Taylor & Francis
Taylor & Francis Group

Journal of Obstetrics and Gynaecology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ijog20

The effect of gestational diabetes mellitus on occurrence of the pelvic girdle pain and symptom severity in pregnant women

Nilüfer Kablan, Habibe Ayvacı, Merve Can, Yaşar Tatar, Pınar Kumru & Sadık Şahin

To cite this article: Nilüfer Kablan, Habibe Ayvacı, Merve Can, Yaşar Tatar, Pınar Kumru & Sadık Şahin (2022) The effect of gestational diabetes mellitus on occurrence of the pelvic girdle pain and symptom severity in pregnant women, Journal of Obstetrics and Gynaecology, 42:6, 2058-2063, DOI: 10.1080/01443615.2022.2081491

To link to this article: https://doi.org/10.1080/01443615.2022.2081491

JOURNAL OF OBSTETRICS AND GYNAECOLOGY
2022, VOL. 42, NO. 6, 2058–2063
https://doi.org/10.1080/01443615.2022.2081491

Taylor & Francis
Taylor & Francis Group

RESEARCH ARTICLE

The effect of gestational diabetes mellitus on occurrence of the pelvic girdle pain and symptom severity in pregnant women

Nilüfer Kablan[a], Habibe Ayvacı[b], Merve Can[c], Yaşar Tatar[d], Pınar Kumru[b] and Sadık Şahin[b]

[a]Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İstanbul Medeniyet University, Istanbul, Turkey; [b]Ministry of Health, Zeynep Kamil Women and Pediatric Training and Research Hospital, Istanbul, Turkey; [c]Plato Vocational School, Department of Physiotherapy and Rehabilitation, Ayvansaray University, Istanbul, Turkey; [d]Faculty of Sports Sciences, Marmara University, Istanbul, Turkey

ABSTRACT

The primary objective of this study was to examine the effect of gestational diabetes mellitus (GDM) on pelvic girdle pain (PGP) occurrence and symptom severity. Pregnant women who were with/without GDM, 20–40 years of age, and also in the second and third trimesters of pregnancy were included in the study. PGP provocation tests were administered to 187 pregnant women to determine the presence and severity of PGP. Based on the test results, the study subjects were divided into two groups; Group 1 (GDM+, PGP+; n:32) and Group 2 (GDM−, PGP+; n:35). Both groups were asked to fill in the Pelvic Girdle Questionnaire (PGQ). The relationship between the presence of GDM and the presence of PGP was found to be significant ($p = .043$). It was found the groups were similar in view of pain, and also in PGQ total/subscale scores ($p > .05$). Although GDM has no effect on symptom severity, it has been determined that it may relate to the development of PGP. Therefore, early interventions (nutrition, exercise, belt using, etc.) are recommended to prevent the development of PGP in pregnant women with a family history of diabetes, with a previous diagnosis of diabetes and/or with GDM detected in their previous pregnancies.

Clinical Trial Number: 04769375

IMPACT OF STATEMENT

- **What is already known on this subject?** Gestational diabetes mellitus and pelvic girdle pain are pathologies that develops secondary to pregnancy-related systemic and biomechanical changes.
- **What do results on this study add?** GDM may related the development of PGP.
- **What are the implications of these findings for clinical practice and/or further research?** Early interventions (nutrition, exercise, belt using, etc.) and strict control of pregnant women in view of PGP is recommended to prevent the development of PGP in pregnant women with a family history of diabetes, with previous diagnosis of diabetes and/or with GDM detected in their previous pregnancies. The evaluation of pregnant women for PGP before administering interventions, such as exercise and diet (both decrease the pro-inflammatory markers), following the diagnosis of GDM and the measurement of plasma anti- and pro-inflammatory marker values in the same time period will further reveal the relationship between GDM and PGP.

