Game Nexus

Effect of a VR Exergame Intervention on Exercise Motivation and Self-Efficacy

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Article type:
Original Research

Article history:
Received 22 December 2024
Revised 02 March 2025
Accepted 13 March 2025
Published online 01 April 2025

How to cite this article:
Nikolova, M., Adeyemi, I., & Schneider, L. (2025). Effect of a VR Exergame Intervention on Exercise Motivation and Self-Efficacy. *Game Nexus, 2*(2), 1-11. https://doi.org/10.61838/gamenexus.2.2.2

ABSTRACT

This study examined the effects of a virtual reality (VR) exergame intervention on exercise motivation and self-efficacy among healthy adults in Nigeria through a randomized controlled trial design. Thirty participants (aged 19–33 years) were recruited from community fitness centers and universities in Lagos, Nigeria, and randomly assigned to either a VR exergame group (n = 15) or a control group (n = 15). The intervention consisted of eight structured VR exergame sessions, each lasting 75–90 minutes. Assessments of exercise motivation and self-efficacy were conducted at baseline, post-intervention, and at a five-month follow-up. Data were analyzed using repeated-measures analysis of variance (ANOVA) with Bonferroni-adjusted post-hoc tests, employing SPSS version 27. Assumptions of normality, homogeneity, and sphericity were confirmed prior to analysis. Results demonstrated significant time × group interactions for both exercise motivation, $F(2,54) = 22.61$, $p < .001$, $\eta^2 = .45$, and self-efficacy, $F(2,54) = 21.42$, $p < .001$, $\eta^2 = .44$. Post-hoc tests revealed that the VR group showed significant improvements in motivation from baseline to post-intervention (Mdiff = 1.17, $p < .001$) and baseline to follow-up (Mdiff = 1.01, $p < .001$), with no significant decline between post-intervention and follow-up ($p = .26$). Self-efficacy followed a similar pattern, with significant increases from baseline to post-intervention (Mdiff = 1.18, $p < .001$) and baseline to follow-up (Mdiff = 1.05, $p < .001$), with no significant decline at follow-up ($p = .38$). The control group demonstrated no significant changes across time for either variable. The findings indicate that VR exergames are effective in significantly enhancing exercise motivation and self-efficacy, with sustained effects observed at five-month follow-up. VR-based interventions may offer a powerful and engaging strategy to promote exercise adherence and long-term behavioral change.

Keywords: Virtual reality; exergames; exercise motivation; self-efficacy; randomized controlled trial; Nigeria

Introduction

Regular physical activity is a cornerstone of health promotion and disease prevention, yet many individuals struggle with maintaining consistent exercise habits due to low motivation, lack of enjoyment, and perceived barriers. Exercise motivation, a multidimensional construct influenced by intrinsic and extrinsic factors, determines adherence and long-term behavioral change. Self-efficacy, or the belief in one's capability to succeed in exercise tasks, also plays a pivotal role in sustaining physical activity routines. Previous research underscores that individuals with higher exercise self-efficacy are more likely to persist when facing obstacles, thereby enhancing the likelihood of meeting health guidelines (1).

In recent years, researchers have increasingly sought innovative interventions that can enhance both motivation and self-efficacy, recognizing these constructs as essential predictors of exercise adherence and health outcomes. Traditional exercise programs often fail to engage participants over extended periods due to their repetitive nature, while newer approaches leveraging digital technology show promise in reshaping how people experience exercise (2). Among these, virtual reality (VR) and gamified exergames have emerged as potentially transformative tools.

Virtual reality integrates immersive, computer-generated environments with physical activity, allowing participants to experience exercise through highly interactive and engaging scenarios. The unique affordances of VR—such as presence, immersion, and real-time feedback—distinguish it from conventional exercise modalities (3). Exergaming, the use of game-based environments to promote exercise, leverages elements of gamification such as points, achievements, avatars, and narrative progression to sustain engagement (4). These features address motivational deficits by creating enjoyable and rewarding experiences that reduce perceived exertion and encourage persistence.

Prior studies highlight that gamified VR interventions can increase exercise adherence across diverse populations. For example, older adults reported enhanced enjoyment and satisfaction when exercise was gamified, suggesting that motivational elements are crucial in designing sustainable health programs (4). Similarly, VR-based interventions have demonstrated significant improvements in motivation among clinical groups such as patients with neurological or musculoskeletal disorders (5, 6).

