The Effects of Immersion in a Virtual Reality Game: Presence and Physical Activity

Shengjie Yao and Gyoung Kim(✉)

Media, Interface, and Network Design (M.I.N.D) Lab,
Syracuse University, Syracuse, USA
{syao06, gmkim}@syr.edu

Abstract. This study explored the effects of immersion in virtual reality games on physical exercise performance. Traditional exercising was compared with a VR exercising set up. In the experiment, subjects were asked to play a cycling game with a stationary bike on different immersion levels. The non-VR group played the game with traditional PC set-up on a flat screen while VR-group played the game in a full VR setting using the Head-Mounted Display. The input remained the same to eliminate other possible effects on the result. The travel distance within the game was recorded and analyzed. The results showed that subjects within the VR set up showed a longer travel distance as well as a higher level of presence and psychological arousal. That is to say, this study provided the evidence of VR exercising games can increase user's physical exercising performance.

Keywords: Health · Exercise · Virtual reality · Biking · VR workout · VR bike

1 Introduction

Lacking physical exercises have become one leading factors of people's healthy nowadays. According to World Health Organization, insufficient physical activity is one of the leading factors that can cause death. [1] On the other hand, people are spending more time on video games. The idea of "combining entertainment with exercise" has become more and more popular. [2]

Various computer games have been used as a tool to conduct physical exercises. Rivaling traditional exercising, the fundamental assumption generated by these exergames is that the game engages users to interact with the game content while doing the exercise at the same time. During game play, the sense of doing tiring exercise reduces thus making doing exercises a joyful activity. A lack of enjoyment is known as the biggest enemy to physical exercises. Researches have shown that such exergames are capable of making the physical activities more enjoyable, therefore, increase their effectiveness and sustainability. [3]

VR exercising games, in particular, have the ability to embody a user into the actual game play itself. From previous studies [4–6], VR exercising games are thought to be

X. Fang (Ed.): HCII 2019, LNCS 11595, pp. 234–242, 2019.
https://doi.org/10.1007/978-3-030-22602-2_18

more effective in increasing user's motivation and exercising performance. Many scholars found [7, 8] that the degree of immersion could affect the level of psychological processes of accepting VR as the real world.

For those reasons, this paper aimed to explore the possible influence of VR exercise games inducing user's exercise motivation and physical performance. We hypothesized that the immersive virtual environment could induce a higher level of presence(immersion) at user's perspective, so users can more focus on the situation of exercising in the game

1.1 VR Exercising Games

Typical VR exercising games (VR health games) aimed to replicate a traditional sport or physical exercise using the motion sensor inside a virtual reality system. In other words, body movement of the user acts as an input device of the game. Take Vir-zoom, a VR biking game, as an example. The user controlled their game behavior via a stationary bike designed specifically for the game. The leg's cycling movements controls the moving forward in the game while the body leaning left or right (captured by the motion sensor) is used as the turning mechanism within the game. By replacing controller with body movements, the user is expected to gain physical exercise benefits while playing the game. While current VR exercising games cannot reproduce the same level of physical movement as traditional physical exercising, the benefits of them are to provide interactive media content. These interactive media content engage users' activity and involvement thus turn into better physical exercise outcomes.

The interactive media content as well as the realistic replication of these exergames are likely to increase immersion of users. Studies have found that immersive game content can increase user's enjoyment of the exercising experience. [9] As enjoyment is a critical factor in increasing physical exercising outcomes, the VR exercising games seems to be promising in future exercising environments.

2 Immersion in the Virtual Environment

Immersion is a psychological feeling of being inside the virtual environment [10]. Conceptualized as a mental state of being involved in the game, immersion is also a multifaceted concept involving media (medium), users and contexts. [11–13] Users feel immersed with VR content based on themselves and social contexts as well as the hardware contributed to this experience. That is to say, the level of immersion heavily depends on the capability of the hardware. The more capable the hardware is to replicate the real world, the more possible that the users feel immersed within the virtual environment.

Within the realm of VR exercising games, a more immersive experience would therefore require better suited hardware. Take stationary bike as an example, an HMD VR set up is thought to be more immersive than a traditional 2D set up as they provide wider range of sensory channel even though the users work on the same stationary bike. The underlying reason is that the VR HMD provided a wider field-of-view than a traditional 2D set up therefore a user's immersion of vision is greater influenced.

