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Effects of a virtual reality exergame on cardiorespiratory function in older adults

Dina Fatiyah Bakri[1*], Melda Warliani[1], Yose Waluyo[1], Husnul Mubarak[1], Nilla Mayasari[1], Andi Alfian Zainuddin[2]

[1]Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia;
[2]Department of Public Health, Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia.

*Corresponding author:
Dina Fatiyah Bakri;
Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia;
dinafatty@gmail.com

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ABSTRACT

Introduction: With increasing life expectancy, the elderly population is at higher risk for cardiorespiratory decline. Exercise is known to reduce this decline, but adherence to exercise programs can be low. Virtual reality (VR) exergaming offers an engaging alternative, potentially increasing motivation while providing similar benefits. This study aimed to evaluate the effectiveness of VR exergaming in improving cardiorespiratory function in elderly individuals.

Methods: A randomized controlled trial was conducted with 40 elderly participants (VR exergaming, n=24; conventional aerobic exercise, n=16). Both groups exercised three times per week for six weeks. The VR group used Ring Fit Adventure on the Nintendo Switch, while the control group performed structured aerobic exercises. Cardiorespiratory parameters—heart rate (HR), respiratory rate (RR), blood pressure (BP), predicted maximal oxygen uptake (VO_2 max) from the 6-minute walking test (6MWT), peak expiratory flow rate (PEFR), and peak cough flow rate (PCFR)—were assessed before and after the intervention.

Results: Significant improvements were observed in VO_2 max, RR, BP, PEFR, and PCFR in both groups, though HR did not change significantly. Despite baseline differences in VO_2 max, overall improvements were comparable between the two groups.

Conclusion: VR exergaming was as effective as conventional exercise in improving cardiorespiratory function in older adults and offers an engaging and enjoyable alternative.

Keywords: cardiorespiratory function, elderly, exergame, virtual reality.
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INTRODUCTION

As a result of aging, there is a decline in cardiovascular and respiratory function. Various structural and functional changes—such as alterations in the left ventricle, decreased myocardial contractility, and increased vascular stiffness—contribute to cardiovascular dysfunction.[1] Similarly, changes in respiratory function, including reduced thoracic compliance, disruption of the alveolar supporting structures, and weakness of the accessory respiratory muscles, can lead to respiratory dysfunction.[2]

Aging is often accompanied by a progressive decline in cardiovascular and respiratory function, including reduced myocardial contractility, vascular stiffness, decreased thoracic compliance, and weakening of respiratory muscles. These physiological changes may lead to diminished aerobic capacity, impaired gas exchange, and increased vulnerability to chronic diseases. Regular physical activity is well recognized as a key strategy to counteract such decline, as it improves oxygen transport, enhances vascular function, and strengthens respiratory efficiency. However, adherence to conventional exercise programs among older adults remains low, frequently due to barriers such as reduced mobility, lack of motivation, or limited access to suitable exercise facilities.

Given the decline in physiological cardiorespiratory function associated with aging, incorporating regular exercise can offer significant benefits. Exercise induces adaptations in various cell types, enhancing aerobic capacity through mitochondrial biogenesis in adipocytes, myocytes, and cardiomyocytes. It also improves oxygen transport efficiency via vasodilation and angiogenesis. Additionally, exercise provides long-term anti-inflammatory effects, which can counteract the chronic inflammation often linked to cardiovascular disorders and improve the efficiency of gas exchange.[3,4] Despite these benefits, most elderly individuals do not engage in regular exercise, often due to physical disabilities, lack of motivation, or limited access to exercise facilities.

