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Risk factors for pregnancy-related pelvic girdle pain: A cross-sectional study

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Abstract

The risk factors for pregnancy-associated pelvic girdle pain (PPGP) remain unclear in China, and clinical prediction tools are lacking. To address this gap, a cross-sectional study was conducted involving 416 pregnant and postpartum women from the Guangdong Women and Children Hospital, aiming to investigate PPGP prevalence, identify risk factors, and develop a predictive nomogram. Data were collected via structured questionnaires and medical records. Feature selection was performed using Least Absolute Shrinkage and Selection Operator (LASSO) regression, followed by multivariate logistic regression to identify significant predictors. The model's performance was validated through calibration plots and decision curve analysis. The results demonstrated that the prevalence of PPGP was 58.7%, and the independent predictors of PPGP included previous low back/pelvic girdle pain (LBP/PGP) history (OR=5.33, *P*<0.001), family PGP history (OR=1.81, *P*<0.001), miscarriage history (OR=1.62, *P*=0.03), sitting (OR=1.10, *P* < 0.05) and walking (OR=0.87, *P* < 0.05) time per day for the last week. The predictive model showed moderate accuracy with an area under the receiver operating characteristic curve of 0.735. In summary, **t**his study highlights the high prevalence of PPGP and offers a risk assessment tool for late pregnancy and postpartum women. *(Afr J Reprod Health 2025; 29 [5]: 36-52).*

Keywords: Pregnancy- related pelvic girdle pain, Risk factors, Nomogram, Pregnancy, Prevalence

Résumé

Les facteurs de risque de douleurs pelviennes liées à la grossesse (PPGP) restent flous en Chine, et les outils de prédiction clinique font défaut. Pour combler cette lacune, une étude transversale a été menée auprès de 416 femmes enceintes et en post-partum de l'hôpital pour femmes et enfants du Guangdong. Elle visait à étudier la prévalence des PPGP, à identifier les facteurs de risque et à élaborer un nomogramme prédictif. Les données ont été recueillies au moyen de questionnaires structurés et de dossiers médicaux. La sélection des caractéristiques a été réalisée par régression LASSO (Least Absolute Shrinkage and Selection Operator), suivie d'une régression logistique multivariée afin d'identifier les prédicteurs significatifs. Les performances du modèle ont été validées par des graphiques d'étalonnage et une analyse de la courbe de décision. Les résultats ont montré que la prévalence de la lombalgie post-partum était de 58,7 %. Les facteurs prédictifs indépendants de cette affection comprenaient les antécédents de lombalgie/douleur de la ceinture pelvienne (LDP/LDP) (OR = 5,33, p < 0,001), les antécédents familiaux de lombalgie (OR = 1,81, p < 0,001), les antécédents de fausse couche (OR = 1,62, p = 0,03), le temps passé en position assise (OR = 1,10, p < 0,05) et le temps de marche (OR = 0,87, p < 0,05) par jour au cours de la semaine précédente. Le modèle prédictif a montré une précision modérée, avec une aire sous la courbe de la fonction d'exploitation du récepteur de 0,735. En résumé, cette étude souligne la forte prévalence de la lombalgie post-partum et offre un outil d'évaluation du risque pour les femmes en fin de grossesse et en post-partum. *(Afr J Reprod Health 2025; 29 [5]: 36-52).*

Mots-clés: Douleurs de la ceinture pelvienne liées à la grossesse, Facteurs de risque, Nomogramme, Grossesse, Prévalence

Introduction

Pelvic girdle pain (PGP) is delineated by discomfort localized around the sacroiliac joints, frequently manifesting between the posterior iliac crest and the gluteal sulcus. This pain may extend to the posterior aspect of the thigh or manifest concomitantly with the joint or in isolation. The pain sensation can be dull, sharp, or grinding and can range in intensity from mild to severe with patients exhibiting

reduced tolerance in standing, walking, and sitting[1]. Therefore, pregnancy-related pelvic girdle pain (PPGP) is not only prevalent during pregnancy and the postpartum period[2] but also frequently persists in subsequent pregnancies, and it can endure for up to a decade after childbirth[3-6]. Subsequent investigations have demonstrated that pelvic pain results in more pronounced functional limitations compared to low back pain (LBP)[7]. Additionally, a cohort study indicated that patients undergoing pregnancy-related pelvic low back pain demonstrated a heightened prevalence of comorbidities, disruptions in family relationships, elevated depressive symptoms, and extended sick leave in comparison to pregnant and postpartum people devoid of such pain[8].

Due to the lack of standardized norms and definitions and the diversity of research design, prior investigations into prevalence rates have yielded a broad spectrum of statistics, ranging from 7% to 84%[9-13]. In addition, there is no clear distinction between PGP and LBP in a considerable amount of studies. Meanwhile, certain investigations were retrospective, and potentially susceptible to recall bias. Vleeming et al. reported a nearly 20% prevalence of pelvic pain during pregnancy, supported by substantial evidence[14]. Moreover, considerable geographic variation exists in the prevalence and severity of pregnancy-related pelvic pain, with a majority of studies predominantly conducted in European regions[10]. While research findings suggest that the etiology of PPGP remains elusive, a robust association of PPGP exists with factors including laborious tasks involving frequent twisting and bending of the back, previous incidents of LBP, PGP, pelvic trauma, and psychological distress[7,11]. The correlation between PPGP and numerous factors, including smoking during pregnancy, early menarche, body mass index, gestational age, age, exercise level, work experience, job satisfaction, and education level, yielded conflicting outcomes in the literature[1,9-11,15-17].

In addition, family history has been suggested as a possible risk factor for PPGP, and recent research has reported that a family history of PGP during pregnancy in Australia was the strongest predictor of PGP[11]. Several recent studies have suggested that postpartum pelvic girdle pain is associated with factors such as nausea and vomiting during pregnancy, seated breastfeeding position, and cesarean section delivery, but further research is required in this area[18]. Currently, there is a notable scarcity of studies addressing the incidence and factors influencing pregnancy-related pelvic girdle pain in mainland China[19].

