

The effect of using virtual reality equipment on people's motivation to exercise

ShiKuan Li

University of Twente
PO Box 217, 7500 AE Enschede
the Netherlands

s.li-5@student.utwente.nl

ABSTRACT

During the Covid-19 situation, many countries imposed various prohibitions and curfews, which caused students to spend more time on online education than usual. Their physical activity level has dropped significantly, which means they are remarkably lacking exercise [19]. Long-term lack of exercise will have adverse effects on our mental health, such as anxiety and depression. [23, 30]. Studies have pointed out that HIIT (High-Intensity Interval Training) can promote mental health while enhancing people's cardiorespiratory abilities [3]. Also, students can efficiently perform it in their rooms as this exercise method is not restricted by the venue [27]. More importantly, research shows that using virtual reality for HIIT training can help people get better exercise results [11]. Thus, this study focuses on how VR equipment affects university students' motivation to exercise and willingness to maintain a good physical condition compared with traditional HIIT. In this experiment, participants were divided into two groups and performed fitness exercise under different conditions. One group made HIIT exercises with the help of VR equipment, and the other group took HIIT exercises without using VR. After the experiment, we measured participants' motivation to exercise in different exercise modes through the sport motivation scale and questionnaire. The results show that people who use VR equipment to take exercise show higher motivation to exercise. Moreover, the study also found that using VR for exercise can make people spend more time exercising.

Keywords

Virtual Reality (VR), HIIT, University Student, Motivation, Exercise, Covid-19

1. INTRODUCTION

Under the outbreak of covid-19, many countries have adopted measures to control the epidemic, such as quarantine, curfew, online teaching at universities, and suspension of business in public areas (restaurants, gyms, shopping centres). As a result, it has become more common for university students to stay at their home [32]. Due to the closure of indoor exercise facilities

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

35th Twente Student Conference on IT, June, 19th, 2021, Enschede, The Netherlands. Copyright 2021, University of Twente, Faculty of Electrical Engineering, Mathematics and Computer Science.

such as gymnasiums and swimming pools, lack of exercise environment and equipment has become the reason for the lack of exercise for university students. Relevant research shows that 40%-50% of university students do not take any physical exercises [17]. Meanwhile, students who take physical activity show different degrees of reduction in training time and intensity during the Covid-19 period (dropped between 35% to 52.8% for the different intense level of exercise) [19]. Long-term lack of exercise affects people's bodies and minds, such as chronic diseases and anxiety disorders [4, 30]. Therefore, it is essential to find a sport that can be promoted in the university to ensure that students can get enough training to ensure their physical and mental health.

High-intensity interval training, also known as HIIT, is an exercise method not restricted by venue or equipment requirements, allowing people to get enough physical activity in a short time without moving from home [27, 31]. However, people could get injured during HIIT exercise if they did not take standardised movements [27]. Also, unbearable fatigue caused by the incorrect choice of exercise difficulty is why people give up halfway. Therefore, helping people choose the appropriate difficulty in HIIT exercise and guiding them to make standard movements has become a problem. This problem may have a suitable solution with the popularisation of VR technology in recent years. There exists multiple fitness and sports VR software in the form of the game on the market, such as boating, boxing or yoga simulation games to instruct people to exercise.

Related research points out that the gamification of exercise can make people feel more interested in the exercise. In addition, VR for sports activity can make people obtain a better training result [11]. Nevertheless, the motivation of people using VR technology for exercise is unknown. Therefore, it is necessary to study whether the use of VR promotes people's motivation to perform daily exercises.

1.2 Problem Statement

Existing studies have shown that VR equipment in HIIT training can achieve better training results [2, 11, 33]. However, whether VR equipment can increase people's willingness to maintain a healthy physical condition and motivation to exercise is still unknown, especially for people who have no basis in sports. Also, the fatigue caused by HIIT training often becomes the reason for them to give up. At the same time, the more critical issue is that everyone's physical fitness and stamina are different. Thus it is difficult to unify the difficulty of HIIT exercise in the experiment because improper training difficulty will affect the measurement of participants' motivation to exercise.

Therefore, this research explores the impact of VR itself on people's motivation to exercise. Therefore, it is more important to pay attention to the interaction between people and VR.

Regardless of the difference in exercise difficulty selection between individuals, each participant selected the intensity of exercise that suits them.

1.3 Research Question

The following research question can be led based on the problem statement above.

How does the daily use of the VR game "oh shape" as a sport exercise better impact students' motivation to exercise and willingness to maintain a good physical condition than high-intensity interval training (HIIT)?

The proposed research question can be answered into three sub-questions:

1. Compared with traditional HIIT, will the use of VR equipment make people perform longer exercise time?
2. How much motivation people can acquire through daily exercise on VR/HIIT?
3. What is the difference between people's willingness to maintaining a good physical condition by taking VR exercise or HIIT?

An experiment is needed during the research to obtain people's motivation to take physical activity under different exercise conditions (exercise under VR and HIIT exercise) and conclude through statistical analysis.

