

## ORIGINAL ARTICLE

## IJPHY POSTURAL CONTROL IN HEALTHY YOUNG ADULTS WITH AND WITHOUT CHRONIC MOTION SENSITIVITY

<sup>1</sup>Ayahya D<sup>\*2</sup>Johnson EG<sup>3</sup>Daher NS<sup>1</sup>Gaikwad SB<sup>1</sup>Deshpande S

## ABSTRACT

**Background:** Postural control requires complex processing of peripheral sensory inputs from the visual, somatosensory and vestibular systems. Motion sensitivity and decreased postural control are influenced by visual-vestibular conflicts. The purpose of this study was to measure the difference between the postural control of healthy adults with and without history of sub-clinical chronic motion sensitivity using a computerized dynamic posturography in a virtual reality environment. Sub-clinical chronic motion sensitivity was operationally defined as a history of avoiding activities causing dizziness, nausea, imbalance, and/or blurred vision without having a related medical diagnosis.

**Methods:** Twenty healthy adults between 22 and 33 years of age participated in the study. Eleven subjects had sub-clinical chronic motion sensitivity and 9 subjects did not. Postural control was measured in both groups using the Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR). The CDP-IVR reports an over-all equilibrium score based on subjects' center of gravity displacement and postural sway while immersed in a virtual reality environment. Subjects were tested on stable (condition 1) and unstable (condition 2) platform conditions.

**Results:** There was no significant difference between the two groups in terms of mean age, height, weight, body mass index in kg/m<sup>2</sup>, postural control scores for conditions 2, and average ( $p>0.05$ ). However, significant differences were observed in mean postural control for condition 1 between groups ( $p=0.03$ ).

**Conclusions:** Results of this study suggest that healthy young adults without chronic sub-clinical motion sensitivity have better postural control than those with chronic sub-clinical motion sensitivity. Further investigation is warranted to explore wider age ranges with larger samples sizes as well as intervention strategies to improve postural control.

**Keywords:** Motion sensitivity, motion sickness, postural control, balance, computerized dynamic posturography, virtual reality

Received 30<sup>th</sup> November 2015, revised 18<sup>th</sup> December 2015, accepted 01<sup>st</sup> January 2016



www.ijphy.org

10.15621/ijphy/2016/v3i1/88898

<sup>1</sup>Doctoral Student,  
Loma Linda University,  
School of Allied Health Professions,  
Department of Physical Therapy,  
Loma Linda California.

<sup>3</sup>Assistant Professor,  
Loma Linda University,  
School of Allied Health Professions,  
Department of Allied Health Studies,  
Loma Linda California.

## CORRESPONDING AUTHOR

<sup>\*2</sup>Johnson EG

Professor, Loma Linda University,  
School of Allied Health Professions,  
Department of Physical Therapy,  
Loma Linda California.

## INTRODUCTION

The ability to maintain balance is essential for everyday life. Postural control is the ability to maintain equilibrium and orientation in a gravitational environment [1]. It involves the control of body's position in space in order to obtain stability and orientation [2]. Postural control is a complex process requiring central processing of peripheral sensory inputs [3]. These peripheral sensory inputs include the visual, somatosensory and vestibular systems working together to maintain postural control [4]. Sensory input and processing conflicts, particularly between the visual and vestibular systems, can result in disturbance of postural control leading to disequilibrium and motion sickness [4]. Motion sickness, or motion sensitivity, is defined as disorientation of space and is a common symptom related to dizziness and impaired postural control [5] [6]. Additional symptoms associated with motion sensitivity include nausea, vomiting and cold sweating [6]. Motion sensitivity is affected by factors such as gender, age, psychological status, and environmental factors [7]. Motion sensitivity and impaired postural control can occur in healthy adults while exploring visual surroundings, particularly while standing on unstable surfaces [6].

Hoffman et al reported that immersion virtual reality (IVR) is a false reality created in the mentality of the virtual reality (VR) user with the help of advanced computer technology [8]. The virtual environment creates a false sense of movement by entering a computer-generated world with converging various multisensory inputs [8]. Motion sensitivity and decreased postural control can be exacerbated in VR environment [6] [9] [10].