According to some clinical doctors, PPGP carries the risk of disability and long-term effects[20]. Hence, integral to its management is the early identification of PPGP through straightforward empirical methods. A nomogram facilitates the conversion of conventional predictive model formulas into a singular numerical estimate, indicating the likelihood of an event[21]. This aids in clinical decision-making during individual patient consultations. Presently, there is a scarcity of clinical predictive models pertaining to the risk of PPGP. Therefore, this study aimed to document the prevalence of PPGP, examine its predictors, and validate a nomogram for its prediction

Methods

Research procedure

The study was a cross-sectional study conducted at the Guangdong Women and Children Hospital in China. Data collection spanned from 22 March to 4 July, 2023. The study used a structured self-administered questionnaire (Additional file) from the Pelvic Girdle Pain Questionnaire[22,23] , the Numeric Rating Scale(NRS) and other relevant literature[24,25]. All data were collected by the principal investigator.

Sample size determination

This was a single-center cross-sectional study with incidental sampling. According to the findings of the pre-test, the prevalence of pregnancy-related pelvic girdle pain was determined to be 33.3%, using PASS 21 to calculate a sample size of N=366, and taking into account a 20% loss-to-follow-up rate, a minimum of 458 participants presenting to the clinic during pregnancy as well as postpartum needed to be surveyed.

Participants

Participants aged 20 years or older who attended the obstetrics outpatient clinic of Guangdong Women

and Children Hospital during their 34th – 36th gestational weeks or within 42 days postpartum were enrolled in this study..

Definitions and covariates

PPGP is defined as pain between the posterior iliac crest and the gluteal sulcus, particularly at the sacroiliac joint attachment, possibly radiating to the back of the thigh, occurring during late pregnancy or within 10 weeks of delivery[5]. In this study, the primary outcome was self-reported PPGP, which was assessed using dichotomous questions at 34-36 weeks of pregnancy or within 42 days postpartum. For pregnant participants, the questions addressed any symptoms of pain related to pregnancy, while postpartum participants were asked about symptoms related to the postpartum period. Individuals were classified as having PPGP if they responded 'yes' to a specific question (Q35 or Q36, S1, Figure 1) regarding pain localization, which included a visual aid of the pelvic girdle to assist in identifying the affected area.

Physical activity and pain severity: Each participant completed the Chinese version of the Pelvic Girdle Pain Questionnaire (PGQ), a well-established instrument in research for assessing the impact of PPGP on daily activities and quality of life[0]. Participants experiencing pelvic girdle pain assessed their pain intensity using a Numerical Rating Scale (NRS) ranging from 0 (indicating no pain) to 10 (representing the highest level of pain). Additionally, they self-reported the persistence of their pelvic girdle pain by responding to inquiries regarding its characteristics.[24,25]

Data collected: Gestational age, number of deliveries, neonatal weight and current pregnancy type (singleton, twin, triplet) were documented in the medical record and confirmed by self-report. Participants self-reported measured height, current weight (heaviest weight during pregnancy), pre-pregnancy weight, age at menarche, education and literacy level (primary and junior high school, high school/technical school/secondary school, college, bachelor's degree, postgraduate and above), and average monthly income.

Participants were asked if they had a history of low back pain or pelvic girdle pain, if they smoked or drank alcohol during pregnancy, if they had nausea and vomiting during pregnancy, if there was a family history of PPGP (specifically among their maternal aunts or sisters), which was recorded as yes/no or unsure.

Participants self-reported the number of hours they had worked in the previous week (0h, <20h, 20-40h, >40h), the average number of hours per day they had spent lying down, sitting, standing and walking in the previous week (in hours), the average number of hours of exercise per day before and during pregnancy (0h, <1h, 1-2h, >3h), and postpartum participants were asked the average number of hours of exercise per day after delivery (0h, <1h, 1-2h, >3h). A five-point Likert scale was used to record both the amount of work done by the participants and their job satisfaction.

Statistical analysis

The point prevalence of pregnancy-related pelvic girdle pain (PPGP) was determined by the ratio of participants identified with PPGP to the total number of participants in the study.

Baseline characteristics of participants with and without PPGP were compared to assess potential confounding factors. Continuous variables were assessed for normality (Shapiro-Wilk test) and homogeneity of variance (Levene's test). Based on these results, parametric (independent t-test) or non-parametric (Mann-Whitney U test) methods were applied for group comparisons, while categorical variables were analyzed using Pearson's chi-square test or Fisher's exact tests. To examine the correlation between PGQ and NRS scores, the Spearman correlation test was carried out. We performed LASSO (Least Absolute Shrinkage and Selection Operator) regression using the "galmet" package in the R programming environment. This approach is well-suited for compressing high-dimensional data and can be employed to analyze the optimal predictive risk factors associated with the disease[26]. Following the selection of features with nonzero coefficients in the LASSO regression model, multivariable logistic regression analysis was conducted on patients experiencing pregnancy-related pelvic girdle pain (PPGP). The analysis included factors that were significant in univariate analyses as well as risk factors shown in previous studies, such as history of miscarriage, income, education level, work intensity and activity level in the late stages of pregnancy, with the aim of identifying all relevant risk factors[2,9-11,15-17].