KEYWORDS
Gestational diabetes mellitus; GDM; pelvic girdle pain; PGP; pregnancy

Introduction

A sequence of adaptations related to systemic and biomechanical changes occurs in pregnancy, which is a natural process; however, these changes may lead to the development of secondary pathologies in some cases. Gestational diabetes mellitus (GDM), is one of the most common metabolic disorders during pregnancy and affects 9%–26% of all pregnancies (Sacks et al. 2012). It has been defined as glucose intolerance with onset (Dirar and Doupis 2017) or first recognition during pregnancy (Challis et al. 2009). GDM results from insulin resistance developing despite the increasing insulin demand that occurs as the foetus grows (Dirar and Doupis 2017). It has been reported that, in addition to increased diabetogenic hormone secretion from the placenta, decreased adipokine secretion in parallel with maternal weight gain and increased secretion of adipocytokines, such as tumour necrosis factor α (TNF-α), play a role in the development of insulin resistance (Dirar and Doupis 2017). Moreover, it was determined that, along with the increased insulin resistance in most pregnant women with GDM, the pancreatic β cells are unable to secrete sufficient amounts of insulin, and thus contribute to the development of hyperglycaemia (Challis et al. 2009). This condition is usually diagnosed at 24–28 weeks of gestation during which placental lactogen secretion rises (Woodside and Bradford 2021) and it has been observed that glucose intolerance returns to normal postpartum in the majority of the cases (Coustan et al. 2010).

CONTACT Nilüfer Kablan niluferkablan@yahoo.com İstanbul Medeniyet University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Istanbul/Turkey

The inflammatory process observed in normal pregnancy, along with an increase in maternal adipose tissue (Challis et al. 2009), has been reported to be similar to that observed in T2DM and obesity (Shoelson et al. 2007; Challis et al. 2009). Normal pregnancy has been defined as an inflammatory process due to the physiological adaptations that occur in the maternal immune system to prevent rejection of the developing foetus. Similarly, cytokine secretion varies even in pregnancies without any complications, and this consequently contributes to the inflammatory process by disrupting the balance between pro- and anti-inflammatory cytokines (Challis et al. 2009). In addition to the role of pro-inflammatory cytokines such as TNF-α and IL-6 in the pathophysiology of GDM, which act by increasing insulin resistance (Abell et al. 2015), it has been determined that hyperglycaemia-induced inflammatory process and oxidative stress cause an elevation in TNF-α and IL-6 levels (Briana and Malamitsi-Puchner 2009). In other words, while pro-inflammatory markers contribute to the development of GDM, the presence of GDM appears to be a factor that further triggers the inflammatory process in pregnant women (Fasshauer et al. 2014).

Pelvic girdle pain (PGP) is another pathologic condition that develops secondary to pregnancy-related systemic and biomechanical changes. It is another one of the common musculoskeletal disorders associated with pregnancy and is estimated to affect 10%–65% of pregnant women (Kovacs et al. 2012; Owe et al. 2016). It is characterised by pain between the glutaeal line and the posterior iliac crest, especially intense in the sacroiliac joints (SIJ), and in some cases, involves the symphysis pubis (Vleeming et al. 2008). Although its aetiology and pathophysiology have not been fully understood, it is believed that PGP may result from increased mobility in the SIJ in response to hormonal and biomechanical changes (Vleeming et al. 2008; Aldabe et al. 2012). Meijer et al. (2020) have reported that repetitive microtrauma caused by increased loading due to biomechanical changes may trigger local inflammation and be the factor that initiates PGP.

Although the manifestation of GDM and PGP occur in similar time periods, these two factors have been studied separately. The fact that the onset of PGP, which is frequently detected after week 18 of pregnancy (Vleeming et al. 2008), is parallel to the onset of GDM and that both pathologies are associated with the inflammatory process raises the question of whether GDM has an impact on the manifestation of PGP. Accordingly, to the best of our knowledge, the effect of the coexistence of two different factors that trigger inflammation-induced pain on symptom severity in pregnant women has not been investigated yet. Hence, this study aimed to examine the effect of GDM on PGP occurrence and symptom severity. We hypothesised that the presence of GDM is both related to the occurrence of PGP and increases its severity.

Material and methods

Study design and participants

This cross-sectional study was conducted between April and August 2021, at the Department of Obstetrics and Gynaecology in Zeynep Kamil Women and Paediatric Training and Research Hospital. Pregnant women who were 20–40 years of age and diagnosed as having GDM for the first time as well as those who did not have GDM, were in second and third trimesters of pregnancy, and had a physically inactive lifestyle were included in the study. The exclusion criteria included developing diabetes before pregnancy as well as having orthopedic/neurological problems that may cause biomechanical alignment deviations; chronic lumbopelvic pain history before pregnancy; pregnancy-related complications; and history of spine, pelvis, or lower extremity fractures/operation in the previous 6 months. Prior to the assessment, the pregnant women were informed about the aim and content of the study, and signed consent was obtained from all the participants.

