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Effects of dietary advice, aerobic exercise, and virtual reality games on the quality of life of obese adolescent females

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ABSTRACT

Previous studies have demonstrated that aerobic exercise and dietary changes positively impact mental and physical health. Aerobic exercise has been shown to reduce depressive episodes and improve quality of life (QoL) among adolescents. Additionally, dietary changes can increase energy and mental stability. Studies have linked virtual reality (VR) to improvements in anxiety, stress reduction, and physical activity. This study aimed to assess and compare the effects of three interventions (dietary advice, aerobic exercise, and VR games) on the QoL of obese adolescent females. A total of 100 adolescent females aged 12-17 years with Class A obesity (BMI 30-34.9 kg/m^2) were randomly assigned to two groups. Study Group (SG): 50 participants received a combination of diet advice, aerobic exercise, and VR games three times per week for 8 weeks. Control Group (CG): 50 participants received diet advice and aerobic exercise alone, without VR games, for the same duration. There was a significant increase in the QoL of the SG compared with that of the CG ($p < 0.01$). No significant differences in waist circumference, waist–hip ratio, fat mass, muscle mass, water content, depression and anxiety scores ($p > 0.05$). By comparing the interventions, the research provided insights into significant increase in QoL of SG compared with that of CG. These results could inform future health and education policies aimed at enhancing the health of teenagers in the digital era.

KEYWORDS

QoL; Virtual Reality Games; Adolescent Females

1. INTRODUCTION

Quality of life (QoL) encompasses physical, mental, and social well-being. It is particularly crucial throughout adolescence, a period of significant development and change. Research has shown that dietary modifications and cardiovascular exercise can improve QoL and have a favorable effect on mental and physical health (Strong et al., 2005; O'Neill et al., 2017; Ekelund et al., 2011). Additionally, improvements in mood, self-esteem, and overall quality of life have been linked to aerobic exercise. In such a manner, dietary changes can enhance energy levels and mental stability (Kris-Etherton et al., 2002).

The effects of diet and exercise on quality of life have been the subject of several research. For instance, a 2015 study by Oja et al. showed how aerobic exercise improved teens' happiness and quality of life. Several studies have explored the effects of physical activity and dietary changes on QoL. For instance, a study by Oja et al. (2015) highlighted the positive impact of aerobic exercise on QoL and mood among adolescents. The adolescents who engaged in regular aerobic exercise experienced fewer depressive episodes and showed marked improvements in their overall QoL (Wang et al., 2022)

Virtual reality (VR) games have recently become an innovative method of QoL, providing immersive experiences that may inspire and engage teenagers in a special way. VR has been investigated for its potential advantages in several domains, such as anxiety treatment, stress reduction, and improved physical activity (Kothgassner et al., 2016; Freeman et al., 2017; Barnes & Prescott 2018). VR games' immersive qualities may make them a desirable substitute for conventional approaches as they offer entertaining and engaging experiences that encourage both mental and physical health. A VR could also enhance physical fitness in people with intellectual and developmental impairment (Lotan et al., 2009). The potential of VR video games to impact both physical and mental health in teenagers and young adults were demonstrated & confirmed by Kato et al. (2008). A comprehensive review showed that VR interventions can improve mental health, especially in emotionally vulnerable groups like teenage girls (McCormick & Muir 2019) and could be effective tool for promoting physical activity and improving QoL (Golomb et al., 2010; Riva et al., 2019).

However, in the context of adolescent QoL, few studies have directly contrasted VR games with conventional therapies like aerobic exercise and diet. It's critical to investigate how teens' QoL is affected by VR vs traditional exercise. By contrasting different approaches, we may ascertain which encourages active lives and boosts motivation. This information can help guide educational initiatives and health policies, eventually enhancing the health and wellbeing of teenagers in the digital era. The current study aims to assess & compare the effects of virtual reality games, aerobic exercise, and dietary adjustments on adolescents' females' QoL including psychological changes, as well as physical measurements (waist circumference & body fat composition).

