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SMARTWATCH-BASED ACTIVITY TRACKING VERSUS STANDARD EXERCISE ADVICE IN GLYCEMIC CONTROL AMONG OVERWEIGHT ADULTS

Original Article

Muhammad Imtiaz Subhani[1]*, Muhammad Affan Nadeem[2]

Muhammad Imtiaz Subhani*
Clinical Physiotherapist, A.O Orthopedic and Rehabilitation Center, Pakistan.
khawajam579@gmail.com

Muhammad Affan Nadeem
Affa2620@gmail.com
Junior Cardio Physiologist, Dr. Ziauddin Hospital, Pakistan.
https://orcid.org/0009-0002-4418-6815

Corresponding	Muhammad Imtiaz Subhani* khawajam579@gmail.com Clinical Physiotherapist, A.O Orthopedic and Rehabilitation Center, Pakistan.
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Abstract

Background: Physical inactivity and sedentary behavior are major contributors to poor glycemic control and metabolic disorders in overweight adults. Conventional exercise counseling often fails to ensure sustained behavioral change due to lack of real-time feedback and self-monitoring. Wearable technology, particularly smartwatches, offers an innovative approach by promoting consistent activity tracking and motivation through instant feedback mechanisms.

Objective: To evaluate whether smartwatch-guided physical activity enhances glycemic control more effectively than conventional exercise advice among overweight adults.

Methods: A six-month randomized controlled trial was conducted in South Punjab involving 120 overweight adults aged 25–55 years. Participants were randomly allocated to a smartwatch-guided intervention group or a control group receiving standard exercise advice. The intervention group used smartwatches for daily activity tracking and goal setting. Fasting blood glucose (FBG), glycated hemoglobin (HbA1c), body mass index (BMI), waist circumference, and physical activity levels were measured at baseline, 12 weeks, and 24 weeks. Data were analyzed using independent t-tests, paired t-tests, and repeated-measures ANOVA for normally distributed variables, with significance set at $p < 0.05$.

Results: The smartwatch group demonstrated significant improvements in glycemic parameters, with mean FBG decreasing from 116.4 ± 7.8 mg/dL to 101.3 ± 6.4 mg/dL and HbA1c from 6.2 ± 0.3% to 5.7 ± 0.3% ($p < 0.001$). The control group showed smaller changes (FBG: 115.9 ± 7.5 to 109.4 ± 6.8 mg/dL; HbA1c: 6.1 ± 0.4 to 5.9 ± 0.4%). BMI and waist circumference declined significantly only in the smartwatch group. Physical activity indicators, including step count and active minutes, were markedly higher among smartwatch users.

Conclusion: Smartwatch-based physical activity tracking produced superior improvements in glycemic control and activity adherence compared to standard exercise advice. The findings support the integration of wearable technology into community-level interventions for metabolic health improvement.

Keywords: Body Mass Index, Exercise Therapy, Glycemic Control, Overweight, Physical Activity, Smartwatch, Type 2 Diabetes Prevention

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Introduction

Physical inactivity has emerged as one of the most significant contributors to the global epidemic of obesity, metabolic syndrome, and type 2 diabetes mellitus(1). Modern lifestyles characterized by prolonged sitting, low physical exertion, and excessive caloric intake have created an environment in which maintaining metabolic balance has become increasingly difficult(2). Among the key metabolic disturbances associated with sedentary behavior, impaired glycemic control stands as a major risk factor leading to prediabetes and diabetes in overweight and obese adults(3). Regular exercise and sustained physical activity are widely recognized as cornerstones of glycemic management; however, the challenge lies not in the knowledge of these benefits but in the consistent adherence to physical activity routines over time. Traditional exercise counseling or general advice, although frequently offered in primary and preventive healthcare settings, often fails to produce meaningful behavioral change(3). This limitation arises from the absence of real-time feedback, motivation, and self-monitoring tools that are crucial for long-term engagement in physical activity(4).