In the study, 200 pregnant women were evaluated, and demographic (age, height, weight, weight gain, BMI, etc.), clinical (GDM diagnosis, low back/pelvic trauma/chronic pain history, dyshernia, spinal stenosis, ankylosing spondylitis, etc.), and pregnancy-related (number of pregnancies, gestational week, and presence of pregnancy-related complications) data were recorded. Twelve pregnant women with pregnancy-related complications and one pregnant woman with a history of pain related to disc herniation were excluded from the study. PGP provocation tests were administered to 187 pregnant women to determine the presence and severity of PGP. Based on the results of the tests, the pregnant women were divided into two groups Group 1 (GDM+, PGP+; n:32; mean age:31.41 ± 5.47 years) and Group 2 (GDM−, PGP+; n:35; mean age:27.71 ± 5.02 years). Following pain assessments, both groups were asked to fill in the Pelvic Girdle Questionnaire (PGQ) (Figure 1).

Pain assessment

The intensity of pain felt in the pelvis during activities of daily living (P-ADL) and prolonged sitting/standing (P-PSS) was evaluated using the Visual Analog Scale (VAS). The participants were asked to mark the level of their current pain status on a scale ranging from no pain (0) to worst pain imaginable (10) (Bertuit et al. 2018).

PGP provocation tests

To detect the presence of PGP, (a) Posterior Pelvic Pain Provocation (P4); (b) Patrick FABER; and (c) Modified Trendelenburg tests were performed bilaterally, and each of the test results was recorded to be positive if the pain was felt in the relevant region during the test. Symphsis Pubis Palpation test (d) was administered as pain palpation provocation test. The test was considered positive in the presence of pain with palpation that lasted for at least 5 seconds after the removal of palpation pressure. The degree of difficulty that may be experienced due to PGP was investigated using the Active Straight Leg Raise test (e). The test was accepted positive if the degree of difficulty experienced while performing the test was 2 or more. The diagnosis of PGP was based on one of the (a) and (e) tests being positive for the right/left or both sides and at least one of the (b), (c), and (d) tests

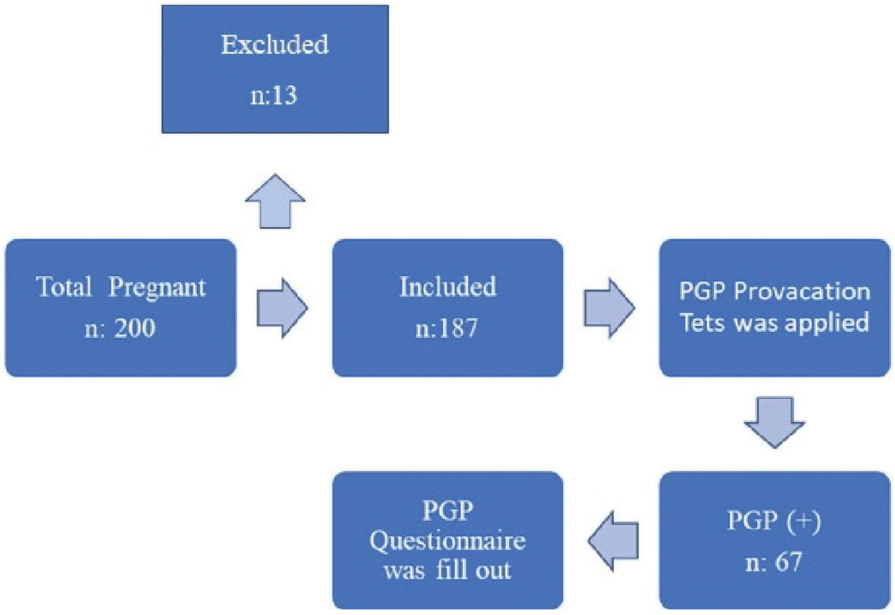

Figure 1. Flowchart of the study.

being positive. Pain intensity experienced in all tests was evaluated using the VAS and recorded (Vøllestad and Stuge 2009; Elden et al. 2016).

