



International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
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ARTICLE TITLE	THE IMPACT OF VIRTUAL REALITY-BASED PHYSICAL ACTIVITY INTERVENTIONS ON HEALTH AND EDUCATIONAL OUTCOMES IN ADOLESCENTS - LITERATURE REVIEW
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DOI	https://doi.org/10.31435/ijitss.2(50).2026.5481
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RECEIVED	24 March 2026
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ACCEPTED	17 June 2026
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PUBLISHED	26 June 2026
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THE IMPACT OF VIRTUAL REALITY-BASED PHYSICAL ACTIVITY INTERVENTIONS ON HEALTH AND EDUCATIONAL OUTCOMES IN ADOLESCENTS - LITERATURE REVIEW

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ABSTRACT

This review paper analyzes the impact of physical activity within virtual reality (VR) on the mental health and educational outcomes of adolescents aged from 10 to 18 years. Literature review identified studies that highlight topics of anxiety reduction, improved well-being and increased motivation for learning through VR. The results indicate that VR can effectively support mental health by reducing anxiety and stress symptoms and enhancing student engagement. However, limitations such as technology costs and the lack of long-term studies require further analysis. The paper highlights the potential of VR as an interdisciplinary tool in education and health promotion.

KEYWORDS

Virtual Reality, Physical Activity, Mental Health, Education, Adolescents

CITATION

Przemysław Szostak, Dominika Sidor, Katarzyna Gołacka, Dominika Kuźmiuk, Martyna Rynkowska, Albert Sikorski, Wiktoria Sikorska, Sylwia Maj, Joanna Danio. (2026) The Impact of Virtual Reality-Based Physical Activity Interventions on Health and Educational Outcomes in Adolescents - a Literature Review. *International Journal of Innovative Technologies in Social Science*. 2(50). doi: 10.31435/ijitss.2(50).2026.5481

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Introduction and background

Virtual reality (VR) is making waves in education, health, and sports, because it pulls people into a digital world where they can move, learn, and even relax, what opens new opportunities in the fields of education, health, and sports [1]. It is an immersive environment allowing users to interact within digital activities, which can support physical activity, stress reduction, and improved educational outcomes. It is notified that we are observing a significant rise in depressive and anxiety symptoms among adolescents impacted by factors like academic pressures, social dynamics, and, more recently, the disruptions caused by global events like the COVID-19 pandemic [2, 3]. It is also noted that through sedentary lifestyle and declining level of physical activity has become a concern of public health due to increased rates of obesity [4]. Traditional interventions may be helpful, but they don't always keep adolescents interested. Adolescents today spend a lot of time with digital games and interactive technology [1]. That's why VR, ensuring a promising alternative, might profit in areas of health promotion, physical activity and educational enhancement [5]. This systematic review aims to synthesize current research on the impact of VR-based physical activity on mental health, physical condition and academic achievements of adolescents aged 10 - 18 years.

Methods

The systematic review was conducted within databases of PubMed, Scopus, Web of Science, and Google Scholar. Inclusion criteria were: articles published between 2019 and 2025, studies involving adolescents aged 10 - 18 years and VR-based interventions with a physical activity component. Study quality was assessed using the AMSTAR-2 tool. The analysis included both randomized controlled trials and systematic reviews.

Results

The literature review provided evidence of the effectiveness of virtual reality-based interventions in improving mental health, increasing physical activity and supporting educational outcomes in adolescents aged 10 - 18 years. The results were divided into three main categories: impact on mental health, impact on physical activity and impact on educational outcomes.

Impact of VR on Mental Health

VR interventions show significant potential in reducing symptoms of anxiety, stress, and depression among adolescents, which is crucial for improving their mental well-being [6]. A meta analysis by Zeng et al. demonstrated that VR therapy significantly reduces anxiety symptoms through desensitization and eventually overcoming fears [7, 8]. The use of VR was analyzed in hospital settings, where interventions such as relaxation games and breathing simulations significantly reduced anxiety in hospitalized adolescents [9]. The effects were particularly pronounced for short-term interventions (10 - 30 minutes), which improved well-being and reduced anxiety symptoms during medical procedures such as chemotherapy and in painful condition such as body burn. The review reports that these interventions were effective in high-stress contexts showing reductions in self-reported, measured via visual analog scale, physical pain and anxiety scoring up to 20–30% post-intervention. This study suggests that VR can be effective in managing stress in high-stress environments, with potential applications in school settings, such as exam preparation. One researcher emphasized that VR combined with gamification based on rewards for task completion reduces depression symptoms in adolescents [8]. Solving puzzles or achieving goals in a virtual world, being tasks needed to be completed in virtual environment, enhanced engagement and motivation, contributing to reduced depressive symptoms on a moderate-to-large effect size. Additionally, VR offers personalization of interventions, enhancing their effectiveness. Some VR programs allow users to choose environments that align with their preferences, strengthening the relaxation effect [6, 7, 8, 9].