With that being discussed, with other elements of the exercising controlled, the VR set up is capable of delivering more immersive experience.

As an ongoing procedure, an immersive experience can be judged by its level of immersion. [14] Higher level of immersion therefore affect the experience in ways such as user's presence, arousal and other related elements. Studies have also shown that higher level of immersion can have a positive effect on the enjoyment of the whole experience in exercising which is proven to be an essential factor in the outcomes of physical exercises. [3] At this point, it can be predicted that higher level of immersion may have positive effect on physical exercise outcomes.

2.1 Presence: Are You Really There?

Presence and immersion are closely related to one another. Some scholars treat presence and immersion as a synonymous concept [15] which indicates that adding presence to the concept of immersion is only a confusion. Yet, Immersion can also be treated as a synchronicity of media, user, and contexts where presence is only a human consciousness of being there. Based on Slater and Wilbur's study [16], presence is a function of user psychology of recognizing being inside a virtual setting while immersion as the quality of this experience.

To form presence, scholars treat it as a two-step process [17] of perceiving this virtual environment as a plausible space via spatial cues than experience his or herself inside this space [18]. As defined in Wirth et al.'s study [17], presence is "a binary experience, during which perceived self-location and, in most cases, perceived action possibilities are connected to a mediated spatial environment, and mental capacities are bound by the mediated environment instead of reality". Therefore, the presence level indicates a person's perception of this virtual environment as an actual space and his ability to act in this process.

In Bailey et al's [19] study, researchers observed the level of presence to reflect the immersion level. A sense of "being there" in the VR realm indicates a user's sense of their body being inside the virtual environment instead of the physical environment. [13] The presence level is a sign of immersion. With higher level of immersion, a higher level of presence may be observed.

Hereby, we hypothesize that:

H1. Higher level of immersion of a VR exercise game will increase the user's sense of presence in the exercise environment.

2.2 Arousal

Arousal is a psychological and physiological state which are affected by the individual's level of attention and readiness for physical response [20]. That is to say, if an individual focused his or her attention on the content, the likelihood that this individual has a higher level of arousal is expected. While exercising naturally affect user's arousal by forcing individuals to focus on the physical activity, there are possibilities to increase user's arousal level by making them more focused on the exercising activity. As suggested by other scholars, the realism generated by video games (such as graphics and sounds) gets user's attention thus make users more focused on the content.

VR exergames replicates real-world physical activity and add interactive contents which draw user's attention. Studies have proven positive linkages between immersion and attention to the content. Therefore, higher level of immersion (which can be observed by measuring people's level of presence) may have a positive effect on user's attention then increase user's level of arousal.

As VR exercising games increase user's presence and generate a much more realistic environment than a traditional set up, a higher level of user arousal is expected in VR exercising games.

Therefore, we hypothesize that:

H2. VR exercising games will increase user's arousal level than traditional 2D set up.

H3. User's presence level in VR exercising games will increase user's arousal level in a VR exercising set up.

2.3 Physical Exercising

Whether user enjoyed doing physical exercising as well as whether they pay attention to the training process can have a huge impact on the final outcome of the exercising. As discussed above, VR exergames provides a higher level of immersion therefore increases user's presence and arousal.

Physical exercising outcomes can be affected by the media platform and content. It is highly anticipated that a better physical exercising performance is affected by the level of immersion in a Virtual Reality game. By reproducing physical activity using sensors and other visual cues, the actual exercising performance generated by the user might increase.

Therefore, we hypothesize that:

H4. User's exercising performance will increase in high immersive virtual reality exercising game. (Fig. 1.)

