The Effects of Smartphone App-Based Exercise Management on Physical Activity, Fear of Childbirth, and Quality of Life among Pregnant Women in Indonesia: An Interventional Study

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Abstract

Background: Pregnancy, a vital phase in a woman's life, entails immense physical, psychological, and emotional alterations that might affect maternal health. Physical activity during pregnancy improves health outcomes; however, adherence to the recommendation is low. Moreover, fear of childbirth (FoC) has a negative impact on maternal mental health and quality of life (QoL). Mobile health (mHealth) interventions, especially those delivered through smartphone-based exercise management applications, provide a scalable solution to improve maternal health outcomes

Objective: The purpose of this study was to assess the impact of an exercise management intervention based on a smartphone app on physical activity, FoC, and QoL in pregnant women in Indonesia

Methods: A quasi-experimental design using repeated measures was conducted at Public Health Centers in West Java, Indonesia. We recruited 240 pregnant women who were randomly allocated to an intervention group (n=120) that received the app-based program and a control group (n=120) that only received standard prenatal care. Data were obtained at baseline (T0), after intervention (T1), and one month follow-up (T2). Outcomes were assessed using the Pregnancy Physical Activity Questionnaire (PPAQ), Wijma Delivery Expectation Questionnaire (WDEQ-A), and Quality of Life Gravidarum (QOL-GRAV). Statistical analysis was conducted by repeated measures ANOVA with Bonferroni post-hoc tests. Cohen's d was used to calculate effect sizes

Results: The intervention group had significant increases in physical activity levels from T0 to T1 ($p<0.001$, Cohen's $d=0.65$) and from T0 to T2 ($p<0.001$, Cohen's $d=0.72$), whereas there were no significant changes in the control group. FoC scores were significantly lower at T1 ($p<0.001$, Cohen's $d=0.52$) and T2 ($p<0.001$, Cohen's $d=0.56$) compared to T0 in the intervention group, but no changes were observed in the control group. QoL scores increased significantly in the intervention group from T0 to T1 ($p<0.001$, Cohen's $d=0.60$) and from T0 to T2 ($p<0.001$, Cohen's $d=0.68$), while there were no significant changes noted in the control group

Conclusions: The exercise management intervention utilizing the smartphone app was effective in increasing physical activity, reducing FoC, and improving QoL among Indonesian pregnant women. The intervention represents a scalable and accessible mechanism through which maternal health can be improved in limited resource contexts. Large-scale, long-term studies are needed to evaluate the sustainability of the benefits observed and the incorporation of mHealth solutions in standard prenatal management

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The Effects of Smartphone App-Based Exercise Management on Physical Activity, Fear of Childbirth, and Quality of Life among Pregnant Women in Indonesia: An Interventional Study

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Original Paper

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Abstract

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Conclusion: The exercise management intervention utilizing the smartphone app was effective in increasing physical activity, reducing FoC, and improving QoL among Indonesian pregnant women. The intervention represents a scalable and accessible mechanism through which maternal health can be improved in limited resource contexts. Large-scale, long-term studies are needed to evaluate the sustainability of the benefits observed and the incorporation of mHealth solutions in standard prenatal management.

Keywords: pregnancy; physical activity; fear of childbirth; quality of life; smartphone app; mobile health

Introduction

Background

Pregnancy is a significant and important period in a woman's life that brings dramatic physiological, psychological, and emotional changes [1]. These changes, while normal, can lead to

adverse consequences on maternal health and well-being, particularly in low-resource settings. Maternal health continues to pose a major worldwide issue, where pregnancy-related complications are major contributors to maternal morbidity and mortality rates [2]. The WHO estimates 810 women die from preventable causes during pregnancy or childbirth every day, with more than 90% of those deaths occurring in low- and middle-income countries (LMICs) [3].

On the other hand, the maternal mortality rate (MMR) in Indonesia is still quite high, with an estimation of 177 maternal deaths per 100,000 live births in 2020 [4]. Postpartum haemorrhage (27%), hypertensive disorders (25%), and infections (11%) are the leading causes of maternal mortality in Indonesia [5,6]. Limited access to skilled birth attendants (people skilled in normal delivery), insufficient healthcare facilities, and cultural restrictions (women's delayed or no visit to healthcare facilities) may play a significant role in this [5,6,7]. Socioeconomic factors exacerbate these challenges, with rural communities facing additional barriers due to a lack of both access and health services [7,8]. Innovative and scalable interventions to address these challenges are needed to improve maternal health outcomes in Indonesia.

Literature review

Exercise in pregnancy is an established determinant for maternal as well as fetal health. Exercise during pregnancy has been shown to decrease the risk of gestational diabetes, hypertension, and excessive weight gain while improving mental well-being [9]. Despite these benefits, many pregnant women do not achieve the recommended levels of physical activity. Globally, studies estimate that less than 20-30% of pregnant women meet recommended guidelines for physical activity during pregnancy, while the remaining 70-80% fail to achieve recommendations [10]. The proportion of pregnant women with inadequate physical activity in Indonesia is even higher, where approximately 85% of pregnant women do not meet the recommended physical activity guidelines due to cultural norms, lack of awareness, and limited access to safe exercise facilities [11].

