

Postprint: Determinants of Physical Activity Behavior in Pregnant Women Based on Structural Equation Modeling

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Abstract

Objective: To conduct an in-depth analysis of influencing factors of pregnant women's exercise behavior based on survey research. **Methods:** A questionnaire survey was administered to 650, 650, and 750 pregnant women in early, middle, and late pregnancy stages, respectively, to investigate exercise behavior. Structural equation modeling (SEM) was employed for influencing factor analysis. The model primarily included four latent variables: pregnant women's attitude toward exercise behavior, subjective norm of exercise behavior, exercise behavioral intention, and exercise behavior, with corresponding observed variables set for each latent variable. **Results:** The age of pregnant women was concentrated between 18-35 years; both the pregnant women and their husbands had relatively high education levels; the education levels of the pregnant women's mothers and mothers-in-law were relatively low; the primary caregivers during pregnancy were their mothers, followed by their husbands. Regarding transportation modes, women in early, middle, and late pregnancy primarily walked, took buses, and used special transportation, respectively. The main form of exercise across all pregnancy stages was walking. Women in all pregnancy stages tended to engage in sedentary physical activities; the higher the exercise intensity, the less the exercise time. SEM analysis results showed that pregnant women's exercise behavior was influenced by behavioral intention (standardized regression coefficient was 0.372); behavioral attitude and subjective norm influenced exercise behavior by affecting behavioral intention (standardized regression coefficients were 0.140 and 0.669, respectively). **Conclusion:** The exercise behavior of pregnant women across all pregnancy stages was unreasonable, with a single exercise form and insufficient exercise time and intensity. Subjective norms indirectly influence pregnant women's exercise behavior through their effects on behavioral attitude and behavioral intention, suggesting that health education should be strengthened for pregnant women's primary caregivers.

Full Text

Preamble

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Abstract

Objective: To analyze factors influencing maternal physical activity behaviors based on survey research. **Methods:** Self-designed questionnaires were administered to investigate exercise behaviors among 650, 650, and 750 pregnant women in their first, second, and third trimesters, respectively. Structural equation modeling (SEM) was employed for factor analysis. The model included four latent variables: attitude toward exercise behavior, subjective norms regarding exercise behavior, exercise behavior intention, and actual exercise behavior, with corresponding observed variables for each latent variable. **Results:** Participants were aged 18–35 years; both the pregnant women and their husbands had relatively high education levels, while the women's mothers and mothers-in-law had relatively low education levels. The primary caregivers during pregnancy were the women's own mothers, followed by their husbands. Regarding transportation modes, women in early, middle, and late pregnancy primarily walked, took buses, and used dedicated transportation, respectively. The main form of exercise across all trimesters was walking. Women in all pregnancy stages tended toward sedentary physical activities, with greater exercise intensity associated with less exercise time. SEM analysis revealed that pregnant women's exercise behavior was influenced by behavioral intention (standardized regression coefficient = 0.372); both behavioral attitude and subjective norms affected exercise behavior by influencing behavioral intention (standardized regression coefficients = 0.140 and 0.669, respectively). **Conclusion:** Exercise behaviors among pregnant women across all trimesters were inadequate, characterized by monotonous exercise forms and insufficient duration and intensity. Subjective behavioral norms indirectly influenced exercise behavior through effects on behavioral attitude and intention, suggesting that health education should target pregnant women's primary caregivers.

Keywords: pregnant women; physical activity; structural equation modeling

Introduction

In recent years, with increasing awareness of perinatal health care, numerous studies have confirmed that safe exercise during pregnancy benefits both mothers and fetuses, significantly reducing the incidence of various pregnancy com-

plications. Exercise during pregnancy can lower the risk of gestational diabetes, reduce cesarean section rates, and alleviate maternal depression and anxiety. Nevertheless, globally, few women maintain exercise during pregnancy, with only one-fifth following guidelines proposed by the American College of Obstetricians and Gynecologists (ACOG). Research indicates that some women who exercised before pregnancy reduce or even abandon exercise behavior during pregnancy.

Studies on factors influencing exercise behavior during pregnancy show that 85% of American pregnant women consider internal psychological barriers as the main obstacle to exercise, followed by influences from friends, policy factors, and lack of health awareness among caregivers. In China, primary reasons for unwillingness to exercise include safety concerns, lack of knowledge about exercise, personal habits, and family disapproval.