2. RELATED WORK

2.1 Importance of Exercise

Many studies have shown that proper physical activity will significantly benefit our physical and mental health [5, 18, 23, 24, 34]. In terms of physical health, 150 minutes of moderate-intensity aerobic exercise per week can significantly reduce the risk of cardiovascular disease [23, 34]. It can also lower blood pressure and improve our high cholesterol caused by an unhealthy diet [34]. More importantly, the all-cause mortality rate of people who take regular exercise is 33% lower than the all-cause mortality rate of people who do not exercise [5]. At the same time, proper physical activity can help us build strong and healthy muscles, reduce cancer incidence, improve sleep quality [5]. Regular exercise also shows several benefits for our mental health. It can help us reduce the stress and anxiety caused by all aspects [24], help us focus, get a better memory, and make us more confident [18]. Therefore, it is essential to ensure proper exercise to obtain a healthy lifestyle.

Although proper exercise has many benefits to our physical and mental health [24], people's actual physical activity is far from enough. According to survey data released by the WHO, 35% of Europeans have not reached the minimum level of physical activity recommended for maintaining health [15], and this rate is expected to increase in the future [15]. The lack of exercise is even more severe among the university student population. Research has shown that 40% to 50% of university students do not perform any exercise [17]. Long-term lack of exercise and academic pressure negatively affect students, such as anxiety and depression [4, 19]. Furthermore, some studies also pointed out that students should take an appropriate amount of exercise per week, help them being more focused on learning, getting better memory, and acquiring higher scores [23]. Therefore, it is significant to form a habit of adequate amount of physical activity for university students.

Students have to receive online education during the Covid-19 period, which means that they need to spend more time using electronic devices and stay in their rooms. Therefore, students got fewer opportunities to go outside and practice outdoor activities [32]. Relevant data shows that university students in different countries have shown a different level of decreased physical activity than before the outbreak (dropped between 35% to 52.8% depending on different intense exercise levels) [19]. At the same time, the closure of various public facilities, such as gymnasiums and swimming pools, has led university students to spend even less time on exercise. Therefore, university students urgently need an exercise method that is not restricted by venues, facilities and other factors to meet the physical activity required to ensure physical and mental health. HIIT high-intensity interval training seems to be a viable option in the exercise mode that meets these conditions [31].

2.2 HIIT (High-Intensity Interval Training)

HIIT (high-intensity interval training) is a training method that contributes to physical and mental health in many aspects [27, 28, 31]. It is not affected by venues and exercise equipment and is suitable for indoor environments. Moreover, it is an effective way to achieve sufficient exercise without spending a lot of time [27]. HIIT can be applied to any form of exercises such as poppy jump, rowing machine and indoor cycling [3, 27]. It includes vigorous short-term exercises with rest or low-intensity activity between each of them. The process of vigorous exercise can range from 45 seconds to several minutes. A complete HIIT exercise duration can be between 15 to 30 minutes [27]. It is a convenient choice for people who are too busy for long time activities. It does not need to be in a professional venue such as a gym and does not need professional fitness equipment, which means that it is very suitable for students.

HIIT is effective in reducing body fat, improving cardiovascular function and metabolism compared with other exercise methods. In a study of 2015 [21], the result shows that HIIT only takes half the time compared to other exercise methods based on the same physical benefits [28]. Although HIIT has many benefits to physical health, it is often difficult for people with no fitness experience to persist in HIIT. A possible reason is a necessity for people to select a level of training intensity that would suit them. An inadequate exercise intensity or non-standard movements would mean that novices are likely to be injured due to excessive exertion. Thus, it may require a certain amount of experience in training to work efficiently with HIIT. However, in recent years, the vigorous development of interactive technology in various fields has shown the possibility of solving this problem.

2.3 Technology in Sport

With technology development, more and more wearable devices, visual stimulation devices, scene simulation training devices are applied to the sports field [1,8,13,29].

In [1], Adesida et al. evaluated the use of wearable technology in sport to enhance performance and prevent injury. In addition, Liberman et al. [8] proved that the use of information technology in training to improve people's vision, audition, and proprioception could enhance skill acquisition and sports performance. Meanwhile, Franz [13] et al. indicated that using interactive technology can easily change training difficulty to make the training process more efficient.

Compared with these technologies, the use of virtual reality in sports is more extensive. For example, people can change the simulated environment in virtual rowing training to get a richer visual experience and change the training difficulty, increasing training efficiency. More importantly, many studies have shown that VR use in sports can make participants more engaged and concentrate [10,18], and it can increase training satisfaction and enjoyment [7,26]. At the same time, studies have shown that gamification of exercise can attract people to exercise. For example, a bicycle fitness game called Rift-a-bike (immersive fitness game) has achieved great success in improving user's enjoyment and enhancing their experience during physical activity [10].

2.4 Virtual Reality and HIIT

There are also studies showing that virtual reality has great potential in HIIT training. For example, a study conducted in 2019 [2] showed that it is achievable to perform HIIT training in a VR environment by combining changes in the rhythm of music and actions to avoid obstacles. Moreover, the research also indicates that VR improves people's satisfaction with exercise and enjoyment. Meanwhile, another study showed that virtual reality technology could increase the performance of HIIT exercises [11]. Under the identical exercise time and exercise intensity, people using VR equipment for HIIT exercise can get a higher heart rate than without using VR for HIIT exercise. A higher heart rate means higher calories consumed during the exercise, explaining why people can perform better by exercising in VR [11].

