

# Leveraging Virtual Reality and Exergames to Promote Physical Activity

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**Abstract.** This work introduces a Virtual Reality Exergame application to promote physical activity. With obesity on the rise, it is more important than ever to encourage and motivate people to be active. Exercise helps with the expenditure of energy via body movements, which is key to living a healthy life. However, exercise by itself is not an engaging activity for most people. The objective of the exergame introduced in this work is to encourage users to perform full-body movements to pass through a series of obstacles and achieve higher scores, unlock content, and complete a series of achievements. The application implements a variety of game elements to help motivate users to play the game and perform physical activity. Each of the game elements can be toggled on or off depending on whether the player feels they are benefitting or hindering the experience. This feature allows users to customize the application. Moreover, this exergame application leverages Virtual Reality and Depth-sensor technology to help provide users with an immersive first-person experience. While in the game, users can visualize their motions. This is because the users can control their virtual avatar with their body movements with the use of the depth-sensor. It is expected that this immersivity will motivate and encourage the users even more. The objective of this work is to introduce this Virtual Reality Exergame application as well as the hardware and software development aspects of it.

**Keywords:** Virtual Reality, Exergame, Physical Activity, Obesity

## 1 Introduction

Obesity within the United States and the world is on the rise. Obesity is defined as abnormal or excessive fat accumulation that may impair health [1]. Within the United States, 42.4% of adults are obese as well as 13% of the world adult population [1,2]. This is an important issue as obesity and being overweight can lead to major health issues including heart disease, stroke, type 2 diabetes, and some types of cancer [2]. Each of these are detrimental to a person's health and can lead to premature death.

One method for the prevention of obesity is regular physical activity and healthier eating habits [1]. Obesity is caused when a person consumes more calories than they burn or use up. This causes an imbalance in the energy that is stored in fat and the

energy that is used to perform physical activity. When somebody exercises they can burn those stored calories from the food that was eaten. However, one limitation to the exercise method is individual motivation to exercise. Even in those who are obese, some might not feel motivated enough to exercise and improve their condition [3]. One potential solution would be to promote physical activities through Exergames.

Exergames are active video games that can help in promoting exercise for users. These exercise games are beneficial for adapting sedentary games into ones that can make the user physically active [4]. Exergames can also help make standard physical activity more fun and enjoyable. One study examined that exergames, compared to traditional machine exercise, promoted better self-efficacy, positive engagement, enjoyment, stress management, and reduction in depressive symptoms [5]. Unfortunately, most existing exergames lack immersivity and engagement to motivate the user to continue using the application and exercising [6]. Leveraging Virtual Reality (VR) and body tracking technology could help improve the engagement and immersive factor of exergames that would then promote healthy exercising habits.

VR provides a first-person experience for the user and immerses them within the game world. Two key elements, interactivity and telepresence, contribute to immersion within VR. The immersion created from these two VR elements contributes to the satisfaction of the user when playing the VR exergame [7]. The satisfaction from the immersion in turn creates enjoyment for the user when playing the exergame. Studies comparing VR headsets to traditional screens have determined that VR is more beneficial for immersivity and motivation of exercising [8]. The motivation and enjoyment of the user from the exergame are demonstrated through these studies [7,8]. However, many of the existing exergame studies do not leverage VR technologies and focus on basic exercise or rehabilitation. Standard exergames also lack the immersivity that VR can provide for motivation. VR could play an important role in helping promote exercise through exergames to burn extra calories.

This study presents an application that leverages VR, Exergames, Depth-sensor technology, and full-body movement for the promotion of physical activities. Each of these elements will be presented through the developed exergame as a means for the promotion of exercise and engaging activities. The application presented also has the potential for more adaptations and changes to allow for more user engagement and increase self-willingness to play the exergame, thus exercising. The engagement through this exergame and its attributes could help motivate people to participate in daily exercise and move their whole body, thus helping prevent obesity through physical activity.