In addition to these issues, pregnant women also have to deal with Fear of Childbirth (FOC), which is an anxiety disorder due to concerns about labor and delivery [12]. FOC is thought to affect 20–25% of pregnant women globally, with the reported prevalence much higher in low- and middle-income countries (LMICs), where it can be as high as 30–40% [13,14,15]. The prevalence of FOC in Indonesia is 28–35%, with higher rates among first-time mothers and women with previous traumatic childbirth experiences [16]. FOC is multifactorial, with psychological, social, and cultural elements. Factors contributing are limited childbirth education, negative cultural perception of childbirth, and history of traumatic childbirth experiences [17]. In Indonesia, cultural stigmas of childbirth — including views toward labor as a painful and hazardous process — contribute to FOC [18]. Moreover, many women are not sufficiently prepared for the physical and emotional challenges of childbirth due to poor access to quality prenatal care and counseling services [19,20]. FOC significantly influences maternal mental health along with adverse outcomes, such as increased rates of cesarean, prolonged labor, and postpartum depression [21]. Women suffering from severe FOC are twice as likely to demand elective cesarean sections, even in the absence of other medical indications [22]. Thus, addressing FOC is important for enhancing maternal and neonatal health, especially in low-resource settings such as Indonesia.

Physical inactivity, along with FOC and other pregnancy-related stressors, plays a key role in the quality of life (QoL) of pregnant women [23,24]. Quality of life during pregnancy consists of physical, emotional, and social well-being affected by health status, social support, and access to health care [25]. In Indonesia, the prevalence of poor QoL among pregnant women, identified by three studies, was found to range between 45–65%, with higher percentages reported in rural and

low-income populations [26,18]. As an illustration, in one study, 58% of pregnant women scored below the median QoL threshold on validated scales, and poor access to health care, economic strain, and cultural stigma (e.g., pressure to prioritize familial over self-care) were significant contributing factors [29]. In another study, pregnant women reported lower levels of self-esteem, which correlated with the fear of childbirth and low levels of social support [30]. Effective and low-cost interventions that can be adapted to the specific context empowering pregnant women in low-income countries are needed.

The existing interventions to promote physical activity, alleviate FOC, and improve QoL among pregnant women include prenatal classes, counseling, and group exercise programs [31–34]. However, cultural barriers led to a refusal to join the groups, resulting in low participation by the eligible women [9]. Challenges of those interventions include logistics (e.g., venue availability), security concerns, and low adherence in later pregnancy stages [35]. These interventions rarely consider nearby beliefs (e.g., group exercises that contradict modesty) and are limited by short-term funding and the dependence on foreign facilitators, which restricts long-term potential impact [36].

The use of mobile health (mHealth) technologies in the form of smartphone applications has been developed recently and is gaining popularity as a platform for delivering personalized and accessible interventions [37,38]. Mobile apps have shown promise in promoting physical activity, providing psychological support, and improving health outcomes among a wide range of populations [39]. Nonetheless, knowledge of the effectiveness of smartphone app-based exercise management for pregnant women is still limited, especially in LMICs like Indonesia.

There are some smartphone applications that currently exist to support prenatal exercise, such as MobileMoms [40], Yourtime [41], and Smart Fitness [42]. Although these apps offer advantages, their high mobility factor, combined with the absence of safety monitoring for pregnant women with high-risk pregnancies, is not beneficial [41]. Previously developed prenatal exercise applications have many advantages, such as personalized exercise plans adapted to different stages in pregnancy and users' exercise conditions, easily accessed exercise sessions enabling users to exercise at any time, and evidence-based application content aligned with the American College of Obstetricians and Gynecologists (ACOG) guidelines [1,44]. Although it covers mental health and fear of childbirth, it is low in interactivity. Most of these applications are not culturally adapted for low- and middle-income country (LMIC) contexts, such as the provision of modesty-compliant workouts or Bahasa Indonesia language support [45]. Furthermore, concerns regarding the scarcity of evidence to support these apps are exacerbated by the fact that most apps have not been clinically tested in LMIC settings, and none have been evaluated in Indonesia specifically. Moreover, the cost associated with premium features acts as a barrier for low-income users, limiting their access to essential exercise guidance [46]. Safety gaps represent another urgent challenge, as the majority of applications lack risk stratification or feedback from clinicians in real-time [47].

Goal of This Study

This study seeks to fill this gap by examining the effects of a smartphone app-based exercise management intervention on physical activity, FOC, and QoL among pregnant women in Indonesia. Utilizing the omnipresence of smartphones and increasing popularity of mHealth, the aim of this study was to demonstrate the scalability and accessibility of a solution to enhance maternal health outcomes in a resource-poor setting.

