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The Impact of Exergaming on Women's Affective Responses to Exercise: Increasing Opportunities for Physical Activity

This Senior Project is approved as acceptable

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The Impact of Exergaming on Women's Affective Responses to Exercise: Increasing Opportunities for Physical Activity

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Honors Thesis

Abstract

Despite strong evidence that regular physical activity (PA) is protective against adverse health outcomes, less than ½ of U.S. adults, and only ~20% of U.S. adult women, are meeting CDC minimum PA recommendations for health. Increasing PA among adults is a key Healthy People 2030 objective and yet evidence shows that PA engagement remains relatively unchanged. Thus, exploring opportunities to increase both access to PA opportunities, and ways to increase PA engagement, is an important public health priority area. Research suggests that positive affective responses to PA are associated with increased PA adherence. Recently, exergaming has emerged as a fun, interactive format for PA engagement, yet little is known about the potential for exergaming to increase PA participation in women. The purpose of this study was to compare affective responses to PA performed on a treadmill (walking/jogging) vs. a virtual-reality (VR) exergaming bout, to explore exergaming as a novel method to increase PA behavior in women.

Healthy, sedentary and lightly physically active women (n = 15; mean age 32.5 +/- 12.3 y) were recruited via on online survey. Participants completed: (1) an enrollment session which included the Physical Activity readiness Questionnaire, anthropometrics, and resting hemodynamics (heart rate and blood pressure) and a VR exergaming bout; (2) a treadmill exercise bout. Each exercise bout lasted 13 min., which included a 3-min warm up and 10-min conditioning phase. Both the VR and treadmill sessions were designed to allow participants to exercise at moderate to vigorous intensity during the 10-min conditioning bout. Heart rate was recorded every two minutes for each exercise, along with maximum rate of perceived exertion (RPE), using the Borgh-20 scale. Short, qualitative interviews were conducted at the end of each session to assess participants' affective responses to each exercise bout.

Although average HR during the exergaming session was not significantly different than the treadmill session ($t= 0.04$, $p= 0.97$), max RPE was significantly lower for the exergaming session vs. the treadmill $t= -2.48$, $p= 0.03$). Compared to the treadmill exercise, participants reported that the exergaming session was novel and entertaining with representative descriptions including "that was awesome;" "it was really fun;" and "it was exciting." When asked, all participants noted that they would recommend exergaming to a friend.

Though these results are preliminary, it is noteworthy that women reported lower levels of perceived exertion, and more positive affective responses during the VR exercise, even though their physiological responses showed no difference between the exergaming session and the treadmill session. Considering that positive affective responses to exercise are predictive of future exercise participation, it is possible that VR-based exergaming may be an effective method for increasing PA in women.

Introduction

Physical activity is widely recognized for its numerous health benefits, ranging from improved cardiovascular health to mental well-being. However, participation in regular PA remains poor across many populations, particularly among women. Various factors contribute to this issue including lack of time, time constraints due to caregiving responsibilities, safety concerns, and lack of appropriate facilities. Emerging technologies, particularly virtual reality (VR), have shown promise in enhancing user engagement and overcoming certain barriers to PA. The immersive and interactive nature of VR presents a novel opportunity to create environments where individuals can exercise at their own pace, in the comfort of their homes, with minimized social pressures. While VR's potential to facilitate PA has been explored in certain contexts, there is a notable gap in research specifically examining the impact on sedentary women's

physical activity behaviors. This thesis aims to address this gap by investigating how VR can be used as a tool to promote physical activity. The purpose of this study is the explore the affective response to VR-based interventions in increasing physical activity levels among sedentary women, to identify whether this technology can be an alternative solution to traditional exercise.

Literature Review

Engaging in regular physical activity is extremely important for one's health. When individuals adopt a sedentary lifestyle, they become more at risk for developing chronic diseases, including osteoporosis, cardiovascular disease (CVD), diabetes, hypertension, certain cancers, and mental health disorders. Sedentary behavior is defined as any waking behavior with an energy expenditure of 1.5 metabolic equivalent tasks (MET) or less, such as sitting or leaning (Park et al., 2020). 1.5 METs require minimal effort, so little energy is needed to complete the task. High levels of sedentary behavior are associated with an increased risk of all-cause mortality. Engaging in moderate to vigorous PA is linked to a lower risk of mortality, highlighting the protective benefits of staying active (Migueles et al., 2021). However, sedentary behavior is prevalent in modern lifestyles, particularly because of increased screen time, sedentary jobs, and non-active commuting. It has been demonstrated that regularly participating in PA can significantly improve health outcomes and reduce the effects of sedentary behavior (Park et al., 2020).

The American College of Sports Medicine (ACSM) recommends that all healthy adults aged 18-65 should participate in at least 30 minutes of moderate-intensity physical activity five days a week or participate in 20 minutes of vigorous-intensity aerobic activity three days a week to help prevent adverse health outcomes (ACSM, 2022). On average, only 1 in 4 adults in the US population currently meet these recommendations for physical activity and exercise (CDC,

2020). When focusing on the total population, women are less likely to meet these recommendations than men. In addition, according to the CDC, around 25.7% of the female U.S. population is sedentary as of 2020. There are likely many reasons why individuals, especially women, are not meeting the minimum recommended PA levels for health. These can include a lack of time, money, or environmental restrictions (Herzao- Beltrán et al., 2017).

Another barrier is accessibility. Where an individual lives can determine if there is a convenient and safe place to exercise. For example, research suggests that farther proximity to recreational areas such as green space (park areas) has been associated with lower levels of PA, and increased obesity rates (Kim et al, 2021). Individuals living in areas with limited access to parks, gyms, or community centers will likely find engaging in regular PA and exercise more challenging. In addition, some locations do not have many sidewalks, bike paths, and recreational spaces, further limiting what an individual can accomplish. Lower income houses are more at risk for obesity and other disease because they are less likely to have immediate access to green spaces, which reduces their PA levels (Kim et al, 2021).

To focus on women, physical inactivity negatively impacts body composition, strength performance and health outcomes. For example, physical inactivity in women has been linked to higher rates of breast cancer, colon cancer, heart disease, and other chronic health conditions (Kyu et al., 2016). Moreover, physical inactivity has been associated with an increased risk of mental health disorders (including depression and anxiety) in women (Crowley, 2023). Additionally, according to Jordan Hernandez-Martínez et al. (2023), a sedentary lifestyle can increase body fat and decrease muscle strength in women. With the reduction of muscle strength and increased body fat it can negatively impact women's health as it raises risk for various chronic diseases and functional limitations (World Health Organization, 2024).

There is a strong body of evidence to suggest that regular PA significantly reduces the risk of many chronic diseases, yet as previously discussed, the majority of U.S. adults do not meet the recommended minimum PA levels for health. The reasons for this are likely multifactorial, but there are commonly reported barriers to PA, which may, in part, explain why PA levels are so low among U.S. adults. One of the most common barriers is lack of time. Many adults must juggle work, family responsibilities, and other commitments, making it difficult to prioritize PA and exercise in their daily routines (Herzao- Beltrán et al., 2017). In addition, low motivation or interest in exercise can prevent someone from starting or maintaining an active lifestyle. Another barrier is the perception of exercise being too strenuous or unenjoyable. For some, the fear of injury or current health conditions also affects their lack of training (Herzao- Beltrán et al., 2017).

For women, there may be additional unique barriers to PA. For example, Aneesh and Mahanta (2022) found that the most common motivators for regular PA among women were disease prevention and weight loss, especially in younger women (Aneesh & Mahanta, 2022). The major barriers they noted were environmental factors like weather. Safety concerns were also a factor, such as isolated, poorly lit streets that are far from a gym or a park, which may deter adults, especially women, from exercising (Aneesh & Mahanta, 2022). Lack of motivation and lack of time has been determined not only by Aneesh and Mahanta's study but by many others as well, including Kazuhiro Harada et al. (2019), whose findings suggest that work hours are associated with reduced exercise behaviors (Kazuhiro Harada et al., 2019). Work can limit the amount of physical activity and exercise one can get, especially for those with sit-down jobs who work long hours. Sedentary behaviors while at work can result in negative health consequences later in life.

