West Science Social and Humanities Studies
Vol. 03, No. 09, September 2025, pp. 1254-1266

The Effect of Engagement in Digital Health Challenges and Gamification Features of Applications on Increasing Physical Activity Among Millennials in Jakarta

Heni Widyaningsih[1], Rani Eka Arini[2], Paramita Andiani[3]
[1] Universitas Negeri Jakarta
[2,3] Universitas Nusa Putra

Article Info

Article history:

Received Sep, 2025
Revised Sep, 2025
Accepted Sep, 2025

Keywords:

Digital Health
Gamification
Physical Activity
Millennials
Jakarta

ABSTRACT

This study investigates the impact of participation in digital health challenges and the gamification features of mobile applications on increasing physical activity among millennials in Jakarta. With the rapid adoption of digital health platforms, gamification and interactive challenges have emerged as effective tools to encourage healthier lifestyles. A quantitative approach was employed using 150 respondents, selected from Jakarta millennials, who completed a structured questionnaire based on a five-point Likert scale. Data analysis was conducted using SPSS version 25, including validity and reliability testing, classical assumption tests, regression analysis, and hypothesis testing. The results indicate that both participation in digital health challenges and gamification features significantly and positively influence physical activity levels. Furthermore, simultaneous testing showed that both variables together exert a strong and significant effect. The findings highlight the importance of integrating gamified elements and health challenges in digital platforms to sustain motivation and promote long-term behavioral change. This research contributes to the literature on digital health interventions and provides practical recommendations for application developers, healthcare providers, and policymakers in promoting active lifestyles among millennials.

Corresponding Author:

Name: Heni Widyaningsih
Institution: Universitas Negeri Jakarta
Email: heniwidyaningsih@unj.ac.id

1. INTRODUCTION

The advancement of digital technology has significantly transformed various aspects of daily life, including health promotion and physical activity. In recent years, the integration of mobile health (mHealth) applications has gained popularity as an innovative tool for encouraging healthier lifestyles, particularly among younger generations. One of the most prominent strategies employed by these applications is the use of digital health challenges and gamification features, which aim to increase user engagement, motivation, and long-term behavioral change. The effectiveness of these strategies is supported by various studies, which highlight their potential in encouraging physical activity and improving health outcomes. mHealth

applications have been shown to positively influence physical activity among adolescents and young adults, with a systematic review finding that these applications can significantly increase activity levels, although the impact varies depending on the type of application used [1]. In South Africa, factors such as facilitating conditions, social influence, and performance expectancy have been identified as key drivers for the adoption of mHealth applications among youth, suggesting that these factors should be considered in app development [2]. Gamification, particularly social comparison-oriented strategies, has been effective in enhancing physical activity and emotional well-being among young adults, as demonstrated by a randomized controlled trial that showed improvements in moderate physical activity and social functioning, although the effects on sleep and step counts were not significant [3]. Furthermore, gamification strategies such as self-monitoring and challenges are particularly effective for physical activity, while other health behaviors may benefit from different approaches, such as cooperation for dieting [4]. Despite these potential benefits, sustaining user engagement and achieving long-term behavior change remain challenges, thus personalized design options and iterative design cycles with end-users are recommended to refine gamification strategies and enhance their effectiveness [4]. However, the effectiveness of mHealth applications in promoting physical activity is still under-researched, with few applications rigorously tested in research studies [5].

Millennials in urban areas such as Jakarta are highly connected to technology and frequently use mobile applications, yet sedentary lifestyles and lack of consistent physical activity remain major challenges. According to the World Health Organization (WHO), physical inactivity is a key risk factor for non-communicable diseases, including cardiovascular disorders, diabetes, and obesity, highlighting the need for innovative interventions that motivate active lifestyles. Technology plays a dual role as both a contributor to inactivity and a potential solution, with mobile health applications offering personalized activity recommendations and tracking features that encourage healthier routines. Sedentary lifestyles are common among urban millennials, contributing to obesity and related health issues [6], and adolescents engaged in high sedentary activity face a 30% higher risk of obesity [7]. Mobile health applications using biofeedback sensors can provide context-aware activity suggestions [8], though studies show 46% of users exercise less than 15 minutes daily, indicating room for improvement [8]. Research in Jakarta further shows that such applications can influence healthier behaviors among Generation Z [9], but barriers such as weather and work commitments continue to hinder consistent physical activity [8].

