# Immersion in Virtual Reality Video Games for Improving Physical Performance Measures: A Review

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*Abstract* –**Virtual reality (VR) active video gaming, also called "exergaming" has become an emerging trend in entertainment but also fitness, education and health sectors. It requires bodily movements to play and function as a form of physical activity (PA). Since this type of gaming is becoming more and more popular and accessible and the trends suggest that it may become a mainstream media, the scientific community is discussing on its usefulness. There are number of claims about its ability to improve health via an increase in PA but researchers also argue that it is still a form of time spent in front of monitor which comes with many negative sides. The aim of this paper is to do an overview of the scientific research domain and outline the strengths, weaknesses and opportunities of immersive VR gaming to promote PA.**

**The available evidence indicates that active video games can replace sedentary time spent in front of a computer or TV with physical activity and make a measurable contribution to the improvement of health. However whether it is a sustainable way to motivate gamers in PA is questionable.**

*Keywords* – **active video gaming; virtual reality; physical activity; sedentary behavior; obesity.**

## I. INTRODUCTION

The book by Chris Crawford, [1], could be considered one of the first expanded texts to explore computer games. It discusses the future of computer games and presents the grounds for their recognition as a form of art. Many critics at the time are skeptical, arguing that this industry could not keep interest for a long time and there is no opportunity for development. With the development of technology, however, the computer games industry has grown enormously, and today it is obvious that this development will continue.

Computer games over the last decade have changed dramatically. They have become increasingly sophisticated, varied, realistic and social. Today they are considered to be the largest and fastest growing market segment of the multi-billion-dollar entertainment industry, being comparable and often overtaking the cinema industry.

Studies show that 97% of American teenagers regularly play some sort of digital games. The computer games market is making new records every year and is expected to reach 90 billion dollars in 2020. So far, there are about 2.5 billion gamers around the world. 73% of US mobile phone owners play mobile games. More than 64% of the US population are gamers [2]. This eloquent data requires a serious insight into the essence of computer games.

"Virtual reality was once the dream of science fiction. But the Internet was also a dream, as well as computers and smartphones. The future is coming." This Mark Zuckerberg quote is part of a 2014 post [30], and since then technology has not stopped developing. VR is entering many aspects of our daily life. This "non-physical reality", which does not exist physically, but on the basis of information technology and computer systems, is becoming increasingly widespread and is constantly expanding its scope of usability.

Currently the VR helmets and consoles are created to allow the system to track and respond to user movements; gloves designed to feel the touch to look as if the consumer has something in his hand. These initial projects will later serve as a basis for other developments that will occur: VR model interaction products; 270 degree projection room, called "Virtual Theater Environment"; Second Life (SL), created by Linden Lab, where users are completely immersed in 360 degree virtual reality (the software allows building virtual objects that a user can control and interact with, such as more complex 3D objects called "sculpties", the textures of clothing and other objects, animations, gestures are created using external programs. Users (46 mln. registered until 2016) retain the copyright to any content they created); computer-based room; virtual libraries, museums, galleries, theaters; "Street view" an option introduced by Google that displays panoramic views from different locations and features stereoscopic 3D mode; realistic 3D 2D TV effect where a camera detects the viewer's view of the TV, and if the viewer moves, everything on the screen is re-orientated appropriately.

As many opportunities as it offers, VR gaming also brings a lot of problems. A number of experts associate the stagnant daily life in front of the computer and the daily inactivity with teenager obesity reaching epidemic proportions in developed countries. In the United States the prevalence of overweight children increased by 182 percent between 1971-74 and 1999-2000 [3]. Similar increases have been reported for Canada, Finland and China [4], [5], [6]. In New Zealand, one third of children are currently overweight or obese [7]. Obesity is associated with a number of negative health effects, including an increased incidence of type II diabetes and an increased risk of cardiovascular disease [8], [9]. It is believed that this increase in obesity is associated with changes in the

physical and social environment that are increasingly encouraging a high energy intake and sedentary behavior [10].

Technological advances have led to a dramatic increase in the time people spend in sedentary screened activities such as watching TV, playing video games and using computers. These screen-based activities are believed to displace active behavior and are independently related to obesity [11] and other adverse health outcomes such as hypertension [12]. Worldwide, the majority of adolescents do not reach the recommended physical activity [13], which affects their physical and mental health [14], [15], [16]. Screen time represents the largest part of the children's sedentary time [17].

