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Research Article

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Physical Activity Guideline Adherence and Its Psychosocial Correlates among Chinese Women in Late Pregnancy: A Multicentre Cross-Sectional Study

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Abstract

Background: Adherence to physical activity (PA) guidelines in pregnancy is low globally, and evidence in Chinese women is scarce, and available Chinese studies have focused predominantly on early pregnancy, leaving the correlates of guideline adherence in late pregnancy—when activity declines most steeply—poorly characterized. This study aimed to describe physical activity patterns among pregnant women in three Chinese provinces, examine centre-level variation in these patterns, and identify factors associated with meeting international PA recommendations in a sample predominantly in late pregnancy. **Methods:** A cross-sectional survey of 335 pregnant women in three provinces (94.6% in the third trimester) used validated Chinese PPAQ, EBBS and P-ESES scales. Compliance was defined as ≥ 150 min/week moderate-intensity sports/exercise activity (≥ 450 MET-min/week, ACOG-aligned). Multivariable logistic regression adjusted for nine parameters including maternal age, gestational age, education, employment and study centre; a pre-specified sensitivity analysis refitted the model using an all-domain adherence outcome (≥ 450 MET-minutes/week across all PPAQ domains). **Results:** Centres differed in sedentary time and light-to-moderate PA intensity ($p < 0.05$) but not in overall compliance or in barriers, benefits and self-efficacy (all $p > 0.05$). Univariable analyses linked barriers (OR=0.92), benefits (OR=1.03) and self-efficacy (OR=1.05) to PA adequacy, yet only perceived barriers remained significant in the adjusted model (aOR=0.93,

$p=0.004$; Nagelkerke $R^2=0.085$). **Conclusions:** Barriers were the only psychosocial factor independently associated with meeting PA recommendations, suggesting that perceived barriers may represent a candidate target for future intervention studies. In a pre-specified sensitivity analysis using the all-domain outcome (79.1% adherent), none of the psychosocial correlates remained associated with adherence, whereas both Zhejiang and Shaanxi showed lower adjusted odds than Guangdong, indicating that the psychosocial association was specific to the sports/exercise domain. Findings support transferability across settings rather than province-level generalization; the cross-sectional design limits causal inference.

Keywords: Physical activity; Pregnant women; Perceived barriers; Exercise self-efficacy; Health Belief Model; Multi-centre study; Cross-sectional study; China; Late pregnancy

Background

Physical activity (PA) is any movement generated by skeletal muscle contractions that significantly raises caloric needs beyond resting energy expenditure [1]. Encouraging physical activity is a global health priority because it can alleviate non-communicable disease burdens and enhance population health[2]. Regular physical activity has been shown to prevent and manage noncommunicable diseases (NCDs) like heart disease, stroke, diabetes, and breast and colon cancer. Additionally, it helps prevent hypertension, obesity, and overweight, as well as improve mental health, quality of life, and well-being[3]. Engaging in physical activity during pregnancy offers advantages for both maternal and fetal health, including a decreased risk of adverse outcomes like gestational diabetes, hypertension, and preeclampsia, as well as reduced overweight and obesity and enhanced mental well-being. Engaging in regular physical activity during pregnancy effectively mitigates both short-term and long-term complications for newborns[4,5]. The World Health Organization has issued guidelines recommending that all pregnant women without contraindications participate in at least 150 minutes of moderate-intensity aerobic physical activity per week throughout pregnancy to optimize maternal and fetal outcomes[6]. The American College of Obstetricians and Gynecologists (ACOG) issues a concordant recommendation of at least 150 minutes per week of moderate-intensity aerobic activity during pregnancy, framed explicitly as an exercise prescription—for example, brisk walking, swimming, stationary cycling, or low-impact aerobics[7]. Notably, the evidence linking maternal activity to improved maternal and fetal outcomes, including reduced risks of gestational diabetes, hypertensive disorders of pregnancy, and excessive gestational weight gain, derives predominantly from such planned, structured exercise rather than from incidental daily activity[4,7].

Despite global and Chinese recommendations for pregnant women to engage in at least 150 minutes of moderate-intensity physical activity per week, most do not meet these guidelines[8,9]. A recent systematic review estimated that only about 21% of Chinese pregnant women achieve recommended PA levels, with substantial regional and trimester differences[8]. Many studies are limited to a single centre or region, typically conducted in one city such as Tianjin, Shanghai, or Guangzhou, or within a

single hospital[10–12], complicating the differentiation between environmental specificity and behavioural universality. China's vast territory and diverse cultural and economic factors may lead to varying levels of physical activity, and whether the psychological mechanisms influencing behaviour possess cross-situational robustness remains unclear. Moreover, the available Chinese evidence is concentrated in early pregnancy[10,13,14]: recent studies have enrolled women predominantly or exclusively in the first trimester, and no multicentre study has characterized the psychosocial correlates of guideline adherence in late pregnancy, when physical discomfort peaks and the decline in activity is most pronounced.

Beyond the demographic and regional influences described above, how psychosocial factors—such as perceived benefits, perceived barriers, and exercise self-efficacy—jointly relate to PA guideline adherence among Chinese pregnant women remains unclear. Although exercise self-efficacy and perceived benefits are frequently reported as important cognitive correlates of PA[13,14], behavioural research in NAFLD patients suggests that immediate, tangible barriers such as physical discomfort during exercise and time constraints are among the most commonly reported and influential obstacles to meeting physical activity recommendations[15]. Pregnancy health behaviours are often more strongly constrained by short-term physical barriers (such as fatigue, nausea, and discomfort); in contrast, appeals to long-term, abstract health benefits are often insufficient to promote actual behavioural changes[16–18]. We therefore hypothesized that perceived barriers would be independently associated with PA guideline compliance among Chinese pregnant women, particularly in late pregnancy, even after adjustment for perceived benefits, self-efficacy, and sociodemographic factors.