PGQ

The PGQ questionnaire was filled in following face-to-face interviews with the pregnant women. The PGQ was developed by Stuge et al. (2011) to evaluate the quality of life of pregnant women with PGP. The cultural adaptation, validity, and reliability of the Turkish version of the scale were done by Yelvar et al. (2019). The questionnaire consists of the PGQ-Activity subscale, which includes 20 questions to investigate the degree of difficulty experienced due to pain during activities of daily living, and of the PGQ-Symptom Subscale, which includes 5 questions that examine the severity of pain felt at different times of the day. Questions 1–20 and 22–25 in the questionnaire are rated as not at all (0), very little (1), somewhat (2), and to a great extent (3), and the 21st and 22nd questions are rated as none (0), a little (1), moderate (2), and quite a bit (3) on a 4-point Likert Scale. A high score indicates that activities of daily living are highly affected by PGP.

Ethical approval

Ethics committee approval was obtained from the Clinical Research Ethics Committee of Zeynep Kamil Women and Paediatric Training and Research Hospital, (03.02.2021/31). A clinical Trial record was obtained (NCT 04769375). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Statistical analysis

Based on a similar study, (Evensen et al. 2016) the sample size was determined using the G*Power 3.1.9.2 (Kiel University, Kiel, Germany), and the minimum number of pregnant women with PGP for each group was calculated as 32 (0.07 effect size, $\alpha = 0.05$, 85% power). Sixty-seven pregnant women were evaluated against the possibility of dropout rate, and the study was completed with a total of 67 pregnant women.

In this study, all statistical analyses were performed using IBM SPSS for Windows (Version 22.0. Armonk, NY:IBM Corp.). The level of significance was set at $p \leq .05$. Descriptive statistics (mean and standard deviation) were used to describe the groups. The normal distribution of the data was examined using the Shapiro–Wilk test. Data were also examined and accepted as being sufficiently normal if the skewness and kurtosis were within the range of −2 to +2. The independent t-test was used for between-group comparisons for normally distributed data, and the Mann–Whitney U test was used for assessing data that did not show normal distribution. The difference between qualitative/categorical variables was analysed using the Pearson Chi-Square test (χ^2). Fisher's Exact Test was used when the χ^2 test was not valid based on the observed and expected values.

Results

The relationship between the presence of GDM and the presence of PGP was found to be significant ($p = .043$). The distribution of the pregnant women in terms of the presence of GDM and PGP and the number of pregnancies is shown in Figure 2.

Although the groups were similar in terms of height, weight, weight gain during pregnancy, pre-pregnancy/pregnancy BMI, and gestational week, age ($p = .005$) and the number of pregnancies ($p = .032$) were found to be significantly different between the groups (Table 1).

Only three pregnant women were found to have smoked before pregnancy (1 from Group 1; 2 from Group 2). It was determined a total of 7 pregnant women (n:4 in Group 1; n:3 in Group 2) had experienced PGP in a previous pregnancy.