Gamification, defined as the application of game-like elements such as points, badges, leaderboards, and rewards in non-gaming contexts, has been shown to enhance user motivation by creating enjoyable and competitive experiences, while participation in digital health challenges—such as step count competitions, fitness milestones, and group-based activities—encourages consistent physical activity by fostering accountability, achievement, and community support. Together, these elements reshape the way millennials perceive and engage with health-related behaviors by making physical activity more enjoyable and sustainable. Gamification has been effectively used to increase motivation and engagement in physical activity through rewards, competition, and incremental challenges [10], and studies on older adults also confirm its significant impact on motivation compared to non-gamified approaches, underscoring its adaptability across different demographics [11]. Within mobile health (mHealth) apps, gamification elements such as challenges, feedback, and social comparison play a critical role in sustaining user engagement [12], with intrinsic and extrinsic game elements complementing each other to promote long-term use [12]. The growing popularity of gamification in health contexts is supported by research showing positive outcomes in

engagement and behavior change [13], though challenges remain in fully understanding the motivational role of game elements and ensuring the long-term effectiveness of gamified health interventions [12].

Previous studies have highlighted the positive effects of gamification on health behavior change and the effectiveness of health challenges in increasing physical activity, yet empirical research focusing specifically on millennials in Jakarta remains limited. Given the cultural and lifestyle characteristics of this demographic, tailored digital health strategies are essential for effectively influencing their physical activity levels. Gamification, which incorporates elements such as points, leaderboards, and challenges into non-game contexts, has been shown to positively influence physical activity, though findings are often mixed and rely on self-reported data [14], [15]. The combination of wearable devices and gamification further enhances user engagement, with features like self-monitoring and rewards playing significant roles [14]. Mobile health (mHealth) applications, popular among younger generations including millennials, provide accessible tools for supporting healthy behaviors through monitoring features and gamification elements [4], [9]. In Jakarta, the adoption of mHealth apps among Generation Z reflects a growing trend that could extend to millennials, emphasizing the need to understand user experiences and preferences to optimize app design and effectiveness [9]. Nonetheless, sustaining engagement remains a challenge, with varying user preferences requiring personalized design and iterative development with feedback [4]. Moreover, the role of "superusers" or highly engaged participants can significantly influence broader user communities, suggesting that community support and cooperative game elements could further enhance the effectiveness of gamified health interventions [16].

This study aims to analyze the impact of participation in digital health challenges and the gamification features of mobile health applications on increasing physical activity among millennials in Jakarta. By employing a quantitative approach with 150 respondents, measured using a five-point Likert scale and analyzed with SPSS version 25, this research seeks to provide evidence on the extent to which these digital interventions contribute to healthier lifestyles. The findings are expected to offer valuable insights for mobile application developers, public health practitioners, and policymakers in promoting sustainable physical activity behaviors through digital platforms.

2. LITERATURE REVIEW

2.1 Digital Health Applications

Digital health applications, particularly mobile health (mHealth) apps, have become important tools for promoting physical activity and wellness, especially in urban areas with high smartphone penetration like Jakarta, offering cost-effective features such as step counters, calorie trackers, and personalized workout plans. These apps empower individuals to manage their well-being and are highly relevant for millennials who are closely connected to digital platforms. Evidence shows that mHealth apps can enhance physical activity through monitoring tools and personalized feedback that support behavior change and motivation [5], [17], and research indicates they can improve health outcomes by expanding access to information and services [18]. However, their effectiveness remains under-researched, with concerns about privacy and data security requiring attention to sustain user trust [5], [17]. In cities like Jakarta, where smartphone usage is high, these applications provide practical opportunities

for health promotion [19], and millennials' digital connectivity further strengthens their potential to drive widespread positive health behavior change [18].

2.2 *Gamification in Health Applications*

Gamification in health applications leverages game design elements to enhance user engagement and motivation, particularly among millennials who are familiar with digital and interactive environments, making routine health tasks more enjoyable and competitive while promoting sustained participation in physical activities. By integrating points, badges, leaderboards, and incremental challenges, gamification significantly boosts intrinsic motivation, which is essential for long-term behavior change. Research identifies gamification as a novel intervention for physical activity through rewards, competition, and challenges that increase engagement in non-game contexts [10], while its use in mobile health (mHealth) apps sustains user participation with features such as challenges, feedback, and social comparison that influence both intrinsic and extrinsic motivation [12]Gamification provides motivational experiences similar to games, helping maintain user interest and fostering positive behaviors like regular physical activity [20], with studies confirming its effectiveness in enhancing user engagement and motivation in health contexts [21]. Nonetheless, challenges remain in understanding the balance between intrinsic and extrinsic elements for sustained engagement [12], and while supported by theoretical and empirical evidence, issues such as user retention and long-term viability of gamified health apps continue to be significant considerations [20].