Methods

Study design and setting

quasi-experimental study with a repeated-measures design was conducted at the Public Health Center (PHC) in West Java, Indonesia. There were 18 pregnant women who took exercise management interventions between May-September 2024. Participants were allocated into two groups: an intervention group (n=120) receiving the app-based program and a control group (n=120) receiving standard prenatal care. Data were collected at three time points: baseline (T0), immediately after intervention (T1), and one-month post-intervention (T2).

Intervention protocol

The intervention employed a smartphone app on Android and Windows mobile platforms. Personalized Health Information Plan: The literature on the implementation of best practices through mobile technology was reviewed, including journal articles, books, YouTube videos, and podcasts. It was a server-client architecture based on HTTP and Web API protocols, with MySQL databases and an Apache Tomcat/Spring Framework backend.

A mobile application was created using the Android SDK (Software Development Kit). The mobile application included the following nine major modules: ID login, physical activity information for pregnant women with an interactive quiz, aerobic exercise video, resistance exercise video, aerobic exercise training module, resistance exercise training module, motivational interviewing session, question and answer corner, self-assessment tools (Figure 1). The intervention was conducted for 1 month

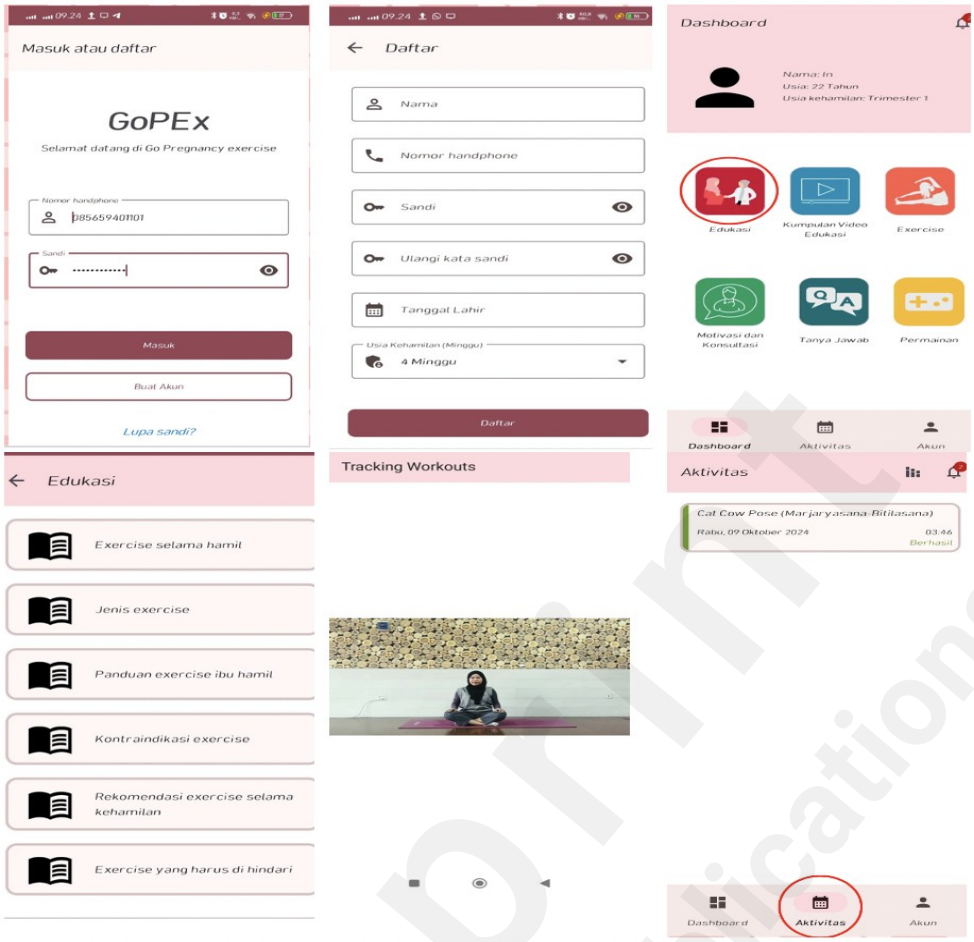

Figure 1. Example of Smartphone App-Based Exercise Management

Sample

Overall, there were 240 pregnant women in the study, 120 in the intervention group, and 120 in the control group. Inclusion criteria for participation were healthy pregnant women aged ≥18 years, pregnant women in trimester I and II, recommended by a healthcare practitioner to participate in physical exercise, able to read, write, and participate in the program, and subjects signed informed consent and agreed to participate in the study. exclusion criteria were pregnant women with mental health problems, pregnant women with complications, including heart or lung disease; cerclage; multiple pregnancy with risk factors for preterm labor; placenta previa after 26 weeks; preterm labor or ruptured membranes; pre-eclampsia or pregnancy-induced hypertension; and severe anemia.

