Peer-reviewed version available at Int. J. Environ. Res. Public Health 2019, 16, 3673; doi:10.3390/ijerph16193673

Article

Assessment of enjoyment and intensity of physical activity in immersive virtual reality on the omni-directional Omni treadmill and Icaros flight simulator in the context of recommendations for health

Małgorzata Dębska[1], Jacek Polechoński[1,*], Arkadiusz Mynarski[1], Piotr Polechoński[2]

[1] Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, 43-512 Katowice, Poland; m.debska@awf.katowice.pl (M.D.), j.polechonski@awf.katowice.pl (J.P.), a.mynarski@awf.katowice.pl (A.M.)

[2] Faculty of Physiotherapy, The Jerzy Kukuczka Academy of Physical Education in Katowice, 43-512 Katowice, Poland; piotr.polechonski.kontakt@gmail.com (P.P.)

* Correspondence: j.polechonski@awf.katowice.pl; Tel.: +48-32-207-5358

Abstract: The aim of the study is to assess enjoyment and intensity of physical exercise while practicing physical activity (PA) in immersive virtual reality (IVR) using innovative training devices (omni-directional Omni treadmill and Icaros Pro flight simulator). The study also contains the results of subjective research on the usefulness of such a form of PA in the opinion of users. In total, 61 adults (10 women and 50 men) took part in the study. To assess the enjoyment level (EL) Interest/Enjoyment subscale of Intrinsic Motivation Inventory (IMI) was used. Exercise intensity was assessed during 10-minute sessions of active video games (AVGs) in IVR based on heart rate (HR). The average enjoyment level during physical exercise in IVR on the tested training devices was relatively high (Omni 5.74 points, Icaros 5.60 points). In the opinion of the majority of participants, AVGs on IVR training devices constitute a sufficiently useful form of movement to meet the needs of PA practiced in free time, and they can even replace some of the classic forms of movement. Intensity of PA during games on training devices was at the level recommended for health benefits for 92% (Omni) and 84% (Icaros Pro) of its duration. Based on the conducted research, it can be assumed that AVGs in IVR using a multi-directional treadmill and a flight simulator can be an effective tool for increasing participation in health-oriented PA.

Keywords: health-oriented physical activity ; immersive virtual reality, virtual reality; intensity of physical activity

1. Introduction

The lack of movement (hypokinesia) is the main cause of the incidence of chronic non-communicable diseases, causing 71% of all deaths per year, including as much as 40% of premature deaths [1]. Therefore, health promotion activities are currently focused on searching for tools popularizing modern physical activity (PA), attractive for people, tailored to their interests, fitness abilities and leisure time budgets.

The development of modern technology is considered to be one of the reasons for the decreasing PA level in everyday life [2]. Due to the fact that they constitute an inseparable element of the development of civilization in recent years, technological innovations have been used to popularize PA among the public. The first manifestation of this action was the creation of active

video games (AVGs), in which the player controls the course of the game with movements of his/her body, becoming its active participant and not a passive player. Subsequently, the so-called "Exergames" were introduced, i.e. differentiated interactive training programs, often with the assistance of a virtual trainer, the goal of which is PA.

So far, published scientific reports confirm a high level of enjoyment during various AVGs and exergames [3–5]. It should be noted that according to the results of research on components of behavioral engagement in performing PA, enjoyment is its significant predictor, regardless of age of the study participants [6–9] and their health status [10–12]. It was also observed that due to the high rating of the attractiveness of games of this type, players are able to perform PA longer in an interactive form, compared to classic PA, which may translate into better health effects [13].

In addition, the results of monitoring the parameters of physical exercise during many active video games showed that their values are at the level recommended for health by international organizations [14–19] and contribute to the health benefits of both healthy people [13,20,21] and patients [22–24].

Another aspect of using technological progress in improving public health is the transfer of AVG to virtual reality (VR) – a computer-created space to which users move using special goggles. These goggles enable the players to be cut off from the real world, making them part of the game and multiplying the emotions they experiences during it [25]. This most advanced technique, enabling the highest degree of realism in which a person is cut off from the visual and auditory stimuli of the real environment, and instead receives the image and sound, and even tactile sensations of the simulated world, is often referred to as immersive virtual reality (IVR) [26,27].

Analysis of the few research studies concerning PA in VR that have been created over the last few years, indicates the possibilities of using this modern technology in physiotherapy. A study conducted by Baños et al. [28] shows that walking on a treadmill performed in the virtual world can be better tolerated by obese children than the same physical effort in a traditional form. VR allows for the distraction of the participants from the discomfort that accompanies PA. In addition, moving around in VR turned out to be more attractive to obese children than a typical treadmill walk. According to the authors, the use of VR technology in training programs may be a factor increasing motivation to exercise, which may be important in the prevention of overweight and in the fight against obesity. It seems that the reduced feeling of discomfort during exercise in a virtual environment and the attractiveness of this type of PA can be also used in therapeutic treatment in patients with other dysfunctions, which are accompanied by various ailments associated with physical effort. Reports by Baños et al. [28] seem to confirm the results of a study conducted by Matsangidou et al. [29], which showed that PA in VR can affect the perception of pain observed during isometric exercise, which results in lower subjective perception of exercise severity and, consequently, the possibility of continuing the activity and a higher assessment of its attractiveness in comparison with PA performed in a classical manner.

