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Virtual Reality Exergaming and Cardiorespiratory Fitness in Young Adults: A PRISMA-Based Systematic Review

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Abstract
Background: Virtual reality (VR)–based exercise has emerged as an innovative approach to promote physical activity and improve cardiorespiratory fitness. Its immersive and interactive nature may enhance exercise engagement and adherence, particularly among young adults.
Objective: This systematic review aimed to synthesize evidence on the effects of VR-based exercise interventions on physiological and cardiorespiratory fitness outcomes.
Methods: This review was conducted in accordance with the PRISMA 2020 guidelines. A comprehensive search was performed across PubMed, Scopus, and Google Scholar using relevant keywords related to VR, exergaming, and cardiorespiratory fitness. A total of 205 records were identified, with an additional five records from other sources. After screening and eligibility assessment, 39 studies were included in the initial qualitative synthesis. Of these, 19 primary studies reporting physiological outcomes were included in the final analysis. Data extraction and narrative synthesis were conducted, and methodological quality was assessed using the Cochrane RoB 2 tool for randomized controlled trials and a structured appraisal approach for non-randomized studies.
Results: The included studies demonstrated that VR-based exercise can elicit moderate-intensity cardiovascular responses and improve outcomes such as VO_2max, VO_2peak, heart rate, and functional capacity. Several randomized controlled trials reported improvements comparable to conventional exercise interventions. In addition, VR-based exercise was associated with higher levels of enjoyment, motivation, and adherence.
Conclusion: VR-based exercise represents a promising strategy for improving cardiorespiratory fitness and promoting physical activity. However, further high-quality studies with standardized protocols are needed to strengthen the evidence base and support clinical implementation.

Keywords
Virtual Reality; Exergaming; Cardiorespiratory Fitness; Young Adult; Exercise Therapy

Introduction

Cardiorespiratory fitness (CRF) is a fundamental component of physical fitness and an important indicator of overall health status. Adequate levels of CRF are associated with reduced risk of cardiovascular disease, metabolic disorders, and all-cause mortality, whereas low CRF has been consistently linked to increased cardiometabolic risk and diminished functional capacity.[1,2] Maintaining optimal CRF is essential across the lifespan, as lifestyle behaviors established in early adulthood may persist into later life and influence long-term health outcomes.[2]

Despite the well-documented benefits of regular physical activity, global evidence indicates that insufficient physical activity remains highly prevalent. According to the World Health Organization, a large proportion of adolescents and adults fail to meet recommended physical activity guidelines, contributing to increased sedentary behavior and declining aerobic fitness levels.[3] Modern lifestyles characterized by prolonged screen exposure, academic or occupational demands, and reduced participation in structured exercise contribute to this trend, ultimately increasing the risk of chronic disease.[4]

Traditional exercise interventions, including aerobic and resistance training programs, are widely recommended to improve cardiorespiratory fitness. However, adherence to conventional exercise remains a significant challenge. Common barriers include low motivation, lack of enjoyment, and time constraints, which often limit sustained participation in physical activity. These challenges highlight the need for innovative exercise approaches that can enhance engagement while maintaining adequate physiological stimulus.[5]

Recent advances in digital technology have introduced virtual reality (VR) as a novel approach for exercise and rehabilitation. VR creates immersive, computer-generated environments that enable users to interact with simulated scenarios in real time. When combined with physical activity, VR can facilitate exergaming, in which gameplay elements are integrated with body movements to produce physical exertion.[6] VR-based exercise systems typically incorporate motion tracking, interactive feedback, and immersive environments that transform traditional exercise into engaging experiences.[7]

The integration of immersive environments and gamification elements may provide several advantages. VR-based exercise has been shown to enhance enjoyment, motivation, and user engagement, which may contribute to improved adherence. In addition, immersive VR environments can simulate various physical activities, such as cycling, running, boxing, and sports-based movements, potentially generating sufficient cardiovascular stimulus to improve physiological outcomes.[8]

Previous studies have investigated the effects of VR-based exercise across diverse populations and settings, reporting improvements in aerobic capacity, heart rate responses, functional performance, and behavioral outcomes such as motivation and adherence.[9] However, the existing evidence remains heterogeneous in terms of study design, intervention protocols, duration, and outcome measures. Variations in VR technology, level of immersion, and exercise modalities further complicate the interpretation of findings.[7]

Given the growing interest in immersive exercise technologies, a comprehensive synthesis of current evidence is needed to better understand the effectiveness of VR-based exercise interventions. Therefore, this systematic review aimed to evaluate the effects of virtual reality–based exercise on physiological and cardiorespiratory fitness outcomes, including aerobic capacity, heart rate responses, and exercise intensity, as well as related behavioral outcomes.

