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The Impact of Video Games on Physical Activity and Motivation for Exercise Using VR Technology

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ABSTRACT

The goal of this paper is to research the impact of VR games on physical activity, and whether a certain effort exists that would make exercising using the VR technology possible and give motivation to physically active as well as physically inactive people. Although there has been re-search proving VR games enable physical activity and motivation, there is no information about the level of physical activity that physically active and inactive persons experience, nor is there any information on the difference in their motivation to exercise when being immersed into a virtual world. By using the VR equipment, playing Beat Saber game and listening to "Eye of the Tiger", as well as by analyzing the questionnaire, the obtained results will show that it is more difficult to motivate physically active people to engage in this type of exercise. However, as far as the strain is concerned, there is almost no difference between the two groups.

1. Introduction

In the 21st century, as people are surrounded by their mobile phones screens, computers, televisions and other devices, they are also being increasingly confined into their small spaces where they can have fun and communicate with the whole world. The only difference in the fact that the person does not have to move, not even to stretch the legs. All that is takes is to sit on the couch, or at a desk, and interact with the world. The century we live in is definitely the century of "physical non-movement". Using the language of science, this type of life is called sitting or sedentary lifestyle and it is described for different fields of (in) activity such as work, travelling to work or school and free time [1]. These fields are additionally categorized as discretionary and non-discretionary fields. Behaviors such as sitting at work, in school, or riding a bus or car belong to non-discretionary behavior field, while watching television, reading a book, playing computer games belong to discretionary behavior field [2].

Sedentary lifestyle, apart from defining exactly what it describes, is mostly seen and considered in a negative context because it is linked to different problems offered and caused by the mentioned lifestyle. This primarily concerns physical health - obesity, in-creased risk of heart disease, diabetes type 2, different types of cancer such as colon cancer [1]. However, physical (in)activity is followed by mental health issues such as depression, one of the most well-known illnesses [3]. Physical activity and mental health are closely related, since physical activity can attenuate mood disorders, among which is mild and moderate depression, anxiety, stress and bipolar disorder. However, these scientific fields have not been researched enough and there isn't sufficient evidence on correlation [4].

Although people get ill from different illnesses during their lifetime, this does not stop them to continue living an unhealthy lifestyle, eat unhealthy food and not move. A question arises about the reasons that stop people from moving, starting to exercise, even when this is necessary due to some health reasons; how can they be motivated to adopt a healthier lifestyle. In her work on motivation and obstacles for physical exercise, a sports psychologist Renata Barić says that motivation is everything from the outside and inside that pushes us to be active, or in other words that makes us achieve our goals. Motives can be primary (inane) such as thirst or hunger, and secondary (acquired) such as need for recognition, for company [5]. She also mentions Beck's basic motivation premise which says that people are more prone to behaviors that they will benefit from, and avoid the behaviors that bring them discomfort or an undesirable outcome, i.e. a result of their behavior [5]. Psychology calls this the Law of Effects, the basic learning law which says that a person will repeat a certain activity if this activity brings him/her satisfaction in form of a reward [6]. People are motivationally complex beings. Their way of thinking influences their experience, what they do, how often they do it and what the effects of a certain behavior are [5].

There is an increasing number of research that include indirect influence of video games on movement, as mentioned in the introduction. In his research on adaptive video games with storytelling that draw attention to exercise, Christopher Burt concluded video games (in this case Sea Monkeys) that enable body movement can be a good fitness solution [7]. When talking about the influence games have on mood, Thomas G. Plante should be mentioned. He came to the conclusion, riding a bike and playing VR games, that virtual reality partially improves the positive effect it has on mood in combination with riding a bike; it increases pleasure and energy while decreasing fatigue. On the other hand, exercising without VR technology shows increased tension, fatigue and lower levels of energy in participants [8].

The conclusion of the Finkelstein model is that the motivation itself plays a significant role in physical activity.

Resting heart rate and target heart rate were measured, and Likert scale from 1 to 7 (1 - not intensive at all; 7 - extremely intensive) was filled in. Both measures gave a subjective experience of strain, i.e. results on the intensity of exercise [9].

Gamification should not be disregarded as an important fact that motivates people to exercise. Kari et al. [10] wanted to know how the use of an exercising application influenced user's motivation for exercise and behavior, with a special focus on the role of gamification in the entire process. They came to the conclusion that an exercising application could increase user's motivation for exercise since its usage increases the awareness of each individual on the behavior during exercise and the effect itself, and at the same time it enables physical development [10]. Previous research, such as the ones by Ahtinen and Baravata [11, 12], suggest that gamification has positive influence on motivation for exercise, since the gamification experience itself is positive. However, Kari's research brought something new and very important regarding gamification as a "means" for motivation to exercise. The conclusion was that different people have different experience of gamification, and that personal characteristics such as habits, competitiveness and attitude to sports technologies influence the level of impact gamification has on the motivation for exercise [10].