2.3 *Digital Health Challenges*

Digital health challenges within health applications, such as step competitions and group challenges, play a vital role in promoting physical activity by fostering accountability, social recognition, and competitiveness, thereby motivating users to achieve personal goals while enhancing long-term commitment. The integration of social features in mobile health applications (MHAs) positively influences user behavior and outcomes by providing a platform for both personal and social engagement, which are crucial for sustaining healthy lifestyles. Social Fitness Applications (SFAs) have been shown to significantly increase user participation in physical activities through goal setting and social support, leading to stronger commitment and greater health awareness [22], while their versatility allows users to track progress and engage in community challenges tailored to individual preferences [22]. Social features in MHAs, such as competition and peer support, are associated with healthier workout behaviors and improved body satisfaction [23], with hybrid concepts like leaderboards and community challenges effectively motivating users to stay active [24]. Designing MHAs to facilitate social support is therefore essential, especially for users facing health

challenges, as balancing social and health agendas can increase engagement and motivation [25], while innovations such as virtual coaches like FittleBot enhance community sense and compliance by providing personalized recommendations and team-based support [26].

2.4 *Physical Activity and Health Outcomes*

Physical activity is a critical factor in preventing chronic diseases and enhancing overall health, as emphasized by the World Health Organization, yet many millennials in Jakarta remain inactive due to sedentary lifestyles and technological reliance. Physical inactivity is a major risk factor for cardiovascular diseases, diabetes, and certain cancers [27], [28], while regular exercise helps prevent obesity, musculoskeletal problems, and mental health issues such as depression and anxiety [29]. A dose-response relationship also exists between physical activity levels and reduced mortality and disease incidence, underscoring the importance of consistent exercise [30]. However, Jakarta's millennials face barriers including sedentary work environments, limited time, and digital distractions [27], with inactivity contributing to significant economic costs, as active individuals incur 30% lower medical expenses compared to their inactive counterparts [30]. Digital health platforms incorporating gamification offer a potential solution by making physical activity more engaging and accessible, increasing participation through features such as personalized exercise recommendations, progress tracking, and social interaction [29], [31].

2.5 *Millennials and Technology Adoption*

Millennials, as digital natives, are highly receptive to digital health interventions that integrate gamification and social engagement, making them particularly effective in influencing physical activity levels through interactive and user-friendly designs. Gamification strategies in mHealth interventions, such as leaderboards and progress bars, have been shown to improve moderate physical activity and emotional well-being among young adults, as demonstrated in the LevantApp study, which found that social comparison-oriented gamification can enhance engagement and health outcomes, though its impact varies across metrics [3]. Similarly, the "Tweeting to Health" intervention that combined Fitbits with Twitter increased physical activity and improved dietary habits through gamified challenges, showcasing the potential of wearable technology and social media in fostering healthy behaviors [32]. Beyond gamification, social influence and community support play a vital role, as millennials are motivated by virtual communities and social networks that provide peer support, accountability, and access to health coaches [33]. Social factors such as peer comparison and facilitating conditions have been found to significantly shape millennials' engagement with mobile health technologies, reinforcing the importance of integrating both

technological and social elements in health promotion strategies [2].

2.6 Previous Empirical Studies

Several empirical studies have demonstrated the positive role of digital health interventions in promoting physical activity, particularly through gamification features that enhance user engagement and adherence to health-related behaviors. Participants using gamified apps were found to engage for more days compared to non-gamified apps (113 days vs. 81 days), with leaderboards and status views identified as the most effective features in driving engagement through social comparison [34]. Similarly, competitive and cooperative gamification designs in mobile fitness applications increased daily steps and sustained engagement, with competition improving appraisal support and cooperation enhancing companion support, both contributing to long-term physical activity [35]. Social exergames that integrate competition, rewards, and cooperation have also been effective in motivating physical activity by creating engaging and socially fulfilling experiences, though their impact depends on factors such as group size and player matching [36]. While these findings confirm that competition and cooperation in digital health challenges increase motivation and physical activity levels, most studies have been conducted in Western contexts, leaving limited research on urban millennials in Southeast Asia, particularly Jakarta, thereby underscoring the need for localized studies that consider cultural and contextual influences on digital health adoption.

2.7 Research Gap and Framework

While existing literature supports the effectiveness of gamification and health challenges in promoting physical activity, little is known about their combined effects among millennials in Jakarta. Previous research has not adequately addressed how cultural, social, and technological factors shape the success of these interventions in Indonesia. This study fills the gap by analyzing the relationship between participation in digital health challenges, gamification features, and physical activity levels using quantitative methods. The conceptual framework posits that both independent variables—participation in digital health challenges and gamification features—positively influence the dependent variable, physical activity among millennials.

3. METHODS

3.1 Research Design

This study employed a quantitative research design to examine the impact of participation in digital health challenges and gamification features of mobile health applications on increasing physical activity among millennials in Jakarta. A survey method was utilized, with data collected through a structured questionnaire. The quantitative approach was chosen because it allows for statistical testing of hypotheses and provides empirical evidence regarding the relationships between variables.