Due to the growing popularity of PA in a virtual environment, special training devices for training in VR began to be created. Omni-directional treadmills, flight and diving simulators, cycling simulators etc. are created, enabling active movement in the virtual world. These training devices are equipped with sensors that reflect the user's body movements in VR. Thanks to the devices for PA in VR, the users becomes a part of the artificially created world, and the movements of their body control the course of a chosen game, sports training or visiting virtual destinations [25,30].

Previously published articles on PA in VR focus on the possibility of its implementation in public health activities. Many publications emphasize the potential of this form of movement, recognizing it as a modern trend in healthcare [31,32], mainly in the field of secondary prevention [28,33,34]. However, there are no scientific reports verifying the level of enjoyment and parameters of physical exercise in the context of pro-health recommendations, during such a form of PA in the case of people without a diagnosed disease, which is the basis for assessing its suitability in the universal health promotion and prevention of. Moreover, in literature there are currently no publications presenting the results of research on this issue with the use of special training devices for PA in VR.

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2019, 16, 3673; doi:10.3390/ijerph16193673

In connection with the above, the aim of the study was to evaluate enjoyment and intensity of physical effort while practicing physical activity in immersive VR using innovative training devices (omni-directional Omni treadmill and Icaros Pro flight simulator). The study also contains the results of subjective research on the usefulness of such a form of physical effort in the opinion of users.

2. Materials and Methods

2.1. Participants

Sixty-one adults participated in the study recruited from among participants of the Silesian Festival of Science (Poland), where equipment and software allowing for PA in VR was presented. Inclusion criteria included: age (>18), signing a statement about good general health and the lack of medical contraindicators to participate in the study (physical limitations affecting exercise e.g.: pregnancy, injury, etc., no history of seizures or epilepsy, taking any medications affecting heart rate). In the studies using the Omni treadmill (Virtuix) (Fig. 1) thirty-six adults participated, including six women (age 28.3±11.6, height 168.2±5.8, weight 61.3±5.6) and thirty men (age 25.6±8.2, height 179.2±5.9, weight 80.0±10.2). Icaros Pro flight simulator (Icaros GmbH) (Fig. 2) was tested by twenty-five people: four women (age 32.0±13.0, height 165.5±5.9, weight 61.0±7.2) and twenty-one men (age 24.7±8.6, height 178.4±7.2, weight 77.7±10.5). Among all the studied people, eleven young men (age 19.7±2.5, height 176.3±6.3, weight 74.0±9.9) completed training sessions on both training devices, therefore the comparison of intensity of physical activity and the enjoyment level during PA on selected training devices applied to part of the group only.

More than half of the participants (34 people) declared that they had previously experienced immersive VR using computer games using VR headset, while no one had previously had the opportunity to practice PA in virtual reality on the tested training devices.

2.2. Procedures

The research procedure consisted of a 10-minute session of an active video game on at least one of the two studied simulators. Before proceeding to the above research activities, the researchers matched the devices to the participant's height, explained the purpose of the game and explained how to use it and move in VR. Then a 2-minute trial game took place, followed by a proper game that lasted 10 minutes. Users could stop participating in the study at any time. In the group that tested both devices, training sessions were held in the following order: Omni treadmill (O) (dominance of aerobic endurance exercise), Icaros Pro (I) flight simulator (dominance of strength endurance exercise) and a 30-minute break to rest between them.

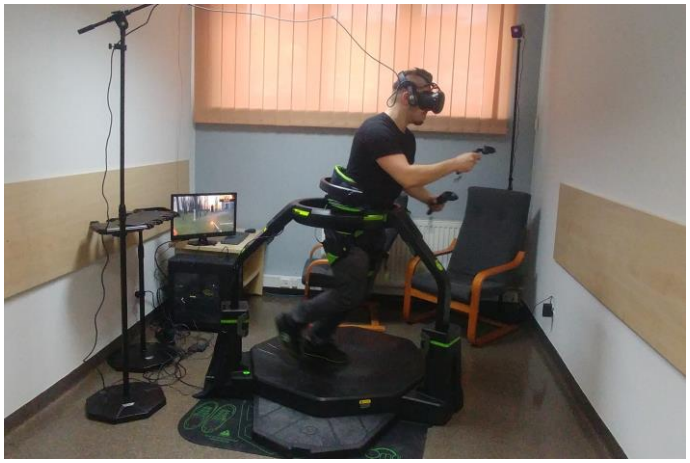

Figure 1. Omni-directional Omni treadmill enabling locomotive movements in VR
Source: author's elaboration

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2019, 16, 3673; doi:10.3390/ijerph16193673

Figure 2. Icaros Pro – flight simulator in VR
Source: author's elaboration

2.3. Methods and tools

The game using Omni treadmill *"Travar Training OPS"* consisted of covering the obstacle course and shooting the indicated targets in the shortest possible time. The necessity to cover the designated course forced the player to perform locomotive movements (walking, running). VR image projection and control of the movement of the upper limbs while moving on the treadmill were carried out thanks to the HTC VIVE goggles and controllers co-operating with the Omni platform. The goal of the *"Flight"* game on the Icaros Pro flight simulator was to control a flying ship by moving the body in a position supporting themselves on the forearms and lower legs. The activity was more static than moving on the Omni treadmill, and piloting required the player to constantly control the position of their body and balance in space by appropriate tightening and loosening of the muscles. For the projection of the VR image, Samsung Gear goggles were used.