In China, prenatal care has traditionally prioritized fetal safety monitoring, nutritional guidance, and risk screening, and structured physical activity counselling is not yet routinely integrated into antenatal visits[19,20]. Although national recommendations encourage regular moderate-intensity activity for women with uncomplicated pregnancies[21], implementation in routine obstetric practice remains limited. Clarifying which modifiable psychosocial factors are most closely associated with guideline adherence in this setting is essential for designing feasible promotion strategies within the existing maternal health system. Therefore, this study aimed to: (1) describe the patterns and centre-level variations of PA among pregnant women in three Chinese provinces; and (2) identify factors independently associated with PA guideline compliance, and examine whether perceived barriers remain associated with meeting international PA recommendations after mutual adjustment; and (3) assess the robustness of the psychosocial associations through a pre-specified sensitivity analysis using an all-domain adherence outcome.

Methods

Study design and setting

This multicentre cross-sectional survey was conducted between 27 January and 21 February 2024 at one tertiary hospital in each of three provinces selected to capture geographical and climatic diversity

across China: Zhongshan Hospital of Traditional Chinese Medicine (Guangdong, southern, subtropical), The First Affiliated Hospital of Ningbo University (Zhejiang, eastern, temperate), and Xi'an Fourth Hospital (Shaanxi, northern, continental). All eligible pregnant women attending routine antenatal visits during the recruitment period were invited to complete an electronic questionnaire administered via the Wenjuanxing ("Questionnaire Star"; www.wjx.cn) platform. The study is reported in accordance with the STROBE statement for cross-sectional studies[22].

Participants

Women were eligible if they were aged 20–45 years and had a singleton pregnancy. Exclusion criteria were a history of habitual abortion or preterm birth, premature rupture of membranes, persistent vaginal bleeding, placenta previa, severe anaemia, systemic disease, mental illness, or cognitive impairment. Additionally, they needed to comprehend the study's purpose and procedures and participate voluntarily. At each centre, eligible pregnant women were invited by trained research staff during their routine antenatal visits within the recruitment window. The number of women invited at each site was not prespecified, and the resulting site-level sample sizes (149, 109, and 77) reflect the patient volume and recruitment capacity of each centre during this four-week period. Women's decisions not to participate were not systematically recorded, so a true response rate could not be calculated. A submission was considered incomplete when any mandatory item was unanswered, and inconsistent when it contained logically contradictory or implausible values; such submissions were rejected by the platform before data export, so the analysed dataset contained no missing values (Figure 1).

Sample size

The sample size was estimated for the prevalence of compliance with physical activity guidelines. Based on our preliminary study conducted in Guangdong Province in 2017, which reported a compliance rate of 22.1%[23]. The required sample size was calculated using the formula for a single proportion, $n = Z^2p(1-p)/E^2$, with $Z = 1.96$ (95% confidence level), $p = 0.221$, and $E = 0.05$, yielding a minimum of 265 participants. The target was increased to 295 to allow for an anticipated 10% attrition. In addition, the effective sample size for the primary multivariable logistic regression was assessed post hoc: with 97 outcome events and 9 parameters in the parsimonious adjusted model, the events-per-variable ratio was 10.8, meeting the conventional criterion of at least 10. The final analytical sample ($n = 335$) exceeded the required sample size.

Relationship to companion publications. The dataset analysed here ($n = 335$) is shared with two companion publications from the same cohort. The first is a convergent mixed-methods study examining whether the Exercise Benefits/Barriers Scale and the Pregnancy Exercise Self-Efficacy Scale capture the lived exercise experiences of Chinese pregnant women[24]. The second compared two domain-inclusion criteria for defining PA guideline adherence (all-domain versus exercise/leisure-time only), quantified the classification agreement between them, and examined their associations with gestational weight gain[25]. The present manuscript addresses distinct research

questions: centre-level variation in physical activity patterns and the psychosocial correlates (perceived benefits, barriers, and exercise self-efficacy) of meeting international PA recommendations, which neither companion study examined. One figure overlaps between this manuscript and the companion study[25]: the prevalence of all-domain adherence (79.1%), which was a primary outcome in that study and is reported here solely as the outcome of a pre-specified sensitivity analysis; the two manuscripts draw different conclusions from this estimate. No other results are duplicated.

Ethical Approval

The Ethics Committee of the Philippine Women's University (ERB2024_007) provided single IRB oversight and approved the multi-center protocol for all three data collection sites. The First Affiliated Hospital of Ningbo University granted additional local ethics approval (Approval No.)0.2024 035 A-1), the site contributing the largest participant sample. Participants gave electronic written informed consent before joining the study.

Measures

Physical activity. Physical activity during pregnancy was assessed using the Pregnancy Physical Activity Questionnaire (PPAQ[26]), which measures the duration, frequency, and intensity of activity across 31 items in five domains: household/caregiving (10 items), occupational (5 items), sports/exercise (8 items), transportation (5 items), and inactivity (3 items)[27]. The Chinese version has demonstrated good psychometric properties, with a content validity index of 0.94, a test–retest reliability of 0.944, and a correlation of 0.768 with energy expenditure measured by human motion energy consumption meter. Based on energy expenditure, each item is classified as sedentary (<1.5 METs), light intensity (1.5–2.9 METs), moderate intensity (3.0–6.0 METs), or vigorous intensity (>6.0 METs)[28].

Primary outcome. The primary outcome was compliance with PA guidelines, operationalized within the sports/exercise domain of the PPAQ. For each participant, the durations of activities classified as moderate intensity (3.0–6.0 METs) were summed to obtain weekly minutes of moderate-intensity exercise. In accordance with the WHO 2020 guideline[5], women accumulating at least 150 min/week of moderate-intensity aerobic exercise—equivalent to at least 450 MET-minutes (7.5 MET-hours) at the 3.0-MET threshold—were classified as meeting the recommendation (coded 1); all others were coded 0. Activities in the household/caregiving, occupational, and transportation domains, and any activity below 3.0 METs, were not counted toward this outcome. This exercise-based definition was adopted for two reasons. First, the study aimed to characterize exercise behaviour—planned, structured, and repetitive movement performed to improve or maintain fitness[1]—because the evidence linking maternal physical activity to improved maternal and fetal outcomes derives predominantly from structured aerobic exercise interventions[4,7]. Second, this operationalization is concordant with ACOG Committee Opinion No. 804, whose recommendation of at least 150

min/week of moderate-intensity aerobic activity is framed as an exercise prescription, with examples limited to exercise-type activities[7]. This definitional difference is addressed explicitly when our adherence rate is compared with those of other studies.

