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Yapay Zeka Destekli Ciddi Oyunun Sağlıklı Yaşam Biçimi Davranışları Üzerindeki Etkisi: Yarı Deneysel Bir Çalışma

Effects of an Artificial Intelligence–Supported Serious Game on Healthy Lifestyle Behaviours: A Quasi-Experimental Study

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ABSTRACT

Aim: This study aimed to evaluate the effects of an AI-powered serious game on healthy lifestyle behaviours among adults undergoing diabetes risk assessment. Methods: A single-group quasi-experimental design was conducted with 60 adults without a diabetes diagnosis. The Health-Promoting Lifestyle Profile-II (HPLP-II) was administered at four time points over six months, assessing health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, stress management, and total score. Perceived behavioural impact of game mechanics was evaluated using a structured assessment form. Data were analysed using repeated-measures ANOVA with Greenhouse-Geisser and Bonferroni corrections. Results: HPLP-II total scores showed progressive improvement across all time points ($p<.001$). Physical activity demonstrated the greatest change with increasing effect sizes over time ($\eta p^2=.134$, $p<.001$), while health responsibility showed consistent improvements across all follow-up points ($\eta p^2=.222$, $p<.001$). Nutrition scores improved over time but did not reach statistical significance after correction ($p=.013$). Sixty percent of participants reported identification-based motivation, and 95% would recommend the game. Conclusion: AI-powered serious games may serve as a promising support tool for diabetes prevention by improving health responsibility and physical activity over six months. The progressive increase in physical activity contrasts with literature showing declining effects, suggesting that AI-based personalisation may sustain long-term motivation.

Keywords: *Artificial intelligence, Diabetes mellitus, Video games, Health behavior*

ÖZ

Amaç: Bu çalışma, diyabet riski değerlendirilmesi yapılan yetişkinlerde yapay zeka destekli bir ciddi oyunun sağlıklı yaşam biçimi davranışları üzerindeki etkinliğini değerlendirmeyi ve katılımcıların hastalığa yönelik davranış değişikliklerini incelemeyi amaçlamaktadır. Yöntem: Çalışma, diyabet tanısı almamış 60 yetişkin ile tek gruplu yarı deneysel tasarımda yürütülmüştür. Sağlıklı Yaşam Biçimi Davranışları Ölçeği-II (SYBDÖ-II) altı aylık süreçte dört zaman noktasında uygulanmış; sağlık sorumluluğu, fiziksel aktivite, beslenme, manevi gelişim, kişilerarası ilişkiler, stres yönetimi alt boyutları ve toplam puan değerlendirilmiştir. Oyun mekaniğinin algılanan davranışsal etkisi yapılandırılmış bir değerlendirme formu ile ölçülmüştür. Veriler Greenhouse-Geisser ve Bonferroni düzeltmeleri uygulanarak tekrarlı ölçümler ANOVA ile analiz edilmiştir. Bulgular: SYBDÖ-II toplam puanı tüm ölçüm noktalarında progresif artış göstermiştir ($p<.001$). Fiziksel aktivite alt boyutu zaman içinde artan etki büyüklükleriyle en güçlü değişimi ($\eta p^2=.134$, $p<.001$), sağlık sorumluluğu ise tüm izlem noktalarında tutarlı iyileşme göstermiştir ($\eta p^2=.222$, $p<.001$). Beslenme alt boyutu puanları zaman içinde artış göstermiş ancak düzeltme sonrasında istatistiksel anlamlılık düzeyine ulaşamamıştır ($p=.013$). Katılımcıların %60'ı özdeşleşme güdüsüyle motive olduğunu bildirmiş, %95'i oyunu tavsiye etmiştir. Sonuç: Yapay zeka destekli ciddi oyunların, sağlıklı davranış geliştirme ve fiziksel aktivite davranışlarını altı ay boyunca iyileştirerek diyabet önlemeye katkı sağlayabileceği düşünülmektedir. Fiziksel aktivitedeki progresif artışın etkilerin zamanla azaldığını gösteren literatürle çelişmesi, yapay zeka tabanlı kişiselleştirmenin uzun vadeli motivasyonu sürdürebileceğine işaret etmektedir.

Anahtar Kelimeler: *Yapay zeka, Diyabetes mellitus, Video oyunları, Sağlık tutumu*

INTRODUCTION

As of 2024, 589 million adults worldwide live with diabetes, and this number is projected to reach 853 million by 2050. Lifestyle-related risk factors such as physical inactivity, unhealthy diet, and obesity play a major role in the development of type 2 diabetes. According to International Diabetes Federation (IDF) data, 252 million adults with diabetes remain undiagnosed, meaning that 43% of individuals with diabetes are unaware of their condition (1). Interventions at the pre-diabetes stage can halt or even reverse disease progression. Despite available prevention strategies translating risk awareness into sustained behavioural change remains a critical challenge (2). American Diabetes Association (ADA) and Diabetes Self-Management and Education (DSME) programs emphasize the central role of behavioural change in addressing this growing public health crisis (3).