3.2 Population and Sample

The population of this research consisted of millennials living in Jakarta who

actively use mobile health applications that incorporate digital challenges and gamification features. A purposive sampling technique was applied to select respondents who met the criteria of being within the millennial age range (1981–1996) and having prior experience with health applications.

A total of 150 respondents were selected as the research sample, which meets the minimum requirement for statistical analysis using SPSS. This sample size is considered adequate for detecting significant relationships in regression-based analysis [37].

3.3 Variables and Operational Definitions

The study examined three main variables, namely Participation in Digital Health Challenges (X1), Gamification Features (X2), and Physical Activity (Y). Participation in Digital Health Challenges (X1) was defined as the degree of involvement of respondents in structured health-related activities provided by digital applications, such as step count competitions, group challenges, and milestone achievements. Gamification Features (X2) referred to the presence and use of game-like elements in health applications, including points, badges, leaderboards, levels, and rewards, which serve to motivate users to maintain physical activity. Physical Activity (Y) was defined as the level of respondents' engagement in physical exercise and movement, measured in terms of frequency, duration, and consistency of activity promoted by the use of digital health applications. All variables were measured using indicators that were transformed into questionnaire items and assessed through a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

3.4 Research Instrument

The primary data collection instrument used in this study was a structured questionnaire consisting of four sections: Section A captured demographic information such as age, gender, occupation, and frequency of app usage; Section B contained items measuring participation in digital health challenges (X1); Section C included items measuring gamification features (X2); and Section D comprised items measuring physical activity (Y). To ensure clarity, validity, and reliability, the questionnaire was pre-tested with a small group of respondents prior to its full distribution.

3.5 Data Collection Procedure

Data were collected through an online survey distributed via social media platforms (WhatsApp, Instagram, and Telegram) and professional networks. Respondents were given a consent form ensuring confidentiality and voluntary participation. Data collection was conducted over a period of four weeks to obtain the target sample size.

3.6 Data Analysis Technique

The collected data were coded and analyzed using SPSS version 25 through several steps: descriptive analysis was first conducted to describe respondents' demographic characteristics and provide an overview of responses to each variable; validity and reliability tests using Pearson correlation and Cronbach's Alpha were then applied to ensure the questionnaire items were accurate and consistent; classical assumption tests, including normality, multicollinearity, and heteroscedasticity, were performed to confirm the suitability of the regression model; multiple linear regression analysis was employed to examine the effects of participation in digital health challenges (X1) and gamification features (X2) on physical activity (Y); and finally, hypothesis testing was carried out using the t-test for individual effects and the F-test for simultaneous effects, with a significance level set at 0.05.

4. RESULTS AND DISCUSSION

4.1 Descriptive Analysis

The descriptive analysis was conducted to provide an overview of the respondents' demographic characteristics and

their responses to the research variables, namely participation in digital health challenges (X1), gamification features (X2), and physical activity (Y). A total of 150 millennials in Jakarta participated in this study. In terms of gender, 83 respondents (55.3%) were female and 67 respondents (44.7%) were male, indicating a fairly balanced distribution with a slightly higher proportion of females. The age of respondents was within the millennial range (25–39 years), with the majority (64%) aged 25–30 years and 36% aged 31–39 years. Regarding occupation, 98 respondents (65.3%) were employed full-time, 32 respondents (21.3%) were students, and 20 respondents (13.4%) were self-employed. In terms of health app usage frequency, 108 respondents (72.0%) reported daily use of digital health applications, while 42 respondents (28.0%) used them three to five times per week. This profile reflects that most participants were young professionals and students who actively engage with mobile health applications on a regular basis.

Descriptive statistics for the research variables were calculated using mean and standard deviation values based on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). For participation in digital health challenges (X1), the mean score was 4.12 with a standard deviation of 0.68, indicating that most respondents agreed that step competitions and milestone tracking motivated them to increase their activity levels. Gamification features (X2) had a mean score of 4.05 and a standard deviation of 0.71, showing that respondents generally perceived points, leaderboards, and badges as enjoyable and motivating elements that encouraged them to remain active. Meanwhile, physical activity (Y) had the highest mean score of 4.18 with a standard deviation of 0.66, suggesting that respondents consistently engaged in higher levels of physical activity after using health applications, thereby reflecting positive behavioral changes.

4.2 Measurement Model Evaluation (Validity and Reliability Tests)

Before testing the hypotheses, the validity and reliability of the research instrument were evaluated to ensure that the questionnaire items accurately measured the intended constructs. The evaluation consisted of two main steps: validity test and reliability test.