Other barriers to PA in women include caregiving responsibilities, menstrual cycle symptoms, and pregnancy. Many women are stay-at-home moms or are the primary caretakers for their children, which can limit their available time and energy for physical activity. The demands of parenting can make it challenging to create time for exercise, and finding childcare is often taxing and expensive. For example, a study by El Ansari and Lovell (2009) found strong relationships between participants and the number of children being a barrier to exercise. Their results found a positive association between participants' number of children and women's perceived exercise such that a higher number of children was associated with higher barrier intensity for PA, so women with more children were less likely to participate in exercise. (El Ansari & Lovell, 2009). This study suggests that caregiving responsibilities for women may be a strong barrier to regular PA. The menstrual cycle can affect energy levels, mood, and physical comfort, influencing a woman's motivation and ability to exercise. In addition, symptoms like cramps, fatigue, and mood swings can raise depression and anxiety during a women's luteal phase of menstrual cycle, making exercise less appealing, so they are less likely to participate in it (Prado et al., 2021). Women going through pregnancy may also experience fatigue and physical discomfort, which can deter them from exercising. Additionally, many women may not receive appropriate PA counseling/education, making them hesitant to exercise due to safety concerns for themselves and/or their babies (Badon et al., 2021).

These barriers can make exercising challenging, which is why so many don't. For this reason, it is important to understand barriers and facilitators to PA in women. Changing one's behavior is never easy; however, some models have been designed to provide a framework for understanding human behavior change and the different techniques to address it. The social-ecological model (SEM; see figure 1 below), for example, considers the multiple levels of

influence behavior. It emphasizes the complex relationship between individual, relationship, community, and societal factors in shaping behavior and health outcomes (Williams & Asare, 2022). It recognizes that human behavior is influenced by multiple levels of influence, including personal, such as knowledge and skills; interpersonal relationships like family and friends; community, as in schools and neighborhoods, and broader societal factors like policies and cultural norms.

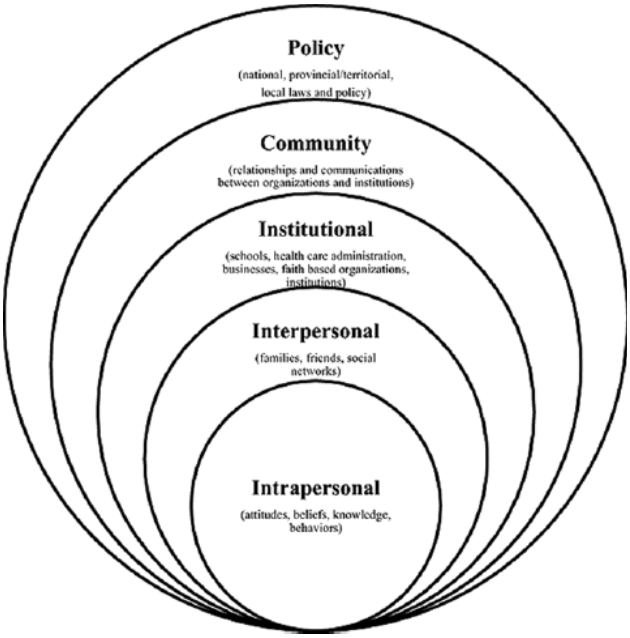

Figure 1. The Socio-ecological model (SEM). From "The socio-ecological model: A multifaced approach for I-O psychologists to design interventions targeted at reducing police violence," by M.S Williams & J. G. Asare, 2023, Industrial and Organizational Psychology, 15(4), (10.1017/iop.2022.81). Copyright 2023 by Cambridge University Press on behalf of the Society for Industrial and Organizational Psychology.

Another health behavior change model, the health belief model (HBM) model suggests that individuals' perceptions of the benefits and barriers to changing their behavior will influence their readiness for that change. A person's willingness to engage in health-promoting behavior is influenced by multiple perceptions. One is perceived severity, which is the belief regarding how

serious the health threat is and its potential consequences. Another is how susceptible one believes they are to developing a health issue. Another perception is the potential benefits that would come from taking action to reduce risk and improve health. An additional side would be the barriers that could occur when trying to change. Cue to action is another that suggests that the triggers that prompt individuals to engage in health-promoting behaviors, such as informational campaigns. One other perception is self-efficacy, which is one's confidence in one's ability to successfully perform the behavior needed to achieve the desired health outcome. According to a study by Shao et al (2018), to promote healthy lifestyles including PA, they introduced an educational program that covered type, duration, frequency, and intensity of exercise while also addressing the benefits and barriers to exercise. Their results showed significant improvements in the interventions groups beliefs in PA, demonstrating how HBM can be an effective model in promoting PA (Shao et al., 2018).

Another behavior change model is the transtheoretical model (TTM; see figure 2 below). This is one of the most applied theoretical bases for changing behaviors like smoking, alcohol abuse, school bullying, and physical activity behavior (Raihan & Cogburn, 2023). This model focuses on long-term behavior and goes into detail about the different steps that cause behavior to change. This model suggests that everyone is at a different stage in their readiness to change their behavior. The first stage is precontemplation. When one is in this stage, they have yet to realize they need to change their behavior or are aware but have no interest in doing so. The next stage is the contemplation stage, where the individual starts to think about changing their behavior. The next stage is when they start their plan to change, the preparation stage.

Next is action, when the individual activates their plan to change their behavior. The last stage is the maintenance stage. Maintaining the new behavior will be challenging and can often

be tempting to go back to the old one. Around 15% of people who relapse go back to the preconception stage, and 85% go back to the contemplation stage (Raihan & Cogburn, 2023). It is recommended that individuals be active in their maintenance for at least the first three to six months of this stage because of how tempting it is to relapse (Raihan & Cogburn, 2023). TTM has been shown to be beneficial to PA behavior. A study by Pirzaddeh et al. (2015) studied how the TTM can promote PA in women. Their results showed that TTM intervention resulted with a significant increase in PA 6 months after intervention (Pirzaddeh et al., 2015). This model also emphasizes the importance of self-efficacy (a key component of the TTM) to keep up with the behavior change, which is shown in the intervention group of the study as their self-efficacy increased over time, increasing their PA levels (Pirzaddeh et al., 2015).

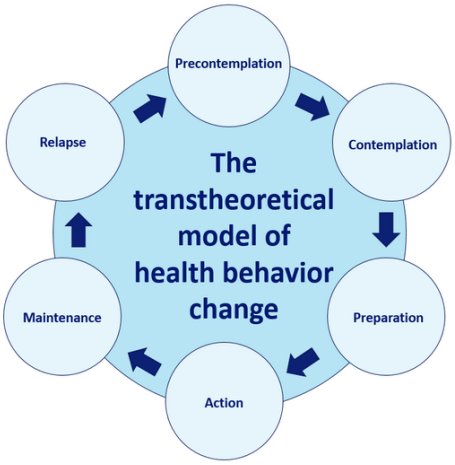

Figure 2. The Transtheoretical model (TTM). From "Stimulating the Uptake of Preconception Care by Women with a Vulnerable Health Status Through mHealth App–Based Nudging (Pregnant Faster): Cocreation Design and Protocol for a Cohort Study," by Smith, S. M., Bais, B., M'hamdi, H. I., Schermer, M. H. N., & Steegers-Theunissen, R. P. M., (2023), *JMIR Research Protocols, 12(1), (doi.org/10.2196/45293).* Copyright 2024 by PubMed Central.

Another health behavior change theory, Social Cognitive Theory (SCT) explains the importance of observational learning, imitation, and modeling in shaping behavior and personality, all of which are integral to the adoption and maintenance of physical activity behavior. Individuals learn not only through direct experiences but also by observing others and the consequences of their actions. Key concepts include self-efficacy and reciprocal determinism, highlighting the interplay between personal factors, environmental influences, and behavior. When exercising, the quality of motivation is related to fulfilling psychological needs for autonomy, pleasure, and relatedness (Rodrigues et al., 2023). When these factors are fulfilled, they develop a greater sense of autonomous motivation which is driven by intrinsic enjoyment and personal value (Rodrigues et al., 2023). This theory highlights the role of cognitive processes in understanding how social environments impact exercising behavior.