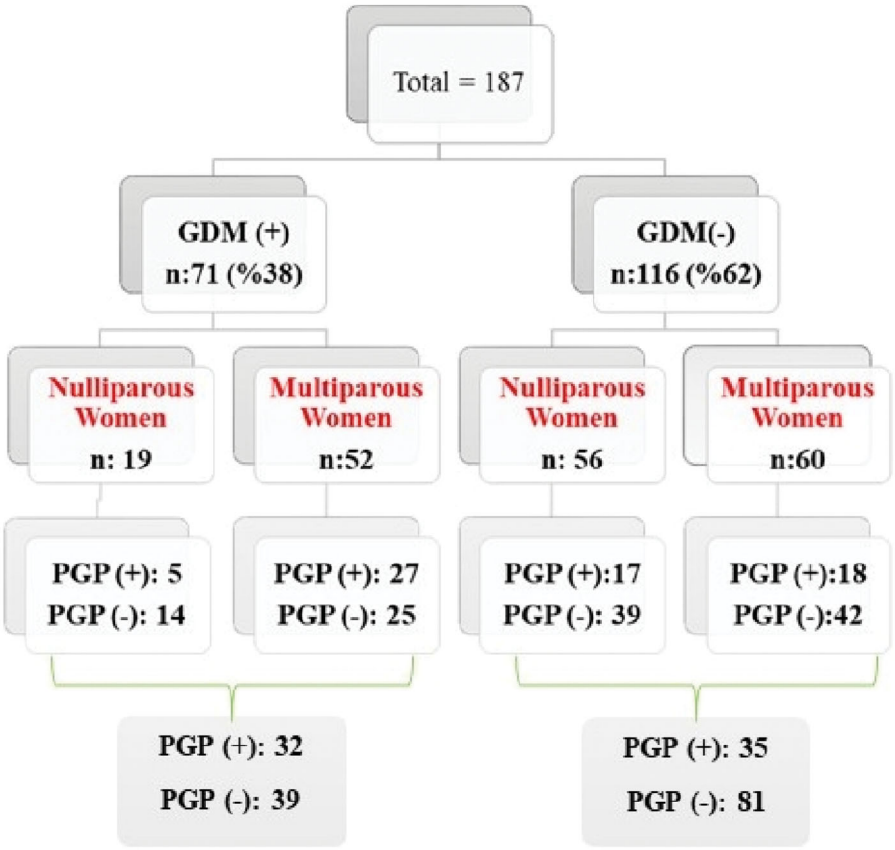

Figure 2. Distribution of pregnant women.

The blood sugar of all pregnant women with GDM was regulated (by diet, n: 23; by insulin, n:9).

It was determined that % distribution and pain intensity on PGP provocation tests with positive findings were similar between the groups ($p > .05$) (Table 2).

P-ADL and P-PSS values did not differ significantly between the groups ($p > .05$). The difference between the groups in PGQ total and subscale scores was not found to be significant ($P > .05$) (Table 3).

Discussion

In the present study, we investigated the effect of GDM on the development of PGP and its symptom severity and found that GDM may trigger the development of PGP but had no effect on symptom severity.

The fact that pregnancy-related characteristics were generally similar between the groups has shown that the risk factors that may lead to the development of PGP have no distinctive effect on the outcome. There are different opinions on the effect of the number of pregnancies, which differed significantly between the groups, on the development of PGP. The consensus is that the number of pregnancies does not pose a risk factor for the development of PGP (Wu et al. 2004; Albert et al. 2006; Vleeming et al. 2008; Walters et al. 2018)

The presence of a relationship between inflammation and insulin resistance has been established. Although low-grade inflammation is present in normal pregnancy (Barbour et al. 2007), TNF-α and IL-6, the major biological markers of inflammation, were found to be significantly increased in pregnant women with GDM (Nergiz et al. 2014; Korkmazer and Solak 2015) Similarly, it has been reported that increased mechanical stress on the joints stimulated cytokine release (IL-1β, IL-6, and TNF-α) (Stannus et al. 2010) and a low-grade inflammatory process progresses and increases pain sensitivity following microtrauma (Pinho-Ribeiro et al. 2017). In this study, although PGP was observed in 30% of pregnant women with normal glucose levels, it was observed in 45% of pregnant women with GDM, suggesting that the inflammatory process caused by GDM combined with microtrauma-derived inflammation and related to the PGP manifestation. The significant correlation between the presence of GDM and the presence of PGP in this study supports this conclusion. Both the findings have confirmed our first hypothesis.

When the BMI values of the groups were examined, both the groups were found to be in the overweight (GDM+:27.07 ± 5.21; GDM−:25.55 ± 5.53/25 − 29.9) category before pregnancy; however, during pregnancy, the second group maintained its overweight (29.65 ± 4.87/25–29.9) status, but the GDM group shifted the obesity category (30.94 ± 5.72/30 − 34.9) (Kim et al. 2010). It has been reported that stress conditions, such as obesity, cause an elevation in the number of macrophages that secrete pro-inflammatory cytokines (TNF-α, IL-6, IL-1β) in the adipose tissue; decrease the release of adiponectin, an anti-inflammatory marker; and stimulate insulin-sensitivity (Galic et al. 2010) Tashani et al. (2017) found that obese people were more sensitive to blunt pressure

Table 1. Demographic and descriptive characteristics of the participants.

