APPLICATION OF VIRTUAL REALITY TO THE ENHANCEMENT OF PHYSICAL ACTIVITY AND SPORTS FOR HEALTHY INDIVIDUALS. A SYSTEMATIC REVIEW

Milena Kuleva
National Sports Academy "Vassil Levski", Sofia, Bulgaria

ABSTRACT

As technology advances, virtual reality (VR) becomes more prevalent in various fields of endeavor. Virtual reality is frequently associated with entertainment for adolescents. This is not always the case, however. Military, medicine, education, and architecture could all benefit from virtual reality, and in these fields, with complete confidence, sports and physical activity could also be added. As the origins of virtual reality are examined, it could be confirmed that people have always desired to recreate reality, beginning with drawings and progressing through cinema and photography to modern technologies that attempt to recreate the environment, real objects, states, etc., as accurately as possible. This study aims to analyze the available and accessible literature that has examined the application of different types of virtual reality. In order to fulfill the set objective, access through the virtual library of SUNY Empire State College was used. The researched databases were ProQuest, MEDLINE (with Full Text), PloS ONE, JSTOR, Library and Information Science and Technology Abstracts with Full-Text, EBSCOhost, LearnTechLib, Sage Journals, and Science Direct. The PRISMA guidelines were utilized to guide the review's conduct. The total number of sources studied was 2800, and through the PRISMA model, the final amount of analyzed articles was reduced to 11. According to the set inclusion and exclusion criteria, the articles considered comprehensively explained the methodology employed and delved into the effects of virtual reality on sports and physical activity among the participants. Virtual reality technology provides a personalized experience by adapting to the individual's interests and abilities. It has been discovered that immersive VR exergames can result in the same or greater exercise intensity than conventional exercise conditions. Exergaming in virtual reality could be especially beneficial for promoting physical activity and overall societal health.

OPEN ACCESS

Submitted: 7 June 2023
Accepted: 5 July 2023

ORCID
Milena Kuleva
https://orcid.org/0000-0002-6467-9644

Cite this article as:
Kuleva, M. (2023). Application of virtual reality to the enhancement of physical activity and sports for healthy individuals. A systematic review. *Journal of Applied Sports Sciences*, Vol.1, pp. 69 - 79. DOI: *10.37393/JASS.2023.01.7*

Keywords: *exergaming, sport, physical activity, systematic review, technology*

INTRODUCTION

As technology advances, the topic of virtual reality (VR) becomes more common in various spheres of activity. The phrase "virtual reality" is frequently associated with adolescent entertainment. However, this is not always the case. Medicine, education, sports, architecture, and the military might all benefit from virtual reality. If we look at the reasons for the appearance of virtual reality, it could be linked to the fact that people have always wanted to recreate reality, starting from drawings, going through cinema and photography to modern technologies that recreate the environment, real objects, states, etc. as identically as possible.

The question of who the creator of virtual reality was is highly controversial. The term was first used in the mid-1980s when Jaron Lanier, founder of VPL Research, began to develop the gear needed to experience what he called "virtual reality", including goggles and gloves. In 1956, Morton Heilig, who was a specialist in American filmmaking, created

what he called the Sensorama machine, which was a simulated urban environment in which a motorcycle was ridden (Figure 1). The machine was a multisensory simulation that allowed one to see the road, hear the motor of the bike, feel the vibration, and smell the exhaust fumes of the bike. Again, Heilig patented the Telesphere Mask in 1960.