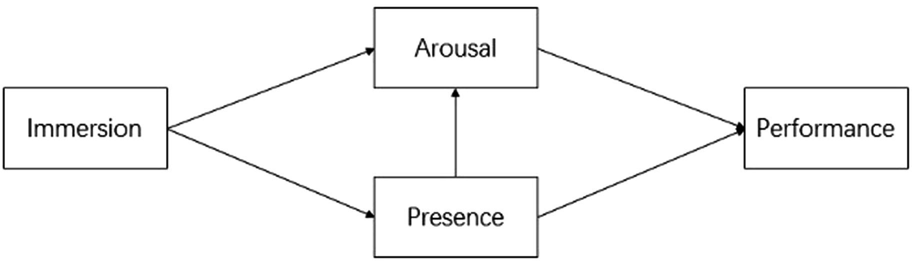

Fig. 1. Research model of the study

3 Method

A between-subject experiment design was used to test our hypotheses: whether the different levels of immersion (standard 2D set up or VR set up) affect people's exercise performance. The Subjects were divided into two groups with different level of immersion, non-VR exercising group (with 2D flat screen), and VR exercising group (wearing a Head-Mounted Display). Both groups played the same VR biking game (VIR zoom) under different experimental settings yet on the same stationary bike which is used in VIR zoom game. The non-VR group played the game with traditional PC set-up on a flat screen while VR-group played the game in a full VR setting using the VR Head-mounted display (Vive) developed by HTC. The input remained the same to eliminate other possible effects on the result.

3.1 Apparatus

Two level of immersion was operationalized using two set up: a virtual reality set up using HTC VIVE representing high level of immersion and a flat screen set up representing low levels of immersion. The head-mounted display system requires less than 10 ft from the sensor to recognize user's movement. As this study require a certain amount of workout, a cycling game developed by VIR zoom was used. The input was the same on both set up. The cycling system is capable of adapting to both conditions as well.

3.2 Measurements

Presence. Presence was measured using the ITC-SOPI questionnaire [21]. A total number of 12 items was measured including factors of "Sense of Physical Space," "Engagement," and "Ecological Validity." The subjects rated their level of agreement on a ten-point scale from 1 (strongly disagree) to 10 (strongly agree). Example items include: "I had a sense of being in the scenes displayed," "I felt that the characters and/or objects could almost touch me," and "I felt I was visiting the places in the displayed environment."

Arousal. Arousal was measured using the Perceived Arousal Scale [22] which contains 24 items such as "Active," "Energetic," "Exhausted," and "Inactive." Subjects rated their level of agreement on a ten-point scale from 1 (strongly disagree) to 10 (strongly agree).

Physical Exercise Performance. Physical Exercise Performance was measured by distance of travel.

Travel distance. Travel distance in the game was also recorded using the include display within the game. The result was recorded after each section of the game in kilometers.

3.3 Procedure

Subjects were randomly divided into two groups. Each subject was asked to finish a demographic questionnaire regarding their age, gender and race. Each subject was then asked to play the same stage of VR cycling game VIR zoom for 10 min. After 10 min, the travel distance of each subject within the game was recorded. After the cycling section of the experiment, subjects were asked to complete a questionnaire assessing their level of presence and arousal within the game.

4 Results

4.1 Subjects

A total of 32 subjects participated in the experiment. They were randomly assigned to the VR (n = 16) and non-VR (n = 16) groups. Mean age of the subjects was 22.3125 (SD = 1.99).

4.2 Hypothesis Testing

Hypothesis 1 predicted that the level of immersion would increase user's feeling of presence. To test H1, the presence level within the VR group was compared to the ones within the non-VR group. The presence level of users in a VR set-up (7.63) was higher than a non-VR set up (7.49).H1 was supported.

Hypothesis 2 predicted that the level of immersion would increase user's feeling of arousal. To test H2, the arousal level within the VR group was compared to the ones within the non-VR group. The arousal level of users in a VR set-up (6.00) was higher than a non-VR set up (5.70). H2 was supported.

Hypothesis 3 predicted that the higher level of presence would indicate higher level of arousal. To test H3, a Pearson's R correlation was calculated between the user's arousal level and the user's presence level within the VR group. There was a positive correlation between user's arousal level and user's presence level ($r = .522$, $p < .05$). The higher user fell presence in a VR exercising game, the higher arousal level they might have playing VR exergames. H3 was supported.

Physical exercise performance is measured using travel distance within the game. To test H4, the mean of the travel distance within the VR group was compared to the mean of the travel distance within the non-VR group. The travel distance within the VR