## 2 Literature Review

Participating in physical activity and regulating the consumption of unhealthy foods are the two basic ways of preventing obesity or overweight [1]. WHO promotes ways to prevent obesity at the individual level; limiting energy intake from fats and sugars, eating more fruits and vegetables, and engaging in regular physical activity. These methods rely on the individual to be proactive in exercising. In a survey about obesity prevention, 26% of the participants cited motivation as a blocking attribute to starting

regular physical activity [9]. Many participants stated that they need to find “the right ways to do it [exercise]” or thinking that they just do not need to. Machines at the gym might also not be suitable for obese people and thus making it less effective [10]. One way to motivate individuals to perform physical activities could be through the use of exergames and Virtual Reality.

## 2.1 Exergames

Exergames are an alternative to traditional exercise; they allow the user to perform the exercise while also engaging with a video game. Through this method, those that may not normally perform typical exercise can be motivated through exergames. These can come in the form of specialized gym equipment or a home-based commercial video game [11,12]. One of the most popular Nintendo Switch™ titles is an exergame; Ring Fit Adventure™ is rank 12 in Switch sales at 5.84 million units sold [13].

Many of the exergame studies related to obesity focus on the effectiveness of exergames on children or young adults [14–16]. Two of these studies focused on the use of commercial exergames in children's exercise and if it provided any significant difference in obesity levels compared to regular exercise. One study reported that after 24 weeks of exergaming utilizing the Microsoft Kinect, participants recorded a reduced BMI z-score, systolic and diastolic blood pressure, cholesterol levels, and moderate to vigorous physical activity levels [14]. Another study reported that after 6 weeks of exergaming, the participants reported a better waist to hip ratio as well as resting heart rate [15].

Exergames utilize different game design elements to promote users to perform physical activities through enjoyment and engagement. However, studies have shown that individuals' preferences for game elements differ [17]. Thus, different elements might provide different individual results depending on individual characteristics, like player type or game element preferences [18]. The complexity of the physical tasks itself has also been shown to influence user performance; the more complex the task is, the more motivated the individual needs to be in order to perform it [19].

There is a potential that exergames might not motivate its users, given individual differences and task complexity. For example, one study examining older adults' response to a full-body motion exergame demonstrated negative effects on engagement [20]. It was not obvious for participants the direction they should move in order to move the in-game avatar when played on a flat-screen TV. Participants also reported a disconnect with the avatar, stating that the avatar did not move with their body. Utilizing leveraging VR and Depth-sensor technology, exergames could overcome issues of lack of engagement and immersivity to provide a more motivating and enjoyable experience.

## 2.2 Virtual Reality and Exergames

Virtual Reality could benefit exergames by improving user's motivation for exercise as well as their heart rate when completing VR exergame-induced exercise [8,21]. One study examining different exercises through exergames observed an increase in heart

rate while playing the immersive VR version of the game compared to a regular screen. A volleyball full-body exergame increased the user's average heart rate by 3 beats-per-minute (bpm) more than the flat-screen version of the same exergame. When comparing the volleyball full-body exergame versus an archery game that only works the upper body, users experience an increase of 10 bpm on their average heart rate [21]. This increase in heart rate could have come from the participant utilizing their whole body while immersed within the game world. Participants stated that it felt like the VR exergame was better at immersion and visualization of motion when completing tasks. Another study focusing on a running exergame came to the same conclusion that utilizing VR in exergames can benefit a user's exercising experience [8]. These studies demonstrate how VR could be used for exercise promotion, however, it is not necessarily beneficial for those with obesity. An exergame based around running might be beneficial for exercise purposes, but the participant might not be able to complete the tasks asked by the exergame due to being obese or overweight. An exergame that takes the condition of the user in mind would be ideal for obesity prevention.

Observing the benefits that exergames and VR could bring to obesity prevention, this work presents a VR exergame that could be utilized as a method of physical activity. An immersive VR exergame could benefit the user in engagement and motivation to continue utilizing the exergame for extended use. An exergame that could be used at various difficulties and promotes physical activity, however, utilizes full-body exercise could be beneficial for the prevention of obesity.