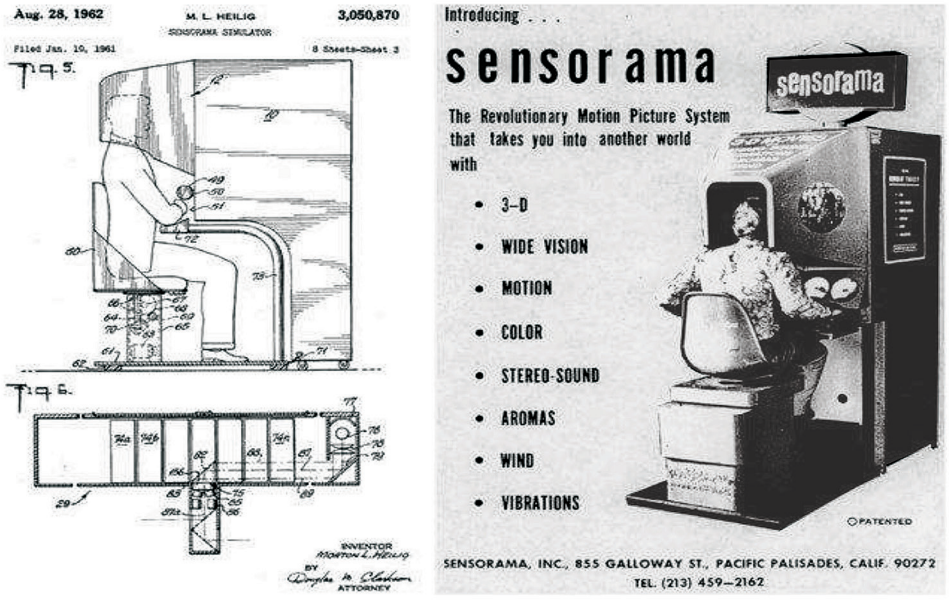

Figure 1. *First virtual reality applications: Sensorama Machine by Morton Heiling First virtual reality applications: Sensorama Machine by Morton Heiling.*

The development of these technologies is impressive and constantly evolving. Virtual reality is increasingly being applied, and its effects are explored accordingly. Its benefits are many, and its applications are comprehensive. If any definition of virtual reality can be given, it would be that VR is a computer simulation of a three-dimensional artificial environment based on computer technology. This virtual reality aims to reproduce an environment as realistically as possible, using all human senses - hearing, sight, touch, and sometimes even smell. What makes virtual reality is its maximum believability. Another extremely important condition is to have human interaction with the objects in the virtual environment. Virtual environments have varying degrees of "immersion" based on different stimuli.

Virtual reality (VR) is a computer-generated environment that gives the user the feeling that they are mentally or physically present in a different location. Virtual reality is often viewed as an immersive and hierarchical desktop technology that has the potential to enhance one's reality experience. Virtual reality (VR) systems are classified into three types. There are non-immersive, immersive, and semi-immersive virtual reality experiences based on one of the core components of virtual reality (Qian, McFonough & Gao, 2020). The application of VR in the field of sports studies began in the 1990s. When applied to sports, virtual reality technology has the ability to give a platform for those who may not be able to participate in a range of sport training activities. VR technology is used in sports sciences to improve overall physical activity (PA) levels through exergames, performance development programs with technical or tactical training applications, and sports injury recovery (Denche-Zamorano et al., 2023).

There are also different types of realities

- Augmented reality (AR) is a type of virtual reality technology that blends what the user sees in their real surroundings with digital content generated by computer software. Another reality is Mixed reality (MR) - the merging of the real world and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real-time (Mathew & Pillai, 2020). Cyberspace is sometimes defined as a networked virtual reality. Simulated reality is a hypothetical virtual reality as truly immersive as the actual reality, enabling an advanced lifelike experience or even virtual eternity. Multisensory extended reality (XR) integrates the five traditional senses: sight, hearing, smell, taste, and touch. Perception involves signals that go through the nervous system, as vision involves light striking the eye's retina, odor molecules mediate the smell, and hearing involves pressure waves. Sensory cues of multisensory extended reality include visual, auditory, olfactory, haptic, and environmental. XR can also be considered the most advanced and immersive reality. Manufacturers of this type of device find its application, for example, in reproducing tourist destinations.

In terms of applicability, different virtual realities could be applicable in many fields of activity. For the purpose of this article, the main focus of the research will be to explore the possibilities that virtual reality offers for improving physical activity through its application. Based on this, the objective is formulated.

This study aims to analyze the available and accessible literature that has examined the application of different types of virtual reality and summarize the possibilities of application in the field of sports and physical activity.

METHODOLOGY

This study is a literature review of the available literature that aims to examine the maximum amount of research related to the applicability of virtual reality in the domains of physical activity and sport.

In order to fulfill the set objective, access to the virtual library of SUNY Empire State College, which provides access to a vast number of databases with scientific information, was used. These include ProQuest, MEDLINE (with Full Text), PloS ONE, JSTOR, Library and Information Science and Technology Abstracts with Full-Text, EBSCOhost, Learn-TechLib, Sage Journals, and Science Direct. Additional research was also done in the Web of Sciences and SCOPUS databases.

The search principle for articles used the following keywords: 'Virtual reality' AND 'physical activity'; 'VR' AND 'sport*'; 'AR' AND 'Physical activity'; 'AR' AND 'Sport*'.