Methods

This study employed a systematic literature review design conducted in accordance with the PRISMA 2020 guidelines. The objective of this review was to synthesize available evidence regarding the effectiveness of virtual reality–based exercise interventions on physiological and cardiorespiratory fitness outcomes. A comprehensive literature search was performed across three major electronic databases, namely PubMed, Scopus, and Google Scholar, which were selected due to their extensive coverage of biomedical, health science, and exercise physiology research. The search strategy was developed using combinations of relevant keywords and Boolean operators, including “virtual reality,” “VR,” “exergaming,” “active video game,” “cardiorespiratory fitness,” “VO_2max,” and “aerobic capacity.” An example of the search string used was (“virtual reality” OR “VR”) AND (“exergaming” OR “active video game”) AND (“cardiorespiratory fitness” OR “VO_2max” OR “aerobic capacity”). Only peer-reviewed articles published up to the most recent available year were included.

Eligibility criteria were established prior to the screening process to ensure consistency. Studies were included if they investigated virtual reality–based exercise or exergaming interventions and reported physiological or cardiorespiratory outcomes, such as VO_2max, VO_2peak, heart rate, heart rate variability, exercise intensity, or functional capacity. Eligible studies consisted of original empirical research, including randomized controlled trials, crossover trials, experimental studies, pilot studies, and observational studies involving human participants. Review articles were initially considered during the identification phase to ensure comprehensive coverage of the literature; however, they were excluded from the final analytical synthesis. Studies were excluded if they did not involve VR-based exercise interventions, did not report relevant physiological outcomes, or were non-English publications, editorials, or conference abstracts without full text.

The study selection process followed the PRISMA framework. A total of 205 records were identified through database searching, with an additional five records obtained from other sources. After removing duplicates, 205 records remained for title and abstract screening. During this stage, studies that did not meet the inclusion criteria were excluded. Subsequently, 58 full-text articles were assessed for eligibility, of which 24 were excluded due to reasons such as irrelevant outcome measures, absence of VR-based exercise interventions, or insufficient methodological information. In total, 39 studies met the eligibility criteria and were included in the initial qualitative synthesis. However, for the purpose of in-depth analysis, only primary studies reporting physiological or cardiorespiratory outcomes were retained, resulting in a final inclusion of 19 studies. The screening process was conducted independently by two reviewers, and any disagreements were resolved through discussion.

Data extraction was carried out systematically using a standardized form. Extracted information included study characteristics such as authors, publication year, study design, sample size, participant characteristics, type of virtual reality intervention, comparator conditions, duration and frequency of the intervention, outcome measures, and main findings. Additional variables, including exercise intensity, adherence, and motivational outcomes, were also recorded when available. The extracted data were then organized into a structured table to facilitate comparison across studies.

Given the heterogeneity in study designs, intervention protocols, and outcome measures, a quantitative meta-analysis was not conducted. Instead, a narrative synthesis approach was used to integrate findings across studies. The synthesis focused on key indicators of cardiorespiratory fitness, including aerobic capacity (VO_2max and VO_2peak), heart rate responses, and exercise intensity. Secondary outcomes such as functional capacity, exercise adherence, and perceived exertion were also considered to provide a broader understanding of the effects of VR-based exercise interventions.

To enhance methodological transparency, the quality of the included studies was assessed using a structured risk of bias approach. Randomized controlled trials were evaluated using the RoB 2, which assesses bias across domains including the randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results. Non-randomized studies were evaluated separately using a structured methodological quality assessment approach focusing on domains such as selection bias, performance bias, detection bias, and attrition bias.

Based on the assessment, randomized controlled trials were categorized as having low risk of bias or some concerns, while non-randomized studies were classified as having good or moderate methodological quality. The results of the risk of bias assessment for randomized controlled trials are presented in Table 2, while the methodological quality assessment for non-randomized studies is summarized in Table 3.