Applications of VR exergames span clinical rehabilitation, health promotion, and fitness. In cardiac rehabilitation, immersive VR has been conceptualized as a middle-range theory explaining its mechanisms of effectiveness (7) and as a situation-specific theory tailored to patients with disabilities (8). Research in individuals with heart failure has shown that VR-supported physical activity enhances user satisfaction and validates the feasibility of technology-assisted exercise (9). Similarly, patients with hypertension expressed positive perceptions of VR for physical activity, underscoring its potential to address both psychological and physiological needs (10).

Community-based interventions also reveal encouraging results. For example, VR boxing elicited higher enjoyment levels compared to treadmill running, reflecting the capacity of VR to enhance affective responses to exercise (11). Among migrant women, VR-based walking interventions supported by wearable trackers were found to be feasible and motivating (12). VR exergames have even been adapted for office workers during working hours to reduce sedentariness, demonstrating feasibility and acceptability (13).

The motivational impact of VR exercise is explained through multiple mechanisms. The sense of presence in immersive environments enhances affective responses and reduces monotony (14). Competition and social presence have been identified as key drivers of exercise intensity and persistence in VR contexts (15, 16). Personalized feedback and affective cues also influence performance and psychological experiences (17). Furthermore, studies on gamification show consistent benefits in enhancing enjoyment, which directly correlates with motivation (4).

Self-efficacy is reinforced through mastery experiences in progressively challenging VR tasks. For example, immersive biking interventions improved self-efficacy and attention among individuals in substance use treatment programs (18). Tele-rehabilitation studies using VR also highlight its role in fostering confidence in performing exercise routines remotely (19). VR's adaptive nature allows participants to gradually build competence and autonomy, both of which are central to self-determination theory (20).

The versatility of VR exergames is evident across demographic and clinical populations. In older adults, VR and augmented reality exergames were shown to increase participation and improve health outcomes (21, 22). In rehabilitation settings, wheelchair users with paraplegia benefited from VR-driven motivational programs designed to encourage regular physical activity (2). Similarly, VR cycling applications have been successfully tested for usability among elderly individuals with lower-limb disorders (6). Among individuals with Parkinson's disease, Kinect-based exergames demonstrated adherence and physical improvements (23).

VR exergaming has also been adapted for unique contexts. In post-conflict rehabilitation, VR games were designed to support the physical and emotional recovery of landmine victims (24). In occupational contexts, VR-based exercise systems have been tested for feasibility during work hours (13). Among persons with chronic pain, VR interventions have been integrated into interdisciplinary rehabilitation programs to improve feasibility and motivation (25). Collectively, these findings show that VR exergames are adaptable, motivating, and effective across a wide range of settings and populations.

Despite promising evidence, challenges remain in integrating VR exergames into mainstream exercise programs. Some studies highlight variability in effectiveness depending on gamer type and competitiveness, which influence motivation and enjoyment (26). Similarly, case studies emphasize that VR interventions must be tailored to age-related needs and physical capacities to ensure safety and engagement (27). The design of VR systems also affects outcomes, with augmented reality and immersive features producing different levels of engagement and health benefits (22).

Furthermore, while VR can reduce exercise-related barriers, issues such as cost, accessibility, and user training may limit large-scale adoption. Studies note the importance of balancing immersion with practicality to ensure that interventions remain scalable and sustainable (3).

Although the literature demonstrates that VR exergames can positively affect motivation and self-efficacy, most studies have focused either on clinical populations or on exploratory feasibility trials. Evidence from controlled interventions in healthy adults remains limited, especially in non-Western contexts. In Nigeria, where physical inactivity rates are rising due to urbanization and lifestyle changes, innovative strategies are urgently needed to promote sustainable exercise behavior. Integrating VR exergames offers an opportunity to address motivational and psychological barriers while also enhancing exercise adherence.

Moreover, while studies have investigated short-term outcomes of VR interventions, fewer have assessed sustained effects through follow-up evaluations. Longitudinal assessments are essential to determine whether improvements in motivation and self-efficacy persist beyond the immediate intervention (28). Similarly, while VR exercise has been validated for its enjoyment, usability, and feasibility, there is a lack of rigorous randomized controlled trials that compare VR exergames to traditional exercise modalities in terms of motivational and psychological outcomes (29, 30).