While VR technology is mostly directed towards entertainment, it has a much wider benefit in different areas of human activity such as flight simulators or treating phobias or posttraumatic stress disorder; and it is becoming more directed towards some type of intervention in medical treatments, or more precisely in pain relief treatments. This need existed before VR technology was used and it was addressed by other means such as sound stimulation (for example music), audiovisual stimulation (for example television), and by including the user in interaction (for example video games) which can help the patient in offering him a distraction from pain [13].

In his research, Hoffman et al. [13] studied the benefit of VR technology as a distraction in treating burns of two male adolescents at the age of 16 and 17 who needed daily bandage changes and wound cleaning by comparing it to a conventional video game. A subjective feeling of pain and anxiousness could be seen in the visual analogue pain scale, and the results were very good. The seventeen-year-old had a harder time dealing with the pain. Still, compared to a conventional game, he had a 50% decrease in the feeling of pain and anxiousness while using VR [14].

Research considered to be very important is the one in which VR was used as a pain killer during the entire session of cleaning wounds of 19 patients at the age from 8 to 65. This research did not record any side effects that would be caused by using VR technology such as nausea or dizziness, which can occur after using VR for an extended time. The authors of the research said that using such immersive technology for longer time periods was safe since it could potentially decrease the feeling of pain [15].

There are several research on the Beat Saber game, one of which studies how VR games, i.e. Beat Saber, influences certain side effects such as nausea. The results showed there were no strong proofs that would show harmfulness of Beat Saber VR game regarding the adjustment of the eye and eyesight, or the feeling of nausea 40 minutes after finishing the game. However, there is a certain percentage of persons (14%) who reported high levels of nausea in that phase. This would mean that it is recommended for users to give themselves time and rest after they have finished playing a VR game (in the case mentioned this would refer to Beat Saber) so that their condition would not worsen. The exercising games using the VR headset can encourage people to exercise, although this has not been researched enough. Any side effects should be carefully monitored so that the positive effects that VR exercising games give could be ensured [16].

2. METHODOLOGY AND MATERIALS

This research used the empirical research and questionnaires to collect data on students at University North. The questionnaire was designed in Google Forms and consisted of two parts - before playing and after playing the VR game. This gave a more thorough insight into each participant's physical activity and their experience using the VR technology.

On the day of the research itself, each participant had a chance to try out the VR game Beat Saber so that the VR headset and controller can be tested, as well as the game itself. During the research, all the participants filled out the first part of the questionnaire, and their heart rate was taken before the game. Afterwards the participants played Beat Saber game with the background music "Eye of the Tiger" three times in a row. The game was set in such a way that the participant couldn't lose the game, but could see the progress he/she made. Once the game was finished each participant filled out the second part of the questionnaire, including having his/her heart rate per minute taken using a mobile application "Heart Rate Monitor". The application was tested using a blood pressure monitor and manual heart rate measurement to show whether the application was useful, in other words whether it measured the heart rate accurately.

Since the impact of VR game on physical activity and motivation for exercise were compared between physically active and inactive persons, it was necessary to have about the same number of students who engaged in a physical activity and those who did not. In the beginning the goal was to have a minimum of 60 students participating in the re-search. Considering most students had online classes and practical courses, a smaller number of people decided to participate in the research, 37 people in total. This was the reason for a different approach in data processing.

A questionnaire was used for gathering data. Each participant received the questionnaire prior to research, and at the end it was turned in to the responsible person con-ducting the research. The questionnaire itself had a description and purpose of research clearly stated. The questionnaire was anonymous for all the participants. The questionnaire was divided into two parts.

In the first part there were basic facts questions about the participant (age, sex), his/her physical activity, any possible health issues which could be the reason for participant not to participate in the research, how they felt at that moment, some previous experiences they had using VR technology and the sense of rhythm. This all was used to get the most relevant data possible.

The Godin-Shephard leisure-time physical activity questionnaire [17] was used to determine the activities for each participant. It consisted of three questions about the number of time a person exercises more than 15 minute per week during their leisure time, whether it was an exercise which a. significantly increases their heart rate, (for example: vigorous swimming, running, soccer, vigorous bicycling, vigorous

dancing, ...); b. without significant fatigue, i.e. moderate exercises, (for example: fast walking, easy bicycling, easy swimming, dancing, ...); and c. usual activities, (for example: yoga, bowling, golf, fishing, strolling or easy walking, ...) [17].

The following formula was used for obtaining the results:

$$\text{Activity} = (9 \times a) + (5 \times b) + (3 \times c)$$

The obtained results grouped the participants into active, moderately active and in-sufficiently active persons. The participants were divided into two groups for the purpose of this research: physically active persons with the lowest score of 24, and physically inactive persons with the maximum score of 23.

The second part of research, participants' heart rate was measured; this was first done for the resting heart rate using a mobile application and later after playing the game, in order to determine if the exercising was efficient enough. Two formulas were used for this purpose which give, when combined, a maximum heart rate for each person:

- For male participants, according to Roberg and Landwehr's formula: 205.8-0.685 x years
- For female participants, according to Gulati formula: 206.0-0.88 x years.