Downs et al. used the Theory of Reasoned Action (TRA) as a framework to study factors influencing exercise behavior during pregnancy, demonstrating that pregnant women's exercise intention determines whether they actively exercise, and that intention is determined by subjective social norms. China has not yet established a standardized system for exercise during pregnancy, and existing research on influencing factors mostly involves simple analyses of current status without theoretical foundation, failing to deeply examine how various potential variables affect pregnant women's exercise behavior. Therefore, based on previous survey research and guided by TRA, this study constructed a structural equation model to deeply analyze factors influencing exercise behavior among Chinese pregnant women, providing scientific evidence for targeted, personalized exercise guidance and training.

1.1 Study Subjects

Using convenience sampling, 2,070 pregnant women at various gestational stages who established prenatal care cards or received antenatal examinations at a tertiary maternal and child specialty hospital in Chengdu were selected as study participants. Inclusion criteria: (1) Pregnant women in early (<14 weeks), middle (24-28 weeks), and late (>32 weeks) pregnancy without internal or surgical complications; (2) Voluntary participation with signed informed consent. Exclusion criteria: (1) Women with mental disorders that would hinder cooperation.

1.2 Methods

1.2.1 Survey Instruments Based on literature review and the TRA framework, self-designed questionnaires were developed. After expert evaluation and pilot testing, the final versions were the "Exercise Behavior Survey for Early Pregnancy," "Exercise Behavior Survey for Middle Pregnancy," and "Exercise Behavior Survey for Late Pregnancy." Each survey included three parts: general information, exercise behavior, and self-reported physical activity. (1) General information: nine items including age; (2) Exercise behavior: including trans-

portation modes and regular exercise types; (3) Physical activity self-report: adapted from a Danish scale that classifies pregnant women's physical activity into nine levels (A-I), with reliability of 0.87 and validity of 0.75.

1.2.2 Sample Size According to reference [17], average gestational weight gain was 13.8 kg with a standard deviation of 5.2 kg. With test level $\alpha = 0.05$, $u = u_{0.05} = 1.96$, and allowable error of 3%, i.e., $\bar{x} - \bar{x} = 3\% \times 13.8 \times 3\% = 0.414$ kg, $s = 5.2$ kg, the sample size was: $n = (1.96 \times 5.2 / 0.414)^2 = 606$

1.2.3 Data Collection Researchers first explained the purpose, principles, and methods of the survey to participants. After obtaining consent and signed informed consent forms, researchers provided one-on-one guidance while participants completed the questionnaires. Completion time was 20-30 minutes, with immediate clarification of questions and on-site collection.

1.2.4 SEM Analysis of Influencing Factors Structural equation modeling, also known as latent variable modeling, is an important statistical method in contemporary behavioral and social research. Its equations include random variables (observed, latent, and error variables) and structural parameters. SEM is primarily used to analyze complex relationships among observed variables, particularly to explore relationships among latent variables. This study used TRA as a framework for survey design and constructed an SEM to analyze factors influencing pregnant women's exercise behavior based on survey results. The initial model hypothesized relationships where behavioral attitude and subjective norms affected behavioral intention, and behavioral attitude, subjective norms, and behavioral intention directly affected behavior. The TRA framework is shown in [Figure 1: see original paper], and variables involved in the SEM are listed in .

1.2.5 Statistical Methods Epidata was used to establish the database, and SAS 9.1 was used for statistical analysis. Demographic data and exercise behaviors were described using rates, proportions, and means. Chi-square tests were used to compare differences in exercise behaviors before and during pregnancy. SEM was used to explore causal relationships among variables and deeply analyze factors influencing pregnant women's exercise behavior. $P < 0.05$ was considered statistically significant.

2.1 Demographic Characteristics

Questionnaires were distributed to 660, 660, and 750 women in early, middle, and late pregnancy, respectively, with 624, 619, and 738 valid questionnaires returned (effective response rates of 95%, 94%, and 98%). Results showed similar demographic characteristics across pregnancy stages. Ages were primarily 18-35 years; pre-pregnancy BMI was mostly in the normal range; except for middle

pregnancy, women in early and late pregnancy had relatively high household incomes; proportions of primiparous and multiparous women were approximately 50%; both pregnant women and their husbands had relatively high education levels; mothers and mothers-in-law of the pregnant women had relatively low education levels (over 50% with junior high school or less); primary caregivers were the women's own mothers, followed by their husbands ().