A priori power analysis (G*Power 3.1.9.7) indicated that for an independent t-test model, a sample size of 240 (120 in each group) was necessary, assuming a medium effect size (Cohen's d = 0.5) [48], α = 0.05, power = 95%. In this study, convenience sampling was performed in Public Health Center West Java, Indonesia.

Instrument

A structured questionnaire designed for this study obtained data on age, education, occupation, gestational age, parity, body mass index (BMI), living with family, gestational age, history of abortion, employment status, and number of children.

Pregnancy Activity Questionnaire (PPAQ) is a validated 32-item questionnaire used to assess

frequency, duration, and intensity of physical activity engaged in during pregnancy [49]. Responses are coded as sedentary, light, moderate, or vigorous activity levels. The English version was found to be highly reliable (Cronbach's α = 0.82) [49]. To ensure cross-cultural validity, the PPAQ was translated into Bahasa Indonesia, in compliance with the Cross-Cultural Adaptation methodology [50], which included independent two bilingual translators translating the tool into Bahasa Indonesia. Linguistic and conceptual equivalence was established through the resolution of discrepancies by a committee of obstetricians, public health experts, and linguists. Then a third translator retranslated the Indonesian version into English, without access to the original version. The Indonesian PPAQ was pilot-tested for clarity and cultural relevance in 30 pregnant women. Structural validity was confirmed by confirmatory factor analysis (CFA) (CFI = 0.92, RMSEA = 0.06). Internal consistency was excellent (Cronbach's α 0.79).

Wijma Delivery Expectation Questionnaire (WDEQ-A) is a 33-item Likert-scale (0–5) instrument that measures FoC severity. Total scores can range from 0–165. Scoring ranges from 0-3 for each item, totaling a 5-item score, which can indicate more FoC [51].

The Swedish version exhibited high reliability (α = 0.87) [51]. The WDEQ-A was translated and adapted with respect to Indonesian culture. Forward-backward translation was done independently by translators, followed by the reconciliation of semantic and idiomatic discrepancies. A panel of midwives, psychologists, and obstetricians rated item relevance (Content Validity Index = 0.91). About 30 pregnant women completed the translated version and confirmed comprehension through feedback. The Bahasa Indonesia version had good internal consistency (α = 0.83) and two-week test-retest reliability (ICC = 0.85).

Quality of Life Gravidarum (QOL-GRAV) is a 25-item questionnaire consisting of three domains (physical, emotive, and social) regarding the QoL [52]. Scales go from 25–100, with higher scores indicating higher QoL. The original version showed good reliability (α = 0.89). The QOL-GRAV was adapted according to Beaton et al.'s framework for cross-cultural validation [50]. A multidisciplinary team conducted a pilot study to ensure the specificity of the tool was appropriate to the target population and administered to 30 pregnant women, where minor updates were made to improve clarity. Confirmatory factor analysis (CFA) confirmed the factor structure (RMSEA = 0.07, CFI = 0.94). Internal validity of the Indonesian version was strong (α = 0.85) and convergent validity measured with SF-12 showed r = 0.76.

Procedure

All ethical protocols, such as informed consent processes and voluntary participation, were followed in accordance with approval from the Institutional Review Board of STIKep PPNI Jawa Barat (IRB No. III/098/KEPK/STIKep/PPNI/Jabar/III/2024). Anonymized datasets and metrics (i.e., questionnaire responses and app-derived metrics) were then stored on secure password-protected servers with regular audits for verification of data integrity and completeness. Participants were recruited in collaboration with Public Health Center West Java, Indonesia, where healthcare practitioners screened for eligible pregnant women during routine check-ups. Clinic staff invited potentially eligible respondents to participate and provided information sheets with details about the study purpose, procedures, and voluntary participation.

Baseline data collection occurred in both the intervention and control groups for all participants before the start of the study. Questionnaires were administered (electronically or in-person) by trained research assistants, who provided clarification as necessary to ensure accurate responses. For the intervention group, the program began with a structured educational phase on the first day of the intervention. Subjects attended 6 virtual workshops adapted via the smartphone application regarding exercise guidelines, contraindications, and principles of motivational

interviewing (MI). Within the app's interactive platform, participants engaged in small-group discussions (5–10 participants per group) focused on strategies to promote self-efficacy and goal-setting. Participants were asked to document daily exercise habits — including duration, intensity, and perceived exertion — via the app's digital diary feature. It also prompted automated, personalized messages from facilitators using an in-app chat function, based on principles of motivational interviewing, to reinforce adherence and address barriers to participation. The control group had standard prenatal care, including routine clinical check-ups and general exercise recommendations, without access to the app or structured intervention components. Data collection for follow-up occurred at one time point: T2 (1-month post-baseline).