All procedures in this systematic review were conducted using publicly available data from published studies; therefore, ethical approval was not required. This methodological approach was designed to ensure transparency, reproducibility, and adherence to international standards for systematic review reporting.

Results

A comprehensive literature search was conducted across multiple electronic databases, including PubMed, Scopus, and Google Scholar, complemented by manual searching to ensure the identification of relevant studies. A total of 210 records were identified, of which 205 originated from database searches and five from additional sources. After removing five duplicate records, 205 records remained for title and abstract screening.

During the screening phase, 147 records were excluded due to irrelevance to virtual reality–based exercise, non-target populations, absence of cardiorespiratory outcomes, or non-primary study designs. Subsequently, 58 full-text articles were assessed for eligibility, all of which were successfully retrieved. Of these, 24 articles were excluded because they did not report relevant physiological or cardiorespiratory outcomes, did not involve VR-based exercise interventions, or lacked sufficient methodological information.

Following the eligibility assessment, 39 studies were included in the qualitative synthesis. After further evaluation at the final synthesis stage, 20 studies were excluded due to being review articles, bibliometric studies, or lacking relevant physiological outcomes. Ultimately, 19 studies were included in the final analysis. The overall study selection process is illustrated in Figure 1.

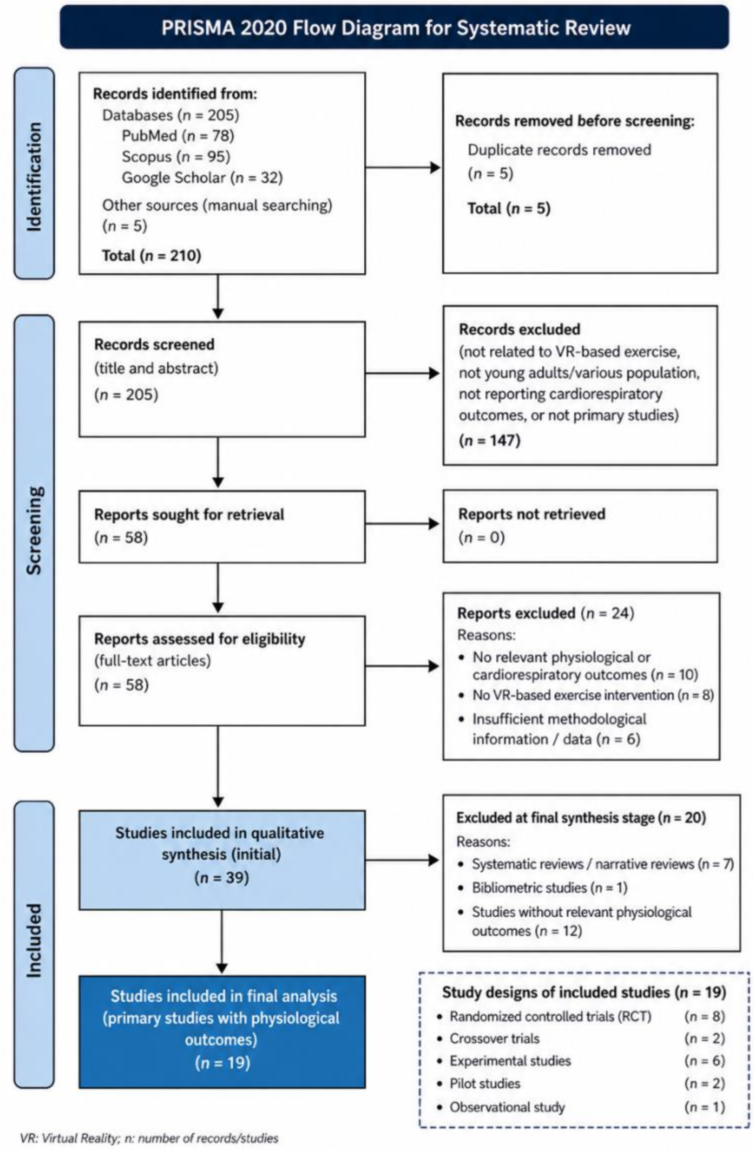

Figure 1. PRISMA Flow Diagram

Subsequently, for the purpose of detailed analysis in this review, only primary studies reporting physiological or cardiorespiratory outcomes of VR-based exercise interventions were included in the final synthesis table. After excluding secondary studies such as systematic reviews, narrative reviews, and studies without relevant physiological outcomes, a total of 19 studies were retained for in-depth analysis (Table 1).