As the topic is relatively new, a limit of articles was set for the period 1 January 2010 until 30 June 2022.

Inclusion criteria

1. A virtual environment is used in the research, and its type is clearly indicated.
2. Physical activity or sport has been applied, the effects of which are reported in the results of the relevant article.
3. The paper is published in English.
4. Participants in the study must be a minimum of 5 people.
5. There should be a clearly described research protocol.
6. If possible, the study's results should be clearly described, tabulated, and presented graphically.

Exclusion criteria

1. The research should be based on a case study.
2. The study does not indicate informed consent from participants or legal representatives.
3. The study is not published in English.

4. No physical activity or sport was practiced with the study participants.
5. The researched participants were diagnosed with a disease and were not entirely healthy or were in a hospital setting.

RESULTS

The results that came in were 3305 in total. Among them, 2680 articles, 417 Newspaper Articles, 113 Conference Proceedings, 27 Newsletter Articles, 25 eBooks, 17 Web Resources, 7 Dissertations, 7 Book Chapters, 6 Text Resources, 3 Reviews, 2 Reference Entries, and 1 Report. For the purposes of the research, it was essential to have a methodology described that had a defined scientific structure. Therefore, only Articles, Conference proceedings, and Dissertations were analyzed. The total number of sources studied was 2800. The articles were reviewed and divided into the following categories: studies with a medical focus, studies with a rehabilitation focus, studies with a psychological focus, studies with an educational focus, and those that fell within the scope of this study - studies having to do with sport and physical activity in healthy people. The PRISMA guidelines were utilized to guide the review's conduct (Page et al., 2021).

Figure 2 lists the articles included in this review, and Table 1 explains the characteristics and results of the studies included.