Groups	Age (year) mean ± SD	Height (cm) mean ± SD	Weight (kg) mean ± SD	W.G. (kg) mean ± SD	Pre-BMI kg/cm^2 mean ± SD	BMI kg/cm^2 mean ± SD	Parity Num. mean ± SD	Preg. Week mean ± SD
Group 1 (n:32)	31.41 ± 5.47	161.57 ± 6.53	80.90 ± 15.90	10.68 ± 7.31	27.07 ± 5.21	30.94 ± 5.72	2.72 ± 1.32	32.47 ± 3.67
Group 2 (n:35)	27.71 ± 5.02	161.58 ± 6.05	76.62 ± 14.91	10.48 ± 4.84	25.55 ± 5.53	29.65 ± 4.87	2.03 ± 1.24	29.97 ± 6.53
P	**0.005**	0.995	0.260	0.894	0.266	0.338	**0.032**	0.056

Group 1: GDM(+), PGP(+); Group 2: GDM(−), PGP (+); GDM: Gestational Diabetes Melllitus; W.G: Weight Gain.
BMI: Body Mass Index; Parity Num: Parity Number; Preg. Week: Pregnancy Week; P: Independent *T* test. $P \leq .05$.

Table 2. Frequency and pain intensity of positive response tests of participants.

		Group 1 (n:32)		Group 2 (n:35)			
Parameters	Side	%	Mean ± SD	%	Mean ± SD	*P*	*P**
Pelvic Pain Provocation (P4) Test	Right	62.5	3.68 ± 2.08	51.4	4.56 ± 2.52	.461	.259
	Left	46.9	4.64 ± 2.30	62.9	4.45 ± 2.24	.225	.809
Patrick Faber Test	Right	46.9	3.50 ± 2.24	31.4	4.00 ± 2.14	.219	.578
	Left	34.4	3.40 ± 1.83	51.4	3.89 ± 2.13	.218	.549
Modifiye Trendelenburg Test	Right	31.3	4.67 ± 1.50	32.4	4.64 ± 2.61	1.000	.976
	Left	40.6	4.92 ± 2.57	38.2	4.38 ± 2.72	1.000	.620
Active Straight Leg Rise Test	Right	34.4	1.00 ± 1.36	45.7	1.20 ± 1.15	.455	.519
	Left	37.5	1.19 ± 1.27	25.7	0.82 ± 1.04	.430	.206
Symphsis Pubis Palpation Test	–	34.4	4.64 ± 2.29	37.1	3.42 ± 2.23	1.000	.211

Group 1: GDM(+), PGP(+); Group 2: GDM(−), PGP (+); GDM: Gestational Diabetes Melllitus; *P*: Chi-Square; *P**: Indepented *T* test; $p \leq .05$.

Table 3. Pain intensity and PGQ scores of participants.

	Group 1 (n:32)	Group 2 (n:35)	
Parameters	Mean ± SD/Median (min-max)	Mean ± SD/Median (min-max)	*P*
P-DLA	6.06 ± 2.60	5.23 ± 2.78	.211
P-PSS	8 (0–10)	7 (4–10)	.569*
PGQ-Activity (%)	51.82 ± 18.24	57.10 ± 16.10	.216
PGQ-Symptoms (%)	62.29 ± 19.93	55.68 ± 17.59	.158
PGQ-Total (%)	54.00 ± 17.71	57.21 ± 15.89	.440

Group 1: GDM(+), PGP(+); Group 2: GDM(−), PGP (+); GDM: Gestational Diabetes Melllitus.
P-DLA: Pain-Daily Life Activities; P-PSS: Pain-Prolonged Sitting/Standing; PGQ: Pelvic Girdle Questionnaire.
P: Independent *T* test; *: Mann Whitney *U* test; $p \leq .05$.

pain than non-obese people. It has been reported that obesity increases nociceptor sensitivity by stimulating the release of pro-inflammatory markers (McVinnie 2013). From this point of view, the higher rate of PGP in the GDM group may also be a result of the obesity-associated inflammatory process in this group.

Considering the inflammatory processes associated with pregnancy, obesity, and GDM, the severity of pain in PGP provocation tests were expected to be higher and, accordingly, the degree of difficulty in daily living activities would be higher in pregnant women with GDM. However, the findings do not confirm our hypothesis at this point. Both the groups declared that they could not participate in physical activity due to PGP, which shows that they did not benefit from the exercise-induced reduction in pro-inflammatory markers (Hayashino et al. 2014; Woodside and Bradford 2021). On the other hand, the implementation of a nutrition program in the GDM group following the diagnosis may have resulted in a decrease in the severity of pain by causing a decrease in the rate of secretion of inflammatory markers until the study period.