Exergaming offers a promising alternative that combines the benefits of exercise with interactive technology, potentially overcoming some of the barriers to traditional exercise, particularly regarding motivation. Virtual reality (VR)-based exergames enable users to perform structured exercises and receive real-time feedback. This approach can reduce patients' perceived effort and may improve adherence.[5] By merging physical training with immersive gameplay, VR exergames may elicit similar or even superior physiological adaptations compared to traditional exercise, while addressing motivational barriers. Evaluating their impact on parameters such as maximal oxygen uptake (VO_2 max), blood pressure, respiratory rate, and expiratory flow could provide valuable insights into their role as a sustainable strategy for maintaining health and functional independence in aging populations. Previous studies have demonstrated that exergames can enhance balance, gait, and even cognitive function in the elderly population—factors that contribute to maintaining independence[6]. However, research on the effectiveness of exergames in improving cardiorespiratory function among the elderly remains limited. This study aims to evaluate the effects of VR exergames on cardiorespiratory function in the elderly population.

METHODS

This study was a single-blind randomized controlled trial (RCT) conducted from March to April 2024 in Makassar, Indonesia. Cluster sampling was used to select the study samples from Hasanuddin University Hospital and the elderly community in Makassar city. Individuals were screened for participation in the study, and randomization was performed after recruitment to ensure a balanced sample group distribution.

The inclusion criteria for this study were participants aged 60 years or older, able to watch television from a distance of 2 meters, having no cognitive impairment as assessed using the Montreal Cognitive Assessment - Indonesia (MoCA-Ina), and willing to participate in the study for six weeks. The exclusion criteria included a history of decompensated congestive heart failure, unstable angina, or arrhythmias; uncontrolled hypertension or hemodynamic instability; history of fracture or orthopedic surgery within the last six months; being on an orthopedic surgery waiting list; history of myocardial infarction or stroke within the last six months; use of a wheelchair; severe visual or hearing impairment; and the presence of peripheral neuropathy or other medical conditions that could interfere with exercise. The dropout criteria consisted of participant death during the study, failure to attend three consecutive exercise sessions within two weeks, unwillingness to continue participation, persistent adverse effects such as cybersickness, dizziness, nausea, or fatigue for two consecutive sessions, and the occurrence of hemodynamic or neurological complications during exercise.

Baseline and post-intervention assessments were performed. The examinations included HR, respiratory rate (RR), blood pressure (BP), predicted maximal oxygen uptake (VO_2 max), peak expiratory flow rate (PEFR), and peak cough flow rate (PCFR). VO_2 max was estimated using the 6-minute walk test (6MWT) with Nury's formula[7]. Peak expiratory flow rate (PEFR) and peak cough flow rate (PCFR) were measured using the Philips® Respironics Peak Flow Meter HS755. Cognitive function was assessed using the Indonesian version of the montreal cognitive assessment (MoCA-Ina). Exercise intensity was evaluated using the Borg Scale, 6–20 version.

Before the intervention, all study participants provided written informed consent. A baseline assessment was conducted, including a review of demographic data, medical history, physical examination, and key study parameters. In addition, a pre-exercise evaluation was also conducted to ensure participant safety during the exercise. Then, participants were introduced to the intervention according to their group.

The intervention was conducted for 6 weeks. Participants participated in three supervised workouts each week. Each training session was preceded by a 10-minute warm-up, followed by main intervention, and closed with 10-minute cooldown. The VR exergame group performed structured exercises using Ring Fit Adventure on the Nintendo Switch console. The training program was progressive, with increasing intensity each week. The training intensity was targeted at 40–60% of heart rate reserve (HRR), with rates of perceived exertion ranging from 12 to 13 on the Borg Scale. The conventional aerobic exercise group performed structured training using videos with the same intensity and progression as the VR exergame group. The training supervisor supervised the training sessions and ensured that the movements were performed correctly to maximize the effectiveness of the training and reduce the risk of injury. Compliance was monitored using an attendance list, and HRR was assessed using a smart band. If participants reported any complaints, the exercise was temporarily stopped for clinical evaluation and management was carried out according to the complaint.