Serious games have emerged as a promising digital health intervention for promoting health education and behaviour change. Accessible via mobile devices and the internet, these games have been increasingly used in diabetes education and risk awareness interventions (4-6). Previous studies have shown that serious games can improve diabetes-related knowledge and support short-term behaviour change; however, most interventions remain limited to brief engagement periods and lack guideline-based personalization mechanisms (7-9).

In recent years, artificial intelligence (AI) technologies have been increasingly integrated into digital health interventions for diabetes risk prediction and personalized behavioural support (10,11). Despite this progress, significant gaps remain in the literature. Most existing applications rely on static data input, lack compliance with clinical guidelines, and do not incorporate regular content update mechanisms. Evidence on the long-term behavioural impact of AI-powered serious games and guideline-based personalization remains particularly limited (7-9).

To address these gaps, this study developed an AI-powered serious game integrating diabetes risk assessment with personalized behavioural feedback based on clinical guidelines. The study aimed to evaluate the effectiveness of this system on healthy lifestyle behaviours among individuals at diabetes risk over a six-month follow-up period and to examine participants' changes in behaviour toward the disease. It was hypothesized that participation in the AI-assisted serious game would result in significant improvements in Health-Promoting Lifestyle Profile-II (HPLP-II) total and subscale scores over six months.

MATERIAL and METHOD

Study place, and design

This study was designed as a single-group, pretest–post-test quasi-experimental study without a control group. The intervention and data collection were conducted between May 1 and May 7, 2025, using community-based recruitment through purposive snowball sampling in Isparta, Türkiye. Follow-up assessments were conducted at 1, 3, and 6 months after completion of the intervention.
Sample size estimation was performed using G*Power 3.1.9.7. Assuming a moderate effect size ($f = 0.25$), $\alpha = 0.05$, and power = 0.80 for repeated-measures ANOVA, the minimum required sample size was calculated as 34. To account for potential attrition, 68 participants were initially recruited; the study was completed with 60 participants. The final sample size exceeded the minimum required number to maintain adequate statistical power.

Population

Participants were recruited using purposive snowball sampling to facilitate rapid enrolment within a limited time frame and to reach individuals potentially at moderate-to-high risk of diabetes who might not otherwise volunteer for digital health interventions.

Eligibility criteria were applied prior to enrolment. Inclusion criteria were: (1) aged 18 years or older, (2) no prior diagnosis of diabetes, (3) literacy sufficient to understand study procedures, (4) no communication impairments, (5) adequate technological literacy to use the mobile application, and (6) willingness to participate in the study and complete 6-month follow-up assessments. Exclusion criteria included diagnosed diabetes, visual or hearing impairments interfering with game use, psychiatric illness, and inability to complete follow-up assessments.

A total of 68 participants were enrolled during the recruitment period. Of the eight participants lost during follow-up (three at 1 month, four at 3 months, and one at 6 months), three could not be reached by telephone at the scheduled time points and were classified as lost to follow-up, while the remaining five withdrew after stating that they no longer wished to continue. After attrition across follow-up assessments, 60 participants completed all follow-up measurements and were included in the final per-protocol analysis (Figure 1).

