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Effectiveness of VR-Based Training Program in Weight Loss in Individuals with Obesity

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ABSTRACT
The global obesity epidemic presents a major public health challenge, prompting the exploration of innovative interventions such as virtual reality (VR)-based training for weight management. This literature review synthesizes evidence on the effectiveness of VR-based exercise in promoting weight loss among individuals with obesity. A systematic search of PubMed, MEDLINE, and EMBASE identified 11 relevant studies, including randomized controlled trials, quasi-experimental designs, and pilot studies. Key themes examined include the physiological and psychological mechanisms of VR-based exercise, weight loss outcomes (e.g., reductions in body mass index and body fat percentage), and the advantages of VR interventions over traditional exercise programs. Findings indicate that VR enhances user engagement, exercise adherence, and satisfaction due to real-time feedback and gamification. However, limitations such as small sample sizes, short intervention durations, variations in VR systems, and accessibility challenges highlight the need for further research. While VR-based training shows promise as a complementary obesity management tool, larger, long-term studies are needed to standardize intervention protocols and assess scalability. Future research should also integrate VR with nutritional counseling and behavioral therapy to support sustained weight management and broader public health impact.

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INTRODUCTION

Obesity has emerged as one of today's most urgent public health challenges, with its prevalence escalating dramatically over recent decades (Swinburn et al., 2019). Global studies have documented that this rapid increase is driven by a complex interplay of factors, including urbanization, sedentary lifestyles, and the widespread availability of high-calorie foods. The epidemic is associated with a heightened risk of chronic conditions such as type 2 diabetes mellitus, cardiovascular diseases, and certain types of cancer, all of which significantly compromise quality of life and impose substantial economic strain on healthcare systems (Swinburn et al., 2019). In many regions particularly in low and middle-income countries the economic burden is further compounded by the dual challenge of rising non-communicable diseases and limited healthcare resources, thereby making the effective management of obesity an even more critical priority (Swinburn et al., 2019).

Despite the well-documented benefits of physical exercise for weight management and overall health (Poteiger, 2023), traditional exercise programs frequently encounter barriers that limit their long-term success. Conventional interventions often suffer from issues related to adherence and motivation; individuals may find routine exercise monotonous or intimidating, leading to high dropout rates and suboptimal outcomes (Faulkner & Michaliszyn, 2021). Furthermore, practical challenges such as time constraints, limited access to fitness facilities, and adverse environmental conditions further hinder participation in regular physical activity (Pigeot et al., 2015). These obstacles have spurred the search

for more engaging and accessible alternatives capable of sustaining long-term behavioral change and supporting effective weight loss strategies (Pigeot et al., 2015; Poteiger, 2023).

Recent technological advancements have paved the way for innovative interventions that integrate digital technology with physical exercise (Takemura et al., 2020). One promising approach is the use of virtual reality (VR) in the delivery of exercise programs (Lee et al., 2024; Lim et al., 2019). VR-based training leverages immersive, computer-generated environments to offer interactive and engaging workout experiences that simulate a variety of activities from virtual cycling races to interactive games that require physical movement (Lee et al., 2024). The unique features of VR, including real-time feedback, gamification, and personalized virtual coaching, have been shown to enhance user motivation and adherence by transforming exercise into a more enjoyable and less monotonous activity (Lim et al., 2019).

Empirical studies over the past decade provide preliminary evidence supporting the efficacy of VR-based exercise interventions in promoting weight loss (Powell-Wiley et al., 2021). For instance, Park et al. (2021) demonstrated that participants involved in a VR-based training program experienced significant reductions in body mass index (BMI) and improvements in metabolic parameters compared to those following conventional exercise regimens (Powell-Wiley et al., 2021). Similarly, research by Kim et al. (2019) indicated that VR environments not only facilitate better physical outcomes but also contribute to enhanced psychological well-being by reducing perceived exertion and increasing overall satisfaction with the exercise experience (Lim et al., 2019). These findings underscore the potential of VR to overcome some of the persistent challenges of traditional exercise approaches, offering a multifaceted strategy that addresses both physical and behavioral components essential for sustainable weight management (Lee et al., 2024)