Sensitivity analysis. In a pre-specified sensitivity analysis, adherence was additionally operationalized across all PPAQ domains: moderate-intensity activity (≥ 3.0 METs) accumulated in the household/caregiving, occupational, sports/exercise, and transportation domains was summed, and women accumulating at least 450 MET-minutes/week (≥ 7.5 MET-hours) were classified as adherent (coded 1; all others coded 0). The same a priori nine-parameter multivariable model was refitted with this outcome (Supplementary Table S1).

Exercise benefits and barriers. Perceived exercise benefits and barriers were assessed using the Exercise Benefits/Barriers Scale (EBBS) [29], which comprises 43 items in two subscales: Exercise Benefits (29 items) and Exercise Barriers (14 items). Items are rated on a four-point Likert scale from 1 (strongly disagree) to 4 (strongly agree), with higher subscale scores indicating greater perceived benefits or barriers, respectively. The standardized Cronbach's α coefficients were 0.952 for the total scale, 0.953 for the Benefits subscale, and 0.886 for the Barriers subscale.

Exercise self-efficacy. Pregnancy exercise self-efficacy was assessed using the 10-item Chinese version of the Pregnancy Exercise Self-Efficacy (P-ESES)[30]. Items are rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), yielding a total score of 10–50, with higher scores indicating greater self-efficacy. The Cronbach's α of the total scale was 0.804.

Covariates. Sociodemographic characteristics (age, education, employment status, residence, and household income) and obstetric characteristics (gestational age and parity) were collected through structured items in the same electronic questionnaire.

Statistical Analysis

Data were exported from the Wenjuanxing platform into Excel and analysed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA). Before analysis, extreme values of the energy-expenditure estimates were checked against the original questionnaire records and confirmed to match the submitted responses; no observations were excluded as outliers.

Participant characteristics are summarized descriptively: means with standard deviations for normally distributed continuous variables, medians with interquartile ranges for non-normally distributed variables, and frequencies with percentages for categorical variables. Between-centre differences in physical activity levels, perceived exercise benefits and barriers, and exercise self-efficacy were examined using one-way analysis of variance or Kruskal–Wallis tests, as appropriate, and categorical variables were compared using the chi-square test. For Kruskal–Wallis tests yielding significant overall results, pairwise comparisons were performed against the Guangdong centre and evaluated against a Bonferroni-adjusted threshold of $p < 0.0167$ ($0.05/3$); unadjusted p values are reported for transparency.

Univariable and multivariable logistic regression analyses were conducted to identify factors associated with meeting the PA recommendation. Multicollinearity among predictors was assessed using variance inflation factors, and model fit was evaluated with the Hosmer–Lemeshow goodness-of-fit test. The univariable analyses, performed without multiplicity control, were regarded as exploratory and hypothesis-generating, whereas the multivariable model was specified a priori. As a pre-specified sensitivity analysis, the a priori nine-parameter multivariable model was refitted using the all-domain adherence outcome (see Measures), with the results reported in Supplementary Table S1. All tests were two-tailed, and $p < 0.05$ was considered statistically significant.

Results

Characteristics of the Participants

Table 1 lists the sociodemographic and obstetric characteristics of the study participants. The mean age was 30.6 ± 3.5 years, the mean height was 161.2 ± 5.5 cm, the mean gestational week was 34.3 ± 4.9 weeks. Most participants had a tertiary education ($n=259$, 77.3%), were in late pregnancy ($n=317$, 94.6%), and were employed ($n=227$, 67.8%). Most of the women were nulliparous ($n = 244$, 72.8%) and living in the urban area ($n = 294$, 87.8%), and 43.0% ($n=144$) co-resided with parents or parents-in-law. 60% of the participants ($n = 201$) had an annual household income between 100k and 300k RMB.

Participants' Physical Activity Levels

The participants' Physical Activity levels and patterns are shown in Table 2. The participants were generally physically inactive, with most sedentary and engaging in low-intensity physical activities, fewer engaging in moderate-intensity physical activities, and almost none engaged in vigorous-intensity physical activities. Using the metabolic equivalent to measure total energy expenditure, the mean total energy expenditure was 183.56 MET-hours/week, and the median was 173.73(129.73,224.63) MET-hours/week. Among the 335 pregnant women, 50 (14.9%) did not engage in any form of exercise. Ninety-seven participants (29%) engaged in at least 150 minutes per week of moderate-intensity sports/exercise activity, equivalent to 450 MET-minutes or 7.5 MET-hours[31,32]. Walking was the most common form of exercise for pregnant women, reported by 265 participants, accounting for 79.1% of the total participants. Under this exercise-domain-based definition, concordant with the ACOG recommendation[7], these 97 individuals (29.0%) were classified as meeting the exercise guideline during pregnancy. When moderate-intensity activity accumulated across all PPAQ domains was operationalized as ≥ 450 MET-min/week (≥ 7.5 MET-hours at the 3.0-MET threshold, the all-domain counterpart of our primary definition), 265 of 335 women (79.1%) met this WHO-based criterion, compared with 29.0% under the exercise-domain definition.

In terms of activity intensity, pregnant women consumed more than half of their daily energy from sedentary activities. Low-intensity activities accounted for 27.1% of the total daily energy expenditure, and moderate-intensity and above activities accounted for 18.4% of the total energy

expenditure (MPA 18.0% plus VPA 0.4%; Table 2), indicating that pregnant women were generally in a state of physical inactivity. Nearly 60% of energy was consumed in domestic activities, followed by occupational activities. Energy expenditure in transportation accounted for 9.8% of total energy expenditure, and only 3.1% was consumed in exercise.