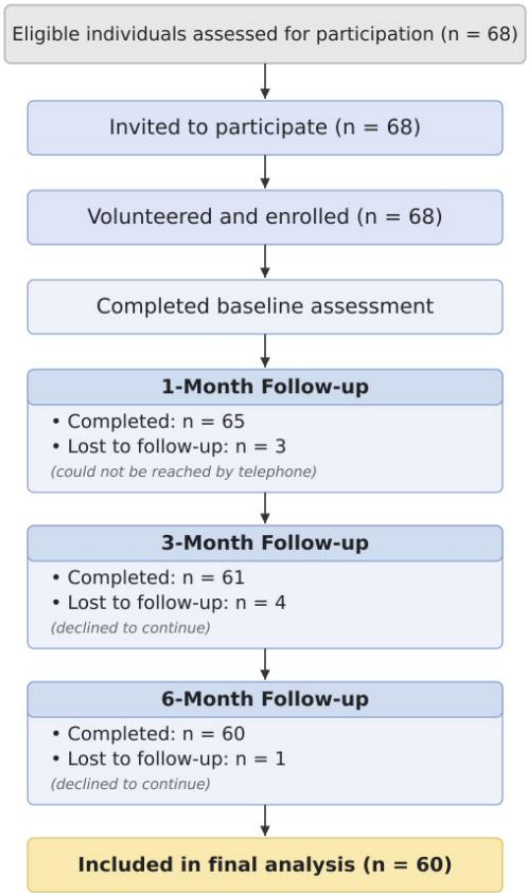

Figure 1. Flow diagram

Development of AI based serious games

The serious game called "Blue Ring Island," used in the research, is a mobile application developed by researchers using the Unity game development engine. The game is designed in an adventure-simulation hybrid format and aims to improve participants' healthy lifestyle behaviours using the storytelling (gamification through narrative) method. In the game's basic scenario, the user travels to a health-themed island and, upon arrival, determines their diabetes risk according to FINDRISK criteria as their first task. The user interface of the serious game is shown in Figure 2. The integrated FINDRISK questionnaire module used for diabetes risk assessment is presented in Figure 3. Figure 4 shows the task behaviours according to FINDRISK.

Figure 2. Main user interface of the "Blue Ring Island" serious game

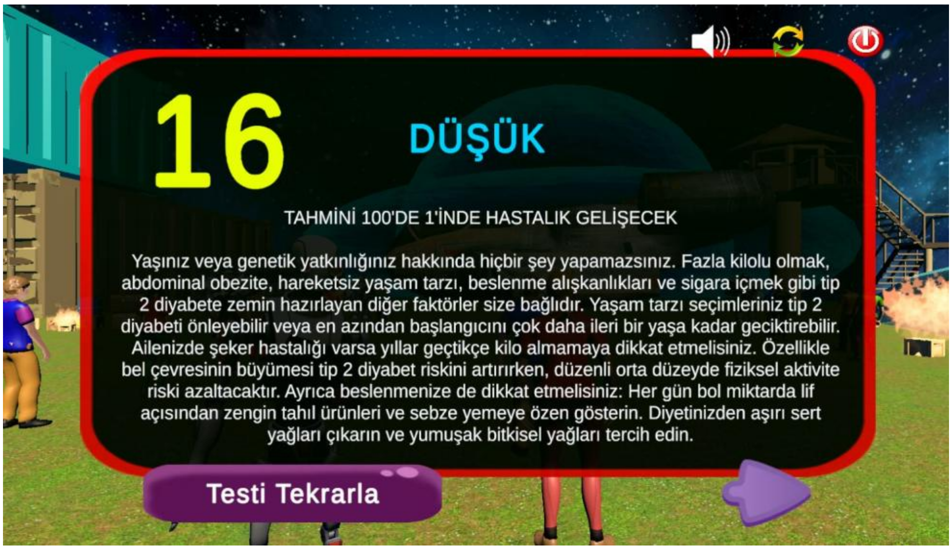

Figure 3. FINDRISK diabetes risk assessment result screen

Figure 4. AI-generated task assignment screen based on FINDRISK risk level screen

In the risk assessment process, the user answers eight questions of the FINDRISK questionnaire (age, body mass index, waist circumference, physical activity level, vegetable and fruit consumption, hypertension medication use, history of high blood sugar, family history) in an interactive format. The artificial intelligence algorithm analyses these answers in real time and calculates the user's diabetes development risk score. After the risk score is determined, the system provides the user with personalized feedback specific to the risk level (low, mildly high, moderate, high, very high) and assigns short-term tasks to improve healthy lifestyle behaviours. The game's artificial intelligence system was trained based on the ADA Standards of Care 2024 and the IDF Diabetes Atlas 11th Edition guidelines. Diabetes risk factors, prevention strategies, and lifestyle interventions from these guidelines were integrated into the AI model using prompt engineering. In technical terms, the system operated as a guideline-constrained, rule-based decision layer. No personally identifiable data were used as model inputs, and no adaptive learning occurred during the study; the mapping between risk score and recommendation remained fixed throughout the intervention to ensure reproducibility and clinical consistency. This approach minimized the risk of the system making non-clinical or erroneous recommendations and ensured that all outputs were consistent with evidence-based medicine principles. The tasks assigned in the game included short-term behavioural change goals applicable in real life (e.g., walking for 30 minutes a day, consuming five servings of fruits and vegetables daily, exercising regularly three days a week).