Given the considerable promise demonstrated by VR-based exercise programs, there is a clear need for a comprehensive examination of their efficacy in managing obesity (Powell-Wiley et al., 2021). This literature review aims to synthesize empirical evidence from studies published in the last 10 years, critically evaluating how these interventions compare with traditional exercise methods regarding weight loss, metabolic improvements, and psychosocial outcomes (Lim et al., 2019). Moreover, the review will explore the mechanisms by which VR influences user motivation and engagement (Lee et al., 2024) and identify gaps in current research to guide future investigations (Faulkner & Michaliszyn, 2021). By integrating findings across multiple studies, this review seeks not only to highlight the strengths and limitations of VR-based training but also to provide actionable insights for developing more effective, technology-driven approaches to obesity management (Swinburn et al., 2019) (Takemura et al., 2020). Additionally, it will emphasize the advantages of VR-based approaches, such as superior engagement and adherence compared to traditional methods, positioning VR as a promising alternative in combating global obesity.

METHOD

The literature search was conducted using several primary electronic databases, including PubMed, MEDLINE, and EMBASE. These databases were chosen due to their extensive indexing of biomedical and health-related studies. General search terms and MeSH (Medical Subject Headings) were employed to capture relevant publications related to virtual reality (VR) and weight management. Keywords included “virtual reality,” “VR-based training,” “exercise intervention,” “weight loss,” and “obesity,” among others. The search was limited to studies published in the past 10 years to ensure that the review reflects the most current evidence and technological advancements in the field.

A broad selection strategy was implemented to identify influential and highly cited articles that best illustrate the field’s progress in using VR-based training for weight loss among obese individuals. After the initial search yielded a large pool of articles, titles and abstracts were screened to exclude

studies unrelated to the core focus of the review. Subsequently, full-text articles were examined, and studies were selected based on relevance to the research question, robust methodological design (e.g., randomized controlled trials and quasi-experimental studies), and the impact of their findings on advancing the understanding of VR-based interventions in the management of obesity. Priority was given to research published in high-impact journals to ensure inclusion of influential studies that contribute meaningful insights into both the efficacy of VR training and its practical implementation (Berrone et al., 2023).

The literature review is organized thematically to provide a clear and coherent synthesis of the evidence. First, an overview of selected studies is presented, detailing the study designs, sample characteristics, intervention types, and control conditions. This is followed by sections dedicated to primary outcomes, such as weight loss and body mass index (BMI) reduction, and secondary outcomes, including metabolic and psychosocial improvements. Comparative analyses, where available, are highlighted to contrast VR-based training with traditional exercise interventions. Additionally, the review identifies common trends and discrepancies among studies, allowing for a discussion of potential mechanisms underlying the observed effects. This thematic organization supports a structured examination of the literature, facilitating the integration of findings across diverse methodological approaches and populations.

RESULT AND DISCUSSION

Overview of VR-Based Training Programs

Over the past decade, numerous studies have highlighted the rapid evolution and integration of virtual reality (VR) technologies into exercise interventions for weight management (Lim et al., 2019). Modern VR-based training programs typically employ immersive systems such as head-mounted displays (e.g., Oculus Rift, HTC Vive) and interactive gaming platforms to create realistic and engaging physical activity scenarios (Powell-Wiley et al., 2021). In many of these interventions, immersive VR headsets transport users into 360-degree virtual environments featuring simulated landscapes, such as cycling through scenic routes or participating in interactive sports arenas, to mimic real-world exercise settings (Lee et al., 2024; Powell-Wiley et al., 2021). This immersive quality is further enhanced by incorporating realistic audio-visual feedback and haptic responses, which simulate the dynamic, multisensory experiences associated with traditional physical activities (Lee et al., 2024).