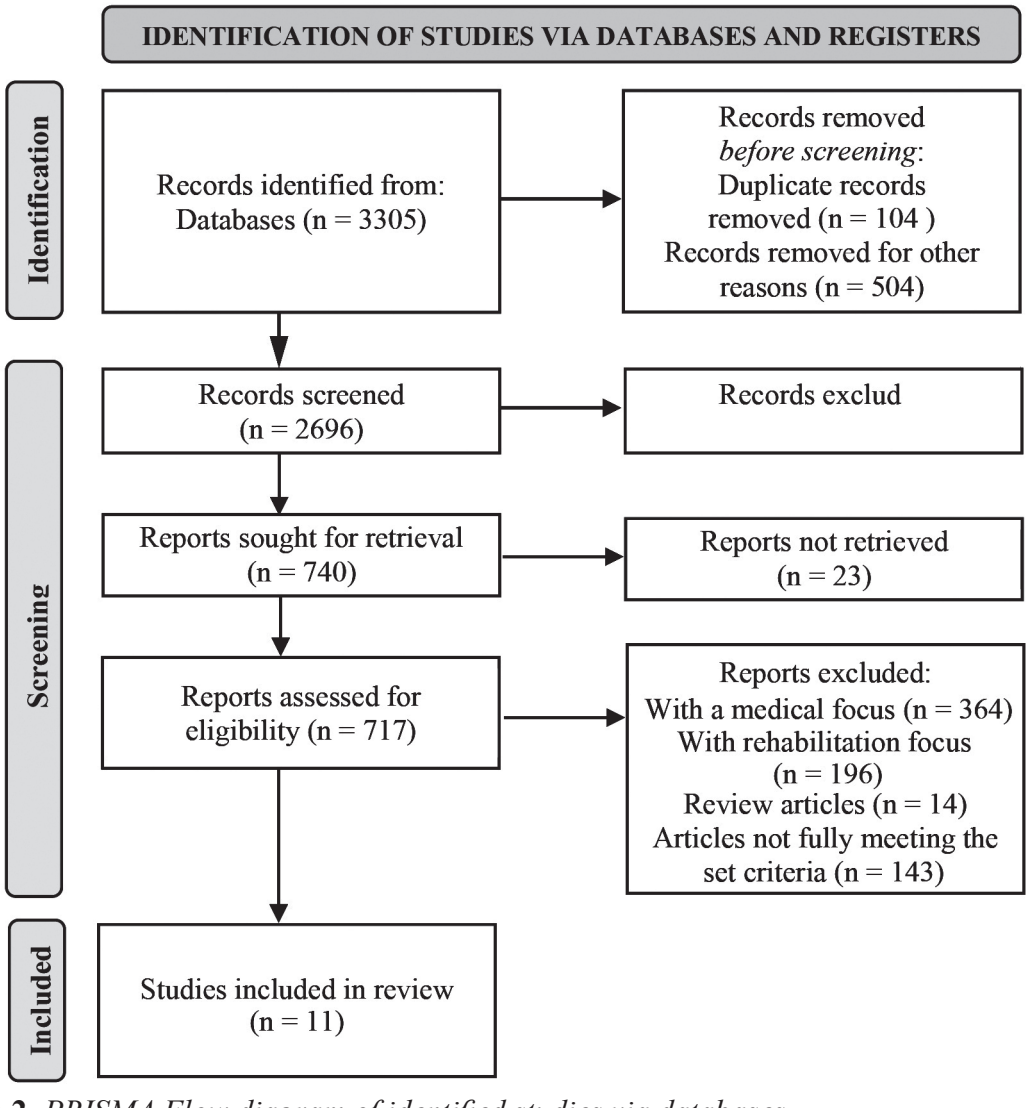

Figure 2. *PRISMA Flow diagram of identified studies via databases*

Table 1. *Characteristics of the identified studies*

N	Paper Ref	Years	Sample	Purpose and measures	VR technology and output display	Country of the research	Physical Movements/ Task	Intensity	General effect (reported)
1.	Active video game-based physical activity vs. aerobic exercise and cognitive performance in older adults: a randomized controlled trial *Authors*: Alexsander Vieira Guimaraes, Aline Rodrigues Barbosa, Vandrize Meneghini	2018	Individuals of both sexes, aged 55 years or older	Compare the effects of active video game-based (AVG) physical activity with aerobic exercise on cognitive performance in healthy older adults.	Microsoft Xbox 360 Kinecttm console 240-×180-cm projection screen (Epson Powerlite 96W)	Brazil	60 minutes (5 to 10 minutes for the initial warm-up, 40–45 minutes for playing the sports games, and 5–10 minutes for stretching at the end)	The intensity of the activity was monitored by the heart rate monitor (Polar® S810i model).	Positive effect
2.	Virtual reality exergaming improves affect during physical activity and reduces subsequent food consumption in inactive adults. *Authors*: Sarah Sauchelli, Jeffrey M. Brunstrom	2022	34 adults (27 women)	Effects of VR exergaming on appetite and food choice	HTC Vive PRO Headset Secondary SAMSUNG screen	United Kingdom	15–25 min of static cycling	After a 5-min warm-up, the pedaling resistance was increased, and the researcher monitored heart rate to support participants achieve a heart rate within 65% and 85% of age-determined maximum heart rate.	Positive effect
3.	Mild Physical Activity Does Not Improve Spatial Learning in a Virtual Environment *Authors*: Tavor Ben-Zeev, Inbal Weiss, Saar Ashri, Yuval Heled, Itay Ketko, Ran Yanovich and Eitan Okun	2020	20 healthy young male adults (18–30 years old)	To address whether aerobic physical activity improves long-term spatial learning and memory in humans.	"Vizard 5 Virtual Reality" software, using Oculus Rift DK2 virtual reality goggles N/A	Israel	The 12-week program included moderate aerobic exercise three times per week, starting with 2 weeks of 30-minute walking sessions followed by 2 weeks of 6 intervals of 5min walk and 5min run for 30min.	Subjects were told to keep a steady pace during training. Every 2 weeks, the running interval lengthened until it reached 40 minutes.	No positive effect found.
4.	Immersive Virtual Reality Exergames to Promote the Well-being of Community-Dwelling Older Adults: Protocol for a Mixed Methods Pilot Study *Authors*: Samira Mehrabi, John E Muñoz; Aysha Basharat; Jennifer Boger, Shi Cao, Michael Barnett-Cowan, Laura E Middleton	2021	12 people, ≥60 years	Determine the feasibility, usability, and acceptability of a 6-week VR exergame intervention and the feasibility of the assessment protocol among community-dwelling older adults.	VR exergame (Seas The Day), on an Oculus Quest 2 (Facebook Reality Labs) headset N/A	Canada	The 6-week study, with three different activities: (1) a tai chi warm-up, (2) a rowing conditioning exercise, and (3) a fishing cooldown.	Light to moderate intensity when playing the game	A potential benefit of physical and mental well-being.