Participants were limited to actively playing the game for one week, during which time they were expected to complete risk assessments and learn their assigned tasks. After completing the game, participants were asked questions to evaluate the effectiveness of the game mechanics, user experience, and motivational elements. The participants were expected to apply these tasks to their daily lives, and changes in healthy lifestyle behaviours were measured using the HPLP-II at 1, 3, and 6 months. Importantly, active gameplay was deliberately restricted to this single one-week period. At the end of the week, participants' access to the application was withdrawn so that the behavioural effect of the initial, intensive exposure could be observed in isolation, without ongoing exposure to the digital intervention. During the subsequent six-month follow-up, participants did not play the game again. They received no reminder messages, SMS prompts, booster sessions, or additional clinical or educational support from the research team. Follow-up assessments at 1, 3, and 6 months were obtained solely by telephone to administer the HPLP-II, with no intervention content delivered during these calls. This design was intended to ensure that any observed changes in lifestyle behaviours reflected behaviour initiated during the one-week exposure rather than the cumulative effect of repeated or sustained use of the game.

Questionnaire

Descriptive information form

This is a 12-question form prepared by researchers to assess patients' sociodemographic characteristics such as age and gender; some medical and family history information related to their disease, health behaviour, and diabetes education status.

Type 2 diabetes risk questionnaire (FINDRISK)

Developed by the Finnish Diabetes Association, FINDRISK is a questionnaire consisting of 8 questions that can determine a person's risk of developing diabetes in the next 10 years. Accordingly, the risk of developing diabetes in 10 years is defined as: low risk (<7 points) 1%, mildly high risk (7-11 points) 4%, moderate risk (12-14 points) 16%, high risk (15-20 points) 33%, and very high risk (>20 points) 50%. The scale has been translated into 15 different languages, including Turkish, by the International Diabetes Federation. Individuals with a scale score of 15 or higher are advised to visit diabetes, endocrinology, and internal medicine outpatient clinics and undergo laboratory tests (12). In this study, FINDRISK was administered within the game to all enrolled participants as a risk-stratification tool that personalized the recommendations and was not used as an eligibility criterion.

Healthy lifestyle behaviours scale-II (HPLP-II)

The Turkish validity and reliability study of the scale, developed by Walker et al. based on Pender's "Health Promotion Model," was conducted in 2008. The scale has a total of 52 items and 6 sub-dimensions. The sub-dimensions are physical activity-exercise, stress management, interpersonal relationships, spiritual development, health responsibility, and nutrition. The lowest possible score on the scale is 52, and the highest is 208. The Cronbach Alpha value, which constitutes the reliability coefficient of the scale, was determined to be 0.92 (13).

Game mechanics evaluation form

Researchers developed an evaluation form based on Self-Determination Theory (14) to assess the effectiveness of the game "Blue Ring Island, the Transtheoretical Model (15), and the literature on serious game evaluation. Expert opinion was obtained for the content validity of the form. The form consists of 18 questions and includes three main sections: (1) Behavioural Impact of Game Mechanics (13 questions, 5-point Likert: 1=Not Effective at All, 5=Very Effective, score range: 13-65), (2) Behavioural Motivation Assessment (3 multiple-choice questions evaluating motivation type, behavioural change stage, and behavioural domain), (3) Game Experience and Sustainability (2 questions, 5-point Likert, score range: 2-10). High scores for Sections A and C indicate a more effective game experience, while Section B descriptively assesses the participants' motivation profile and behavioural change stages.

Data collection

The data collection process was carried out in three phases over two weeks:

Preparation phase (2 days): Participants received training on the use of the AI-powered serious game, personal data privacy, and critical evaluation techniques. Participants were instructed not to enter any personally identifiable information into the system.

Application phase (1 week): Participants began playing the game in the endocrinology outpatient clinic using tablets provided by the researchers or their own smartphones. The first session was conducted under the supervision of researchers, and participants were given detailed guidance on the game mechanics, the functioning of the AI system, and how the assigned tasks would be applied in real life. Participants were able to request clarification if needed. Researchers did not intervene in the process to maintain independent participant-AI interaction.

Evaluation and follow-up phase (6 months): After the game was completed, participants were given a reflective evaluation form describing their game experience. Participants' healthy lifestyle behaviours were evaluated using the HPLP-II at 1 month, 3 months, and 6 months after the game was completed. All participants had basic knowledge of diabetes risk factors and healthy lifestyle behaviours before participating in the game. However, none of the participants had prior experience using AI-assisted games. The primary outcome was change in total HPLP-II score over time. Secondary outcomes included changes in HPLP-II subscales and game evaluation measures.

Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as mean ± standard deviation or frequency and percentage. Repeated measures ANOVA was performed to evaluate changes across time. The assumption of sphericity was assessed using Mauchly’s test. When the assumption was violated, the Greenhouse–Geisser correction was applied. Bonferroni-adjusted post hoc tests were conducted for pairwise comparisons. Effect sizes were reported as partial eta squared (ηp^2). Statistical significance was set at $p<0.05$. Blinding was not feasible due to the nature of the behavioural intervention; participants and researchers were aware of the intervention exposure. Eight participants were lost during follow-up. Analyses were conducted using data from the 60 participants who completed all follow-up assessments. Normality of distributions was assessed using

the Shapiro-Wilk test; baseline scores were approximately normally distributed (all $p > .05$).
To control for family-wise error rate across seven outcomes (six subscales plus total score), Bonferroni correction was applied ($\alpha = 0.05/7 = 0.007$). No statistical imputation methods were applied for missing data.

Ethic approval

This study was conducted in accordance with the Declaration of Helsinki and approved by the Suleyman Demirel University Health Sciences Ethics Committee (Approval No: E.1010667, Date: 12.05.2025). All participants provided written informed consent after receiving detailed information about the study objectives, procedures, and their right to withdraw at any time without penalty.

RESULTS

A total of 60 participants were included (mean age: 38.83 years, range: 25–83). Half were single, and half were married. Most participants (86.7%) reported no chronic disease, and 41.7% had a family history of diabetes. The majority (73.8%) had prior knowledge about diabetes (Table 1, Table 2).

Table 1. Demographic characteristics of participants (n=60)

Variables	n	%
Age (years)		
Mean ± SD	38.83 ± 9.37	
Min-Max	25-83	
Gender		
Male	35	58.3
Female	25	41.7
Marital Status		
Single	30	50.0
Married	30	50.0
Educational Level		
Bachelor's degree	33	55.0
High school	15	25.0
Primary school	7	11.7
Middle school	4	6.7
Doctoral degree	1	1.7
Occupation		
Student	19	31.7
Retiree	15	25.0
Nurse	10	16.7
Tradesman	8	13.3
Teacher	3	5.0
Farmer	2	3.3
Private sector	2	3.3
Police officer	1	1.7
Living area		
Provincial centre	43	71.7
Metropolitan city	10	16.7
District	6	10.0
Village	1	1.7

Table 2. Clinical characteristics of participants (n=60)

Variables	n	%
Presence of Chronic Disease		
No	52	86.7
Yes	8	13.3
Type of Chronic Disease		
Asthma	2	3.3
Hypertension	1	1.7

Pharyngitis	1	1.7
FMF with rheumatism	1	1.7
Multiple conditions*	1	1.7
Family History of Diabetes		
No	35	58.3
Yes	25	41.7
Prior Diabetes Knowledge		
Yes	45	73.8
No	15	26.2
Source of Diabetes Knowledge (n=45)		
School-based education	13	28.9
University	2	4.5
Other sources**	30	66.7

*Multiple conditions include prostate reflux, heart failure, lymphoma, and acute kidney failure
**Other sources include media, healthcare facilities, family members, and personal research

Mean scores and standard deviations for HPLP-II subscales and total score across time points are presented in Table 3. After applying Bonferroni correction for multiple comparisons ($\alpha = 0.007$), repeated measures ANOVA demonstrated significant time effects for Health Responsibility, $F(1.14, 67.26) = 16.81$, $p < .001$, $\eta p^2 = 0.222$; Physical Activity, $F(1.77, 104.24) = 9.16$, $p < .001$, $\eta p^2 = 0.134$; and Total Score, $F(1.63, 96.23) = 14.97$, $p < .001$, $\eta p^2 = 0.202$ (Table 3). Nutrition showed a trend toward significance but did not survive Bonferroni correction, $F(1.76, 103.90) = 4.85$, $p = .013$, $\eta p^2 = 0.076$. No significant time effects were observed for Spiritual Growth, Interpersonal Relations, or Stress Management (all $p > .05$; Table 3). The total HPLP-II score increased from 138.48 ± 24.62 at baseline to 141.38 ± 21.70 at 6 months.

Bonferroni-adjusted post-hoc pairwise comparisons ($\alpha = 0.0083$) revealed specific patterns of change (Table 3). Health Responsibility increased significantly from baseline to all follow-up time points: 1-month (MD = 0.83, 95% CI [0.29, 1.37], $p < .001$), 3-month (MD = 0.87, 95% CI [0.32, 1.41], $p < .001$), and 6-month (MD = 0.90, 95% CI [0.34, 1.46], $p < .001$), with no significant differences between follow-up time points (all $p > .05$). Physical Activity showed a significant increase from baseline to 6-month (MD = 1.20, 95% CI [0.32, 2.08], $p = .003$), with non-significant trends at earlier time points (baseline to 1-month: MD = 0.33, $p = .093$; baseline to 3-month: MD = 0.58, $p = .052$). Total Score increased significantly from baseline to all follow-up points: 1-month (MD = 1.55, 95% CI [0.45, 2.65], $p = .001$), 3-month (MD = 2.28, 95% CI [0.73, 3.84], $p = .001$), and 6-month (MD = 2.90, 95% CI [1.16, 4.64], $p < .001$). Additionally, Total Score increased from 1-month to 6-month (MD = 1.35, 95% CI [0.13, 2.56], $p = .025$), indicating progressive improvement over time (Table 3).