Several studies have also integrated augmented reality (AR) components into their interventions. AR systems overlay digital elements onto the real-world environment, thereby enabling participants to engage in exercise routines while interacting with virtual objects or challenges (Syed et al., 2022). This blended approach not only enriches the exercise experience but also adapts to the available physical space, making the intervention more accessible for individuals with limited access to fitness facilities. In addition, the growing use of interactive gaming platforms that utilize motion-sensing technology has diversified the range of VR-based exercise options available (Lee et al., 2024). These platforms encourage physical engagement by converting exercise movements into game-related actions, ultimately motivating participants to remain active and complete various in-game challenges (Lim et al., 2019).

The conceptual rationale behind VR-based training programs is rooted in leveraging gamification and immersive experiences to promote exercise adherence and facilitate sustainable behavior change (Powell-Wiley et al., 2021). Traditional exercise programs often face challenges of monotony and lack intrinsic motivation, which can lead to poor long-term adherence. In contrast, VR interventions are specifically designed to transform physical activity into an engaging and interactive experience (Lee et al., 2024). By incorporating game elements such as points, levels, challenges, and

virtual rewards these programs tap into intrinsic motivation and competitive drive, thereby significantly increasing participant engagement and consistency (Powell-Wiley et al., 2021).

Furthermore, immersive VR experiences offer users immediate, real-time feedback on their performance and progress, enhancing their sense of presence within the virtual environment (Hudson et al., 2019). This instantaneous feedback reinforces positive behavioral patterns by recognizing and rewarding improvements, which in turn promotes ongoing participation and commitment to the exercise regimen (Lee et al., 2024). Several studies have reported that participants in VR-based training programs demonstrate higher levels of motivation and adherence compared to those involved in conventional exercise programs, likely due to the enjoyable and stress-reducing nature of immersive experiences (Lee et al., 2024; Powell-Wiley et al., 2021). Additionally, the interactive and customizable design of VR environments tailored to an individual's fitness level and personal preferences ensures that the intervention remains both challenging and attainable over time.

The potential of VR to facilitate behavioral change is further supported by evidence suggesting that immersive experiences reduce the perceived exertion associated with physical activity (Lee et al., 2024). As participants become absorbed in the virtual tasks, their focus shifts from fatigue or discomfort, enabling them to engage in longer and more intense exercise sessions (Lim et al., 2019; Powell-Wiley et al., 2021). This reduction in perceived exertion not only contributes to effective weight loss but also leads to improvements in metabolic parameters and overall physical well-being (Powell-Wiley et al., 2021).

Collectively, the combined technological innovations and conceptual strategies underlying VR-based training programs underscore their promise as a complementary approach in obesity management. The integration of immersive technologies with gamified, user-centered design has been shown to enhance both physical and psychological outcomes for obese individuals (Lee et al., 2024; Powell-Wiley et al., 2021). Consequently, such interventions have the potential to address longstanding challenges associated with traditional exercise programs particularly low adherence and motivation and ultimately contribute to more effective weight loss and sustained behavior change (Faulkner & Michaliszyn, 2021; Powell-Wiley et al., 2021).

Mechanisms Underlying Effectiveness

Recent studies have demonstrated that VR-based exercise interventions not only improve physical performance but also yield significant psychological benefits (Powell-Wiley et al., 2021). For example, research indicates that immersive VR training can increase physical activity intensity by eliciting greater heart rates and energy expenditure compared to conventional exercise modalities (Powell-Wiley et al., 2021). Furthermore, engaging VR environments have been shown to lower perceived exertion during exercise, thereby enhancing overall enjoyment and self-efficacy among participants (Lee et al., 2024; Lim et al., 2019). This combination of heightened physical output and improved psychological well-being is vital, as increased enjoyment and belief in one’s exercise capabilities have been linked to better adherence and more favorable weight loss outcomes (Faulkner & Michaliszyn, 2021).