For the assessment of the enjoyment level (EL) Interest/Enjoyment subscale of Intrinsic Motivation Inventory (IMI) was used [35]. It is a multidimensional measurement grounded on the Self-Determination Theory (SDT) used in assessing the subjective experiences of participants when developing an activity [36]. The Interest/Enjoyment subscale assesses the interest and inherent pleasure when doing a specific activity. It has been used in previous virtual reality exercise studies [3,21,37] and has shown good reliability and validity [35]. According to the inventory instruction participants ranked their agreement with each statement on a Likert scale of 1 ("not at all true") to 7 ("very true"). Responses were averaged to create the overall enjoyment scale scores (range 1–7). The subjective assessment of the suitability of PA in VR on the studied training devices was verified using the author's own questionnaire containing 5 questions with a "yes or no" scale. The participants were asked the following questions: If you had an Omni treadmill/Icaros device, would you perform physical activity in VR? Would you recommend practicing physical activity in VR on the Omni treadmill/Icaros device to others?; Do you think that practicing physical activity on the Omni treadmill/Icaros device can be a supplement to physical activity of an aerobic/strength nature (exercises in a support position) in free time?; Do you think that practicing physical activity on the Omni treadmill/Icaros device can meet the needs related to physical activity performed in free time in the field of locomotion exercises (walking, running) (Omni)/in the area of exercises in a support position (Icaros)?; Do you think that physical activity on the Omni treadmill/Icaros device can replace typical, real forms of physical activity in free time, such as: walking, running (Omni)/typical exercises in a support position (Icaros)? On the basis of the participants' answers, fractions of the participants assessing the abovementioned aspects of usefulness PA in VR positively (yes) and negatively (no) were calculated.

During AVGs on the training devices, heart rate (HR) was monitored using the Vantage V pulse meter by Polar. The intensity of physical exercise was determined on the basis of the average percentage of maximum heart rate (% HRmax) obtained by each participant during the test.

Previously, the HRmax value was calculated from the formula by Tanaka et al. [38]. The exercise load was estimated based on the PA intensity classification proposed by the American Heart Association [39]. According to it, HRavg<50%HRmax means low intensity, 50%HRmax≤HRavg<70%HRmax - moderate, and HRavg≥70%HRmax - high. The data obtained in this manner was referred to the criteria of health-related recommendations in the scope of intensity of aerobic physical exercises, according to which those of at least moderate intensity (≥50%HRmax) are beneficial for health [40,41]. The total time of HR maintenance during a 10-minute effort on the tested training devices was also estimated in three intensity zones: low, moderate and high.

2.4. Ethics

The study procedures were reviewed and approved by the Research Ethics Committee of the Jerzy Kukuczka Academy of Physical Education in Katowice (protocol code – 9/2018, date of approval – 2018.04.19). It was conducted in accordance with the Declaration of Helsinki. All participants took part in the study voluntarily and could discontinue their participation at any time. They have provided written consent for the use of information collected during examination.

2.5. Statistical Analysis

Statistica 13.0 (StatSoft, Inc.) was used to carry out statistical calculations. The analysis of measurement data was carried out using basic descriptive statistics. The results of the survey were presented in percentages. The consistency of the distribution was estimated using the Shapiro-Wilk test. The non-parametric Wilcoxon test was used to assess the significance of the differences between the mean values of results during PA on O and I.

3. Results

3.1. Enjoyment level

In the group having the Omni a session, the average enjoyment level (EL) during physical activity was 5.74±0.86 points, while in those testing the Icaros flight simulator it was 5.60±0.88 on a 1-7 Likert scale. Comparing the results for excitement/interest subscale of IMI of the participants who completed their training sessions on both training devices demonstrated significant differentiation ($p<0.01$) of the EL in favor of PA on the first training device (Omni: 6.13±0.9; Icaros: 5.18±0.7 points).

3.2. Intensity level in the context of health recommendations

The average heart rate during PA in VR on the omni-directional Omni treadmill was 149.5±22.3 bpm and was significantly higher ($p <0.01$) than observed on the Icaros Pro flight simulator – 121.4±18.0 bpm. A similar statistically significant relationship was found analyzing the average percentage of maximum heart rate (% HRmax). The estimated parameter for people playing on the treadmill was 76.8% HRmax (high intensity) and it was significantly higher ($p<0.01$) than on Icaros Pro - 62.5% HRmax (moderate intensity). It is worth noting that for all subjects, regardless of the training device used, the intensity of physical activity exceeded 50% of HRmax, and was therefore sufficient to obtain health benefits [39–41] (Fig. 3). For the vast majority of time practicing PA in VR on both training devices, the intensity of exercise remained at a pro-health (moderate or high) level. In the case of training on the Omni treadmill, the health-beneficial effort lasted for 92% (552s), and on the Icaros Pro flight simulator for 84% (502.4s) of the duration of the game. During training, on the first of these devices PA with high intensity of 74% (441.8s) clearly dominated, while practicing AVGs on the second training device was mainly associated with moderately intense physical activity - 57% (339.4s) (Fig. 4).

