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Article

The Integration of Virtual Reality Technology in Physical Education Settings: Effects on Students' Physical Activity and Motor Skills

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Abstract

Objective: This study aims to examine the effect of integrating virtual reality (VR) technology in physical education (PE) settings on the development of motor skills among students.
Materials and methods: The study used a 8-week pre-test and post-test control group experimental design involving 70 participants divided evenly into an experimental group ($n = 35$) that received a VR-based intervention program and a control group ($n = 35$) that followed traditional PE learning. Physical activity (ActiGraph GT9X Link accelerometer) and motor skills (Test of Gross Motor Development) were assessed at pretest and posttest.
Results: A significant effect of the teaching factor ($p < .001$), the time factor ($p < 0.001$) to the teaching × time interaction factor ($p = 0.003$) that influenced physical activity component. Significant effects were found for the teaching effect factor ($p < .001$), the time effect factor ($p < 0.001$) to the teaching × time interaction factor ($p < 0.001$) that affects the Locomotor skills component. Significant effects were found for the teaching effect factor ($p = 0.015$), the time effect factor ($p < 0.001$) to the teaching × time interaction factor ($p < 0.001$) that affects the Object control skills component.
Conclusion: The integration of virtual reality technology in physical education settings has been shown to significantly increase physical activity and motor skills among students. Structured and standardized VR-based intervention programs demonstrate high consistency of implementation and have been empirically proven to be effective as pedagogical tools for meaningful teaching in school physical education settings.

Keywords: Virtual reality-based physical education; physical activity, locomotor skills; object control skills

Introduction

The development of digital technology over the past two decades has opened up transformative opportunities for the world of education, including in the context of physical education (PE) (Martín-Rodríguez & Madrigal-Cerezo, 2025). In this context, the traditional PE paradigm has shifted towards PE that involves technological assistance in order to keep up with the times and ultimately achieve more optimal learning outcomes (Zhong et al., 2025). Among the various modern technological innovations that have emerged are smartphones, tablets (Saiz-González et al., 2025), augmented reality (Liang et al., 2023) and virtual reality (VR) (Pérez-Muñoz et al., 2024). Essentially, VR occupies a strategic position as an immersive learning medium capable of replicating movement experiences in a virtual environment within the PE setting. Furthermore, VR is a type of technology that is currently experiencing increased popularity and has become a trend in the field of PE. This is supported by two previous systematic review studies that collected data from WOS, Scopus, and PubMed, which have recorded a significant surge in research on the use of VR in physical education, with the highest concentration in the 2021–2024 period, reflecting the acceleration of global academic interest in this topic (Fernández-Vázquez et al., 2024).

In this context, VR emerges as a promising solution with the potential to help teachers achieve more optimal learning outcomes (Karadag et al., 2025). Several empirical studies have demonstrated the effectiveness of VR-based interventions in improving physical fitness and motor coordination (Giakoni-Ramírez et al., 2023; Komariah et al., 2024). Furthermore, Bae, (2023) found that a VR-based PE program implemented in elementary school students in South Korea significantly improved physical fitness components compared to the control group, indicating the potential of VR as a substitute or complement to traditional teaching methods. Meanwhile, a systematic review conducted by Utamayasa & Mardhika, (2024) revealed that interactive VR can promote improvements in students' motor skills. On the other hand, the literature also reveals a number of challenges in implementing VR in PE environments, including: limitations in school infrastructure, gaps in teacher competence in operating technology, and limitations in study design, with the majority using small samples and short intervention durations. This indicates that while the initial evidence is very promising, further research is needed to strengthen the evidence base for the use of VR in PE (Pérez-Muñoz et al., 2024).

Physical activity is a fundamental element that determines the long-term health and quality of life of students today and in the future (Sampaio et al., 2025). In the context of PE in schools, physical activity is key for students to learn motor skills. According to the World Health Organization (WHO), physical activity is any movement of the body produced by skeletal muscles that requires energy expenditure. According to one study, the recommended amount of physical activity is 60 minutes per day in PE class. In addition, student achievement in PE class depends on the amount of time spent exercising, and being physically active is important for them (Pelemiš et al., 2024). Several reports from experts show that consistent physical activity can provide several benefits, such as reducing cardiovascular disease (Jevdjevic et al., 2025), reducing obesity, reducing chronic pain (Latino & Tafuri, 2023) and ultimately reducing the risk of death (Kljajević et al., 2022). It has also been reported that physical activity has been proven to significantly reduce stress, depression, or anxiety disorders (Brioa Saez et al., 2025).