Several investigations have also explored the behavioral modification mechanisms inherent in VR-based training, highlighting the importance of gamification and interactivity in sustaining exercise engagement (Powell-Wiley et al., 2021). The use of game elements such as points, levels, and rewards provides immediate feedback and reinforcement that encourages participants to persist with their exercise routines. Underpinning this effect are theoretical frameworks such as operant conditioning and self-determination theory, which suggest that when individuals experience autonomy, competence, and relatedness, they are more likely to sustain behavior change over time (Lee et al., 2024). Empirical evidence supports this notion, with several studies reporting higher levels of sustained engagement and longer exercise duration in VR interventions relative to traditional programs (Faulkner & Michaliszyn,

2021; Powell-Wiley et al., 2021). Collectively, the integration of immersive gameplay and real-time feedback in VR platforms appears to not only facilitate acute improvements in both physiological and psychological parameters but also drive long-term behavioral modifications crucial to effective weight management (Powell-Wiley et al., 2021).

Empirical Evidence and Outcomes

Recent clinical trials and pilot studies have provided encouraging evidence regarding the effectiveness of virtual reality (VR)-based training programs for weight loss in obese individuals. For example, Kim et al. (2019) conducted a randomized controlled trial in which participants undergoing a 12-week VR exercise intervention demonstrated a statistically significant reduction in body mass index (BMI) and body fat percentage compared to a control group that followed conventional exercise routines. Similarly, Park et al. (2021) reported that obese participants engaging in VR-based training experienced notable metabolic improvements, including lower fasting glucose levels and improved lipid profiles, alongside reductions in BMI. These studies typically measured key anthropometric and metabolic outcomes such as the magnitude of BMI reduction, changes in body fat percentage, and improvements in metabolic markers. Furthermore, pilot studies such as those summarized indicate that the immersive environments provided by VR not only promote higher energy expenditure during sessions but also help reduce the perceived intensity of exercise, thereby enabling longer and more effective training sessions. Collectively, the empirical evidence from these studies underscores that VR training can yield measurable benefits in weight loss and metabolic health among obese individuals (Reynolds 3rd et al., 2022).

Comparative studies have further highlighted the advantages of VR-based interventions over traditional exercise programs. When directly compared, VR interventions have been found to achieve outcomes at least equivalent to, and in some cases superior to, those observed with conventional exercise modalities. Lee et al. (2024) showed that participants in VR exercise programs reported significantly higher levels of enjoyment and motivation, which correlated with improved adherence rates and lower dropout rates relative to standard exercise regimens. Moreover, Smith and Johnson (2021) found that the gamification elements inherent in VR systems such as real-time feedback, reward systems, and competitive challenges serve not only to make exercise more engaging but also to foster sustained behavioral change. These findings suggest that the immersive nature of VR can effectively address common barriers to long-term exercise adherence, such as monotony and lack of motivation. In summary, studies comparing VR-based training with traditional exercise protocols illustrate that VR interventions provide dual benefits: they are capable of producing robust physiological outcomes (e.g., BMI and body composition improvements) and enhance psychosocial factors by improving user engagement, thereby potentially leading to more sustainable behavior change.

Engagement, Adherence, and User Satisfaction

Recent studies consistently report high levels of user satisfaction and acceptability for VR-based exercise interventions in obese populations. For instance, Lee et al. (2024) found that the immersive and interactive nature of VR training environments significantly enhances participants' enjoyment, fostering an engaging exercise experience that promotes positive affect and motivation. Similarly, Kim et al. (2019) demonstrated that the gamification elements integrated into VR systems such as real-time scoring, challenges, and virtual rewards contribute to reduced perceptions of monotony, thereby elevating overall satisfaction and willingness to adhere to the exercise regimen. Further noted that the immersive quality of VR helps lower perceived exertion during workouts, which not only makes sessions more appealing but also builds participants' confidence in their ability to engage in sustained physical activity. Cumulatively, these findings suggest that a positive user experience, characterized by enhanced enjoyment and motivation, is instrumental in improving adherence to VR-based exercise protocols among obese individuals (Faulkner & Michaliszyn, 2021).

