Original Article

Running virtual: The effect of virtual reality on exercise

COLEEN McCLURE, DAMIAN SCHOFIELD

Department of Computer Science, State University of New York, Oswego, New York, United States of America

ABSTRACT

Research has shown that exercise among college aged persons has dropped over recent years (Lindahl, 2015; Sheppard, 2016). Many factors could be contributing to this reduction in exercise including: large workloads, the need to work during school, or perhaps technology use. A number of recent studies are showing the benefits of using virtual reality systems in exercise and are demonstrating that the use of such technology can lead to an increase in the number of young adults engaging in exercise. This study focuses on the effects that virtual reality has on heart rate and other bodily sensations during a typical work out. This study also analyses the participants ability to pay less attention to their bodily sensations during exercise when using a virtual reality system. During this experiment, participants were exposed to two different conditions. Condition one being a traditional work out, riding an exercise bike at a middle tension level. Condition two was the same but the participant was wearing a virtual reality headset. The data collected led to the conclusion that working out while wearing a virtual reality headset will lead to a higher heart rate, and in turn can lead to burning more calories during a workout. The study also found participants who wore the virtual reality headset were able to remove themselves from their bodily sensations allowing them to workout longer. **Keywords:** Virtual Reality (VR); Heart Rate (HR); Exercise; Beats Per Minute (BPM); Bodily Sensations (BS).

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Corresponding author. *Department of Computer Science, State University of New York, Oswego, New York, 13126, United States of America.*
E-mail: schofield@cs.oswego.edu
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INTRODUCTION

Virtual reality (VR) is a simulated experience that can be similar to or completely different from the real world. Applications of virtual reality can include entertainment (i.e. gaming) and educational purposes (i.e. medical or military training). Other, distinct types of VR style technology include augmented reality and mixed reality.

Currently standard virtual reality systems generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items. The effect is commonly created by VR headsets consisting of a head-mounted display with a small screen in front of the eyes but can also be created through specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback but may also allow other types of sensory and force feedback through haptic technology.

Over the past ten years, VR has developed into a technology that is used for more than just video games. This technology is being used in education, training for jobs, the medical field, and much more. VR is changing the way humans perform many tasks and is helping in many diverse areas of life. As the technology progresses, there will be more specific focus on the use of VR in physical fitness and health (Nichols and Patel, 2002).

One specific area of interest is young adults at the collegiate level. Buckworth and Nigg (2004) found that the average level of exercise among college males ranks higher than those of women but reports that both men and women at the college age are mainly sedentary when compared to acceptable levels of physical fitness. These results indicate that since the general level of exercise among college students is low, therefore, during exercise, you may expect (on average) a higher heart rate.

This study hypothesizes that using a VR headset while exercising will increase the level of the participant's heart rate, even higher or at a faster rate than a workout when not wearing a virtual reality headset. This study also hypothesizes that participants will have lower levels of bodily sensations during the VR condition.

Exercise and technology

In many areas of society exercise has seen a major resurgence in the past decade. As obesity has increased in America, many citizens, in particular young adults, turned to exercise. For those experiencing obesity, physical disabilities, and illnesses exercising can pose a challenge (Steptoe et al, 2002). The introduction of technologies, such as VR, can aid those who struggle with exercise. While VR can be helpful for those with challenges it can be perhaps be even more helpful for those who do not experience such hurdles. The use of VR systems in exercise can decrease a person's bodily sensations while increasing heart rate allowing for better results from exercise.

Exercise among college aged adults

For college aged students, exercise is critical to their ability to learn, be social, and mature. However, college aged adults are experiencing life at a much faster rate, and under more pressure, than ever. Transitioning to adulthood can leave little time for self-care, and therefore tasks such as exercise often get left behind. Gonçalves and Martínez (2018) recently reported that college aged males performed more exercise than women, with 89% of males reporting physical activity whereas only 62% of women reported physical activity.

The importance of exercise for young adults comes into focus when data is used to correlate any increase in student grades to corresponding increases in exercise. Speaking about the importance of exercise Fricke et al (2018) stated:

"The incentives appear to have improved grades by enhancing the effectiveness of studying and encouraging students to spend more time in class."