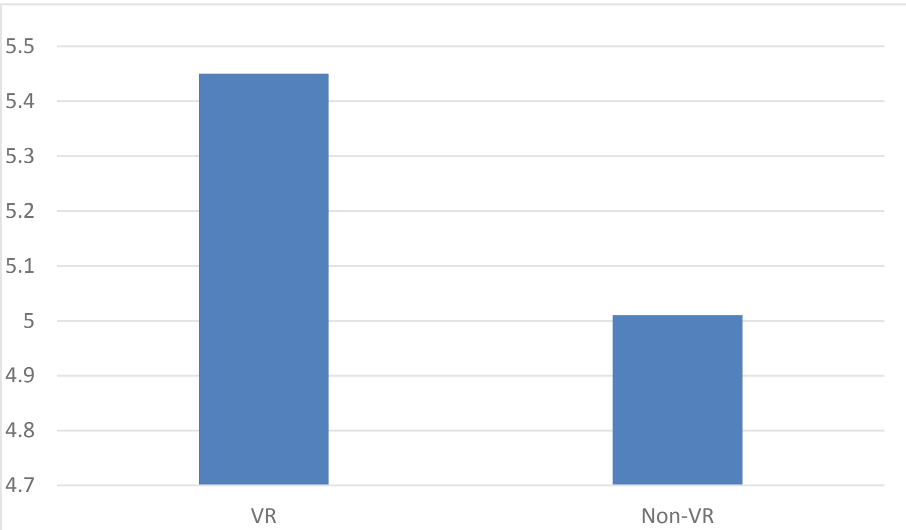

Fig. 2. Travel distance difference between two groups

group (5.45) is significantly higher than the travel distance within the non-VR group (5.01). (Fig. 2.) H4 was supported.

5 Discussion

The results showed that subjects reported a higher presence level when playing the biking simulation game in a virtual reality environment. This result confirmed that the virtual environment did generate a higher level of presence and immersion when users are playing exergames. When users are playing exergames, the possibilities are, they think of themselves as in the real exercising situation rather than a computer-generated game. While this study did not test whether other factors within the virtual reality games have impact on user's presence, it is quite clear that the presence and immersion level are higher within the VR exergames.

A higher level of arousal was found in subjects within the VR exercising group. This indicates the possible linkage between higher level of immersion with higher level of arousal. With higher level of arousal, users may have higher level of attention and readiness to the activity. As discussed in previous sections, higher level of arousal may have a positive linkage with the physical exercising outcomes. Since this study measured arousal using self-reported data, whether biological arousal can also be observed is not known at the current stage of the study. This may be confirmed in a future study.

Longer travel distance was also found in VR settings as one of the indicators of higher exercise performance. While there are individual differences between subjects in their actual exercise capability, the result is promising as more subjects within the VR group has a longer travel distance than those who are in the non-VR group. The longer distance travelled within the game indicates a higher motivation level to do exercises. The longer distance traveled, the possible better physical exercise outcomes can be.

6 Conclusion

The current study provided the evidence of virtual reality's ability to increase user's exercise performance. As a tool, virtual reality is capable of delivering interactive and immersive exercising game experience. The more immersive the experience is to the user, the better outcome the users can get from the whole process. Current study is not sufficient in backing up virtual reality as an effective exercising tool. Limitations include possible flaw in self-reported data as well as insufficient sample size. However, the trends of virtual reality increasing exercising performance is significant based on the current data.

More application of virtual reality in gamifying physical exercises is foreseen as it provides a higher exercise performance within the same level of time. A future study will include physiological measurements to have more accurate physical activity data.

Acknowledgments. This research was supported by Media, Interface, and Network Design (M.I.N.D.) Lab at Syracuse University. We are thankful to Dr. Frank Biocca, Director of the lab, for his comments on an earlier version of the manuscript, although any errors are our own and should not tarnish the reputation of his esteemed professional.