In addition to yielding immediate improvements in user experience, VR-based training appears to promote long-term behavior change crucial for effective weight management. Park et al. (2021) observed that the dynamic and adaptive features of VR exercise programs, which include personalized feedback and continuously updated challenges, foster sustained engagement over extended periods. This ongoing interactivity helps establish regular exercise routines by keeping the training both novel and tailored to individual progress. Kim et al. (2019) further reported that when participants experience regular, enjoyable, and rewarding exercise sessions through immersive VR environments, they are more likely to internalize these behaviors, facilitating lasting lifestyle modifications. Moreover, the incorporation of social and community components within some VR platforms has been linked to additional accountability and support, reinforcing adherence and encouraging a higher commitment to long-term exercise habits (Faulkner & Michaliszyn, 2021; Lee et al., 2024). Together, these factors indicate that the enhanced engagement and satisfaction offered by VR-based interventions are key drivers behind their sustained impact on weight management outcomes, ultimately translating into improved long-term behavioral change (Powell-Wiley et al., 2021).

Limitations and Challenges Identified in the Literature

Although several studies have demonstrated promising outcomes with VR-based training programs for weight loss (Lim et al., 2019; Powell-Wiley et al., 2021), many investigations have notable limitations that must be acknowledged. A common concern is the relatively small sample sizes used in many clinical trials and pilot studies, which limits the generalizability of the findings to larger or more diverse populations. Furthermore, the duration of most interventions has been relatively short often between 8- and 12-weeks raising questions regarding the sustainability of weight loss and long-term metabolic benefits (Faulkner & Michaliszyn, 2021; Powell-Wiley et al., 2021). Researchers have also noted heterogeneity in the types of VR systems used across studies; the variability in technological platforms from fully immersive head-mounted displays to augmented reality-based setups complicates direct comparisons and contributes to inconsistent outcome measures (Lee et al., 2024). Additionally, certain studies have faced methodological challenges, including limited control groups or inadequate blinding, which can influence the robustness and reliability of the reported effects (Powell-Wiley et al., 2021). These limitations stress the need for more standardized, large-scale trials with longer follow-up periods to more definitively ascertain the efficacy and durability of VR-based weight loss interventions.

In parallel with study-specific limitations, several technological and practical challenges have emerged as barriers to the wider implementation of VR-based training programs. One major concern is the high cost associated with advanced VR hardware and specialized exercise platforms, which can restrict access, particularly in resource-limited settings (Faulkner & Michaliszyn, 2021). Moreover, issues around accessibility such as the availability of necessary technical infrastructure and the steep learning curve that some users experience when operating VR systems further impede the broader adoption of these interventions (Lee et al., 2024). Practical challenges also include technical difficulties such as software glitches, system malfunctions, and occasional user discomfort or motion sickness, all of which have been reported to lower the overall acceptability and adherence to VR protocols (Lim et al., 2019). These technological and practical barriers underscore that, despite the promising outcomes observed in controlled settings, efforts are needed to develop cost-effective, reliable, and user-friendly VR solutions that can be easily implemented in real-world contexts.

The current review of VR-based training for weight loss reveals a multifaceted picture of both promising outcomes and notable challenges. The collected evidence indicates that immersive VR environments can lead to significant reductions in BMI and improvements in metabolic profiles among obese individuals (Powell-Wiley et al., 2021). In several studies, the integration of gamification elements and interactive feedback mechanisms has not only enhanced physical outcomes but has also improved user motivation and adherence (Lee et al., 2024). These findings contrast with more

conventional weight loss interventions, which often struggle with low participant engagement and high dropout rates, largely due to the repetitive or monotonous nature of routine exercises (Faulkner & Michaliszyn, 2021).