Descriptive data were used to summarize baseline data. Normality tests were performed using the Shapiro-Wilk test. Comparisons between groups were performed using independent t-tests if the data were normally distributed, or Mann-Whitney U tests if the data were not normally distributed. Comparisons within groups before and after intervention were performed using paired t-tests or Wilcoxon signed-rank tests according to the results of the data normality test. Categorical data were analyzed using the chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant. All data analysis was performed using SPSS 24.

RESULTS

A total of 40 participants were included in the study analysis. Of these, 24 were assigned to the intervention group, and the remaining 16 were in the control group. Baseline demographic and physiological data for both groups are presented in Table 1.

The age distribution in both groups was comparable. The mean age was 67.21 ± 5.38 years in the intervention group and 64.81 ± 3.92 years in the control group (p = 0.14). Gender distribution was similar, with 16.67% male participants in the intervention group and 31.25% in the control group (p = 0.35). The educational background of the participants varied, with more individuals in the control group having completed higher education; however, this difference was not statistically significant (p = 0.09). The mean body mass index (BMI) was higher in the intervention group (27.58 ± 3.94 kg/m²) than in the control group (25.33 ± 3.24 kg/m²), but this difference was also not statistically significant (p = 0.07).

Table 1. Baseline characteristics of virtual reality exergame (intervention) and aerobic exercise (control) groups

Characteristic	Intervention (n = 24)	Control (n = 16)	*P*-value
Age (years); mean ± SD	67.21 ± 5.38	64.81 ± 3.92	0.14
Sex			0.35
Male; n (%)	4 (16.67)	5 (31.25)	
Female; n (%)	20 (83.33)	11 (68.75)	
Highest educational level			0.09
University education; n (%)	12 (50)	10 (62.5)	
Non-University education; n (%)	12 (50)	6 (37.5)	
Body mass index (kg/m^2); mean ± SD	27.58 ± 3.94	25.33 ± 3.24	0.07
≥25.0 kg/m^2; n (%)	19 (79.17)	8 (50)	
<25.0 kg/m^2; n (%)	5 (20.83)	8 (50)	
Heart rate (beats/min); mean ± SD	77.13 ± 8.47	77.19 ± 8.17	0.98
Respiratory rate (breaths/min); median (min-max)	20 (20 – 22)	20 (20 – 22)	0.15
Blood pressure			
Systolic (mmHg); mean ± SD	144.75 ± 11.80	142.81 ± 12.52	0.6
Diastolic (mmHg); mean ± SD	87.29 ± 11.63	86.88 ± 10.95	0.91
Predicted VO_2 max (mL/kg/min); mean ± SD	14.02 ± 2.78	18.74 ± 4.68	0.01
PEFR (L/sec); median (min-max)	4.27 (2.88 – 9.56)	3.31 (2.22 – 7.40)	0.06
PCFR (L/min); median (min-max)	253.96 ± 72.13	270 (180 – 490)	0.13

kg/m^2, kilogram per meter squared; L/min, liter per minute; L/sec, liter per second; mL/kg/min, milliliter per kilogram per minute; min-max, minimum-maximum; mmHg, millimeter mercury; n, frequency; PCFR: peak cough flow rate; PEFR: peak expiratory flow rate; SD: standard deviation.

Table 2. Results of pre- and post-cardiorespiratory function test between virtual reality exergame (intervention) and aerobic exercise (control) groups