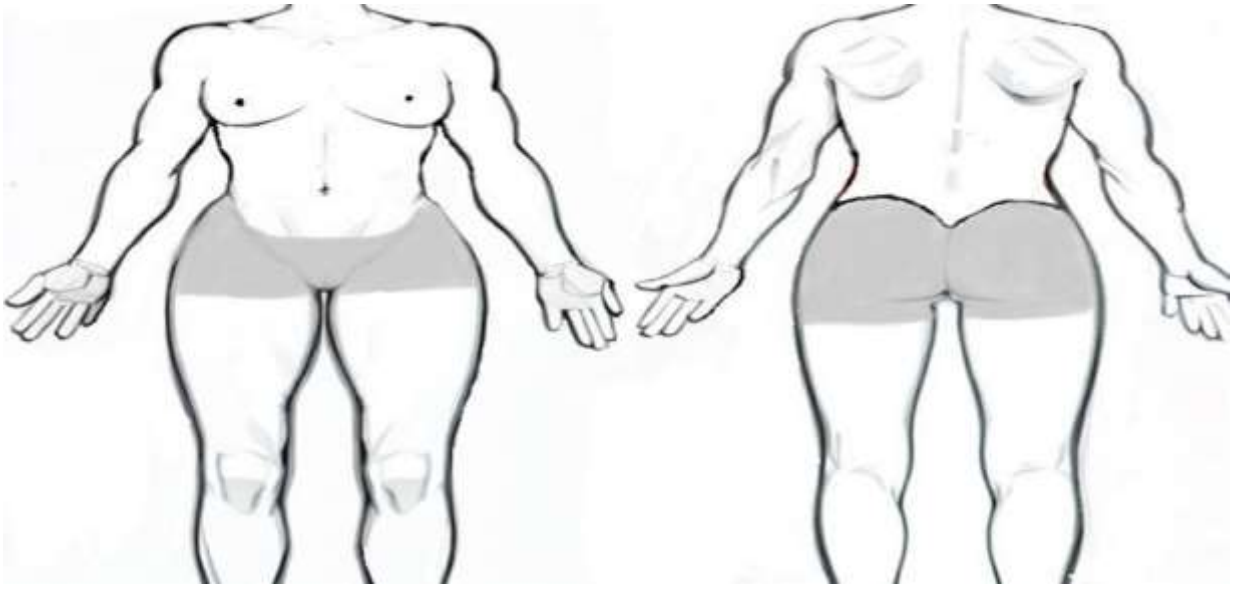

Figure 1: Schematic diagram of the distribution of pain locations in the pelvic girdle

The multivariable logistic regression analysis was employed for the development of a predictive model[27].

The features were evaluated using odds ratios (ORs) with accompanying 95% confidence intervals (CIs), and the associated P-values were derived accordingly. All statistical significance levels were two-sided. Subsequently, features with a significance level of $P \leq 0.05$ were chosen, and a nomogram prediction model was constructed utilizing the "replot" package. The accuracy of these selected features was assessed through various metrics, including nomogram-predicted probability of pregnancy-related pelvic girdle pain (PPGP) incidence risk, calibration, F1-score, receiver operating characteristic (ROC) curve analysis, and decision curve analysis (DCA).

We employed the technique of "multiple imputation" to address missing covariates, thereby mitigating potential selection bias arising from the exclusion of participants with incomplete data. Statistical analyses were carried out using R software (version 4.1.6, R Foundation for Statistical Computing, Vienna, Austria) and IBM SPSS for Windows version 27.0 (Statistical Package for Social Science 27.0, IBM Company, Chicago, IL, United States). The ROC curve, along with the Area Under the Curve (AUC), serves as a valuable method for assessing the performance of biomedical and chemoinformatics data[0]. Decision Curve Analysis (DCA) can be employed as a tool for evaluating performance measures in prediction models[29]. The reliability and replicability of the aforementioned study methods have been demonstrated in numerous other investigations[0,0].

Ethical considerations

The study was approved by the Ethics Committee of Guangdong Women and Children Hospital (ethical number: 202301363). Prior to the initiation of any procedures, all participants completed an informed consent form and were informed of the purpose and methods of the study.

Results

Characteristics of the study population

A total of 458 participants were recruited for the study, of whom 416 were screened for eligibility, aged between 21 and 56 with a mean age of 32 (29,34) years. The average age for first pregnancy was 28 (25,30) years, with 13 participants aged over 35 years and 403 participants aged 35 years and below. **Table1** provides a detailed overview of the sociodemographic and obstetric-related characteristics of the participants.

Table1: Sociodemographic characteristics and obstetric characteristics of women with PPGP and women without PPGP

Predictor Variable	All Participants (N=416) Number(%)	With PPGP (N=239) Number(%)	Without PPGP (N=177) Number(%)	*P* Value
Age, yr	32.0 (29.0, 34.0)	31.0 (29.0, 34.0)	32.0 (29.0, 34.0)	>0.90
Age at first pregnancy，yr	28.0 (25.0, 30.0)	28.0 (25.0, 30.0)	27.0 (25.0, 30.0)	0.60
Age of menarche	13.00 (12.00, 14.00)	13.00 (12.00, 14.00)	14.00 (13.00, 15.00)	0.01*
Height, cm	159.0 (155.4, 162.1)	159.0 (156.0, 162.0)	159.0 (155.0, 163.0)	0.80
Pre-pregnancy body mass, kg	52（48,58）	52（48,58）	51（48,57）	0.44
Pre-pregnancy body mass index, kg m-2	20.53（18.91,22.50）	20.70(18.91,22.81)	20.50(18.97,22.17)	0.56
Miscarriages frequency	0(0,1)	0（0,1）	0（0,1）	0.15
Average per day for the last week，h				
Lying down	9（8,10）	9（8,10）	9（8,10）	0.87
Sitting	6（4,8）	6（4,8）	5(3.5,8)	0.00**
Walking	3（2,4）	1(1,2)	2(1,3)	0.01*
Standing	1.5（1,2.5）	3(1,4)	3(2,5)	0.31
Miscarriages history				0.06
Yes	133（32.0）	85（35.6）	48（27.1）	
No	283（68.0）	154（64.4）	129（72.9）	
Previous LBP/PGP				0.00**
Yes	122（29.3）	102（42.7）	20（11.3）	
No	294（70.7）	137（57.3）	157（88.7）	
Family history of PGP				0.00**
Yes	232（56）	153（64）	79（45）	
N0	184（44）	86（36）	98（55）	
Smoking during pregnancy				0.74
Never	413（99.3)	237（99.2）	176（99.4）	
Occasionally	3(0.7)	2（0.8）	1（0.6）	
Frequently	0(0.0)	0（0）	0（0）	
Alcohol Consumption During Pregnancy				0.59
Never	402(96.6)	230（96.2）	172（97.2）	
Occasionally	14(3.4)	9（3.8）	5（2.8）	
Frequently	0（0）	0（0）	0（0）	
Nausea and vomiting during pregnancy				0.79
Never	68（16.3）	37（15.5）	31（17.5）	
Nausea alone	110（26.4）	63（26.4）	47（26.6）	
Vomiting alone	22（5.3）	11（4.6）	11（6.2）	
Nausea and vomiting	216（51.9）	128（53.6）	88（49.7）	
Work physical intensity	2.25±0.976	2.17±0.951	2.37±0.998	0.2
Very light	119(28.6)	76（31.8）	43（24.3）	