2.2 Exercise Patterns

2.2.1 Exercise Types Regarding transportation modes, women in early, middle, and late pregnancy primarily walked, took buses, and used dedicated transportation, respectively. After pregnancy, the main exercise type across all stages was walking ().

2.2.2 Exercise Intensity and Duration The study found that women across all pregnancy stages spent considerable time in sedentary physical activities, with greater exercise intensity associated with less exercise time ().

2.3 Model Establishment and Revision

SEM evaluation commonly uses indices including χ^2 , RMR, RMSEA, GFI, NFI, and CFI. The χ^2 test assesses goodness-of-fit, with smaller χ^2 and χ^2/df values indicating better fit. GFI represents the degree to which variance and covariance explained by the model can explain variance and covariance in the data, with values >0.90 indicating good fit. NFI and PNFI reflect differences between the hypothesized model and an independence model assuming no covariation among observed variables, with NFI >0.90 and PNFI >0.50 indicating good fit. The RMSEA coefficient is not affected by sample size or model complexity, with values of 0–0.05 indicating excellent fit, 0.05–0.08 good fit, 0.08–0.10 acceptable fit, and >0.10 indicating poor fit. CFI also reflects differences from an independence model, with values closer to 1 being better and PCFI >0.5 indicating good fit.

Initial model analysis indicated poor fit. Parameter estimation results showed that pregnant women's education level was not directly related to behavioral intention ($P > 0.05$); monthly income was not directly related to exercise behavior or subjective norms ($P > 0.05$); although the correlation between behavioral attitude and subjective norms was statistically significant, the correlation coefficient was very small. Model modification aims to adjust the initial model by deleting or adding paths to generate an optimal model. Therefore, these causal relationships were deleted during modification. Parameter comparisons between initial and modified models are shown in .

2.4 Model Parameter Results

Pregnant women's exercise behavior was influenced by behavioral intention (standardized regression coefficient = 0.372). Behavioral attitude and subjective

norms affected exercise behavior by influencing behavioral intention (standardized regression coefficients = 0.140 and 0.669, respectively). Monthly income and pregnant women' s education level indirectly affected exercise behavior by influencing behavioral attitude (standardized regression coefficients = 0.120 and 0.108, respectively). Mother' s education level indirectly affected exercise behavior by influencing subjective norms (standardized regression coefficient = 0.205). The modified parameter model is shown in [Figure 2: see original paper].

3.1 Current Status of Exercise Behavior Among Pregnant Women

Our previous survey results revealed inadequate exercise behaviors across all pregnancy stages, characterized by monotonous exercise forms, preference for sedentary physical activities such as walking, and insufficient exercise duration and intensity. Walking, as a simple and safe exercise, was most popular among pregnant women in this study, consistent with findings from a meta-analysis. However, diverse exercise forms are suitable for pregnant women, including prenatal gymnastics, yoga, cycling, and water exercises, all with confirmed safety. In this study, fewer than 20% of women practiced prenatal gymnastics in early pregnancy, with rates below 10% in middle and late pregnancy, and no women engaged in high-intensity physical activity (Type I) across any stage. These findings indicate that exercise implementation during pregnancy is suboptimal.

Pregnancy is a special process, and physical activity during this period may affect pregnancy status and outcomes. Moderate exercise during pregnancy not only reduces risks of cardiovascular disease, gynecological tumors, gestational diabetes, and preeclampsia, but also decreases the incidence of various neonatal birth defects. Conversely, failure to maintain exercise or severely insufficient exercise during pregnancy leads to corresponding adverse consequences. Therefore, exercise during pregnancy has special significance, and its forms and content are also distinctive. ACOG guidelines explicitly state that "pregnant women without complications should engage in moderate physical activity for at least 30 minutes daily or on most days of the week," such as stair climbing, brisk walking, prenatal yoga, health exercises, and water activities. This suggests that future health education should enrich exercise forms during pregnancy and encourage increased exercise duration and intensity.