Table 1. *Characteristics of the identified studies (Continued)*

N	Paper Ref	Years	Sample	Purpose and measures	VR technology and output display	Country of the research	Physical Movements/ Task	Intensity	General effect (reported)
5.	Ellic's Exercise Class: promoting physical activities during exergaming with immersive virtual reality *Authors*: Lizhou Cao, Chao Peng, Yangzi Dong	2020	11 males and 9 females (aged 18-37)	To understand participants' performance, gaming experience, and effectiveness in motivating them to move, and their exercise intensity levels	Oculus Touch controllers and the display devices Fitbit device and large fat-screen display (LFD)	USA	6 trials (3 games × 2 display devices). There was a 5-min break between trials.		Positive effect for activity and engagement, but negative for heart rate data and decreased energy expenditure.
6.	Promoting Sports Engagement during the COVID-19 Pandemic via Virtual Reality Games *Authors*: Hana Hanifah, Yuko Ito, Dary Patrick Gamboa Yao, Natsuka Suyama and Kaoru Inoue	2021	20 participants, aged 19-29 years	Examining sports engagement and health when utilizing a commercial VR game in young adults and the relationship between sports engagement and health.	"Oculus Quest" Mirrored on a separate tablet	Japan	Sessions lasting for a total of approximately 45–60 minutes per session, with sessions held one to two days apart, depending on the participant's availability.	N/A	Positive effect
7.	Acute Effects of Virtual Reality Exercise Biking on College Students' Physical Responses *Authors*: Nan Zeng, Wenxi Liu, Zachary C. Pope, Daniel J. McDonough, and Zan Gao	2018	48 college students	Acute effects of a VirZoom VR exercise bike (vBike) on college students' physical responses compared to an exergaming bike (eBike) and a traditional stationary exercise bike (tBike).	VirZoomVR Exercise Bike (vBike), --- Spirit Fitness XBR25 Recumbent Bike Spirit Fitness XBU55 Upright Bike (tBike). PlayStation VR -- integrated Gamercize unit connected to a Microsoft Xbox 360 console.---	USA	20-minute cycling sessions are calculated on different games.	Moderate intensity	Positive effect
8.	Affective and Attentional States When Running in a Virtual Reality Environment *Authors*: David L. Neumann and Robyn L. Moffitt	2018	46 university students (21 male, 25 female)	Psychological states when engaging in physical exercise in a VR environment.	VR environment - Netathlon® 2XF running/skiing software. Participants ran on a Marquee Fitness MT80 treadmill. MW870UST BenQ data projector	Australia	21 min running trial	Light activity in the first minute of the trial and intensity steadily increased until the completion	Positive effect

Table 1. *Characteristics of the identified studies (Continued)*

N	Paper Ref	Years	Sample	Purpose and measures	VR technology and output display	Country of the research	Physical Movements/ Task	Intensity	General effect (reported)
9.	Applicability of an Immersive Virtual Reality Exercise Training System for Office Workers during Working Hours *Authors*: Evlalia Touloudi, Mary Hassandra, Evangelos Galanis, Marios Goudas and Yannis Theodorakis	2022	40 female employees (20 to 61 years old)	To examine the acceptance, future adoption, interest/enjoyment, and usability of an immersive virtual reality system for exercise training by office workers during breaks within their working hours.	Cycle-ergometer (stationary seated bike type; Toorx, Chrono Line, BRX R 300) with Bluetooth capability and a Meta Quest 2 N/A	Greece	15-minute session	Moderate intensity and "self-selected intensity"	Positive effect
10.	Can Physical Activity in Immersive Virtual Reality Be Attractive and Have Sufficient Intensity to Meet Health Recommendations for Obese Children? A Pilot Study *Authors*: Jacek Polechonski, Katarzyna Nierwinska, Barbara Kalita and Piotr Wodarski	2020	11 obese children (8-12 years old)	To assess the attractiveness and intensity of physical exercise while playing active video games (AVGs) in IVR on an omnidirectional treadmill by obese children and to present the results compared to health recommendations (PA).	HMD and HTC VIVE controllers compatible with the OMNI platform. N/A	Poland	15-minute exercise on the exercise machine	Intensity of PA of obese children playing both games was high (HRavg > 77% HRmax). evaluated using six intensity zones: <50% HRmax, 50–59% HRmax, 60–69% HRmax, 70–79% HRmax, 80–89% HRmax, and 90% HRmax.	Positive effect
11.	Is Your Virtual Self as Sensational as Your Real? Virtual Reality: The Effect of Body Consciousness on the Experience of Exercise Sensations. *Authors*: Matsangidou, Maria and Ang, Chee Siang and Mauger, Alexis R. and Intarasirisawat, Jittrapol and Otkhmezuri, Boris and Avraamides, Marios	2017	80 (21 males and 59 females)	To investigate whether the effectiveness of VR in reducing the feeling of exercise pain and effort is moderated by Private Body Consciousness (PBC).	Samsung Galaxy Gear1 head-mounted-display (HMD). N/A	United Kingdom	Participants' one-repetition maximum (1RM3), for 180o of dominant arm elbow flexion ranged from 5 to 30 kg, with a mean of 11.9 kg (SD = 6.2).	Isometric contraction for as long as the participants could with their elbow at an angle of 90o flexion.	Positive effect