In recent years, the integration of digital health technologies has reshaped approaches to lifestyle modification and chronic disease prevention. Smartwatches and wearable activity trackers represent a rapidly growing frontier in this domain, combining behavioral science with technological innovation to enhance adherence and self-awareness(5). These devices provide continuous monitoring of step count, heart rate, calories burned, and other health-related metrics. By delivering instant feedback, personalized reminders, and activity goals, they can transform the abstract recommendation of "exercise more" into a measurable, goal-oriented process. The gamification of physical activity—through progress charts, milestone badges, and data-driven reinforcement—has been shown to strengthen motivation, accountability, and user engagement. Consequently, smartwatch-guided interventions have the potential to bridge the critical gap between awareness and action that traditional exercise advice often leaves unaddressed(6).

Moreover, the use of wearable technology extends beyond behavioral modification; it provides valuable data that can guide personalized interventions and enable healthcare professionals to track progress objectively. Smartwatches offer an opportunity for both individuals and clinicians to monitor daily movement patterns in real-time, facilitating timely adjustments in activity intensity or duration. The feedback loop created by such technology can enhance intrinsic motivation and promote self-efficacy—key determinants of sustained behavioral change. For overweight adults struggling with glycemic instability, these features may translate into better glucose utilization, improved insulin sensitivity, and overall metabolic health(7).

Despite the promise of wearable devices, scientific evidence comparing their efficacy to conventional exercise counseling remains limited and somewhat inconclusive. Some studies have reported significant improvements in physical activity levels and weight management among smartwatch users, while others suggest that enthusiasm wanes over time, leading to minimal differences in long-term outcomes. Additionally, most existing research has focused on weight loss or general physical activity rather than directly assessing changes in glycemic parameters such as fasting glucose, HbA1c, or insulin sensitivity(8). Therefore, there remains a need for robust, controlled studies that evaluate whether smartwatch-guided activity tracking can produce clinically meaningful improvements in glycemic control compared with standard exercise advice alone(9).

Another important consideration is that overweight adults often face unique barriers to regular exercise, including low motivation, time constraints, musculoskeletal discomfort, and lack of social support. Smartwatches, with their individualized goal-setting and progress tracking features, may offer a solution that integrates seamlessly into daily routines(10). They allow users to self-regulate behavior, receive motivational cues, and monitor progress without requiring constant clinical supervision(11). This autonomy and convenience may be particularly beneficial in promoting adherence among individuals who are otherwise resistant to structured exercise programs. Furthermore, integrating wearable technology into preventive health strategies could reduce the burden on healthcare systems by empowering individuals to take a more active role in managing their metabolic health(12).

Given these considerations, it becomes imperative to examine whether technology-driven physical activity interventions can outperform traditional advice-based methods in improving glycemic regulation(13). The potential public health implications of such findings are considerable, as even modest improvements in glycemic control among overweight individuals could reduce the risk of developing type 2 diabetes and its associated complications(13).

The present randomized controlled trial was therefore designed to test the hypothesis that smartwatch-guided physical activity produces greater improvement in glycemic control compared to conventional exercise advice among overweight adults. The primary objective of this study is to determine whether continuous, technology-assisted activity tracking leads to superior outcomes in glycemic markers, physical activity levels, and overall metabolic health.

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Methods

This randomized controlled trial was conducted in South Punjab over a period of six months to assess whether smartwatch-guided physical activity improves glycemic control more effectively than standard exercise advice among overweight adults. Participants were recruited from local community health centers and fitness clinics through announcements and screening camps. A total of 120 adults aged between 25 and 55 years were enrolled after meeting the inclusion criteria, which required a body mass index (BMI) between 25 and 34.9 kg/m² and fasting blood glucose levels ranging from 100 to 125 mg/dL, indicating impaired fasting glucose but not overt diabetes. This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from A.O Orthopedic and Rehabilitation Center, Pakistan. Individuals with diagnosed diabetes mellitus, cardiovascular disease, musculoskeletal disorders limiting physical activity, or those currently engaged in structured exercise programs were excluded from participation. Pregnant or lactating women, individuals taking medications influencing glucose metabolism, and smartwatch users prior to the study were also excluded to maintain uniformity.

Sample size estimation was based on previous trials evaluating lifestyle interventions for glycemic control, assuming an effect size of 0.5 in HbA1c reduction with a power of 0.8 and a significance level of 0.05. This calculation yielded a minimum of 50 participants per group, which was inflated to 60 per group to account for potential dropouts, resulting in a final sample size of 120 participants.