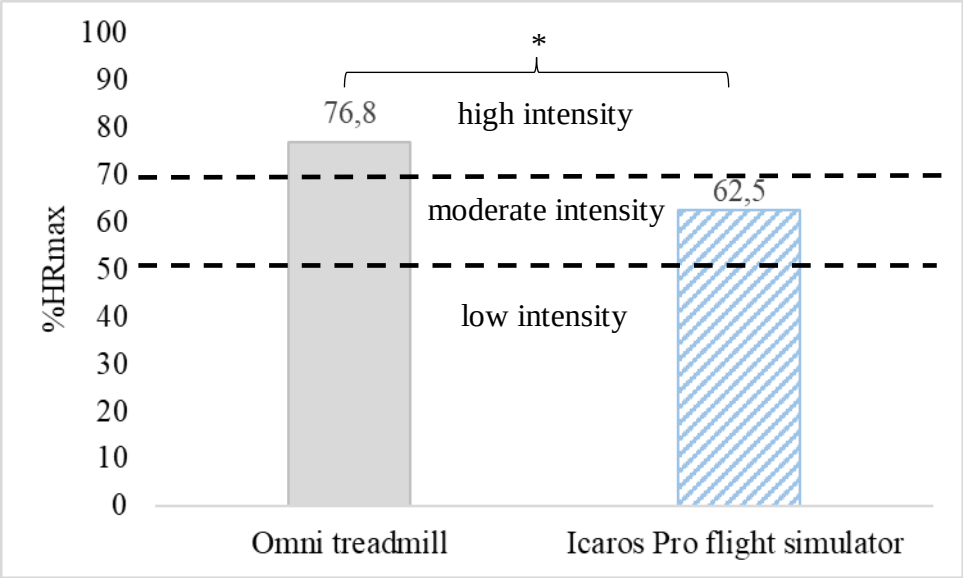

Figure 3. Average intensity of physical effort during AVGs in VR on the Omni treadmill and Icaros Pro flight simulator, * – p<0.01

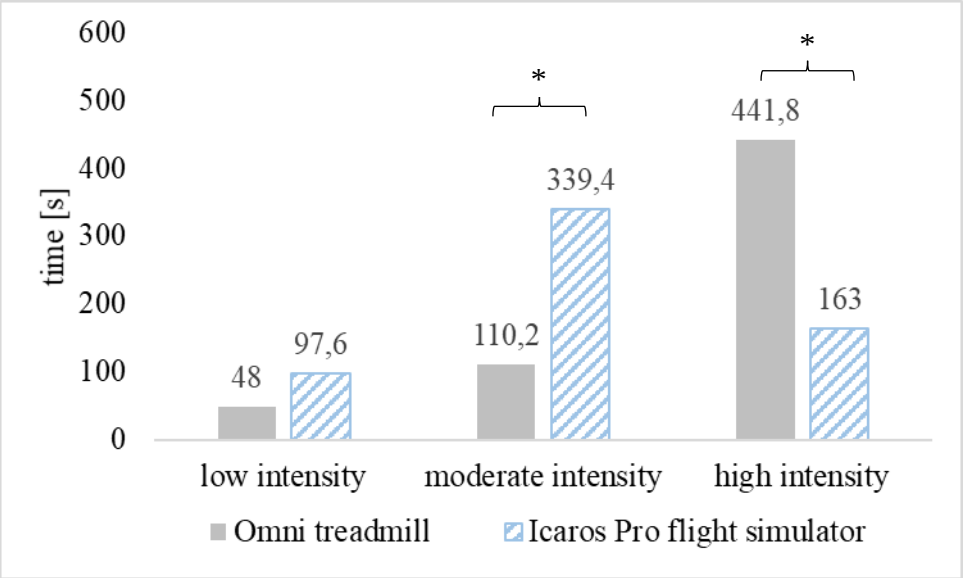

Figure 4. Duration of physical activity at different intensity intervals when practicing 10-minute AVGs on the Omni treadmill and Icaros Pro flight simulator, * – p<0.01

3.3. Usefulness of physical activity in VR with the use of innovative training devices in the opinion of the participants of the study

The vast majority of people testing Omni (92%) and Icaros Pro (88%) devices claimed that having this type of training devices they would be practicing PA in VR. Almost every user of the treadmill (97%) and flight simulator (96%) would recommend PA on the tested devices to others.

All the participants were convinced that practicing PA on both training devices could be supplementary to PA practiced in free time. A clear majority of users of the multidirectional treadmill (72%) were of the opinion that training in VR on this device can meet the needs of PA practiced in free time in the field of locomotion-based exercises (walking, running). An even more numerous representations of the participants exercising on Icaros (80%) had a similar view on the subject of the tested flight simulator in the context of the possibility of performing exercises in a

Peer-reviewed version available at Int. J. Environ. Res. Public Health 2019, 16, 3673; doi:10.3390/ijerph16193673

support position on this training device. A large proportion of people training on the treadmill (44%) were even of the opinion that PA on the Omni platform can replace typical, real forms of physical activity practiced in free time, such as walking and running. However, most participants testing Icaros (60%) were convinced that simulator training is able to replace typical exercises in a support position (Table 1).