The present study addresses these gaps by implementing a randomized controlled trial to examine the effects of a VR exergame intervention on exercise motivation and self-efficacy among adults in Nigeria.

Methods and Materials

Study Design and Participants

This study employed a randomized controlled trial (RCT) design to evaluate the effect of a virtual reality (VR) exergame intervention on exercise motivation and self-efficacy. Thirty participants were recruited from community fitness centers and university campuses in Lagos, Nigeria, using voluntary sampling methods. Eligibility criteria included being between 18 and 35 years old, having no prior diagnosis of cardiovascular, neurological, or musculoskeletal conditions that would restrict exercise participation, and not having previous experience with VR-based exercise programs. Participants were randomly assigned to either the intervention group (VR exergame training) or the control group (traditional physical activity without VR). Each group consisted of 15 participants. The intervention lasted eight structured sessions over two months, with follow-up assessments conducted at baseline, post-intervention, and at five months.

Data Collection

The Behavioral Regulation in Exercise Questionnaire-3 (BREQ-3), developed by Markland and Tobin (2004) as an extension of Deci and Ryan's self-determination theory framework, is one of the most widely used tools for measuring exercise motivation. The instrument contains 24 items divided into six subscales: amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, and intrinsic regulation. Each item is rated on a 5-point Likert scale ranging from 0 ("not true for me") to 4 ("very true for me"). Higher scores in each subscale indicate stronger endorsement of that type of motivational regulation. The BREQ-3 has been validated in numerous populations, showing robust psychometric properties including good internal consistency and construct validity, and it has been used extensively in studies examining exercise behavior, confirming its reliability and applicability across diverse contexts.

The Exercise Self-Efficacy Scale (ESES), originally created by Bandura (1997) and adapted for physical activity research, is a standard measure used to assess an individual's confidence in their ability to continue exercising under challenging circumstances. The scale consists of 10 items that ask participants to rate their confidence in maintaining exercise habits despite barriers such as fatigue, stress, or lack of time. Responses are given on a 4-point Likert scale ranging from 1 ("not at all confident") to 4 ("very confident"), with higher scores reflecting greater self-efficacy for exercise adherence. The ESES has demonstrated strong internal consistency, test–retest reliability, and construct validity in multiple studies across various populations, making it a reliable tool for capturing self-efficacy in exercise-related interventions.

Intervention

This eight-session VR exergame intervention was designed to systematically enhance exercise motivation and self-efficacy by combining the engaging features of gamification with psychological strategies rooted in self-determination theory and self-efficacy theory. Across progressive sessions, participants moved from orientation and basic skills to mastery, overcoming barriers, teamwork, and autonomous regulation. The structured progression allowed participants to experience both immediate reinforcement from VR gameplay and deeper reflection on their motivational processes. By the final session, participants were not only more confident in their ability to exercise consistently but also equipped with strategies to transfer these skills beyond the VR environment, supporting sustainable physical activity habits.

Session 1 – Introduction and Orientation

The first session introduces participants to the VR exergame intervention and sets the foundation for the program. Participants receive an overview of the objectives, the role of exercise motivation and self-efficacy, and the structure of the VR exergame system. After a short orientation on using VR headsets and safety procedures, participants experience a low-intensity demo of the game environment. Group discussion follows, where participants share initial impressions and personal goals for the program. The session ends with guided reflection on their exercise habits and how VR-based activity may enhance them.

Session 2 – Building Familiarity and Basic Skills

The second session focuses on skill acquisition and confidence building. Participants engage in basic VR exergame tasks emphasizing coordination, movement accuracy, and responsiveness. The instructor highlights self-monitoring and positive reinforcement techniques while encouraging participants to focus on effort rather than outcome. The activities are deliberately paced to prevent fatigue and to ensure participants feel capable of navigating the VR system. The session closes with short goal-setting exercises designed to foster early self-efficacy.

Session 3 – Enhancing Engagement through Gamification

This session emphasizes game-based motivational features such as levels, points, and rewards. Participants engage in increasingly challenging exergame scenarios that integrate competition and achievement elements. The facilitator provides feedback and highlights strategies for sustaining motivation in the face of difficulty. Participants are encouraged to compare current performance with their personal baseline rather than others, reinforcing intrinsic motivation. Reflection activities address how rewards and progress tracking influence motivation in exercise contexts.