After baseline assessments, participants were randomly assigned into two equal groups using computer-generated randomization. The intervention group received a commercially available smartwatch capable of tracking steps, heart rate, and energy expenditure. Each participant was trained to synchronize the device with a mobile application that provided real-time feedback, daily activity goals, and motivational reminders. They were instructed to achieve a minimum of 150 minutes of moderate-intensity activity per week, in line with global physical activity recommendations. The control group received standard exercise advice in the form of a counseling session delivered by a physiotherapist, emphasizing the importance of regular physical activity, healthy eating, and lifestyle modification. No wearable device or digital feedback was provided to the control group.

Data were collected at baseline, at 12 weeks, and at the end of 24 weeks. Glycemic control was assessed using fasting blood glucose and glycated hemoglobin (HbA1c) measured by enzymatic colorimetric assay and high-performance liquid chromatography (HPLC), respectively. Secondary outcomes included body weight, BMI, and waist circumference measured using standardized anthropometric procedures. Physical activity levels were quantified through the International Physical Activity Questionnaire (IPAQ) for the control group and smartwatch data logs for the intervention group.

All data were recorded using a standardized proforma and analyzed using SPSS version 26. Normality of data was confirmed through the Shapiro–Wilk test. Between-group comparisons for continuous variables were performed using independent sample t-tests, while within-group changes over time were assessed using paired t-tests. Repeated measures ANOVA was employed to analyze differences in glycemic parameters across multiple time points. Categorical variables were compared using chi-square tests where applicable. A p-value of less than 0.05 was considered statistically significant.

Throughout the study, participants received monthly follow-up calls to ensure compliance and address any technical difficulties related to smartwatch usage. This methodological approach ensured that the intervention's effectiveness was evaluated not only in controlled conditions but also in a real-world context reflective of community-based health practices in South Punjab.

Results

A total of 120 participants were enrolled and randomly assigned into two groups of 60 each. The mean age of the smartwatch group was 42.3 ± 6.7 years, while that of the control group was 41.9 ± 6.4 years. The groups were comparable at baseline in terms of gender distribution, body mass index, and baseline glycemic parameters. Mean baseline BMI was 29.8 ± 2.5 kg/m² in the smartwatch group and 29.6 ± 2.3 kg/m² in the control group. Baseline fasting blood glucose (FBG) and HbA1c were 116.4 ± 7.8 mg/dL and 6.2 ± 0.3 % in the smartwatch group, and 115.9 ± 7.5 mg/dL and 6.1 ± 0.4 % in the control group, respectively, with no significant difference between groups.

At 12 weeks, participants in the smartwatch group demonstrated a significant reduction in FBG to 108.2 ± 6.9 mg/dL, which further declined to 101.3 ± 6.4 mg/dL by week 24 ($p < 0.001$). In contrast, the control group showed a smaller reduction from 115.9 ± 7.5 mg/dL to 111.7 ± 7.0 mg/dL at 12 weeks and 109.4 ± 6.8 mg/dL at 24 weeks ($p = 0.032$). The between-group comparison revealed a statistically significant difference in FBG at 24 weeks ($p < 0.001$). A similar trend was observed in HbA1c levels, where the smartwatch group showed a progressive decline from 6.2 ± 0.3 % at baseline to 5.7 ± 0.3 % at week 24, whereas the control group decreased only to 5.9 ± 0.4 % ($p = 0.004$). Figure 1 and Figure 2 illustrate these glycemic changes over time.

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Anthropometric outcomes supported the glycemic findings. The smartwatch group experienced a mean weight reduction from 84.6 ± 8.3 kg to 80.9 ± 7.6 kg ($p < 0.001$), accompanied by a decrease in BMI from 29.8 ± 2.5 kg/m² to 28.5 ± 2.3 kg/m². Waist circumference decreased by an average of 4.3 cm in this group. Conversely, the control group showed smaller and non-significant changes in weight (83.8 ± 8.1 kg to 82.7 ± 7.9 kg; $p = 0.08$) and BMI (29.6 ± 2.3 kg/m² to 29.3 ± 2.2 kg/m²).