Many people avoid exercise because of how it makes them feel when performing it. This behavior can be explained by hedonic theory. The hedonic theory states that humans tend to seek out activities that are pleasurable and tend to avoid activities that are unpleasant or painful. Each person has a different preference for what they find pleasurable or painful. This theory can offer useful insights into why individuals may avoid being physically active. Rhodes and Kates (2015) found, through a systematic review, that individuals who experience positive affect during exercise are more likely to maintain higher levels of PA over time. To have a positive affect during exercise means to experience improved mood, increased energy, and/or a feeling of accomplishment. Rhodes and Kates' review highlights the importance of focusing on the affective response to exercise to promote long-term engagement in physical activity (Rhodes & Kates, 2015).

Regarding virtual reality applications for physical activity behavior, the Cognitive Affective Model of Immersive Learning (CAMIL) is a theoretical framework specifically designed to explore how immersive VR enhances learning. It considers cognitive and affective dimensions to explain how these factors interact in immersive learning environments (Makransky & Peterson, 2021). The CAMIL model suggests that immersive environments facilitate better information encoding and retrieval due to their interactive nature, which allows users to customize and explore content more actively (Makransky & Peterson, 2021). CAMIL also emphasizes users' emotional experiences during VR sessions which can significantly affect their motivation and engagement levels.

To promote cognitive and affective engagement, Makransky and Peterson suggest that it is important to ensure that users can actively engage with the environment, create realistic scenarios that will resonate with the users, provide immediate feedback to enhance learning and motivation, and ensure social elements are incorporated such as peer collaboration or interactions with virtual characters (Makransky & Peterson, 2021). In the context of VR exercise, cognitive engagement is facilitated through active participation, allowing users to interact with virtual environments and make decisions that will influence their VR experience. Affective factors are demonstrated by how VR environments are designed to create enjoyable and motivating experiences.

Considering the influence of affective responses to PA and long-term PA adoption, it would seem important to investigate PA modalities that promote positive affective responses. One method that may do this is exergaming. Exergaming is a PA mode that incorporates PA into the gameplay and serves as a promising alternative for those who may not like traditional exercise. This method plays into the Gamification theory, which is the idea that people will be

more likely to enjoy and retain information when it is shown in a game-like manner (Xu et al., 2021). Exergaming creates an immersive environment that motivates its users to move more. Games such as “Just Dance” or “Beat Saber” incorporate elements of competition and achievement, making exercise less of a chore and more fun.

There is also a wide demographic appeal to exergaming, as anyone from youth to older adults can participate. For the younger population, exergames can help with their motor skills, teamwork, and strategic thinking while also engaging in regular PA. For older adults, according to a systematic review by Street et al. (2017), exergaming seems to be an effective method of increasing PA. Specifically, they found that low participation in exergaming did not lead to many anthropometric changes. However, when participants regularly engaged in moderate to high amounts of exergaming, significant anthropometric changes were found such as weight loss, decreased BMI, and improved blood test results. Additionally, their results suggest that individuals need to participate in exergaming sessions at least three times a week for these positive results (Street et al., 2017).

Exergaming has been shown to positively impact PA. A pilot study was conducted that was aimed at sedentary female university students to increase their PA levels by using XBOX Kinect (Roopchand-Martin et al., 2015). The study found changes in physical fitness levels, with 96% having an increase in flexibility and body composition, with 46% of participants improving, and overall health, with 79% having an improved resting heart rate and 92% having improved maximal oxygen consumption. In addition, nine out of twenty-six participants continued the exercise program (Roopchand-Martin et al., 2015).

A popular platform for exergaming is virtual reality (VR), an immersive technology that creates a simulated environment that allows users to interact with digital 3D spaces. VR engages

multiple senses, often including sight and sound, and can even use haptic feedback to enhance the experience. Affordance theory connects different concepts in how they interact (Ji Hye et al., 2016). VR connects to the affordance theory as users can explore virtual worlds and participate in interactive experiences, all while having a sense of being in the environment. Affordance theory emphasizes how game design encourages specific action based on players' skills and the feedback they receive. Cognitive affordance theory is also applied to VR as it is the concept of how users learn and understand an interface. A device needs to be designed directly by considering human cognitive aspects so that they will be able to learn and operate it (Ji Hye et al., 2016). VR was created to be user-friendly and highly customizable to best fit the user so they can easily learn the device and have a desire to use it. Virtual Reality can be used in multiple fields, including education, gaming, training, and therapy, offering a unique way to experience content and interact with digital environments.

VR enhances exercise by transforming traditional workouts into immersive and engaging experiences. By using games for exercise, VR may increase enjoyment and motivation, which could potentially lead to increased exercise adherence. The interactive nature of VR exercise games creates a unique competitive environment which may entice individuals to work harder (Qian et al., 2020). Additionally, there is a wide variety of workouts available, from rhythm-based games to virtual fitness classes, these options keep users motivated to continue their fitness journeys. Many VR games will also provide real-time feedback on performance, which allows users to adjust their form and intensity. Many VR games also provide multiplayer features, which foster a sense of community and boost accountability and motivation. Virtual workouts can be tailored to various levels of fitness, which can be comforting for those who may feel intimidated by traditional gym settings. In a gym setting, individuals may worry about being

judged by others, either by how their body looks or by their inability to perform exercises correctly (Auster-Gussman et al., 2021). This is known as social physique anxiety, which is more common in women (Hagger & Stevenson, 2010). These reasons turn many away from the gym, which can increase the chance of not meeting activity time recommendations, increasing risk for sedentary behavior.

VR can be a method to reduce this anxiety. It can be used as part of exposure therapy, a common technique in treating anxiety disorders because individuals can confront anxiety-provoking stimuli in a safe environment (Donnelly et al., 2021). VR allows the customization of scenarios and provides controlled and repeatable experiences. This reduces individuals' anxieties because the individual will not need to interact with other people if they do not want to, they can stay in the comfort of their homes as well as not worry about being compared or comparing themselves at the gym.

If we follow hedonic theory, individuals will be more likely to engage in exercise if they find it enjoyable. A study by Mestre et al. (2011) explored how VR impacts exercise performance enjoyment and how it drew attention away from exercise on a stationary bike. Their goal was to see if VR enhanced the overall exercise experience compared to regular exercise methods, specifically biking. Their findings supported increased enjoyment and greater dissociation from exercising, making the exercise feel less strenuous (Mestre et al., 2011). They also found evidence that VR might improve performance metrics like distance and intensity. They concluded that VR can be a valuable tool for making exercise more engaging and enjoyable, which can lead individuals to a more active lifestyle (Mestre et al., 2011). Another study came to similar conclusions after comparing 15 articles that investigated the psychological effects of VR exercise (Qian et al., 2020). They mentioned that VR exercise has the potential to have a positive

effect on an individual's psychological, physiological, and rehabilitative outcomes compared to traditional exercise (Qian et al., 2020).

Virtual reality headsets are also convenient as they are small and easily portable. This device allows for home-based exercise, which may be particularly attractive to women who have caregiving responsibilities at home, for example. Because VR exercise sessions can accommodate busy schedules, this may also be appealing to women who may be juggling multiple home and work responsibilities.

Several types of exercise-based games can be played using a VR headset. "Beat Saber" is a popular VR-mediated exergame that requires players to move their bodies rhythmically to slash blocks. Because of the continuous movements performed throughout the game, Beat Saber has the potential to support participants in achieving moderate to vigorous PA intensities. This game also improves hand-eye coordination because of its fast-paced nature. This game is customizable, as the player has a variety of song choices, can choose difficulty, change colors, and change the game environment. A study conducted by Sousa et al. (2022) hypothesized that active virtual reality (AVR) would result in greater moderate-vigorous physical activity (MVPA), no matter the method of monitoring PA, while also having more cognitive benefits than either sedentary virtual reality (SVR) or the control group. To test this hypothesis, they tested active VR (AVR) in a sedentary college population and had them play "Beat Saber," an active, full-body movement game, and "Thumper," an inactive game in which the player only moves their fingers (Sousa et al., 2022). Their results found that heart rate went up significantly playing "Beat Saber" compared to "Thumper." "Beat Saber" also scored higher values of positive responses on the post-session questionnaire (Sousa et al., 2022). With "Beat Saber" being immersive, highly customizable, and fun, it can be an effective alternative option to traditional exercise.

“Supernatural” is another popular exergaming option because it provides a variety of workouts that cater to different fitness levels and goals. The visuals are set in astatically pleasing locations to enhance player experience, make the workouts more adventurous, and focus less on the exertion. “FitXR” is also popular, like “Supernatural,” as it offers a variety of workouts that require full-body engagement. This game encourages longer sessions and consistent exercise habits through the combination of music, movement, and competition.