Determining whether the exercise was effective is obtained by dividing the heart rate during exertion by the maximum heart rate. If the percentage obtained is between 50% and 85%, a person achieved an efficient level of exercise. The target heart rate was determined by the American Heart Association [18].

The following 23 questions related to the participant's physical and mental state during and after playing the VR game. Flow State Scale explored by Jackson and Marsh [19] was used for this purpose. The scale measures flow in sport and physical activity settings [19]. The original version of the scale consists of 37 items, but in this paper it was adjusted for the purposes of research by changing or adding certain items. There are 23 questions below related to this research, and they measure how challenging (demanding) the game for the player was and what his/her sense of control over the game was, how much the participant enjoyed the game and lost track of time, and whether the game left a positive impression on the participant in terms of fun and motivation for exercise. Results are obtained using the Likert scale for each question from 1 to 5 (1 = strongly agree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree). Table A1 can be viewed in Appendix of this manuscript.

In order to determine the actual physical strain when playing a game, the target heart rate and the maximum heart rate according to the previously mentioned formula are measured, and by obtaining the percentage determined by the American Centers for Dis-ease Control and Prevention:

- Moderate-intensity exercise: 50 – 70%
- Vigorous-intensity exercise: 70 – 85%

The calculated physical effort will be compared with the obtained subjective feeling of physical effort. This will then either accept or reject the hypothesis: VR games make it easier to endure physical exertion than classic ways of exercise do, both for people who do not engage in physical activity as well as for those who are physically active.

3. RESEARCH RESULTS

In order to obtain valid results, descriptive statistics methods such as arithmetic mean and standard deviation, numerical values expressed as percentages, Kolmogorov-Smirnov test for deviation from normal distribution, and Spearman correlation coefficient were used.

A total of 37 respondents aged 19 to 40 participated in the mentioned study, out of which 54.1% were female and 45.9% male.

In order to group the participants into two groups, those physically active and the inactive ones, it was necessary to state how many times a week they exercise vigorously with significantly faster heart rate, without significant fatigue, and how many times a week they did usual activities. Godin-Shephard leisure-time physical activity questionnaire was used. The obtained results showed that 16 people were physically active (43.2%), while the remaining 21 ones were physically inactive (56.8%).

Also, regarding physical activity, i.e. inactivity, participants had to state their reasons for inactivity, if they had any. Multiple answers could be chosen. So, 10 participants (43.5%) stated that they did not engage in physical activity due to lack of time, 19 participants (82.6%) were not sufficiently motivated, and one person (4.3%) stated another reason.

In order to get a better insight into how many participants had a sense of music (which is important for more relevant results, having in mind that playing rhythmic games is being tested), participants had to answer whether they had an ear for music and a sense of rhythm. 27 participants (73%) gave an affirmative answer, 6 participants (16.2%) did not know, two (5.4%) answered "No", and two (5.4%) said that they did not entirely have those characteristics.

It was also important to determine which participants played video games more of-ten than others, or did not play those games at all. So, 22 participants (59.5%) answered that they belonged to the casual players category, eight (21.6%) admitted to playing video games every day, only three (8.1%) placed themselves in the moderate players category, while four (10.8%) said they did not play video games at all.

This little research discovered some interesting results in terms of playing VR computer games from which it was evident that a very small number of participants had con-tact with VR games. Only three participants (8.1%) played a VR computer game before this research was conducted; one of the respondents played Beat Saber, while the other two said they did not remember exactly what game they played.

The last question in the first part was about their current state: "How do you feel at the moment? (for example, do you feel agitation, increased heart rate, some physical pain.) Why? (for example excitement because of the research). Most participant said they felt ex-cited because of the research.

3.1 Objective and subjective efficiency of exercise

Before playing the Beat Saber game, each participant's resting heart rate was measured, and the heart rate was measured after playing the game. This was done to see if there was any significant difference between the resting heart rate and the heart rate after fifteen minutes of playing. To determine the efficiency of exercise by playing the Beat Saber game, each participant's heart rate at the end of the game was divided by his or her maximum target heart rate value. The obtained percentage showed whether the person had any exercising benefit from playing the game. As earlier mentioned, if obtained percentage amounted at least 50%, the exercise was efficient. Furthermore, these percentages could be divided into two categories - moderate exercise from 50 to

70%, and vigorous exercise from 70 to 85%. The results showed that four students (10.8%) did not benefit from exercise playing the Beat Saber game, 31 (83.8%) found themselves in the moderate exercise category, and only two students (5.4%) had a vigorous exercise experience. It is important to note that out of four students who did not have any exercising benefit, one person was categorized inactive, while the remaining three students were categorized physically active.