We already know that the use of VR technology can improve the results of HIIT training. However, the ability of virtual reality to motivate and make people willing to exercise is still unknown. Considering the importance of sports for our health in daily life, it is necessary to study and evaluate VR's impact on such motivation and willingness to do sports.

3. METHODOLOGY

3.1 Experiment Design

Sixteen university students conducted this experiment between 21-24 years of age.

This experiment aims to determine whether VR equipment can make people have higher motivation and time to exercise than traditional HIIT exercise.

Hypothesis 1: Participants tend to spend more time on VR exercise than regular high-intensity interval training.

Hypothesis 2: participants are more motivated to exercise through VR equipment than regular high-intensity interval training.

Hypothesis 3: participants are more willing to maintain a good physical condition through VR exercise than regular high-intensity interval training.

Participants were divided into two groups. Each group performed two experiment conditions: one group performs VR exercise and performs HIIT without using VR. The other group performs the same but in a different order. The experiment considered within-group design and between-group design at the same time. Therefore, when analysing the differences in exercise motivation between the two groups under different

training conditions, the motivation of the same group under two different exercise method will also be analysed.

	Week1	Week2
Group1	VR	HIIT
Group2	HIIT	VR

3.2 Experiment Set-Up

Recommended using the following equipment for participants to experiment, HTC Vive (Pro), Oculus Rift/Quest 2, and Play Station VR.

To simulate the situation where the public area was closed during Covid-19 and the frequency of students going outside decreased, all participants experimented in their homes/rooms to ensure the same experimental environment.

The VR exercise software selected in the experiment is a fitness somatosensory game called "Oh Shape"(Figure 5 and 6), which is very suitable software for this experiment. This somatosensory game can meet the exercise intensity required for HIIT training and has different difficulty levels, which is convenient for participants to choose based on their physical conditions.

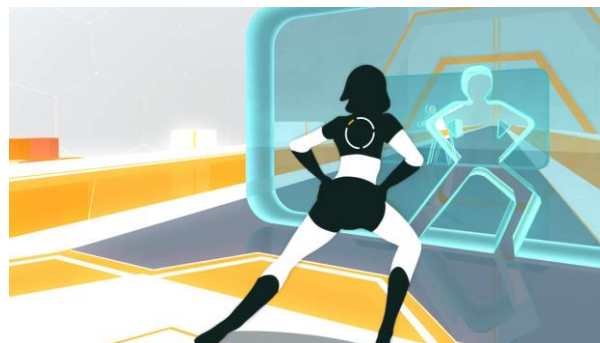


Figure 5: "oh shape process 1"



Figure 6: "oh shape process 2"

3.3 Experiment process

The first round of experiments (between-group design experiment) lasted seven days in total. On the first and second days of the experiment, each group of members performed VR exercise and HIIT exercise under their requirements. The recommended exercise time was about 30 minutes each time. The physical condition of the participants determines the specific time. After each exercise, participants needed to record and report the daily exercise time. On the third day of the experiment, all participants rested for one day and resumed exercise on the fourth and fifth days. On the sixth day, the participants continued to rest, completed the last exercise on the seventh day and filled out the questionnaire. Through this 7-day experiment, it is possible to analyse the difference in motivation to exercise and willingness to maintain a good physical condition between members who use VR for exercise and HIIT exercise.

A with-in group design experiment is needed to eliminate the deviation caused by fatigue. All participants will rest for three days before the start of the second round of experiments. At the beginning of the second round of experiments, the two experimental groups adopted opposite exercise methods, which means that the group that previously used VR exercise will perform HIIT training without the help of VR. The group that had previously performed HIIT training without the help of VR conducted the second round of experiments using VR equipment. The experiment also took seven days and was the same as the first-round process. Participants also filled out the questionnaire on the 7th day after the end of the experiment. It is used to analyse the difference in motivation in the same group under two different exercise modes.

3.4 Experiment Measurement

In order to analyse the difference in training time under different exercise methods, we recorded the training time of the participants. Furthermore, to specifically analyse the motivation to exercise, this experiment uses the sports motivation scale (SMS-6) questionnaire [6] to quantify the participants' motivation. Finally, at the end of the experiment, we will combine the interview and open questions to analyse participants' willingness to maintain a healthy body under different exercise methods. All the data obtained during the experiment will be demonstrated through statistical methods and then used to answer research questions.

SMS-6 questionnaire [6]: The sport motivation scale, developed to measure people's motivation to participate in sports. It contains 24 questions that require participants to self-assess and score to quantify motivation.

Example question of SMS-6 questionnaire:

1. For the excitement I feel when I am really involved in the activity on the scale from 1 to 7
2. Because it is absolutely necessary to do sports if one wants to be in shape on the scale from 1 to 7
3. For the satisfaction I experience while I am perfecting my abilities on the scale from 1 to 7

4. RESULTS

4.1 Differences in Exercise Time

To intuitively reflect the difference between HIIT exercise using VR and without VR, it is necessary to observe the

duration of the continuous exercise of participants in these two different methods.

The eight members of each group have performed five times HIIT training in 7 days, and each group has obtained 40 records of the time spent. The following table is a data analysis of the two groups.