Table 1. Usefulness of physical activity in VR using innovative training devices (omni-directional Omni treadmill and Icaros Pro flight simulator) in the assessment of study participants

Question	Omni users (n=36)		Icaros users (n=25)	
	Yes/ Agree	No/ Disagree	Yes/ Agree	No/ Disagree
If you had an Omni treadmill/Icaros device, would you perform physical activity in VR?	92%	8%	88%	12%
Would you recommend practicing physical activity in VR on the Omni treadmill/Icaros device to others?	97%	3%	96%	4%
Do you think that practicing physical activity on the Omni treadmill/Icaros device can be a supplement to physical activity of an aerobic/strength nature (exercises in a support position) in free time?	100%	0%	100%	0%
Do you think that practicing physical activity on the Omni treadmill/Icaros device can meet the needs related to physical activity performed in free time in the field of locomotion exercises (walking, running) (Omni)/in the area of exercises in a support position (Icaros)?	72%	28%	80%	20%
Do you think that physical activity on the Omni treadmill/Icaros device can replace typical, real forms of physical activity in free time, such as: walking, running (Omni)/typical exercises in a support position (Icaros)?	44%	56%	60%	40%

4. Discussion

So far, many studies have been published verifying the pro-health nature and enjoyment of physical activity during AVGs [5,42–45]. Unlike our study, however, they did not evaluate PA in immersive VR, in which man is cut off from the visual and auditory stimuli of the real environment, and instead he/she receives the image and sound of the simulated world. Moreover, there are few publications aimed at assessing the above-mentioned parameters during PA using innovative VR training devices. In this context, our study seems original.

The assessment of enjoyment during PA is of great importance in shaping the motivational instruction to take action, which from the perspective of public health is currently, among others, regular participation in physical activity [9,46]. The results of many studies have shown that enjoyment is a significant predictor of PA participation regardless of the age of the participants [6–9] and their health [10–12]. Over the past few years, there have been publications on this topic in the context of undertaking physical activity in VR. According to the results of these studies, the attractiveness of various forms of PA in VR is higher in relation to identical forms of PA taken in the classical way [25,28,29].

High enjoyment rating during PA in VR is confirmed by the results of this study. The EL both during physical activity on the Omni treadmill (5.74±0.86 points) as well as on Icaros (5.60±0.88 points) was higher than the level demonstrated by other authors verifying the level of this parameter for various active video games [3–5]. Comparison of the enjoyment level during PA between the tested training devices showed a significant difference in favor of the Omni treadmill. The probable reason for this was the need to maintain a proper body balance for continuous 10-minute sessions on Icaros, which was a difficult task for the participants.

The high assessment of the usability of PA in VR on training devices is also emphasized by the participants' declarations, which showed that having such training devices they would be happy to train on them and would recommend this form of PA to their friends. The vast majority of study participants were also of the opinion that PA on the Omni treadmill and the Icaros flight simulator is useful enough to meet the needs of PA practiced in free time, and a large part even claimed they could replace some classic forms of PA with it.

In the studies presented in this paper, the PA parameters were also evaluated in terms of their health-enhancing character. It turned out that the intensity of physical activity during a game on the tested devices for PA in VR was on average at the level recommended for health benefits for 92% (Omni treadmill) and 84% (Icaros Pro) of its duration. It is worth noting that the average heart rate during the Omni treadmill session (149.5±22.3 bpm) was significantly higher ($p < 0.01$) than that observed on the Icaros Pro flight simulator (121.4±18.0 bpm). This probably results from a different type of exercise on both simulators. Locomotion movements dominated on the treadmill, while physical activity of the flight simulator users consisted mainly in balancing their body in space.

Previously published publications emphasize the potential of PA in IVR considering it a modern trend in healthcare [31], mainly in the field of secondary prevention [28,33,34]. The high assessment of the enjoyment level during physical activity in VR and the conviction of its usefulness as an innovative, attractive form of PA with adequate intensity for health benefits, demonstrated in the study, draw attention to the usefulness of PA in VR on the tested training devices in the context of increasing PA adherence. This is very important due to the insufficient participation in PA, often underlined in publications as the most frequent reason for not following pro-health recommendations in this area of behavior and its reasons such as finding it inconvenient to exercise, lack of self-motivation and finding exercises boring [47–50]. Taking into account the positive reception of such solutions by users and the dynamic development of modern computer technology, there are many indications that training devices cooperating with immersive VR can be widely used in the promotion of health and physical rehabilitation.

The results of this study should be viewed in the context of several limitations. Due to the lack of other studies on the same issues, further research is necessary to verify the level of physical activity parameters and enjoyment in the case of various games and training programs practiced on training devices in VR, in order to determine those that may constitute a complement or alternative to classic health-oriented forms of PA. The findings of this manuscript should be also investigated in different population groups.