The variety of fitness programs available through virtual reality caters to the individual to their different interests and fitness levels. From dance workouts to immersive games, the individual can choose the activities they enjoy. The gamification aspect of VR can boost motivation, track the user’s progress, earn rewards, or even allow for interactive competition with others. This interactive environment not only promotes physical fitness but also encourages a positive outlook toward exercise, making it a convenient and effective method for those looking to stay active without having to leave home.

There are multiple advantages to utilizing VR-based exercise programs over traditional exercise. A study comparing VR and non-VR exercise using a ski exergame found that VR significantly enhanced the range of motion of the ankle compared to non-VR exercise (Ko et al., 2020). Electroencephalography data from this study also showed that VR exercise promoted more favorable sensorimotor waves, which indicates improved concentration levels (Ko et al., 2020). These findings suggest that by utilizing VR exercise may not only improve physical capability, like increased joint movement, but can also have a positive effect on cognitive aspects like focus, which can make exercise more engaging and effective.

Immersion in VR creates a strong sense of presence in what participants are seeing, making it possible for users to feel that they are truly a part of the virtual environment. This increased

engagement enhances emotional connection and focus, allowing exploration of scenarios that may be dangerous in the real world or mirror the real world exactly (Piccione et al., 2019). Agency refers to the user's ability to make choices that influence the virtual environment (Piccione et al., 2019). This interactive quality encourages users to experiment freely with how they can personalize their experiences in ways that traditional environments cannot be manipulated.

Could VR exergames help reduce barriers to Regular Physical Activity?

One major influence on PA is having access to places to be physically active. This may be particularly impactful for individual in low-income and rural communities, where safe places for PA may be scarce (Kim et al., 2021). Because VR can be used anywhere and allows the user to feel like they are anywhere, VR-based programs have the potential to reach individuals in underserved areas.

Another factor that influences PA includes one's financial situation. Some may not be able to pay for gyms, recreational centers, or fitness classes. Virtual reality headsets are more cost-effective compared to traditional workout settings like the gym. The average VR headset can range from $300 to $1000, depending on the model and features. This is a high initial investment, but it is usually only a one-time payment. Gym memberships, on the other hand, will have monthly fees. These fees can range between $10 to $100 a month depending on location, company, and gym quality (Schwahn, 2023). A VR headset may cost more money upfront, but it will be more cost-effective in the long run. The VR headset can also be shared among multiple users, while a gym membership is only for that individual to use.

Finally social support influences PA engagement and lack of social support around PA may be a barrier. VR can address this issue as it can facilitate social interactions and community

building. It allows its users to connect with others, share experiences, and participate in group activities, which can enhance motivation. It also eliminates the feeling of intimidation one might feel in a traditional gym setting or the fear of working out alone.

Because VR-mediated exercise programs can be accessed even in the participant's home, it gives it an advantage over traditional exercise, which might require travel to a gym or other facility. The importance of this can perhaps be most strongly illustrated by the impacts of the COVID-19 pandemic on PA levels and associated health outcomes. In 2020, the world was essentially shut down due to a pandemic. During this time, stay-at-home orders prevented many individuals from accessing places to be physically active. Consequently, PA levels dropped significantly during the pandemic, and rates of chronic disease, including obesity and mental health problems, increased dramatically (Hanifah et al., 2021).

A study conducted by Hanifah et al. (2021) sought to increase sports engagement during the pandemic through VR gaming. They found through Pearson correlation that VR exercise games can have positive effects on influencing sports engagement and health among their participants (Hanifah et al., 2021). There were significant positive correlations between sports engagement and components of Short Form- 36 (SF-36), such as the Physical Component Study (PCS) and vitality, which suggests that higher engagement in VR sports is associated with better physical health and energy levels (Hanifah et al., 2021). This study demonstrates how, even when people can't leave their homes or cannot go to certain locations, VR may be an important option for maintaining PA levels and improving health.

To date, however, few studies have compared exergaming to traditional exercise, and even fewer have investigated this in women. Importantly, to our knowledge, to date, no studies have investigated these relationships in sedentary women, a population at higher risk for chronic

health problems related to physical inactivity. Moreover, considering the importance of positive affective responses to exercise-on-exercise adherence and the observations that exergaming appears to elicit positive affective responses, it is important to investigate whether differences exist in affective responses to exercise during exergaming vs. traditional exercise (such as a treadmill exercise). This study, therefore, aims to address these gaps by investigating differences in affective responses to exercise between a VR-mediated exergame bout and a traditional treadmill exercise bout in sedentary women.

Methods

Participants

Participants were recruited via campus surveys and word of mouth. The inclusion criteria were sedentary or lightly physically active women (completing less than 150 minutes of moderate physical activity/week) between the ages of 18 and 55. The exclusion criteria were women who regularly participated in $\geq$150 minutes of moderate PA/week. Additional exclusions included women who were pregnant or who had chronic health issues that would impact their ability to safely participation in exercise.

Study Design

Before entering the study, participants took an online screening survey to ensure they met the inclusion criteria. The survey assessed self-reported physical activity participation (weekly minutes of PA and intensity of PA), age, and medical contraindications to participating in moderate to vigorous intensity PA.

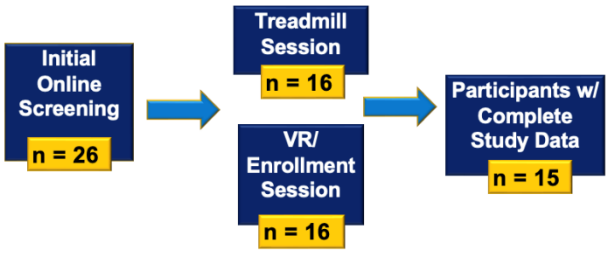

Figure 3. Flow of Participants Through the Study

If eligible for the study after the initial online screening, participants were invited to the Laboratory of Applied Physiology (LAP) on the NCWU campus for two study sessions: (1) a virtual reality exergaming session, and (2) a treadmill walking exercise. Flow of participants through the study is illustrated in figure 3. When the participant arrived at their first session, the virtual reality exercise, they first had to fill out a Physical Activity Questionnaire (PAR-Q+) to ensure it was safe for the participant to take part in this study. The PAR-Q+ is a widely-used self-report screening tool designed to assess an individual's readiness for engaging in physical activity (Thomas et al., 1992). The PAR-Q + includes questions about personal health and medical history, and is used to identify potential risks or limitations that might affect the safety of someone participating in physical activity. When deemed eligible, they then completed the Center for Epidemiological Studies-Depression Scale (CES-D); the Spielberger Trait Anxiety Scale (STAI, form Y1); the Pittsburgh Sleep Quality Index (PSQI); the International Physical Activity Questionnaire (IPAQ); the Perceived Stress Scale (PSS); the Self Efficacy for Exercise (SEE) scale. These questionnaires are in appendices A - I.

The CES-D is a self-reporting scale designed to measure depressive symptomatology in the general population (Vilagut et al., 2016). The STAI- trait form is used to measure trait anxiety. This is a 20-item scale with the score range between 20-80, with higher scores

indicating higher trait anxiety levels (Marteau & Bekker, 1992). The PSQI is a 19-item self-report to measure retrospective sleep quality and disturbances over the past month. PSQI scores ≥ 5 are indicative of poor sleep (Buysee et al., 1989). The IPAQ is physical activity recall instrument, which yields information about volume of physical activity, and sitting time, in the last week (Lee et al., 2011). The PSS is a 14-item that is used to assess perceived stress. It is a measure of the degree to which situations in one's life are appraised as stressful (Lee, 2012). Lastly, the SEE scale consists of nine situations that might affect participation in exercise. For each situation, the participant rated their confidence level on a scale from 10 (very confident) to 0 (not confident) on if they could exercise three times a week for 20 minutes at a time (Resnick & Jenkins, 2000).