In addition to objectively assessing the efficiency of exercising using VR games, participants had to give their subjective experience of the effort invested into playing Beat Saber. There were 26 participants (70.3%) who said that it was not challenging at all, and 11 (29.7%) said that playing Beat Saber. in terms of physical effort, was moderately challenging. If we just look at the above-mentioned exercise performance table which shows how 31 participants had a moderate exercise experience, two vigorous exercise experience, and only two participants did not benefit from exercising while playing Beat Saber, it could be concluded that exercising with Beat Saber reduced the feeling of strain. Physically active and inactive students were divided into two separate tables in order to get more accurate data. Since the percentages showed the efficiency of exercising, they were aligned with the answers from the questionnaire. Table 1 below illustrates their relation:

Table 1. The relation between the objective efficiency of exercising in percentages aligned with the ranking and the subjective feeling of strain

	Efficiency of exercising	**Efficiency of exercising from 1 to 3**	**Subjective feeling of strain**
No strain/it is not strenuous at all	< 50%	1	1
Moderate exercise/moderately strenuous	50-70%	2	2
Vigorous exercise/extremely vigorous	70-85%	3	3

Since there was a smaller number of participants (physically active and inactive, when divided, they give a sample of less than 30), the Spearman rank coefficient of correlation method was used. This correlation was intended to determine the correlation between the actual, objective state of strain and the subjective feeling one. If the strength of the correlation was strong, it would mean that the objective state of strain corresponded to the subjective one, that is, that their subjective sense of strain coincided with the real objective state. The results showed that in both cases (with both physically active and inactive) the correlation strength was weak. In physically active persons rs = 0.44, and in physically inactive persons rs= 0.39. This means that their subjective feeling did not coincide with the real objective state. By taking a look at the results from the table, it can be seen that most students (both physically active and inactive ones) did not feel any strain while playing Beat Saber. On the other hand, the objective data show they were moderately un-der strain, i.e. that had a moderate exercising experience.

3.2 Flow state scale

The participants' flow state scale, while playing the VR game, showed very positive results that were obtained by determining the frequency, arithmetic mean and standard deviation for each statement as it can be seen it the table 2. As the Kolmogorov-Smirnov test showed that all distributions deviated from the normal, except for the arithmetic mean, the mode and median for the results were determined.

Table 2. Central tendency measures and standard deviations of statements from the Flow State Scale

	Central tendency measures			**St. dev**
	Mean	**Mod**	**Med**	
The game was challenging.	4.08	4	4	0.76
I had a feeling of control over everything I was doing.	3.78	4	4	0.82
I knew exactly what to do at each moment I was playing the game.	4.19	5	4	0.78
I was well aware of how good I was at the game.	4.76	5	5	0.49
My attention was focused entirely on the game.	4.57	5	5	0.60
I had a feeling the time passed by quickly.	4.92	5	5	0.28
Each movement I made was automatic.	3.59	4	4	0.93
I did not care what I looked like during the game.	3.81	5	4	1.31
I lost track of time.	4.59	5	5	0.69
I was completely concentrated.	4.38	4	4	0.59
I played the game spontaneously, automatically, without thinking about each move.	3.54	4	4	0.80
I did not care what others thought of me while I was playing.	3.92	5	4	1.19
At some moments of playing it seemed to me that time passed by slowly.	**1.31**	**1**	**1**	0.62
I enjoyed playing the game.	4.78	5	5	0.58
I would love to play this game again because of doing some physical activity.	4.08	5	4	1.01
I think my time was well spent playing this game.	4.57	5	5	0.69
While I was playing I did not feel strain.	4.00	5	5	1.20
After I finished playing I felt great.	4.62	5	5	0.59
I find this type of physical activity more attractive than the classical type of exercise.	3.73	5	4	1.28
During the game I thought I would quit because of the strain.	**1.03**	**1**	**1**	0.16
The game was boring.	**1.14**	**1**	**1**	0.67
I liked the way I felt while playing the game and would love to repeat it.	4.84	5	5	0.44
I would love to play this game for fun.	4.92	5	5	0.28

By looking at the flow state scale, it is clear that most students agreed (4) and completely agreed (5) with the statements describing the flow state scale characteristics. The central tendency measures (arithmetic mean, mode, median) showed that statements contrary to the flow state characteristics ("At some moments of playing it seemed to me that time passed by slowly", "While playing the game I thought I would quit because of a lot of strain", "The game was boring") had values of 1, i.e. that students did not completely agree with the above mentioned.

3.3 Motivation

By using the statements from the Flow Scale other results could be obtained such as motivation for exercising for physically active and inactive people who use the VR technology. The results showed that both participant groups have a desire for exercising using VR technology. However, the questionnaire was not defined by YES or NO question, but instead by the Likert scale used for the Flow Scale purpose. Nevertheless, it could be concluded that physically inactive people are more motivated for exercise (arithmetic mean = 4; standard deviation = 1.09) using VR technology than physically active people (arithmetic mean = 3.38; standard deviation = 1.45), which is evident from the tables.