Slightly light	107(25.7)	61（25.5）	46（26）	
Neither heavy nor light	159(38.2)	89（37.2）	70（39.5）	
Slightly heavy	27(6.5)	12（5.0）	15（8.5）	
Very heavy	4(1.0)	1（0.4）	3（1.7）	
Work satisfaction	3.59±0.876	3.57±0.886	3.62±0.891	0.54
Very bad	4(1.0)	2（0.8）	2（1.1）	
Somewhat bad	22(5.3)	14（5.9）	8（4.5）	
Neither bad nor good	189(45.4)	109（45.6）	80（45.2）	
Somewhat good	126(30.3)	74（31.0）	52（29.4）	
Very good	75(18.0)	40（16.7）	35（19.8）	
Work status (hours of employment last week)				0.36
None	98（23.6）	59（23.6）	39（22.0）	
<20	89（21.4）	47（19.7）	42（23.7）	
20-40	150（36.1）	82（34.3）	68（38.4）	
>40	79（19.0）	51（21.3）	28（15.8）	
Level of education				0.08
junior high school and below	38（8.7）	15（6.3）	23（13.0）	
high school graduation	37（8.9）	22（9.2）	15（8.5）	
undergraduate	296（71.2）	172（72.0）	124（70.1）	
postgraduate and above	45（10.8）	30（12.6）	15（8.5）	
Pregnancy type				0.03*
Single pregnancy	400（96.1）	234（97.9）	166（93.8）	
Multiple pregnancies	16（3.9）	5（2.1）	11（6.2）	
Exercise duration （hours per day during pregnancy）				0.20
<1	232（55.8）	142（59.4）	90（50.8）	
1-2	82（19.7）	40（16.7）	42（23.7）	
>3	17（4.1）	8（3.3）	9（5.1）	
None	85（20.4）	49（20.5）	36（20.3）	
Exercise duration (pre-pregnancy hours per day)				0.28
<1	214（51.4）	131（54.8）	83（46.9）	
1-2	107（25.7）	55（23.0）	52（29.4）	
>3	25（6.0）	12（5.0）	13（7.3）	
None	70（16.8）	4（17.2）	29（16.4）	
Income(CNY/month)				0.10
<5000	47（11.3）	23（9.6）	24（13.6）	
5000-10000	117（28.1）	75（31.4）	42（23.7）	
10001-15000	87（20.9）	56（23.4）	31（17.5）	
15001-20000	74（17.8）	38（15.9）	36（20.3）	
>20000	91（21.9）	47（19.7）	44（24.9）	

The prevalence of PPGP, degree of pain in PPGP participants and their daily activities limitation

This study comprised 416 pregnant and postpartum women, with 144 cases during pregnancy and 272 cases after delivery. The overall incidence of pelvic girdle pain (PPGP) was 57.5 % (239/416), including 52.1 %(75/144) during pregnancy and60.3 % (164/272) after delivery. PPGP was present in 239 participants in the study population during pregnancy and postpartum.

The median self-reported pain score, assessed using the NRS, was 3, indicating mild pain.

Table 2: Pain and functional limitations for women with PPGP

Factors	Women with PPGP (n=239) Number(%)	correlation coefficient
NRS*	3(2, 5)	
0-3	137(57.3)	
4-6	80(33.5)	
7-10	22(9.2)	
PGQ activity subscale	20(13, 29)	0.513#
PGQ symptom subscale	5 (2, 7).	0.538#
PGQ total	25 (17, 36)	0.532#

Table 3: Screening out risk factors for PPGP by LASSO Regression

Factors	Coefficients	Lambda.1se
Previous LBP/PGP	1.15	-0.25
Family history of PGP	0.18	
Miscarriages history	0.01	
Sitting time per day for the last week(h)	0.02	
Walking time per day for the last week(h)	-0.01	

Of these, 137 participants had a score of 1 to 3 (mild pain), 80 had a score of 4 to 6 (moderate pain), and 22 had a score of 7 to 10 (severe pain).

The impact of pain on participants' activities of daily living was assessed using the PGQ scores, with a questionnaire score of 25 (17, 36), an activity subscale score of 20 (13, 29), and a symptom subscale score of 5 (2, 7). Statistical analysis showed a significant correlation between NRS, PGQ, and their various scales, as shown in Table 2. Note: Data are presented as n (%), mean±SD or median (IQR). "*" represents significant differences in the distribution within the groups. "P#"represents a significant correlation between the marked scales and NRS scales. PGQ, pelvic girdle pain questionnaire. NRS, numerical rating scale.

Association between candidate predictive variables and PPGP

The outcomes of the univariate logistic regression analysis for these potential predictors are reported in Table 1. Univariate analysis showed the following significant differences in patients with PPGP compared with the group without PPGP: age of menarche (P=0.01), sitting time per day for the last week (P<0.001), walking time per day for the last week (P=0.01), previous LBP/PGP(P<0.001), family history of LBP\PGP (P<0.001) and type of pregnancy (P=0.03).

Selection and design of feature

We systematically assessed the association of age of menarche, pregnancy type, history of miscarriage, previous low back pain (LBP) or pelvic girdle pain (PGP), family history of LBP/PGP, pre-pregnancy body mass index, daily exercise hours during pregnancy, daily sitting/walking/standing/lying/working hours during the last week, physical intensity of work, education level, and income level with pregnancy-related pelvic girdle pain (PPGP) using LASSO regression coupled with logistic regression analysis. A total of 15 variables were initially considered. LASSO regression was employed to identify non-zero features, resulting in five potential predictors for PPGP (as shown in Table 3 and Figure 2A and 2B). Subsequently, logistic regression analysis was conducted to identify the independent risk factors associated with PPGP. The final model included five significant risk factors, all with p-values less than 0.05 (see Table 4).

Figure 2 :(A) The graph depicts the partial likelihood deviance (binomial deviance) curve plotted against the logarithm of lambda. (B) LASSO coefficient profiles for the 15 selected features are illustrated, providing valuable insights into the significance of each feature in the context of the regression model. LASSO, least absolute shrinkage and selection operator.

