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Virtual reality within the areas of sport and health

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Abstract

Introduction. The aim of this study is to identify and summarize current research on virtual reality in the environments of sport and health. Despite the fact that virtual reality can be used in sports training, this issue is not sufficiently addressed in scientific research. Material and Methods. Based on keywords, studies were selected from electronic databases that addressed virtual reality (immersive and non-immersive) in an environment of sport or health. These studies were examined and their results were summarized in the present paper. Results. The analyzed publications focused mainly on the issue of rehabilitation. We also found that in many studies, authors often do not distinguish between immersive and non-immersive virtual reality. On the basis of the discovered information, it can be concluded that the environment of virtual reality can be beneficial for improvements in sports performance and motor control. Conclusions. Immersive virtual reality can be used to influence reaction times and decision making in sports. In addition, it appears to be beneficial in the training of a given motion task during rehabilitation. We realize that virtual reality cannot fully replace sports training, but it can be effectively used as a means of motor control improvement.

KEYWORDS: sport performance, anticipation, ideomotor training, rehabilitation, motor control.

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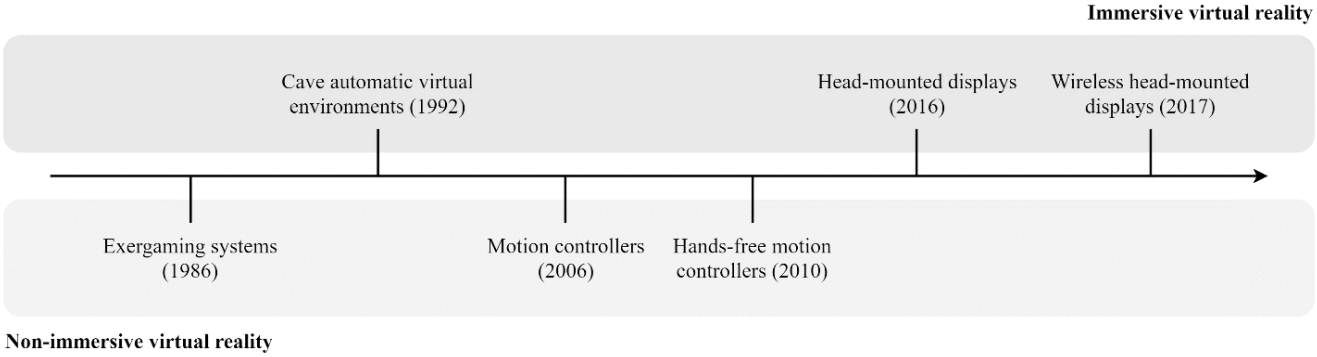
Introduction

Outside of the typically associated fields of entertainment, health, the military and others, virtual reality is discussed more and more frequently in connection with improvement in sports performance. Each of us can imagine different environments under the term of virtual reality. For some, it is a novelty connected to playing video games, while others see it as more specifically useful in areas such as medicine or sports. Today, virtual reality introduces an environment beyond our "real" world that is customizable according to the user's needs through various devices and systems controlled by personal computers, laptops, or cellphones. As has been mentioned above, virtual reality offers wider possibilities of utilization due to technological progress. More and more experts, however, agree that its usefulness is essentially unlimited. Virtual reality has been attracting much attention in recent years not only in the entertainment industry, but also in the fields of sport and education [21]. For a better understanding of the studied problem, it is necessary to first explain other terms such as non-immersive virtual reality (VR) and immersive VR. In the case of non-immersive VR, we are talking about the use of external devices when playing video games. In 1986, one of the first so-called exergaming systems was created (the concept was created by combining the words exercise and gaming), where participants took part in physical activities by playing video games. Gradual technology development gave birth to other systems (such as Nintendo Wii, Microsoft Kinect) which use motion sensors to capture a player's movements in order to control the game.