After filling out the forms, their resting heart rate (RHR) and blood pressure (RBP) were taken using manual and automatic methods. For manual methods, heart rate was measured through placing two fingers on the radial artery, counted for 30 seconds, and then multiplied the result by 2 for resting heart rate. To find resting blood pressure, the participant was instructed to sit up with both their feet rested on the floor. The cuff was then wrapped around the arm, placed around heart level. A stethoscope was then placed on the brachial artery, below the cuff. The cuff is blown up to around 200 mm HG. The cuff pressure was slowly released to around 2-3 mm HG/sec and make note of the first Krotkov sound, indicating systolic blood pressure. Cuff pressure release was continued until the Krotkov sounds became muffled, then disappeared. This is the 5th Krotkov sound and indicates diastolic pressure. For the automated method, RHR and BP were recorded using the Omron HEM-907XL.

Next, their height (cm) and weight (kg) were taken. When measurements were complete, participants were then put on a polar heart monitor placed on the bottom of the sternum. This

monitor was wirelessly connected to a polar watch where heart rate was visibly displayed. Target heart rate (THR) zone was also calculated to know where their heart rate should be working at a moderate- vigorous intensity level. The formula used to calculate THR was ACSM's Target Heart Rate equation (THR = ((HRmax – HRrest) x % Intensity) + HRrest)). Percent intensity in this equation was assigned to be 50% of Heart Rate reserve (HRR), which equates to moderate intensity exercise (ACSM, 2022). Thus, every participant had a personalized THR.

Right before the sessions began they were instructed to take a State Trait Anxiety Inventory (STAI), state version form Y-1 (see appendix C), to measure how they were feeling in that exact moment. After that, they were taught how to use the VR device. They were then given the instructions for "Beat Saber" and completed a 3minute warm up using Beat Saber, which also served as their familiarization session for the task. Because the Beat Saber game stops briefly and restarts the level if the participants fails during the task, participants were instructed to walk in place when this happened, to prevent their heart rate from slowing during this minor break in activity.

The goal of the VR session was to get the participants to reach their target heart rate zone. They began with a 3-minute warm up to the song "Hundred-Dollar Bill" to get an idea how to play the game and increase their heart rate in the process. After completing the 3-minute warm-up, they went into a 10-minute exercise bout to the song "Heavyweight" and then "Power of the Saber Blade." When the exercise session was over, they were then instructed to complete the STAI, state version again and completed visual analog scales (VAS) to assess their affective responses during the VR session (see appendix J). They were also asked about their rate of perceived exertion (RPE) during the most physically challenging part of the exercise session, using the Borg Rate of Perceived Exertion scale (see appendix H). Their heart rate was

monitored and collected every 1 minute for 5 minutes total immediately post exercise. The session finished with a qualitative interview (see appendix I) to gain an understanding about how they felt about the session and their impressions of the VR device as an alternative exercise method.

The next session, on a later date, was the treadmill exercise session. When the participant arrived, they completed the STAI, state version, form Y-1. Then, their resting heart rate and blood pressure were taken. The participant then put on the polar heart rate monitor and watch to measure their heart rate during the exercise. Like the VR session, this session consisted of a 3-minute warm-up on the treadmill and then a 10-minute workout, keeping the participants in their target heart rate (THR) zone.

The treadmill was adjusted accordingly to get each one within their zone. For every 2 minutes on the treadmill their heart rate was taken to see if they were in the THR zone. If they weren't the treadmills speed or grade was increased based on participant preference. Once the participant reached their THR zone, the speed and grade was kept constant until the end of the 10-minute bout. Participants then completed a brief automated cool-down on the treadmill, before stopping completely.

When the treadmill exercise was completed, they filled out the STAI, state version (form Y-1), and affective response to exercise VAS scales, in the same manner as the VR exercise session. Additionally, like the VR session, their heart rate was monitored every minute for 5 minutes after the treadmill exercise. The session then finished with a qualitative interview (see appendix J) to gather more context about their attitude towards the treadmill exercise session, how they felt about the experience overall, and if they would recommend VR based exercise to a friend.

Data Reduction and Analysis

Questionnaire data was inputted into Microsoft Excel. Entered data was reviewed by two members of the research team to ensure accuracy and detect any data entry error. To maintain confidentiality on all the data, all participants were de-identified on hardcopy data and files were locked away in a cabinet, only to be accessed by members of the research team. All data was coded with a study subject number, so the study ID number linking identifying information was kept separate from any study data. Descriptive statistics (means, standard deviations, and proportions) were conducted for demographic and behavioral characteristics of the study population. Paired t-tests were used to test for differences in RPE, HR, affective responses to the exercise sessions (namely, concentration and effort during each task) between the VR and treadmill sessions. All p-values reported were 2-sided with an alpha level of 0.05. All statistical analyses were performed using SAS 9.4 (SAS Institute, Inc., Cary, North Carolina).

For the qualitative interview data, key words and phrases were taken from the VR and treadmill session that best summarized how most participants felt about each one. Advantages and disadvantages were also identified through common themes seen throughout the data. From this deduction, graphs were made to help the audience understand the difference between the participants perceptions of VR and the treadmill (See figure 8-11). This qualitative data was then compared to the quantitative data to identify if they were consistent to one another.

Results

Participant Characteristics

Participant characteristics are listed in table 1. This analysis includes 15 participants who had complete study data. The mean age of participants was 32.5 ± 12.3 years. Sixty percent of participants identified themselves as white, 33% identified as black, and 6.67% identified as

other. The level of education completed by the participants was a Bachelor's Degree (35.71%), some college (21.43%), Associate Degree (14.29%), Master's Degree (14.29%), High School Diploma (7.14%), and Doctorate Degree (7.14%). For marital status, 57.14% identified as single (never married). Others were married (28.57%), not married but living with partner (7.14%), Divorced (7.14%), and separated (7.14%). Their employment status at the time of the study included 9 employed full time (64.29%), 4 students (28.57%), and 1 unemployed (7.14%). Annual income ranged from under $10,000 annually to over $100,000 annually with 14.29% earned under $10,000, 7.14% earned between $15,000-$20,000, 21.43% earned between $35,000-$50,000, 28.43% earning between $50,000-$75,000 yearly, 7.14% earned over $100,000 annually, and 21.43% did not disclose.

The mean BMI of the participants was 31.4 ± 9.1 kg/m^2. At enrollment, participants completed a mean of 40 ± 70.1 minutes of moderate to vigorous physical activity (MVPA) per week. 71.43% of participants reported no previous VR experience while 28.57% reported that they had previous experience using VR. Only 1 participant from the study owned a VR headset at the time the study took place.

Table 1. Participant Characteristics

Participants, n	15
Age, years (mean ± SD)	32.5 ± 12.3
Race	
White, n (%)	9 (60%)
African American, n (%)	5 (33.33%)
Other, n (%)	1 (6.67%)
Education Level	
High School Diploma, n (%)	1 (7.14%)
Some College, n (%)	3 (21.43%)
Associate's degree, n (%)	2 (14.9%)
Bachelor's Degree, n (%)	5 (35.71%)
Master's Degree, n (%)	2 (14.29%)
Doctorate Degree, n (%)	1 (7.14%)
Marital Status	
Married	4 (28.57%)
Not Married	11 (71.43%)
Employment	
Employed Full Time, n (%)	9 (64.29%)
Unemployed, n (%)	1 (7.14%)
Student, n (%)	4 (28.57%)
Income	
Under $50,000/year	6 (42.86%)
Between $50,000-$100,000/year	4 (28.57%)
Over $100,000/year	1 (7.14%)
Did Not Disclose	3 (21.43%)
MVPA min/week (mean ± SD)	40 ± 70.1
VR Experience	
Yes, n (%)	4 (28.57%)
No, n (%)	10 (71.43%)
Own VR Headset	
Yes, n (%)	1 (7.14%)
No, n (%)	13 (92.86%)
BMI ($kg \cdot m^{-2}$) (mean ±SD)	31.4 ± 9.1

MVPA = moderate to vigorous physical activity; VR = Virtual Reality; BMI = Body Mass Index

Main Analyses

Although the average heart rate (HR) did not differ significantly between the two exercise sessions (t =0.04, p = 0.97; see figure 4), a significant difference was observed in the maximum Rating of Perceived Exertion (RPE; t = -2.48, p = 0.03; see Figure 5). Specifically, participants reported a lower maximum RPE during the VR session (11.1 ± 2) compared to the treadmill session (13 ± 2.2). In addition, participants indicated significantly higher levels of concentration (t = -2.18, p = 0.05; see Figure 6) and effort (t = -3.39, p = 0.004; see Figure 7) during the VR session relative to the treadmill exercise.