Another aspect that is no less important for students is motor skills, which are one of the fundamental competencies that are the core objectives of PE in schools (Zhou et al., 2021). These motor skills encompass two main dimensions, namely gross motor skills, which involve the coordination of large muscle groups such as running, jumping, and throwing (Piotrowski et al., 2025) and fine motor skills, which refer to the precision of small muscle movements (Zhang et al., 2024). Good mastery of motor skills at school age contributes significantly to active participation in sports, long-term physical health, and the cognitive and social development of students (Fu & Ji, 2023). However, various reports indicate that conventional teaching methods in PE often face limitations in providing sufficient repetitive practice, precise real-time feedback and a safe learning environment for exploring high-risk movements (Fernández-Vázquez et al., 2024).

The present study

To the best of our knowledge, there has been no specific and comprehensive study examining the integration of VR technology in PE settings on the improvement of physical activity and motor skills among elementary school students. Previous studies have focused on examining the effects of VR, physical activity, and motor skills through systematic reviews (Fu & Ji, 2023; Sun & Chen, 2024), so the generalization of the findings is still limited. Therefore, this study aims to investigate the effect of VR integration on the development of physical activity and motor skills among elementary school students in a formal PE setting.

Materials and Methods

Study Design

This study used a quantitative approach with a pretest-posttest control group experimental design. The experimental group received a VR-based intervention program, while the control group followed traditional PE learning for an equivalent duration. Thus, the stages in this study design are: information collection and anthropometric measurements, pretest (physical activity and motor skills), random assignment, experimental group (VR 3 sessions/week), control group (traditional PE teaching or without VR), posttest (physical activity and motor skills) until data analysis (Fig. 1).

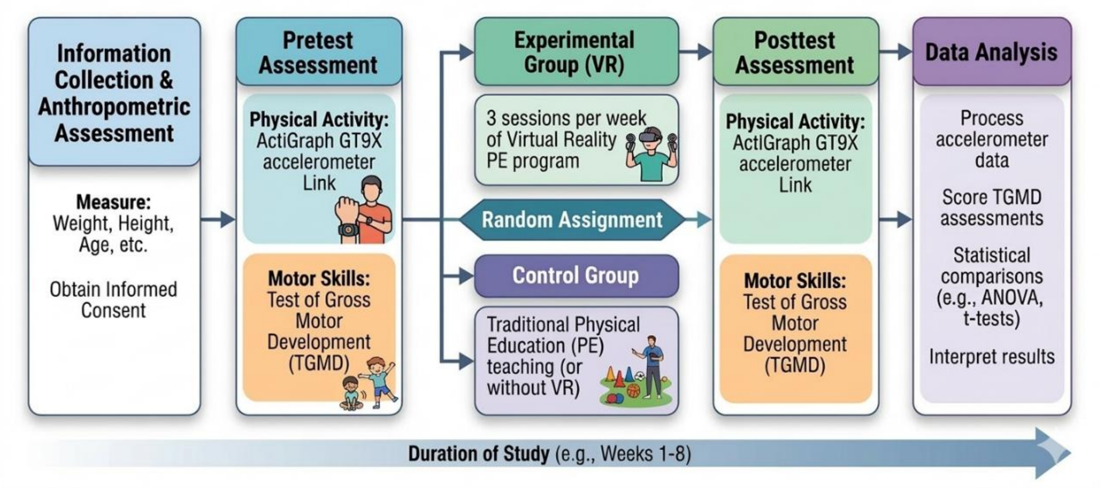

Figure 1.

Experimental study design

Sample Size Calculation and Participants

The sample size was determined using G*Power version 3.1.9.7 analysis with effect size parameters f = 0.25, α = 0.05, and power (1-β) = 0.80, resulting in an estimated minimum of 64 participants. Considering a potential dropout rate of 5%, the total sample was set at 70 students. With the minimum number of participants known, male and female students in grades V and IV from two public elementary schools in Tunisia were selected using the following inclusion criteria: (i) actively enrolled in a formal PE program, (ii) no history of chronic diseases that could interfere with the intervention program, (iii) no history of cybersickness, and (iv) written consent from parents or guardians. From the selection results, 70 students were divided evenly into an experimental group (VR, n = 35) and a control group (CG, n = 35). Before the study was conducted, all participants were given information about the voluntary nature of the study, its rules, and its benefits. In addition, they were given the freedom to withdraw from our research activities at any time. This study has been approved by the Ethics Committee of the Elementary School in Tunisia (registration number: 975/2024) and our study was conducted in accordance with the principles of the Declaration of Helsinki (2013) (Battaglia et al., 2020).