DISCUSSION

The virtual experimental environment utilizes technology for physical activity (Dan, Chao & Yue, 2021). It generates a totally virtualized world without introducing virtual elements within real spaces, unlike augmented reality (AR). VR technology can recreate and explore different environments for studying different types of phenomena (Calabuig-Moreno et al., 2020). KINECT and other virtual reality technology are used for physical activity. The virtual model of the training field uses 3D SMAX tools, and the system uses CryEngine engine technology to convert the training field (Dan, Chao & Yue, 2021). AR is used to help patients with physical rehabilitation, allowing them to perform virtual exercises and track their progress in real-time. VR-based games generate controlled environments that offer the possibility to assess and enhance cognitive and motor rehabilitation. (Denche-Zamorano et al., 2023). However, the use of virtual reality technology for improving physical activity has gained significant attention in recent years.

According to the set inclusion and exclusion criteria, the articles considered comprehensively explained the methodology employed and delved into the effects of virtual reality on sports and physical activity among the participants. The table indicates that only eleven papers met all of the criteria for inclusion and exclusion. The analysis of these papers revealed that indoor physical activities were the most common type of exercise, focusing on aerobic workouts involving stationary bicycles or treadmills. Furthermore, the research predominantly took place in indoor settings.

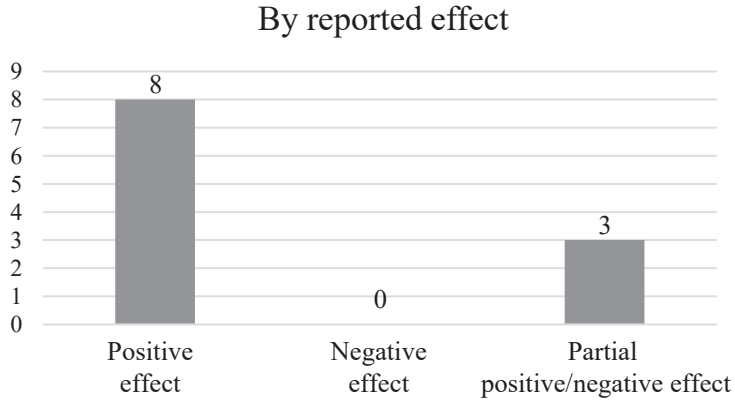

Figure 3. *Studied articles by reported effect.*

Performance in exergames can be primarily impacted by the player's motivation [e.g., winning orientation vs. Goal orientation (Gill & Deeter, 1988)]. Hence, it is important to understand the target group of people and define what motivations they would have when playing the games. The games inspire a desire for general physical exercises rather than for health recovery (e.g., rehabilitation). During the play, a player's attention will be diverted to how to stand out in the games. The player will unconsciously gain some bursts of energy by consciously performing exercise-inspired gaming actions to achieve high scores.

As VR-based exergames are becoming an extra supplement for exercise, the games we developed would engage people to exercise daily and motivate people who do not exercise very often. (Cao, Peng, & Dong, 2021).

Outcome analysis

Discussing some of the results and effects discovered in the reviewed studies is also essential. In the study by Guimares, Barbosa, and Meneghini (2018), it was determined that the study's results were inflated, and it was concluded that the results and program adherence suggest that sports AVG may be used as an alternative form of exercise for elderly individuals because it produces cognitive performance effects comparable to aerobic exercise.

In addition to increased physical activity, adding virtual reality (VR) to a cycling exercise increases inactive adults' affective experience of physical activity and decreases their subsequent food intake. Virtual reality technology has the potential to help individuals in weight management programs become more active, especially those who are prone to overeating after exercise.