The study looked at grades from students across two semesters and found significant results indicating that exercise will increase a student's grades. The study also notes that exercise on campus will generally enhance student performance on campus (Fricke et al, 2018).

As the transition to adulthood takes place many young adults experience greater levels of stress. These stresses vary due to experiences, but in general most young adults report feeling high levels of stress, especially those who are students. Meyers and Larson (2018) report on an investigation which illustrated the importance of exercise for students. The experiment found that physical activity can greatly reduce stress in an academic setting. The ability to reduce stress can have a large impact on, exercise will also enhance the student's ability to perform at higher levels of academic performance (Myers and Larson, 2018).

The impact of technology on humans is more prevalent than ever, we are constantly surrounded by devices that jostle for our attention. The risk associated with new technology, and the effect on the health of humans has become increasing important. In recent years, cell phones have become an important focus in the lives of many young adults. College professors commonly note the large distraction that cellular devices cause. Studies have shown that cell phone usage is mainly sedentary and can have effects on health. When using a cell phone during exercise the level of intensity reduces (Barkley et al, 2016). Research has also shown that frequent cell phone users tend to be less healthy than those who have less cell phone usage. There is a correlation between frequent cell phone usage and the amount an individual will use a cell phones while exercising, thus decreasing the effect of the exercise. College aged students generally have high amounts of cellular use implying that this will also decrease the effectiveness of their physical activity (Barkely, 2016).

Although technology is now essential to our lives, the use of technology has often caused barriers to human health. The use of VR systems has the potential to change this trend. Combining VR systems with exercise can create a new outlet for young adults. The use of this technology has the potential to reduce stress, boost the effectiveness of exercise, and be more enjoyable than a standard work out.

Heart rate

Measuring heart rate traditionally is something done as a medical procedure. Recently, the ability to monitoring one's own heart rate using portable technology has become available (Jeong et al, 2009). In the United States, many citizens are making a push towards living a healthier life. In order to achieve a healthier lifestyle, it is important to understand one's body and its internal workings. The monitoring of body functions, such as heart rate, can help people understand how their body is being affected by different factors in their life (Berntson et al, 1997).

College aged students spend a large portion of their day both in class and interacting with technological devices. Both of these activities are mostly sedentary not allowing students much time for physical activity. Understanding heart rate during sedentary behaviour is critical to investigating heart rate during exercise. A recent experiment from Sweden investigated different heart rate monitors and their ability to measure heart rate at a sedentary level. The study used two different devices to measure heart rate. One device being a

heart rate-based activity monitor and the other being a fit bit flex which is a wrist heart rate monitor. The investigation found that the fit bit flex was unable to identify a difference in sitting and standing, and movement while sitting could be tracked as movement. The experiment also found that participants that have lower resting heart rates may see a less significant change in heart rate with higher levels of activity (Åkerberg, 2015).

Sedentary behaviour can be monitored using a variety of different devices. Over the past decade these have become more popular with a section of the population wearing them daily. There have been a number of studies investigating the effects of technology on heart rate. One study focused specifically on the use of VR and exercise by measuring heart rate awhile playing video games (Jagadheeswari et al, 2018). The experimenters selected two different video games both rated at different levels to see the difference in heart rate while playing each game. This study concluded that M rated games caused higher heart rates and E rated games saw a minor, less significant, raise in heart rate. The study also found that males heart rates were affected more than women. Since M rated games can cause a higher heart rate, they may be more successful in attempts to burn more calories (Jagadheeswari et al, 2018).

In a further study on the effects of VR on heart rate of musicians found that heart rate can be manipulated based on the settings of the virtual experience the participant is exposed to. The results concluded that when immersed in a VR setting heart rate levels rise more than average (Evelyn, 2003).

Other studies have also shown that the use of VR systems can increase heart rate among users. Researchers have also suggested that the higher heart rate caused by the VR systems may be due to levels of anxiety or claustrophobia experienced within the virtual environments (Tsai et al, 2018). When this effect is occurring, the rise in heart rate no longer becomes healthy or beneficial for the user.