Between-Centre Comparisons of PA and Psychosocial Scores

Table 3 showed significant differences in sedentary behaviour, low-intensity PA, and moderate-intensity PA across the three study centres (all omnibus $P < 0.05$). Pairwise comparisons were evaluated against a Bonferroni-adjusted significance threshold of $p < 0.0167$ ($0.05/3$ comparisons against the Guangdong centre). After correction, only the differences in low-intensity PA remained statistically significant: low-intensity PA was lower in Zhejiang (33.95 [19.34, 55.48]) and Shaanxi (29.75 [16.8, 61.08]) than in Guangdong (53.73 [26.95, 87.5]; unadjusted $p < 0.001$ and $p = 0.002$, respectively). The nominally higher sedentary score in Shaanxi versus Guangdong (112 [73.33, 137.64] vs. 88.2 [54.51, 125.3]; unadjusted $p = 0.03$) and the nominally lower moderate-intensity PA in Zhejiang versus Guangdong (17.75 [7.73, 34.41] vs. 22.05 [12.7, 49.03]; unadjusted $p = 0.046$) did not survive the correction. The differences in Total PA, VPA, DPA, TPA, OPA, LTPA (exercise), E-Benefits, E-Barriers, and P-ESES across the three centres were not statistically significant (all $P > 0.05$).

Figure 2 illustrates the comparison of physical activity compliance rates among pregnant women across three provinces: Guangdong ($n=109$), Zhejiang ($n=149$), and Shaanxi ($n=77$). The analysis revealed no statistically significant differences among the three provinces ($\chi^2 = 2.005$, $df = 2$, $p = 0.367$). Error bars indicate 95% confidence intervals.

Factors Associated with Physical Activity Compliance

Table 4 displays the logistic regression analyses, both univariable and multivariable, examining factors linked to compliance with physical activity. Univariable analysis revealed significant associations between physical activity compliance and three psychosocial variables: exercise benefits score (OR = 1.03, 95% CI 1.01–1.05, $p = 0.007$), exercise barriers score (OR = 0.92, 95% CI 0.88–0.97, $p < 0.001$), and self-efficacy score (OR = 1.05, 95% CI 1.01–1.10, $p = 0.024$). No demographic, obstetric, or regional factors showed significant associations with physical activity compliance in univariable analysis.

In a multivariable analysis accounting for demographic, obstetric, psychosocial, and regional factors, the exercise barriers score was the only variable that remained statistically significant (OR = 0.93, 95% CI 0.89–0.98, $p = 0.004$). A one-point increase in the exercise barriers score correlated with a 7% reduction in the odds of meeting physical activity guidelines. Expressed on a more clinically intuitive scale, each 5-point increase in the barriers score corresponded to approximately 30% lower odds of guideline compliance (OR = 0.70, 95% CI 0.56–0.90 per 5-point increment). In the multivariable model, the exercise benefits score (OR = 1.01, 95% CI 0.99–1.04, $p = 0.376$) and self-efficacy score (OR = 1.04, 95% CI 0.98–1.10, $p = 0.202$) were not statistically significant, indicating

that their univariable associations were no longer statistically significant after mutual adjustment; this attenuation may reflect shared variance among correlated predictors or reduced precision rather than confounding.

As a sensitivity analysis, the same nine-parameter model was refitted with adherence defined across all PPAQ domains (≥ 450 MET-minutes/week; 265 of 335 women, 79.1%; Table S1). Under this broader outcome, none of the psychosocial correlates remained associated with adherence (exercise benefits: aOR 1.02, 95% CI 0.99–1.05, $p = 0.296$; exercise barriers: aOR 1.01, 95% CI 0.96–1.06, $p = 0.711$; self-efficacy: aOR 1.00, 95% CI 0.94–1.06, $p = 0.969$), indicating that the correlates identified in the primary analysis were specific to the sports/exercise domain. In contrast, regional differences emerged under the all-domain outcome: compared with Guangdong, women in Zhejiang (aOR 0.42, 95% CI 0.20–0.86, $p = 0.017$) and Shaanxi (aOR 0.31, 95% CI 0.14–0.71, $p = 0.005$) had lower odds of adherence. The model showed acceptable calibration (Hosmer–Lemeshow $\chi^2 = 6.823$, $df = 8$, $p = 0.556$), although the overall model was not statistically significant ($\chi^2(9) = 13.551$, $p = 0.139$); given the high adherence rate (79.1%), the minority class comprised only 70 events (events-per-parameter ≈ 7.8), and, given that the omnibus model test was not statistically significant, these regional estimates should be regarded as exploratory; this analysis is therefore presented as a sensitivity check only.

Discussion

This multi-centre study examined physical activity patterns and their psychosocial determinants among 335 pregnant women (predominantly in the third trimester) across Guangdong, Zhejiang, and Shaanxi provinces in China. Our study addresses a notable gap, because existing Chinese evidence has been drawn largely from first-trimester cohorts, whereas physical and time barriers to activity are most pronounced in late pregnancy. Three significant insights emerged. First, only 29% of pregnant women met the exercise guideline, indicating that the majority did not reach the recommended ≥ 7.5 MET-hours per week of moderate-intensity sports/exercise activity. Second, despite observing provincial differences in sedentary behaviour and activity intensity distributions, the compliance rates were notably similar across the three provinces (25.7%, 28.2%, and 35.1%, respectively; $\chi^2 = 2.005$, $p = 0.367$). Third, exercise barriers were identified as the only factor independently associated with physical activity compliance in the multivariable analysis (OR = 0.93, 95% CI 0.89–0.98, $p = 0.004$). Our study's compliance rate of 29.0% aligns with earlier findings from Western and Asian populations, indicating that insufficient physical activity during pregnancy is a worldwide public health issue. Hesketh and Evenson found that 23.4% of pregnant women in the United States met the 2015 American College of Obstetricians and Gynecologists (ACOG) guideline when adherence was operationalized as at least 150 min/week of self-reported leisure-time moderate-to-vigorous activity in NHANES interview data[33]. Direct cross-study comparisons of adherence rates should nonetheless be made cautiously, because the operational definitions of “meeting the guideline” differ across studies. Notably, most of the international estimates cited here—including those of Hesketh and Evenson, Amezcua-Prieto et al., and Okafor and Goon—were likewise derived from self-reported

leisure-time or sports/exercise-domain activity and are therefore broadly comparable with our exercise-domain-based estimate; residual heterogeneity arises from differences in intensity thresholds (moderate-to-vigorous versus moderate only), minimum bout and frequency requirements, and trimester composition, and such definitional heterogeneity has been highlighted as a major source of variation in prevalence estimates across countries[9]. A comparable adherence rate was observed in Europe, with 20.3% of pregnant women in Spain meeting leisure-time physical activity recommendations[34]. In South Africa, 25.7% of pregnant women met the recommended activity level, which was operationalized through the sport/exercise score of the PPAQ[35]. Previous studies in China have reported low levels of physical activity among pregnant women. For instance, Zhang et al. found that only 11.1% of pregnant women in Tianjin met the physical activity recommendations[11]. The consistently low compliance rates across diverse cultural and geographic settings suggest that pregnancy itself presents universal barriers to physical activity engagement, including physical discomfort, fatigue, and concerns about fetal safety.