The included studies demonstrated considerable heterogeneity in study design, participant characteristics, intervention protocols, and outcome measures. The study designs consisted of randomized controlled trials, crossover trials, experimental studies, pilot studies, and observational studies.

Participants across the included studies were predominantly healthy young adults, although several studies also involved specific populations such as older adults, hypertensive individuals, firefighters, burn patients, and clinical populations with musculoskeletal conditions. Sample sizes varied substantially, ranging from small pilot studies with fewer than ten participants to large observational cohorts involving several thousand individuals.

The virtual reality interventions employed across studies varied in terms of technological platforms and exercise modalities. Many studies utilized immersive VR systems with head-mounted displays, while others employed non-immersive systems such as console-based exergaming (e.g., Kinect or Wii) or screen-based virtual environments. Exercise modalities included VR cycling, virtual running, boxing simulations, resistance training, balance training, and active video gaming.

The duration of interventions ranged from single-session experimental protocols to structured training programs lasting between four and twelve weeks. Most intervention-based studies implemented exercise frequencies of two to five sessions per week. The intensity of VR-based exercise was generally reported to fall within moderate cardiovascular intensity, although this varied depending on the type of VR application and exercise modality.

The cardiovascular and physiological outcomes assessed across studies also varied. The most frequently reported outcomes included aerobic capacity indicators such as VO_2max and VO_2peak, heart rate responses, heart rate variability, and exercise intensity expressed as a percentage of heart rate reserve. Functional capacity measures, including the six-minute walk test and mobility assessments, were also commonly reported. In addition, several studies evaluated behavioral and perceptual outcomes such as exercise adherence, enjoyment, motivation, and perceived exertion.

A summary of the key characteristics of the included primary studies is presented in Table 1.

Table 1. Summary of Representative Studies on Virtual Reality Exergaming and Cardiovascular Outcomes

No	Author (Year)	Design	Sample	Population	VR Intervention	Comparator	Duration / Frequency	Outcome Measures	Main Findings
1	Brandao-Leandro et al. (2021)[1]	RCT	72	Hypertensive adults	Nintendo Wii-based exercise	Conventional training	8 weeks, 3×/week	6MWT, BP	Improved functional capacity and BP reduction
2	Rutkowski et al. (2021)[2]	Crossover	65	Healthy adults	Immersive VR cycling	Non-VR cycling	Single session	HR, HRV	Higher engagement, comparable physiological load
3	Lemmens (2023)[3]	Experimental	96	Young adults	VR exercise environment	Non-VR condition	Single session	Exercise duration, RPE	Increased exercise persistence
4	Yuenyongchaiwat et al. (2024)[4]	Pilot	30	Adults	VR aerobic exercise	None	Single session	HR, BP	Significant hemodynamic response
5	Bosy-Westphal et al. (2021)[5]	Observational	4649	General population	Treadmill test (reference CRF)	–	Single test	VO_2max	Baseline CRF association
6	Khundam & Noël (2021)[6]	Experimental	30	Adults	VR running simulation	VR variations	Single session	HR	Comparable cardiovascular demand
7	Campo-Prieto et al. (2022)[7]	RCT	24	Older adults	VR balance training	Conventional therapy	6 weeks	Berg Balance Scale, TUG	Improved balance and mobility
8	Kim et al. (2024)[8]	RCT	20	Firefighters	Mixed-reality training	Control exercise	6 weeks	VO_2peak	Significant CRF improvement
9	Machado et al. (2019)[9]	RCT	51	Knee OA patients	VR rehabilitation	Conventional therapy	8 weeks	WOMAC, function test	Improved function and pain
10	Del Corral et al. (2023)[10]	RCT	33	Older adults	VR exercise program	Control group	12 weeks	Functional capacity tests	Significant improvement
11	Sadeghi et al. (2021)[11]	RCT	58	Older adults	VR balance training	Conventional exercise	8 weeks	TUG, balance tests	Improved mobility
12	Mologne et al. (2023)[12]	RCT	32	Young adults	VR resistance training	Traditional training	6 weeks	Strength, VO_2	Improved strength and aerobic capacity
13	Basha et al. (2022)[13]	RCT	40	Burn patients	Xbox Kinect training	Conventional rehab	12 weeks	VO_2peak	Significant CRF improvement
14	Stewart et al. (2022)[14]	Experimental	32	Young adults	VR active gaming	Lab exercise	Single session	HR, VO_2	Comparable intensity to moderate exercise
15	Oginni et al. (2024)[15]	Experimental	30	Women	VR aerobic exercise	Control	4 weeks	BP, HR	Reduced blood pressure
16	Rubio-Arias et al. (2024)[16]	Crossover	22	Adults	VR boxing exercise	Circuit training	Single session	HRR	Faster recovery response
17	Evans et al. (2021)[17,18]	Experimental	36	Young adults	VR exergaming	Control	Single session	HRR	Moderate intensity achieved
18	Feodoroff et al. (2019)[18]	Experimental	25	Adults	VR exercise simulation	–	Single session	HR	Moderate cardiovascular response
19	França et al. (2025)[19]	Pilot	7	Older adults	VR exergame	–	4 weeks	Physical activity level	Increased activity participation