Association of candidate predictive variables PPGP

Multivariate logistic regression analysis revealed that people with family history of PGP (OR: 1.81, 95% CI: 1.17–2.82, $P < 0.05$), miscarriages history (OR: 1.62, 95% CI: 1.02–2.60, $P < 0.05$) and longer sitting time per day for the last week (OR:1.10, 95% CI: 1.02–1.19, $P < 0.05$) had a higher risk of PPGP. Previous history of LBP/PGP (OR: 5.33, 95% CI: 3.12–9.47, $P < 0.001$) had the highest risk of PPGP. However, appropriate walking duration per day (OR: 0.87, 95% CI: 0.77–0.99, $P < 0.05$) was inversely associated with PPGP (Table 4).

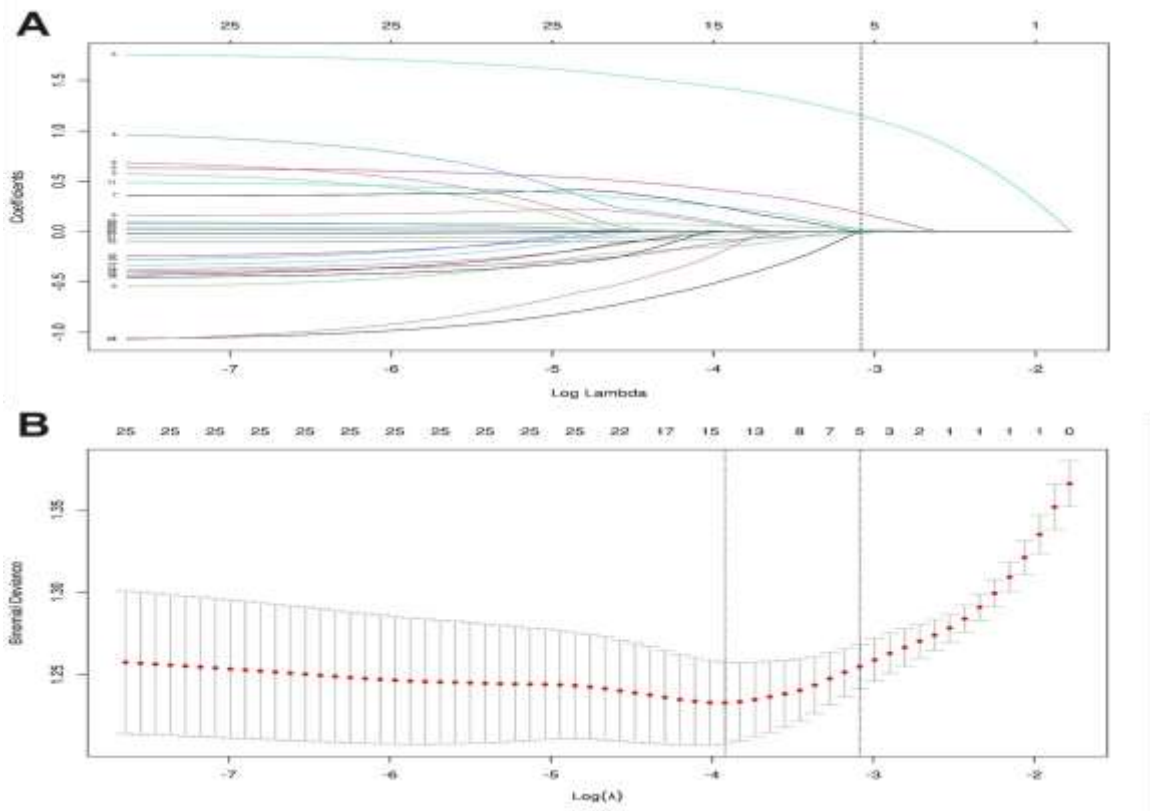

Figure 2: Feature selection via LASSO binomial regression model

Table 4: Screening out risk factors for PPGP by Logistic Regression

Factors	β-Coefficients	OR(95%CI)	P-value
Pregnancy type	-1.042	0.35(0.10-1.08）	0.069
Previous LBP/PGP	1.673	5.33(3.12-9.47)	＜0.001
Family history of PGP	0.594	1.81(1.17-2.82)	0.008
Miscarriages history	0.481	1.62(1.02-2.60)	0.043
Sitting time per day for the last week(h)	0.09	1.10(1.02-1.19)	0.012
Walking time per day for the last week(h)	-0.013	0.87（0.77-0.99）	0.028

Table 5: The Model to Predict PPGP Established by Logistic Regression

Factors	β-Coefficients	OR(95%CI)	P-value
Previous LBP/PGP	1.678	5.36(3.14-9.50)	＜0.001
Family history of PGP	0.602	1.83(1.18-2.84)	0.007
Miscarriages history	0.489	1.63(1.02-2.62)	0.039
Sitting time per day for the last week(h)	0.103	1.11(1.03-1.20)	0.007
Walking time per day for the last week(h)	-0.121	0.89（0.78-1.00）	0.046

Development of multivariate predictive nomogram

Based on the outcomes of LASSO regression and multiple logistic regression analyses, we included five independent predictive factors: Previous history of LBP/PGP, family history of PGP, history of miscarriages, daily sitting time over the past week, and daily walking time over the past week to construct a predictive model (Table 5), presented visually as a nomogram diagram (Figure 3). Logistic regression analysis utilizing the sample data with PPGP indicated that all identified risk factors exhibited p-values below 0.05 (Table 6).

Table 6: C-Index in the Array

C-index(95%CI)	F1	Sensitivity	Specificity	n
0.735(0.687-0.783)	0.702	0.686	0.638	416