The purpose of this study was to measure the difference between the postural control of healthy adults with and without any history of sub-clinical chronic motion sensitivity using a VR environment. We operationally defined sub-clinical motion sensitivity as a history of avoiding activities causing dizziness, nausea, imbalance, and/or blurred vision without having a related medical diagnosis.

## METHODS

Twenty healthy male and female subjects 22 to 33 years of age were recruited for the study. Eleven subjects reported sub-clinical chronic motion sensitivity and 9 subjects did not. Sub-clinical chronic motion sensitivity was operationally defined as a history of avoiding activities causing dizziness, nausea, imbalance, and/or blurred vision without having a related medical diagnosis. Subjects with sub-clinical motion sensitivity were included if they responded "yes" to avoiding at least one of the following activities on the questionnaire: reading in a moving vehicle, traveling on winding roads, boats or ships, airplanes, horseback riding, roller coasters, and/or quick movements. Subjects without sub-clinical chronic motion sensitivity reported "no" to all activities on the same questionnaire. Subjects were excluded if they reported cervical spine orthopedic impairments, vestibular impairments, neurological pathology, or currently being on any medications causing dizziness or

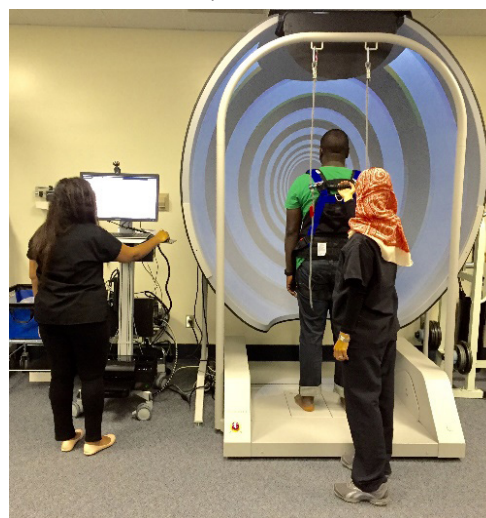
imbalance. All subjects signed a Loma Linda University's Institutional Review Board approved informed consent prior to participation in the study.

## Procedures

There were two groups in this study, eleven subjects in the sub-clinical chronic motion sensitivity group and 9 subjects in the non-motion sensitivity group. Postural control was measured in both groups using the Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR) [11]. See Figure 1. The CDP-IVR reports an over-all equilibrium score based on subjects' center of gravity displacement and postural sway while immersed in a virtual reality environment [12] [13] [14].

Postural control was measured under two conditions. Condition 1 measured postural control on a stable forceplate with eyes open while focusing on a virtual reality infinite tunnel visual flow (Figure 1). The infinite tunnel provided the visual illusion that subjects were moving towards the tunnel in an anterior direction. Condition 2 included the additional challenge of an unstable forceplate. Each condition lasted twenty seconds and was repeated three times and an average was calculated.

**Figure 1:** Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR)



## Statistical Analysis

Data was analyzed using SPSS Statistics Grad Pack 22.0 PREMIUM for windows. Descriptive statistics was used to summarize the data. Data was reported as mean  $\pm$  standard deviation (SD) for quantitative variables and frequency and percent (%) for categorical variables. Normality of quantitative variables was examined using Kolmogorov Smirnov test and box plots. To compare the means of height, weight, and body mass index (BMI) between the two groups, an independent t-test was conducted. Differences in mean age and postural control scores for all conditions (1, 2, and average) by group type were assessed using Mann-Whitney U test. The distribution of gender by group was examined using Fisher's Chi-square test. The level of significance was set at  $p \leq 0.05$ .

## RESULTS

There was no significant difference noted between the motion sensitivity ( $n_1=11$ ) and the non-motion sensitivity groups ( $n_2=9$ ) in terms of mean age, height, weight, BMI at baseline ( $p>0.05$ ). Seven subjects (63.68%) in the motion sensitivity group were females compared to 4 female subjects (44.4%) in the non-motion sensitivity group ( $p=0.34$ ). See Table 1.