On the other hand, Mehrabi et al. 2022, considered the feasibility of conducting exercises through VR for older adults in a home environment. They also confirm that gameplay metrics have the potential to be powerful descriptors of elements related to physical and cognitive functioning, which are essential aspects when tracking the progress and benefits of exercise programs.

Research by Cao, Peng, & Dong (2021) concluded on the use of Head Mounted Devices (HMDs) that there is a greater possibility that players will choose to play more trials of a VR-based exergame and, as a result, enhance their physical activities over the long term if they use HMDs.

According to the study by Hanifah et al. (2022), the potential for virtual reality (VR) sports activities to positively impact sports participation and health among participants, with vigor and dedication positively impacting health. Also, a positive correlation between sports participation and health-related factors was observed after playing VR sports activities. Intriguingly, perseverance and vigor emerged as crucial factors for enhancing health while participating in VR sports. Almost the same conclusion comes from Zeng et al., 2022 who state that "VR, therefore, potentially may serve as a tool health professionals use to promote PA participation and adherence among healthy young adults."

A positive effect was also found in the study by Neumann & Moffitt (2018), who, from a psychological perspective, found the effect that higher levels of immersive tendencies and greater attention/absorption in the virtual reality environment were associated with more positive (or less negative) emotional states. It is also mentioned that any influence that brings enjoyment would be positive.

The researchers Touloudi et al. 2022, who studied administrative employees and not active athletes, also reported a fairly positive effect in terms of perception. In order to reach a conclusion, the authors state that extended studies are necessary to determine the cumulative effect of exercise and increased physical activity in relation to sedentary lifestyles.

In their study, Polechonski et al. 2020 examined the effects of regular gameplay on the health of overweight children and found positive results. This was also connected to age-appropriate play scenarios for children rather than an effort to promote physical activity.

Matsangidou et al., 2019, also reached an intriguing and encouraging conclusion, confirming through their study that "VR technology can play a significant role in reducing the sensations of pain and effort caused by exercise." Here, the immersive environment and increased interest have an effect, reducing the negative feelings associated with the performed exercises.

In their 12-week study, Ben-Zeev et al. 2020 failed to find any significant differences

between the two groups investigated in terms of spatial learning and memory, and there was no increase in VO2 max.

CONCLUSION

In conclusion, it could be stated that virtual reality technology provides a personalized and adaptive experience by adapting to the individual's interests and abilities. It has been discovered that immersive VR exergames can result in the same or greater exercise intensity than conventional exercise conditions but with higher ratings of enjoyment and interest. In addition, virtual reality technology can assist elderly individuals, children, employees, students, and many others to improve their physical performance and increase motivation. Exergaming in virtual reality could be especially beneficial for promoting physical activity and overall health in persons with disabilities and mental health issues.

However, the use of virtual reality technology for physical activity still faces some limitations and obstacles.

Overall, it can be concluded from the conducted research that sports and physical activity performed using VR technology can be engaging, enjoyable, and conducive to a healthy lifestyle.

REFERENCES

Ben-Zeev, T., Weiss, I., Ashri, S., Heled, Y., Ketko, I., Yanovich, R., & Okun, E. (2020). Mild Physical Activity Does Not Improve Spatial Learning in a Virtual Environment. *Frontiers in Behavioral Neuroscience, 14*, 584052–584052. https://doi.org/10.3389/fnbeh.2020.584052

Calabuig-Moreno, F., González-Serrano, MH., Fombona, J., García-Tascón, M. (2020). The Emergence of Technology in Physical Education: A General Bibliometric Analysis with a Focus on Virtual and Augmented Reality. *Sustainability 12*(7):2728. https://doi.org/10.3390/su12072728

Cao, L., Peng, C., & Dong, Y. (2021). Ellic's Exercise Class: promoting physical activities during exergaming with immersive virtual reality. *Virtual Reality : the Journal of the Virtual Reality Society, 25*(3), 597–612. https://doi.org/10.1007/s10055-020-00477-z

Dan, L., Chao, Y., Yue, G. (2021). Research on College Physical Education and Sports Training Based on Virtual Reality Technology. *Mathematical Problems in Engineering,* vol. 2021. https://doi.org/10.1155/2021/6625529

Denche-Zamorano, A., Rodriguez-Redondo, Y., Barrios-Fernandez, S., Mendoza-Muñoz, M., Castillo-Paredes, A., Rojo-Ramos, J., Garcia-Gordillo, M. A., & Adsuar, J. C. (2023). Rehabilitation Is the Main Topic in Virtual and Augmented Reality and Physical Activity Research: A Bibliometric Analysis. *Sensors (Basel, Switzerland), 23*(6), 2987. https://doi.org/10.3390/s23062987

