group: 28.75±3.93	24-28 week gestations are included	Control group: Routine exercise and health education during pregnancy. Exercise group: Multiple 4-week quantitative moderate-intensity exercise interventions with training (at least 30 minutes per day, at least 150 minutes per week).	P-ESES p<.001 Fasting blood glucose p:0.012 2 hour postpartum blood sugar P: 0.001	In the exercise group, there was an increase in the pregnancy exercise self-efficacy scale score, overcoming movement disorder, overcoming emotional disorder and overcoming support disorder scores significantly improved, fasting blood sugar and 2-hour postpartum blood sugar levels decreased, and the rate of macrosomia birth and cesarean section decreased.	6/10
Barakat, Ruben, et al.2013.	To examine the effect of regular moderate-intensity exercise on the incidence of GDM (primary outcome) and the association of exercise intervention with GDM on birth weight and risk of macrosomia, gestational age, risk of cesarean delivery, and maternal weight gain (secondary outcomes).	510 women with GDM 82 participants did not continue the study. Exercise group(n:210) Control group(n:218)	Control group: 31±4 Exercise group: 31±3	24-26 week gestations are included	Control group: Advice on the positive effects of physical activity, regular visits to midwives, obstetricians and family doctors, exercise on their own. Exercise group: Moderate-intensity resistance and aerobic exercises (three times a week, 50-55 min/session) in a trained manner.	Risk of newborns with macrosomia (p=0.013) Risk of cesarean section (p=0.058) Exercise-GDM risk (p=0.63)	It has been shown that supervised, moderate-intensity exercise intervention three times a week during the second and third trimesters of pregnancy does not reduce the risk of developing GDM. In the exercise group; The risk of having a GDM-related disease, the risk of having a newborn with GDM-related macrosomia, and having a cesarean delivery was reduced, and the gestational age was similar in the treatment groups. Maternal weight gain was found to be lower.	6/10

Yaping, Xie, et al. 2021	To investigate the effects of structured moderate-intensity aerobic exercise on blood sugar, insulin and pregnancy outcomes in women with GDM.	N: 101 women with GDM 12 participants did not continue the study Exercise group (n:43) Control group (n:46)	Control group: 31.35 ± 4.72 Exercise group: 31.47 ± 4.06	24-31 week gestations are included	Control group: Diet, online education and routine prenatal care Exercise group: 6 weeks of moderate-intensity aerobic exercise (50-60 min) in addition to the same conditions given to the control group.	Fasting blood glucose (p=0.000) 2-hour postprandial blood glucose (p=0.000) Insulin dose (p=0.031) Insulin use rate (p=0.02)	Compared to pre-intervention, a significant difference was found in fasting blood glucose and 2-hour blood glucose after three meals in both groups, A significant difference was found in the average fasting blood sugar, average 2-hour postprandial blood sugar, insulin dose and usage rate between the experimental and control groups after the intervention. All parameters in the exercise group are lower than the control group. Moderate aerobic exercise may help improve blood sugar control and insulin use in patients with GDM.	6/10
Xie, et al. 2021	Effects of resistance exercise on blood glucose levels and pregnancy outcomes in women with gestational diabetes.	100 pregnant women with GDM (8 people in the aerobic exercise group and 6 people in the resistance exercise group did not continue the exercise program.) Aerobic exercise group (n=43) Resistant exercise group (n=43)	20-40 years Aerobic exercise group (31.47±4.06) Resistive exercise group (31.84±5.19)	24-31 week gestations are included	It was applied 3 days a week, 50-60 minutes a day, for 6 weeks, 2 sets of 2 repetitions in the first 2 weeks, 2 sets of 3 repetitions in the 3rd week, and 2 sets of 4 repetitions after the 4th week. Aerobic exercise group: They performed walking, neck and arm stretching exercises, and lower extremity aerobic exercises. Resistive exercise group: Performed resistance exercises for upper and lower extremities	Fasting blood glucose p=0.031 2-hour postprandial blood glucose p=0.000	Fasting and postprandial blood sugar levels decreased in both groups after exercise. Postprandial blood sugar and exercise compliance were found to be significant in the resistant exercise group.	7/10

Downs, et al. 2018.	Evaluation of the effects of theory-based, face-to-face and home exercise intervention for the control group on exercise and motivational determinants, blood glucose levels and insulin use.	65 pregnant women with GDM (6 participants from the control group, 9 participants from the home exercise group, and 9 participants from the face-to-face exercise group did not continue the exercise program.) Control group (n=15) Home exercise group (n=13) Face-to-face exercise group (n=13)	Pregnant women who were at least 18 years old were included. Control group (32±3) Home exercise group (33±5) Face-to-face exercise group (32±5)	Gestations of at least 20 weeks' gestation were included.	The use of pedometers was recommended for all groups. Home exercise group: Once every 2 weeks, participants were encouraged to exercise on their own in a 45-minute telephone session. Face-to-face exercise group: 2 days a week, moderate-intensity aerobic exercise (treadmill, bicycle, etc.), 70 minutes of exercise a day.	Exercise-blood sugar (p=0.02)	Face-to-face exercise programs resulted in greater reductions in weekly fasting and postprandial blood sugar levels than other groups. Participants in the face-to-face group started using insulin at a later week of gestation than participants in the control and home exercise groups. Face-to-face exercise programs were effective in improving exercise motivation behavior in pregnant women with GDM.	6/10
Youngwanichsetha et al. 2014.	To investigate the effect of mindful eating and yoga exercise on blood sugar levels in pregnant women with GDM.	189 pregnant women with GDM 29 participants did not continue the study. Intervention group (n=80) Control group (n=80)	Intervention group (32.58±5.01) Control group (31.24±4.54)	24-30 week gestations are included	For 8 weeks, 5 days a week, 15-20 minutes of yoga exercises per day were applied as 10 repetitions of each posture. Intervention group: Deep breathing techniques, posture and movement exercises	Fasting plasma glucose (p=0.012) 2-hour postprandial plasma glucose (p=0.001) HbA1c (p=0.016)	Significantly reduced fasting plasma glucose, 2-hour postprandial blood glucose, and glycosylated hemoglobin (HbA1c) values were seen in the intervention group. Yoga exercises had positive effects on glycemic control in pregnant women with GDM.	7/10

Qazi, et al. 2020	To evaluate the effects of structured exercise regimen on glycosylated hemoglobin and C-reactive protein in women with gestational diabetes.	54 pregnant women with GDM 4 participants did not continue the study. exercise group (n=25) control group (n=25)	20-40 years old intervention group (34.36±5.21) control group (35.92±5.24)	20-36 week gestations are included	It was applied 2 days a week for 5 weeks and 40 minutes a day. Exercise group: Moderate intensity aerobic, stabilization (10 repetitions) and pelvic floor muscle exercises (20 repetitions) were applied. Along with exercise, diet and medical treatment intervention program were also applied. Control group: Diet, medical treatment and posture training were applied.	HbA1c (p=0.002) CRP (p=0.001)	Structured exercise regimen helped to lower glycosylated hemoglobin and C-reactive protein values in patients with gestational diabetes.	5/10

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