

Investigation of the effect of virtual reality on postural stability in healthy adults

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ABSTRACT

Previous research has shown that individuals behave differently in certain virtual reality tasks. The effect of VR on human posture and stability is an important factor that can influence the future applications of VR devices. This current study seeks to investigate how a person's postural stability differs between VR and normal environment while attempting to replicate the influence of target distance on sway. Ten healthy subjects were tested in both environments with targets varying in distance. The results found a significant difference in postural stability for normal anatomical stance tasks between VR and normal environments.

Keywords: Virtual Reality, Postural Stability, Center of Pressure (CoP)

Index Terms:

Human-centered computing—Human-computer interaction—HCI design and evaluation methods—Laboratory experiments

1 INTRODUCTION

While often overlooked posture is of paramount importance in everyday behaviors. When a person's stability is compromised, they are at a heightened risk of falling. A person's stability can be compromised in several ways, such as a person's supporting surface, aging, or the demands of a task. Focusing on the latter, it has been shown that when a person views a nearby object, they have less postural sway compared to when an object is placed further away [1]. Postural stability can be evaluated using the degree of motion of one's center of pressure (CoP) during the normal stance. Postural stability boundary is a well-defined method to quantify the CoP movement during the stability tasks. [5]

Through the advent of virtual reality (VR), it has been demonstrated that these devices serve purposes that extend beyond entertainment. For instance, VR devices have been used as a way to augment physical rehabilitation [4]. However, it is unclear if a person's behavior in certain VR settings is akin to their real-world behavior. Studies examining perceptual judgments have shown that individuals tend to underestimate distances in VR compared to the real-world [2]. With authors suggesting that this may be attributed to a person's sense of presence in these settings [3].

Therefore, it is essential to understand how a person's behavior differs in VR compared to a real-world setting. By having a robust understanding of these differences, health care practitioners and researchers will have a better grasp on expectations. Thus, the objective of this project was to compare the influence of viewing distance in VR and the real-world on postural stability.

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2 METHODS

2.1 Participants

Ten healthy participants (Mean age of 28.2 (SD: 3.59), Male:8) were recruited for this study. The experiment protocol was approved by the Institutional Research Board (IRB) of the University. All the subjects signed a consent form before participating in the study.

2.2 Procedure

The procedure required the subject to stand on a force platform (AMTI OR6 Platform) and maintain a standard anatomical position while gazing at a target positioned at three different distances (50cm, 100cm, and 300cm). During anatomical position, the subject's body is upright, directly facing forward with their feet opened to the shoulder width and were flat and parallel. The upper limbs are positioned on the side of the body with palm facing forward. The experiment consisted of two sections: the VR environment and the non-VR environment (NVR). The VR environment was presented using an HMD device (*HTC Vive*). The VR environment and target were designed to replicate the NVR environment and target (See Figure 1). The VR environment was designed using Unity. For each

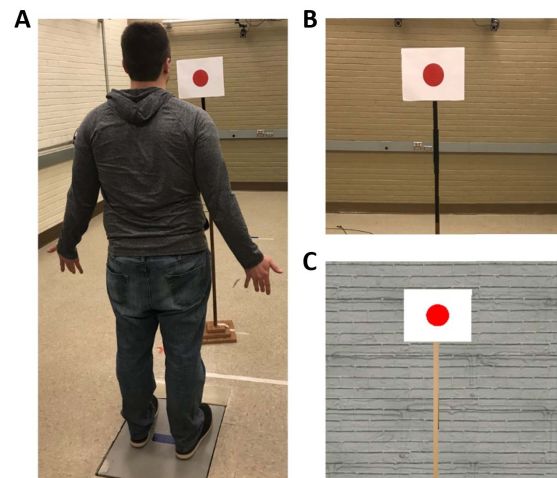


Figure 1: A. Experimental Setup for NVR Portion B. NVR Target C. VR Target

section, subjects were asked to stand still for 20 seconds and focus their gaze on the target's red circle for all three distances. The task was repeated three times for each distance. The order of the sections and distances were randomized for all participants (See Figure 2). In order to evaluate the effect of VR on functional postural stability, immediately before and after using HMD participants were asked to sway in anterior/posterior and medial/lateral direction while maintaining their balance on the force platform.