1. Validity Test

Validity was assessed using the Pearson Product-Moment correlation between each indicator score and its corresponding total construct score, with results compared against the r-table value of 0.161 (df = 148, α = 0.05), where an item is considered valid if the correlation coefficient (r-count) exceeds the r-table value and is significant at $p < 0.05$. For Participation in Digital Health Challenges (X1), all 8 items had correlation coefficients ranging from 0.523 to 0.742 ($p < 0.001$), exceeding the threshold. For Gamification Features (X2), all 7 items showed correlation coefficients between 0.511 and 0.726 ($p < 0.001$), indicating strong validity. For Physical Activity (Y), all 6 items had correlation coefficients between 0.548 and 0.764 ($p < 0.001$), confirming validity. Therefore, all items across the three constructs were valid and suitable for further analysis.

2. Reliability Test

Reliability was tested using Cronbach's Alpha, with a coefficient above 0.70 indicating that the construct is reliable and has internal consistency. The results showed that Participation in Digital Health Challenges (X1) had a Cronbach's Alpha of 0.874, Gamification Features (X2) had 0.861, and Physical Activity (Y) had 0.889. Since all values exceeded the 0.70 threshold, the instrument was deemed reliable and consistent in measuring the constructs.

4.3 Classical Assumption Tests

To ensure the accuracy and robustness of the regression model, several classical assumption tests were conducted.

These included tests of normality, multicollinearity, and heteroscedasticity.

1. Normality Test

The normality of residuals was tested using the Kolmogorov–Smirnov test and supported by a histogram and P–P plot. The Kolmogorov–Smirnov test produced a significance value of 0.200 ($p > 0.05$), indicating that the data were normally distributed, while the histogram showed a bell-shaped curve and the P–P plot displayed points close to the diagonal line, further confirming normality. Therefore, the residuals of the regression model met the normality assumption.

2. Multicollinearity Test

Multicollinearity was assessed using Tolerance and Variance Inflation Factor (VIF) values, where a tolerance value greater than 0.10 and a VIF value below 10 indicate the absence of multicollinearity. The results showed that Participation in Digital Health Challenges (X1) had a tolerance of 0.653 and a VIF of 1.532, while Gamification Features (X2) had a tolerance of 0.678 and a VIF of 1.476. Since both predictors met the criteria, the analysis confirmed that there were no symptoms of multicollinearity.

3. Heteroscedasticity Test

Heteroscedasticity was tested using the Glejser test and a scatterplot of residuals, where the Glejser test results showed significance values above 0.05 for all independent variables, indicating no heteroscedasticity problem, and the scatterplot displayed a random distribution without any specific pattern, further confirming the absence of heteroscedasticity.

4.4 Regression Analysis

Multiple linear regression was conducted to examine the effect of participation in digital health challenges (X1) and gamification features (X2) on physical activity (Y) among millennials in Jakarta. The regression equation obtained from SPSS analysis is $Y = 1.124 + 0.426X1 + 0.391X2 + e$, where Y represents physical activity, X1 is participation in digital health challenges, X2 is gamification features, and e is the error term. The constant (α) of 1.124 indicates that even in the absence of participation in challenges (X1) and gamification features (X2), there is still a baseline level of physical activity reported by millennials.

The coefficient analysis showed that participation in digital health challenges (X1) had a regression coefficient (β) of 0.426 with a t-value of 6.215 and $p < 0.001$, indicating a positive and significant effect. Similarly, gamification features (X2) had a regression coefficient (β) of 0.391 with a t-value of 5.874 and $p < 0.001$, also showing a positive and significant effect. These results confirm that both independent variables contribute positively to physical activity, meaning that higher engagement in digital health challenges and stronger exposure to gamification features are associated with higher physical activity levels among respondents.

In terms of model fit, the R^2 value was 0.612, which means that 61.2% of the variation in physical activity can be explained by the two predictors, while the Adjusted R^2 of 0.605 confirms the robustness of the model after accounting for the number of predictors and sample size. The remaining 38.8% of variation is influenced by other factors not examined in this study, such as lifestyle, social environment, or personal motivation. Furthermore, the ANOVA test showed an F-value of 54.328 with $p < 0.001$, indicating that the regression model is statistically significant, and that participation in digital health challenges (X1) and gamification features (X2) together significantly influence physical activity (Y).

Discussion

The results of this study highlight the significant role of digital health challenges and gamification features in increasing physical activity among millennials in Jakarta. Both independent variables—participation in digital health challenges (X1) and gamification features (X2)—were found to have positive and significant effects on the dependent variable, physical activity (Y).

Furthermore, when tested simultaneously, both variables demonstrated a strong combined influence, reinforcing the importance of integrating behavioral motivation with engaging digital strategies.