Our study revealed an interesting contrast between the centre-level differences in activity intensity distributions and the uniformity in overall compliance rates. Table 3 showed significant differences among the three centres in sedentary behaviour, light-intensity activity, and moderate-intensity activity (all $p < 0.05$). Because each province was represented by a single hospital, province and study centre are fully confounded in our data; the between-province comparisons below should therefore be read as comparisons among the three participating centres. Yet, the proportions meeting the recommended guidelines were remarkably similar across Guangdong, Zhejiang, and Shaanxi ($\chi^2 = 2.005$, $p = 0.367$). This pattern suggests that women may adopt different behavioural strategies to cope with pregnancy-related physical changes depending on their local context, while ultimately achieving comparable overall activity levels. For example, women in one province may compensate for higher sedentary time with more structured exercise, while those in another province may accumulate activity through household tasks and walking. The cultural homogeneity in pregnancy-related beliefs and practices across China may override regional differences in lifestyle and economic development, which may partly explain the similar compliance rates across centres, although centre-specific factors (such as patient case mix and local counselling practices) cannot be disentangled from provincial influences in this design.

The clearest finding from our study was the independent association of exercise barriers with PA compliance. In a multivariable analysis accounting for demographic, obstetric, psychosocial, and regional variables, the exercise barriers score was the only factor that remained statistically significant (OR = 0.93, 95% CI 0.89–0.98, $p = 0.004$). Each one-point increase in this score corresponded to a 7% reduction in the odds of meeting physical activity guidelines. This aligns with the Health Belief Model (HBM), which identifies perceived barriers as among the strongest determinants of health behaviour adoption[36]. Pregnant women encounter distinct physical and psychological challenges that can hinder regular activity, including concerns about fetal safety, physical discomforts like nausea

and back pain, time limitations, and insufficient social support[11,37]. Our results suggest that these perceived barriers showed a more robust adjusted association with physical activity behaviour than sociodemographic characteristics or motivational factors like perceived benefits and self-efficacy.

The pre-specified sensitivity analysis helps delimit the scope of the barriers finding. When adherence was operationalized across all PPAQ domains, the psychosocial correlates were no longer associated with adherence, whereas the two non-Guangdong centres showed significantly lower adjusted odds of adherence. One interpretation is that perceived barriers are tied specifically to deliberate, structured exercise behaviour rather than to incidental activity accumulated through domestic, occupational, or transportation domains. Under this reading, would suggest that barrier-reduction counselling could target the initiation and maintenance of planned exercise, not merely total daily movement. The emergence of regional differences under the all-domain outcome—with Zhejiang and Shaanxi below Guangdong—suggests that between-centre differences may be carried mainly by non-exercise domains, although with one centre per province this pattern cannot be separated from centre-specific influences, and the all-domain model was limited to a minority class of only 70 non-adherent women (≈ 7.8 observations per parameter), so these regional estimates warrant cautious interpretation.

The shift from significant to non-significant results for exercise benefits and self-efficacy between the univariable and multivariable analyses warrants cautious interpretation. In univariable analysis, both exercise benefits (OR = 1.03, $p = 0.007$) and self-efficacy (OR = 1.05, $p = 0.024$) were significantly associated with PA compliance, but neither remained significant in the adjusted model ($p = 0.376$ and $p = 0.202$, respectively). Loss of statistical significance after adjustment does not by itself establish confounding or mediation; it may reflect correlations among predictors, shared variance, or reduced precision. exercise benefits were moderately correlated with both exercise barriers ($r = -0.250$, $p < 0.001$) and self-efficacy ($r = 0.576$, $p < 0.001$). Cross-sectional data cannot distinguish among confounding, mediation, and collinearity; longitudinal or experimental designs with formal mediation analyses would be needed to clarify these pathways[38,39].

These findings carry theoretical implications for understanding physical activity behaviour during pregnancy. Within the Social Cognitive Theory (SCT) framework, self-efficacy is often positioned as a central determinant of health behaviour[40]. In our data, the bivariate correlation between exercise barriers and PA ($r = -0.181$) was similar in magnitude to that of self-efficacy ($r = 0.206$), yet only barriers remained statistically significant in the adjusted model. This pattern is consistent with the Health Belief Model's emphasis on perceived barriers[36] and suggests that, in late pregnancy, external constraints may be closely tied to behaviour. However, statistical significance in a single adjusted model cannot establish the relative causal importance of correlated factors; this interpretation should therefore be regarded as hypothesis-generating rather than as a refutation of the self-efficacy perspective.

This has important implications for intervention design, suggesting a shift from solely bolstering individual beliefs to systematically identifying and addressing contextual barriers. Our data suggest

that during pregnancy, barriers may be largely externally determined—physical symptoms, time constraints, family opposition, safety concerns—rather than reflecting internal confidence deficits. This interpretation is consistent with Harrison et al., who found that pregnancy-specific barriers often exist independently of women's exercise capabilities[18]. Furthermore, the strong correlation between exercise benefits and self-efficacy ($r = 0.576$) supports Bandura's conceptualization of reciprocal determinism, wherein outcome expectations and efficacy expectations reinforce each other[41]. However, our multivariable findings suggest that this reinforcing cycle may be insufficient to overcome significant perceived barriers. Reverse causation is also plausible—women who are less active may perceive or report more barriers—and the cross-sectional design cannot establish the direction of this association.