5. Conclusions

1. The average enjoyment level during physical activity in VR on the tested training devices was high. In the case of the Omni treadmill, it was 5.74 points, while in the case of the Icaros flight simulator it was 5.60 points.
2. In the opinion of the majority of participants, active video games practiced on the omni-directional Omni treadmill and Icaros flight simulator in immersive VR constitute a useful form of movement to meet the needs of PA practiced in free time, and they can even replace some classic forms of movement.
3. Intensity of PA during games on training devices was at the level recommended to obtain pro-health benefits for 92% (Omni treadmill) and 84% (Icaros Pro flight simulator) of its duration.

4. The average heart rate during activity sessions on the Omni treadmill (149.5±22.3 bpm) was significantly higher than that observed on the Icaros Pro flight simulator (121.4±18.0 bpm), which probably results from a different type of exercise on both training devices. During the 10-minute game on the first device, high intensity physical activity dominated, while in the case of the second training device - physical activity of moderate intensity dominated.
5. Due to the fact that in the opinion of users, PA in VR on the tested training devices is an enjoyable and useful form of movement, and research shows that its intensity is at the level recommended for obtaining health benefits, it may be assumed that this form of movement can be an effective tool for increasing participation in health-oriented PA.

Author Contributions: conceptualization, J.P.; methodology, M.D. and J.P.; formal analysis, M.D. and J.P.; investigation, M.D., J.P., A.M. and P.P.; data curation, M.D., J.P., A.M. and P.P.; writing—original draft preparation, M.D. and J.P.; writing—review and editing, M.D., J.P., A.M. and P.P.; visualization, M.D. and J.P.; supervision, M.D. and J.P.; project administration, M.D., J.P.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest.

References

1. World Health Organization *World health statistics 2018: monitoring health for the SDGs*; World Health Organization: Luxembourg, 2018;
2. Ramón, J.C.; Verdaguer, F.J.P.; Conti, J.V.; Rotger, P.A.B.; Sampol, P.P. Adolescencia, sedentarismo y sobrepeso: análisis en función de variables sociopersonales de los padres y del tipo de deporte practicado por los hijos (Adolescence, physical inactivity and overweight: analysis based on socio-personal variables of the paren. *Retos* **2015**, *0*, 5–8.
3. Lyons, E.J.; Tate, D.F.; Ward, D.S.; Bowling, J.M.; Ribisl, K.M.; Kalyararaman, S. Energy Expenditure and Enjoyment during Video Game Play: Differences by Game Type. *Med. Sci. Sports Exerc.* **2011**, *43*, 1987–1993.
4. Lyons, E.J.; Tate, D.F.; Ward, D.S.; Ribisl, K.M.; Bowling, J.M.; Kalyanaraman, S. Engagement, enjoyment, and energy expenditure during active video game play. *Health Psychol. Off. J. Div. Health Psychol. Am. Psychol. Assoc.* **2014**, *33*, 174–181.
5. Mullins, N.M.; Tessmer, K.; McCaroll, M.L.; Peppel, B.P. Physiological and Perceptual Responses to Nintendo® Wii Fit™ in Young and Older Adults. *Int. J. Exerc. Sci.* **2012**, *5*, 79–92.
6. Crain, A.L.; Martinson, B.C.; Sherwood, N.E.; O'Connor, P.J. The long and winding road to physical activity maintenance. *Am. J. Health Behav.* **2010**, *34*, 764–775.
7. Gao, Z.; Podlog, L.; Huang, C. Associations among children's situational motivation, physical activity participation, and enjoyment in an active dance video game. *J. Sport Health Sci.* **2013**, *2*, 122–128.
8. Lewis, B.A.; Williams, D.M.; Frayeh, A.L.; Marcus, B.H. Self-Efficacy versus Perceived Enjoyment as Predictors of Physical Activity Behavior. *Psychol. Health* **2016**, *31*, 456–469.
9. Rhodes, R.E.; Warburton, D.E.R.; Bredin, S.S.D. Predicting the effect of interactive video bikes on exercise adherence: An efficacy trial. *Psychol. Health Med.* **2009**, *14*, 631–640.
10. Charlier, C.; Van Hoof, E.; Pauwels, E.; Lechner, L.; Spittaels, H.; De Bourdeaudhuij, I. The contribution of general and cancer-related variables in explaining physical activity in a breast cancer population 3 weeks to 6 months post-treatment. *Psychooncology.* **2013**, *22*, 203–211.
11. Jin, J.; Yun, J.; Agiovlasitis, S. Impact of enjoyment on physical activity and health among children with disabilities in schools. *Disabil. Health J.* **2018**, *11*, 14–19.