First, the finding that participation in digital health challenges significantly affects physical activity is consistent with prior research showing that goal-setting, competition, and community involvement enhance motivation to adopt healthier habits, as these challenges create a sense of accountability and achievement, particularly among millennials who are receptive to structured activities mediated by technology. Social media fitness applications foster accountability and provide crucial support, especially for sedentary individuals beginning exercise routines, while also facilitating a sense of community that sustains motivation and commitment to physical activity [38]. Fitness trackers and their gamification elements, such as challenges and achievements, have been shown to significantly motivate users, with surveys reporting that 61% of participants engaged in competitions and 89% recognized achievements, thereby enhancing both intrinsic and extrinsic motivation [39]. Similarly, participation in social media challenges like #13in2013 increased physical activity by encouraging participants to complete more races and cover more miles than in previous years, while also contributing to weight loss and improved physical health [40]. Internet-mediated programs such as Active U, which integrate goal setting and optional team participation, further demonstrate the effectiveness of structured digital programs in promoting sustained engagement in physical activity by providing both support and motivation [41].

Second, the significant effect of gamification features highlights the importance of interactive and rewarding elements—such as points, leaderboards, progress tracking, and rewards—in encouraging users to maintain healthy behaviors, as gamification influences psychological engagement by making routine health activities enjoyable and socially competitive. For millennials, who often seek instant feedback and interactive experiences, gamification transforms physical activity from a mundane obligation into an enjoyable, achievement-oriented experience. Gamification applies game mechanics like rewards, competition, and incremental challenges to non-game contexts, effectively promoting physical activity and other health behaviors [10], while strategies such as points, badges, and rankings have proven effective in public health interventions targeting physical activity, nutrition, and smoking cessation [42]. Gamified mobile health (mHealth) apps further sustain engagement by integrating feedback, challenges, and social comparison, which enhance intrinsic and extrinsic motivation [12]. Evidence from gamified physical activity apps shows that users engage more and increase activity levels compared to non-gamified versions, with leaderboards and status features particularly effective in promoting social comparison and engagement [34]. Beyond individual outcomes, gamification in health and fitness apps provides motivational, social, and emotional benefits, supporting behavior change and improving health outcomes, with growing adoption suggesting a promising future for its role in public health and wellness [43].

Third, the simultaneous effect of both digital health challenges and gamification features underscores the synergistic relationship between structured health programs and engaging digital features. While health challenges provide clear goals and measurable targets, gamification enhances the emotional and motivational aspects of participation. Together, they create a comprehensive framework that sustains user interest, promotes consistent physical activity, and contributes to long-term behavioral change.

These findings are particularly relevant in the context of Jakarta, where millennials represent a tech-savvy demographic that heavily relies on mobile applications for lifestyle management. The integration of gamification into digital health platforms aligns well with the digital habits of

this population, making it a practical strategy for public health promotion. Moreover, the study supports the growing body of literature emphasizing that technology-driven health interventions can be both cost-effective and impactful in urban settings.

In practice, the results suggest that application developers, healthcare providers, and policymakers should prioritize embedding gamification elements and interactive challenges into digital health initiatives. Doing so not only boosts short-term participation but also fosters long-term adherence to healthy lifestyles. Future programs could further enhance engagement by combining gamification with personalization, social interaction, and reward mechanisms tailored to user preferences.

5. CONCLUSION

This study concludes that participation in digital health challenges and the integration of gamification features significantly improve physical activity among millennials in Jakarta. The t-test results confirmed that each variable has a positive and significant effect, while the F-test showed that both variables together exert a stronger influence. These findings suggest that structured digital health challenges provide accountability and measurable goals, while gamification features create enjoyment and sustained engagement. The combination of these two strategies is particularly effective for millennials, who are highly engaged with mobile technology and receptive to interactive experiences. In the context of Jakarta, where lifestyle-related health issues are increasing, such digital interventions can play a vital role in promoting public health.

From a practical perspective, application developers should design health platforms that not only include goal-oriented challenges but also embed interactive gamification elements such as points, leaderboards, and rewards. At the same time, healthcare providers and policymakers can leverage these tools to design cost-effective and scalable programs that foster healthier behaviors among urban populations, ultimately contributing to the reduction of sedentary lifestyles and the prevention of chronic diseases.

REFERENCES

[1] F. Fitriani and S. Mulyono, "MOBILE HEALTH DAN EFEKTIVITASNYA TERHADAP AKTIVITAS FISIK REMAJA: LITERATUR REVIEW," *J. Ris. Kesehat. POLTEKKES DEPKES BANDUNG*, vol. 15, no. 2, pp. 364–372, 2023.

[2] N. C. W. Mtshali, P. Ndayizigamiye, I. Govender, and K. Maguraushe, "Fostering Youth Wellbeing Through mHealth Apps: Embracing Physical Activity for a Healthier Lifestyle," in *International Working Conference on Transfer and Diffusion of IT*, Springer, 2023, pp. 416–428.