### **3 Application**

#### **3.1 Gameplay**

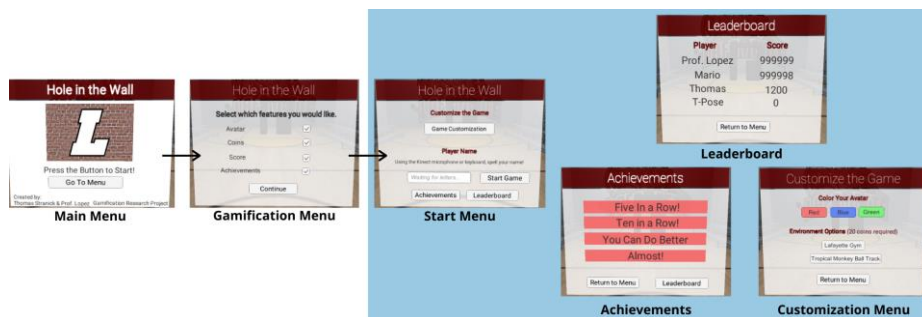
The focus of the gameplay is to encourage exercise through full-body movements. The VR aspect introduced through the headset allows for greater immersivity and engagement with the user and could help motivate players to exercise. Users must stretch and move to pass a series of 14 obstacles that come towards them. These obstacles are made in different shapes and orientations such that the player is required to maneuver their body to fit the shape. Figure 1 demonstrates some of these diverse shapes and a player crouching through a low wall. The player is scored based on how much of their player avatar interacts with the walls as they pass the user. If the player does not hit any of the walls they score higher points compared to the one who hit the wall. This scoring method encourages the player to continue playing to achieve a higher score. The Unity3D game engine ([www.unity3d.com](http://www.unity3d.com)) was utilized to create the VR exergame and integrate the hardware components (see section 3.2).

The use of the depth sensor technology allowed for a more immersive "pressing" of the menu buttons. This removed the need for any external controllers which could break the immersion. Unity's voice recognition package was also utilized to alleviate the need for a keyboard when entering the user's player name.



**Figure 1.** Example Obstacles

Many elements of the exergame are gamified such as the coin collection system, the achievement system, and the leaderboard. These elements could benefit the user in the promotion of physical activity [22]. The coin collection system allows the user to pick up coins while moving through the obstacles utilizing the collision boxes. These coins are placed where the player needs to reach or stretch their hand to reach them. Having the user move more when playing the game adds an element of challenge as well as encourages more exercising to be done while playing. The coins also can unlock a new tropical map when enough are collected, giving the player something to work towards. Achievements are given to the player when they meet a certain requirement while playing the exergame. Player competition may also contribute to a user's experience, the leaderboard allows scores to be recorded and matched against set values or previous players. Each of these menus can be seen in Figure 2, this indicates how one would navigate to each of these menus as well.



**Figure 2.** Menu Navigation

### 3.2 Hardware

To provide a full-body immersive VR experience, the Microsoft Kinect™ and the Oculus Rift™ were chosen. The hardware could be integrated with the game through the Unity game engine where specific features of the game could be tailored for each of these devices. The Microsoft Kinect™ was used to track user motion and translate it to the in-game avatar. This allows the in-game avatar to mimic the user's body motion and encourage exercise through the full-body motion that comes with dodging the obstacles.

The immersion aspect of the VR exergame could be brought by the Oculus Rift™ headset. This immersion brought about by the VR headset and Kinect is shown in Figure 3. When the user moves their arms, they can watch the in-game avatar's arms move in the same way. The user's vision is strategically placed within the avatar's head to make the in-game avatar feel like the player's own body. Each of these hardware combinations helps bring about the immersion and feeling of presence within the game. This immersion provides engagement and thus user satisfaction, encouraging the user to proactively engage in physical activities [8,21]. Figure 3 also shows the relations between the hardware, software, and user immersion. The Kinect allows for full-body motion to be translated into the game world. The Oculus Rift brings the user into the game world through an immersive lens. To combine the two, Unity can provide the full exergame VR full-body experience that the user can utilize to prevent obesity and practice healthy physical activity habits.



**Figure 3.** Interconnection of hardware, software, and immersion

## 4 Conclusion

Future work regarding the exergame would look at the comparison of the added immersivity that VR could bring to a non-VR version of the same exergame. The game could also be tuned more towards obesity prevention if it is found that some obstacles are not exercised or obesity friendly. Lastly, one limitation of utilizing the VR headset comes from a smaller field of view. Although VR presents a first-person view, the field of view can take away from that immersivity. Future work could look at mitigating this issue and designing the game to accommodate the lack of peripheral vision.

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