3.4 Nausea and headache

VR technology is constantly progressing; however, the feeling of nausea and headaches still occurs. Several causes could be the cause of it. Some causes are stereo images in VR headsets, incorrect calibration or poor focus simulation, and convergence and eye accommodation [20]. One of the causes can definitely be the nature of a VR game or the way the game is played. If the space is wider, there is more chance to move in the virtual world (for example, in the VR game Half Life: Alyx), the above-mentioned consequences may occur; or in the case of Beat Saber, where the player only needs to stand and play with his hands, the feeling of dizziness and headache is absent, because there is no need to turn the head. However, due to their inexperience with using the VR technology, some players occasionally turn their heads or even move their whole bodies in place, which was evident in the research. In order to get more relevant results about the experience of playing VR games in terms of motivation, exercise and flow, students had to answer whether they felt nausea or headache at any time. The results were more than positive. 35 respondents out of 36 said that their Beat Saber game did not cause nausea (97.2%), and only one person felt nauseous after playing the game. The results were similar concerning the headache - 34 respondents out of 36 (94.4%) did not have any headaches, and two participants (5.6%) said they had headaches after playing the game. When it comes to giving up, everyone said they could play the game to the end, while one person did not comment on the two previous questions.

The participants could give their own comment on the VR game at the end of the questionnaire. The comment could be regarding their satisfaction, what they liked or didn't like in the game, what they would change about the game, and whether the VR headset bothered them. Since this was not mentioned in the question, the participants generally did not mention exercise or motivation. However, their impressions completed the picture and the answers from the questionnaire. Most participants said that they would like to play the Beat Saber again, but would choose other modes and other songs; the VR headset did not bother them. Here are some of the answers given in the questionnaire:

"The game is super fun! I would love to try out other songs and modes! It was challenging. The headset did not bother me."

"I liked everything, except of the controller which had a delay and took some getting used to. I would not change the setting right now, maybe later as I become better in the game. Although I wear prescription glasses. VR headset did not bother me."

"I liked the game, the song is good, game mode too. The game was a bit fuzzy at moments. The VR headset was very good, I just wonder how comfortable it is after a longer period of playing."

"The game is easy to understand, which means you can get the "real" game playing soon. I would like to try out other songs and modes. I was bothered by a low framerate when turning my head. Still, it was not a problem to play without turning my head too much."

"The game was fun, but it was difficult to stay concentrated during the third round in the row. I needed a lot of time (the entire song) to get used to it and get the feeling of space and distances. After that it was fun and my movements were automatic. I has a slight headache after playing the game."

"The game is interesting and simple, it is all about the feeling, reflexes and timing. The people who are into music could do better, since the rhythm is important. All in all, it was an interesting experience."

"The game was excellent and I would love to use it for exercising, providing this exercise gives results. I don't think that the easy mode is enough for a good quality of exercise so I would like to try out more difficult modes. The VR headset was surprisingly comfortable and light."

"A very interesting game. In the beginning the game was difficult but later it became easy. I would like to play it again. I did not feel a strain, but this could have been different had I played a more difficult mode."

"I really liked the game a lot! Something new! Still, I think I am not the type who plays video games every day and I could not substitute any physical activity for playing games. This is a virtual world after all, and we should be enjoying the real world. Beat Saber is a great game to play from time to time, but I would not play it daily."

4. DISCUSSION

A total of 37 participants took part in this research. The participants were students from the University North who joined this research by filling out a Google Forms application, or by directly showing up at the research without prior registration. The participants' age range was between 19 and 40 years old, out of which 54.1% were female and 45.9% male.

In order to obtain the results, the participants were grouped into two groups - those who are physically active and those who are physically inactive. In order to group them, they had to say in the questionnaire how often they were active during the week according to Godin-Shephard questionnaire. The obtained results showed that 16 people were physically active (43.2%) while the remaining 21 people were physically inactive (56.8%). The participants who are not physically active, when stating their reasons for inactivity, mostly say that they do not have the time (43.5%) or motivation (82.6%).

Regarding the experience with VR technology, there were

only three participants (8.1%) who had experience playing VR computer game before this research. Only one participant staid that he played Beat Saber, and the other two did not remember exactly which game they had played.

4.1 Exercising by using VR technology can replace classic type of exercise

By taking a look at Cristopher Burt's research on adaptive storytelling games that create interest for exercising, it can easily be concluded that body-moving video games can promote physical activity. There were 25 participants who did or did not exercise regularly in his research. The results of the research showed that the heart rate in both types of participants fell into a targeted "moderate zone", that is, each participant experienced a moderate intensity cardiovascular exercise [7]. By measuring the heart rate before and after playing the VR game, and then by using different formulas in this research, the results showed that 31 subjects experienced moderate exercise (83.8%) and two experienced vigorous exercise (5.4%), while four individuals did not benefit significantly from the exercise. The results are very well aligned with Cristopher Burt's research, which confirms that exercising using VR technology can replace classic type of exercise, because the value of the heart rate indicates that the person benefited from the physical activity.