[3] B. Sañudo *et al.*, "A randomized controlled mHealth trial that evaluates social comparison-oriented gamification to improve physical activity, sleep quantity, and quality of life in young adults," *Psychol. Sport Exerc.*, vol. 72, p. 102590, 2024.

[4] F. Ehrler and K. Blondon, "Adapting Gamification Strategies According to Targeted Health Behavior Change: Findings from a Focus Group," in *Digital Health and Informatics Innovations for Sustainable Health Care Systems*, IOS Press, 2024, pp. 1125–1129.

[5] S. S. Coughlin, M. Whitehead, J. Q. Sheats, J. Mastromonico, and S. Smith, "A review of smartphone applications for promoting physical activity," *Jacobs J. community Med.*, vol. 2, no. 1, p. 21, 2016.

[6] S. O. Lontoh and A. Halim, "Karakteristik Pola Aktivitas Fisik Dan Indeks Massa Tubuh Pada Masyarakat Dewasa Muda Tomang Jakarta Barat," *Ebers Papyrus*, vol. 29, no. 2, pp. 39–48, 2023.

[7] S. Sukatemin, H. I. Muhalla, M. Muarrofah, D. A. Utari, and V. Y. Fitriani, "Sedentary Lifestyle and the Threat of Obesity Among Young People," *J. Acad. Sci.*, vol. 2, no. 1, pp. 232–240, 2025.

[8] H. F. Badawi, H. Dong, and A. El Saddik, "Mobile cloud-based physical activity advisory system using biofeedback sensors," *Futur. Gener. Comput. Syst.*, vol. 66, pp. 59–70, 2017.

[9] R. Fildansyah, "Pengaruh Penggunaan Aplikasi Mobile Health (Health) dan Fitur Pemantauan Kesehatan Terhadap Gaya Hidup Sehat," *J. Multidisiplin West Sci.*, vol. 2, no. 06, pp. 473–482, 2023.

[10] K. Pickering and A. Pringle, "Gamification for physical activity behaviour change," *Perspect. Public Health*, vol. 138, no. 6, pp. 309–310, 2018.

[11] D. L. Kappen, P. Mirza-Babaei, and L. E. Nacke, "Older adults' motivation for physical activity using gamified technology: an eight-week experimental study," in *International Conference on Human-Computer Interaction*, Springer, 2020, pp. 292–309.

[12] A. S. Mustafa, N. Ali, J. S. Dhillon, and D. Sedera, "An integrated model for evaluating the sustainability of gamified mobile health apps: An instrument development and validation," in *Healthcare*, MDPI, 2023, p. 1051.

[13] V. R. Aulia, A. P. Subriadi, and R. Nadlifatin, "Gamification: A comprehensive review of literature," in *2022 1st International Conference on Information System & Information Technology (ICISIT)*, IEEE, 2022, pp. 277–282.

[14] L. Xu *et al.*, "The effects of mHealth-based gamification interventions on participation in physical activity: systematic review," *JMIR mHealth uHealth*, vol. 10, no. 2, p. e27794, 2022.

[15] J. Koivisto and J. Hamari, "Gamification of physical activity: A systematic literature review of comparison studies.," *GamiFIN*, pp. 106–117, 2019.

[16] T. Van Mierlo, D. Hyatt, A. T. Ching, R. Fournier, and R. S. Dembo, "Behavioral economics, wearable devices, and cooperative games: results from a population-based intervention to increase physical activity," *JMIR serious games*, vol. 4, no. 1, p. e5358, 2016.

[17] J. Zhao, B. Freeman, and M. Li, "Can mobile phone apps influence people's health behavior change? An evidence review," *J. Med. Internet Res.*, vol. 18, no. 11, p. e287, 2016.

[18] L. Harrington, "From apps to mHealth: informing, interacting, and changing behavior," *AACN Adv. Crit. Care*, vol. 29, no. 3, pp. 240–243, 2018.

[19] R. Damaševičius, J. Kim, and V. Z. Dourado, "use of smartphone applications to increase physical activity and fitness," *Frontiers in Public Health*, vol. 9. Frontiers Media SA, p. 713306, 2022.

[20] D. Cedeño, "Uso de la gamificación en el contexto de la salud panameña," 2020.

[21] P. Buckley and E. Doyle, "Gamification and student motivation," *Interact. Learn. Environ.*, vol. 24, no. 6, pp. 1162–1175, 2016.

[22] C. Luo, "An exploration of the impact of fitness apps on individual exercise behaviour," *Rev. Psicol. del Deport. (Journal Sport Psychol.*, vol. 33, no. 1, pp. 385–393, 2024.

[23] S. A. Tikkanen and M. Barnhouse, "The effects of personal and social uses of mobile health applications on healthy behaviors," *Commun. Stud.*, vol. 68, no. 2, pp. 152–172, 2017.