12. Ungar, N.; Wiskemann, J.; Sieverding, M. Physical Activity Enjoyment and Self-Efficacy As Predictors of Cancer Patients' Physical Activity Level. *Front. Psychol.* **2016**, *7*.
13. Kraft, J.A.; Russell, W.D.; Bowman, T.A.; Selsor, C.W.I.; Foster, G.D. Heart Rate and Perceived Exertion During Self-Selected Intensities for Exergaming Compared to Traditional Exercise in College-Age Participants. *J. Strength Cond. Res.* **2011**, *25*, 1736.
14. Mellecker, R.R.; McManus, A.M. Active video games and physical activity recommendations: A comparison of the Gamercize Stepper, XBOX Kinect and XaviX J-Mat. *J. Sci. Med. Sport* **2014**, *17*, 288–292.
15. Naugle, K.E.; Naugle, K.M.; Wikstrom, E.A. Cardiovascular and Affective Outcomes of Active Gaming: Using the Nintendo Wii as a Cardiovascular Training Tool. *J. Strength Cond. Res. Natl. Strength Cond. Assoc.* **2014**, *28*, 443–451.
16. O'Donovan, C.; Hussey, J. Active video games as a form of exercise and the effect of gaming experience: a preliminary study in healthy young adults. *Physiotherapy* **2012**, *98*, 205–210.
17. Polechoński, J.; Mynarski, W.; Garbaciak, W.; Fredyk, A.; Rozpara, M.; Nawrocka, A. Energy Expenditure and Intensity of Interactive Video Dance Games according to Health Recommendations. *Cent. Eur. J. Sport Sci. Med.* **2018**, *24*, 35–43.
18. Sween, J.; Wallington, S.F.; Sheppard, V.; Taylor, T.; Llanos, A.A.; Adams-Campbell, L.L. The Role of Exergaming in Improving Physical Activity: A Review. *J. Phys. Act. Health* **2014**, *11*, 864–870.
19. Lau, P.W.C.; Liang, Y.; Lau, E.Y.; Choi, C.-R.; Kim, C.-G.; Shin, M.-S. Evaluating Physical and Perceptual Responses to Exergames in Chinese Children. *Int. J. Environ. Res. Public. Health* **2015**, *12*, 4018–4030.
20. Gonzales, C.S.; Gómez, N.; Navarro, V.; Cairós, M.; Quirce, C.; Toledo, P.; Marrero-Gordillo, N. Learning healthy lifestyles through active videogames, motor games and the gamification of educational activities - ScienceDirect. **2016**.
21. Lyons, E.J.; Tate, D.F.; Komoski, S.E.; Carr, P.M.; Ward, D.S. Novel approaches to obesity prevention: effects of game enjoyment and game type on energy expenditure in active video games. *J. Diabetes Sci. Technol.* **2012**, *6*, 839–848.
22. Kafri, M.; Myslinski, M.J.; Gade, V.K.; Deutsch, J.E. Energy Expenditure and Exercise Intensity of Interactive Video Gaming in Individuals Poststroke , Energy Expenditure and Exercise Intensity of Interactive Video Gaming in Individuals Poststroke. *Neurorehabil. Neural Repair* **2014**, *28*, 56–65.
23. Palacios-Cena, D.; Ortiz-Gutierrez, R.M.; Buesa-Estellez, A.; Galan-Del-Rio, F.; Cano-De-La-Cuerda, R. Multiple sclerosis patients' experiences in relation to the impact of the kinect virtual home-exercise programme: a qualitative study - European Journal of Physical and Rehabilitation Medicine 2016 June;52(3):347-55 - Minerva Medica - Journals. *Eur. J. Phys. Rehabil. Med.* **2016**, 347–355.
24. Staiano, A.E.; Flynn, R. Therapeutic Uses of Active Videogames: A Systematic Review. *Games Health J.* **2014**, *3*, 351–365.
25. Carvalho, B.; Soares, M.; Neves, A.; Soares, G.; Lins, A. Virtual reality devices applied to digital games. A literature review. In *Ergonomics in Design: Methods and Techniques*; CRC Press: Boca Raton, 2016; pp. 125–136 ISBN 978-1-4987-6071-3.
26. van Dam, A.; Laidlaw, D.H.; Simpson, R.M. Experiments in Immersive Virtual Reality for Scientific Visualization. *Comput. Graph.* **2002**, *26*, 535–555.
27. Southgate, E.; Smith, S.P.; Cividino, C.; Saxby, S.; Kilham, J.; Eather, G.; Scevak, J.; Summerville, D.; Buchanan, R.; Bergin, C. Embedding immersive virtual reality in classrooms: Ethical, organisational and educational lessons in bridging research and practice. *Int. J. Child-Comput. Interact.* **2019**, *19*, 19–29.

