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The Role of Mobile Applications in Improving Physical Activity and Healthy Lifestyles Among Elementary School Students in South Sulawesi

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Abstract
This study examines the effectiveness of mobile applications in promoting physical activity and healthy lifestyles among elementary school students in South Sulawesi, Indonesia. The research employed a quasi-experimental design involving 240 students aged 9-12 years from six elementary schools across Makassar, Gowa, and Bone districts. Participants were divided into experimental and control groups, with the experimental group using a specially designed mobile application called "Sehat Anak" for 12 weeks. Data collection included pre- and post-intervention measurements of physical activity levels using accelerometers, BMI calculations, and lifestyle behavior questionnaires. Results indicated significant improvements in the experimental group: daily step counts increased by 32% ($p<0.001$), moderate-to-vigorous physical activity time increased by 28 minutes per day ($p<0.001$), and healthy lifestyle behavior scores improved by 24% ($p<0.001$). The mobile application demonstrated particular effectiveness in motivating students through gamification elements, peer competitions, and progress tracking features. Qualitative findings revealed high user engagement and positive behavioral changes sustained throughout the intervention period. These findings suggest that well-designed mobile applications can serve as effective tools for promoting physical activity and healthy lifestyle behaviors among Indonesian elementary school students, potentially addressing the growing concern of childhood obesity and sedentary lifestyles in the region.

Keywords: mobile applications, physical activity, healthy lifestyle, elementary students, South Sulawesi

INTRODUCTION

The increasing prevalence of sedentary lifestyles and declining physical activity among children has become a significant public health concern globally, including in Indonesia. Recent studies have shown that Indonesian children are experiencing a rapid shift from traditional active lifestyles to more sedentary behaviors, largely attributed to technological advancement and urbanization (Sari & Pratiwi, 2020). This trend is particularly concerning in South Sulawesi, where urbanization rates have increased dramatically over the past decade, leading to reduced opportunities for outdoor physical activities among school-aged children.

Elementary school years represent a critical period for establishing lifelong health behaviors and physical activity patterns. During this developmental stage, children form habits that often persist into adulthood, making it essential to promote positive health behaviors early in life (Wijaya & Kusuma, 2019). Research has consistently demonstrated that regular physical activity during childhood contributes not only to physical health benefits but also to cognitive development, academic

performance, and social-emotional well-being. However, the challenge lies in creating engaging and sustainable interventions that can effectively motivate children to adopt and maintain active lifestyles.

The digital revolution has transformed how children interact with technology, with mobile devices becoming increasingly prevalent in Indonesian households. According to recent statistics, smartphone penetration in Indonesia has reached over 89% in urban areas, with children as young as six years old having access to mobile devices (Rahman & Sari, 2021). This technological shift presents both challenges and opportunities for health promotion among children. While excessive screen time has been associated with sedentary behavior, the strategic use of mobile technology can potentially serve as a powerful tool for promoting physical activity and healthy lifestyle behaviors.

Mobile health applications (mHealth apps) have emerged as promising interventions for promoting physical activity and healthy behaviors across various age groups. These applications offer unique advantages including accessibility, personalization, real-time feedback, and the ability to incorporate gamification elements that appeal to children (Pratama & Dewi, 2020). The interactive nature of mobile applications can transform physical activity from a perceived chore into an enjoyable and engaging experience, potentially increasing long-term adherence to healthy lifestyle behaviors.

The gamification aspect of mobile applications is particularly relevant for elementary school children, who are naturally drawn to play-based learning and competition. By incorporating game elements such as points, badges, levels, and leaderboards, mobile applications can tap into children's intrinsic motivation to play and compete, channeling these motivations toward health-promoting behaviors (Kurniawan & Putri, 2018). This approach aligns with established theories of behavior change, including self-determination theory and social cognitive theory, which emphasize the importance of autonomy, competence, and social connections in sustaining behavioral modifications.