Physical activity indicators revealed markedly higher engagement among smartwatch users. Mean weekly step count in the intervention group was 8,543 ± 1,124 steps, compared with 6,251 ± 987 in the control group ($p < 0.001$). Active minutes per week averaged 176 ± 32 minutes in the smartwatch group and 124 ± 27 minutes in the control group. The International Physical Activity Questionnaire (IPAQ) total score showed a significant difference, with 2,620 ± 418 MET-min/week in the smartwatch group versus 1,815 ± 396 MET-min/week in the control group ($p < 0.001$).

Repeated-measures ANOVA demonstrated significant time-by-group interactions for both FBG ($F = 18.4$, $p < 0.001$) and HbA1c ($F = 9.7$, $p = 0.002$), indicating a greater rate of glycemic improvement in the smartwatch group across the study duration. No adverse events were reported in either group, and device adherence in the intervention group remained above 90% throughout. These findings indicate consistent improvements in physical activity behavior and metabolic outcomes among participants receiving smartwatch-guided interventions compared with those who received standard exercise advice.

Table 1: Baseline Demographic Characteristics

Variable	Smartwatch Group (n=60)	Control Group (n=60)
Age (years)	42.3	41.9
Male (%)	58.3	55.0
Female (%)	41.7	45.0
BMI (kg/m²)	29.8	29.6
Baseline Fasting Glucose (mg/dL)	116.4	115.9
Baseline HbA1c (%)	6.2	6.1

Table 2: Glycemic Control over Time

Time Point	Smartwatch FBG (mg/dL)	Control FBG (mg/dL)	Smartwatch HbA1c (%)	Control HbA1c (%)
Baseline	116.4	115.9	6.2	6.1
12 Weeks	108.2	111.7	5.9	6.0
24 Weeks	101.3	109.4	5.7	5.9

Table 3: Anthropometric Changes after 24 Weeks

Parameter	Smartwatch Baseline	Smartwatch 24 Weeks	Control Baseline	Control 24 Weeks
Body Weight (kg)	84.6	80.9	83.8	82.7
BMI (kg/m²)	29.8	28.5	29.6	29.3
Waist Circumference (cm)	97.4	93.1	96.9	95.8

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Table 4: Physical Activity Indicators

Measure	Smartwatch Group	Control Group
Mean Weekly Steps	8543	6251
Active Minutes/Week	176	124
IPAQ Score (MET-min/week)	2620	1815