Table 3. Changes in HPLP-II subscale and total scores over time (n=60)

Subscale	Baseline M ± SD	1-Month M ± SD	3-Month M ± SD	6-Month M ± SD	F (df1, df2)	p	*ηp²*
Health Responsibility	23.52 ± 5.19	24.35 ± 4.30	24.38 ± 4.25	24.42 ± 4.22	**16.81** (1.14, 67.26)	**<0.001***	**0.222**
Physical Activity	20.08 ± 5.17	20.42 ± 4.77	20.67 ± 4.51	21.28 ± 3.90	**9.16** (1.77, 104.24)	**<0.001***	**0.134**
Nutrition	23.20 ± 5.21	23.48 ± 4.82	23.73 ± 4.51	23.63 ± 4.70	4.85 (1.76, 103.90)	0.013†	0.076
Spiritual Growth	25.57 ± 4.40	25.57 ± 4.40	25.77 ± 4.51	25.65 ± 4.27	0.94 (1.93, 113.55)	0.395	0.016
Interpersonal	25.50 ± 4.55	25.53 ±	25.53 ±	25.53 ±	0.35	0.709	0.006

Subscale	Baseline M ± SD	1-Month M ± SD	3-Month M ± SD	6-Month M ± SD	F (df1, df2)	p	ηp^2
Relations		4.49	4.54	4.49	(2.05, 120.76)		
Stress Management	20.62 ± 4.46	20.68 ± 4.41	20.68 ± 4.41	20.87 ± 4.25	2.09 (1.80, 106.34)	0.131	0.034
Total Score	138.48 ± 24.62	140.03 ± 22.97	140.77 ± 22.23	141.38 ± 21.70	**14.97** (1.63, 96.23)	**<0.001***	**0.202**

M: mean; *SD*: standard deviation; *F*: F-statistic with Greenhouse-Geisser correction (Mauchly's test significant for all outcomes, all $p < 0.001$); df1: numerator degrees of freedom; df2: denominator degrees of freedom; ηp^2: partial eta-squared.
* Significant after Bonferroni correction for multiple comparisons (α = 0.007; 0.05/7 outcomes).
† Improvement did not reach statistical significance after Bonferroni correction.
Bonferroni-adjusted post-hoc pairwise comparisons are reported in the Results section.

The distribution of participants across FINDRISK categories is shown in Table 4. Most participants were classified as moderate risk (40.0%), and 20.0% were in the high-risk category.

Table 4. Distribution of FINDRISK diabetes risk categories (n=60)

FINDRISK Risk Category	n	%
Low (<7 points)	11	18.3
Slightly elevated (7-11 points)	13	21.7
Moderate (12-14 points)	24	40.0
High (15-20 points)	12	20.0

The game evaluation results are summarized in Table 5. The Behavioural Impact score was high (55.97 ± 9.34; range: 13–65), with excellent internal consistency (Cronbach's α = .95). The overall game experience was positively rated (4.20 ± 0.51 out of 5). Identified regulation was the most common motivation type (36.7%), and most participants were in the contemplation (38.3%) or preparation (25.0%) stages of behaviour change. Nutrition (28.3%) and general health awareness (26.7%) were the most frequently reported domains of influence. Nearly all participants (98.3%) reported that they would recommend the game. No adverse events or unintended effects were reported during the intervention or follow-up period.

Table 5. Game mechanics evaluation results (n=60)

Variable	Value
Behavioural Impact (min 13–max 65)	55.97 ± 9.34
Motivation Type	
Identified regulation	22 (36.7%)
Intrinsic motivation	13 (21.7%)
External motivation	13 (21.7%)
Introjected regulation	7 (11.7%)
Autonomy	5 (8.3%)
Stage of Change	
Contemplation	23 (38.3%)
Preparation	15 (25.0%)
Pre-contemplation	10 (16.7%)
Action	8 (13.3%)
Maintenance	4 (6.7%)
Behavioural Domain Affected	

Variable	Value
Nutrition	17 (28.3%)
General health awareness	16 (26.7%)
Physical activity	13 (21.7%)
Stress management	9 (15.0%)
Health check-up behaviour	5 (8.3%)
Game Experience (1–5)	4.20 ± 0.51
Recommendation	
Yes	59 (98.3%)
Undecided	1 (1.7%)
No	0 (0%)

DISCUSSION

This study evaluated the effects of the AI-assisted serious game Blue Ring Island on healthy lifestyle behaviours in individuals at risk of diabetes. The findings demonstrated significant improvements over time in Health Responsibility, Physical Activity, and total HPLP-II scores. These changes suggest that the intervention contributed to positive behavioural tendencies, particularly in domains directly targeted by the game.