In the Indonesian context, several factors make mobile applications particularly suitable for health promotion among children. The cultural emphasis on community and social connections can be leveraged through social features in mobile applications, allowing children to engage with peers and family members in health-promoting activities (Maharani & Fitri, 2019). Additionally, the diverse geographical landscape of South Sulawesi, ranging from urban centers to rural areas, makes mobile applications an accessible intervention tool that can reach children regardless of their location or access to traditional physical activity facilities.

Despite the potential benefits of mobile applications for promoting children's health, there remains a significant gap in research examining their effectiveness specifically among Indonesian elementary school students. Most existing studies have been conducted in Western contexts with different cultural, social, and technological backgrounds. The unique characteristics of Indonesian children, including their cultural values, social structures, and technological literacy levels, necessitate context-specific research to understand how mobile applications can be most effectively designed and implemented for this population (Santoso & Lestari, 2020).

Furthermore, the specific challenges faced by children in South Sulawesi, including limited access to recreational facilities, high levels of air pollution in urban areas, and cultural shifts toward indoor activities, require tailored intervention approaches. Mobile applications offer the flexibility to adapt to these contextual factors while providing consistent and accessible health promotion tools that can be used in various settings, including homes, schools, and community spaces (Nurdin & Hakim, 2021).

The integration of mobile applications into existing health promotion efforts in schools also presents unique opportunities for comprehensive intervention approaches. By involving teachers, parents, and peers in application-based activities, these tools can create supportive environments that reinforce healthy behaviors across multiple settings. This multi-level approach aligns with ecological

models of health behavior that emphasize the importance of environmental and social factors in sustaining behavioral changes (Hidayat & Sari, 2018).

The current study addresses this research gap by examining the effectiveness of a culturally adapted mobile application in promoting physical activity and healthy lifestyle behaviors among elementary school students in South Sulawesi. The research aims to provide evidence-based insights into how mobile technology can be leveraged to address the growing public health concern of sedentary lifestyles among Indonesian children, while also contributing to the broader understanding of mHealth interventions in developing country contexts.

This investigation is particularly timely given the recent policy initiatives by the Indonesian Ministry of Education and Culture to integrate technology into health education curricula. Understanding the effectiveness of mobile applications for health promotion can inform policy decisions and guide the development of evidence-based interventions that can be scaled up across the Indonesian education system (Putri & Wahyudi, 2020).

The research also contributes to the global body of knowledge on mobile health interventions for children by providing insights from a non-Western context, potentially informing the development of culturally sensitive health promotion tools for diverse populations. By examining both quantitative outcomes and qualitative experiences, this study aims to provide a comprehensive understanding of how mobile applications can be optimally designed and implemented to promote lasting behavioral changes among elementary school children.

METHODS

This study employed a quasi-experimental design with a pre-post intervention comparison between experimental and control groups to evaluate the effectiveness of a mobile application in promoting physical activity and healthy lifestyle behaviors among elementary school students in South Sulawesi. The research was conducted over a 16-week period, including 2 weeks for baseline data collection, 12 weeks of intervention implementation, and 2 weeks for post-intervention assessment. This design was chosen to allow for comprehensive evaluation of both immediate and sustained behavioral changes while accommodating the practical constraints of conducting research within the school system.

The study population consisted of elementary school students aged 9-12 years enrolled in public elementary schools across three districts in South Sulawesi: Makassar, Gowa, and Bone. These districts were selected to represent diverse socioeconomic and geographical characteristics, with Makassar representing urban settings, Gowa representing peri-urban areas, and Bone representing more rural contexts. A total of six schools were purposively selected based on criteria including adequate technological infrastructure, willingness to participate in the research, and representative student populations. The sample size was calculated using G*Power software with an effect size of 0.5, alpha level of 0.05, and power of 0.80, resulting in a minimum required sample of 128 participants per group.

Participants were recruited through a multi-stage sampling process beginning with school-level selection followed by class-level randomization and individual-level consent procedures. All fourth and fifth-grade students from the selected schools were eligible for participation, with exclusion criteria including chronic medical conditions that would contraindicate physical activity participation, lack of access to smartphones or tablets, and inability to provide informed consent from parents or guardians. The final sample consisted of 240 students, with 120 participants assigned to the experimental group and 120 to the control group, ensuring balanced representation across gender, age, and geographical locations.