3.2 SEM-Based Analysis of Influencing Factors

SEM analysis revealed that pregnant women' s exercise behavior depends on behavioral intention. Behavioral intention refers to the inclination toward a behavior, representing the motivation and cognitive tendency before action. It can stimulate individuals to take positive actions toward specific goals, with positive behavioral intentions typically producing positive exercise behaviors. In this study, observed variables for behavioral intention were whether the woman agreed that the behavior was beneficial and whether she was internally moti-

vated to exercise, with standardized regression coefficients of 0.742 and 0.772, respectively. These results suggest that pregnant women's personal willingness and views affect their behavioral intention, highlighting the importance of early health education to help them recognize the benefits of exercise for mother and child, generate exercise needs, and form positive exercise intentions.

The study demonstrated that pregnant women's behavioral attitude and subjective norms determine exercise behavioral intention, with subjective norms exerting far greater influence than attitude. Observed variables for subjective norms were the degree to which pregnant women complied with their mothers' and husbands' opinions, with standardized regression coefficients of 0.739 and 0.633, respectively, indicating that mothers and husbands as primary caregivers significantly influence behavioral intention. Research by Liu Zhiqin et al. showed that swimming, despite proven safety, is not accepted by pregnant women and their families. SEM analysis provides deeper interpretation: unreasonable subjective behavioral norms restrict pregnant women's exercise behavior. This suggests that future health education should include pregnant women's mothers and husbands, informing them about the purpose and significance of exercise during pregnancy so they can actively help form positive behavioral intentions and reasonable exercise behaviors.

Primary caregivers have the most significant impact on exercise behavior. Studies show that husbands' exercise habits and companionship positively influence pregnant women's exercise. However, in this study, primary caregivers were the women's own mothers, followed by their husbands, and mothers generally had low education levels. Following traditional Chinese beliefs, they often think pregnancy should involve "quiet rest" rather than physical activity, substantially limiting exercise behavior across all pregnancy stages. Therefore, health education for them should adopt vivid formats such as video presentations and scenario simulations to help them truly understand the importance of exercise during pregnancy, form standardized understanding, accompany pregnant women in exercise, and positively influence their behavior.

Pregnant women's own attitudes affect behavioral intention as an independent factor. Attitude represents the result of individuals' utilitarian choices in social life. When pregnant women recognize and internalize perspectives about exercise, they form stable attitudes that lead to behavioral intention and influence behavior. Knowledge about the dangers of unreasonable exercise and benefits of reasonable exercise were observed variables for attitude, with standardized regression coefficients of 0.837 and 0.853, respectively. Wang Xin et al. found that only 2.1% of pregnant women chose pelvic floor muscle exercises, attributing this not only to low education and poor awareness but also to inability to persist and lack of interest. SEM analysis provides deeper interpretation: pregnant women have not yet formed positive, correct attitudes toward reasonable exercise during pregnancy. Despite relatively high education levels in this sample, fewer than 20% practiced gymnastics in early pregnancy, with rates below 10% in middle and late pregnancy, and no women engaged in high-intensity ac-

tivity, indicating that knowledge and attitudes about exercise during pregnancy require improvement. Future health education should actively inform pregnant women about the benefits of exercise and dangers of unreasonable exercise to help them form positive behavioral intentions. Multiple formats such as prenatal schools, new media platforms, hotline consultations, and personalized guidance should be used to increase knowledge about exercise during pregnancy, enhance interest, and promote persistence throughout pregnancy.

The structural equation model also showed that pregnant women's education level and family income affect behavioral attitude—higher education and income correlate with better attitudes. This suggests that special attention should be paid to populations with low education and income, using targeted health education methods to enhance their exercise motivation.

Compared with previous research, this study is the first to apply SEM to analyze factors influencing exercise during pregnancy, clearly categorizing several major influencing aspects. The study verified the direct effect of behavioral intention on exercise behavior and particularly clarified the substantial indirect effect of subjective social norms on exercise behavior, providing clear direction for future health education.

Due to the current lack of guidelines and evaluation standards for exercise during pregnancy in China, accurate assessment of participants' exercise behavior is challenging. This suggests the need for strengthened research and education on exercise during pregnancy, standardization of exercise protocols, and early development of Chinese guidelines to regulate guidance and management. Future research could incorporate exercise types and energy expenditure into SEM for comprehensive analysis.

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