This study has some limitations. We are of the opinion that studies with a larger sample size will produce more comprehensive results in detecting the effect of GDM on the occurrence of PGP. In addition, the evaluation of pregnant women for PGP before administering interventions, such as exercise and diet (both decrease the pro-inflammatory markers), following the diagnosis of GDM and the measurement of plasma anti- and pro-inflammatory marker values in the same time period will further reveal the relationship between GDM and PGP. Measuring the pressure-pain threshold in palpation provocation tests with a digital algometer will provide more objective data on the impact of GDM on nociceptor sensitivity.

In conclusion, although GDM has no effect on symptom severity, it has been determined that it may relate the development of PGP. Therefore, early interventions (nutrition, exercise, belt using, etc.) and close antenatal supervision of pregnant women at risk in view of PGP are recommended to prevent the development of PGP in pregnant women with a family history of diabetes, with previous diagnosis of diabetes and/or with GDM detected in their previous pregnancies.

Ethical approval

The study was approved (03.02.2021/31) by the Ethical Committee of Zeynep Kamil Women and Paediatric Training and Research Hospital and all participants provided written informed consent.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Nilüfer Kablan http://orcid.org/0000-0002-3135-4608
Habibe Ayvacı http://orcid.org/0000-0002-8517-0556
Merve Can http://orcid.org/0000-0001-9824-4377
Yaşar Tatar http://orcid.org/0000-0001-6815-301X
Pınar Kumru http://orcid.org/0000-0002-8905-1909
Sadık Şahin http://orcid.org/0000-0002-7107-9719

References

Abell SK, Courten BD, Boyle JA, Teede HJ. 2015. Inflammatory and other biomarkers: role in pathophysiology and prediction of gestational diabetes mellitus. International Journal of Molecular Sciences 16: 13442–13473.

Albert HB, Godskesen M, Korsholm L, Westergaard JG. 2006. Risk factors in developing pregnancy-related pelvic girdle pain. Acta Obstetricia et Gynecologica Scandinavica 85:539–544.

Aldabe D, Milosavljevic S, Bussey MD. 2012. Is pregnancy related pelvic girdle pain associated with altered kinematic, kinetic and motor control of the pelvis? A systematic review. European Spine Journal 21: 1777–1787.

Barbour LA, McCurdy CE, Hernandez TL, Kirwan JP, Catalano PM, Friedman JE. 2007. Cellular mechanisms for ınsulin resistance in normal pregnancy and gestational diabetes. Diabetes Care 30:S112–S119.

Bertuit J, Van Lint CE, Rooze M, Feipel V. 2018. Pregnancy and pelvic girdle pain: analysis of pelvic belt on pain. Journal of Clinical Nursing 27: e129–e137.

Briana DD, Malamitsi-Puchner A. 2009. Reviews: adipocytokines in normal and complicated pregnancies. Reproductive Sciences 16:921–937.

Challis JR, Lockwood CJ, Myatt L, Norman JE, Strauss JF, Petraglia F. 2009. Inflammation and pregnancy. Reproductive Sciences 16: 206–215.

Coustan DR, Lowe LP, Metzger BE, Dyer AR. 2010. The Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study: paving the way for new diagnostic criteria for gestational diabetes mellitus. American Journal of Obstetrics and Gynecology 202:654.e1–e6.

Dirar AM, Doupis J. 2017. Gestational diabetes from A to Z. World Journal of Diabetes 8:489–506.

Elden H, Gutke A, Kjellby-Wendt G, Fagevik-Olsen M, Ostgaard HC. 2016. Predictors and consequences of long-term pregnancy-related pelvic girdle pain: a longitudinal follow-up study. BMC Musculoskeletal Disorders 17:1–13.

Evensen NM, Kvåle A, Brækken IH. 2016. Convergent validity of the timed up and go test and ten-metre timed walk test in pregnant women with pelvic girdle pain. Manual Therapy 21:94–99.

Fasshauer M, Blüher M, Stumvoll M. 2014. Adipokines in gestational diabetes. The Lancet Diabetes & Endocrinology 2:488–499.

Galic S, Oakhill JS, Steinberg GR. 2010. Adipose tissue as an endocrine organ. Molecular and Cellular Endocrinology 316:129–139.