Our findings have important implications for prenatal care and public health interventions. First, healthcare providers should prioritize routine assessment of exercise barriers during prenatal visits, as they represent the factor most consistently associated with meeting physical activity guidelines. Instruments like the Exercise Benefits and Barriers Scale are readily applicable in clinical settings. Second, counselling should be individualized to address specific barriers identified by each pregnant woman, rather than providing generic recommendations to “exercise more.” For example, for women with safety concerns, providers can offer evidence-based reassurance and specific safety guidelines; for those with physical discomfort, appropriate exercise modifications can be recommended; and for those with time constraints, time-efficient exercise options can be suggested. Third, the similar compliance rates observed across the three centres tentatively suggest that barrier-focused interventions may be transferable across diverse Chinese settings; confirmation in studies recruiting multiple centres per province would be needed before national-level generalization.

This study has several strengths. The multicentre design spanning three diverse provinces (Guangdong, Zhejiang, and Shaanxi) covers geographically and economically diverse regions of China, although each province contributed a single study centre. The sample size ($n = 335$) was adequate for the prevalence-estimation objective, and the comprehensive assessment of demographic, obstetric, psychosocial, and regional factors—using validated measures—allowed us to identify exercise barriers as the only factor independently associated with PA compliance.

It is important to acknowledge several limitations. The cross-sectional design limits causal inference, preventing determination of whether barriers lead to low activity or the reverse. The predominance of third-trimester participants (94.6%) limits our understanding of how predictors may vary across pregnancy stages. Physical activity was evaluated through a self-reported measure derived from the PPAQ, which is susceptible to recall bias and social desirability; using objective tools like accelerometers would be more ideal. Finally, the relatively homogeneous sample (predominantly urban, college-educated, middle-income) may limit generalizability to rural or less educated populations. Moreover, with only one hospital recruited per province, province and study centre are fully confounded, and the observed regional patterns may reflect centre-specific rather than genuinely

provincial effects. In addition, although the parsimonious model achieved an events-per-variable ratio of 10.8, the limited number of events ($n = 97$) still warrants cautious interpretation of non-significant findings. In addition, because non-participation was not systematically recorded, selection bias related to non-response could not be assessed. In addition, submissions rejected by the platform as incomplete or inconsistent could not be characterised, and the direction of any resulting bias is unknown. Finally, PA compliance was operationalized as self-reported moderate-intensity activity in the sports/exercise domain of the PPAQ, which captures guideline-relevant exercise but not moderate-intensity activity accumulated in other life domains. Consequently, the 29.0% adherence rate should be interpreted as exercise adherence and is likely lower than estimates that count moderate-intensity activity from all domains. Finally, the all-domain model was limited to a minority class of only 70 non-adherent women (≈ 7.8 observations per parameter); its estimates should be regarded as hypothesis-generating. Future research should address these limitations through longitudinal designs tracking physical activity patterns across pregnancy trimesters. Objective measures, such as accelerometers, would complement self-report data and provide more accurate assessments. Intervention studies are needed to test the effectiveness of barrier-reduction strategies, particularly randomized controlled trials comparing barrier-focused counselling versus standard care. Additionally, dimension- and item-level analyses of the barriers subscale—for example, identifying whether fatigue, time constraints, safety concerns, or family opposition contribute most strongly to non-adherence—would sharpen intervention priorities, and we intend to report such analyses in future work.

Conclusions

This study reveals low rates of physical activity compliance among Chinese pregnant women—predominantly in the third trimester—with exercise barriers being the factor most consistently associated with guideline compliance and a potentially actionable intervention target. The consistency of findings across the three participating centres—each the sole centre in its province—suggests potential transferability, which should be confirmed in studies sampling multiple centres per province. Healthcare providers should prioritize routine barrier assessment and tailored counselling over generic recommendations. Because the association of perceived barriers with adherence was specific to structured exercise in late pregnancy, routine barrier assessment and tailored counselling should focus on helping women initiate and maintain planned moderate-intensity exercise. Addressing exercise barriers is crucial for enhancing pregnancy outcomes, given the established benefits of physical activity for both maternal and fetal health.

Abbreviations

PA, physical activity; MET, metabolic equivalent of task; TEE, total energy expenditure; SED, sedentary behaviour; LPA, light-intensity physical activity; MPA, moderate-intensity physical activity; VPA, vigorous-intensity physical activity; DPA, domestic physical activity; TPA,

transportation physical activity; OPA, occupational physical activity; LTPA, leisure-time physical activity (mainly exercise); PPAQ, Pregnancy Physical Activity Questionnaire; EBBS, Exercise Benefits/Barriers Scale; P-ESES, Pregnancy Exercise Self-Efficacy Scale.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Philippine Women's University (ERB2024_007), which provided institutional oversight for the doctoral project across all data collection sites. Additional local ethics approval was obtained from The First Affiliated Hospital of Ningbo University (Approval No. 2024 035A-1), the site contributing the largest participant sample. For the remaining two hospitals, data collection was conducted with institutional permission, and all participants provided electronic written informed consent, in compliance with the Declaration of Helsinki.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data in any form (e.g., personal identifiers, images, or recordings). All data were anonymized prior to analysis, and participants consented to the use of their anonymized data for research and publication during the informed consent process.

Availability of data and materials

The data analysed in this study were collected as part of the first author's doctoral dissertation (Philippine Women's University, 2024, unpublished) and derive from a single cohort of 335 pregnant women recruited in three Chinese provinces. This cohort is shared with two companion publications[24,25]; the extent and nature of the overlap are described in the "Relationship to companion publications" statement. The datasets generated and/or analysed during the current study are not publicly available in order to protect participant confidentiality but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JL conceptualised the study, collected data and drafted the manuscript; YW, XL and HL collected data and contributed to recruitment at the three study sites; JL and JTS performed the statistical analysis; JTS supervised the study and critically revised the manuscript. All authors read and approved the final manuscript.

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Clinical Trial Number

Not applicable.