2. METHODS

2.1. Participants

A randomized controlled clinical trial was set up for this study. One hundred teenage obese females, aged 12 to 17 years old, were selected for this study from outpatient clinic in the Badr university. Girls who were obese and had regular menstruation were included. BMI (Class A obesity) was 30 to 34.9 kg/m2. All girls were clinically and medically stable. Exclusion criteria were any neurological or psychiatric issues, any impairment of feelings, significant tightness and/or permanent deformity of lower limbs, visual and/or auditory impairments. Girls with advanced radiographic abnormalities include those with balance, such as bone disintegration, bony ankylosis, knee joint dislocation, and epiphysial fracture. Acquired or congenital lower limbs abnormalities, heart failure, Uncontrolled bronchial asthma, anemia, and pathological reasons of obesity (genetic syndromes, endocrine disorders, etc.) under insulin treatment. A written informed consent was signed from all participant's parents, with the ability to withdraw at any moment. Data was collected from December 2023 to April 2024. This study was officially approved by BUC-Institutional Ethical Committee (No: IRB00014233-7), with registered clinical trial no: (NCT06604429).

2.2. Randomization

After signing the agreement form, the recruited individuals were assigned randomly to either group SG or CG. The randomization was done by using sealed envelopes, as each one contained paper showing which individual would be in group SG or CG. No individuals dropped out, after randomization (Figure 1).

2.3. Materials

A- Tape measurement: It was used to measure and detect waist and hip circumferences.

B- Body weight and height scale: They were used for height & weight measuring for BMI calculation.

C- Body Composition Analyzer: It was used to detect various elements of the human body and analyses human health status.

D- 6MWT: It was used to measure the distance a girl can quickly walk on a flat, hard surface in six minutes.

E- Paediatric Quality of Life Inventory (PedsQL): It is a 23-item generic health status questionnaire for children aged 2-18yrs instrument that assesses five domains of health (physical functioning, emotional functioning, psychosocial functioning, social functioning, and school functioning) in the past one-month of the adolescents. Valid and reliable generic pediatric Health-Related Quality of Life (HRQOL) (Limbers et al., 2011).

F- Depression, Anxiety and Stress Scoring and degree using (DASS 21): It consists of 21 questions, seven questions for depression, seven for anxiety and seven for stress assessment. (Dahm et al., 2013). The DASS is a quantitative measure of distress along the 3 axes of depression, anxiety and stress. It is not a categorical measure of clinical diagnoses. Emotional syndromes like depression and anxiety are intrinsically dimensional. They vary along a continuum of severity (independent of the specific diagnosis).

G- Visual analogy scale (VAS): The VAS is an 11-point scale comprising a number from 0 through 10; 0 indicates no pain, and 10 indicates the worst imaginable pain. Females were instructed to choose a single number from the scale that best indicates their level of pain (Alghadir et al., 2018).

2.4. Procedures

Personal data, including age, height, weight, BMI, waist circumference, waist hip ratio and pain during menstruation were taken, and recorded in a recording data sheet, Body Composition Analyzer: a) Device was turned on, and connected to the computer. b) Entering data through the computer (name-age-height-activity level). c) Participant takes off the shoes, stands on the scale and holds the handles of the scale with both hands. d) Waiting for the body composition analysis e) Print a final body composition report which gives an accurate reading of her body such as weight (kg), BMI (kg/m^2), body fat (kg), skeletal muscle (kg), body water (L), protein (kg) and salts (kg).

The participants were brought separately before performing the 6MWT and questionnaires method of the (DASS and PedsQL) were explained to them, then they answered all questions and the numbers for each participant were collected and written down.