V1		VR	HIIT
Group1	Mean	24.300	16.550
	N	40	40
	Std. Deviation	5.1996	2.1358
	Kurtosis	-.859	-.416
	Skewness	.202	.160
Group2	Mean	21.975	15.125
	N	40	40
	Std. Deviation	4.6767	3.1557
	Kurtosis	1.333	-.638
	Skewness	1.199	.121
Total	Mean	23.137	15.838
	N	80	80
	Std. Deviation	5.0510	2.7717
	Kurtosis	-.371	-.312
	Skewness	.635	-.153

Table 1: Time consumption analysis for each experimental group

For the participants from the VR group (Group 1), the results show participants spent on average 24 minutes on exercise each time. Compared with the average exercise time of 15 minutes in the HIIT group (Group 2), people using VR to perform HIIT exercise can last longer. The distribution of this result is shown in Figure 1.

For the analysis, we use the skewness symmetry and the Kurtosis measure to investigate if the distribution of the data is normal." With a sample size of $N = 40$, we got a skewness close to zero (skewness = 0.202) and a Kurtosis value close to -1 (Kurtosis = -0.859). Data is considered normally distributed with a skewness between -3 and 3 and a Kurtosis value in the range of +/-2. We may then conclude that the experimental data is normally distributed.

Meanwhile, the data from each group could be considered independently from each other as participants took enough rest before each exercise as 24-48 hours of rest between exercises is considered sufficient [22]. Therefore, we can use the two-sample Z-test, a parametric test on the difference $\mu_1 - \mu_2$ where μ_1 = average exercise time of VR by group 1 and μ_2 = average exercise time of HIIT by group 2.

The null hypothesis, H_0 , has been defined that there is no difference in the average time spent on exercise through VR and HIIT ($\mu_1 - \mu_2 = 0$). The alternative hypothesis, H_1 , there exists a difference in the average time spent on exercise through VR and HIIT ($\mu_1 - \mu_2 \neq 0$). The statistical result shows that at 10% significance level ($\alpha = 0.1$), the p-value = 1.11×10^{-15} is zero, the smaller the p-value, the more it supports H_1 , which means the difference of average exercise time between the Group 1 (VR) and Group 2 (HIIT) is big enough to be statistically significant. The time consumption graph (figure2) of the two exercise modes can intuitively indicate the difference between the time consumed by VR and HIIT.

After the control experiment in the second week ended, we got the data from the same group under different training methods. Skewness approaches 0, and Kurtosis is -0.4 in group 1 HIIT exercise. Thus, the data approximates a normal distribution. Meanwhile, the mean exercise time of VR and HIIT is from the same group, so they are not independent. Therefore, we can use the two-sample t-test on $\mu_1 - \mu_2$ to see the difference of exercise time, where μ_1 is the average VR exercise time in group 1 and μ_2 stands for exercise time of HIIT in group 1.

In this two-sample t-test, H_0 : average time spent on VR exercise in group 1 is smaller or equal to the average time spent on HIIT in group 1 ($\mu_1 \leq \mu_2$). H_1 : average time spent on VR exercise in group 1 is greater than the average time spent on HIIT in group 1 ($\mu_1 > \mu_2$). $N = 40$ with $df = 39$. At 10% significance level ($\alpha = 0.1$), the results p-value is equal to 4.88×10^{-12} close to 0, which means that the average time spent on VR exercise in group 1 is greater than the average time spent on HIIT. Moreover, the difference is big enough to be statically significant.

The same method (two-sample t-test) can also be applied to the data sets from group 2 and total. Finally, both results show that participants tend to spend more time on VR exercise than HIIT exercise.

Therefore, we may answer the first research question: People tend to spend more time taking HIIT exercise by VR than regular HIIT exercise.

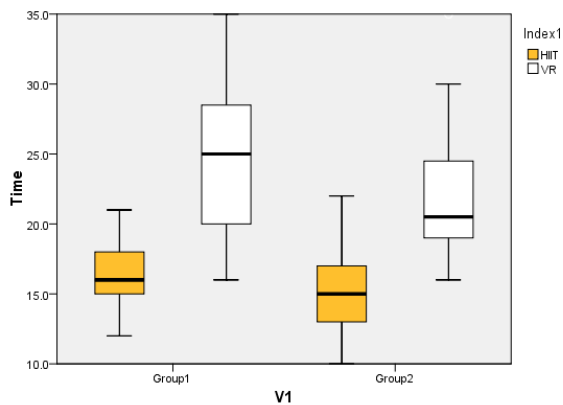


Figure 1: Time consumption distribution (in minutes)

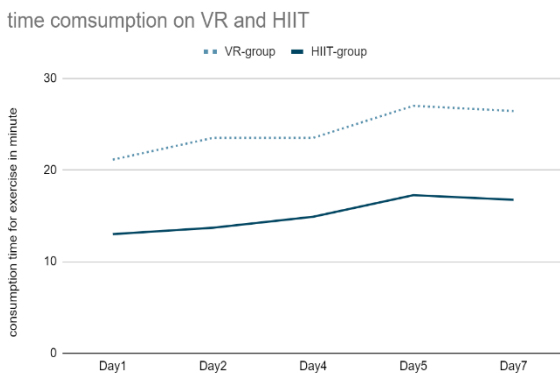


Figure 2: Time consumption of Group 1 and Group 2 (in minutes)

4.2 Motivation Differences

It is necessary to analyse the difference in motivation obtained through different training conditions for solving the second research question. Therefore, at the end of the experiment, we used the SMS-6 questionnaire to quantify the participants' exercise motivation, analyse the data, and obtain the following results. The distribution of this result is shown in Figure 3.