Table 1 summarizes the main characteristics of the included studies. Overall, the included studies demonstrated considerable heterogeneity in study design, participant characteristics, intervention protocols, and outcome measures. The study designs consisted primarily of randomized controlled trials, alongside crossover trials, experimental studies, pilot studies, and observational studies.

The study populations varied across studies, although most involved healthy young adults. In addition, several studies included specific populations such as older adults, hypertensive individuals, firefighters, burn patients, and patients with musculoskeletal conditions. Sample sizes ranged widely, from small pilot studies with fewer than ten participants to large observational cohorts involving several thousand individuals, indicating variability in statistical power across studies.

With regard to interventions, both immersive and non-immersive virtual reality approaches were utilized. Immersive VR systems commonly involved head-mounted displays, whereas non-immersive approaches included console-based exergaming platforms such as Kinect or Wii. The types of exercise implemented through VR environments also varied, including cycling simulations, virtual running, boxing-based activities, resistance training, balance training, and active video gaming.

Intervention duration ranged from single-session experimental protocols to structured programs lasting between four and twelve weeks. In intervention-based studies, training frequency typically ranged from two to five sessions per week. The intensity of VR-based exercise was generally reported to fall within moderate cardiovascular intensity, although variations were observed depending on the type of VR system and exercise modality.

The outcomes assessed across studies primarily focused on physiological and cardiorespiratory responses. The most commonly reported outcomes included aerobic capacity indicators such as VO_2max and VO_2peak, heart rate responses, heart rate variability, and exercise intensity. In addition, several studies reported functional outcomes and behavioral measures, including functional capacity, exercise adherence, motivation, and perceived exertion.

The methodological quality of the included studies is summarized in Table 2 and Table 3. Specifically, Table 2 presents the risk of bias assessment of randomized controlled trials using the Cochrane RoB 2 tool, whereas Table 3 provides the methodological quality assessment of non-randomized studies.

Table 2. Methodological Quality Assessment of Included Studies (JBI Checklist)

No	Study	Randomization Process	Deviations from Intended Interventions	Missing Outcome Data	Measurement of Outcome	Selection of Reported Result	Overall Bias
1	Brandao-Leandro et al. (2021)	Low	Low	Low	Low	Some concerns	Low
2	Campo-Prieto et al. (2022)	Low	Low	Low	Low	Low	Low
3	Kim et al. (2024)	Some concerns	Low	Low	Low	Some concerns	Some concerns
4	Machado et al. (2019)	Low	Low	Low	Low	Low	Low
5	Del Corral et al. (2023)	Low	Low	Some concerns	Low	Low	Some concerns
6	Sadeghi et al. (2021)	Some concerns	Low	Low	Low	Low	Some concerns
7	Mologne et al. (2023)	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
8	Basha et al. (2022)	Low	Low	Low	Low	Low	Low

The synthesized findings from the included studies were further summarized to identify patterns of evidence across major cardiovascular outcomes. The summary of evidence highlights the number of studies examining each outcome, the study designs involved, and the overall direction of findings. This synthesis provides a clearer overview of the strength and consistency of evidence regarding the effects of virtual reality exergaming on cardiorespiratory fitness.