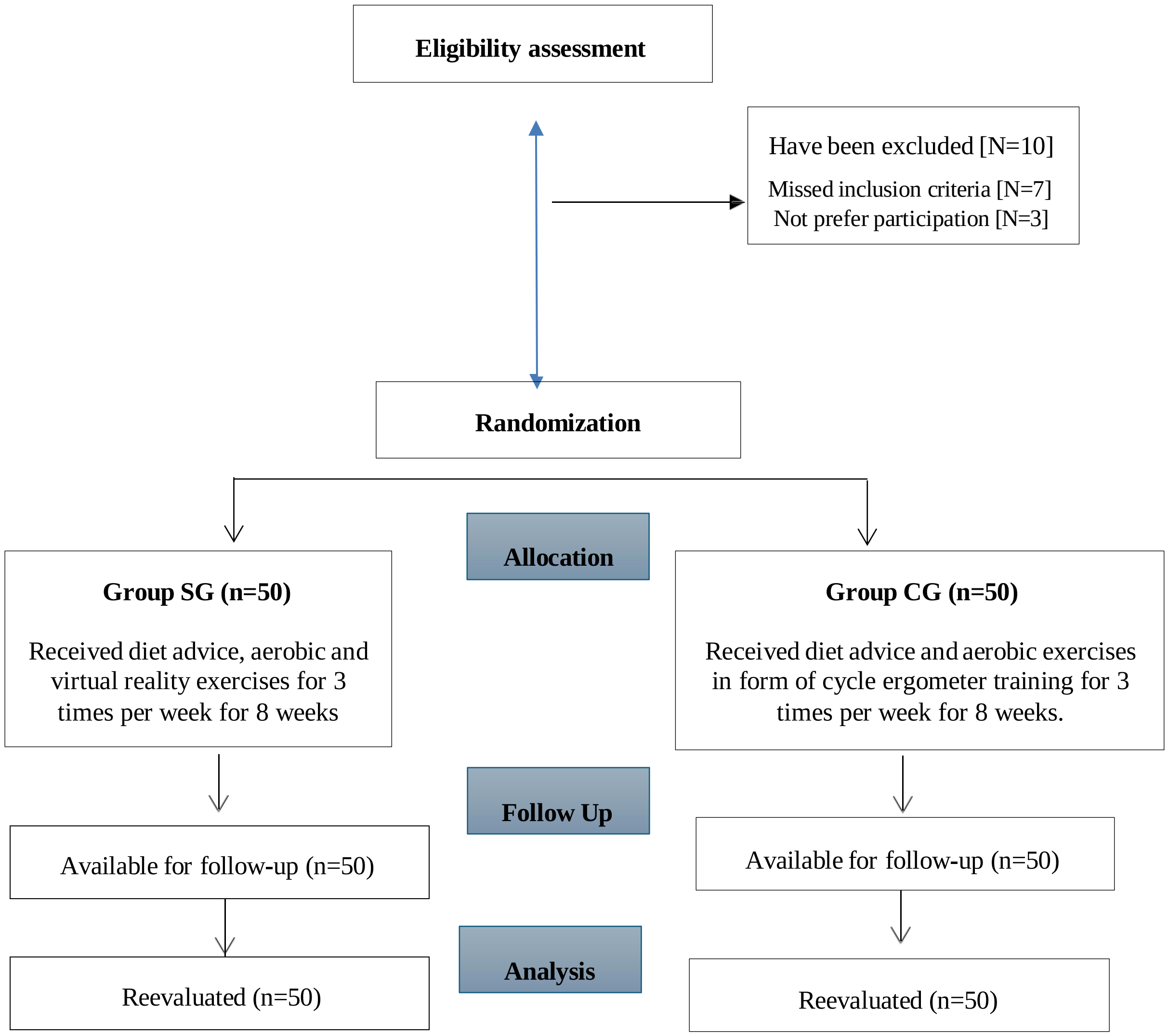

Figure 1. The study flow chart

All participants were prepared, as follows: Physical therapy lab was prepared with all materials, 10 meters corridor & three cones (which were one in the start, one in the middle and one in the end of the corridor) as well as the girls were ready & relaxed for 10 minutes, as well as each one stand and rate their baseline Blood pressure , pulse rate , saturation (SpO2), dyspnea and overall fatigue using Borg scale before and after the 6MWT.Set the lap counter to zero and the timer to 6 minutes. Assemble all necessary equipment (lap counter, timer, clip board, Borg Scale, worksheet) and move to the starting point. The subjects were instructed about the method of applying the test and follow the instruction:

As part of this test, they would walk back and forth for six minutes in this hallway. Six minutes was a long time to walk, so they would probably get out of breath or feel exhausted. As needed, they might slow down, stop, and rest.

Study Group (SG) included 50 girls who received diet advice, aerobic and virtual reality exercises 3 times per week for 8 weeks. They received diet advice and aerobic exercises in the form of cycle ergometer training (Each girl started session with a 5 min of warm-up. The exercise phase is performed at 65-75% of age-predicted peak heart rate using an orbitrack device for 20 minutes) followed by the main part, which consisted of 25 min of exercise when girls immersed in the game and did physical activities for the upper and lower extremities according to the game’s requirements, and finally a 5 min cool-down part to lower the heart rate and end the session with static flexibility routines, the total session that would be applied about 30 min(Virtual reality exercises), whereas Control Group (CG) included another 50 girls who received diet advice and aerobic exercises in form of cycle ergometer training for 3 times per week for 8 weeks. Each girl started the session with a 5 min of warm-up. The exercise phase is performed at 65-75% of age-predicted peak heart rate using an orbitrack device for 20 minutes. Finally, a 5 min cool-down period is permitted, with total session time of 30 min.