Bodily sensations

The human body reacts to exercise in many different ways. Research has shown that workouts can become more appealing with the notion that they will not cause the body physical pain. VR systems can potentially make a workout more appealing and may length the time spent working out by providing a distraction from bodily sensations.

Lara (2018) describes a body as a series of hinges, these hinges are how the body experiences different sensations. As humans it is nearly impossible to think of the simultaneous feeling in the entirety of the body. The mind is only able to focus on one portion of the body at the time. Lara reports that distracting the mind may be the key in disseminating these negative bodily sensations during a workout.

Bodily sensations can be correlated to the space surrounding the body. Both visual and spatial surroundings have different effects on the sensations felt by the human body, both have significant effects. Research has shown that although visual stimuli can affect body sensations, spatial stimuli can have a larger effect. The study found that when the visual stimuli was in closer proximity to the participant there was a higher bodily sensation (Filbrich et al, 2017).

Researchers have found that distracting the mind of obese children that struggle with exercise will enhance their workouts. These distractions improved the physical activity by allowing the participant to run for a longer period of time than would have taken place without the distraction. Researchers have concluded that when the mind is distracted, it takes it longer to realize the bodily discomfort allowing participants to prolong the exercise period (De Bourdeaudhuij, 2002).

Virtual reality and exercise

There are many reasons why college students choose to not work out frequently, but reduction in bodily sensations could provide a better experience for those who do and increase participation in exercise. A recent study worked with overweight children and investigated the correlation between bodily sensations and physical activity (Baños et al, 2016). These children were exposed to two different conditions when they both performed an exercise. One condition was using a VR headset and one without. The study found that the VR headset did indeed distract from bodily sensations. It also provided a more enjoyable workout, as many of the participants reported more enjoyment while using the headset. This study supports the premise that VR environments can enhance workouts and a person's willingness to participate in exercise.

A number of other studies have also reported on the benefits of VR to bodily sensations. One study focused on the rehabilitation of haemodialysis patients, examining fatigue, physical fitness, and body composition over time while using a VR system. Two groups were studied, one group was exposed to the VR system while the other was not. Those who used the VR system during their rehabilitation saw a larger increase in all three aspects being studied (Cho and Sohng, 2014). This leads to the conclusion that if a VR system can support those facing challenges with physical activity, then there may be increased benefits for those who are inclined/able to perform exercise with no barriers.

The benefits of using these systems potentially goes beyond physical fitness and may demonstrate mental health benefits as well. The studies discussed above all illustrate the potential of VR systems to have a positive effect on mental health as well as physical health. An experiment within older adult women used VR to determine if it can positively affect their quality of life. The experiment found that women who participated in the study experienced greater improvements in their mental health than in their physical health (Lee, 2015). The use of the VR system allowed the women to undertake longer workouts which did increase their physical health in addition to the mental health benefits.

METHODOLOGY

The research described in this paper intends to validate the work of the researchers listed above and further demonstrate the benefits of using a VR system when exercising.

Design

The participation pool consisted of twenty-nine college students all above the age of eighteen.

This experiment attempted to determine whether exercise with a VR headset or without a VR headset would provide higher heart rates, which in turn, would result in the burning of more calories. The hypothesis was that users of the VR headset will see a larger increase of heart rate during this condition. The study was based around an exercise routine, specifically riding an exercise bike. The participant experienced two different conditions, one being riding on the bike without a headset, while the other was riding the bike while wearing the VR headset. This is a with-in subjects design study meaning all participants of this study were exposed to both conditions of the independent variable.

Materials

Heart Rate: Heart rate can be measured using many different types of devices. When people think of monitoring their heart rate, it is common to be thought of as a challenging task needing doctors and medical supervision. However, it has become easy and common to track heart rate via portable technologies. Cell phones are now equipped with sensors that can monitor a person's heart rate, many smart watches and

exercise devices also monitor heart rate. For this experiment, the participants wore an exercise band known as an "Apple Watch" in order to record their heart rate during each condition. This was chosen because the device is non-invasive and allows for the subject to feel more at ease during the experiment. The typical heart rate at rest is 60-100 beats per minute. The target heart rate during exercise for those in their twenties is 100-170 beats per minute. Heart rate was be monitored throughout the study to compare the difference in heart rate between those using a VR headset and those without.