There was a significant difference in mean "Sensory Organization test (SOT)" for condition 1 between motion sensitivity and non-motion sensitivity group ( $85.1\pm 10.8$  vs  $92.1\pm 2.3$ ,  $p=0.03$ ). However, there was no significant difference in mean SOT for condition 2 between the two groups ( $48.2\pm 21.4$  vs  $55.3\pm 20.1$ ,  $p=0.23$ ), and for average of the two conditions ( $66.7\pm 15.0$  vs  $73.7\pm 10.6$ ,  $p=0.09$ ). See table 1, graph 1.

**Table 1.** Mean (SD) of general characteristics (n= 20)

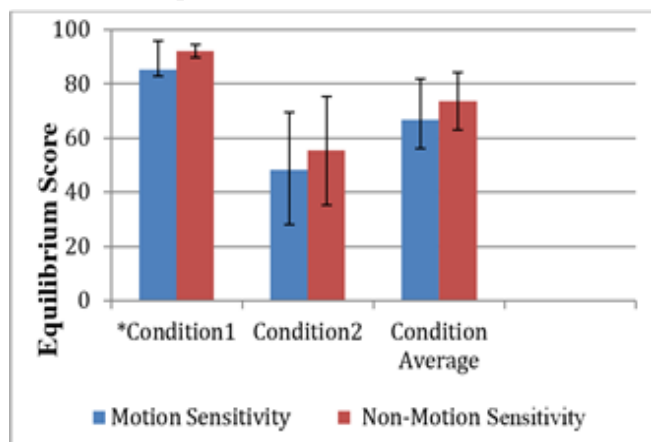
	Motion Sensitivity ( $n_1=11$ )	Non-Motion Sensitivity ( $n_2=9$ )	p -value <sup>a</sup>
Female; n (%) <sup>c</sup>	7(63.6)	4(44.4)	0.34
Age (years) <sup>b</sup>	27.3(4.4)	26.7(3.9)	0.75
Height (inches)	65.1(3.5)	66.3(3.3)	0.43
Weight (lb)	151.5(27.3)	165.5(39.4)	0.36
BMI (kg/m <sup>2</sup> )	25.1(3.5)	26.4(6.0)	0.54
SOT condition 1 <sup>b</sup>	85.1(10.8)	92.1(2.3)	0.03
SOT condition 2 <sup>b</sup>	48.2(21.4)	55.3(20.1)	0.23
SOT average <sup>b</sup>	66.7(15.0)	73.7(10.6)	0.09

Abbreviations: SD=Standard deviation; SOT=Sensory Organization Test

<sup>a</sup> Independent t-test

<sup>b</sup> Mann-Whitney U test

<sup>c</sup> Fisher's Chi-Square



**Graph 1.** Mean  $\pm$  SE of postural control of sensory organization test for condition 1, condition 2, and condition average by type of group (N=20)

\*Significant for Condition 1 ( $p=0.03$ ); SE=Standard error

## DISCUSSION

The purpose of this study was to measure the difference in postural control between healthy young adults with and without chronic sub-clinical motion sensitivity. Postural control was measured with CDP-IVR. The results suggest that young adults without chronic sub-clinical motion sensitivity have better postural control. The young adults with sub-clinical motion sensitivity had more postural sway during both testing conditions although only the first condition was significant. These results support previous reports that individuals with motion sensitivity have poor postural control making it difficult to disregard misleading visual input [15]. Subjects without motion sensitivity could rely on normal sensory integration during the CDP-IVR infinite tunnel visual flow and were better able to maintain their balance. The motion sensitive subjects were likely dealing with an over reliant visual system and the visual-vestibular conflict contributed to increased difficulties in maintaining their balance.

The results of the current investigation suggest that chronic sub-clinical motion sensitivity impairs postural control in healthy young adults. Limitations of this study included using a non-validated self-report activity avoidance questionnaire. Hironori et al reported a variance between "subjective reports of motion sickness or balance and objective decreased postural control" [5]. Alternatively, Cobb described a strong correlation between decreased postural control and self-reported symptoms of simulator sickness [4].