The results show that in the experiment of performing HIIT training five times a week, participants who used VR for HIIT exercise showed higher motivation with a score of 105.5 on average. However, the group's motivation without using VR equipment for HIIT exercise is relatively low, with a score of 89.437 on average.

Motivation scale analysis

V1		VR	HIIT
Group1	Mean	104.375	91.250
	N	8	8
	Std. Deviation	5.2082	6.1354
	Kurtosis	-1.238	.526
Group2	Mean	106.625	87.625
	N	8	8
	Std. Deviation	10.3639	8.5346
	Kurtosis	-1.317	-.438
Total	Mean	105.500	89.437
	N	16	16
	Std. Deviation	8.0083	7.4204
	Kurtosis	-.207	-.370
	Skewness	.571	-.014

Table2: Motivation analysis for each experimental group

The total score of the sports motivation scale (SMS-6) questionnaire is 168. Thus, both the results of the two experimental groups are more than 50% of the total score, which proved that both the use of virtual reality and the HIIT provide them with sufficient motivation to exercise.

Although the sample size $N = 8$ is small, the value of Skewness and Kurtosis show that the data shows a trend of normal distribution. Therefore, we can also use the two-sample Z-test method to test the difference in average motivation to take exercise from these two groups. We take the VR result from group 1 and the HIIT result from group 2. Then define the null hypothesis, H_0 , as there is no difference in the average motivation to exercise through VR and HIIT ($\mu_1 - \mu_2 = 0$). The alternative hypothesis H_1 is that the average motivation to exercise through VR and HIIT is different ($\mu_1 - \mu_2 \neq 0$). At the 10% significance level ($\alpha = 0.1$), the results of the two-sample Z-test shows the p-value = 0.00000215478 approximately zero, which means H_0 has been rejected. In other words, the difference between the average motivation to exercise through VR and HIIT is big enough to be statically significant. The histogram of the two sets of data (Figure 3) can better show the difference between the two sets of data.

The same differences in average motivation participants gain through VR and HIIT can also be reflected within the same group since each group has performed VR exercise and HIIT. However, the motivation score from the same group is dependent, which means a two-sample t-test on the mean of motivation is needed with $\mu_1 =$ average motivation participants gain through VR exercise in group 1 and $\mu_2 =$ average motivation participants gain through HIIT exercise group 1.

This two-sample t-test defines H_0 as the average motivation participants obtained through VR exercise in Group 1 is smaller or equal to the average through HIIT ($\mu_1 \leq \mu_2$). Moreover, we define H_1 as Group 1 obtained more motivation score through VR exercise than HIIT on average ($\mu_1 > \mu_2$). $N=8$ and $df = 7$. At 10% significant level ($\alpha=0.1$). The result of the p-value is 0.000215, close to zero. Thus, we can conclude that at a 10% significant level, people tend to obtain more motivation to exercise through VR than HIIT. The same result can also be obtained using data from Group2.

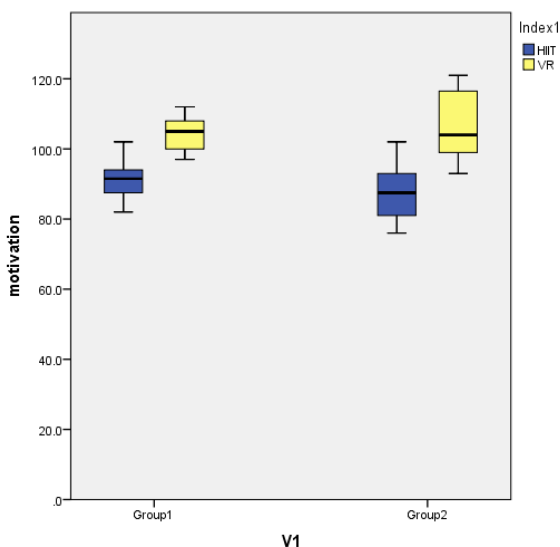


Figure 3: distribution of motivation to take exercise

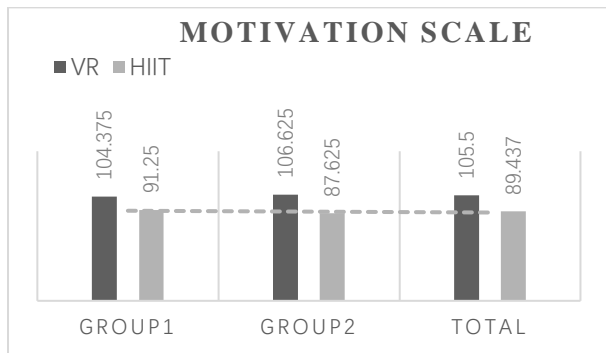


Figure 4: Histogram of motivation to exercise

The results show that the use of VR can make people gain higher motivation to exercise. Moreover, in the interview about exercise satisfaction and self-assessment of the training after the experiment, the participants mentioned that using VR equipment for training is a brand-new experience. It makes them feel more fun to exercise. Participants point out they thought that they were playing games while taking exercise, and time passed remarkably quickly during the VR experience. Although the fatigue caused by movement forced them to stop, participants expressed that they wished to continue with VR exercise if their physical condition allowed. The VR sports software support different difficulty levels of exercise. This design is friendly to beginners to help them find the appropriate intensity. More importantly, participants can distinguish