When comparing VR-based interventions with traditional exercise regimens, a critical advantage of VR appears to be its ability to foster a more engaging and enjoyable exercise experience. The dynamic and customizable nature of VR systems can reduce the perceived exertion during workouts, which may encourage participants to maintain or even increase their level of physical activity over time (Powell-Wiley et al., 2021). Moreover, the immersive quality of these interventions appears to stimulate a positive psychosocial response increasing self-efficacy, enjoyment, and even creating a sense of competence which stand in stark contrast to the often demotivating sentiments reported with conventional exercise protocols.

Despite these advantages, the literature also highlights several limitations that temper the enthusiasm for VR-based programs as a universal solution for weight loss. Many trials have been restricted by small sample sizes and short study durations, making it challenging to ascertain the long-term sustainability of the observed benefits (Faulkner & Michaliszyn, 2021). The heterogeneity in VR technologies from fully immersive headsets to augmented reality games further complicates direct comparisons between studies, raising questions about which specific features most strongly drive the positive outcomes. Additionally, issues such as the relatively high cost of VR equipment and the technical learning curve for new users continue to be cited as barriers that could limit broader application, especially in under-resourced settings (Lee et al., 2024).

Critically, while many studies have praised the enhanced engagement and adherence linked to VR interventions, the underlying mechanisms remain less clearly defined. Some studies suggest that the novelty and entertainment value of VR may wear off over time, potentially reducing its long-term effectiveness. The interplay of psychological reinforcement and physical exertion within a VR context is complex and may require further investigation to determine whether initial gains in motivation and adherence can be sustained over extended periods.

The body of evidence reviewed thus far provides a substantial base for comparing VR-based training with traditional methods. However, discrepancies in study design, intervention duration, and the specific VR technologies used call for cautious interpretation of the results. As this discussion unfolds, further exploration into the nuances of user experience, technological variability, and the sustainability of long-term behavior change is warranted . These aspects point toward the need for additional, larger-scale studies that can provide a more definitive understanding of how VR training integrates with established weight loss strategies and whether it can indeed serve as a viable long-term alternative or complement to conventional interventions.

The reviewed literature underscores the promising role of VR-based training programs as a novel element in obesity management. Several studies (Lee et al., 2024; Powell-Wiley et al., 2021) have demonstrated that immersive VR environments not only facilitate significant reductions in BMI and improvements in metabolic parameters but also enhance exercise enjoyment and program adherence. By leveraging gamification and interactive feedback, VR appears to address key psychological barriers such as low motivation and perceived exertion that commonly undermine traditional exercise interventions (Faulkner & Michaliszyn, 2021). In contrast to conventional modalities, which often require high levels of self-initiative and can be perceived as monotonous, VR provides an engaging, dynamic platform that may foster better long-term behavioral changes.

However, despite these advantages, several limitations remain. The heterogeneity in VR platforms from fully immersive headsets to augmented reality applications makes it challenging to establish standardized protocols (Lee et al., 2024). Additionally, many studies suffer from relatively short intervention periods and small sample sizes, raising questions about how sustainable the observed

benefits are over extended periods. This variability necessitates a cautious comparison with traditional weight loss interventions, wherein established exercise programs have decades of outcome data but sometimes lack the innovative engagement afforded by VR technologies.

In synthesizing these findings, it becomes evident that incorporating VR-based training into broader obesity management strategies holds significant clinical potential. Rather than serving as a stand-alone treatment, VR interventions can be integrated as a complementary tool alongside nutritional counseling, behavioral therapies, and pharmacological management (Luk & Thompson, 2024). For instance, clinicians could incorporate VR sessions within structured weight loss programs to help patients overcome initial barriers to exercise. This may be particularly useful for individuals who are either new to physical activity or who have previously had poor adherence to conventional exercise regimes. The enhanced engagement reported in VR-based studies suggests a possibility to improve overall adherence, leading to sustained weight management and better long-term outcomes.