Body Sensations: Body Sensations were measured using a self-reported questionnaire following each condition. The questionnaire was similar to the one created by De Bourdeaudhuij (2002). The survey asked the participants to rank their sensation from a 1-very low to a 5-very high. This will cover six areas of the body including: respiratory, cardiac, arousal/anxiety, gastro-intestinal, dizziness, and pain.

Satisfaction: Satisfaction was measured based on a questionnaire similar to the one created by De Bourdeaudhuij (2002). Participants answered an additional seven questions after completing the VR condition section of the experiment. These questions attempted to assess the participant's experience and level of enjoyment during this condition. These questions were measured in the same five-point scale as the previous questionnaire.

Procedure

All participants were informed of the contents of the study, and written consent was collected from all participants prior to the experiment. Participants were instructed to wear the Apple Watch (heart rate monitor), prior to getting on the exercise bike. Initial heart rate readings wear taken for each participant to get a baseline measurement for each individual with their heart rates at rest.

The participants were then asked to step onto the exercise bike. The exercise bike was set at medium tension allowing for a brisk peddle. Participants rode at this tension for six minutes allowing time for their heart rate to rise. After these six minutes, the heart rate from was recorded. At this time, participants were allowed to have a drink, and were asked to sit until their heart rate matched their initial heart rate at rest. During this time the bodily sensations questionnaire was completed.

Then participants were asked to return to the bike where a VR headset was placed on the participant. The participant would perform the same six minutes of peddling on the bike at medium tension, this time wearing the VR headset. When wearing the headset, the subject would be exposed to outdoor scenery as if they were riding down a sidewalk. There would be sun and trees as if it were a pleasant summer day. This footage was shown for the entirety of the six minutes. After six minutes, the subject removed the headset and their heart rate was again recorded. The participants then were asked to complete the bodily sensations questionnaire once again, and also to fill out the satisfaction questionnaire.

The study was ended with the participant reading a debriefing form explaining more about the study, allowing for questions and giving the subject one last opportunity to withdraw from the study before their data becomes final. If the subject approved our use of their data, the experiment was complete.

RESULTS

A paired-samples t-test was conducted to compare each participant's heart rate during exercise (riding an exercise bike), both with and without the VR headset.

Table 1. Paired Samples t-Test Results.

	n	M(SE)	t	df	p
With VR	29	116 (2.64)	1.090	28	0.285
Without VR	29	112.1 (3.27)	1.090	28	0.285

As seen in table 1, there was a statistically significant difference between the two versions of the experiment, t (1.090) = 28, p= <.285. An examination of the heart rate levels were higher, while the participant was wearing the VR headset (N= 29, M= 116.0, SE= 2.64) than when using the bike without the use of the VR headset (N=29, M= 112.1, SE= 3.270). These results indicate that working out, specifically using the exercise bike while wearing a VR headset, will lead to a higher heart rate and in turn can lead to burning more calories during a workout. This is also demonstrated visually in figure 1.