whether their actions are standard based on the scores during each exercise, and the scores appear in the global ranking. Players will stimulate competitive psychology due to the score rankings to make the actions more standardised for a higher score to obtain a higher-ranking result. Thus, the second research question can be answered that with the help of VR equipment, people tend to be more motivated to take exercise as using VR makes them feel refreshing, exciting, and more engaging in exercise.

4.3 Willingness to Maintain Good Physical Condition

We have obtained the answers to the first two research questions by analysing the experimental data. The last research question of distinguishing the willingness of participants to maintain good physical conditions is mainly answered in the form of interviews.

The interview included several questions such as "During the exercise in the past week, what impact daily exercise have on your quality of life?", "How do you think about the importance of daily exercise and the importance of maintaining health?" "What is the difference in willingness to maintain a good physical condition compared to using VR and not using VR?" .

The interview results showed that the participants had muscle soreness after the exercise. Still, they believe that this is an intuitive and straightforward proof that taking exercise is effective and indicates that they seriously lack physical activity. According to participants' feedback, they believe that the most intuitive impact of exercise on life is that he gets a better sleep quality and significantly reduces the use of mobile phones while lying in bed for a long time. As a result, their life began to become regular and energetic. Moreover, the participants said that participating in this experiment made them aware of the importance of daily exercise and maintaining a healthy body. Meanwhile, the participants thought that the HIIT exercise method was very effective. Although some participants encountered difficulties initially because they could not choose the exercise intensity that suits them, they gradually found and adapted to the intensity that suits them during the exercise. More importantly, HIIT does not require professional equipment like a treadmill and takes a much shorter time than other exercises. At the same time, HIIT avoids the commuting time needed to go to the gymnasium and truly makes it possible to exercise anytime, anywhere.

Participants expressed the following views on attitude to use VR equipment on the question of willingness to maintain a good physical condition. First, they pointed out that it is a perfect way to use VR equipment to exercise when our attention is focused on completing the game while finishing the required amount of exercise. Second, various exercise-related software on VR, such as beat sabre, simulated boxing or even yoga and other sports that can be performed on VR, provides them with adequate choice. However, this only increases people's exercise motivation as VR makes exercise no longer dull but rather interesting. Finally, participants pointed out that the results and benefits of exercise made them notice the importance of maintaining a good physical condition rather than a VR device. Therefore, participants expressed their willingness to regularly exercise to maintain good physical condition no matter using VR or HIIT. Thus, the VR device itself does not affect people's willingness to maintain their physical condition. Still, people have shown that using VR for exercise is more motivated as this exercise method is more novel, exciting and can enable people to obtain better exercise results.

In summary, the result of the third research question is that there is no difference between people's willingness to maintaining a good physical condition by taking VR exercise or HIIT. However, people show that they prefer to use VR for exercise as VR equipment increases people's motivation to exercise.

5. DISCUSSION

The experimental results have shown the impact of VR on people's exercise in many ways. For example, exercising in a virtual environment can allow people to perform longer exercise time, higher exercise motivation, and exercise games in VR can effectively instruct HIIT exercise through clear movement instructions.

Unlike what is expected, VR has not improved people's willingness to maintain a healthy physical condition. Instead, people express their willingness to live healthily because regular exercise has a positive impact on their lives, regardless of use VR for exercise or not.

Participants show more motivation and satisfaction in VR exercise than HIIT. 71% of the participants argued that they were more focused on getting higher scores and higher rankings in VR to regulate their movements in the game. However, that experiment was conducted with only 16 participants for a duration of 2 weeks. For more accurate experimental results, it is needed to increase the number of participants, as well as lengthen the experiment duration during future experiments. Although participants performed longer exercise time in VR, it is also possible that the participants need to adjust the angle of the VR device due to the shift of the device position caused by the strenuous movement during the exercise. It means that the time to adjust the equipment was also included in the exercise time.

Although the use of VR for exercise shows many benefits, there is an important issue that we cannot ignore. Existing VR exercise software usually exists in the form of games. The ranking and scoring system in the game may lead to excessive incentives for users to exercise, especially users with a strong competitive mentality. This type of user is likely to over-exercise to get a higher score in the game, increasing the risk of injury during exercise.

More importantly, although participants expressed that using VR for exercise is very novel and exciting, it is very uncomfortable to wear VR equipment and headsets when sweating due to strenuous exercise. Thus, if participants consider using VR for daily exercise, it seems very difficult to prevent uncomfortable wearing VR equipment caused by sweating. Meanwhile, even if VR technology has rapid developed in the past few years, the popularity of home VR devices is still sluggish because VR devices on the market are often expensive. Therefore, people are likely to be discouraged by the high prices.