Figure 1. Timeline of VR development

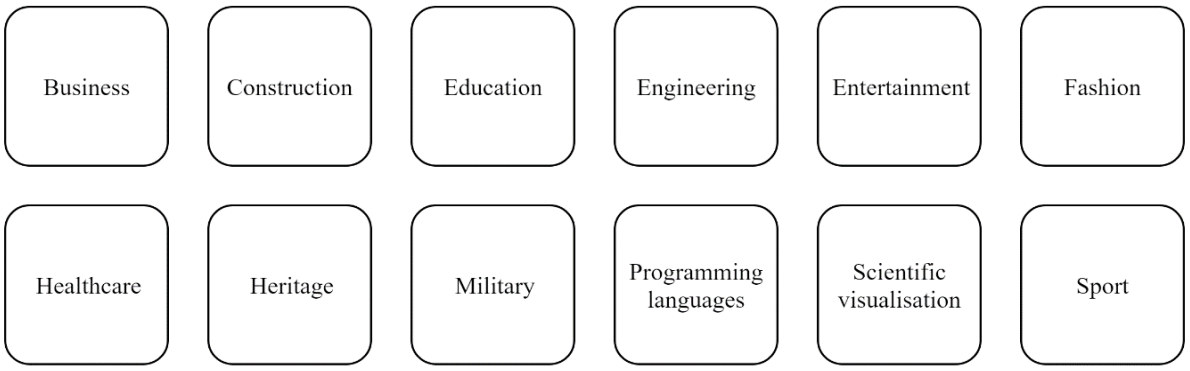


It is precisely this type of technology which is called non-immersive VR. The principle of non-immersive VR is motion game control, which is transmitted through the sensors into the game. An argument for its use, and a list of its benefits, can be based on the inherent effect of a physical load on the human body when playing "interactive" games [13, 32]. Therefore, playing video games is not only a passive leisure activity, but it's effect can also be seen in the development of health-oriented fitness [32, 33]. Authors [24, 26] have previously mentioned this term only in connection with exergaming. The authors monitored physiological responses of game participants. Presently, most attention is paid to the use of virtual reality in psychology, when monitoring brain activity [10, 40]. Immersive reality may be seen to have reached a period of high popularity in 2016 (Figure 1). This version of virtual reality, unlike non-immersive VR, manages to immerse spectators as they enter into a virtual (unreal) world. This is achieved by means of special glasses (a head-mounted display – HMD), which allow participants to enjoy a 360° view of the virtual environment around them. These glasses use sensors that can detect the head's movements which involves six degrees of freedom (the participant can change positions in the virtual environment). Motion sensors are often used with HMDs to bring the movements of the VR participant into the game. So the player is not only a consumer, but can also perform the assigned movement tasks. As a result of all of the above, it can be deduced that VR could be beneficial for motor control in rehabilitation or sport. The participant can, thanks to VR, experience the set situation several times in a row and get feedback about the correct or incorrect motion. All of this can be done without the increased physical demands of real training.

Application of VR

The most common use of virtual reality today is entertainment – games, videos, and more. However, more and more often we encounter the use of VR in other areas (Figure 2). This technology is becoming very popular in various fields of science, such as medicine and rehabilitation [15, 18, 29, 30]. Recently, virtual reality has also begun to appear in the fields of sport (both amateur and professional) and education. The focus of our interest here is mostly on sport, rehabilitation, and physical education.

Figure 2. Areas of possible VR application



Rehabilitation and medicine

The application of VR is, for example, found in the treatment of cerebral palsy or with people who have developmental coordination disorders [4, 7]. Many authors [1, 9, 17, 37] have used VR during the rehabilitation of patients after a stroke. The VR motion program has been conducted in an aerobic mode of low to moderate intensity. It has been found that it is possible to affect the mobility of the upper limbs and the balance of patients [1, 8]. Although there was no evidence that rehabilitation in VR would be more effective than normal rehabilitation, the authors believe that rehabilitation with VR is much more interesting for patients, because they are provided with instant feedback. Further studies deal with the problem of injuries and their therapy. It is interesting to note that most of the studies [16, 27, 28] have been focused on the rehabilitation of sprained ankles. Conclusions drawn from these studies suggest that one advantage of VR is that patients can rehabilitate in their home environment. Also VR is a widely used tool in medicine. Above all, it is used in surgical training or diagnostics [31, 35, 36]. Surgeons may undergosurgical training, thanks to 21st Century technologies, and they may even do this several minutes before they have to carry out these surgical procedures. Virtual "surgery" can mirror reality in every detail, thanks to the adjustability of the VR system.

Sport and health

VR can be used as an alternative to conventional low to medium intensity exercise. Great benefits can be provided to seniors, for example, who can then move actively in a safe and controlled environment. At the same time, VR can be much more fun than regular exercise [5, 11, 14]. However, one disadvantage of VR may be that it diverts attention from the real world (fatigue, pain, and possibly drinking habits), which can then lead to acute exhaustion [22]. An athlete's mental state is an important factor in sports performance. An athlete must be able to cope with stressful situations during a match (e.g., a football penalty kick). Thanks to VR, the competetive environment can be simulated, therefore the athlete can be better mentally prepared [34]. This use of VR may be observed in other fields, and not just in sport [39]. Visual perception, anticipation, and decision making are other components of sport performance that can be stimulated by VR. An example of this might be decision making, which is very important in team sports. One bad decision can decide the whole game. With VR, these key situations can be experienced immersively (from the perspective of the player's eyes) [19, 25, 37]. A very interesting SWOT analysis relating to the use of VR in the examination of human motion was conducted by Dueking, Holmberg, and Sperlich [12]. The authors describe the strengths and weaknesses of this technology and suggest ways to use it. Another means of influencing sports performance is ideomotor training. Here too, VR can prove to be useful. Reaction time, which is an important component of sports performance in a wide range of sport disciplines, can be improved through the use of VR. In everyday life, situations that can cause injury or even be life-threatening can be expected. In this context, Michnik, et al. [20] stated that when training evasive maneuvers against a flying object in VR a transfer of this training to a real evnironment can be expected, thereby reducing the occurence of injuries. Therefore, the application of VR in sports where a fast defensive response is needed might be beneficial (boxing, fencing, karate, etc.). By training evasive maneuvers in VR it is possible to reduce the risks of receiving hits from opponents and this may possibly result in providing better protection for the health of the athlete.