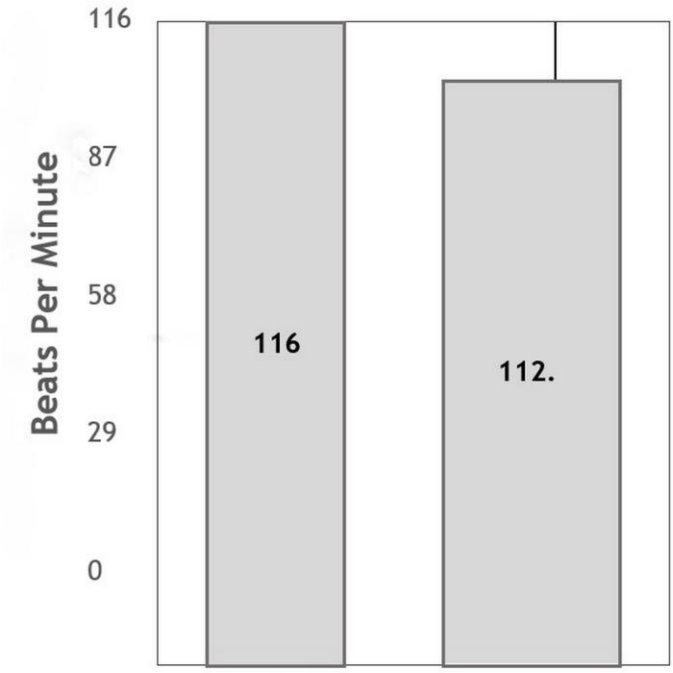

Figure 1. Difference in heart rate while participants partake in each condition.

As seen in figure 2, there was a major difference in both conditions in reference to bodily sensations. An examination of the bodily sensations were higher, while the participant was wearing the VR headset (N= 29, M=2.25) than when using the bike without the use of the VR headset (N=29, M= 1.95).These results do not support the hypothesis that the use of a VR headset during exercise would decrease the users sense of pain or bodily distress. Although, the majority of participants reported they felt strongly that they could continue the workout longer while wearing the virtual reality headset.

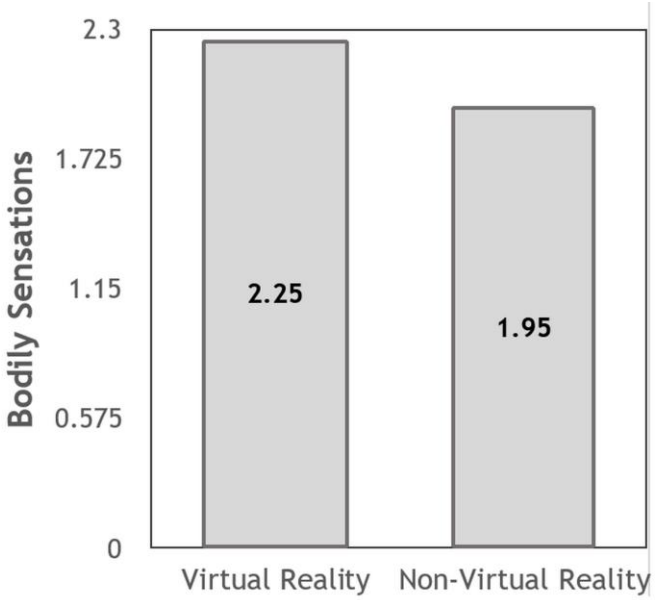

Figure 2. Difference in bodily sensations felt during each condition.

A survey was completed in order to determine whether users found more satisfaction in a workout which included VR, and the results were overwhelmingly positive. Over 50% of participants stated that they preferred the VR condition compared to the traditional workout, and that they were able to better focus. As well as focus 62% of participants stated that they could continue to exercise longer while using the VR headset.

DISCUSSION AND CONCLUSIONS

The idea of virtual reality and exercise novel and there are limited examples of experiments in the literature. However, results so far are promising and propose a positive technological future where future users of such technology may achieve their most healthy selves, both mentally and physically. The experiment described in this paper has shown that using a VR system while performing a workout has a positive impact and increases the heart rate of the person exercising, as was hypothesized. Although, the same results were not shown for bodily sensations.

The results correlate with previous research in this area, where other research studies also indicated that the use of VR headsets will lead to an increase in heart rate and increased physical and mental health. By implication this could also lead to an increase in participation in workouts, specifically among college aged students. The use of such VR systems may enhance the way humans perform many everyday tasks and can have positive impacts on health if implemented correctly.

There were a number of limitations with this study. Given more time to conduct this study, there could have been a comparison of health levels over a period of time with or without the use of a VR headset, which would give a firmer determination of whether the use of VR headsets during workouts can help humans reach an optimal health and fitness level in a shorter time compared to a typical workout.

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