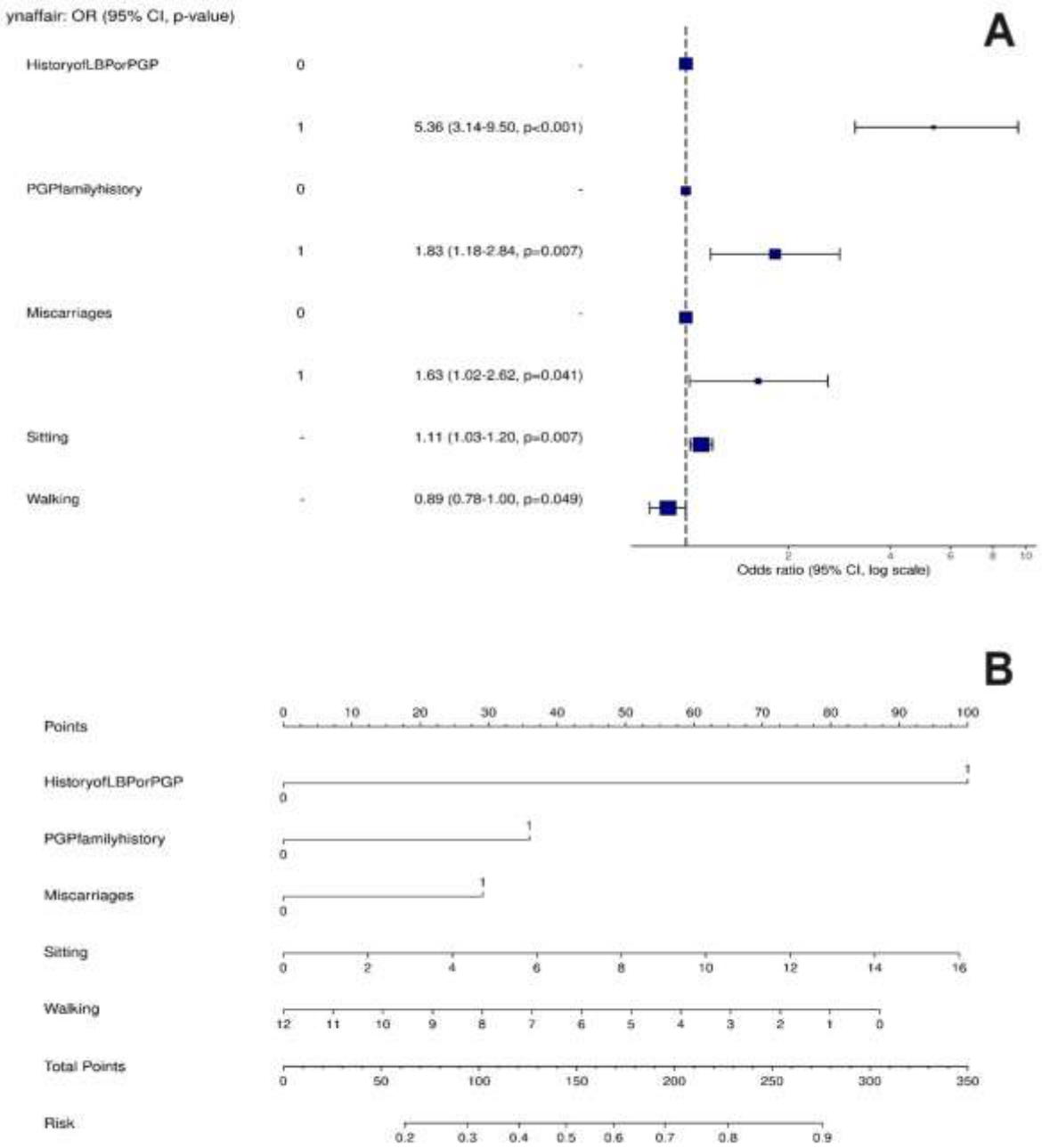

Figure 3: Analysis outputs and nomogram development

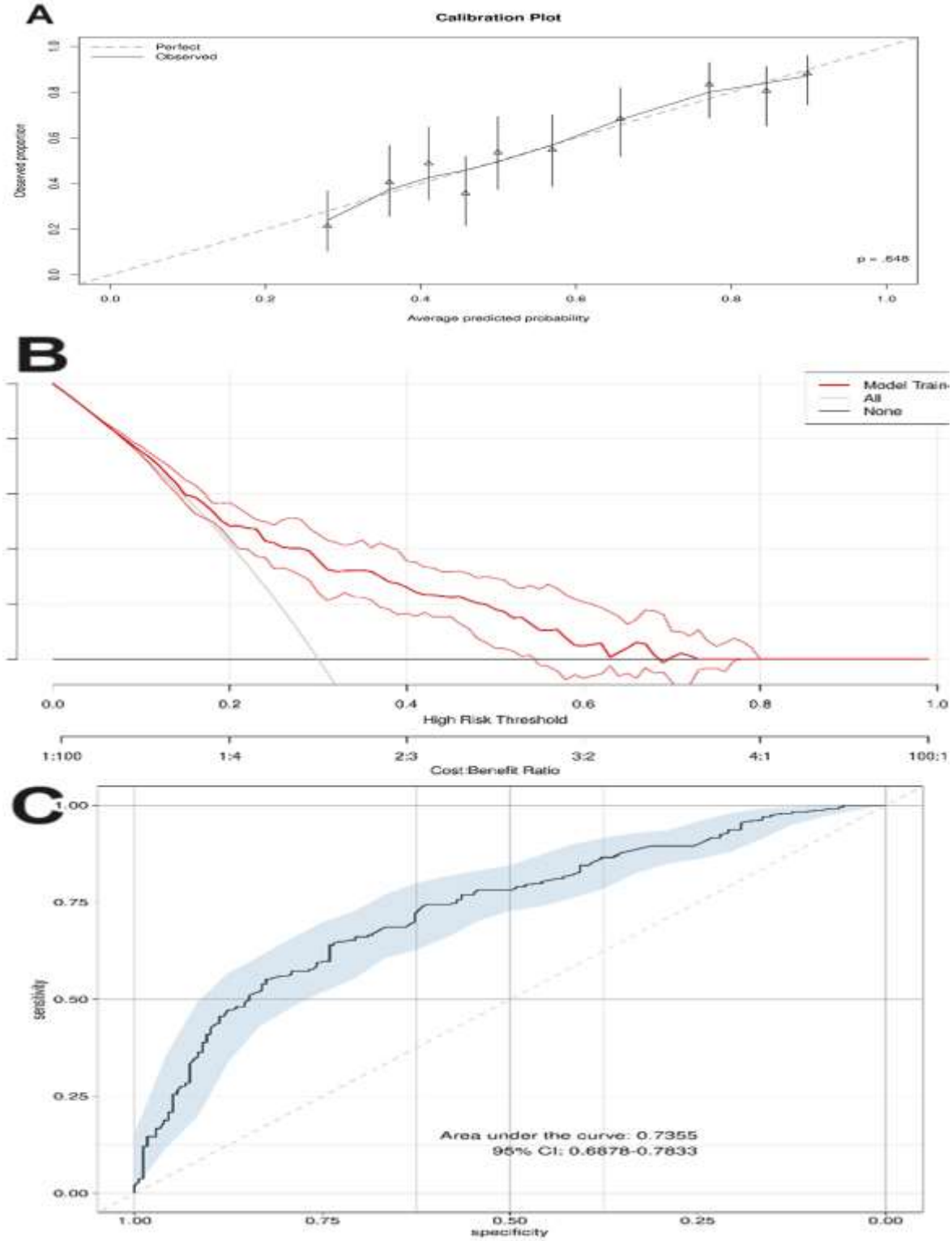

Figure 4: Evaluation Metrics of PPGP Risk Nomogram

Figure 3: (A) Forest plot exhibiting the Odds Ratio (OR) of the selected feature. The forest plot serves as a visualization tool for the outcomes of logistic regression analysis. (B)Developed nomogram for

PPGP. Notes: Development of a nomogram for Pregnancy-Related Pelvic Girdle Pain (PPGP). The nomogram was constructed based on data from the cohort, integrating previous LBP/PGP**,** family history of PGP, miscarriages history, sitting time per day for the last week and walking time per day for the last week.

Performance of the PPGP Risk nomogram

For 416 PPGP patients in the array, the calibration curve of the nomogram to predict the PPGP patients showed moderate calibration (Figure 4A and B). The area under the Receiver Operating Characteristic (ROC) curve was determined to be 0.735 (Figure 4C), indicating a moderately effective performance. In summary, based on the aforementioned validation, the nomogram associated with the model exhibits a moderate predictive ability of predictive ability.

Figure 4: ((A) Calibration curves illustrating the predictive performance of the PPGP risk nomogram across the array of predictions. The x-axis denotes the predicted incidence risk, while the y-axis represents the actual self-reported PPGP. The diagonal dotted line represents perfect prediction by an ideal model, whereas the solid line reflects the performance of the nomogram. A closer alignment to the diagonal dotted line indicates superior prediction accuracy. (B) Pooled Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) curve. The y-axis signifies the true positive rate of the risk prediction, while the x-axis denotes the false-positive rate.

The black line represents the performance of the nomogram. (C) Decision Curve Analysis for the incidence risk nomogram of PPGP. The y-axis indicates the net benefit, with the red line representing the incidence risk nomogram of PPGP. The gray line depicts the assumption that all patients self-report as PPGP, while the black line illustrates the assumption that no patients self-report as PPGP

Discussion

Prevalence of PPGP was consistent with other Studies

In this prevalence study, it was identified that pelvic girdle pain is a widely encountered issue during pregnancy and postpartum. More than half of the people who participated in this research had reported experiencing pregnancy-related pelvic girdle pain. In prior research, the study population was typically limited to people during pregnancy or postpartum exclusively[0,0]. This study includes both pregnant and postpartum women, providing a more comprehensive view of PPGP prevalence.

Nearly half of the participants reported moderate to severe pelvic girdle pain, and 22 participants experienced sleep disruption due to this pain. 8.8% (21/239) of the participants had activity subscale scores greater than 40, and the pain had a significant impact on their daily activities.

We discovered that a considerable number of individuals experienced high levels of pain, but only a few of them had a substantial influence on their everyday activities. This is consistent with the contradictory outcomes concerning pain intensity and disability scores obtained in prior investigation[34].