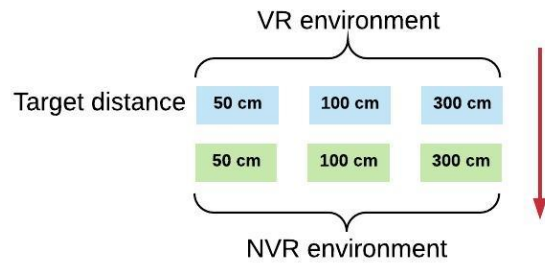


Figure 2: A flow-chart showing the sequence of conditions.

2.3 Data analysis

The position of CoP in each trial was recorded using the force platform with a sampling frequency of 241.45 Hz. The CoP position was then used to calculate the postural stability boundary. Postural stability boundary is defined as the best fitting ellipse to the 90% of the maximum CoP position in each direction of anterior/posterior and medial/lateral. In this paper, the area of the best fitting ellipse is calculated which is defined as the sway area for each trial. The total distance of the trajectory CoP followed would be defined as the sway length.

3 RESULTS

Wilcoxon Signed Rank Test was conducted to examine the difference in the functional sway area on two task conditions - before and after VR. There was no significant difference ($V = 10, p = 0.08398$). Same phenomenon was observed for the sway length. (See Figure 3).

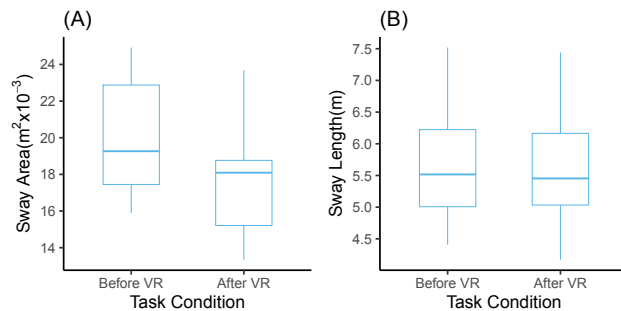


Figure 3: Functional Sway measures of before and after VR: A. Sway Area B. Sway Length

There were significant differences both in the sway area and the sway length by the task condition. 2-Way Repeated Measure ANOVA revealed that the task condition was a significant factor for the sway area ($F_{1,9} = 31, p < 0.001$, See Figure 4A) and the sway length ($F_{1,9} = 33.89, p < 0.001$). Neither the interaction between the task condition and the target distance nor the target distance alone was significant. Nevertheless, for the sway area measure, sphericity assumption was violated for the target distance, indicating significant individual variability present in the response to the targets of distinct displacement (See Figure 4B). Appropriate correction (Greenhouse-Geisser) was applied.

4 DISCUSSION

This current study found a non-significant effect of the influence of an HMD on functional sway. Nonetheless, a significant difference was observed for the sway area for VR and NVR conditions. These

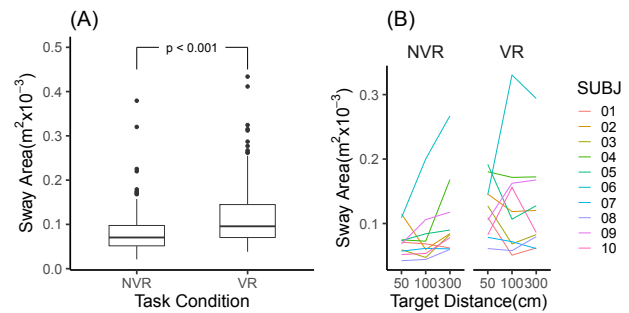


Figure 4: Observation of different behaviors in VR: A Sway area by the task condition B Individual variability for the target distance

results together provide an insight to the after-effects of using VR. While individuals may behave differently with the HMD on, the lasting effect of VR experience might be ephemeral. Furthermore, observing a significant individual variability in the response to different target directions while experiencing VR leads the researchers to ask what individual characteristics may be generating this result. The results of the sway area between VR and NVR coincide with those of Bles et al. [1]. For future studies, more variation in the target and distance, as well as more complex postural stability assessment methods, is required to further investigate the difference between VR and NVR environments.

5 CONCLUSION

This study aimed to investigate the influence of VR on postural stability. The results from this study show that for the normal anatomical stance condition, there is a significant difference between VR and NVR environment. This result may provide researchers and clinicians with insight that can be used to design more sophisticated VR rehabilitation applications. Also, future research is needed to understand more complex biomechanical tasks such as gait or range of motion analysis before a definitive conclusion can be reached.

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