4.2 Easier endurance of physical strain while using VR

Virtual reality, unlike conventional television and computer video games that capture the viewer's attention, is an immersive system which offers something new and different; it monitors head movements, combines different equipment with sensors to achieve greater interactivity by creating a realistic impression. Besides providing entertainment, VR technology is much more useful in various fields of human activity, one of which is the treatment of phobias or post-traumatic stress disorder, ranging from treating physical ailments such as cancer or cleaning wounds from burns. Hoffman emphasized the importance of using non-pharmacological intervention to relieve pain. Injuries that cause burns are one of the most painful injuries to treat, and the presence of such pain causes changes in anatomy, neurophysiology and pharmacokinetics that make standard pharmacological treatment by using pain killers less effective. Additionally, the level of pain that patients with burns experience may have a negative effect on their later stages of treatment. He concluded in his research that VR technology can distract a person from pain. During the research, the participants did not stop feeling pain, but it was easier for them to cope with it, and this reduced their feeling of pain and anxiety by 50% while using VR [14]. Van Twallert came to similar conclusions in his research. In addition to the fact that VR technology reduces the feeling of pain, by using VR technology as a pain killer, 19 patients did not experience any side effects from using VR technology such as nausea or dizziness [15].

In research including 37 participants, 16 who were physically active and 21 physically inactive, it was necessary to determine the objective state of physical strain each participant had by calculating the maximum heart rate per minute and measuring heart rate after playing Beat Saber. The obtains results could then be compared to a subjective feeling of physical strain. Spearman rank coefficient of correlation was used and the following values were obtained: rs = 0.44 for physically active persons, and rs = 0.39 for physically inactive persons. The result that was obtained indicated a strong correlation which showed that the participants' subjective feeling did not match the real objective situation. In other words, most students (both active and inactive ones) exercised with a moderate effort that did not match their subjective feeling - their feeling was that they did not feel that effort. It can be concluded from the results that VR games make it easier to endure physical strain than classic ways of exercise do. This is true both for people who do not engage in physical activity as well as for those who are physically active.

When providing numerical values followed by measurement units, please leave a regular space or non-breaking space between each value and the measurement unit. This also includes percentages and degrees Celsius (eg. 42% or 35%, 234°C, 504K). This rule also applies to the unit for litre, which is recommended to be capital "L".

4.3 Flow state

Computer games have always brought people fun and entertainment, allowing them to lose track of time and worries. In his article on flow state in games, Chen presents a Flow State theory that says the game should balance between the challenge and the player's ability to overcome the challenge [21]. If the challenge is too difficult, it creates the feeling of anxiousness, and the player loses his will to play. Finkelstein conducted very important research on participants' flow while playing the Astrojumper VR game. She introduced the Flow State Scale [16] used in this research. The results in both scales agree that VR game can lead to a flow state. The research results prove that by calculating mode and median, most students agree (4) or completely agree (5) with statements describing the flow state characteristics. On the other side, the claims contrary to the flow state characteristics ("At some moments of playing it seemed to me that time passed by slowly", "While playing the game I thought I would quit because of too much strain", "The game was boring") have values 1, i.e. that students do not completely agree with the above mentioned. This all brings to the conclusion that the participants lost tract of time and their surroundings while exercising. This is additionally confirmed by the results of the Likert scale. The results showed that 26 participants (70.3%) completely lost track of time, 7 (18.9%) marked the scale 4 out of 5, and only four (10.8%) remained neutral (they marked the scale 3 out of 5). The results on the environment were very scattered. The statements "I didn't care how I looked while playing" and "I didn't care what others thought of me while I was playing" showed a lower arithmetic mean (3.81 for the first statement and 3.92 for the second one) and a greater degree of dispersion (1.31 for the first statement and 1.19 for the second one). However, if you take a look at the answers on the Likert scale and the overall flow state, most participants did not care about the environment. This also confirms that the concept of VR games allows the people to lose track of time and environment while exercising.

4.4 Flow State Scale and motivation for exercise

The already mentioned Finkelstein research studies the motivation for exercise using VR game. Its results showed that Astrojumper game successfully influenced the participants' motivation to exercise. Participants in the research met the

criteria vigorous exercise. The results showed that Astrojumper allowed from moderate to high level of physical activity. Motivation-related results showed that this game successfully motivated the participants to exercise [9]. Thomas Kari, who mainly researched the influence of gamification on motivation and physical development, obtained positive results [10].

The results of this research showed that VR games can stimulate motivation for exercise using the statement from the Flow State Scale, both in physically active and physically inactive people. It can be seen from the table that physically inactive people are more motivated to exercise using VR technologies, which is visible from results of the arithmetic mean and the standard deviation for physically inactive persons (AS = 4; SD = 1.09) and physically active persons (AS= 3.38; SD = 1.45). The results confirm that VR games encourage motivation for physical activity in people who are both physically active and in-active; however, VR games have a greater impact on physically inactive people for exercise than they do on physically active people.