Data analysis

Data analysis was performed in SPSS version 26.0 (IBM Corp, Armonk, NY). Baseline demographic characteristics were reported using descriptive statistics. Repeated-measures ANOVA was used to test within-group and between-group differences in physical activity, FoC, and QoL across the three measurement points (T0, T1, T2), followed by Bonferroni post-hoc tests. Effect sizes used Cohen's d; intention-to-treat analysis with multiple imputation was employed for handling missing data. $P<0.05$ was considered statistically significant.

Results

An initial cohort of 400 pregnant women was recruited for the study, with eligibility based on predefined inclusion criteria (e.g., gestational age, absence of high-risk conditions). Of those who declined participation, we had 40 (10%) who reported personal/logistical barriers, lack of interest, or time constraints, and 120 (30%) excluded for not meeting inclusion criteria. Sixty percent of the remaining eligible sample (n=240) agreed to participate in the study, so the final sample consisted of 120 participants per group (the intervention group and control group). At baseline, a 60% response rate was seen, indicating strong engagement among eligible candidates. The recruitment process is systematically illustrated in Figure 1, as the CONSORT flow diagram showing the workflow from initial screening to attrition due to ineligibility and declination.

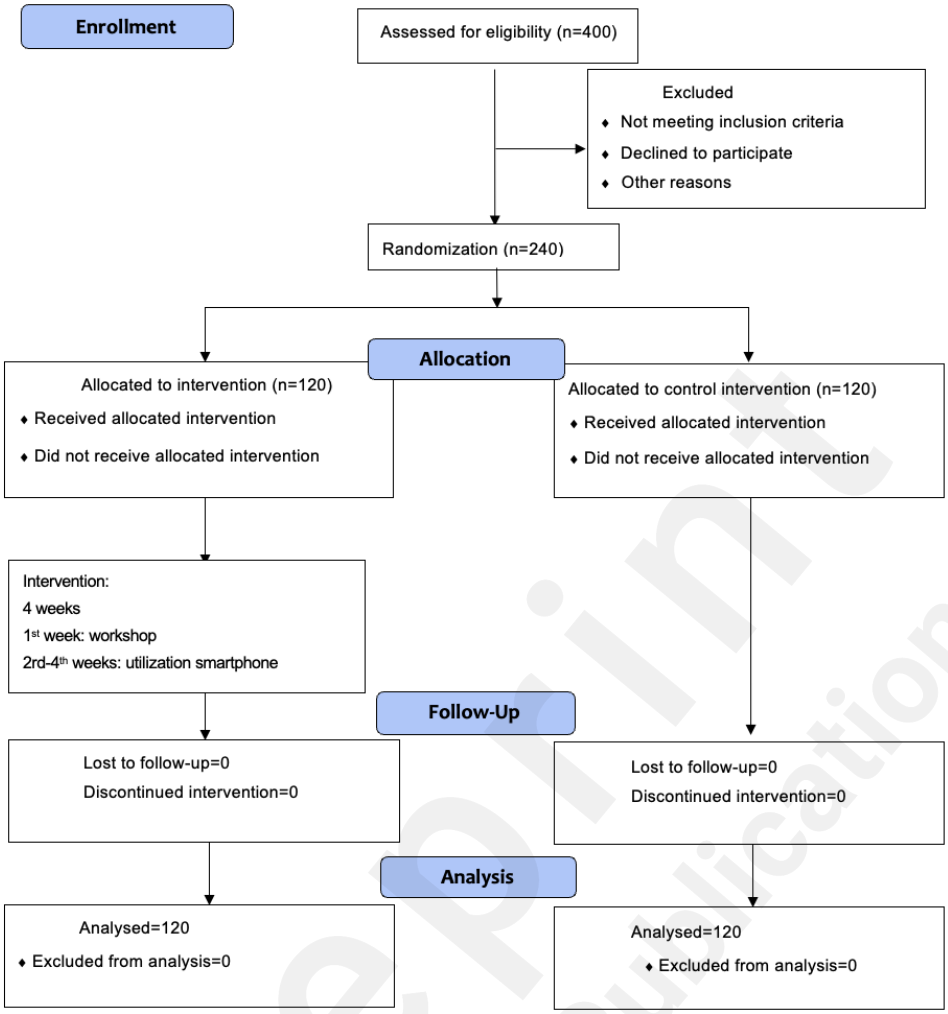

Figure 1. ONSORT 2010 Flow Diagram

Demographic Characteristics

No significant differences were observed between the intervention and control groups in baseline demographic or clinical variables ($p > 0.05$ for all comparisons). The homogeneity of the groups supports the validity of subsequent analyses (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Participants