6. CONCLUSION

This article outlines the impact of using VR to exercise on people's motivation to exercise, exercise time and willingness to maintain a healthy physical condition.

Experimental results show that people who perform HIIT exercise under VR equipment show longer exercise time. In addition, people's motivation and exercise satisfaction are higher than those who do HIIT exercise without VR equipment. At the same time, because VR exercise can score the standard

of the action and rank the results of the exercise, people feel more involved and competitive in the exercise. However, the participants also reported that sweating under strenuous exercise caused the VR device to be saturated with sweat, making it uncomfortable to wear.

The use of VR does not affect people's willingness to maintain a good physical condition. Instead, it is the benefits of exercise that make people show their willingness to keep a healthy physical condition.

7. REFERENCES

- [1] Adesida, Y. et al. 2019. Exploring the Role of Wearable Technology in Sport Kinematics and Kinetics: A Systematic Review. *Sensors*. 19, 7 (Apr. 2019), 1597.
- [2] Aaron Keesing, Matthew Ooi, Ocean Wu, Xinghao Ye, Lindsay Shaw, and Burkhard C. Wünsche. 2019. HIIT With Hits: Using Music and Gameplay to Induce HIIT in Exergames. In *Proceedings of the Australasian Computer Science Week Multiconference (ACSW 2019)*. Association for Computing Machinery, New York, NY, USA, Article 36, 1–10. DOI:<https://doi.org/10.1145/3290688.3290740>
- [3] Batacan, R. B. (2017, March 1). Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. *British Journal of Sports Medicine*. <https://bjsm.bmj.com/content/51/6/494.short> (1)(7)
- [4] Booth, F. W., Roberts, C. K., & Laye, M. J. (2012, April 2). Lack of Exercise Is a Major Cause of Chronic Diseases. *Wiley Online Library*. <https://onlinelibrary.wiley.com/doi/abs/10.1002/cphy.c110025>
- [5] *Benefits of Physical Activity*. (2021, April 5). Centers for Disease Control and Prevention. <https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm>
- [6] Clifford Mallett, Masato Kawabata, Peter Newcombe, Andrés Otero Forero, Susan Jackson, Sport motivation scale-6 (SMS-6): A revised six-factor sport motivation scale. *Psychology of Sport and Exercise*, Volume 8, Issue 5, 2007, Pages 600-614, ISSN 1469-0292, <https://doi.org/10.1016/j.psychsport.2006.12.005>.
- [7] Dębska, M.; Polechoński, J.; Mynarski, A.; Polechoński, P. Enjoyment and Intensity of Physical Activity in Immersive Virtual Reality Performed on Innovative Training Devices in Compliance with Recommendations for Health. *Int. J. Environ. Res. Public Health* 2019, 16, 3673.
- [8] Dario G. Liebermann, Larry Katz, Mike D. Hughes, Roger M. Bartlett, Jim McClements & Ian M. Franks (2002) Advances in the application of information technology to sport performance, *Journal of Sports Sciences*, 20:10, 755-769, DOI: 10.1080/026404102320675611
- [9] Derek Ball. 2020. Rest days are important for fitness – here's why, according to science. (November 2020). Retrieved June 20, 2021 from <https://theconversation.com/rest-days-are-important-for-fitness-heres-why-according-to-science-143875>
- [10] Elena Tuveri, Luca Macis, Fabio Sorrentino, Lucio Davide Spano, and Riccardo Scateni. 2016. *Fitmersive Games: Fitness Gamification through Immersive VR*. In *Proceedings of the International Working Conference on*