Interventions aimed at reducing screen time are largely unsuccessful as gamers appreciate these activities [18]. When developing approaches to reducing sedentary time and increasing physical activity, Marshall SD [19] recommends maintaining the context of preferred activity. Consequently, researchers who have focused their efforts on maintaining the health of the population, are developing methods that use technology as part of the solution rather than as part of the problem.

One such intervention is the use of active video games through VR technology which allow players to interact physically (with the movement of the arm, legs or the whole body) with screen images in various activities such as sports (for example, football, boxing, martial arts) and other activities (dancing, simulations and etc.). The games are movement tracked or camera dependent (Sony EyeToy), Infrared Sensor (Nintendo Wii and XaviX), Laser (Lasersquash), Dawson Dance Revolution, XaviX J-mat and ApartGame or Modified ergometer (Xerbike or GameCycle). This active component largely replaces the sedentary manual controller of traditional video games, where the buttons are used to manage the game and no real phisycal movement is required. Research explores the usefulness of active video games to replace sedentary video games as a means of increasing physical activity.

We could assume that, like in every sphere of human activity, as with any technology, we can find opportunities for new applications, prospects for improvement, but also negative effects can be found.

## II. CURRENT RESEARCH

On the one hand, VR is seen by a number of authors as one more mind-distraction technology along with all screen-watching technologies that certainly have negatives - loss of skills for in-depth reading, mental concentration, etc. But researches also note the possibilities of acquiring new skills and abilities. It is even pointed out that games can sharpen thought and reflexes. Breaking from reality is a category that may have different aspects of consideration - from the positive effects of alternative virtual reality to limiting social communication.

Computer games can greatly contribute to the subjective mental well-being of the person by bringing him into a world where he can do everything and give him a sense of strength, competence and social affiliation. Virtual reality can provide an opportunity for self-assertion, relaxation and suppression of tension, compensating negative emotions from everyday life, develop imagination and creativity.

One of the greatest benefits of active VR games is that they increase motivation and engagement with physical activity [20]. This is confirmed by the results of researches demonstrating that active games attract, through virtual stimulants (level completion, competing with other players), both immersion and enjoyment [21]. The importance of pleasure is gaining more and more attention in research, as it seems important to maintain a higher level of physical activity [22]. Furthermore, it has been found that greater enjoyment within physical activity is important for cognitive benefits, which in turn have a positive impact on academic achievements [23].

Another advantage of this type of games is that they help to reach specific groups of people [35]. This can be especially important for children who do not succumb to recommended physical activity through traditional methods or who spend a lot of time playing video games. Time spent in screen-watching activities is considered to be the main reason for low physical activity in children. Thus, active gaming has been shown to have the potential to reduce obesity [24]. With the help of this technology one of the greatest demotivators for physical activity - video games can become a useful motivator. VR games can be integrated into schools by contributing to children's activity and therefore promoting positive effects on the body mass index and physical condition. Moreover, children with attention deficit or hyperactivity disorder, who spend more time playing video games, could find VR games as a viable option for replacing the inactive screen-based activities [25]. VR games can also be targeted at people who are looking for an entertaining way of home exercise. One of the main shortcomings of physical activity in the gym or running in the park is that they do not provide enough motivation and satisfaction for a large number of people. VR games can provide an alternative to attract this group of people.

Also, the game can be tailored to the needs of the individual [35]. To emphasize physical activity, users can also use extra weights for hands and feet to achieve the desired difficulty. Important human characteristics, such as age, safety level, can be taken into account to avoid under-load or overload. In-game correction via an algorithm combined with immediate feedback to the individual has the potential to ensure that individuals will always use it optimally. For example, the physical and cognitive challenge can be observed and corrected [26]. In this way not only the physical but also the mental benefits that are important for the promotion of academic achievement [23] can be strengthened, which adds value to this technology. There are unlimited possibilities for creating games for specific learning purposes. Using such adaptations ensures that the development of skills in physical education or elite sports can be trained [27]. At present, however, the most frequent implementation of VR technology is in rehabilitation. Advantages in this area are demonstrated by studies that show that VR gaming improves the motor skills of typically developing children, acting as a useful rehabilitation tool in this group (for example, balance control).