Guimarães, A. V., Barbosa, A. R., & Meneghini, V. (2018). Active videogame-based physical activity vs. aerobic exercise and cognitive performance in older adults: a randomized controlled trial. *Journal of Physical Education and Sport, 18*(1), 203–209. https://doi.org/10.7752/jpes.2018.01026

Hanifah, H., Ito, Y., Yao, D. P. G., Suyama, N., & Inoue, K. (2022). Promoting Sports Engagement during the COVID-19 Pandemic via Virtual Reality Games. *Occupational Therapy International, 2022,* 4824152–10. https://doi.org/10.1155/2022/4824152

Mathew, P. & Pillai, A. (2020). Chapter 2 in Virtual and Augmented Reality in Education, Art, and Museums. *Role of Immersive (XR) Technologies in Improving Healthcare Competencies: A Review.* 10.4018/978-1-7998-1796-3.ch002.

Matsangidou, M., Ang, C. S., Mauger, A. R., Intarasirisawat, J., Otkhmezuri, B., &

Avraamides, M. N. (2019). Is your virtual self as sensational as your real? Virtual reality: The effect of body consciousness on the experience of exercise sensations. *Psychology of Sport and Exercise, 41,* 218–224. https://doi.org/10.1016/j.psychsport.2018.07.004

Mehrabi, S., Muñoz, J. E., Basharat, A., Boger, J., Cao, S., Barnett-Cowan, M., & Middleton, L. E. (2022). Immersive Virtual Reality Exergames to Promote the Well-being of Community-Dwelling Older Adults: Protocol for a Mixed Methods Pilot Study. *JMIR Research Protocols, 11*(6), e32955–e32955. https://doi.org/10.2196/32955

Neumann, D. L., & Moffitt, R. L. (2018). Affective and Attentional States When Running in a Virtual Reality Environment. *Sports (Basel), 6*(3), 71–. https://doi.org/10.3390/sports6030071

Page, MJ., McKenzie, JE., Bossuyt, PM., Boutron, I., Hoffmann, TC., Mulrow, CD., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ 372*:n71. https://doi.org/10.1136/bmj.n71

Polechoński, J., Nierwińska, K., Kalita, B., & Wodarski, P. (2020). Can Physical Activity in Immersive Virtual Reality Be Attractive and Have Sufficient Intensity to Meet Health Recommendations for Obese Children? A Pilot Study. *International journal of environmental research and public health, 17*(21), 8051. https://doi.org/10.3390/ijerph17218051

Qian, J., McDonough, D. J., & Gao, Z. (2020). The Effectiveness of Virtual Reality Exercise on Individual's Physiological, Psychological and Rehabilitative Outcomes: A Systematic Review. *International journal of environmental research and public health, 17*(11), 4133. https://doi.org/10.3390/ijerph17114133

Sauchelli, S., & Brunstrom, J. M. (2022). Virtual reality exergaming improves affect during physical activity and reduces subsequent food consumption in inactive adults. *Appetite*, 175, 106058–106058. https://doi.org/10.1016/j.appet.2022.106058

Guimarães, A. & Barbosa, A. & Meneghini, V. (2018). Active videogame-based physical activity vs. aerobic exercise and cognitive performance in older adults: a randomized controlled trial. *Journal of Physical Education and Sport, 18*(1), Art 26, pp. 203 - 209 https://doi.org/10.7752/jpes.2018.01026.

Touloudi, E., Hassandra, M., Galanis, E., Goudas, M., & Theodorakis, Y. (2022). Applicability of an Immersive Virtual Reality Exercise Training System for Office Workers during Working Hours. *Sports (Basel), 10*(7), 104–. https://doi.org/10.3390/sports10070104

Zeng, N., Liu, W., Pope, Z. C., McDonough, D. J., & Gao, Z. (2022). Acute Effects of Virtual Reality Exercise Biking on College Students' Physical Responses. *Research quarterly for exercise and sport, 93*(3), 633–639. https://doi.org/10.1080/02701367.2021.1891188

Corresponding author:

Milena Kuleva, PhD
Department of Language Learning and Information Technology
National Sports Academy "Vassil Levski"
21, Acad. Stefan Mladenov str.
Studentski grad, 1700 Sofia, Bulgaria
E-mail: milena.kuleva@nsa.bg