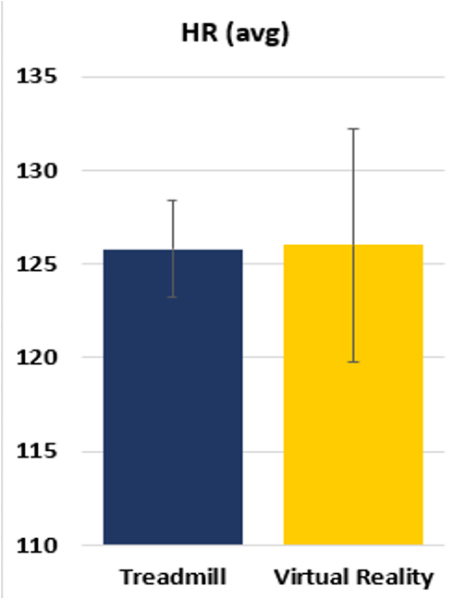

Figure 4. Average Heart Rate. (p = 0.97)

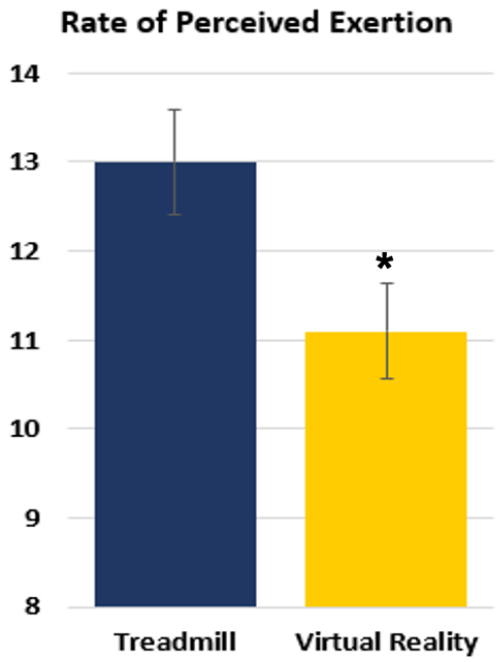

Figure 5. Max RPE. *Significant difference ($p \leq 0.05$)

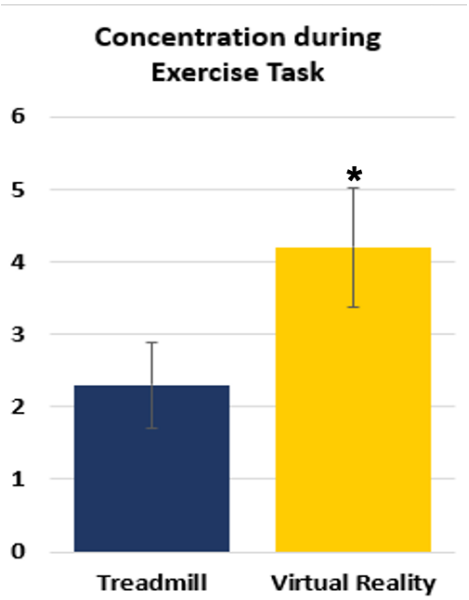

Figure 6. Average Concentration During Exercise Task. *Significant difference ($p \leq 0.05$)

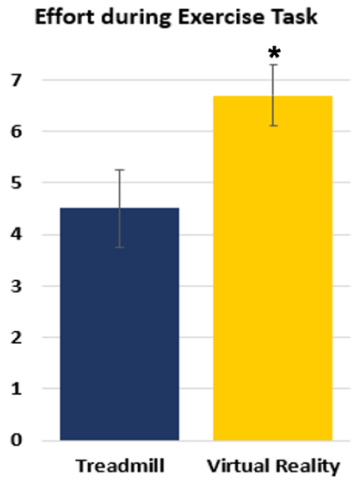

Figure 7. Average Effort During Exercise Task. *Significant difference ($p \leq 0.05$)

As shown in figures 8-11 participants described VR as fun, motivating, and less intimidating. One shared, “It didn’t even feel like a workout – it was just fun, and I loved the visuals and music!” The treadmill felt familiar but less engaging. “The treadmill just felt boring after trying the VR,” noted one participant, while another found it clears their mind. Barriers to VR included safety, space, and access. “I couldn’t see my surroundings – I kept worrying I’d knock something over.” These insights suggest that VR physical activity has the potential be more engaging and enjoyable compared to traditional exercise like the treadmill. These also highlight the tradeoffs between the engaging potential of VR and the practical considerations of its use.

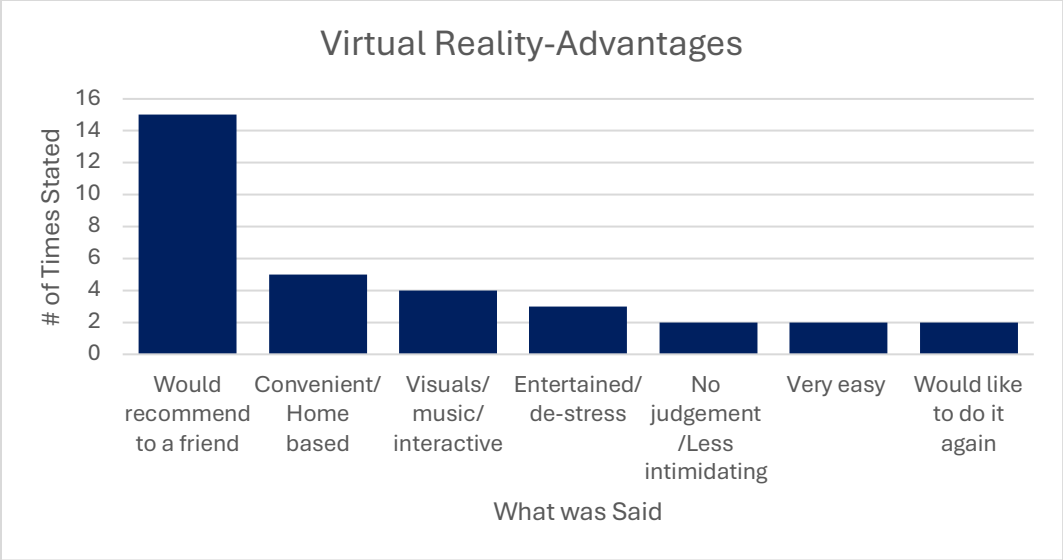

Figure 8. Graph of Virtual Reality Advantages, as Reported in the Qualitative Interview

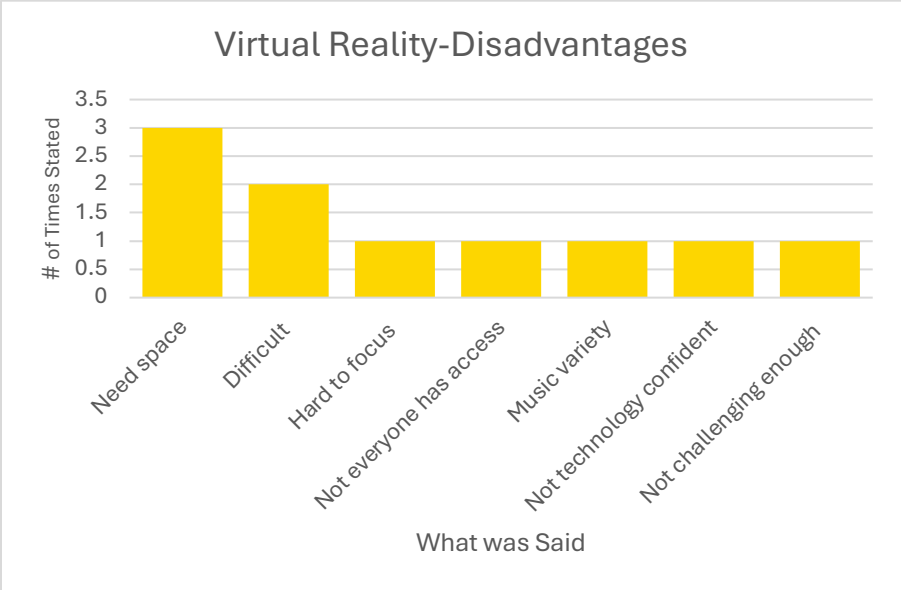

Figure 9. Graph of Virtual Reality Disadvantages, as Reported in the Qualitative Interview