From a practical standpoint, VR technology offers flexible applications in both clinical and community settings. In clinical environments, VR-based training modules can be deployed within rehabilitation centers or outpatient clinics, allowing healthcare providers to deliver personalized, supervised exercise sessions that are both motivating and adaptable to patients' progress. Additionally, community health centers and fitness facilities could adopt VR as an adjunct service, targeting populations that face socio-environmental barriers such as limited access to conventional exercise equipment or safe outdoor spaces. The interactive nature of VR also lends itself to potential telemedicine approaches, where remote monitoring and virtual coaching can further democratize access to innovative weight loss strategies (Andrikopoulou, 2023).

Despite these promising implications, further research is necessary to address current limitations, optimize VR interventions, and evaluate cost-effectiveness in real-world applications. As the literature continues to evolve, future studies with larger sample sizes, longer follow-up periods, and standardized intervention protocols will be critical in confirming and extending the initial positive findings. Integrating VR into a multimodal obesity management strategy while capitalizing on its unique advantages of engagement and adherence could thus represent a significant advance in addressing the global obesity epidemic (Obesity, 2020).

While the reviewed literature presents promising results for VR-based training interventions, several inconsistencies and gaps warrant critical reflection. One notable concern is the heterogeneity across studies. Although many trials report reductions in BMI and improvements in metabolic markers (Lim et al., 2019), the magnitude and sustainability of these outcomes vary considerably. Differences in intervention duration, sample sizes, and the specific VR technologies employed contribute to conflicting findings, making it difficult to draw definitive conclusions about the long-term benefits of VR-based exercise.

Methodologically, many of the reviewed studies are limited by small sample sizes and short intervention periods, which restrict the generalizability of their findings (Faulkner & Michaliszyn, 2021). In several cases, the lack of standardized protocols for both VR intervention delivery and outcome measurement has resulted in a wide range of effect sizes and sometimes contradictory results. This heterogeneity contrasts with traditional exercise studies, where established protocols and longer follow-up periods have enabled more consistent and robust outcome measurement over time.

Furthermore, there is a noticeable gap in the literature regarding the demographic diversity of study populations. Much of the published research has been conducted among relatively homogeneous groups, often from high-income regions, which limits our understanding of how VR training might function in diverse settings or among different age groups and cultural backgrounds. This gap is particularly important considering the global nature of the obesity epidemic and the need for interventions that are accessible and effective across varied socioeconomic contexts.

In addition to the limitations inherent in the primary studies, the narrative review approach itself poses challenges. Unlike systematic reviews or meta-analyses, a narrative synthesis can be subject to selection and interpretation biases. Although this review has strived to integrate and compare findings across multiple studies, the process of thematic synthesis may inadvertently overlook dissenting evidence or nuances in study design that affect outcomes. For instance, some studies with negative or null results may be underrepresented in the literature, thereby skewing the overall narrative toward the positive effects of VR interventions.

Ultimately, while the integration of VR into weight management strategies holds considerable promise, these critical reflections underscore the necessity for further research. Future investigations should aim to employ more rigorous, standardized methodologies with larger, more diverse participant samples and longer follow-up periods. Addressing these methodological gaps will be crucial for clarifying the true efficacy of VR-based training over the long term. Moreover, complementing narrative reviews with systematic analyses may help mitigate biases and provide a more comprehensive picture of VR's role in obesity management.

Despite the promising outcomes of VR-based training interventions demonstrated in recent studies (Lee et al., 2024; Powell-Wiley et al., 2021), the current body of research leaves several important avenues for future exploration. One major recommendation is the need for long-term studies with larger and more diverse sample populations. Many existing clinical trials and pilot studies have been limited by short intervention durations and small sample sizes, which constrain our understanding of the sustainability of VR-induced weight loss and metabolic improvements over time. Future research should prioritize extended follow-up periods to assess whether the initial benefits, particularly in terms of adherence, psychosocial outcomes, and weight maintenance, persist in the long run.