5. CONCLUSION

Computer games have always provided entertainment and fun for their users, but can often have a more engaged role and be used as educational games. There are more and more different devices today that can be used to play certain video games. VR games belong to a newer type of games that use the VR technology with additional equipment. One of the most recognizable equipment is the VR headset that allows you to observe a virtual three-dimensional world, making it much easier to create the impression of immersion. Although it is recommended not to play the VR games for a period longer than half an hour, there are video games that do not cause dizziness, nausea or headache during or after playing the game. Participants played the game Beat Saber for about 15 minutes in this research. That was the duration of the song "Eye of The Tiger" played three times in a row. There were 97.2% participants saying that the VR game did not cause them nausea, and only one person felt nauseous after playing the game. As far as the headache goes, two participants (5.6%) said they experience headache after they playing the game. It is characteristic for VR games to cause such symptoms once the VR headset is removed. Additionally, this research showed that 26 participants (70.3%) did not have a subjective feeling of strain while playing the game, and 11 participants (29.7%) qualified playing Beat Saber, in terms of physical effort, as moderately strenuous. Still, the data that was objectively obtained by measuring participants' heart rate says that there were 31 people who had an experience of moderate exercise, two described it as strenuous, and only two participants said they had no benefit from exercise. Although this was not measured here, the participants' state of flow may play a role in enduring strain more easily, as shown by several past research [22]. Besides that, the experience of flow con-tributes to greater concentration and intrinsic motivation. The results of the research were positive and most students agree (4) and completely agree (5) with the statements de-scribing the flow characteristics. Although it can be concluded from the Flow State Scale that the participants were in a flow state while playing the game, i.e. that they were motivated to play, the goal of this research was to obtain data on whether physically active people would be equally or more motivated to exercise if they exercised just by playing the Beat Saber game. As expected, the motivation for exercise using VR technology was higher in physically inactive individuals.

Regardless of the very positive results, this type of research could be improved in several aspects. The first thing that could be improved is that the research should be con-ducted on a larger sample so that the results are more relevant. As for the research concept itself, it would be ideal if the participants played one game for a longer period, for example two weeks. In that time, they could try other game modes and choose from different songs, which could increase the motivation for exercise in physically active persons. There is room for improvement in the questionnaire as well. Participants could be offered more free answers in order to gain a more detailed insight into their experience of playing and exercising using VR games.

There is a lot of research on games that serve as options for exercise, such as the al-ready mentioned "Just Dance" game. However, there is little research on VR games in which there is almost always a small sample of participants, because they are always in controlled conditions and not at home or in some another environment where they would feel comfortable. Classic games are available to everyone, because users have access to the device they can use to play these games. VR technology is still rather inaccessible among people. In can be expected that VR technology will enter our homes in future. This will al-low for the research to be conducted on larger samples, with longer durations, which is why more people will want to access such research. On top of that, the results will be more relevant because it will be possible to conduct this research at home.

REFERENCES

[1] Rezende, L.F.M.D., Lopes, M.R., Rey-López, J.P., Matsudo, V.K.R., Luiz, O.D.C. (2014). Sedentary behavior and health outcomes: an overview of systematic reviews. PLOS ONE, 9(8): e105620. http://dx.doi.org/10.1371/journal.pone.0105620

[2] Gabriel, K.K.P., Morrow, J.R., Woolsey, A.L.T. (2012). Framework for physical activity as a complex and multidimensional behavior. Journal of Physical Activity and Health, 9(s1): S11-S18. http://dx.doi.org/10.1123/jpah.9.s1.s11

[3] Galper, D.I., Trivedi, M.H., Barlow, C.E., Dunn, A.L., Kampert, J.B. (2006). Inverse association between physical inactivity and mental health in men and women. Medicine & Science in Sports & Exercise, 38(1): 173-178. http://dx.doi.org/10.1249/01.mss.0000180883.32116.28

[4] Sanchez-Villegas, A., Ara, I., Guillen-Grima, F., Bes-Rastrollo, M., Varo-Cenarruzabeitia, J.J., Martinez-Gonzalez, M.A. (2008). Physical activity, sedentary index, and mental disorders in the SUN cohort study. Medicine & Science in Sports & Exercise, 40(5): 827-834. http://dx.doi.org/10.1249/MSS.0b013e31816348b9

[5] Barić, R. (2012). Motivacija i prepreke za tjelesno vježbanje. Arhiv Za Higijenu Rada I Toksikologiju, 63(3): 47-57. https://hrcak.srce.hr/92080

[6] Milošević, Z., Maksimović, N., Milošević, N., Obradović, B. (2010). Teorije povezivanja – praktične implikacijeu sticanju motornih veština. Crnogorska Sportska Akademija, časopis br(23-24): 429-448. http://www.sportmont.ucg.ac.me/clanci/SportMont_Dec