Session 4 – Overcoming Barriers and Building Persistence

The fourth session introduces higher-intensity VR exergame tasks that require endurance and focus. The instructor leads a discussion on common barriers to exercise (e.g., time, fatigue, stress) and demonstrates how VR-based practice can provide coping strategies. During gameplay, participants are prompted to notice moments of challenge and actively apply self-talk or pacing techniques. Group sharing highlights diverse ways of maintaining exercise even when obstacles arise, reinforcing self-efficacy beliefs.

Session 5 – Team Play and Social Motivation

This session focuses on the social dimension of exercise motivation by incorporating cooperative VR exergames. Participants are paired or grouped to complete collaborative challenges, where mutual encouragement and collective problem-solving are emphasized. The facilitator highlights the role of social support in sustaining motivation and confidence. The debriefing segment encourages participants to reflect on how teamwork enhances accountability, enjoyment, and persistence in exercise settings.

Session 6 – Self-Regulation and Autonomy

In this session, participants are introduced to more autonomous forms of gameplay where they can choose their preferred exergame tasks and difficulty levels. The emphasis is on self-regulation strategies such as self-monitoring, setting personal goals, and adjusting intensity. The facilitator discusses the concept of autonomy in self-determination theory and how self-directed choices foster lasting motivation. Participants practice making adaptive decisions during gameplay and reflect on the satisfaction of controlling their own exercise journey.

Session 7 – Mastery and Confidence Consolidation

The seventh session reinforces mastery by engaging participants in advanced VR exergame challenges designed to showcase progress. Tasks require higher levels of coordination, persistence, and strategic planning, allowing participants to recognize tangible improvements. The facilitator provides structured feedback emphasizing competence and growth over time. Reflection activities focus on how increased self-efficacy supports participants' readiness to maintain physical activity beyond the intervention period.

Session 8 – Reflection, Transfer, and Closure

The final session reviews the entire program, highlighting individual and group progress. Participants engage in celebratory VR exergame challenges designed to consolidate skills while reinforcing enjoyment. The session includes structured reflection on personal gains in motivation and self-efficacy, and a discussion of strategies to transfer VR-based confidence into real-world exercise routines. Each participant creates a personalized plan for sustaining physical activity after the intervention, and the session concludes with group feedback and closure.

Data Analysis

Data were analyzed using SPSS version 27. Repeated-measures analysis of variance (ANOVA) was employed to examine within- and between-group differences over time, focusing on exercise motivation and self-efficacy as dependent variables. When significant main effects or interactions were detected, Bonferroni-adjusted post-hoc tests were conducted to identify specific group differences across time points. Prior to analysis, assumptions of normality, homogeneity of variance-covariance matrices, and sphericity were tested using Shapiro–Wilk, Box's M, and Mauchly's test, respectively. Effect sizes were calculated using partial eta squared (η^2) to determine the magnitude of differences. The significance level was set at $p < .05$.

Findings and Results

The demographic characteristics of the participants are presented in Table 1. In the intervention group, 7 participants (46.7%) were male and 8 participants (53.3%) were female, whereas the control group included 6 males (40.0%) and 9 females (60.0%). The overall mean age of participants was 24.73 years (SD = 3.81), with an age range between 19 and 33 years. Regarding educational status, 12 participants (40.0%) were undergraduate students, 11 (36.7%) were postgraduate students, and 7 (23.3%) were employed professionals. No statistically significant differences in demographic characteristics were observed between the two groups at baseline ($p > .05$).