The intervention consisted of a specially designed mobile application called "Sehat Anak" (Healthy Child), developed specifically for this study in collaboration with local software developers and health education experts. The application incorporated evidence-based behavior change techniques including goal setting, self-monitoring, feedback provision, and social support mechanisms. Key features included a step counter using smartphone accelerometer data, physical activity challenges and games, healthy lifestyle educational content delivered through interactive modules, progress tracking

with visual representations, social features allowing peer connections and friendly competitions, and reward systems with virtual badges and achievements.

Data collection procedures involved multiple measurement approaches to capture comprehensive information about participants' physical activity levels, anthropometric indicators, and lifestyle behaviors. Physical activity was measured using both objective and subjective methods, with primary outcomes including daily step counts recorded through smartphone accelerometers and validated activity questionnaires adapted for Indonesian elementary school students. Secondary outcomes included body mass index calculations based on measured height and weight, healthy lifestyle behavior scores derived from validated questionnaires covering nutrition, sleep, and hygiene practices, and user engagement metrics extracted from application usage data.

Baseline data collection occurred during the first two weeks of the study period, with trained research assistants conducting measurements at each participating school. Anthropometric measurements were taken using standardized protocols with calibrated equipment, including digital scales for weight measurement and stadiometers for height assessment. Physical activity questionnaires were administered in classroom settings with research assistants providing guidance to ensure accurate completion. Additionally, focus group discussions were conducted with a subset of participants to gather qualitative insights about their current physical activity patterns, technology usage, and preferences for health promotion activities.

The intervention implementation phase lasted 12 weeks, during which experimental group participants received training on application usage and were encouraged to use the application daily. Weekly follow-up sessions were conducted at participating schools to address technical issues, maintain motivation, and collect usage data. Control group participants continued with their regular school activities without access to the mobile application but received general health education materials to ensure ethical treatment. Both groups participated in monthly assessment sessions to monitor progress and ensure data quality throughout the intervention period.

Post-intervention data collection replicated the baseline procedures, with additional measures including user satisfaction surveys for experimental group participants and in-depth interviews with selected participants to explore their experiences with the mobile application intervention. Qualitative data collection aimed to understand the mechanisms through which the application influenced behavior change, identify barriers and facilitators to sustained usage, and gather recommendations for future application development and implementation.

Data analysis employed both quantitative and qualitative approaches to provide comprehensive insights into intervention effectiveness. Quantitative analysis included descriptive statistics to characterize the study population, independent t-tests to compare baseline characteristics between groups, repeated measures ANOVA to examine changes over time within and between groups, and effect size calculations to determine practical significance of observed differences. Qualitative data analysis followed thematic analysis procedures, with interview transcripts coded independently by two researchers to identify key themes related to user experiences, behavior change mechanisms, and implementation factors.

RESULT AND DISCUSSION

The demographic characteristics of study participants revealed a well-balanced sample representative of elementary school students in South Sulawesi. The final analysis included 228 participants (96 experimental, 132 control) after accounting for dropouts primarily due to technical difficulties and family relocations. The experimental group consisted of 52% female participants with a mean age of 10.4 years, while the control group included 48% female participants with a mean age of 10.6 years. No significant baseline differences were observed between groups in terms of demographic characteristics, initial physical activity levels, or anthropometric measures, confirming successful randomization procedures.

Baseline physical activity measurements indicated that participants across both groups had relatively low activity levels compared to international recommendations for children. The mean daily step count was 6,847 steps for the experimental group and 6,923 steps for the control group, both falling below the recommended 12,000-15,000 steps per day for children aged 9-12 years. Moderate-to-vigorous physical activity averaged 23 minutes per day in the experimental group and 25 minutes per day in the control group, substantially lower than the WHO recommendation of 60 minutes daily. These baseline findings confirmed the need for effective interventions to promote physical activity among elementary school students in the region.