Discussion

The possible effect of immersive VR on behavioral change in the real world has already been dealt with in earlier studies, for example by Bailenson, Patel, Nielsen, Bajscy, Jung and Kurillo [2] or Patel, Bailenson, Hack-Jung, Diankov and Bajcsy [23]. Through repeated visualization the improvement of performances can be achieved in various areas of everyday life and sport [3], because information perceived in the environment is similar to what exists in the real world. By using HMD before the start, a competitor can drive around the race track in advance. Based on the findings of monitored publications it cannot be unambiguously stated that VR training is more effective than real-life training. But VR is becoming more frequently used in professional sports training. In professional sports VR is primarily used for ideomotor training with the use of a 360° video. Thanks to the modifiability of the virtual world, situations and conditions on the track can be adapted to the trainer's requirements and to the current environmental situation (rain, reduced visibility, glare, etc.). For professional athletes, the benefits of VR can be seen in physical preparation after injuries, when athletes are not yet able to undergo full-fledged training in real conditions. VR has also been used in the NBA, American national basketball league [38], to increase the success rate of penalty free throws. The tested basketball player is repeatedly able to "experience" his successful penalty free throw using HMD. Thanks to VR training, the

success rate of free throws has also been increased in the real environment during penalty shots. The main advantage of VR is what is called "micro-learning" or "a lot of repetitions in a short burst", which means that the athlete can experience many game situations in a very short time without the presence of a coach or the environment which is usually necessary to training. The improvement of tactical skills in American football has been monitored in the Casale study [6], which attempted to involve the test subjects in various game situations. Based on the research, it was found that the decision making of players using VR was more effective and faster. The training of new movement skills or the improvement of the quality of motion structures by means of VR has not yet been fully proven. However, thanks to technological advances, there are certainly improvements to be expected within this field. Currently, VR developers are working to bring this technology closer to the "real" environment. For example, if the participant were to use real sports equipment (such as a baseball bat) when using VR, a positive transfer to the real environment could be expected to follow. Research on the effect of virtual reality in reaction time is still insufficient. Affecting this subcomponent of sport performance can undoubtedly influence the overall result. It is also possible to imagine the use of VR even in skiing instruction, where participants would be informed about the "wrong" or "correct" timing of movement through feedback from the instructor or a program. The great advantage of using VR is its relative affordability and the possibility of repeating the same game or race situations. Of course, some disadvantages that researchers must take into account when carrying out their studies should also be mentioned. Despite very rapid development in recent years, VR has its own shortcomings [12]. These shortcomings include the time requirements of setup, a wired connection, worse resolution than that of the human eye, a smaller field of vision, discomfort, input latency, and other material requirements (a computer, room space, etc.). Another disadvantage is the weight of an HMD and its perception by the research participant. The largest manufacturers of VR are already working on the elimination of these issues (wireless connections, higher resolutions, FOV, etc.). Virtual reality is becoming more and more user-friendly. Sensitive individuals may experience anxiety and motion disorder when using VR. However, the use of in sport seems practically unlimited.

Conclusions

The technological achievements of our time do not always have a negative impact on the younger generation, as is often mentioned in scientific publications. Everything has its limits and it is definitely impossible to consider the isolated use of VR as an optimal tool or even the only alternative to physical activity in children and adults in real, natural conditions. Through VR training can be made more attractive to younger and older generations. The conditions found in the surrounding real environment often affect the course of training. In virtual reality this environment is controllable and modifiable. It is important to note that VR is still only in the beginning stages of development, but it can no longer be considered only as a means for entertainment. It is already very widely used across many scientific disciplines. It can be assumed that VR will continue to develop as a technology. Therefore, it is necessary to monitor and discover new possible applications of VR not only in the aforementioned fields, but also in areas where VR has not yet found its place.

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