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Table 1. Characteristics of the participants (n = 335)

Variables	Frequency
Age (years), mean $\pm$ SD	30.6 $\pm$ 3.5
Height (cm), mean $\pm$ SD	161.2 $\pm$ 5.5
Pre-pregnancy weight (kg), mean $\pm$ SD	55.1 $\pm$ 8.1
Current weight (kg), mean $\pm$ SD	66.6 $\pm$ 8.9
Gestational age (weeks), mean $\pm$ SD	34.3 $\pm$ 4.9
Level of education, n (%)	
Junior high and below	14(4.2%)
High school/Technical secondary	34(10.1%)
College/Undergraduate	259(77.3%)
Graduate	28(8.4%)
Current employment status, n (%)	
Employed	227(67.8%)
Unemployed	108(32.2%)
Current stage of pregnancy, n (%)	
First trimester($\leq 13+6$ weeks)	6(1.8%)
Second trimester(14~27+6)	12(3.6%)
Third trimester(≥ 28 weeks)	317(94.6%)
Parity, n (%)	
Nulliparous	244(72.8%)
Parous	91(27.2%)
Residence type, n (%)	
Urban	294(87.8%)
Rural	41(12.2%)
living arrangements, n (%)	
co-residence with parents/in-laws	144(43.0%)
Living separately from parents/in-laws	191(57.0%)

Annual household income(RMB), n (%)	
< 100k	72(21.5%)
100k~300k	201(60%)
>300k	62(18.5%)

Table 2. Physical activity levels of the participants (n = 335).

Variable	Mean	SD	Median (P50)	P25	P75	Min	Max	Percent of TEE(%)
TEE	183.56	87.01	173.73	129.73	224.63	35.63	658.28	100
Divided by activity intensity								
SED	100.12	44.67	100.45	60.73	135.45	2.63	195.83	54.5
LPA	49.78	38.61	39.03	20.65	69.13	4.03	216.30	27.1
MPA	33.09	43.08	18.85	8.53	40.18	0.00	315.27	18.0
VPA	0.57	2.16	0.00	0.00	0.00	0.00	20.25	0.4
Divided by activity domain								
DPA	109.87	58.85	96.60	70.53	131.60	22.05	397.95	59.8
TPA	18.01	19.06	12.25	7.00	21.00	0.00	126.00	9.8
OPA	50.13	47.48	59.85	0.00	76.83	0.00	373.00	27.3
LTPA	5.55	6.64	3.43	0.80	8.25	0.00	46.40	3.1

Table 3. Comparison of physical activity levels, exercise benefits/barriers, and self-efficacy across the three study centres (one tertiary hospital per province) (n = 335).

	Zhejiang (n=149)	Guangdong (n=109)	Shaanxi (n=77)	H	P
Total PA	162.35(126.5,219.91)	183.33(135.56,232.26)	178.33(123.19,228.69)	2.414	0.299
SED	112(62.13,141.75)	88.2(54.51,125.3)	112(73.33,137.64)	8.088	0.018
LPA	33.95(19.34,55.48)a	53.73(26.95,87.5)	29.75(16.8,61.08)a	17.933	<0.001
MPA	17.75(7.73,34.41)	22.05(12.7,49.03)	16(6.49,37.34)	7.481	0.024
VPA	0(0,0)	0(0,0)	0(0,0)	1.82	0.402
DPA	93.45(71.05,126.09)	107.1(71.23,153.83)	89.25(65.8,122.85)	5.657	0.059
TPA	12.25(7,21)	12.25(7,22.75)	13.13(4.38,21.88)	0.015	0.992
OPA	59.85(0,74.11)	56(3.85,76.83)	67.2(6.65,76.83)	3.848	0.146
LTPA	3.55(0.8,8)	3.28(0.8,8)	2.4(0.8,10.35)	0.062	0.969
Exercise-Benefits	87(83,87)	86(82,87)	86(81,91.5)	0.088	0.957
Exercise- Barriers	29(28,32)	29(28,32)	29(27,32)	0.382	0.826
P-ESES	37(32,40)	38(33.5,40)	37(32,40)	1.173	0.556

a: Unadjusted p < 0.0167, meeting the Bonferroni-adjusted threshold for three pairwise comparisons against the Guangdong centre

Table 4. Univariable and multivariable logistic regression analyses of factors associated with physical activity compliance among pregnant women (n = 335).

Variable	Univariable Analysis	Multivariable Analysis
	OR (95% CI), p	OR (95% CI), p
<i>Demographic factors</i>		
Age (years)	1.03 (0.96–1.10), 0.461	1.01 (0.94–1.09), 0.694
Education (Ref: Junior high and below)		
High school/Technical secondary	1.03 (0.47–2.23), 0.951	—
College/Undergraduate	0.85 (0.49–1.48), 0.567	—
Graduate	1.96 (0.89–4.31), 0.095	—
Education (dichotomized): College/undergraduate or above (Ref: High school or below)	—	1.02 (0.48–2.18), 0.954
Employment status: Employed (Ref: Unemployed)	0.89 (0.54–1.47), 0.656	0.81 (0.47–1.39), 0.442
Residence: Urban (Ref: Rural)	0.67 (0.34–1.33), 0.252	—
Living arrangement: Living separately (Ref: Living together)	1.11 (0.69–1.79), 0.680	—
Annual income (Ref:Below 100K)		
100-300K	1.05 (0.65–1.70), 0.844	—
Above 300K	1.21 (0.67–2.20), 0.526	—
<i>Obstetric factors</i>		
Gestational weeks	1.00 (0.95–1.05), 0.918	1.00 (0.95–1.05), 0.980
Trimester (Ref: First trimester)		
Second trimester	1.79 (0.56–5.80), 0.329	—
Third trimester	0.81 (0.29–2.21), 0.674	—
Parity: Parous (Ref: Nulliparous)	0.72 (0.41–1.25), 0.240	—
<i>Psychosocial factors</i>		
Exercise benefits score	1.03 (1.01–1.05), 0.007**	1.01 (0.99–1.04), 0.376
Exercise barriers score	0.92(0.88–0.97), <0.001***	0.93 (0.89–0.98), 0.004**
Self-efficacy score	1.05 (1.01–1.10), 0.024*	1.04 (0.98–1.10), 0.202
<i>Regional factors</i>		
Province (Ref: Guangdong)		
Zhejiang	1.14 (0.65–1.99), 0.656	1.12 (0.62–2.02), 0.718
Shaanxi	1.56 (0.83–2.95), 0.169	1.52 (0.76–3.03), 0.232

Abbreviations: OR (Odds Ratio); CI (Confidence Interval); Ref (Reference category).