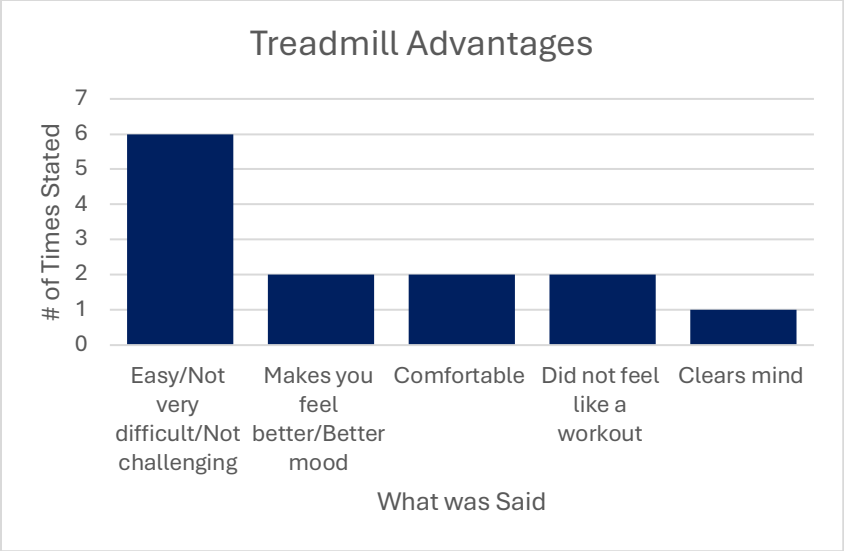

Figure 10. Graph of Treadmill Advantages, as Reported in the Qualitative Interview

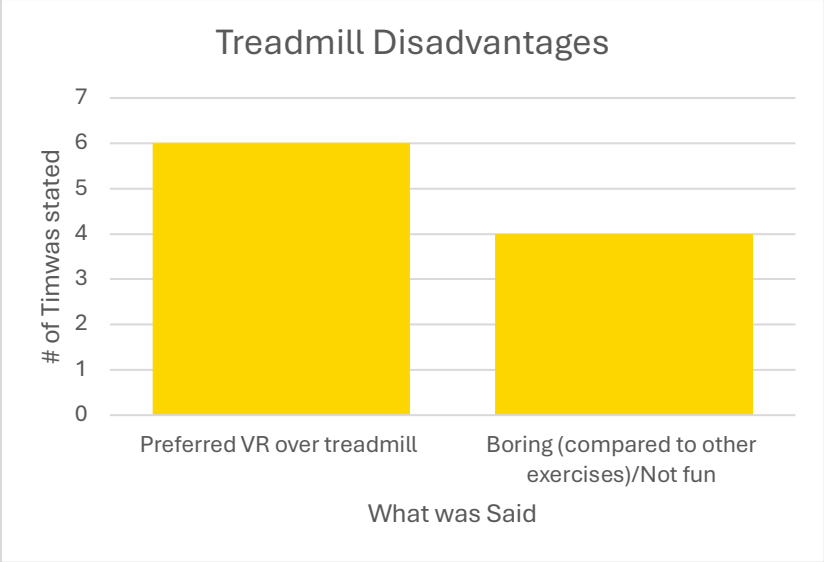

Figure 11. Graph of Treadmill Disadvantages, as Reported in the Qualitative Interview

Discussion

The results of this study provide valuable insights into the comparative experiences of participants when comparing VRs (nontraditional exercise) effectiveness and enjoyably to the treadmill (traditional exercise). Despite no significant differences in the average heart rate

between the two exercise sessions ($t = 0.04$, $p = 0.97$), several other factors, such as perceived exertion, concentration, and effort showed notable differences.

One of the key findings to this study was the significantly lower maximum rating of RPE reported during the VR exercise (11.1 ± 2) compared to the treadmill session (13 ± 2.2). This difference in RPE suggests that participants perceived the VR exercise to be less demanding, despite engaging in similar levels of intensity during the two different exercise bouts. It is possible that the immersive nature of VR can distract from or reduce the subjective perception of effort, which makes the exercise feel less strenuous.

This hypothesis is supported by previous research which suggests that interactive video games result in a reduction of negative emotional states linked to high-intensity exercise, offering a valuable alternative to traditional exercise to fulfill physical activity recommendations (Monedero et al., 2015). Since there is reduced emotional states during high-intensity exercise, the exercise itself is seen as easier and can make it so the participant can last longer compared to traditional exercise. A study conducted by Barwood et al. (2009), looked at the difference between music and video intervention in running. Their results found that the intervention group had similar RPEs to the control group, but the intervention group ran a further distance (Barwood et al., 2009). These results indicate that the intervention can enhance high-intensity tolerance, enabling the participant to endure non-traditional/intervention exercises for a longer period before their RPE aligns with that of traditional exercises.

In addition to lower RPE, participants reported significantly higher levels of concentration during the VR session. This finding suggests that the VR environment may require participants to maintain more cognitive focus during the exercise, possibly due to the interactive or visually immersive elements of the VR experience, which might explain, in part, the perception of lower

exertion during the VR bout. It is possible that participants might be more engaged in the virtual environment, distracting from the physical demands of the exercise itself.

Furthermore, participants indicated significantly higher levels of effort during the VR session), which might indicate higher mental effort during the task. previous research has also suggested that external distractions can help reduce mental strain during high-intensity exercise as it can alter attentional focus, arousal, and self-efficacy (Barwood et al., 2009). It is possible that the increased effort experienced in VR could be linked to the greater cognitive and sensory engagement to navigate the virtual environment. Although the subjective effort was higher, this does not necessarily translate to greater physical exertion, as noted by the lack of significant difference in heart rate between the two sessions. Participants reporting greater work effort, concentration, and RPE, but having similar HR to the treadmill session suggests engagement during the VR session.

Previous studies have also found similar outcomes as a study conducted by Bird et al. (2021), explored different audio-visual stimuli and how it affects exercise perception during cycling. Their results found that VR enhanced pleasure and activation the most, followed by music intervention, then the control condition which had the least positive effects (Bird et al., 2021). These findings highlight VR's ability to improve exercise enjoyment and affective responses and corresponds with our findings.

One limitation of this study was the participants' anticipation and excitement toward use the VR device, which could have influenced their perception of the activity. Given the VR technology can be unique and engaging, participants might have perceived it as more enjoyable than it truly was, influencing their responses. Additionally, the study had a relatively small sample size, with only 15 participants with complete data. This limited number of participants

may not accurately represent the broader population. Another limitation is the order in which the sessions were conducted. Since participants did the VR session first, they may have found it more engaging, their perception if the subsequent treadmill session may have been negatively influenced by comparison, making it seem less enjoyable. This sequencing effect could have introduced bias, as the treadmill session was found to be more boring according to the qualitative analysis.

However, to our knowledge, this is the first study to compare affective and RPE responses between Exergaming and traditional treadmill walking in sedentary women. These findings are important for the design of future exercise programs and suggest that VR could serve as a valuable tool for enhancing exercise experiences. VR has the potential to transform exercise experiences, offering fun, engaging alternative for those who struggle with motivation, experience boredom during tractional workouts, or face environmental or time constraints. However, further research is needed to examine the long-term effects of VR-based exercise, to help determine whether participates will continue to engage with VR exercise or eventually view it as a chore once the novelty of the device wares off.

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Appendix A: Physical Activity Readiness Questionnaire (PAR-Q Plus)

2021 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** _____	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Global Physical Activity Guidelines for your age (https://www.who.int/publications/i/item/9789240015128).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

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FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	YES ☐ NO ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	YES ☐ NO ☐

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	YES ☐ NO ☐
2b.	Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	YES ☐ NO ☐

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm

If the above condition(s) is/are present, answer questions 3a-3d If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	YES ☐ NO ☐
3c.	Do you have chronic heart failure?	YES ☐ NO ☐
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	YES ☐ NO ☐

4. Do you currently have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b If **NO** ☐ go to question 5

4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	YES ☐ NO ☐

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes

If the above condition(s) is/are present, answer questions 5a-5e If **NO** ☐ go to question 6

5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?	YES ☐ NO ☐
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	YES ☐ NO ☐
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?	YES ☐ NO ☐
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	YES ☐ NO ☐
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	YES ☐ NO ☐

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6. **Do you have any Mental Health Problems or Learning Difficulties?** This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome

If the above condition(s) is/are present, answer questions 6a-6b If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Do you have Down Syndrome **AND** back problems affecting nerves or muscles?	YES ☐ NO ☐

7. **Do you have a Respiratory Disease?** *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐

8. **Do you have a Spinal Cord Injury?** *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐

9. **Have you had a Stroke?** *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c If **NO** ☐ go to question 10

9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
9b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐

10. **Do you have any other medical condition not listed above or do you have two or more medical conditions?**

If you have other medical conditions, answer questions 10a-10c If **NO** ☐ read the Page 4 recommendations

10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
10c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: _____

_____

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

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If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

Citation for PAR-Q+
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01-11-2020

Appendix B: Center for Epidemiologic Studies Depression Scale (CESD)

VRPA Study

Enrollment Visit Study ID _____

Center for Epidemiologic Studies Depression Scale (CESD)

Below is a list of the ways you might have felt or behaved. Please tell me how often you have felt this way during the past week.