Characteristic	Intervention Group (n=120)	Control Group (n=120)	p-value
Age (years), mean ± SD	28.4 ± 4.2	27.9 ± 3.8	0.32*
Education Level, *n* (%)			0.45†
High school or less	48 (40.0)	52 (43.3)	
College/University	72 (60.0)	68 (56.7)	
Employment Status, *n* (%)			0.28†
Employed	65 (54.2)	58 (48.3)	
Unemployed	55 (45.8)	62 (51.7)	

Characteristic	Intervention Group (n=120)	Control Group (n=120)	p-value
Gestational Age (weeks), mean ± SD	20.1 ± 6.3	19.8 ± 5.9	0.71*
History of Abortion, *n* (%)	18 (15.0)	15 (12.5)	0.56†
Number of Children, mean ± SD	1.2 ± 0.9	1.3 ± 1.0	0.41*
Body Mass Index (kg/m²), *n* (%)			0.63†
Underweight	10 (8.3)	8 (6.7)	
Normal	85 (70.8)	88 (73.3)	
Overweight/Obese	25 (20.8)	24 (20.0)	
Living with Family, *n* (%)	112 (93.3)	115 (95.8)	0.39†

Note: *Independent t-test; †Chi-square test.

Within-group anlaysis

Repeated-measures ANOVA revealed a significant interaction effect between group and time on physical activity levels ($F(2, 476) = 18.34$, $p < 0.001$, $\eta^2 = 0.07$). Within-group analysis showed that the intervention group experienced a significant increase in physical activity from T0 to T1 ($p < 0.001$, Cohen's $d = 0.65$) and from T0 to T2 ($p < 0.001$, Cohen's $d = 0.72$). In contrast, the control group showed no significant changes over time ($p > 0.05$) (Table 1).

For FoC, a significant interaction effect was observed between group and time ($F(2, 476) = 12.87$, $p < 0.001$, $\eta^2 = 0.05$). Within the intervention group, FoC scores decreased significantly from T0 to T1 ($p < 0.001$, Cohen's $d = 0.52$) and from T0 to T2 ($p < 0.001$, Cohen's $d = 0.56$). The control group exhibited no significant changes in FoC over time ($p > 0.05$) (Table 1).

A significant interaction effect was also found for QoL ($F(2, 476) = 15.23$, $p < 0.001$, $\eta^2 = 0.06$). Within the intervention group, QoL scores improved significantly from T0 to T1 ($p < 0.001$, Cohen's $d = 0.60$) and from T0 to T2 ($p < 0.001$, Cohen's $d = 0.68$). The control group showed no significant changes in QoL over time ($p > 0.05$) (Table 1).

Table 2. Within-Group Analysis: Mean Scores and Standard Deviations Across Measurement Points

Variable	Group	T0	T1	T2	Effect Size (Cohen's d)
Physical Activity	Intervention	45.23 ± 8.12	58.34 ± 7.89*	60.12 ± 7.45*	0.65 (T0-T1), 0.72 (T0-T2)
	Control	44.89 ± 7.98	46.12 ± 8.01	45.78 ± 7.92	-
Fear of Childbirth (FoC)	Intervention	85.67 ± 12.34	72.45 ± 11.23*	70.12 ± 10.89*	0.52 (T0-T1), 0.56 (T0-T2)
	Control	84.89 ± 11.98	83.45 ± 12.01	83.12 ± 11.78	-
Quality of Life (QoL)	Intervention	65.34 ± 9.12	75.23 ± 8.89*	77.45 ± 8.56*	0.60 (T0-T1), 0.68 (T0-T2)
	Control	64.89 ± 8.98	65.12 ± 9.01	65.34 ± 8.92	-

Note: Baseline (T0); immediately after intervention (T1); one-month post-intervention (T2); *Significant within-group changes ($p < 0.001$) compared to baseline (T0).

Between-group analysis

At baseline (T0), there were no significant differences between the intervention and control groups in physical activity, FoC, or QoL ($p > 0.05$). The intervention group had significantly higher physical activity levels than the control group at both T1 ($p < 0.001$, Cohen's $d = 0.58$) and T2 ($p < 0.001$, Cohen's $d = 0.61$), lower FoC scores than the control group at T1 ($p < 0.001$, Cohen's $d = 0.47$) and T2 ($p < 0.001$, Cohen's $d = 0.50$), and higher QoL scores than the control group at T1 ($p < 0.001$, Cohen's $d = 0.55$) and T2 ($p < 0.001$, Cohen's $d = 0.59$) (Table 3).