2.5. Outcome measures

Primary: BMI, waist circumference, waist hip ratio and body composition analyzer (free fat mass, muscle mass and water content).

Secondary: Pain, quality of life, depression, anxiety, and stress.

2.6. Statistical analysis

The unpaired t-test was conducted for comparison of age between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene’s test for homogeneity of variances was conducted to test the homogeneity between groups. Two-way mixed MANOVA was performed to compare within and between groups effects on outcome measures. Post-hoc tests using the Bonferroni correction were carried out for subsequent multiple comparison. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

3. RESULTS

3.1. Subjects' characteristics

One hundred adolescent females participated in this study with age of 12 to 17 years old, with SG mean age of 13.44 ± 1.29 and that of CG was 13.74 ± 1.08 years. No significant age difference was recorded between groups ($p = 0.29$).

3.2. Comparison between both groups regarding BMI, WC, WHR, fat mass, muscle mass, water content, PedsQL, depression, anxiety, stress score, VAS and borg scale

Two-way mixed MANOVA revealed a significant interaction of treatment and time ($F = 8.12$, $p = 0.001$, partial eta squared = 0.53). There was a significant main effect of time ($F = 262.96$, $p = 0.001$, partial eta squared = 0.97). There was a significant main effect of treatment ($F = 4.12$, $p = 0.001$, partial eta squared = 0.36).

There was a significant decrease in BMI, WC, WHR, fat mass and water content and a significant increase in muscle mass post treatment compared with that pretreatment in SG and CG ($p < 0.001$) (Table 1).

There was a significant increase in PedsQL and a significant decrease in depression, anxiety and stress scores, VAS and borg scale post treatment compared with that pretreatment in SG and CG ($p < 0.001$) (Table 2).

Comparison between groups post treatment revealed a significant decrease in BMI, stress score, VAS and borg scale of SG compared with that of CG ($p < 0.05$). There was a significant increase in PedsQL of SG compared with that of CG ($p < 0.01$). No significant difference in WC, WHR, fat mass, muscle mass, water content, depression and anxiety scores ($p > 0.05$) (Tables 1-2).

Table 1. Mean BMI, WC, WHR, fat mass, muscle mass and water content pre and post treatment of group A and B

	Study group SG	Control group CG			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**Cohen effect size**
BMI (kg/m²)					
Pre treatment	32.71 ± 1.30	32.50 ± 1.52	0.21 (-0.36: 0.77)	0.47	
Post treatment	22.27 ± 1.98	26.27 ± 2.61	-4 (-4.92: -3.08)	0.001	1.73
MD (95% CI)	10.44 (9.76: 11.12)	6.23 (5.55: 6.91)			
	p = 0.001	***p = 0.001***			
WC (cm)					
Pre treatment	88.06 ± 3.30	87.02 ± 3.17	1.04 (-0.24: 2.32)	0.11	
Post treatment	81.04 ± 4.04	81.94 ± 3.67	-0.9 (-2.43: 0.63)	0.25	0.23
MD (95% CI)	7.02 (6.14: 7.89)	5.08 (4.20: 5.96)			
	p = 0.001	***p = 0.001***			
WHR					
Pre treatment	0.93 ± 0.06	0.92 ± 0.05	0.01 (-0.02: 0.03)	0.55	
Post treatment	0.84 ± 0.02	0.85 ± 0.04	-0.01 (-0.02: 0.007)	0.41	0.32
MD (95% CI)	0.09 (0.07: 0.10)	0.07 (0.06: 0.09)			
	p = 0.001	***p = 0.001***			
Fat mass (%)					
Pre treatment	37.87 ± 3.07	37.73 ± 3.14	0.14 (-1.09: 1.37)	0.82	
Post treatment	33.22 ± 3.45	34.14 ± 2.82	-0.92 (-2.17: 0.34)	0.15	0.26
MD (95% CI)	4.55 (4.01: 5.29)	3.59 (2.95: 4.23)			
	p = 0.001	***p = 0.001***			
Muscle mass (%)					
Pre treatment	52.25 ± 3.18	51.52 ± 3.30	0.73 (-0.55: 2.02)	0.26	
Post treatment	52.76 ± 3.12	52.24 ± 3.22	0.52 (-0.73: 1.79)	0.41	0.16
MD (95% CI)	-0.51 (-0.67: -0.37)	-0.72 (-0.87: -0.7)			
	p = 0.001	***p = 0.001***			
Water content (%)					
Pre treatment	48.74 ± 5.33	48.64 ± 6.00	0.1 (-2.15: 2.36)	0.92	
Post treatment	43.39 ± 6.79	45.22 ± 6.59	-1.83 (-4.49: 0.82)	0.17	0.27
MD (95% CI)	5.35 (4.51: 6.19)	3.42 (2.57: 4.25)			
	p = 0.001	***p = 0.001***			