Table 1.
Demographic characteristics of participants in both groups

Groups	Age (years)	Height (cm)	Weight (kg)
	X ± Std. Dev	X ± Std. Dev	X ± Std. Dev
VR	14.0 ± 0.686	131 ± 5.28	39.2 ± 4.58
CG	14.2 ± 0.568	134 ± 6.62	41.8 ± 6.99

Note. VR; CG: Control group; X: Mean; Sta.Dev: Standard deviation.

Instruments

Information collection and anthropometric measurements: The research team collected information on age and gender during the first week. Anthropometric measurements related to height were then taken using a height measuring device (seca213, seca, Chiba, Japan) with an accuracy of ±0.1 cm. Body weight was evaluated through bioimpedance analysis (BIA) using TANITA MC-780MA (MC-780MA, Tanita, Tokyo, Japan).

Physical activity: Physical activity assessment in this study used the ActiGraph GT9X Link accelerometer. The device was worn on the right hip for seven consecutive days with instructions to wear it at all times except during sleep. Accelerometer data were processed using the Freedson algorithm to classify activity intensity into sedentary, light, moderate, and vigorous categories based on cut-off points validated for adolescent populations. The main variables extracted included the total number of counts per minute as an indicator of overall activity volume, the duration of moderate to vigorous physical activity in minutes per day, and the number of daily steps as a marker of general mobility. This instrument has been tested in our current study and the results show that the interclass correlation coefficient (ICC) is 0.86.

Motor skills: In the context of our study, assessing motor skills involved the use of the Test of Gross Motor Development-2 (TGMD-2), which covers the dimension of locomotor skills comprising six indicators: (i) running, (ii) horizontal jumping, (iii) galloping, (iv) hopping, (v) leaping, and (vi) sliding. Second, the object control skills dimension includes five indicators: (i) stationary bouncing, (ii) catching, (iii) two-hand striking, (iv) kicking while running, and (v) overhand throwing, which collectively reflect hand-eye coordination and manipulative movement control (Battaglia et al., 2020). Scoring on the TGMD-2 uses a score of 1 if the movement is performed correctly, a score of 0 if it is failed, and a score of 2 if the first and second attempts are performed correctly. The comprehensive FMS score is obtained by adding the test results from the two tests of all skill components. Meanwhile, locomotor and object control scores are calculated as the sum of skill scores in each subscale (Li et al., 2023). Based on these criteria, students will receive raw scores ranging from 0 to 48. In this study, the ICC values for each component of locomotor skills were 0.92 and for object control skills were 0.95.

Procedures

All activities were carried out from the first week to the eighth week of January-March 2025 at a school in Tunisia. In the first week, all participants collected information about their age and gender, followed by a pretest assessment of physical activity and motor skills. In the second week, participants in the VR and CG-based teaching groups carried out learning activities in PE class in the morning, specifically from 8:00 to 9:00 a.m. These activities were carried out until the seventh week. In the last week, or week eight, all participants underwent a post-test assessment in the form of physical activity and motor skills tests. All activities were closely monitored by the research team and assisted by three experts in the field of VR-based PE teaching.

VR Program

The VR and CG programs were implemented at a public elementary school in Tunisia that had adequate sports facilities. The VR and CG programs were implemented from the second week to the seventh week, with students required to wear full sports attire. For more details about the 8-week VR and CG programs, see Table 2.

Table 2.

Comparison of VR vs. CG Programs over 8 Weeks

Week	Learning activities with VR	Traditional Learning Activities	Duration;Rest
1	Pre-test: assessment of students' physical activity and motor skills		
2	Throwing and catching a ball in virtual reality. Jumping over obstacles in virtual reality. Kicking a ball at a target in virtual reality.	Practicing throwing and catching a ball in pairs. Kick the ball into the basket.	60 minutes; each game has a 5-minute break.
5-7	Catching targets (animals) in a virtual environment. Chasing and catching opponents in a virtual environment.	Running zig-zag through cones. Moving the ball from one location to another.	60 minutes; each game has a 5-minute break.
8	Posttest: assessment of students' physical activity and motor skills		

Statistical analysis

The mean (X) and standard deviation (Sta.dev) are reported for all dependent variables separately on the pretest and posttest. Preliminary analyses were conducted to test the statistical assumptions underlying repeated measures ANOVA, including the normality of data distribution using the Shapiro-Wilk test. We conducted a two-way repeated measures ANOVA with the within-subject factors of teaching (VR × CG) and time (pretest × posttest), and the interaction factor of teaching × time. Effect sizes were reported using partial eta squared to evaluate the practical magnitude of the detected effects, with the conventional interpretation that 0.01 indicates a small effect, 0.06 a moderate effect, and 0.14 a large effect. All data were analyzed using Jamovi v.2.3.28 (The Jamovi Project, Sydney, Australia).