Variable	Control group		Intervention group		ΔPre-Post change	
	Pre-test Mean±SD or Median (Range)	Post-test Mean±SD or Median (Range)	Pre-test Mean±SD or Median (Range)	Post-test Mean±SD or Median (Range)	Control Mean±SD or Median (Range)	Intervention Mean±SD or Median (Range)
Heart rate (beats/min)	77.2 ± 8.2	76.5 ± 8.6	77.1 ± 8.5	80.7 ± 8.9	-0.7 ± 7.9	2.5 (-21 – 17)
P-value		0.733		0.051		0.07
Respiratory rate (breaths/min)	20 (20 – 22)	18.5 (17 – 20)	20 (20 – 22)	19 (18 – 20)	-1.4 ± 1.3	-1 (-3 – 0)
P-value		0.003		0.001		0.222
Systolic blood pressure (mmHg)	142.8 ± 12.5	126.5 (119 – 146)	144.8 ± 11.8	136.2 ± 15.3	-8.5 (-41 – 2)	-8.6 ± 14.0
P-value		0.001		0.006		0.289
Diastolic blood pressure (mmHg)	86.9 ±11.0	80 (75 – 92)	87.3 ± 11.6	77 (65 – 114)	-6.2 ± 9.6	-6.5 ± 10.7
P-value		0.028		0.018		0.916
Predicted VO_2 max (mL/kg/min)	18.7 ± 4.7	20.7 ± 4.5	14.0 ± 2.8	15.7 ± 3.5	1.9 (-1.2 – 7.0)	1.63 ± 2
P-value		0.001		0.001		0.859
PEFR (L/sec)	3.3 (2.2 – 7.4)	4.2 (2.9 – 7.8)	4.3 (2.9 – 9.6)	4.6 (2.8 – 10.3)	0.5 ± 0.9	0.5 ± 0.8
P-value		0.032		0.013		0.831
PCFR (L/min)	270 (180 – 490)	323.8 ± 92.9	254.0 ± 72.1	280 (210 – 410)	26.3 ± 32.6	42.3 ± 68.4
P-value		0.010		0.005		0.389

Kg, kilogram; l, liter; max, maximum; min, minutes; mmHg, millimeter mercury; mL, milliliter; PCFR: peak cough flow rate; PEFR: peak expiratory flow rate; sec, second; SD: standard deviation.

Baseline physiological examinations were comparable between the two groups across almost all parameters. There were no significant differences in mean resting heart rate (p = 0.98) or respiratory rate (p = 0.15). However, the intervention group had a significantly lower predicted VO_2 max (14.02 ± 2.78 mL/kg/min) compared to the control group (18.74 ± 4.68 mL/kg/min, p = 0.01), indicating a statistically significant baseline difference in aerobic capacity. No statistically significant differences were observed in PEFR or PCFR between the two groups ($p > 0.05$).

Table 2 presents the changes in cardiorespiratory function parameters before and after the intervention. After six weeks, the VR exergame group exhibited a slight increase in mean heart rate (77.13 ± 8.47 bpm to 80.67 ± 8.91 bpm), whereas the conventional exercise group showed a slight decrease (77.19 ± 8.17 bpm to 76.50 ± 8.62 bpm). However, these changes were not statistically significant in either group ($p > 0.05$). Both groups demonstrated a significant reduction in systolic and diastolic blood pressure ($p < 0.05$). In the VR exergaming group, systolic blood pressure decreased from 144.75 ± 11.8 to 136.17 ± 15.31 mmHg, while in the conventional exercise group, it decreased from 142.81 ± 12.52 to 126.5 (119–146) mmHg. Diastolic blood pressure decreased from 87.29 ± 11.63 to 77 (65–114) mmHg in the VR exergaming group and from 86.88 ± 10.95 to 80 (75–92) mmHg in the conventional exercise group.

A significant decrease in median respiratory rate was observed in both groups ($p < 0.05$). Predicted VO_2 max improved significantly in both groups ($p < 0.05$), increasing from 14.02 ± 2.78 to 15.65 ± 3.46 mL/kg/min in the VR exergaming group and from 18.74 ± 4.68 to 20.73 ± 4.52 mL/kg/min in the conventional exercise group. Both groups also demonstrated significant increases in peak expiratory flow rate (PEFR) and peak cough flow rate (PCFR) ($p < 0.05$). PEFR increased from 4.27 (2.88–9.56) to 4.60 (2.84–10.31) L/sec in the VR exergaming group and from 3.31 (2.22–7.40) to 4.18 (2.91–7.80) L/sec in the conventional exercise group. Additionally, PCFR increased from 253.96 ± 72.13 to 280 (210–410) L/min in the VR group and from 270 (180–490) to 323.75 ± 92.87 L/min in the conventional group.