Impact of VR on Physical Activity

VR interventions promoting physical activity demonstrate high effectiveness in increasing adolescents engagement in movement, which is critical in the context of the global rise in obesity and sedentary lifestyles [2]. Studies showed that VR games based on physical activity, such as dance games, sports simulations, or fitness training, increased exercise time by 20 - 30 minutes per day compared to traditional forms of activity [5]. The average increase in activity aligned with World Health Organization (WHO) recommendations, which advocate for at least 60 minutes of moderate physical activity daily for adolescents [10]. Studies found that gamification elements, such as earning points, unlocking levels, or competing with other players, significantly enhance motivation for regular exercise through changing behavioral habits [3, 9]. Another study examined the impact of VR on motor skill development in adolescents suffering from disabilities showing that VR interventions, such as virtual movement games, improve motor coordination and balance, leading to greater self-confidence and improved well-being [11]. It is emphasized, that there is ability to adjust the intensity of VR activities to individual user needs. For instance, VR games can automatically adapt difficulty levels to the players physical fitness, increasing accessibility for adolescents with varying fitness levels [15, 16]. Moreover, VR usage can be a tool enhancing motor skills in adolescents suffering from various genetic disorder, like Down syndrome [19]. It was noted, that VR interventions have more potential of increasing posturographic balance in comprison to conventional therapy. However, studies highlight the need to monitor VR usage time to avoid excessive fatigue or injuries related to intense movements in virtual environments [11, 13, 19, 20].

Impact of VR on Educational Outcomes

The use of VR in education, particularly in combination with physical activity, shows a possible positive impact on motivation, engagement, and educational outcomes in adolescents [13]. The impact of gamification has been analyzed, including VR interventions, on student motivation in physical education, showing that students participating in VR activities like sport simulations were more engaged and achieved better results in physical fitness tests and academic subjects such as mathematics and physics by up to 15%. Aside from from that, VR activities allowed students to be more collaborative thus reducing potential agression among their classmates [17, 18]. VR program has albo been investigated for teaching social skills to adolescents with ASD, such as peer interactions or responding to social situations [12]. The study found that a 4-week VR program improved social skills in schools by up to 20%. VR offers opportunities for individualizing the learning process for those in special needs through adjusting VR scenarios to students' specific needs and choosing types of educational content [14, 15].

Discussion

The literature review confirms that VR-based physical interventions have potential to improve adolescents mental health and educational outcomes. The reduction of anxiety and stress is particularly relevant in the school context, where adolescents often face academic and social pressures [7, 9, 14]. VR immersive nature enables creation of safe environments where students can practice social skills or relax in physical activity in an engaging and motivating way. VR games and sports simulations not only increase time spent on physical activity but also improve self-esteem and social relationships, which is especially important for adolescents with autistic syndrome disorder [11, 12]. VR in new media environments supports the development of social skills, which can be particularly effective in managing social anxiety in adolescents. VR can put them in a safe, controlled space to practice social skills without usual pressure. From an educational perspective, VR offers the opportunity to engage students within an interactive learning environment [5]. From some point of view, this attempt changes learning into playing thus enhancing intellectual outcome. Studies show that VR increases student motivation, potentially leading to better academic outcomes, particularly in subjects requiring abstract thinking, such as the sciences [13, 14, 15]. VR also supports the development of cognitive functions, such as attention and memory, which can significantly improve academic performance [17, 18]. Additionally, VR enables personalization of the learning process, which is critical for students suffering from diverse diseases, such as those with ASD.