Table 3. Between-Group Analysis: Mean Scores and Standard Deviations at Each Time Point

Variable	Time Point	Intervention Group	Control Group	p-value (Between-Group)	Effect Size (Cohen's d)
Physical Activity	T0	45.23 ± 8.12	44.89 ± 7.98	0.752	-
	T1	58.34 ± 7.89	46.12 ± 8.01	<0.001*	0.58
	T2	60.12 ± 7.45	45.78 ± 7.92	<0.001*	0.61
Fear of Childbirth (FoC)	T0	85.67 ± 12.34	84.89 ± 11.98	0.689	-
	T1	72.45 ± 11.23	83.45 ± 12.01	<0.001*	0.47
	T2	70.12 ± 10.89	83.12 ± 11.78	<0.001*	0.50
Quality of Life (QoL)	T0	65.34 ± 9.12	64.89 ± 8.98	0.712	-
	T1	75.23 ± 8.89	65.12 ± 9.01	<0.001*	0.55
	T2	77.45 ± 8.56	65.34 ± 8.92	<0.001*	0.59

Note: Baseline (T0); immediately after intervention (T1); one-month post-intervention (T2); *Significant between-group differences ($p < 0.001$).

Discussion

The findings indicate that the smartphone app-based exercise management program led to significant improvements in physical activity levels among pregnant women in the intervention group compared to the control group. These positive effects persisted at the one-month follow-up (T2), suggesting the intervention's potential for long-term benefits. The growing popularity of smartphone apps for physical activity can be attributed to their user-friendly design and accessibility, which enhance user engagement and adherence to exercise routines [53]. The observed increase in physical activity among the intervention group underscores the effectiveness of mobile health (mHealth) tools in driving behavioral change [54]. This study highlights the promise of a smartphone-based exercise app that combines structured physical activity with behavioral strategies like motivational interviewing to encourage exercise among pregnant women [55].

Research indicates that behavioral interventions proven effective outside of pregnancy may also benefit pregnant women. Techniques such as self-monitoring, goal-setting, regular feedback, and motivational interviewing have demonstrated success in promoting healthier lifestyle behaviors [56,57]. However, there is a lack of research on adapting these interventions for low-income or

minority pregnant women, who could benefit from more accessible, home-based, or phone-delivered support [58]. According to the American Congress of Obstetricians and Gynecologists (ACOG), pregnant women without medical complications should aim for 30 minutes of moderate physical activity most days of the week [1]. One limitation of the app used in this study is the absence of a social support feature. Incorporating a peer-support network or virtual community could enhance engagement, especially for women facing social or emotional challenges during pregnancy [41]. Another limitation is the relatively short duration of the intervention. While physical activity levels increased in the intervention group over time, a longer follow-up period could reveal whether these improvements are sustained postpartum. Studies suggest that healthy habits developed during pregnancy can persist after childbirth, offering long-term benefits for both maternal and child health [58]. Future research could extend the duration of app use to explore its long-term impact on physical activity behavior. This study adds to the growing evidence supporting the role of digital tools in maternal health, emphasizing the potential of mHealth technology to promote healthy behaviors among pregnant women.

The study also found that the smartphone app-based exercise management program significantly reduced FoC among pregnant women in the intervention group compared to the control group. These effects were maintained at the one-month follow-up (T2), indicating the intervention's potential for long-term benefits. Previous research has shown that pregnant women who engage in regular exercise experience greater reductions in FoC compared to those who only attend traditional childbirth classes [41,60]. This study demonstrates that a structured physical activity program combined with motivational interviewing can effectively reduce childbirth anxiety, a critical factor in maternal mental health. Exercise helps alleviate childbirth fear by managing respiratory and muscle tension and reducing overall anxiety [46]. Motivational interviewing, a client-centered approach to addressing ambivalence, further supports physical activity adoption during pregnancy, promoting adherence and positive outcomes [62,63].

Exercise stimulates endorphin release, improves body image, and fosters a sense of control, all of which contribute to reduced FoC [64]. Regular physical activity during pregnancy has been shown to reduce stress and build resilience against anxiety [65]. FoC can lead to adverse outcomes such as higher rates of cesarean sections, postpartum depression, and difficulties with maternal bonding [66]. With the increasing use of smartphones and mHealth, apps provide a flexible and accessible way to deliver interventions, particularly for pregnant women who may face barriers to traditional in-person counseling [67].

The improvements in quality of life (QoL) observed in this study align with previous research showing that structured exercise programs enhance physical and emotional well-being during pregnancy [68]. However, this study extends the evidence by incorporating a culturally adapted, app-based approach, which may be more scalable and accessible in low-resource settings. The integration of motivational interviewing and interactive features, such as exercise videos and self-assessment tools, likely contributed to the high engagement and adherence rates observed. The inclusion of motivational interviewing in the app provided pregnant women with the encouragement and support needed to maintain regular exercise, making it a valuable tool for improving QoL [69]. By fostering self-efficacy and motivation, motivational interviewing can transform childbirth from a fear-inducing event into a manageable and even positive experience [70]. Research suggests that combining physical activity with psychological interventions amplifies their benefits [71]. The app-based approach likely benefited from the synergy between structured exercise and motivational interviewing, offering a comprehensive strategy for addressing FoC by addressing both physical and mental health needs.