Despite the increases in the aforementioned parameters, no statistically significant differences were found when comparing the changes between groups ($p > 0.05$). This suggests that both interventions have comparable effectiveness in improving cardiorespiratory function. Throughout the six-week intervention period, no adverse events or side effects were reported (i.e., angina/arrhythmia, claudication, cybersickness, dyspnea, nausea, and vomiting) in either the VR exergame group or the conventional exercise group, indicating that both exercise modalities were safe and well tolerated by older adults.

DISCUSSION

This study aims to assess the effectiveness of VR exergames (Ring Fit) compared to conventional aerobic exercise on cardiorespiratory function in elderly. The main cardiorespiratory parameters, including HR, RR, systolic and diastolic BP, predicted VO_2 max, PEFR, and PCFR, were measured before and after the intervention in 40 study participants.

Data analysis showed significant differences in baseline predicted VO_2 max between the two groups. This suggests that participants in the control group began the study with a higher level of cardiorespiratory fitness. Baseline variability in fitness levels may influence the observed effects of the intervention, as initial aerobic capacity can impact the magnitude of improvement achieved during the study period. This difference may have influenced the outcomes of the intervention. Cardiorespiratory fitness may have influenced the degree of improvement in cardiorespiratory parameters in the study. These differences need to be taken into account when interpreting the results of this study. Future studies may want to ensure similar levels of cardiorespiratory fitness between groups at baseline to minimize this confounding factor.[8,9]

In the present study, although not statistically significant, most parameters showed greater improvements in the conventional group. This may be due to the higher baseline BMI in the VR exergame group. There are studies that suggest that individuals with higher BMIs tend to show smaller improvements in cardiorespiratory fitness after exercise. In addition, normal-weight individuals experience greater increases in VO_2 max for the same level of physical activity compared to overweight or obese individuals[10]. Another study that gave HIIT training to healthy individuals, overweight/obese, and athletes showed that HIIT increased VO_2 max in all groups, but the degree of increase varied. Overweight and obese individuals showed smaller increase in VO_2 max compared to normal weight. This suggests that BMI can reduce cardiorespiratory effectiveness of training.[11]

In addition to BMI, age differences may also affect the outcome of the intervention. Participants in the VR exergame group tended to be older. Aging is associated with decreased physiological function. This may limit the benefits gained from exercise. Older individuals may experience sarcopenia, decreased cardiovascular efficiency, and even longer recovery times. This may affect the response to exercise. In addition, chronic diseases, reduced mobility, and lower physiological adaptations also play a role. However, physical activity remains important for older adults to maintain independence and quality of life.[12,13]

Analysis before and after the intervention showed significant improvements in blood pressure in both groups. However, there was no significant change in resting heart rate. This cardiovascular parameter is an important marker of the body's response to regular exercise. Regular exercise improves cardiovascular fitness and blood pressure regulation through several mechanisms. Exercise strengthens the heart muscle, increasing its efficiency in pumping blood, thereby lowering arterial pressure and lowering blood pressure. Exercise also helps improve blood vessel elasticity, endothelial function, and blood flow. In addition, exercise reduces oxidative stress and systemic inflammation that play a role in vascular dysfunction. Furthermore, exercise helps control body weight and insulin sensitivity that play a role in blood pressure regulation.[4,14]

Despite the many benefits of exercise, our study did not show significant changes in resting heart rate. Resting heart rate is also a marker of cardiovascular fitness. Lower values generally indicate cardiac efficiency and a reduced risk of cardiovascular disease. The time to decrease in resting heart rate varies based on baseline fitness, age, and exercise intensity. Generally, a decrease in resting heart rate occurs after 12 weeks of regular exercise. In older adults, this adaptation may be slower. This is influenced by changes in autonomic regulation and cardiac function in older adults. Some studies have shown that a decrease in resting heart rate in older adults requires up to 30 weeks of regular exercise before it can be seen.[15]