Results

As shown in Table 3, the X values for all variables in the VR group changed significantly from the pretest to the posttest. Similar results were found in the CG, showing a change in X values from the pretest to the posttest. In addition, both the VR and CG groups showed normally distributed data for the variables of MVPA, locomotor skills, and object control skills.

Table 3.

Mean (X) and standard deviation (Sta.Dev) for the intervention and control groups

Variable	Group	Pretest		Posttest	
		X ± Sta.Dev	SW (p)	X ± Std. Dev	SW (p)
MVPA [minutes/day]	VR	38.4 ± 6.7	0.234	46.6 ± 5.9	0.267
	CG	37.9 ± 7.1	0.200	40.1 ± 6.8	0.209
Locomotor skills [Score]	VR	15.7 ± 1.24	0.315	23.3 ± 2.09	0.360
	CG	15.5 ± 1.76	0.271	18.8 ± 2.22	0.291
Object control skills [Score]	VR	17.1 ± 1.25	0.146	22.5 ± 2.55	0.185
	CG	20.1 ± 1.78	0.128	21.9 ± 1.59	0.229

Note. VR: Virtual reality; CG: Control group; X: Mean; Sta.Dev: standard deviation; SW: Shapiro Wilk's.

The effects of both teaching methods on physical activity

A significant effect of the teaching factor (VR × CG, F = 42.63; p < .001; n^2 p = 0.353), the time factor (pretest × posttest, F = 86.49; p < 0.001; n^2 p = 0.526) to the teaching × time interaction factor (F = 9.17; p = 0.003; n^2 p = 0.105) that influenced physical activity component (see Table 4).

The effects of both teaching on motor skills

Locomotor skills

Significant effects were found for the teaching effect factor (VR × CG, F = 36.7; p < .001; n2 p = 0.519), the time effect factor (pretest × posttest, F = 551.8; p < 0.001; n2p = 0.942) to the teaching × time interaction factor (F = 155.6; p < 0.001; n2p = 0.821) that affects the Locomotor skills component (see Table 4).

Object control skills

Significant effects were found for the teaching effect factor (VR × CG, F = 6.51; p = 0.015; n^2 p = 0.161), the time effect factor (pretest × posttest, F = 317.15; p < 0.001; n^2 p = 0.903) to the teaching × time interaction factor (F = 95.44; p < 0.001; n^2 p = 0.737) that affects the Object control skills component (see Table 4).

Table 4.

Effects of condition, time, and interaction factors on all variables

Variable	Effect	F	*p*	ηp²
MVPA [minutes/day]	Teaching	42.63	<.001	0.353
	Time	86.49	<.001	0.526
	Teaching × time interaction	9.17	0.003	0.105
Locomotor skills [Score]	Teaching	36.7	<.001	0.519
	Time	551.8	<.001	0.942
	Teaching × time interaction	155.6	<.001	0.821
Object control skills [Score]	Teaching	6.51	0.015	0.161
	Time	317.15	<.001	0.903
	Teaching × time interaction	95.44	<.001	0.737

Discussion

Our current research aims to investigate the effect of VR integration on physical activity and motor skills among elementary school students in a formal PE setting.

Our first finding shows that VR has a higher level of effectiveness than CG in increasing physical activity variables among students. This is certainly because VR can create a learning environment in PE classes that is much newer, more interesting and more challenging for students, thereby encouraging them to participate more actively in PE lessons. Our study findings are in line with a previous study that reported that the application of VR in sports practice led to an increase in the number of children participating in sports (Mcclure & Schofield, 2020). Furthermore, according to Li et al. (2023), training sessions involving VR have great potential to achieve high levels of physical activity and fitness, as VR provides a meaningful, easy-to-do, and enjoyable training experience that can motivate individuals to engage in physical activity. Several recent studies highlight additional benefits of using VR technology (Ramadan et al., 2026), such as reports that VR can provide an immersive training experience by simulating a real-time 3-D environment, which has been documented to promote significantly higher levels of physical activity during sports training sessions (Rahayu et al., 2026). Additionally, another report supports the findings of our study, explaining that there was a higher increase in physical activity in the VR group than in the CG, indicating that VR integrated into exercise has proven to be effective (Maden et al., 2022).