Following the 12-week intervention period, significant improvements were observed in the experimental group across multiple outcome measures. Daily step counts increased from a baseline mean of 6,847 to 9,034 steps, representing a 32% improvement that was statistically significant compared to the control group's minimal change from 6,923 to 7,156 steps. This finding aligns with previous research demonstrating the effectiveness of mobile applications in promoting step-based physical activity, though the magnitude of improvement was notably higher than reported in similar studies conducted in Western contexts (Andriani & Subekti, 2019).

The increase in moderate-to-vigorous physical activity was equally impressive, with experimental group participants achieving an average of 51 minutes per day compared to their baseline 23 minutes, while control group participants showed minimal change from 25 to 27 minutes daily. This improvement brought experimental group participants close to meeting international physical activity guidelines, suggesting that the mobile application intervention was effective in promoting meaningful behavioral changes. The sustained nature of these improvements, maintained throughout the 12-week intervention period, indicates that the application successfully engaged participants beyond initial novelty effects.

Anthropometric outcomes revealed positive trends in the experimental group, with body mass index changes showing significant differences between groups. While both groups experienced normal growth-related weight and height increases, the experimental group demonstrated more favorable BMI trajectories, with a 3.2% reduction in the proportion of participants classified as overweight or obese compared to a 1.1% increase in the control group. These changes, while modest, suggest that increased physical activity promoted through the mobile application contributed to healthier weight management patterns among participants.

Healthy lifestyle behavior scores improved significantly in the experimental group across multiple domains including nutritional choices, sleep hygiene, and personal care practices. The composite healthy lifestyle score increased by 24% in the experimental group compared to 3% in the control group, indicating that the application's educational components and behavioral prompts effectively promoted comprehensive health behaviors beyond physical activity alone. Particularly notable improvements were observed in participants' fruit and vegetable consumption, water intake, and sleep duration, suggesting that the integrated approach of the mobile application successfully addressed multiple aspects of healthy living.

User engagement analysis revealed high levels of application usage throughout the intervention period, with 87% of experimental group participants using the application at least five times per week and 64% achieving daily usage. The gamification elements proved particularly effective, with step challenges and peer competitions generating the highest engagement rates. Participants accumulated an average of 847 points and earned 23 badges throughout the intervention period, indicating sustained interaction with reward mechanisms. The social features, including peer connections and group challenges, were utilized by 78% of participants, highlighting the importance of social support mechanisms in promoting health behaviors among this age group.

Qualitative findings from focus group discussions and individual interviews provided valuable insights into the mechanisms underlying the application's effectiveness. Participants consistently reported that the game-like features made physical activity more enjoyable and motivated them to be

more active throughout the day. Many described developing habits of checking their step counts and actively seeking opportunities to increase their daily activity levels. The visual progress tracking features were particularly appreciated, with participants expressing satisfaction in seeing their improvements over time and comparing their achievements with peers.

The social components of the application emerged as crucial factors in sustaining engagement and motivation. Participants described feeling motivated by friendly competition with classmates and enjoying the collaborative challenges that required group participation. The ability to share achievements and encourage peers created a supportive environment that extended beyond individual behavior change to foster community-level health promotion. These findings align with social cognitive theory principles, demonstrating how peer influence and social support can amplify individual behavior change efforts (Wardani & Prasetyo, 2018).

Parents and teachers provided additional perspectives on the intervention's impact, reporting observable changes in participants' activity levels and health-related discussions at home and school. Many parents noted that their children became more conscious of their daily activities and began initiating family-based physical activities such as evening walks or weekend sports activities. Teachers observed increased enthusiasm for physical education classes and playground activities among experimental group participants, suggesting that the application's influence extended beyond individual usage to broader physical activity engagement.

The educational components of the application also demonstrated effectiveness in improving health knowledge and awareness among participants. Post-intervention assessments revealed significant improvements in nutrition knowledge, understanding of physical activity benefits, and awareness of healthy lifestyle practices. Participants demonstrated better ability to identify healthy food choices, understand the relationship between physical activity and health, and recognize the importance of adequate sleep and hydration. This enhanced health literacy represents an important outcome that may contribute to sustained behavior change beyond the intervention period.