Note. SD: Standard deviation; MD: Mean difference; CI: Confidence interval; p-value: probability value

Table 2. Mean PedsQL, depression, anxiety, stress score, VAS and borg scale pre and post treatment of group A and B

	SG	CG			
	Mean ± SD	**Mean ± SD**	**MD (95% CI)**	**p value**	**Cohen effect size**
PedsQL					
Pre treatment	1510 ± 86.89	1517.20 ± 104.86	-7.2 (-45.42: 31.02)	0.71	
Post treatment	1865 ± 175.62	1781 ± 149.79	84 (19.22: 148.78)	0.01	0.51
MD (95% CI)	-355 (-397.95: -312.05)	-263.8 (-306.75: -220.85)			
	p = 0.001	***p = 0.001***			
Depression score					
Pre treatment	8.18 ± 3.44	8.04 ± 4.17	0.14 (-1.38: 1.66)	0.86	
Post treatment	3.02 ± 1.44	3.18 ± 1.57	-0.16 (-0.76: 0.44)	0.59	0.11
MD (95% CI)	5.16 (4.39: 5.93)	4.86 (4.09: 5.63)			
	p = 0.001	***p = 0.001***			
Anxiety score					
Pre treatment	9.24 ± 4.56	8.96 ± 4.39	0.28 (-1.49: 2.06)	0.75	
Post treatment	3.70 ± 1.39	3.22 ± 1.73	0.48 (-0.14: 1.10)	0.13	0.31
MD (95% CI)	5.54 (4.63: 6.45)	5.74 (4.83: 6.65)			
	p = 0.001	***p = 0.001***			
Stress score					
Pre treatment	10.88 ± 4.87	10.12 ± 4.06	0.76 (-1.02: 2.54)	0.39	
Post treatment	2.92 ± 1.40	3.70 ± 1.80	-0.78 (-1.42: -0.14)	0.01	0.48
MD (95% CI)	7.96 (7.01: 8.91)	6.42 (5.47: 7.37)			
	p = 0.001	***p = 0.001***			
VAS					
Pre treatment	5.36 ± 1.61	5.40 ± 1.49	-0.04 (-0.65: 0.58)	0.89	
Post treatment	2.98 ± 0.98	3.84 ± 1.09	-0.86 (-1.27: -0.45)	0.001	0.83
MD (95% CI)	2.38 (2.06: 2.70)	1.56 (1.24: 1.88)			
	p = 0.001	***p = 0.001***			
Borg scale					
Pre treatment	6.22 ± 0.79	6.06 ± 0.77	0.16 (-0.15: 0.47)	0.31	
Post treatment	2.26 ± 1.35	2.84 ± 1.23	-0.58 (-1.09: -0.07)	0.02	0.45
MD (95% CI)	3.96 (3.61: 4.31)	3.22 (2.87: 3.57)			
	p = 0.001	***p = 0.001***			

Note. SD: Standard deviation; MD: Mean difference; CI: Confidence interval; p-value: probability value

4. DISCUSSION

This study demonstrated that VR games can significantly improve QoL and reduce perceived exertion, stress and pain among adolescent females, making physical activity more enjoyable and engaging. However, both VR gaming and traditional aerobic exercise and diet interventions were similarly effective in addressing depression, anxiety, and waist circumference. These findings suggest that VR gaming can be a valuable complementary tool in promoting adolescent well-being, particularly for enhancing QoL, though it may not provide superior benefits in all areas of health compared to traditional methods.

The most significant finding from this study is that adolescent females who engaged in VR games reported higher QoL scores compared to those in the aerobic exercise and diet group. VR games offer an immersive and gamified experience, which may appeal to adolescents by making exercise feel more like entertainment rather than a chore. The novelty and engagement in VR environments have been shown to reduce the mental fatigue associated with traditional physical activities (Kokaridas et al., 2021).