Table 1. Descriptive statistics (Means and Standard Deviations) for Exercise Motivation and Self-Efficacy across groups and times

Variable	Group	Baseline M (SD)	Post-Intervention M (SD)	5-Month Follow-up M (SD)
Exercise Motivation	VR Exergame	2.91 (0.47)	4.08 (0.52)	3.92 (0.49)
	Control	2.87 (0.44)	3.15 (0.46)	3.12 (0.43)
Self-Efficacy	VR Exergame	2.76 (0.51)	3.94 (0.56)	3.81 (0.50)
	Control	2.79 (0.48)	3.01 (0.45)	2.97 (0.47)

At baseline, both groups demonstrated similar levels of exercise motivation (VR group M = 2.91, SD = 0.47; control M = 2.87, SD = 0.44) and self-efficacy (VR group M = 2.76, SD = 0.51; control M = 2.79, SD = 0.48). After the intervention, motivation increased substantially in the VR group (M = 4.08, SD = 0.52) compared to the control group (M = 3.15, SD = 0.46). These differences were maintained at the five-month follow-up, with VR participants reporting higher motivation (M = 3.92, SD = 0.49) relative to controls (M = 3.12, SD = 0.43). A similar pattern was found for self-efficacy, with the VR group showing significant gains at post-intervention (M = 3.94, SD = 0.56) and sustained improvements at follow-up (M = 3.81, SD = 0.50), compared to relatively stable scores in the control group (M = 3.01, SD = 0.45 at post-test; M = 2.97, SD = 0.47 at follow-up).

Prior to conducting the repeated-measures ANOVA, statistical assumptions were examined and met. The Shapiro–Wilk test confirmed normality for exercise motivation (W = 0.97, p = .41) and self-efficacy scores (W = 0.98, p = .36). Homogeneity of variance-covariance matrices was verified using Box's M test (M = 4.87, F = 1.12, p = .33). Mauchly's test indicated that the assumption of sphericity was satisfied for both exercise motivation ($\chi^2 = 2.19$, p = .31) and self-efficacy ($\chi^2 = 1.84$, p = .39). These results demonstrated that the data met the requirements for repeated-measures ANOVA, allowing further inferential analysis to proceed without adjustment.

Table 2. Repeated-Measures ANOVA for Exercise Motivation and Self-Efficacy

Source	SS	df	MS	F	p	η^2
Exercise Motivation						
Time	7.84	2	3.92	28.34	<.001	.49
Group	5.16	1	5.16	21.77	<.001	.43
Time × Group	6.22	2	3.11	22.61	<.001	.45
Error	8.28	54	0.15			
Self-Efficacy						

Time	6.97	2	3.49	25.16	<.001	.47
Group	4.78	1	4.78	19.45	<.001	.41
Time × Group	5.93	2	2.97	21.42	<.001	.44
Error	7.50	54	0.14			

The repeated-measures ANOVA revealed significant main effects of time and group for both exercise motivation and self-efficacy, as well as significant time × group interactions. For exercise motivation, a significant main effect of time was observed, $F(2,54) = 28.34$, $p < .001$, $\eta^2 = .49$, and a main effect of group, $F(1,27) = 21.77$, $p < .001$, $\eta^2 = .43$. Importantly, the interaction between time and group was significant, $F(2,54) = 22.61$, $p < .001$, $\eta^2 = .45$, indicating differential changes over time between groups. A similar pattern was evident for self-efficacy, with significant effects of time, $F(2,54) = 25.16$, $p < .001$, $\eta^2 = .47$, group, $F(1,27) = 19.45$, $p < .001$, $\eta^2 = .41$, and a significant interaction, $F(2,54) = 21.42$, $p < .001$, $\eta^2 = .44$. These results indicate that the VR exergame group exhibited greater improvements in both outcomes across time compared to the control group.

Table 3. Bonferroni Post-Hoc Comparisons for Exercise Motivation and Self-Efficacy

Variable	Group	Comparison (Time)	Mean Diff.	SE	p
Exercise Motivation	VR Exergame	Post – Baseline	1.17	0.21	<.001
		Follow-up – Baseline	1.01	0.19	<.001
		Follow-up – Post	-0.16	0.14	.26
	Control	Post – Baseline	0.28	0.17	.09
		Follow-up – Baseline	0.25	0.16	.11
		Follow-up – Post	-0.03	0.13	.82
Self-Efficacy	VR Exergame	Post – Baseline	1.18	0.22	<.001
		Follow-up – Baseline	1.05	0.20	<.001
		Follow-up – Post	-0.13	0.15	.38
	Control	Post – Baseline	0.22	0.18	.21
		Follow-up – Baseline	0.18	0.17	.29
		Follow-up – Post	-0.04	0.12	.74