Table 3. Methodological Quality Assessment for Non-Randomized Studies

No	Study	Design	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Overall Quality
1	Rutkowski et al. (2021)	Crossover	Low	Low	Low	Low	Good
2	Lemmens (2023)	Experimental	Some concerns	Low	Low	Low	Moderate
3	Yuenyongchaiwat et al. (2024)	Pilot	Some concerns	Low	Low	Some concerns	Moderate
4	Bosy-Westphal et al. (2021)	Observational	Low	Low	Low	Low	Good
5	Khundam & Noël (2021)	Experimental	Some concerns	Low	Low	Low	Moderate
6	Stewart et al. (2022)	Experimental	Some concerns	Low	Low	Low	Moderate
7	Oginni et al. (2024)	Experimental	Some concerns	Low	Low	Low	Moderate
8	Rubio-Arias et al. (2024)	Crossover	Low	Low	Low	Low	Good
9	Evans et al. (2021)	Experimental	Some concerns	Low	Low	Low	Moderate
10	Feodoroff et al. (2019)	Experimental	Some concerns	Low	Low	Low	Moderate
11	França et al. (2025)	Pilot	Some concerns	Some concerns	Low	Some concerns	Moderate

The methodological quality of the included studies was assessed using the Cochrane RoB 2 tool for randomized controlled trials and a structured quality assessment approach for non-randomized studies.

Among the randomized controlled trials, the overall risk of bias was predominantly low to moderate. Most studies demonstrated a low risk in domains related to deviations from intended interventions and outcome measurement, indicating appropriate implementation of interventions and the use of valid physiological outcome measures such as heart rate, VO_2peak, and functional capacity tests. However, some concerns were identified in the randomization process, primarily due to insufficient reporting of allocation concealment and sequence generation. Additionally, selective reporting bias was observed in a few studies where predefined outcomes were not clearly specified.

For non-randomized and experimental studies, the overall methodological quality ranged from moderate to good. Crossover and observational studies generally demonstrated higher methodological rigor, particularly in controlling measurement bias and ensuring consistency of intervention delivery. In contrast, pilot and experimental studies exhibited some concerns related to sample size limitations, lack of control groups, and potential selection bias.

Overall, the body of evidence suggests acceptable methodological quality, with most studies providing reliable estimates of physiological responses to virtual reality–based exercise interventions. Nevertheless, caution is warranted when interpreting findings from non-randomized and pilot studies due to inherent design limitations and potential bias.

Discussion

The present systematic review synthesized evidence from 19 primary studies examining the effects of virtual reality–based exercise on physiological and cardiorespiratory fitness outcomes. Overall, the findings suggest that VR-based exercise interventions can provide a meaningful cardiovascular stimulus and may contribute to improvements in aerobic capacity, heart rate responses, and functional performance. In addition, immersive exercise environments appear to enhance engagement and motivation, which may support sustained participation in physical activity.

One of the main findings of this review is that VR-based exercise interventions can improve aerobic capacity indicators such as VO_2max and VO_2peak. Several randomized controlled trials included in this review reported improvements in cardiorespiratory fitness following structured VR exercise programs lasting between six and twelve weeks. These improvements were generally comparable to those observed in conventional exercise interventions. The physiological adaptations observed may be attributed to the dynamic and repetitive movements required in VR-based activities, including cycling simulations, boxing exercises, resistance training, and sport-based exergaming, which increase oxygen demand and cardiovascular workload.[1]

Another important finding is that VR-based exercise can achieve moderate levels of cardiovascular intensity consistent with established physical activity guidelines. Across multiple experimental and crossover studies, heart rate responses during VR exercise commonly corresponded to moderate intensity ranges, indicating that VR-based activities can elicit sufficient physiological stimulus to promote cardiorespiratory adaptations.[2] Immersive VR systems that incorporate full-body movement appear to generate greater physiological demand compared with less interactive or non-immersive formats, highlighting the importance of intervention design in achieving optimal training effects.[2]

Beyond physiological outcomes, this review also highlights the role of VR-based exercise in improving behavioral and perceptual aspects of physical activity. Several studies reported higher levels of enjoyment, motivation, and engagement during VR exercise compared with traditional exercise modalities. These findings suggest that the immersive and interactive characteristics of VR technology may reduce perceived exertion and monotony, thereby increasing exercise adherence. Gamification elements such as real-time feedback, scoring systems, and interactive challenges may further enhance user experience and support long-term participation.[3]