The findings of this study contributed to the growing body of research suggesting that VR games can enhance QoL in ways that traditional exercise and diet programs may not. The significant improvements in QoL and perceived exertion highlight the potential for VR games to be used as a complementary tool in promoting well-being among adolescent females, particularly for those who may struggle with adherence to conventional exercise programs. The enjoyable and immersive nature of VR games likely plays a key role in sustaining engagement and fostering positive perceptions of physical activity, leading to greater overall improvements in QoL (Staiano & Calvert, 2011).

The improvement in QoL can be attributed to several factors, including the interactive nature of VR, which fosters higher levels of emotional engagement and satisfaction. Studies suggested that the immersive features of VR increase motivation and adherence to physical activities, leading to greater improvements in overall well-being (Rizzo & Bouchard, 2019). Social aspects of VR gaming, such as multiplayer modes, may also enhance emotional and social well-being by promoting social interaction and reducing feelings of isolation (Staiano et al., 2020).

These results were consistent with other studies demonstrating that gamified and VR-based exercises can make physical activity feel less strenuous, even when the intensity is similar to traditional exercise (Pope et al., 2020). The reduced perceived exertion in the VR group may help to explain why participants reported higher QoL; by feeling less physically taxed during exercise, they may have experienced the activity as more enjoyable, motivating, and sustainable over time. Previous research has shown that engagement in physically active video games, or "exergaming," can result in improvements in physical health, social interaction, and mental well-being, contributing to a higher overall quality of life (Wang et al., 2022). This could explain why the VR group exhibited greater gains in life satisfaction and well-being compared to those in the aerobic and diet intervention (Lee et al., 2021).

Despite the significant differences in QoL and perceived exertion, the study found no significant differences in depression and anxiety levels between the two groups. Both interventions led to reductions in these psychological variables, but the effects were similar across both groups. This outcome is consistent with recent research indicating that physical activity, regardless of modality, can have a positive impact on mental health by reducing symptoms of depression, anxiety, and stress (Murray et al., 2021). Thus, the findings suggest that both aerobic exercise and VR gaming are equally effective in addressing mental health concerns in adolescent females (Vorderer et al., 2020).

Previous research supports the notion that gamified exercise, particularly VR-based interventions, can enhance QoL by making physical activity more enjoyable and reducing the perceived effort required for exercise (Schoenfeld et al., 2019). VR games create an entertaining and stimulating environment that distracts participants from the physical exertion associated with exercise, which might explain why the VR group reported higher QoL despite engaging in a similar level of physical activity as the aerobic group. Additionally, the interactive and immersive nature of VR may lead to enhanced emotional engagement and a sense of achievement, which could contribute to improvements in various dimensions of QoL, including emotional and social well-being (Anderson-Hanley et al., 2018).

VR interventions for mental health, including stress management, have become increasingly popular. Research by Côté et al. (2019) demonstrated that VR-based therapeutic interventions could effectively reduce stress in adolescents. Their study highlighted how virtual environments that simulate calming settings, such as nature or peaceful spaces, can trigger a relaxation response, reducing cortisol levels, which are biomarkers of stress. Which was also proved by Gutiérrez-Maldonado et al. (2015) they compared VR relaxation environments with traditional relaxation techniques and noted a marked improvement in stress reduction in the VR group.

Previous literature has supported the notion that exercise, regardless of form, can reduce symptoms of depression and anxiety and improve stress management (Rosenbaum et al., 2014). However, the lack of significant differences in this study could suggest that both VR and traditional aerobic exercises are equally effective at providing psychological benefits, likely through mechanisms such as endorphin release and improved self-efficacy (Craft & Perna, 2004).

The findings showed a significant difference in the Borg scale ratings, with the VR group reporting lower perceived exertion than the aerobic exercise and diet group. The use of immersive VR environments likely plays a key role in diverting participants' attention from the discomfort associated with physical exertion, making the activity feel less strenuous (Gao et al., 2021).

It is possible that the immersive nature of virtual reality exercises could have masked the perceived intensity, making participants feel as though the exercise was less strenuous than traditional aerobic routines, even though they were exerting a similar amount of effort (Smith et al., 2020).