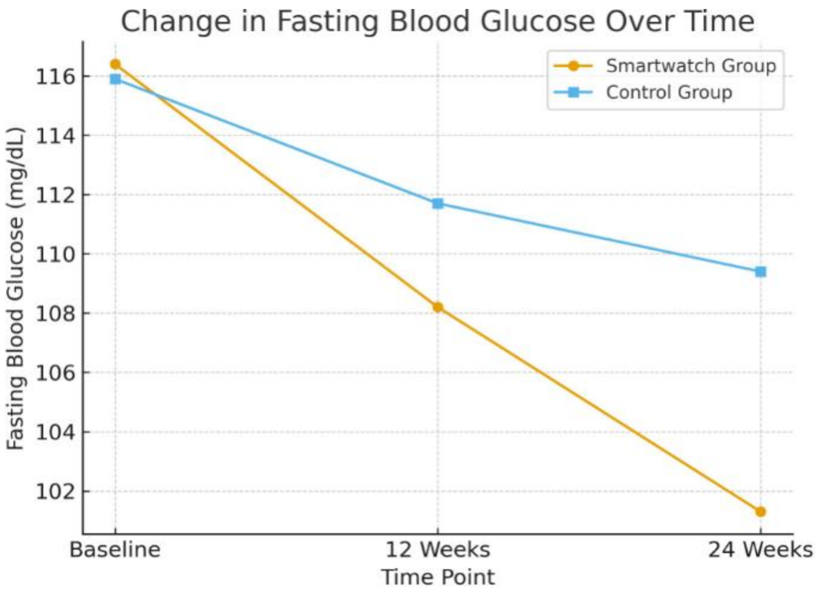

Figure 1 Change in Fasting Blood Glucose Over Time

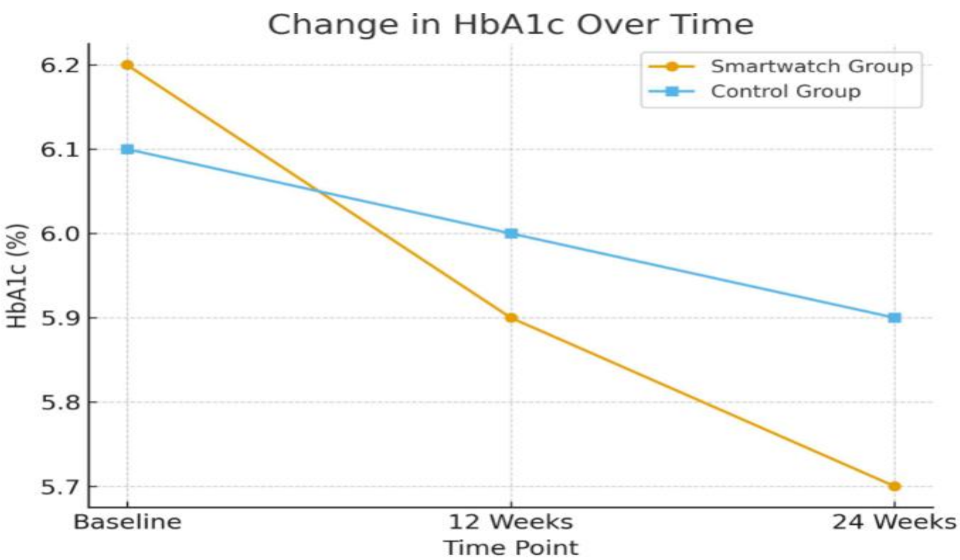

Figure 2 Change in HbA1c Over Time

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Discussion

The findings of this randomized controlled trial demonstrated that smartwatch-guided physical activity significantly improved glycemic control, body composition, and overall physical activity levels among overweight adults compared with conventional exercise advice(14). The consistent reductions observed in fasting blood glucose and HbA1c among participants using smartwatches underscored the effectiveness of technology-assisted interventions in promoting sustainable lifestyle changes(15). These results highlighted the role of wearable technology as a practical and motivational tool for individuals struggling with adherence to exercise recommendations and self-monitoring of health behaviors(16).

The superior outcomes observed in the smartwatch group reflected the advantage of real-time feedback, personalized goals, and continuous self-monitoring provided by wearable devices. Unlike standard counseling, which often relies on verbal advice and self-reported adherence, smartwatches offered a structured and data-driven mechanism to maintain engagement(17). The gamification elements, such as progress tracking and activity reminders, appeared to foster behavioral accountability and intrinsic motivation, which translated into improved physical activity and metabolic outcomes(18). The sustained reduction in fasting glucose and HbA1c over 24 weeks suggested that continuous engagement with self-monitoring tools could positively influence glycemic regulation through enhanced insulin sensitivity and improved glucose utilization in peripheral tissues(19).

These results were consistent with earlier research that indicated a positive relationship between digital activity monitoring and metabolic improvements(20). However, the magnitude of change in glycemic indices observed in the present study appeared more pronounced, possibly due to higher adherence levels maintained by the smartwatch users. The real-time connectivity and immediate feedback loop may have contributed to stronger behavioral reinforcement compared with previous interventions relying on smartphone apps or periodic counseling. Additionally, the incorporation of wearable data offered an objective measure of compliance, reducing reliance on subjective reporting that often introduces bias in lifestyle intervention studies(21).

The observed improvement in anthropometric measures further supported the metabolic findings. The reduction in body weight, BMI, and waist circumference among smartwatch users reflected improved energy balance resulting from increased activity and better lifestyle regulation. Central adiposity reduction, as evidenced by decreased waist circumference, carried particular importance since visceral fat plays a central role in insulin resistance and glucose intolerance. While the control group demonstrated minor improvements, the difference in magnitude indicated that conventional advice alone was insufficient to maintain motivation or induce meaningful behavioral changes over time(22).