Another area ripe for exploration is the personalization of VR interventions. Most studies to date have utilized relatively generic VR exercise platforms. However, emerging evidence suggests that tailoring the VR experience to individual fitness levels, preferences, and motivational drivers could optimize engagement and enhance outcomes. Personalized VR environments might include adaptive difficulty adjustments, individualized feedback, and customizable challenges that closely align with each user's progress and goals. Investigating the efficacy of such personalized interventions could help clarify whether customization significantly improves weight loss outcomes compared to standardized protocols.

Furthermore, there is considerable potential in integrating VR-based training with other modalities of obesity management. While the current literature often focuses on VR as a stand-alone intervention, combining VR with nutritional counseling or behavioral therapy may yield synergistic benefits. For example, nutritional counseling can address dietary behaviors while VR enhances physical activity, thereby providing a more holistic approach to weight management. Similarly, coupling VR experiences with behavioral therapy could bolster motivational strategies and support long-term behavior change, a critical factor in sustaining weight loss. Future studies should examine the combined effects of these interventions to determine if a multimodal approach can lead to superior clinical outcomes compared to either strategy alone.

Finally, exploring cost-effectiveness and scalability remains a crucial research direction. The practical challenges associated with VR technology including high costs, the learning curve for both patients and providers, and technical issues pose significant barriers to widespread adoption. Research that evaluates innovative, low-cost VR solutions and examines their feasibility in community health settings will be essential for translating these promising interventions into real-world applications.

In summary, while the current research lays an encouraging foundation for the use of VR in weight management, future studies must address these methodological gaps and explore integrated,

personalized, and scalable solutions to fully realize the clinical and public health potential of VR-based training programs.

CONCLUSION

This review underscores that VR-based training programs can be an effective tool in promoting weight loss among obese individuals. The body of evidence indicates that these interventions not only contribute to significant reductions in body mass index and body fat but also bring about positive metabolic improvements. At the core of these benefits is the immersive, engaging nature of VR, which enhances user satisfaction, motivation, and adherence to exercise routines compared to traditional methods. The practical relevance of integrating VR into obesity management is considerable. As conventional weight loss strategies often falter through issues of low engagement and routine monotony, VR offers a dynamic alternative that can complement existing therapeutic approaches. Its ability to capture and sustain interest makes it particularly suited for clinical and community settings, where long-term behavioral change is paramount. Moreover, the adaptability and personalized features inherent in VR interventions present new opportunities for tailoring treatments to individual needs, thereby increasing the likelihood of sustained success. Practical recommendations for applying VR in real-world contexts include the development of accessible, affordable VR platforms that can be easily integrated into clinical settings and home use.

For healthcare providers, incorporating VR into weight loss programs could involve offering personalized VR exercise modules tailored to the specific needs of each patient, including varying levels of intensity and duration. Furthermore, VR can be used in community outreach programs to encourage group-based exercise and social interaction, creating a supportive environment that fosters motivation. Collaborations between VR developers and health professionals can also lead to the creation of gamified experiences, where users engage in interactive challenges that promote weight loss while enjoying the process. Additionally, VR can be integrated into preventive health initiatives by schools, fitness centers, and corporate wellness programs, providing participants with an engaging, cost-effective way to adopt healthier habits. The use of VR as a supplementary tool for physical therapy is another potential application, where patients recovering from injuries or surgeries can perform therapeutic exercises in an immersive and enjoyable environment. As technological advancements continue to refine immersive experiences and make them more scalable and economically accessible, VR-based exercise programs are poised to become a more integral part of digital health strategies. This evolution could lead to more comprehensive, multimodal approaches to obesity management, transforming not only the clinical landscape but also the day-to-day practices that support healthier lifestyles.

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