Note: Compliance with physical activity was defined as accumulating at least 150 min/week (≥ 450 MET-minutes) of moderate-intensity activity in the sports/exercise domain of the PPAQ. Covariates for the multivariable model were selected a priori on clinical and theoretical grounds; the final model included 9 parameters (events-per-variable = 10.8). To limit the number of parameters given 97 events and because of sparse cells in the junior-high-and-below (n = 14) and graduate (n = 28) categories, education was dichotomized (college/undergraduate or above vs. high school or below) in the multivariable model; the corresponding estimate is now presented in Table 4. Univariable province estimates were computed from the full analytic sample with Guangdong as reference. Model fit statistics: -2 Log likelihood = 382.659; Cox & Snell R^2 = 0.059; Nagelkerke R^2 = 0.085; Model χ^2 = 20.514 (df = 9), p = 0.015; Hosmer–Lemeshow χ^2 = 3.634 (df = 8), p = 0.889. All variance inflation factors were < 1.6.

Significance levels are indicated as follows: * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

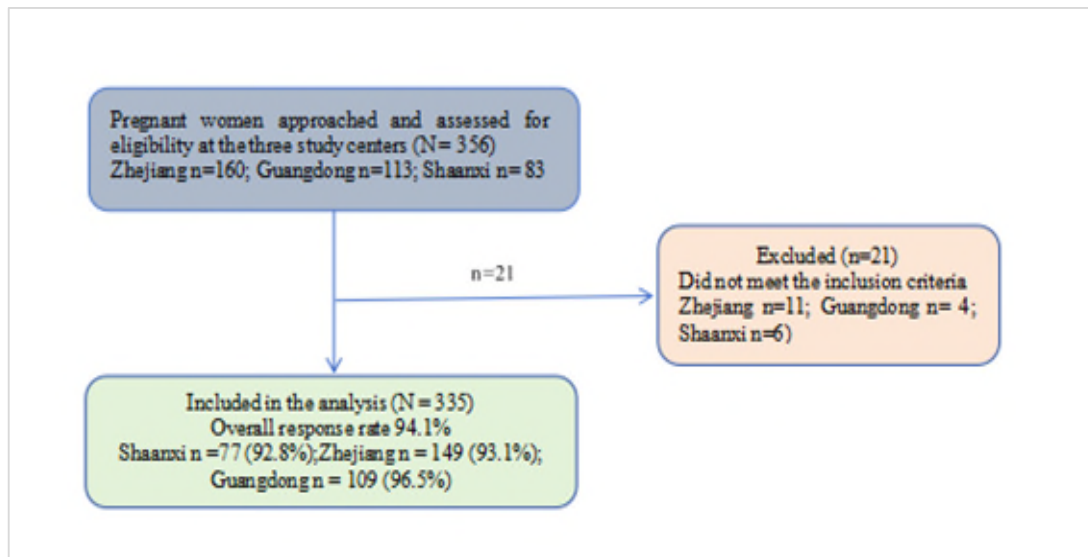


Figure 1. Participant flow diagram. Of the 356 pregnant women who accessed the online questionnaire at the three study centers, 21 were excluded because they did not meet the inclusion criteria (the online questionnaire terminated automatically), and 335 were included in the final analysis. Because invitations declined before questionnaire access were not recorded, a true response rate could not be calculated; this 94.1% refers to the proportion of questionnaire accesses that yielded an eligible, complete submission.

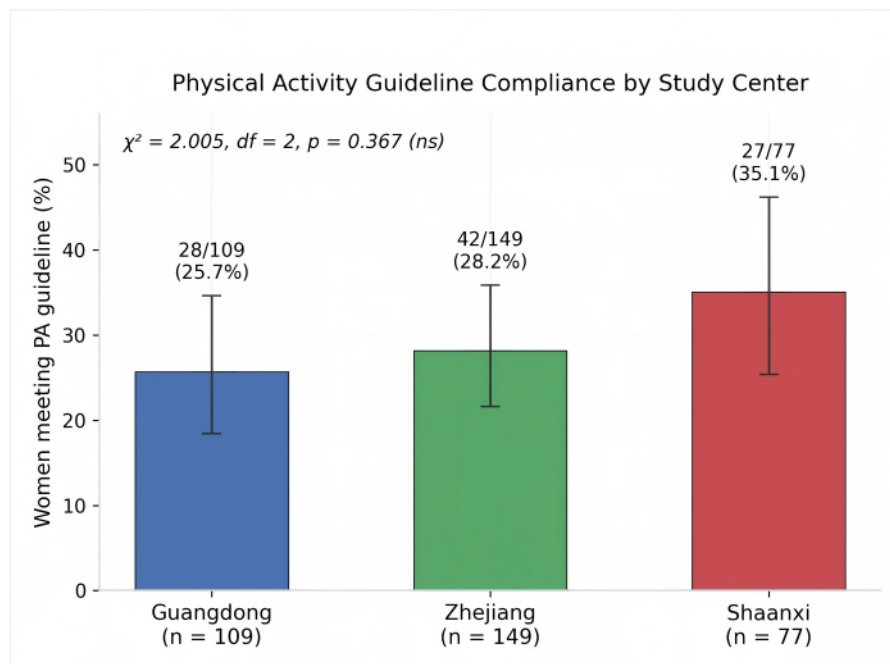


Figure 2. Comparison of physical activity guideline compliance rates among pregnant women in Guangdong ($n = 109$), Zhejiang ($n = 149$), and Shaanxi ($n = 77$) provinces. No statistically significant difference was found among the three provinces ($\chi^2 = 2.005, df = 2, p = 0.367$). Error bars indicate Wilson 95% confidence intervals. Bars are annotated with the number of women meeting the guideline, the group size, and the corresponding percentage.

Supplementary Files

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- [TableS1AlldomainSensitivity.docx](#)