An important strength of this study was its randomized design, which minimized selection bias and ensured comparability between groups. The use of objective outcome measures such as fasting glucose, HbA1c, and digitally recorded step counts enhanced the reliability of findings. This practical design increased the generalizability of results to similar populations where sedentary lifestyles and obesity are prevalent, and access to structured fitness programs remains limited.

Nevertheless, several limitations warranted consideration. The study duration of 24 weeks, while sufficient to observe short-term metabolic improvements, might not fully capture long-term sustainability of behavioral change. Wearable engagement tends to decline over time, and it remains uncertain whether the improvements in glycemic control would persist beyond the intervention period. The study population consisted primarily of motivated individuals recruited through health centers, potentially introducing selection bias toward participants already inclined toward lifestyle modification. Dietary intake, which exerts a substantial influence on glycemic control, was not controlled or monitored, limiting the ability to isolate the independent effect of physical activity. Furthermore, the reliance on a single brand of smartwatch restricted evaluation of whether the observed benefits were specific to the device features or generalizable across different wearable technologies.

Despite these limitations, the study contributed meaningful insights into the growing field of digital health interventions. It demonstrated that wearable technology can effectively bridge the gap between awareness and sustained behavioral change, particularly in populations where lifestyle inertia and motivational barriers hinder adherence to traditional exercise counseling. The integration of digital feedback mechanisms with personalized goal setting provided a powerful framework for self-management of metabolic health. In clinical practice, such interventions could complement existing diabetes prevention programs by offering cost-effective, scalable, and user-friendly strategies to monitor and encourage physical activity.

The findings also suggested important directions for future research. Longitudinal studies of greater duration would help establish the durability of metabolic improvements observed with smartwatch use. Integrating dietary monitoring features or coupling smartwatch interventions with telehealth counseling could further enhance outcomes. Exploring the psychosocial factors influencing engagement, such as motivation, perceived competence, and self-efficacy, would provide a more comprehensive understanding of

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user behavior. Additionally, investigating the cost-effectiveness of implementing smartwatch-guided programs in community health settings could inform public health policies targeting obesity and diabetes prevention.

In summary, this study provided strong evidence that smartwatch-based activity tracking significantly enhanced physical activity levels and improved glycemic control among overweight adults compared with standard exercise advice. The results highlighted the value of wearable technology as a practical adjunct to lifestyle modification programs. Although the long-term sustainability of these effects remains to be established, the integration of digital health tools into preventive care holds considerable promise for reducing the burden of metabolic disorders in at-risk populations.

Conclusion

The study concluded that smartwatch-guided physical activity significantly improved glycemic control, body composition, and physical activity levels among overweight adults compared with standard exercise advice. By promoting sustained engagement and self-monitoring, wearable technology proved to be an effective behavioral tool for enhancing metabolic health. These findings suggest that integrating smartwatch-based interventions into community health programs could serve as a practical and scalable strategy for preventing type 2 diabetes and improving long-term lifestyle adherence in at-risk populations.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Imtiaz Subhani*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Affan Nadeem	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published

References

1. Kraushaar LE. Improving the efficiency of lifestyle change interventions for the prevention of cardiometabolic disease. 2010.

2. Reed W. Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context: University of West London; 2024.

3. Nieste I, Franssen WM, Spaas J, Bruckers L, Savelberg HH, Eijnde BOJPm. Lifestyle interventions to reduce sedentary behaviour in clinical populations: a systematic review and meta-analysis of different strategies and effects on cardiometabolic health. 2021;148:106593.

4. Western MJ, Standage M, Peacock OJ, Nightingale T, Thompson DJJFR. Supporting behavior change in sedentary adults via real-time multidimensional physical activity feedback: mixed methods randomized controlled trial. 2022;6(3):e26525.

5. Hernani MRA, Nepangue JU, Canillas JA, Elumbaring JB, Dagoc PP, Janito CR, et al. Examining the Efficacy of Pedometer Use in Enhancing Fitness Level: The Case of Tertiary Students in a State University. 2025;13(4):877-86.