Although the changes were not statistically significant, we observed a trend toward increased resting heart rate in some participants. Given that exercise is generally associated with decreased resting heart rate, we think this is worth discussing. Fluctuations in resting heart rate may be influenced by several factors, such as BMI, sleep time, and seasonal variations. A large study involving 92,457 participants found that although resting heart rate was generally stable, approximately 20% of participants experienced fluctuations of up to 10 beats per minute or more over a period of one week. This suggests that short-term fluctuations are common and do not necessarily reflect a response to intervention. In the context of exercise interventions, these variations may also be influenced by individual differences in autonomic regulation, adaptation to exercise, stress, and sleep patterns.[16]

Our results are consistent with findings from a randomized controlled trial that assessed the effects of 6 weeks of VR exergames versus conventional exercise on heart rate and blood pressure in older adults with hypertension. The study involved 35 subjects who were randomized into groups with 23 in the VR exergame group and 12 in the conventional exercise group. The intervention included strength and endurance training performed twice a week for 20–30 minutes. Blood pressure and heart rate were measured before, during, and after each exercise session. The results showed significant reductions in systolic and diastolic blood pressure only in the VR exergame group. However, there was no significant difference between groups in overall blood pressure reduction. Furthermore, no reduction in resting heart rate was observed in either group or between group.[17]

Analysis of data before and after the intervention showed statistically significant improvements in PEFR, PCFR, and respiratory rate in both groups. These respiratory parameters indicate that respiratory function responds positively to exercise. The underlying mechanisms of these improvements are autonomic modulation, increased mucociliary clearance, and improved vagal-sympathetic interactions. All of these will contribute to gas exchange capacity. Exercise activates autonomic pathways, which improve respiratory function, ventilation and perfusion efficiency, and increase respiratory muscle strength.[3] The benefits of exercise on respiratory function have been demonstrated in a variety of populations. Studies have shown improvements in respiratory function caused by exercise in healthy adults, and even populations with certain diseases, such as asthma and other chronic lung diseases.[3,18,19]

One randomized controlled trial has compared conventional and VR-based diaphragmatic breathing exercises in 72 patients with chronic obstructive pulmonary disease (COPD). The study participants were divided into two groups (n = 36). The intervention was carried out for 6 consecutive days. The variables assessed before and after the intervention were oxygen saturation, PEFR, and quality of life. The results showed significant improvements in both groups before and after the intervention, but no differences were found when comparing between groups. This is similar to our study which find significant differences in respiratory parameters before and after the intervention, but there was no difference in improvement between groups.[20]

Analysis of data before and after the intervention showed a statistically significant increase in predicted VO_2 max in both groups. This suggests improved cardiorespiratory function following regular exercise. Our findings are consistent with other studies comparing VR exergames to conventional exercise that have shown VR-based exercise to be effective in improving aerobic capacity. In one study, 32 participants were randomized to either a structured VR exergame or independent endurance exercise for 12 weeks. The results showed greater increases in VO_2 max in the VR exergame group. This is likely due to the gaming aspect of VR encouraging participants to continue exercising with minimal rest periods.[5]

Another study compared various fitness parameters, including VO_2 max between VR exergame groups and conventional training. This study showed that the VR group improved more significant in cardiovascular endurance, as measured using one-mile run test. The authors explained this finding as an effect of the engaging nature of VR. This increased adherence and intensity of training, resulting in more significant improvements.[21]

This study found no statistically significant differences in improvement in all cardiorespiratory parameters between groups. A meta-analysis found similar results when comparing physical function after exergame-based and conventional interventions.[22,23] This is thought to be because both groups were given training with comparable intensity, although with different methods. In our study, the training intensity of both groups was adjusted and used aerobic training. Previous studies have shown that training intensity plays a key role in physiological adaptation. Research shows that video game-based training shows similar physiological effects to conventional training if the intensity is adjusted.[24]