The behavioral benefits associated with VR-based exercise have important implications for physical activity promotion. Lack of motivation and low adherence are common barriers to regular exercise, particularly among young adults. VR-based exercise may address these challenges by transforming physical activity into an engaging and enjoyable experience. This shift in perception may contribute to improved adherence and increased likelihood of maintaining long-term exercise habits.[4]

The findings of this review are consistent with previous literature reporting positive effects of virtual reality and exergaming interventions on physical activity and rehabilitation outcomes. However, unlike many previous reviews that focused primarily on clinical populations, this review emphasizes physiological and cardiorespiratory responses across a broader range of populations, including healthy individuals and specific groups such as older adults, hypertensive patients, and clinical populations. This broader perspective highlights the versatility of VR-based exercise across different contexts.[5]

From a physiotherapy and preventive health perspective, VR-based exercise offers several practical advantages. VR systems can be adapted to different fitness levels and functional capacities, making them suitable for diverse populations. Furthermore, VR-based interventions can be implemented in various settings, including clinical environments, community-based programs, and home-based exercise. The interactive nature of VR technology may also enhance patient engagement during rehabilitation, which is a critical factor influencing treatment outcomes.

Despite these promising findings, several limitations should be considered. First, substantial heterogeneity was observed across the included studies in terms of study design, intervention protocols, VR systems, and outcome measures. Differences in the level of immersion, type of exergame, and training protocols may influence physiological responses and limit comparability between studies. Second, sample sizes varied considerably, with several studies involving relatively small samples, which may affect the generalizability of the findings. Third, intervention duration differed across studies, with some investigations limited to single-session or short-term protocols, restricting conclusions regarding long-term effects.

Additionally, variability in outcome measurement methods, particularly for cardiorespiratory fitness indicators, may introduce inconsistencies in the reported findings. Although common outcomes such as VO_2max, heart rate, and functional capacity were frequently reported, differences in measurement techniques and protocols may limit direct comparisons across studies.

The methodological quality assessment further indicated that while randomized controlled trials generally demonstrated low risk of bias, several studies presented some concerns related to randomization procedures and reporting transparency. Non-randomized studies showed moderate methodological quality, with potential limitations related to sample size, study design, and control conditions. These factors should be considered when interpreting the overall strength of evidence.

Future research should focus on conducting well-designed randomized controlled trials with standardized VR exercise protocols and clearly defined outcome measures. Studies with larger sample sizes and longer intervention durations are needed to better understand the long-term effects of VR-based exercise on cardiorespiratory fitness. In addition, future research should explore optimal training parameters, including intensity, frequency, and duration, as well as the integration of VR-based exercise into physiotherapy practice and public health interventions.

Overall, the findings of this systematic review indicate that virtual reality–based exercise represents a promising approach for promoting physical activity and improving cardiorespiratory fitness. By combining immersive environments with interactive exercise experiences, VR technology has the potential to overcome common barriers to exercise participation and support more engaging and sustainable physical activity interventions.

Conclusion

This systematic review demonstrates that virtual reality–based exercise interventions can provide a meaningful cardiovascular stimulus and contribute to improvements in cardiorespiratory fitness. Evidence from 19 primary studies indicates that VR-based exercise is capable of eliciting moderate-intensity physiological responses and may improve aerobic capacity, heart rate responses, and functional performance. In addition, VR-based exercise appears to enhance motivation, enjoyment, and adherence, which are critical factors in sustaining long-term physical activity.

Despite these promising findings, the overall strength of evidence should be interpreted with caution due to heterogeneity in study design, intervention protocols, and outcome measurements. While randomized controlled trials generally support the effectiveness of VR-based exercise, variations in methodology and sample size limit the generalizability of results. Therefore, further high-quality studies are required to establish standardized protocols and confirm long-term benefits.

Author Contribution

Marvel Refando Yosafat: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Writing – Review and Editing, Visualization, and Final Approval.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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Ethics Statement

This study was conducted as a systematic review using previously published studies. Therefore, ethical approval and informed consent were not required. The review protocol was not registered in PROSPERO.

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