- Advanced Visual Interfaces (AVI '16). Association for Computing Machinery, New York, NY, USA, 212–215. DOI:<https://doi.org/10.1145/2909132.2909287>
- [11] Farrow, M. (2018). Virtual-reality exergaming can increase enjoyment and performance during high-intensity interval training. The University of Bath's Research Portal. <https://researchportal.bath.ac.uk/en/publications/virtual-reality-exergaming-can-increase-enjoyment-and-performance>
- [12] Filho, S. A. S. (2020). *COVID-19 and Quarantine: Expanding Understanding of How to Stay Physically Active at Home*. Frontiers. <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.566032/full>
- [13] Franz Konstantin Fuss Editor-in-Chief, Aleksandar Subic Editor-in-Chief & Rabindra Mehta Editor-in-Chief (2008) The impact of technology on sport — new frontiers, Sports Technology, 1:1, 1-2, DOI: 10.1080/19346182.2008.9648443
- [14] J. Wang, Research on Application of Virtual Reality Technology in Competitive Sports, Procedia Engineering, Volume 29, 2012, Pages 3659-3662, ISSN 1877-7058, DOI=<https://doi.org/10.1016/j.proeng.2012.01.548>.
- [15] Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U; Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*. 2012 Jul 21;380(9838):247-57. doi: 10.1016/S0140-6736(12)60646-1. PMID: 22818937.
- [16] Katz, Larry & Parker, James & Tyreman, Hugh & Kopp, Gail & Levy, Richard & Chang, Ernie. (2006). Virtual Reality in Sport and Wellness: Promise and Reality. *International Journal of Computer Science in Sport*. 4. 4-16.
- [17] Keating XD, Guan J, Piñero JC, Bridges DM. A meta-analysis of college students' physical activity behaviors. *J Am Coll Health*. 2005;54(2):116-125. doi:10.3200/JACH.54.2.116-126
- [18] Lee, H. T. (2018, December 19). *The effect of sports VR training for improving human body composition*. EURASIP Journal on Image and Video Processing. <https://jivp-eurasipjournals.springeropen.com/articles/10.1186/s13640-018-0387-2>
- [19] López-Valenciano, A. (2021). *Impact of COVID-19 Pandemic on University Students' Physical Activity Levels: An Early Systematic Review*. Frontiers. <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.624567/full>
- [20] Lucas Martins de Souza, Irem Gokce Yildirim, Anya Kolesnichenko, and Taiwoo Park. 2016. World Of Riders: Exercising is Fun. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts (CHI PLAY Companion '16). Association for Computing Machinery, New York, NY, USA, 55–60. DOI:<https://doi.org/10.1145/2968120.2971807>
- [21] Nicolas Vignais, Richard Kulpa, Sébastien Brault, Damien Presse, Benoit Bideau, Which technology to investigate visual perception in sport: Video vs. virtual reality, *Human Movement Science*, Volume 39, 2015, Pages 12-26, ISSN 0167-9457, DOI:<https://doi.org/10.1016/j.humov.2014.10.006>.
- [22] Nast, C. 2021. Here's How Much Rest You Actually Need in Between Strength Workouts. SELF. <https://www.self.com/story/rest-strength-workouts>.
- [23] *Physical Activity And Health*. (2015, July 23). Eufic. <https://www.eufic.org/en/healthy-living/article/physical-activity-and-health>
- [24] Penedo, Frank Ja; Dahn, Jason Ra,b Exercise and well-being: a review of mental and physical health benefits associated with physical activity, *Current Opinion in Psychiatry*: March 2005 - Volume 18 - Issue 2 - p 189-193
- [25] Science, C. (2013, June 8). *Virtual Reality for Sport Training*. Virginia Tech. <https://vtechworks.lib.vt.edu/handle/10919/23179>
- [26] Stefan Gradl, Bjoern M. Eskofier, Dominic Eskofier, Christopher Mutschler, and Stephan Otto. 2016. Virtual and augmented reality in sports: an overview and acceptance study. In Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct (UbiComp '16). Association for Computing Machinery, New York, NY, USA, 885–888. DOI:<https://doi.org/10.1145/2968219.2968572>
- [27] Sissons, B. (2020, January 13). *What are the benefits of high intensity interval training (HIIT)?* MedicalNewsToday. <https://www.medicalnewstoday.com/articles/327474>
- [28] Shiraev, T., & Barclay, G. (2012). Evidence based exercise: Clinical benefits of high intensity interval training. *Australian Family Physician*, 41(12), 960–962. <https://search.informit.org/doi/10.3316/informit.998344208782447> Siracuse, B., & Rynecki, N. (2019, February). The Journal of Sports Medicine and Physical Fitness 2019 July;59(7):1206–12. Edizioni Minerva Medica. <https://www.minervamedica.it/en/journals/sports-med-physical-fitness/article.php?cod=R40Y2019N07A1206>
- [29] Sigmund Loland (2002) Technology in sport: Three ideal-typical views and their implications, *European Journal of Sport Science*, 2:1, 1-11, DOI: 10.1080/17461390200072105
- [30] Taquet, M. B. (2021, January 1). Mood Homeostasis Before and During the Coronavirus Disease 2019 (COVID-19) Lockdown Among Students in the JAMA. <https://jamanetwork.com/journals/jamapsychiatry/article-abstract/2768363>
- [31] Trine Karlsen, Inger-Lise Aamot, Mark Haykowsky, Øivind Rognmo, High-Intensity Interval Training for Maximizing Health Outcomes, *Progress in Cardiovascular Diseases*, Volume 60, Issue 1, 2017, Pages 67-77, ISSN 0033-0620, <https://doi.org/10.1016/j.pcad.2017.03.006>.
- [32] University of Amsterdam (2020, May 6). The Intelligent Lockdown: Compliance with COVID-19 Mitigation Measures in the Netherlands by Malouke Esra Kuiper, Anne Leonore de Bruijn, Chris Reinders Folmer, Elke Olthuis, Megan Brownlee, Emmeke Barbara Kooistra, Adam Fine, Benjamin van Rooij :: SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3598215
- [33] Varela-Aldás J., Fuentes E.M., Palacios-Navarro G., García-Magariño I. (2020) A Comparison of Heart Rate

in Normal Physical Activity vs. Immersive Virtual Reality Exergames. In: Ahram T., Karwowski W., Pickl S., Taiar R. (eds) Human Systems Engineering and Design II. IHSED 2019. Advances in Intelligent Systems and Computing, vol 1026. Springer, Cham.
https://doi.org/10.1007/978-3-030-27928-8_104

- [34] World Health Organization. (n.d.). *Benefits of regular physical activity*. Retrieved June 15, 2021, from <https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/benefits-of-regular-physical-activity>