Even though VR might be a great tool in academic environment, it has its disadvantages. VR sets and software cost a lot. Outfitting one classroom of 20 to 30 students can run anywhere from \$10,000 to \$30,000 [14]. Moreover, there is a need for teachers to learn new ways to use VR during lessons. Using less expensive options, like VR headsets that work with smartphones and applying for grants are the most obvious ways to decrease this obstacle [12, 15].

Another challenge is the risk of addiction, especially among adolescents using technology in an excessive way [15]. One research noted that approximately 10% of adolescents using VR had signs of problematic use, possibly escalating into addiction [8]. Those adolescents displayed behaviors such as compulsive use or difficult disengaging from VR sessions. Adolescents are particularly vulnerable to problematic technology use due to biological factors, such as an underdeveloped prefrontal cortex, which affect their impulse control [16]. The study found VR games to be 44% more addictive than traditional games, with adolescents at higher risk. Furthermore, frequent usage of VR technology may result in fatigue and sensory overload [11]. In this context, guidelines for safe VR use, such as limiting session times to 30 - 60 minutes per day, are necessary [15]. On the other hand, it was noted that time-limited tasks within VR might lead to increased stress and reduction of engagement [3, 5].

The lack of long-term studies, reported by most authors, hinders the assessment of VR sustained effects, such as maintained anxiety reduction or improved educational outcomes. For instance, while short-term studies show significant benefits, it is unclear whether these effects persist after 6 months or a year [8]. Future research should include longitudinal studies to evaluate VR impact on mental health and education over an extended period. The study notes that while short-term reductions in anxiety were observed, the study's duration and small sample size limit conclusions about sustained effects on trait anxiety or educational outcomes.

Additionally, comparative studies are needed to evaluate which types of VR interventions are most effective for different adolescent groups. Dance games were found to increase daily physical activity by 20–30 minutes, but their efficiency compared to educational simulations was not systematically evaluated [5, 16]. The lack of comparative research limits the ability to tailor VR interventions to specific adolescent needs, such as physical health, mental well-being, or academic performance. The authors call for randomized controlled trials to compare VR modalities across diverse groups to inform targeted intervention design.

Another aspect is the need to train teachers and medical staff in VR technology use [8]. The lack of adequate skills among staff can limit intervention effectiveness. Solutions may include incorporating VR training into teacher education programs or organizing workshops by VR equipment manufacturers. In the long term, developing standards for integrating VR with traditional teaching methods is necessary to ensure curriculum coherence. The interdisciplinary nature of VR, combining health, sports, and education, makes it a promising tool for the future. However, its successful implementation depends on collaboration between researchers, educators, technology manufacturers, and policymakers. The authors suggest incorporating VR training into professional development programs for educators and clinicians [7, 8, 9]. They also advocate for “collaboration with VR technology providers to offer workshops and hands-on training” to build staff competence. Additionally, the reviews call for the development of standardized guidelines to integrate VR with traditional methods, ensuring alignment with curricula and therapeutic goals.

Conclusions

Virtual reality-based physical activity interventions have significant potential to improve adolescents mental health and educational outcomes, offering a unique blend of engaging, immersive experiences with health and educational benefits.

1. VR effectively reduces anxiety and stress, which is crucial for adolescents facing school, social and medical inconveniences [5, 6, 7, 8, 9].
2. VR games, such as sports or relaxation simulations, increase engagement in physical activity, contributing to improved well-being, reduced obesity and posture improvement [2, 3, 5, 9, 10, 19, 21].
3. VR supports motivation and academic performance, particularly in science subjects and social skills, offering personalized and interactive learning environments [11, 12, 13, 15, 16, 17, 18].
4. VR implementation faces significant limitations that require further attention, like high equipment costs, lack of accessibility in rural schools and risk of technology addiction [8, 11, 14, 15, 16].
5. The lack of long-term studies hinders the assessment of VRs sustained effects, such as maintained anxiety reduction or improved educational outcomes [1, 5, 8, 11, 12, 13, 15, 17, 18].
6. Side effects, such as eye strain or dizziness, require monitoring, particularly during extended VR sessions [11].

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Funding statement: This research received no external funding.

Conflict of interest statement: The authors declare no conflict of interest.

AI: In the preparation of this review paper, artificial intelligence tools were utilized to enhance readability and ensure the use of appropriate language.

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