28. Baños, R.M.; Escobar, P.; Cebolla, A.; Guixeres, J.; Alvarez Pitti, J.; Lisón, J.F.; Botella, C. Using Virtual Reality to Distract Overweight Children from Bodily Sensations During Exercise. *Cyberpsychology Behav. Soc. Netw.* **2016**, *19*, 115–119.
29. Matsangidou, M.; Ang, C.S.; Mauger, A.R.; Intarasirisawat, J.; Otkhmezuri, B.; Avraamides, M.N. Is your virtual self as sensational as your real? Virtual Reality: The effect of body consciousness on the experience of exercise sensations. *Psychol. Sport Exerc.* **2019**, *41*, 218–224.
30. Ceurstemont, S. Optical illusions help you explore a virtual world on foot. *New Sci.* **2013**, *218*, 22.
31. Chow, Y.-W.; Susilo, W.; Phillips, J.G.; Baek, J.; Vlahu-Gjorgievska, E. Video Games and Virtual Reality as Persuasive Technologies for Health Care: An Overview. *JoWUA* **2017**, *8*, 18–35.
32. Yeh, T.-M.; Pai, F.-Y.; Jeng, M.-Y. The Factors Affecting Older Adults' Intention toward Ongoing Participation in Virtual Reality Leisure Activities. *Int. J. Environ. Res. Public. Health* **2019**, *16*, 333.
33. de Melo, G.E.L.; Kleiner, A.F.R.; Lopes, J.B.P.; Dumont, A.J.L.; Lazzari, R.D.; Galli, M.; Oliveira, C.S. Effect of virtual reality training on walking distance and physical fitness in individuals with Parkinson's disease. *NeuroRehabilitation* **2018**, *42*, 473–480.
34. Gandolfi, M.; Geroin, C.; Dimitrova, E.; Boldrini, P.; Waldner, A.; Bonadiman, S.; Picelli, A.; Regazzo, S.; Stirbu, E.; Primon, D.; et al. Virtual Reality Telerehabilitation for Postural Instability in Parkinson's Disease: A Multicenter, Single-Blind, Randomized, Controlled Trial Available online: https://www.hindawi.com/journals/bmri/2017/7962826/ (accessed on Mar 14, 2019).
35. Mcauley, E.; Duncan, T.; V. Tammen, V. Psychometric Properties of the Intrinsic Motivation Inventory in a Competitive Sport Setting: A Confirmatory Factor Analysis. *Res. Q. Exerc. Sport* **1989**, *60*, 48–58.
36. Deci, E.L.; Eghrari, H.; Patrick, B.C.; Leone, D.R. Facilitating internalization: the self-determination theory perspective. *J. Pers.* **1994**, *62*, 119–142.
37. IJsselsteijn, A.W.; de Kort, Y.A.W.; Westerink, J.; de Jager, M.; Bonants Virtual Fitness: Stimulating Exercise Behavior through Media Technology. *MIT Press J.* **2006**, 688–698.
38. Tanaka, H.; Monahan, K.D.; Seals, D.R. Age-predicted maximal heart rate revisited. *J. Am. Coll. Cardiol.* **2001**, *37*, 153–156.
39. Strath, S.J.; Holleman, R.G.; Richardson, C.R.; Ronis, D.L.; Swartz, A.M. Objective Physical Activity Accumulation in Bouts and Nonbouts and Relation to Markers of Obesity in US Adults. *Prev. Chronic. Dis.* **2008**, *5*.
40. World Health Organization *Global recommendations on physical activity for health.*; World Health Organization: Geneva, 2010;
41. American College of Sport Medicine *ACSM's Guidelines for Exercise Testing and Prescription, Eighth Edition.*; Lippincott, Williams and Wilkins, 2010;
42. Garn, A.C.; Baker, B.L.; Beasley, E.K.; Solmon, M.A. What Are the Benefits of a Commercial Exergaming Platform for College Students? Examining Physical Activity, Enjoyment, and Future Intentions. *J. Phys. Act. Health* **2012**, *9*, 311–318.
43. Graves, L.E.F.; Ridgers, N.D.; Williams, K.; Stratton, G.; Atkinson, G.; Cable, N.T. The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. *J. Phys. Act. Health* **2010**, *7*, 393–401.
44. Polechoński, J.; Dębska, M.; Dębski, P.G. Exergaming Can Be a Health-Related Aerobic Physical Activity Available online: https://www.hindawi.com/journals/bmri/2019/1890527/ (accessed on Jul 24, 2019).
45. Yang, C.; Wickert, Z.; Roedel, S.; Berg, A.; Rothbauer, A.; Johnson, M.; Bredle, D. Time Spent in MVPA during Exergaming with Xbox Kinect in Sedentary College Students. *Int. J. Exerc. Sci.* **2014**, *7*.

46. Hagberg, L.A.; Lindahl, B.; Nyberg, L.; Hellénius, M.-L. Importance of enjoyment when promoting physical exercise. *Scand. J. Med. Sci. Sports* **2009**, *19*, 740–747.
47. Centres for Disease Control and Prevention Overcoming Barriers to Physical Activity Available online: https://www.cdc.gov/physicalactivity/basics/adding-pa/barriers.html (accessed on Oct 24, 2018).
48. Dębska, M.; Mynarski, W.; Biernat, E.; Nawrocka, A.; Bergier, B. Compliance with physical activity health recommendations in members of non-governmental organizations promoting active lifestyle. *Ann. Agric. Environ. Med.* **2019**, *26*, 109–113.
49. Mutikainen, S.; Helander, E.; Pietilä, J.; Korhonen, I.; Kujala, U.M. Objectively measured physical activity in Finnish employees: a cross-sectional study. *BMJ Open* **2014**, *4*, e005927.
50. Mynarski, W.; Rozpara, M.; Nawrocka, A.; Borek, Z.; Powerska, A.; Garbaciak, W. Physical activity of middle-age adults aged 50–65 years in view of health recommendations. *Eur. Rev. Aging Phys. Act.* **2014**, *11*, 141–147.