6. Flack KD, Stults-Kolehmainen MA, Anderson III RE, Handlery R, Creasy SA, Catenacci VAJN. Exploring Strategies to Promote Exercise as a Viable Obesity and Chronic Disease Treatment. 2025;17(12):1997.

7. Pan Z, Li X, Yan Q, Zeng NJJoMIR. Application of Behavioral Science in Digital Therapeutics for Individuals With Prediabetes: Scoping Review. 2025;27:e78891.

Received: 20/Mar/2025
Accepted: 26/Apr/2025
Published:30/Apr/2025

8. Mazeas A. Development and evaluation of a digital intervention based on gamification to promote physical activity of patients with chronic diseases: Université Grenoble Alpes [2020-....]; 2023.

9. Säteri SJJD. The promotion of physical activity with remote technology with a special focus on cardiac rehabilitation. 2025.

10. Arshad MT, Ali M, Maqsood S, Ikram A, Ahmed F, Aljameel A, et al. Personalized Nutrition in the Era of Digital Health: A New Frontier for Managing Diabetes and Obesity. 2025;13(10):e71006.

11. Yu T, Parry M, Yu T, Xu L, Wu Y, Zeng T, et al. Effectiveness of Mobile Health–Based Gamification Interventions for Improving Physical Activity in Individuals With Cardiovascular Diseases: Systematic Review and Meta-Analysis of Randomized Controlled Trials. 2025;13:e64410.

12. Thielen SC, Reusch JE, Regensteiner JGJFiCD, Healthcare. A narrative review of exercise participation among adults with prediabetes or type 2 diabetes: barriers and solutions. 2023;4:1218692.

13. Arguello D, Rogers E, Denmark GH, Lena J, Goodro T, Anderson-Song Q, et al. Companion: A Pilot Randomized Clinical Trial to Test an Integrated Two-Way Communication and Near-Real-Time Sensing System for Detecting and Modifying Daily Inactivity among Adults> 60 Years—Design and Protocol. 2023;23(4):2221.

14. Flølo TN, Tørris C, Riiser K, Almendingen K, Chew HSJ, Fosså A, et al. Digital health interventions to treat overweight and obesity in children and adolescents: An umbrella review. 2025;26(6):e13905.

15. Hematabadi A, Rashidlamir A, Radfar B, Shourabi P, Hajimousaei S, Schauer M, et al. Social Media in Physical Activity Interventions Targeting Obesity Among Young Adults: Trends, Challenges, and Lessons from Instagram, TikTok, YouTube, and Facebook. 2025;5(4):111.

16. Gkintoni E, Vantaraki F, Skoulidi C, Anastassopoulos P, Vantarakis AJBS. Promoting physical and mental health among children and adolescents via gamification—A conceptual systematic review. 2024;14(2):102.

17. 5. Facilitating positive health behaviors and well-being to improve health outcomes: standards of care in diabetes—2025 %J Diabetes care. 2025;48(Supplement_1):S86-S127.

18. Wu P-T, Baltich AA, Chu I-H, Chui KKJD. Wearable Activity Trackers to Improve Physical Activity and Cardiovascular Risk in Type 2 Diabetes: A Randomized Pilot Study. 2025;6(9):97.

19. Ahmad OM, Ibrahim R, Odunsi DI, Mohammed M, Mathew BG, Touny M, et al. Role of mobile health and wearable devices in cardiovascular disease prevention: a comprehensive review. 2025;17(5).

20. Diaz KM, Murdock ME, Clark AW, Kumar S, Jerez V, Serafini MA, et al. Breaking up prolonged sedentary behavior to improve cardiometabolic health (BREAK2): protocol for a dose-finding adaptive randomization trial. 2025;25(1):1929.

21. Daniel K, Daniel V, Solanki P, Solanki A. Regulatory Landscape and Quality Assurance in Nutraceutical Development. Nutraceuticals and Obesity: Routledge; 2025. p. 155-73.

22. Zhang G, Xia Y, Li X, Zhang Y, Xu X, Sun TJPp, et al. A Gamification mHealth Intervention to Enhance Adherence to Personalized Exercise for Older Adults with Chronic Diseases: A Randomized Controlled Trial Protocol. 2025:3145-57.

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