This study examined the effectiveness of a smartphone-based exercise management app

integrated with behavioral intervention techniques, particularly motivational interviewing, on improving QoL scores. Systematic reviews have shown mixed but promising results regarding exercise interventions for pregnant women. Previous research indicated that combined exercise programs positively influenced QoL in two out of three studies, and all studies involving yoga or physical activity suggested potential QoL benefits for pregnant women [72]. Despite some inconsistencies, this body of evidence supports the idea that well-structured exercise programs can effectively enhance QoL during pregnancy.

The observed improvements in QoL reflect the growing recognition of digital health interventions as tools for improving health outcomes. In recent years, digital health technologies, such as smartphone apps, have gained attention for their ability to provide convenient, personalized, and accessible support for managing health-related behaviors [73]. These technologies enable individuals to engage in health-promoting behaviors more effectively by offering continuous feedback and motivation, which are essential for sustaining behavior change. For pregnant women facing physical and emotional challenges, an exercise management app that incorporates motivational interviewing can serve as a powerful tool for promoting a healthier lifestyle and improving mental well-being [72]. This study highlights the potential of a smartphone-based exercise management app, combined with motivational interviewing, as a valuable resource for enhancing QoL among pregnant women. The integration of structured exercise routines with behavior change techniques provides a holistic approach to addressing the physical and psychological demands of pregnancy [71]. While further research is needed to optimize these interventions and assess their long-term effects, the current findings suggest that digital health tools can play a significant role in supporting maternal health. By empowering pregnant women to take an active role in their well-being, mHealth apps represent a promising advancement in prenatal care.

Implications for clinical practice and public health.

First, the smartphone app-based intervention offers a scalable and cost-effective solution to address the growing burden of maternal health challenges in resource-limited settings. By leveraging widely available mobile technology, this approach can overcome barriers such as limited access to healthcare facilities and trained professionals. Second, the intervention's focus on physical activity, FoC, and QoL addresses multiple interconnected dimensions of maternal well-being. For example, increased physical activity may indirectly reduce FoC by improving overall health and self-efficacy, while enhanced QoL may encourage adherence to exercise routines.

Healthcare providers can integrate such interventions into routine prenatal care, particularly for women at risk of sedentary lifestyles, high FoC, or poor QoL. The app's modular design, which includes educational content, exercise videos, and motivational interviewing, can be customized to meet the specific needs of diverse populations. Additionally, the app's backend data collection capabilities enable real-time monitoring of participant engagement and outcomes, facilitating timely interventions and personalized feedback.

Limitations

Despite its strengths, this study has several limitations. First, the quasi-experimental design limits the ability to establish causality, as unmeasured confounding factors may have influenced the results. Future studies should employ randomized controlled trials (RCTs) to strengthen the evidence base. Second, the sample was recruited from a single region in Indonesia, which may limit the generalizability of the findings to other populations or cultural contexts. Third, the reliance on self-reported measures, such as the Pregnancy Physical Activity Questionnaire (PPAQ) and Wijma Delivery Expectation Questionnaire (WDEQ-A), may introduce response bias. Objective measures, such as accelerometer data for physical activity, could enhance the validity of future studies. Finally,

the follow-up period was limited to one month post-intervention, which may not capture the long-term sustainability of the observed effects. Longer follow-up periods are needed to assess the durability of the intervention's benefits.

Conclusions

This study provides robust evidence supporting the effectiveness of a smartphone app-based exercise management intervention in improving physical activity, reducing FoC, and enhancing QoL among pregnant women in Indonesia. The intervention's scalability, accessibility, and sustained benefits make it a promising tool for addressing maternal health challenges in resource-limited settings. Future research should focus on RCTs, longer follow-up periods, and diverse populations to further validate these findings and explore the intervention's broader applicability. By integrating mHealth solutions into prenatal care, healthcare systems can improve maternal health outcomes and reduce disparities in access to quality care.

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Conflicts of Interest

none declared.

Abbreviations

ACOG : American Congress of Obstetricians and Gynecologists
ANOVA : Analysis of Variance
BMI : Body Mass Index
CFA : Confirmatory Factor Analysis
CFI : Comparative Fit Index
FoC : Fear of Childbirth
HTTP: Hypertext Transfer Protocol
ICC : Intraclass Correlation Coefficient
IRB : Institutional Review Board
LMICs : Low- and Middle-Income Countries
mHealth : Mobile Health
MI : Motivational Interviewing
MMR: Maternal Mortality Rate
PPAQ: Pregnancy Physical Activity Questionnaire
QoL: Quality of Life
QOL-GRAV : Quality of Life Gravidarum
RMSEA : Root Mean Square Error of Approximation
SD : Standard Deviation
SDK : Software Development Kit
SPSS : Statistical Package for the Social Sciences
T0 : Baseline Measurement
T1 : Post-Intervention Measurement
T2 : One-Month Follow-Up Measurement
WDEQ-A : Wijma Delivery Expectation Questionnaire Version A
WHO : World Health Organization

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