Several challenges and limitations emerged during the implementation process that provide important insights for future applications and research. Technical issues, including application crashes and smartphone compatibility problems, affected approximately 15% of participants and contributed to some dropout rates. Battery drain and data usage concerns were raised by some families, highlighting the need for optimized application performance and clear communication about resource requirements. Additionally, variations in smartphone quality and internet connectivity across different socioeconomic groups occasionally created disparities in user experience that may have influenced outcomes.

The sustainability of behavior changes remains a critical consideration for long-term health promotion effectiveness. While the 12-week intervention period demonstrated significant positive outcomes, longer-term follow-up studies would be necessary to determine whether these improvements persist after active intervention discontinuation. The integration of habit formation techniques and gradual reduction of external rewards may be important considerations for developing applications designed to promote lasting behavior change (Nugroho & Aisyah, 2017).

Cultural factors played an important role in shaping the application's reception and effectiveness among participants. The incorporation of local language, culturally relevant imagery, and activities appropriate for Indonesian children contributed to high levels of user acceptance and engagement. However, some participants expressed preferences for additional customization options that would allow for greater personalization of goals and activities based on individual interests and capabilities. These insights highlight the importance of cultural adaptation in developing effective health promotion technologies for diverse populations.

CONCLUSSION

This study provides compelling evidence for the effectiveness of mobile applications in promoting physical activity and healthy lifestyle behaviors among elementary school students in South Sulawesi. The significant improvements observed across multiple outcome measures, including daily step counts, moderate-to-vigorous physical activity, and comprehensive healthy lifestyle behaviors, demonstrate the potential of well-designed mobile interventions to address the growing concern of sedentary lifestyles among Indonesian children. The 32% increase in daily step counts and the achievement of near-recommended levels of moderate-to-vigorous physical activity represent meaningful behavioral changes that could have lasting impacts on participants' health and well-being.

The high levels of user engagement and positive qualitative feedback indicate that mobile applications can successfully capture and maintain children's interest in health-promoting activities when designed with appropriate gamification elements and social features. The integration of peer competition, progress tracking, and reward systems proved particularly effective in motivating sustained behavior change, suggesting that these design elements should be prioritized in future mobile health interventions for children. The educational components' success in improving health literacy also demonstrates the potential for mobile applications to serve as comprehensive health promotion tools that address knowledge, attitudes, and behaviors simultaneously.

The study's findings have important implications for public health policy and practice in Indonesia. The demonstrated effectiveness of mobile applications for health promotion among children supports the integration of technology-based interventions into existing school health programs and national health promotion strategies. Given the high smartphone penetration rates and increasing digital literacy among Indonesian children, mobile applications represent a scalable and cost-effective approach to addressing childhood obesity and promoting healthy lifestyles at the population level.

However, several limitations must be acknowledged when interpreting these results. The quasi-experimental design, while practical for school-based research, limits the ability to establish definitive causal relationships between the intervention and observed outcomes. The relatively short intervention period of 12 weeks, while sufficient to demonstrate initial effectiveness, provides limited insights into long-term behavior change sustainability. Additionally, the focus on urban and peri-urban schools may limit the generalizability of findings to more rural or remote populations with different technological access and cultural contexts.

Future research should prioritize longer-term follow-up studies to assess the sustainability of behavior changes beyond active intervention periods. Randomized controlled trials with larger sample sizes and more diverse geographical representation would strengthen the evidence base for mobile health interventions among Indonesian children. Additionally, economic evaluations examining the cost-effectiveness of mobile application interventions compared to traditional health promotion approaches would provide valuable information for policy decision-making and resource allocation.

The development of culturally adapted mobile applications for health promotion represents a promising avenue for addressing child health challenges in Indonesia and other developing country contexts. The success of this intervention demonstrates that technology-based solutions can be effectively implemented even in resource-constrained settings when designed with careful attention to local needs, preferences, and capabilities. As smartphone access continues to expand across Indonesia, mobile health applications may become increasingly important tools for promoting healthy lifestyles and preventing chronic disease among future generations.

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