Previous studies have reported that serious games most consistently improve physical activity behaviours (7,16), and our findings align with this pattern, suggesting that AI-assisted personalization may help maintain behavioural continuity over time. This gradual, sustained increase in behaviour scores following only one week of active gameplay warrants careful interpretation, however, particularly because participants did not play the game again and received no reminders, booster sessions, or clinical support during the six-month follow-up. We do not interpret this pattern as evidence that one week of digital exposure continuously produced behaviour change throughout the follow-up period. Rather, the design intentionally confined the digital exposure to a single intensive week and then removed access, so that any subsequent change would reflect behaviour initiated by, rather than continuously driven by, the intervention. This interpretation is consistent with behavioural-change frameworks in which a brief, well-timed, and sufficiently motivating prompt can trigger the initial adoption of a behaviour, after which the behaviour may be maintained by its own reinforcing consequences rather than by ongoing exposure to the original cue. In the Fogg Behaviour Model, for example, behaviour occurs when motivation, ability, and a trigger coincide; once a manageable behaviour such as a short daily walk is initiated, repetition and self-reinforcement can support its continuation without further external prompting (17). Within the Transtheoretical Model, an intensive personalized experience may move individuals from contemplation or preparation toward action, with the gradual rise in scores reflecting the progressive consolidation of newly initiated behaviours rather than a direct dose-response effect of continued gameplay (15). The fact that game access was withdrawn after one week, and that no other contact beyond telephone-based outcome assessment occurred, strengthens rather than weakens this interpretation, because it reduces the likelihood that the observed trajectory was sustained by repeated digital exposure. This design feature also addresses a gap noted in the recent literature: a contemporary meta-analysis of physical-activity-promoting lifestyle interventions described a smartphone-game study in which participants were permitted to continue using the game after the intervention period, but whether they actually did so was not assessed, leaving the post-intervention behavioural trajectory ambiguous (18). By deliberately withdrawing access after one week, the present study removes this ambiguity and allows the observed changes to be attributed to behaviour initiated during, rather than sustained by, continued gameplay. Nonetheless, in the absence of a control group these alternative mechanisms cannot be definitively distinguished from maturation or other secular influences, and the progressive pattern should therefore be regarded as hypothesis-generating and in need of confirmation in controlled trials. From a clinical nursing perspective, such changes are unlikely on their own to produce large, immediate reductions in diabetes incidence; however, even small shifts in physical activity and health responsibility are clinically relevant in a population undergoing diabetes risk assessment, because sustained increases in routine activity and self-monitoring are associated with improved glycaemic and weight-related outcomes over time (18). The pattern observed here is best understood as an early, awareness-level shift that could plausibly translate into more substantial clinical benefit if reinforced by longer or repeated exposure and by integration with conventional preventive care. Because no minimal clinically important difference has been established for the HPLP-II in this context, these effect sizes should be interpreted as indicators of direction and potential rather than as established clinical thresholds, and future trials incorporating objective and metabolic outcomes are needed to quantify the clinical significance of the behavioural changes reported here.