In this context, the use of VR allows students to actively engage in PE teaching sessions, because VR-based teaching provides variety and enjoyment for students. Another thing that VR offers is direct feedback on the physical activities that students must perform. Furthermore, from a psychological perspective, VR-based teaching is an important stimulus for intention and motivation, and can ultimately influence students to engage in more physical activity. This is also stated by Qian et al. (2020) that for decades physical activity has been the focus of attention and according to the World Health Organization (WHO) about 25% of adults and 80% of adolescents worldwide are physically inactive partly due to social and lifestyle changes, so the presence of VR technology is a tool to trigger interest and increase their physical activity behavior. Thus, VR-based PE instruction is not only a tool that can be used by teachers but also an innovative tool for designing teaching programs that meet the developmental needs of students in the modern era today (Bujang et al., 2025).

The second finding in our current study shows that VR-based PE teaching is also highly effective in improving motor skills among students compared to CG. This is because VR promotes teaching processes that cannot be obtained in traditional teaching. For example, VR can present a virtual physical activity environment that is similar to real-world situations, not to mention that VR offers game features that are more appealing to 10-year-old students. These advantages trigger the optimal development of motor skills. In line with this, a previous study supports our findings, showing that the use of VR on several students has been proven to improve motor skills (Fernández-Vázquez et al., 2024) . The higher improvement in motor skills after the intervention in the VR group shows that the designed learning activity program is attractive to students (Fu & Ji, 2023). A systematic review and meta-analysis study reported similar results, indicating that VR-based game programs have great potential in improving gross and fine motor skills in children (Xue et al., 2024). Thus, our study demonstrates that the primary factor causing significant changes in motor skills is due to VR technology utilizing a system that mimics real-world environments and can provide various activity scenarios (Roostaei et al., 2023). Through the creation of an artificially constructed three-dimensional virtual environment, users interact and influence each other with objects in the virtual environment naturally, thereby greatly expanding students' ability to understand, simulate, and adapt to the world (Karadag et al., 2025) .

Strengths, Limitations and Potential Directions for Future Research

Our current study has several strengths that are worth mentioning. First, we designed a VR-based teaching program that can be easily applied in the context of PE for public elementary school students. Second, the results of this study can be used as a reference by teachers in improving physical activity and motor skills. However, on the other hand, the limitation of our study is the low duration of VR integrated into PE classes, which is around 60 minutes per session. This may reduce the effect of VR on the results obtained. In addition, the participants only came from two public elementary schools in Tunisia. Thus, for future research, we suggest involving participants from several public or private elementary schools in Tunisia. Furthermore, future research could involve other types of research methods, such as mixed methods, so that findings can be obtained from both quantitative and qualitative data. This would allow researchers to discover new and more interesting findings.

Conclusion

Thus, we conclude that VR-based PE teaching programs have been proven effective in improving physical activity and motor skills among public elementary school students in Tunisia. Furthermore, this study highlights the application of VR technology as a modern instructional tool in pedagogy and adaptive in developing student potential. Going forward, these results pave the way for broader integration of VR into PE teaching systems and sports training. Thus, VR can evolve into a comprehensive digital teaching paradigm for the future.

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Author Contributions

Amayra Tannoubi: Conceptualization; Methodology; Software; Validation; Formal Analysis; Investigation; Resources; Data Curation; Writing–Original Draft; Writing–Review & Editing; Project Administration.

Fairouz Azaiez: Conceptualization; Methodology; Software; Formal Analysis; Writing Original Draft; Writing–Review & Editing.

Hamdi Henchiri: Conceptualization; Methodology; Software; Writing–Original Draft; Writing–Review & Editing.

Mohammed A Aljahni: Conceptualization; Writing–Original Draft; Writing–Review & Editing.

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Data Availability Statement

All data in our current study are stored by the first author, but if needed at any time, we can provide them with the first author's permission.

Conflict of Interest

All authors agree and affirm that there are no conflicts of interest in our study entitled "The Integration of Virtual Reality Technology in Physical Education Settings: Effects on Students' Physical Activity and Motor Skills Levels."

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