## CONCLUSION

Results of this study suggest that healthy young adults without chronic sub-clinical motion sensitivity have better postural control than those with chronic sub-clinical motion sensitivity. Further investigation is warranted to explore wider age ranges with larger samples sizes as well as intervention strategies to improve postural control.

## Abbreviations

VR: Virtual reality

CDP-IVR: Computerized dynamic posturography with immersion virtual reality

SD: Standard deviation

SE: Standard error

BMI: Body mass index

SOT: Sensory Organization Test

## Acknowledgment

Authors extend their appreciation to Loma Linda University Department of Physical Therapy for supporting this research.

## REFERENCES

1. Horak FB. Clinical Measurement of Postural Control in Adults. *Phys Ther.* 1987; 67(12):1881-5.
2. Massion J. Postural Control Systems in Developmental Perspective. *Neurosci Biobehav Rev.* 1998; 22(4):465-72.
3. Hassan BS, Mockett S, Doherty M. Static postural

- sway, proprioception, and maximal voluntary quadriceps contraction in patients with knee osteoarthritis and normal control subjects. *Ann Rheum Dis.* 2001; 60(6):612-8.
4. Cobb SV. Measurement of postural stability before and after immersion in a virtual environment. *Appl Ergon.* 1999; 30(1):47-57.
  5. Akiduki H, Nishiike S, Watanabe H, Matsuoka K, Kubo T, Takeda N. Visual-vestibular conflict induced by virtual reality in humans. *Neurosci Lett.* 2003; 340(3):197-200.
  6. Owen N, Leadbetter AG, Yardley L. Relationship between postural control and motion sickness in healthy subjects. *Brain Res Bull.* 1998; 47(5):471-4.
  7. Bos JE, MacKinnon SN, Patterson A. Motion sickness symptoms in a ship motion simulator: effects of inside, outside, and no view. *Aviat Space Environ Med.* 2005; 76(12):1111-8.
  8. Hoffman HG, Patterson DR, Carrougher GJ, Sharar SR. Effectiveness of Virtual Reality-Based Pain Control With Multiple Treatments. *Clin J Pain.* 2001; 17(3):229-35.
  9. Kennedy RS, Lilienthal MG. Implications of balance disturbances following exposure to virtual reality systems. *Virtual Reality Annual International Symposium.* Research Triangle Park, NC, (11-15 Mar 1995). Available at: [http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=512477&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs\\_all.jsp%3Farnumber%3D512477](http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=512477&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D512477)
  10. Akizuki H, Uno A, Arai K, Morioka S, Ohyama S, Nishiike S, et al. Effects of immersion in virtual reality on postural control. *Neurosci Lett.* 2005; 379(1):23-6.
  11. Bertec Corporation [cited 2014 April 15]. Available from: <http://bertec.com/bertecbalance/our-products/dynamic/>
  12. Monsell EM, Furman JM, Herdman SJ, Konrad HR, Shepard NT. Computerized dynamic platform posturography. *Otolaryngol Head Neck Surg.* 1997; 117(4):394-8.
  13. Palm HG, Lang P, Strobel J, Riesner HJ, Friemert B. Computerized dynamic posturography: the influence of platform stability on postural control. *Am J Phys Med Rehabil.* 2014; 93(1):49-55.
  14. Broglio SP, Sosnoff JJ, Rosengren KS, McShane K. A comparison of balance performance: computerized dynamic posturography and a random motion platform. *Arch Phys Med Rehabil.* 2009; 90(1):145-50.
  15. Redfern MS, Yardley L, Bronstein AM. Visual influences on balance. *J Anxiety Disord.* 2001; 15(1-2):81-94.

#### **Citation**

Alyahya D, Johnson EG, Gaikwad SB, & Deshpande NS. (2016). POSTURAL CONTROL IN HEALTHY YOUNG ADULTS WITH AND WITHOUT CHRONIC MOTION SENSITIVITY. *International Journal of Physiotherapy*, 3(1), 1-4.