Significant but modest improvements were observed in the nutrition subscale. It is noteworthy that the improvement observed in nutrition scores did not reach statistical significance after correction, suggesting that the observed change was modest and should be interpreted with caution. This pattern is consistent with prior research indicating that dietary behaviours are more resistant to change and are influenced by broader environmental and social factors (19,20). Although the statistical effect was limited, nutrition was the most frequently reported behavioural domain influenced by the game, suggesting that the intervention may have increased awareness even when behavioural magnitude was small. This apparent discrepancy between participants' perceptions and the measured nutrition scores warrants closer clinical nursing interpretation. It directly extends the observation that participants most often felt the game had influenced them in the domain of nutrition. Nutrition is a shared, modifiable risk factor across a wide range of chronic conditions, and the relevance of dietary behaviour is therefore not confined to individuals already diagnosed with disease but extends to apparently healthy adults undergoing risk assessment, for whom dietary change is a central component of primary prevention (21). Within this preventive context, the fact that 28.3% of participants identified nutrition as the domain most influenced by the game, while the nutrition subscale did not retain statistical significance after Bonferroni correction, illustrates a well-recognised gap between awareness and enacted behaviour. Increasing knowledge or intention regarding healthy eating does not automatically translate into changed dietary practice, because eating behaviour is embedded in a complex web of determinants that lie largely outside an individual's immediate control. Unlike physical activity, which an individual can often initiate independently, dietary change typically requires modifying shopping, cooking, and meal-preparation routines that are frequently shared within a household and shaped by family preferences, cultural food traditions, time constraints, food cost, and local food availability; qualitative evidence shows that such environmental and social barriers consistently undermine dietary efforts even among individuals who are already motivated to eat more healthily (22). These structural and social barriers can blunt measurable change even when personal motivation is high. In addition, a one-week digital exposure may be sufficient to raise awareness but insufficient to support the repeated practice and problem-solving that durable dietary change requires. From a nursing standpoint, this finding underscores that brief digital interventions are most likely to influence nutrition when they are coupled with sustained, individualised dietary counselling, family involvement, and follow-up support that address these environmental and behavioural barriers, rather than awareness-raising alone; evidence from nurse-led education indicates that such structured support yields measurable benefit only when delivered repeatedly over time rather than briefly (23). Nurses are well positioned to provide this continuity of support across the spectrum of chronic-disease prevention, and future iterations of the intervention could embed structured nutritional coaching and household-level strategies to help convert the heightened awareness observed here into measurable dietary change.

No significant changes were observed in the Spiritual Growth, Interpersonal Relations, or Stress Management subscales. The intervention's behavioural focus may explain this finding. The game mechanics were primarily designed to enhance awareness of diabetes risk, self-monitoring, and physical health behaviours, rather than targeting psychosocial or emotional domains. In a recent meta-analysis of digital game interventions, improvements were predominantly observed in physical activity and self-management behaviours, whereas psychological variables showed inconsistent or non-significant effects (16). This pattern suggests that serious games may effectively influence concrete health behaviours but have limited impact on broader psychosocial constructs unless these domains are explicitly embedded within the intervention structure.

Evaluation of the game mechanics revealed a high behavioural impact score with excellent internal consistency. Most participants were in the contemplation or preparation stages of behavioural change, indicating that the intervention primarily supported motivational processes. Identified regulation was the most common motivation type, consistent with Self-Determination Theory, which emphasizes the importance of internalized motivation for sustained behavioural engagement (14).

Overall, participants positively evaluated the game experience, and nearly all indicated they would recommend it. This study suggests that AI-assisted serious games may be a feasible and scalable tool for promoting healthy lifestyle behaviours in individuals undergoing diabetes risk assessment.

CONCLUSION

This study provides preliminary evidence that AI-powered serious games may serve as a promising support tool for diabetes prevention, particularly in improving health responsibility and physical activity behaviours. Training nurses to use AI-powered digital health tools and integrating these systems into diabetes prevention programs can help develop scalable, sustainable prevention strategies. Future research is recommended to test the unique contribution of AI using randomized controlled designs, add objective behavioural measurements using wearable technologies, integrate psychological support modules, and conduct long-term follow-up for 12-24 months. At the policy level, it is recommended that health authorities support pilot applications of AI-powered programs and, if successful, integrate them into national diabetes programs. AI-powered serious games are promising tools in diabetes prevention but need to be integrated with other interventions.

Limitations

This study has several methodological limitations that warrant consideration. First, the single-group pretest-post-test design limits causal inference. Although repeated measures ANOVA demonstrated significant temporal changes, these findings cannot be definitively attributed to the intervention without a control group. Hawthorne effects, maturation, regression to the mean, and historical events represent plausible alternative explanations for observed changes. The study was designed as an exploratory investigation to obtain preliminary evidence before conducting more resource-intensive randomized controlled trials. Second, the use of self-reported measures may introduce reporting bias, as participants may over-report positive health behaviours. Objective measurements using wearable technologies and biomarkers would strengthen future studies. Third, snowball sampling may restrict generalizability and introduce selection bias, as participants were likely more motivated than the general population at risk for diabetes. Fourth, the six-month follow-up period may be insufficient to assess long-term behaviour sustainability and habit formation, which typically requires 12-24 months. Finally, the one-week active game intervention period was brief, and longer exposure with periodic content updates may be needed to support the transition from the motivational to the action stage of behaviour change. Additionally, demographic and clinical variables were not included as covariates in the primary analysis, which may limit the precision of the findings.

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Conflicts of interest
None.

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