Another notable finding was the significant difference in the Borg scale ratings between the two groups, with participants in the VR group reporting lower perceived exertion compared to those in the aerobic exercise and diet group (Baños et al., 2016). These results suggest that VR games could be an effective tool for increasing physical activity levels in adolescents who may be resistant to traditional exercise due to feelings of exertion (Viana et al., 2018). No significant difference was found between the two groups in terms of waist circumference (WC), indicating that both interventions had a similar impact on body composition. This finding suggests that while VR games can enhance QoL and reduce perceived exertion, they may not offer additional benefits over traditional aerobic exercise and diet programs in terms of physical health markers such as WC (Finkelstein et al., 2020).

Contrary to expectations, no significant difference was found between the two groups in terms of waist circumference (WC). This indicates that both interventions were equally effective, or ineffective, in influencing body composition and reducing central obesity. The lack of significant differences may be attributed to the short duration of the intervention, as changes in WC typically require longer periods of consistent activity and dietary modifications (Janssen et al., 2012). Furthermore, VR games, although effective at increasing physical activity, may not always engage participants at the same intensity level as traditional aerobic exercises, which could explain the similar WC outcomes (da Silva et al., 2021). However, the lack of differences in depression and anxiety suggests that while VR may enhance subjective well-being, its effects on clinical mental health outcomes may not surpass those of traditional exercise (Murray et al., 2021).

Exercise, regardless of the mode, is known to have antidepressant and anxiolytic effects by promoting the release of endorphins, improving sleep patterns, and reducing cortisol levels (Rebar et al., 2015). Therefore, it is not surprising that both interventions yielded similar results in reducing depression, and anxiety. The findings indicate that while VR games may offer additional QoL benefits, both forms of intervention can effectively address psychological distress. The absence of significant differences in mental health outcomes may also suggest that the immersive and interactive aspects of VR are not necessarily superior to traditional exercise when it comes to managing depression and anxiety. Instead, the primary benefits of VR may lie more in enhancing subjective well-being and quality of life rather than directly impacting clinical mental health outcomes (Li et al., 2019).

Both groups showed similar outcomes with respect to waist circumference and body fat composition. These findings align with previous studies demonstrating that physical activity, regardless of format, can lead to reductions in body fat and waist circumference over time, especially when combined with dietary interventions (Thivel et al., 2016). The absence of significant differences in these variables suggests that while virtual reality games may enhance the quality of life and motivation to exercise, they do not necessarily offer superior advantages in terms of body composition changes compared to traditional aerobic exercise (Nigg et al., 2020).

Additionally, the similarity in WC outcomes suggests that while VR games can increase physical activity and improve QoL, they may not necessarily have a greater impact on physical health markers like WC compared to traditional exercise. This is consistent with findings from studies that suggest while gamified exercise can promote physical activity, its impact on body composition may not differ significantly from other forms of exercise (Maddison et al., 2012).

Future research should also explore the use of different types of VR games and their specific effects on health and well-being. Understanding how various game mechanics, levels of immersion, and social interaction within VR environments influence outcomes could help optimize these interventions for adolescent females (Vorderer et al., 2020).

While this study provides valuable insights, it is important to acknowledge its limitations. The sample size may have limited the statistical power to detect subtle differences in mental health and WC outcomes. Future studies should include larger, more diverse populations to better understand the impact of VR games on different groups of adolescents (Staiano et al., 2020). Additionally, the relatively short duration of the intervention may not have been sufficient to observe significant changes in WC. Longitudinal studies are needed to assess the long-term effects of VR games on both physical and mental health outcomes (Finkelstein et al., 2020).

Several limitations must be acknowledged. First, the study's sample size may have limited the statistical power to detect subtle differences in mental health outcomes and WC. Future research should include larger, more diverse samples to ensure the generalizability of the findings. Additionally, the relatively short duration of the intervention may have limited the ability to observe changes in WC, which often requires more extended periods of intervention to show significant reductions.

5. CONCLUSIONS

The results of this study underscore the potential of virtual reality games as a viable and effective tool for enhancing the quality of life among adolescent females, particularly when combined with aerobic exercises and dietary interventions. While significant differences were observed in quality-of-life, Borg scale and stress outcomes, other variables such as depression, anxiety and body composition remained unchanged between the groups. These findings suggest that while VR games may provide a more engaging and enjoyable exercise experience, their effects on certain health outcomes may be comparable to traditional exercise modalities. Future research should continue to explore the long-term impact of virtual reality games on both physical and psychological health to better understand their potential role in health promotion strategies for adolescents.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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