[24] Y. Chen, J. Zhang, and P. Pu, "Exploring social accountability for pervasive fitness apps," in *Proceedings of the eighth international conference on mobile ubiquitous computing, systems, services and technologies*, 2014, pp. 221–226.

[25] A. M. Kanstrup, P. S. Bertelsen, and C. Knudsen, "Changing health behavior with social technology? A pilot test of a mobile app designed for social support of physical activity," *Int. J. Environ. Res. Public Health*, vol. 17, no. 22, p. 8383, 2020.

[26] S. M. Lukin, G. M. Youngblood, H. Du, and M. Walker, "Building community and commitment with a virtual coach in mobile wellness programs," in *International Conference on Intelligent Virtual Agents*, Springer, 2014, pp. 279–284.

[27] X. Bigard, "Recommending physical activity for primary prevention of chronic diseases," *Rev. Prat.*, vol. 70, no. 3, pp. 268–272, 2020.

[28] F. Cannata, G. Vadalà, F. Russo, R. Papalia, N. Napoli, and P. Pozzilli, "Beneficial effects of physical activity in diabetic patients," *J. Funct. Morphol. Kinesiol.*, vol. 5, no. 3, p. 70, 2020.

[29] I. Shaw, M. L. Mathunjwa, and B. S. Shaw, "Physical activity and health promotion: a public health imperative," in *Health Promotion-Principles and Approaches*, IntechOpen, 2023.

[30] S. Márquez roSa, J. Rodríguez Ordax, and S. De Abajo Olea, "Sedentarismo y salud: efectos beneficiosos de la actividad física," *Apunts*, vol. 83, pp. 12–24, 2006.

[31] T. A. Rehn, R. A. Winett, U. Wisløff, and Ø. Rognmo, "Increasing physical activity of high intensity to reduce the prevalence of chronic diseases and improve public health," *Open Cardiovasc. Med. J.*, vol. 7, p. 1, 2013.

[32] A. E. Chung, A. C. Skinner, S. E. Hasty, and E. M. Perrin, "Tweeting to health: a novel mHealth intervention using Fitbits and Twitter to foster healthy lifestyles," *Clin. Pediatr. (Phila).*, vol. 56, no. 1, pp. 26–32, 2017.

[33] A. De la Pena and B. Amezcua, "Health Support in the Palm of Your Hand: The Role of Technology in Achieving Health Goals," in *Advances in Health Management*, IntechOpen, 2017.

[34] C. A. Maher *et al.*, "Gamification in a physical activity app: what gamification features are being used, by whom, and does it make a difference?," *Games Health J.*, vol. 11, no. 3, pp. 193–199, 2022.

[35] Z. Ma, Q. Gao, Y. Tian, Y. Chen, and Q. Yuan, "Effectiveness of cooperative and competitive gamification in mobile fitness applications among occasional exercisers," *Behav. Inf. Technol.*, vol. 43, no. 11, pp. 2401–2423, 2024.

[36] G. Chan *et al.*, "Social exergames in health and wellness: a systematic review of trends, effectiveness, challenges, and directions for future research," *Int. J. Human–Computer Interact.*, vol. 41, no. 10, pp. 5894–5925, 2025.

[37] J. F. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, "Multivariate data analysis: Pearson College division," *Pers. London, UK*, 2010.

[38] J. Barnes, Y.-C. Rhee, and R. J. Tallent, "Motivation toward physical activity: Effect of social media community on exercise adherence," *Media Watch*, vol. 7, no. 3, pp. 299–314, 2016.

[39] L. Schaffarczyk and A. Ilhan, "Healthier life and more fun? users' motivations to apply activity tracking technology and the impact of gamification," in *International Conference on Human-Computer Interaction*, Springer, 2019, pp. 124–136.

[40] S. B. Hales, B. Grant, D. J. Barr-Anderson, and G. M. Turner-McGrievy, "Examining the impact of an online social media challenge on participant physical activity and body weight in the United States," *Sport Soc.*, vol. 19, no. 10, pp. 1690–1702, 2016.

[41] L. R. Buis *et al.*, "Evaluating Active U: an Internet-mediated physical activity program," *BMC Public Health*, vol. 9, no. 1, p. 331, 2009.

[42] B. Tesi *et al.*, "'Health is a serious game': Gamification as a tool for primary prevention in Public Health," *Eur. J. Public Health*, vol. 33, no. Supplement_2, pp. ckad160-032, 2023.

[43] V. Saprikis and M. Vlachopoulou, "A Literature Review and an Investigation on Gamified Mobile Apps in Health and Fitness," in *Balkan Conference on Operational Research*, Springer, 2020, pp. 227–234.