Hayashino Y, Jackson JL, Hirata T, Fukumori N, Nakamura F, Fukuhara S, et al. 2014. Effects of exercise on c-reactive protein, ınflammatory cytokine and adipokine in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. Metabolism: Clinical and Experimental 63:431–440.

Kim SY, England L, Wilson HG, Bish C, Satten GA, Dietz P. 2010. Percentage of gestational diabetes mellitus attributable to overweight and obesity. American Journal of Public Health 100:1047–1052.

Korkmazer E, Solak N. 2015. Correlation between ınflammatory markers and ı nsulin resistance in pregnancy. Journal of Obstetrics and Gynaecology 35:142–145.

Kovacs FM, Garcia E, Royuela A, Gonzalez L, Abraira V. 2012. Prevalence and factors associated with low back pain and pelvic girdle pain during pregnancy: a multicenter study conducted in the Spanish National Health Service. Spine 37:1516–1533.

McVinnie DS. 2013. Obesity and pain. British Journal of pain 7:163–170.

Meijer OG, Barbe MF, Prins MR, Schipholt IJL, Hu H, Daffertshofer A. 2020. The pelvic girdle pain deadlock: 2. topics that, so far, have remained out of focus. Musculoskeletal Science and Practice 48: 102166–102111.

Nergiz S, Altı nkaya ÖS, Küçük M, Yüksel H, Sezer SD, Kurt Ömürlü İ, Odabaşı AR. 2014. Circulating galanin and IL-6 concentrations in gestational diabetes mellitus. Gynecological Endocrinology 30:236–240.

Owe KM, Bjelland E, Stuge B, Orsini N, Eberhard-Gran M, Vangen S. 2016. Exercise Level before pregnancy and engaging in high-impact sports reduce the risk of pelvic girdle pain: a population-based cohort study of 39 184 women. British Journal of Sports Medicine 50:817–822.

Pinho-Ribeiro FA, Verri WA, Chiu IM. 2017. Nociceptor sensory neuron-ı mmune ınteractions in pain and ınflammation. Trends in İmmunology 38:5–19.

Sacks DA, Hadden DR, Maresh M, Deerochanawong C, Dyer AR, Metzger BE, Lowe LP, Coustan DR. 2012. Frequency of gestational diabetes mellitus at collaborating centers based on ı adpsg consensus panel-recommended criteria: the Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study. Diabetes Care 35:526–528.

Shoelson SE, Herrero L, Naaz A. 2007. Obesity, inflammation, and insulin resistance. Gastroenterology 132:2169–2180.

Stannus O, Jones G, Cicuttini F, Parameswaran V, Quinn S, Burgess J, et al. 2010. Circulating levels of IL-6 and TNF-α are associated with knee radiographic osteoarthritis and knee cartilage loss in older adults. Osteoarthritis and Cartilage 18:1441–1447.

Stuge B, Garratt A, Jenssen HK, Grotle M. 2011. The pelvic girdle questionnaire: a condition-specific ınstrument for assessing activity limitations and symptoms in people with pelvic girdle pain. Physical Therapy 91:1096–1108.

Tashani OA, Astita R, Sharp D, Johnson MI. 2017. Body mass ındex and distribution of body fat can ınfluence sensory detection and pain sensitivity. European Journal of Pain 21:1186–1196.

Vleeming A, Albert HB, Östgaard HC, Sturesson B, Stuge B. 2008. European guidelines for the diagnosis and treatment of pelvic girdle pain. European Spine Journal 17:794–819.

Vøllestad NK, Stuge B. 2009. Prognostic factors for recovery from postpartum pelvic girdle pain. European Spine Journal 18:718–726.

Walters C, West S, Nippita TA. 2018. Pelvic girdle pain in pregnancy. Australian Journal of General Practice 47:439–443.

Woodside A, Bradford H. 2021. Exercise and the prevention of gestational diabetes mellitus. Nursing for Women's Health 25:304–311.

Wu WH, Meijer OG, Uegaki K, Mens JMA, van Dieën JH, Wuisman PIJM, Ostgaard HC. 2004. Pregnancy-related pelvic girdle pain (PPP), I: terminology, clinical presentation, and prevalence. European Spine Journal 13:575–589.

Yelvar GDY, Çırak Y, Demir YP, Türkyılmaz ES. 2019. Cultural adaptation, reliability and validity of the pelvic girdle questionnaire in pregnant women. Ankara Medical Journal 19:513–523.