This indicates that although pelvic girdle pain in patients exists and has an impact on daily activities, this effect is generally not significant. However, a small number of people still experience severe pelvic girdle pain and have already had a significant impact on daily activities.

The variation in the impact of pain intensity on daily activities may be attributed to the fact that people modify their approach to daily activities to alleviate pain or opt to adjust to the pain.

A multi-country study has shown significant differences in the severity and impact of pelvic girdle pain during pregnancy, with the UK reporting the highest mean pain intensity score of 7.

Women in the UK also reported the highest level of concern about their pelvic girdle pain during pregnancy compared to other countries surveyed[35]. Research has indicated that individuals of Asian descent may have a lower sensitivity to pain when compared to non-Hispanic White individuals[36]. However, this study found that the level of pregnancy-related pelvic girdle pain(3(2,5)) is lower than that reported in some non-Hispanic whites, and the paradoxical nature of this finding may be influenced by many factors, such as cultural differences.

Main risk factors for PPGP

Drawing on prior literature and the outcomes of univariable logistic regression[37], we incorporated 15 potential factors related to the condition for 416

participants. Potential factors such as altered muscle mechanics, strenuous work, a history of low back pain, ethnicity, and the number of previous pregnancies have been identified as having a strong association with PPGP[38,39]. However, there is a lack of consensus regarding the association of these factors with PPGP. According to our multivariate logistic analysis and lasso regression analysis, previous LBP/PGP, family history of PGP, miscarriages history, sitting time per day for the last week and walking time per day for the last week were noteworthy predictors of PPGP patients.

In our study, women with previous LBP/PGP had a higher risk of developing PPGP. Prior episodes of low back pain or pelvic girdle pain were identified as associated with PPGP, consistent with findings from previous research[11,40,41]. Numerous studies have highlighted the recurrence of PPGP, the presence of unidentified risk factors, and the absence of preventive measures and screening tools for its detection[42,43]. The recurrence of PPGP tends to be more frequent, severe, and persistent, thereby constituting a notable public health concern and a significant source of maternal morbidity. Biologically, several mechanisms may underlie this recurrence. Two potential explanations are often considered: one involving the endocrine system and the other concerning the mechanical properties of musculoskeletal tissues[44,45]. Recent studies suggest the potential involvement of hormones such as relaxin and progesterone in influencing the pelvic girdle ligaments and contributing to the separation of the pubic symphysis[45,46].

The study found a significant correlation between PPGP and family history, consistent with national observational studies in Sweden and Australia that also showed familial clustering of PPGP[11,47]. This clustering may be associated with extensive joint activity and changes in the extracellular components of the pelvic ligaments.