1 = Rarely or None of the Time (Less than 1 Day)
2 = Some or a Little of the Time (1-2 Days)
3 = Occasionally or a Moderate Amount of Time (3-4 Days)
4 = Most or All of the Time (5-7 Days)

During the past week:

	Rarely or none of the time (less than 1 day)	**Some or a little of the time** (1-2 days)	**Occasionally or a moderate amount of time** (3-4 days)	**Most or all of the time** (5-7 days)
1. I was bothered by things that usually don't bother me.	□	□	□	□
2. I did not feel like eating; my appetite was poor.	□	□	□	□
3. I felt that I could not shake off the blues even with help from my family or friends.	□	□	□	□
4. I felt that I was just as good as other people.	□	□	□	□
5. I had trouble keeping my mind on what I was doing.	□	□	□	□
6. I felt depressed.	□	□	□	□
7. I felt that everything I did was an effort.	□	□	□	□
8. I felt hopeful about the future.	□	□	□	□
9. I thought my life had been a failure.	□	□	□	□
10. I felt fearful.	□	□	□	□
11. My sleep was restless.	□	□	□	□
12. I was happy.	□	□	□	□
13. I talked less than usual.	□	□	□	□
14. I felt lonely.	□	□	□	□
15. People were unfriendly.	□	□	□	□
16. I enjoyed life.	□	□	□	□
17. I had crying spells.	□	□	□	□
18. I felt sad.	□	□	□	□
19. I felt that people dislike me.	□	□	□	□
20. I could not get "going".	□	□	□	□

Appendix C: Self-Evaluation Questionnaire (STAI Form Y-1)

VRPA

ID:_____ Date:_____ VR Exercise Session

SELF-EVALUATION QUESTIONNAIRE
STAI Form Y-1

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

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STAIP-AD Test Form Y
www.mindgarden.com

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Appendix D: Pittsburgh Sleep Quality Index (PSQI)

VRPA Study

ID:	Date: Time:	Enrollment Visit

Pittsburgh Sleep Quality Index

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

During the past month:

1. During the past month, what time have you usually gone to bed at night? Bed time:_____ ☐am ☐pm

2. During the past month, how long (in minutes) has it taken you to fall asleep each night? _____minutes

3. During the past month, what time have you usually gotten up in the morning? _____ ☐am ☐ pm

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.) _____hours

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
Cannot get to sleep within 30 minutes	☐	☐	☐	☐
Wake up in the middle of the night or early morning	☐	☐	☐	☐
Have to get up to use the bathroom	☐	☐	☐	☐
Cannot breathe comfortably	☐	☐	☐	☐
Cough or snore loudly	☐	☐	☐	☐
Feel too cold	☐	☐	☐	☐
Feel too hot	☐	☐	☐	☐
Have had bad dreams	☐	☐	☐	☐
Have pain	☐	☐	☐	☐
Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s): _____	☐	☐	☐	☐
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	☐	☐	☐	☐
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	☐	☐	☐	☐
	No problem at all (0)	Only a very slight problem (1)	Somewhat of a problem (2)	A very big problem (3)
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?	☐	☐	☐	☐
	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)
9. During the past month, how would you rate your sleep quality overall?	☐	☐	☐	☐

Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR and Kupfer DJ (1989). "The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research." Psychiatry Res 28(2): 193-213.

Appendix E: International Physical Activity Questionnaire (IPAQ)

VRPA Study

IPAQ, short Study ID:_____ Enrollment Visit Date:_____

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

IPAQ, short Study ID:_____ Enrollment Visit Date:_____

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Appendix F: Perceived Stress Scale (PSS)

VRPA

Study_ID:	Date: Time:	Enrollment Visit

Perceived Stress Scale (PSS)

For each of the following questions, we would like to know about how often you have felt or thought a certain way in the **past month**. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather circle the answer that best represents the closest estimate of how you have felt in the **past month**.

	NEVER	ALMOST NEVER	SOMETIMES	FAIRLY OFTEN	VERY OFTEN
1. How often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2. How often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3. How often have you felt nervous and "stressed"?	0	1	2	3	4
4. How often have you dealt successfully with irritating life hassles?	0	1	2	3	4
5. How often have you felt that you were effectively coping with important changes that were occurring in your life?	0	1	2	3	4
6. How often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
7. How often have you felt that things were going your way?	0	1	2	3	4
8. How often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
9. How often have you been able to control irritations in your life?	0	1	2	3	4
10. How often have you felt that you were on top of things?	0	1	2	3	4
11. How often have you been angered because of things that happened that were outside of your control?	0	1	2	3	4
12. How often have you found yourself thinking about things that you have to accomplish?	0	1	2	3	4
13. How often have you been able to control the way you spend your time?	0	1	2	3	4
14. How often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Appendix G: Self Efficacy for Exercise (SEE) Scale

Self-efficacy For Exercise (SEE) Scale

How confident are you right now that you could exercise three times per week for 20 minutes if:

	Not Confident										**Very Confident**
1. The weather was bothering you	0	1	2	3	4	5	6	7	8	9	10
2. You were bored by the program or activity	0	1	2	3	4	5	6	7	8	9	10
3. You felt pain when exercising	0	1	2	3	4	5	6	7	8	9	10
4. You had to exercise alone	0	1	2	3	4	5	6	7	8	9	10
5. You did not enjoy it	0	1	2	3	4	5	6	7	8	9	10
6. You were too busy with other activities	0	1	2	3	4	5	6	7	8	9	10
7. You felt tired	0	1	2	3	4	5	6	7	8	9	10
8. You felt stressed	0	1	2	3	4	5	6	7	8	9	10
9. You felt depressed	0	1	2	3	4	5	6	7	8	9	10

Appendix H: Borg Rate of Perceived Exertion scale

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Appendix I: Qualitative Interview

Participant ID:_____

VR SESSION Brief Questions (2)

1. What was this exercise experience like for you?

2. Describe your impressions of using the virtual reality device.
PROMPT what did you most enjoy?
PROMPT what did you least enjoy?

Participant ID:_____

TREADMILL SESSION Brief Questions (3)

1. What was this exercise experience like for you?

2. What would you like to share about this experience overall?

3. Would you recommend virtual-reality-based exercise to a friend? Why/Why not?

Appendix J: Visual Analog Scales (VAS)

VRPA Study: VR Exercise Session

ID:

Exercise Session Assessment Scale

1. Using the scales below, mark the box below the number which describes your experience during the **exercise bout** that you just completed.

Not Difficult	0	1	2	3	4	5	6	7	8	9	10	Very Difficult

Not Anxious	0	1	2	3	4	5	6	7	8	9	10	Very Anxious

Able to Concentrate	0	1	2	3	4	5	6	7	8	9	10	Not Able to Concentrate

2. Using the scales below, mark the box below the number which describes how much effort you put into the **exercise bout** task that you just completed.

Very Low Effort	0	1	2	3	4	5	6	7	8	9	10	Very High Effort

3. Using the scales below, mark the box below the number which describes how you felt emotionally during the **exercise bout** task that you just completed.

Not at all sad/down	0	1	2	3	4	5	6	7	8	9	10	Extremely sad/down

Not at all worried/nervous	0	1	2	3	4	5	6	7	8	9	10	Extremely worried/nervous

Not at all overwhelmed	0	1	2	3	4	5	6	7	8	9	10	Extremely overwhelmed