_2010_Milosevic_429-436.pdf.
[7] Burt, C.D. (2014). Having fun, working out: Adaptive and engaging video games for exercise. Theses and Dissertations. https://curve.carleton.ca/5a18b479-8edf-45c4-83e3-3bbe542f5312, accessed on Sep. 21.2022.
[8] Plante, T.G., Aldridge, A., Bogden, R., Hanelin, C. (2003). Might virtual reality promote the mood benefits of exercise? Computers in Human Behavior, 19(4): 495-509. http://dx.doi.org/10.1016/S0747-5632(02) 00074-2
[9] Finkelstein, S., Nickel, A., Lipps, Z., Barnes, T., Wartell, Z., Suma, E.A. (2011). Astrojumper: Motivating exercise with an immersive virtual reality exergame. Presence: Teleoperators and Virtual Environments, 20(1): 78-92. http://dx.doi.org/10.1162/pres_a00036
[10] Kari, T., Piippo, J., Frank, L., Makkonen, M., Moilanen, P. (2016). To gamify or not to gamify? Gamification in exercise applications and its role in impacting exercise motivation. BLED 2016 Proceedings. 20. http://aisel.aisnet.org/bled2016/20
[11] Ahtinen, A., Isomursu, M., Huhtala, Y., Kaasinen, J., Salminen, J., Häkkilä, J. (2008). Tracking outdoor sports–user experience perspective. European Conference on Ambient Intelligence, 5355: 192-209. http://dx.doi.org/10.1007/978-3-540-89617-3_13
[12] Bravata, D.M., Smith-Spangler, C., Sundaram, V., Gienger, A.L., Lin, N., Lewis, R., Sirard, J.R. (2007). Using pedometers to increase physical activity and improve health: A systematic review. Jama, 298(19): 2296-2304. http://dx.doi.org/10.1001/jama.298.19.2296
[13] Sharar, S.R., Miller, W., Teeley, A., Soltani, M., Hoffman, H.G., Jensen, M.P., Patterson, D.R. (2008). Applications of virtual reality for pain management in burn-injured patients. Expert Review of Neurotherapeutics, 8(11): 1667-1674. http://dx.doi.org/10.1586/14737175.8.11.1667
[14] Patterson, D.R., Hoffman, H.G., Palacios, A.G., Jensen, M.J. (2006). Analgesic effects of posthypnotic suggestions and virtual reality distraction on thermal pain. Journal of Abnormal Psychology, 115(4): 834. http://dx.doi.org/10.1037/0021-843X.115.4.834
[15] van Twillert, B., Bremer, M., Faber, A.W. (2007). Computer-generated virtual reality to control pain and anxiety in pediatric and adult burn patients during wound dressing changes. Journal of Burn Care & Research, 28(5): 694-702. http://dx.doi.org/10.1097/bcr.0b013e318148c96f
[16] Szpak, A., Michalski, S.C., Loetscher, T. (2020). Exergaming with Beat Saber: An investigation of virtual reality aftereffects. Journal of Medical Internet Research, 22(10): e19840. http://dx.doi.org/10.2196/19840
[17] Godin, G. (2011). The Godin-Shephard leisure-time physical activity questionnaire. The Health & Fitness Journal of Canada, 4(1): 18-22. http://dx.doi.org/10.14288/hfjc.v4i1.82
[18] Virani, S.S., Alonso, A., Benjamin, E.J., et al. (2020) American heart association council on epidemiology and prevention statistics committee and stroke statistics subcommittee. In Heart disease and stroke statistics—2020 update: A report from the American Heart Association. Circulation, 141(9): e139-e596. http://dx.doi.org/10.1161/CIR.00000000000 00950
[19] Jackson, S.A., Marsh, H.W. (1996). Development and validation of a scale to measure optimal experience: The Flow State Scale. Journal of Sport and Exercise Psychology, 18(1): 17-35. http://dx.doi.org/10.1123/jsep.18.1.1710.1123/jsep.18.1.17
[20] Porcino, T.M., Clua, E., Trevisan, D., Vasconcelos, C.N., Valente, L. (2017). Minimizing cyber sickness in head mounted display systems: Design guidelines and applications. In 2017 IEEE 5th international conference on serious games and applications for health (SeGAH), pp. 1-6. http://dx.doi.org/10.1109/SeGAH.2017.7939283
[21] Chen, J. (2007). Flow in games (and everything else). Communications of the ACM, 50(4): 31-34. http://dx.doi.org/10.1145/1232743.1232769
[22] Myers, M.D., Newman, M. (2007). The qualitative interview in IS research: Examining the craft. Information and Organization, 17(1): 2-26. http://dx.doi.org/10.1016/j.infoandorg.2006.11.001

APPENDIX

Layout of the Flow State Scale for each variable can be seen in the Table A1.

Table A1. Flow State Scale layout: challenge of the game and control over the game, flow in game and the passing of time, entertainment and motivation

Challenge and feeling of control over the game	Flow in game	Fun and motivation
The game was challenging.	My attention was focused entirely on the game.	I enjoyed playing the game.
I had a feeling of control over everything I was doing.	I had a feeling the time passed by quickly.	I would love to play this game again because of doing some physical activity.
I knew exactly what to do at each moment I played the game.	Each movement I made was automatic.	I think my time was well spent playing this game.
I was well aware of how good I was at the game.	I did not care what I looked like during the game.	After I finished playing I felt great.
While I was playing I did not feel strain.	I lost track of time.	I find this type of physical activity more attractive than the classical type of exercise.
During the game I thought I would quit because of the strain.	I was completely concentrated.	The game was boring.
	I played the game spontaneously, automatically, without thinking about each move.	I liked the way I felt while playing the game and would love to repeat it.
	I did not care what others thought of me while I was playing.	I would love to play this game for fun.
	At some moments while playing the time passed by slowly.	