In addition, a history of miscarriage is often considered a common and important obstetric factor[48]. Compared with women without a history of miscarriage, women with a history of miscarriage have a higher risk of developing PPGP, and miscarriage is an independent risk factor. This finding contrasts with prior studies[1249] but aligns with reports of severe PGP following early miscarriage[50]. A survey conducted in Eastern Denmark found that most women with pregnant who experienced complications during pregnancy or childbirth had a history of labor or miscarriage. Additionally, pelvic girdle pain was identified as a common complication of pregnancy and childbirth[51]. Furthermore, pregnant women with nonspecific pelvic girdle pain have a higher risk of miscarriage[0], which suggests the potential for a bidirectional pathological association between miscarriage and PPGP. The evidence outlined above indicates a necessity for further exploration of the interrelationship between miscarriage and PPGP, to identify potential shared pathological mechanisms.

The duration of daily sitting during the previous week was linked to PPGP, and the daily duration of walking was likewise significantly associated with PPGP in both lasso and multivariable logistic model, which could be attributed to altered biomechanics[0]. Moreover, it suggested that the risk of experiencing pelvic girdle pain is more probable with increased sitting time especially with uncomfortable posture[54]. Sedentary behavior can be a risk factor for women with pregnant. Therefore, it is important to consider preventive strategies. Additionally, some studies have suggested a correlation between PPGP and changes in pelvic joint mechanics or muscle motor control related to pelvic motion[55].

Women who spend extended periods of time in a seated position, whether during pregnancy or postpartum, may develop pelvic girdle pain due to additional strain and pressure on the pelvic girdle, affecting the myofascial structures surrounding the sacroiliac joints and pubic symphysis[38]. Participation in appropriate exercise or simple activities can be a protective factor for PPGP, which is consistent with the findings of Linda Kahr Andersen *et al*[56]. However, the amount of exercise required for different types of people needs to be discussed[57]. Previous studies have indicated that women who received regular exercise programmes and prenatal exercise appeared to be more effective in managing the progression of pregnancy-related low back pain and pelvic girdle pain, and were able to improve their functional status[58,59]. Furthermore, exercises that improve core stability can be effective in relieving pain in the pelvic girdle of women with pregnant, reducing their disability and improving their quality of life[60]. In summary, although the mechanism by which PPGP occurs is unknown, acknowledging that sedentary may exacerbate pain levels or increase the risk of pain,

while proper walking duration may be a feasible and simple means to prevent the occurrence of PPGP.

It is worth noting that a study of women with pregnant in Ethiopia found that multiple pregnancy was an important predictor of PGP in women with pregnant[61]. However, in our study, pregnancy type was not an important predictor.

Validation and performance assessment of the PPGP Nomogram

Presently, there is a lack of practical predictive tools for identifying individuals in the late stages of pregnancy and the postpartum period who may develop PPGP. Nomograms offer advantages, including user-friendly interfaces, enhanced accuracy, and more comprehensible results. Therefore, we employed data from 239 patients diagnosed with PPGP to construct and validate a nomogram-based risk score for predicting the likelihood of PPGP. To our knowledge, our investigation represents the initial multicenter and thorough retrospective study establishing nomogram models for the prediction of PPGP risk. Within this study, clinical data and demographic information related to individuals with PPGP were used in LASSO logistic regression analysis to estimate risk.

The predictors we incorporated are all objective variables related to PPGP, which effectively assess patients' condition in an objective manner. The complete nomogram model comprised five items: previous history of LBP/PGP, family history of PGP, miscarriages history, sitting time per day for the last week and walking time per day for the last week. Consistent with findings from prior investigations, we observed significance in the aforementioned five factors[11,46,51,54].

Specifically, we assessed model performance through discrimination and calibration curves, as well as Decision Curve Analysis (DCA) within the validation set. The nomogram-based full model demonstrated an Area Under the Curve (AUC) of 0.735 in the Receiver Operating Characteristic (ROC) analysis for the PPGP group, which indicates favorable accuracy and stability. In our cohort, the calibration curve exhibited favorable alignment with the ideal 45° prediction line, indicating reliable calibration of the PPGP risk nomogram, with agreement between predicted and observed outcomes. Additionally, validation within the cohort demonstrated moderate to good discriminatory and validation abilities.

Strengths and limitations

In this study, the pelvic girdle pain (PPGP)-specific questionnaire system was utilised to evaluate the impact of pain on daily functioning, thereby enhancing the assessment targeting. However, the following limitations should be noted: the single-center convenience sampling and cross-sectional design limit the extrapolation of the results; the pain level relies on self-reporting, which may have a recall bias; the evolution of pain is not dynamically monitored, which may affect the timeliness of the prediction model; the model was constructed based on the population of South China, and further validation is needed to determine its applicability in the northern population. Future studies should adopt a multicenter prospective design and incorporate dynamic monitoring of objective indicators to improve the generalizability of the model.

Conclusion

The prevalence of PPGP was found to be substantial, with more than 50% of participants experiencing pelvic girdle pain during pregnancy and the postpartum period. This aligns with findings from prior research studies. Previous history of LBP/PGP, family history of PGP, miscarriages history, average sitting and walking time per day for the last week were all risk factors for PPGP. We constructed a predictive model utilizing self-reported concerns, basic demographic information, lifestyle behaviors, medical history, and other objective parameters to forecast the risk of PPGP. The model exhibited consistently strong discriminatory ability across various datasets. Our developed nomogram aids in identifying individuals at risk of experiencing PPGP during late pregnancy and the postpartum period. It can serve as an adjunct to existing screening methods for PPGP, aiding in enhanced treatment decisions. This includes focusing on women with a history of miscarriage or family history during pregnancy and offering health education to minimize prolonged sitting and walking. Both physicians and physical therapists can utilize this tool to improve patient management. The government should provide

health education to women based on risk factors. By early identification of people at risk and improving activity habits during pregnancy and postpartum, simple and feasible health management strategies can be achieved for prevention or early intervention, thereby further reducing the socio-economic burden associated with this disease.

Authors' contributions

All named authors have substantially contributed to conducting this research and drafting this manuscript. YNH contributed to study conception, study design, data collection, data analysis and interpretation, and finalizing the manuscript. YCL and LLX were involved in study conception and design, analysis and interpretation of data, and drafting the manuscript. PFS and YMC contributed to statistical analysis. CLL and XGZ critically examined the original study data, provided technical guidance, and approved the final manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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