References

1. World Health Organization. (2015). Physical activity (Face sheet no. 385). http://www.who.int/mediacentre/factsheets/fs385/en/
2. Peng, W., Lin, J.H., Pfeiffer, K.A., Winn, B.: Need satisfaction supportive game features as motivational determinants: an experimental study of a self-determination theory guided exergame. Media Psychol. **15**, 175–196 (2012). https://doi.org/10.1080/012.673850
3. Warburton, D.E.: The health benefits of active gaming: separating the myths from the virtual reality. Curr. Cardiovasc. Risk Rep. **7**, 251–255 (2013). https://doi.org/10.1007/s12170-013-0322-0
4. Zeng, N., Pope, Z., Gao, Z.: Acute effect of virtual reality exercise bike games on college students' physiological and psychological outcomes. Cyberpsych. Beh. Soc. Netw. **20**(7), 453–457 (2017). https://doi-org.libezproxy2.syr.edu/10.1089/cyber.2017.0042
5. Mestre, D.R., Ewald, M., Maiano, C.: Virtual reality and exercise: behavioral and psychological effects of visual feedback. Annu. Rev. CyberTherapy Telemed. **9**, 99–103 (2011)
6. Kim, G., Biocca, F.: Immersion in virtual reality can increase exercise motivation and physical performance. In: Chen, J.Y.C., Fragomeni, G. (eds.) Virtual, Augmented and Mixed Reality: Applications in Health, Cultural Heritage, and Industry, vol. 10910, pp. 94–102. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-91584-5_8
7. Pausch, R., Proffitt, D., Williams, G.: Quantifying immersion in virtual reality. In: Proceedings of the 24th Annual Conference on Computer Graphics and Interactive Techniques (SIGGRAPH 1997). ACM Press/Addison-Wesley Publishing Co., New York, NY, pp. 13–18 (1997). https://doi.org/10.1145/258734.258744
8. Bowman, D.A., McMahan, R.P.: Virtual reality: how much immersion is enough? Computer **40**(7), 36–43 (2007). https://doi.org/10.1109/mc.2007.257
9. Slater, M., Wilbur, S.: A framework for immersive virtual environments (FIVE): speculations on the role of presence in virtual environments. Presence: Teleoperators Virtual Environ. **6**(6), 603–616 (1997)
10. Oh, S.Y., Bailenson, J.N., Welch, G.F.: A systematic review of social presence: definition, antecedents, and implications. Front. Robot. AI **5**(14), 1–34 (2018). https://doi.org/10.3389/frobt.2018.00114
11. Hou, J., Nam, Y., Peng, W., et al.: Effects of screen size, viewing angle, and players' immersion tendencies on game experience. Comput. Hum. Behav. **28**, 617–623 (2012)
12. Shin, D.: Do users experience real sociability through Social TV? J. Broadcast. Electron. Media **60**(1), 140–159 (2016)
13. Shin, D., Biocca, F.: Exploring immersive experience in journalism. New Media Soc. **20**(8), 2800–2823 (2018). https://doi.org/10.1177/1461444817733133
14. Mcmahan, A.: Immersion, engagement and presence: a method for analyzing 3-D video games. In: Wolf, M., Perron, B. (eds.) The Video Game Theory Reader, pp. 67–86. Routledge, New York (2003). Chapter on issues of presence and engagement in virtual reality environments and computer games for anthology

15. Slater, M., Wilbur, S.: A framework for immersive virtual environments (FIVE) speculations on the role of presence in virtual environments. Presence: Teleoperators Virtual Environ. **6**(6), 603–616 (1997). https://doi.org/10.1162/pres.1997.6.6.603
16. Wirth, W., et al.: A process model of the formation of spatial presence experiences. Media Psychol. **9**, 493–525 (2007). https://doi.org/10.1080/15213260701283079
17. Cummings, James J., Bailenson, Jeremy N.: How immersive is enough? a meta-analysis of the effect of immersive technology on user presence. Media Psychol. **19**(2), 272–309 (2016). https://doi.org/10.1080/15213269.2015.1015740
18. Bailey, J., Bailenson, J.N., Won, A.S., Flora, J., Armel, K.C.: Presence and memory: immersive virtual reality effects on cued recall. In: Proceedings of the International Society for Presence Research Annual Conference, October 24–26, Philadelphia, Pennsylvania, USA (2012)
19. Sallnäs, E.-L., Rassmus-Gröhn, K., Sjöström, C.: Supporting presence in collaborative environments by haptic force feedback. ACM Trans. Comput. Interact. **7**, 461–476 (2000). https://doi.org/10.1145/365058.365086
20. Barlett, C.P., Rodeheffer, C.: Effects of realism on extended violent and nonviolent video game play on aggressive thoughts, feelings, and physiological arousal. Aggress. Behav. **35**, 213–224 (2009). https://doi.org/10.1002/ab.20279
21. Lessiter, J., Freeman, J., Keogh, E., Davidoff, J.: A cross-media presence questionnaire: the ITC-sense of presence inventory. Presence Teleoper. Virtual Environ. **10**, 282–297 (2001). https://doi.org/10.1162/105474601300343612
22. Anderson, C., Deuser, W.E., DeNeve, K.M.: Hot temperatures, hostile affect, hostile cognition, and arousal: tests of a general model of affective aggression. Pers. Soc. Psychol. Bull. **21**, 434–448 (1995). Perceived Arousal Scale