A physiologic and metabolic study found that aerobic and balance VR games met American College of Sports Medicine guidelines for improving and maintaining cardiorespiratory fitness in middle-aged and older adults [31].

Urban elementary school children engaging in 30 minutes of VR gaming three times weekly had significantly increased physical activity and positive attitudes toward exercise [32].

Another advantage is the high applicability of VR games and increasing accessibility. Until a few years ago, the high cost of hardware and underdeveloped technology did not imply high demand, but today, these games are much better developed and more affordable. Most games use popular gaming consoles, conventional TV screens or home computers. Therefore, they can be played almost anywhere, anytime. Moreover, they find use in some groups of people, such as adults and children, who are inactive and are not interested in traditional physical activity exercises [28]. Thus, it can be concluded that the use of VR games does not necessarily mean reduced physical activity. With this in mind, they can provide a useful addition to traditional methods of physical activity.

It can be said that the major problems of the past - the high hardware price and the small pool of developed games are becoming less of a problem with the increasing demand and supply. There is not a small choice of developed games, and hardware prices are much more affordable for more people. However, according to surveys, these types of games are not for everyone, and they do not always succeed in retaining the interest of players for longer periods [29]. Another logical argument is that VR games are still time spent in front of the screen. There is even concern that VR games can replace traditional exercise and increase the time spent in front of the screen. According to the scientific community VR gaming should not and cannot replace traditional exercise [30].

## III. Challenges

Simulator sickness is a subset of motion sickness that is typically experienced by some users. According to research [33], careless game design when using a head-mounted display is more likely to cause this effect. When a game is giving sensory feedback to the user, it is important that this feedback occurs with minimal delay and motion controls need to be accurate in order to minimize the occurrence of motion sickness.

Another study [34] suggests that VR by itself does not generate a higher level of simulator sickness than a large display. But the study shows that multi-tasking games (for example-games that require full body motion) are more likely to cause motion sickness. Therefore, it suggests the future designer should carefully design a game that may consist of a series of multi-tasking tasks, as it may cause a higher sickness.

VR gaming research is limited, and there are many issues that remain unclear. For example it is unclear whether those types of games are able to keep the interest of players over longer time periods. And there is still a noticeable reservation towards VR games by parents, teachers and caregivers.

Whether VR games increase screen time substantially is also unclear from a scientific standpoint. An increase in screen time has to be monitored carefully in order to prevent potential negative effects.

## IV. Discussion

The purpose of this review was to present an overview of the currently available research on VR gaming and its effect on PA.

As studies recommend maintaining the context of preferred activity when trying to intervene sedentary behavior [19] and most children and adolescents already play video games in Europe and the US, [2] there is no turning back and the question is no longer whether gamers are playing video games and how we can prevent them from doing it, but how can we have a positive impact on the type of digital games they use and the purposes those games have. We cannot overlook the problems; it is necessary to seek ways to resolve them.

Since computer games are and will continue to be an important factor in the lives of present and future generations, it will be important to explore their potential, not only giving positive emotions but also contributing to personal development and improvement. There are still relatively unknown effects that this new media has on the inner world of people. Based on these considerations, we have reason to say that there is a probability of a link not only with a negative effect, but also with a positive effect between playing computer games and physical activity. This relationship is still under-researched. Based on the view that greater efficiency can be sought in the development of methods where technology is used as part of the solution rather than as part of the problem, that it is imperative to study computer games as a means of increasing physical activity and overcoming immobilization by developing appropriate approaches and methods.

## V. Conclusion

We can conclude that active video games are not a substitute for real-world sports, but would be particularly suited to adults and children who have little motivation to do sport activities or appreciate computer games and want to use their useful side.

Physical inactivity is a major factor in the health of children and adults because of the many harmful effects on physical and mental health. Considering that most children and adolescents in Europe and the United States play video games, games with a physical element can become an important tool to promote physical activity, reach individuals that cannot be reached through alternative methods, and to promote positive effects on mental and physical health.

As VR games are very diverse and most studies use different games, more research is needed to explore the main mechanisms as well as their specific characteristics and their impact on PA levels.

## ACKNOWLEDGMENT

This work was supported by the Research and Development Sector at Technical University of Sofia project No 192ПД0013-07: ”Exploring the impact and capabilities of Virtual Reality video games to improve physical activity“.

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