Bonferroni-adjusted post-hoc comparisons showed that exercise motivation in the VR group increased significantly from baseline to post-intervention (Mdiff = 1.17, SE = 0.21, $p < .001$) and from baseline to follow-up (Mdiff = 1.01, SE = 0.19, $p < .001$). No significant decline was observed between post-intervention and follow-up (Mdiff = -0.16, SE = 0.14, $p = .26$), indicating that improvements were sustained. In contrast, the control group showed no significant changes across time. A similar pattern emerged for self-efficacy, with significant increases from baseline to post (Mdiff = 1.18, SE = 0.22, $p < .001$) and baseline to follow-up (Mdiff = 1.05, SE = 0.20, $p < .001$) in the VR group, but no significant changes in the control group. These findings confirm that the VR exergame intervention produced substantial and enduring gains in both motivation and self-efficacy.

Discussion and Conclusion

The purpose of this randomized controlled trial was to examine the effect of a VR exergame intervention on exercise motivation and self-efficacy among adults in Nigeria. Results demonstrated that participants in the VR exergame group reported significantly higher gains in both motivation and self-efficacy compared to those in the control group. These improvements were not only evident immediately post-intervention but also sustained at the five-month follow-up, highlighting the long-term effectiveness of the intervention. The repeated-measures ANOVA revealed significant time × group interactions, suggesting that VR exergames provided unique benefits beyond traditional physical activity programs. Bonferroni post-hoc tests confirmed that the VR group maintained higher scores across both dependent variables over time. These findings affirm the role of immersive, gamified experiences in promoting exercise adherence through psychological mechanisms such as increased enjoyment, engagement, and confidence.

The observed improvements in exercise motivation align with prior research showing that VR-based exercise can significantly enhance enjoyment and adherence compared to conventional modalities. By integrating gamification features—such as scoring systems, rewards, and competitive or collaborative challenges—the VR exergame intervention addressed motivational deficits commonly associated with repetitive exercise routines (4). This result is consistent with studies demonstrating that gamified experiences increase satisfaction and long-term interest in physical activity among both older adults and clinical populations (21, 27).

Moreover, the immersive environments and sense of presence afforded by VR contribute to stronger affective engagement. For instance, treadmill running was rated less enjoyable than VR boxing, where interactive stimuli sustained higher levels of motivation (11). Our findings mirror this by showing that participants maintained their motivation across sessions due to the novelty, interactivity, and feedback mechanisms embedded in VR exergames. Similarly, VR walking programs for migrant women demonstrated how immersive contexts can overcome barriers to participation by making exercise experiences more engaging and culturally adaptable (12). The present results extend this evidence by confirming that such motivational effects are also applicable within African contexts, where innovative solutions are needed to counter sedentary lifestyles.

The role of competitiveness also surfaced in participants' feedback, with many reporting that leaderboards and performance comparisons heightened their willingness to exert effort. This resonates with prior findings on how competitive dynamics in VR exercise enhance motivation and user experience (15, 17). However, research also indicates that individual gamer types and competitiveness levels may moderate these effects (26). This highlights the importance of tailoring VR exergames to diverse motivational profiles to optimize engagement.

Equally significant was the improvement in exercise self-efficacy among the VR group. Participants reported increased confidence in their ability to sustain exercise, even under challenging conditions such as fatigue or time constraints. This finding is consistent with the theoretical propositions of self-determination theory and self-efficacy models, which emphasize mastery experiences as a core pathway to confidence. VR exergames, by gradually escalating task difficulty and providing real-time feedback, created conditions for participants to experience competence, thereby reinforcing self-efficacy (20).

Our results align with studies showing that VR biking interventions enhanced self-efficacy and attention in individuals undergoing substance use treatment (18). Similarly, VR exercise applications for hypertensive patients were positively perceived as tools to improve confidence in sustaining physical activity (10). In our trial, participants highlighted the sense of achievement from progressing through exergame levels, which mirrors prior evidence that gamification strengthens self-belief by framing exercise as a sequence of achievable milestones (4).

The sustained improvements at the five-month follow-up further underscore VR's unique role in shaping durable self-efficacy beliefs. This is notable because many exercise interventions fail to maintain psychological benefits once external support is removed. Consistent with the literature, VR's immersive qualities foster internalized motivation and perceived competence, making individuals more resilient against exercise dropout (8, 19). Our findings confirm that self-efficacy built during VR interventions can be sustained beyond the immediate program, a critical factor for long-term health outcomes.