Although there was no significant difference in outcomes, VR exergames have the advantage of increasing long-term adherence to exercise. The interactive and engaging nature of VR reduces the feeling of monotony from the repetitive nature of exercise. In addition, visual and audio feedback makes it more stimulating than conventional exercise. In the training conditions of a rehabilitation center, conventional exercise can even feel intimidating, whereas VR-based exercise can provide a game-like feeling that makes rehabilitation more enjoyable.[25,26] Despite the benefits, there may be some challenges with using VR as a rehabilitation tool. Older adults may have difficulty using unfamiliar devices. VR may also be perceived as complex and difficult to understand. The high cost of VR may also be a significant barrier to its use. Purchasing and maintaining VR may limit its use to some rehabilitation centers or individuals.[27,28]

No side effects were reported in either group during the study. This suggests that both interventions are safe for older adults.

This is similar in most previous studies showing the safety of VR exergames in older adults. Most studies showed no significant adverse effects. However, some studies have shown mild adverse effects, such as exercise-induced discomfort, knee pain, and thigh pain. However, it is important to note that these reported side effects are not directly caused by the VR exergame. Only a few studies have shown minor adverse effects caused by VR-based training.[29–31]

The main limitation of this study is the statistically significant difference in baseline VO_2 max, which could have influenced the observed results. VO_2 max is a key factor in determining the physiological response to exercise, and this difference may have confounded the findings, particularly regarding improvements in cardiorespiratory function. Another limitation is the relatively short six-week intervention period, which may not have been sufficient to observe long-term improvements in certain physiological parameters, such as resting heart rate, which typically requires 12–30 weeks of consistent exercise to show significant changes, especially in older adults who adapt more slowly to exercise. Additionally, the study's short familiarization time with VR technology may have influenced participants' ability to fully engage with the VR exergames, potentially affecting the outcomes. Furthermore, the use of cluster sampling may introduce limitations in terms of generalizability, as the sample may not be fully representative of the broader elderly population. Additionally, self-selection bias could have influenced participant characteristics, as individuals who opted into the study may already have higher motivation or interest in technology-based interventions.

Future studies should aim to address the limitations of this study by including a larger, more diverse sample to enhance generalizability. A longer intervention period (e.g., 12-30 weeks) should be considered to assess long-term effects, particularly on parameters such as resting heart rate. Additionally, further research should explore the impact of longer familiarization times with VR technology to ensure participants are fully engaged and can maximize the benefits of VR exergaming. Studies utilizing random sampling could help mitigate potential biases related to self-selection. Investigating the potential decline in novelty of VR exergaming over time and strategies to maintain long-term adherence would also be valuable. Additionally, further studies are needed to assess the feasibility and cost-effectiveness of VR exergaming as a tool for widespread rehabilitation and health promotion in elderly populations. Finally, further research should consider comparing VR exergaming with other types of engaging exercise interventions to explore their relative effectiveness and sustainability in elderly populations.

CONCLUSION

In conclusion, this study highlighted that both VR exergaming and conventional aerobic exercise improved cardiorespiratory and respiratory functions (i.e., blood pressure, PEFR, and predicted VO_2 max) in elderly individuals. Although no significant differences were found between the two intervention methods, VR exergames offered the advantage for patient adherence to exercise due to their interactive and engaging nature. These findings suggest that VR exergaming could serve as a promising alternative to traditional exercise, especially in promoting long-term participation in physical activity among older adults.

ETHICAL CONSIDERATION

This study was conducted in accordance with the ethical standards set out in the Declaration of Helsinki. This research was approved by the Research Ethics Commission of the Faculty of Medicine, Universitas Hasanuddin, Makassar, Indonesia (No: 141/UN4.6.4.5.31/PP36/2024).

CONFLICT OF INTEREST

All the authors declare that there are no conflicts of interest.

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AUTHOR CONTRIBUTIONS

All authors have contributed to all processes in this research, including preparation, data gathering, analysis, drafting, and approval for publication of this manuscript.

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