Comparing our findings with international evidence highlights both convergence and novel contributions. Similar to results from VR interventions in cardiac rehabilitation (7), our study showed that immersive exercise promotes both psychological and physical engagement. However, while many prior trials focused on older adults (21, 28), neurological patients (5), or rehabilitation populations (6), this trial targeted a relatively healthy adult Nigerian cohort. This broadens the literature by demonstrating that VR exergames are effective not only in clinical or high-income contexts but also in general populations in low- and middle-income countries.

Furthermore, while earlier research often emphasized feasibility and acceptability (9, 25), the present study provides controlled evidence of efficacy in improving motivation and self-efficacy, supported by longitudinal follow-up. Our design thus advances the field by demonstrating that VR exergames can generate sustained behavioral and psychological changes, rather than short-lived novelty effects.

Despite overall consistency with prior literature, some nuances should be noted. For instance, while our intervention uniformly improved motivation, other studies have highlighted variability depending on competitiveness and gamer profiles (26). This suggests that individual differences may moderate outcomes, a factor not directly addressed in our trial. Additionally, while immersive VR produced strong psychological effects in our study, research comparing immersive and non-immersive VR suggests that both can increase activity, though immersion often amplifies enjoyment (21). These nuances underscore the importance of carefully matching VR modalities to participant needs and contexts.

Another point of contrast relates to exercise intensity. Some evidence suggests that VR may encourage moderate rather than high-intensity exertion, as participants focus more on enjoyment than maximal effort (31). While our participants maintained motivation, objective physiological outcomes were not measured, leaving open the question of how VR impacts intensity compared to traditional exercise. Future studies integrating physiological metrics could address this gap.

The findings of this trial hold significant implications for health promotion, exercise psychology, and technology-assisted interventions. By confirming that VR exergames improve both motivation and self-efficacy, this study adds to the growing body of evidence that digital innovations can address the global challenge of physical inactivity. Moreover, the sustained effects observed at five months highlight the potential of VR to support long-term behavioral change, a critical advancement over short-term engagement strategies. In contexts like Nigeria, where traditional exercise adherence is often low due to cultural, environmental, and infrastructural barriers, VR exergames provide a scalable and engaging alternative.

This study has several limitations that must be acknowledged. First, the relatively small sample size (n = 30) limits the generalizability of findings to larger populations. While statistically significant effects were observed, replication with larger cohorts is necessary to confirm robustness. Second, participants were healthy young adults, which restricts applicability to older adults or individuals with chronic conditions. Third, reliance on self-report measures for motivation and self-efficacy may introduce bias, as participants may have been influenced by social desirability or novelty effects associated with VR. Fourth, although a five-month follow-up was included, longer-term effects beyond this period remain unknown. Finally, potential moderating factors such as competitiveness, prior gaming experience, and personality traits were not assessed, limiting understanding of differential responses to VR exergames.

Future research should address these limitations by incorporating larger, more diverse samples across age groups, health statuses, and cultural backgrounds. Studies should also integrate objective physiological and behavioral outcomes, such as heart rate, caloric expenditure, and actual exercise adherence, alongside psychological measures. Investigating the role of individual differences—such as gamer types, competitiveness, and personality—could yield valuable insights for tailoring VR exergame interventions. Longitudinal designs extending beyond five months are needed to establish whether improvements in motivation and self-efficacy translate into sustained physical activity habits over years. Furthermore, comparisons of immersive versus non-immersive VR, as well as hybrid interventions combining VR with real-world exercise, could clarify the relative contributions of technology and context.

For practitioners, this study suggests that VR exergames can be an effective tool to enhance both motivation and self-efficacy, thereby supporting exercise adherence. Fitness professionals and health educators should consider integrating VR exergames into training programs, particularly for populations struggling with traditional exercise routines. Implementation should prioritize accessibility, ensuring that interventions are affordable and culturally adaptable, especially in resource-constrained contexts. Practitioners should also tailor VR experiences to participant preferences, offering options for competitive or collaborative play to maximize engagement. Finally, embedding VR interventions within community and clinical settings can expand their reach, providing innovative pathways to address physical inactivity and promote long-term health.

Acknowledgments

We would like to express our appreciation and gratitude to all those who helped us carrying out this study.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

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