Original Article

Effects of a smart phone-based game on balance ability and dizziness in healthy adult individuals

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ABSTRACT

Many people use smartphone these days. There are many studies on the effects of smartphones on our bodies, but there is a lack of research on balance and dizziness. The purpose of this study was to determine how a healthy person's balance and dizziness is affected by using smart devices. Twenty four healthy adults in their twenties were assigned to the 10-minute and 20-minute group based on the duration of the smartphone game. To evaluate the effects of smartphone games on the balance and dizziness of the participants, we evaluated their balance and dizziness before and after playing the smartphone game. Balance was measured using a force plate (Wii Balance Board, Balancia version 2.0, Mintosys Inc., Seoul, KR) and dizziness was measured using the Simulator sickness Questionnaire (SSQ). There was a significant difference in balance among both groups before and after playing the smartphone game ($p < .05$); however, there was no significant difference between the two groups ($p > .05$). Regarding dizziness, the SSQ score indicated minimal symptoms in the 10-minute group, while it revealed significant symptoms in the 20-minute group. In this study, playing a smartphone game for 10 minutes and 20 minutes was found to affect balance. Further, it was found that playing a smartphone game for 20 minutes may lead to a significant level of dizziness. **Keywords:** Smart phone; Dizziness; Postural balance.

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INTRODUCTION

Smartphone has become a keyword that explains our society, and individuals use smartphones in their daily life. However, problems related to the use of smartphones as a necessity for life are increasing. The easy availability of smartphones has led to their overuse in everyday life. People do not use smartphones as needed; rather, they spend their time using them as a habit. Further, people are consciously using smartphones to keep up with the times (Lee et al., 2014; Oulasvirta et al., 2012).

These usage patterns can have a negative impact on over-reliance on smartphones (Vuillerme et al., 2002). These problems render the use of smartphones on the go as a habitual activity, and these habits can be a serious problem owing to the risk of injury. Previous studies have reported that performing other tasks while walking can affect balance control, and increase unstable gait pattern and fall risk (Trombetti et al., 2011).

Balance is the ability to stably maintain the body's centre of gravity within its own weight-bearing surface in a given environment (Horak et al., 1989; Shumway-Cook & Woollacott, 1995). Vestibular, visual, and proprioceptive senses comprise the vital sensory system involved in maintaining the balance of the body. Further, the interaction of vestibular function, visual information, proprioceptive senses, and musculoskeletal and cognitive abilities is essential for appropriate balance control (Cheng et al., 2001; Wernick-Robinson et al., 1999). Therefore, if one piece of information is distorted, it can have a substantial effect on balance (Wernick-Robinson et al., 1999). Among them, there are some studies that view has the greatest effect on balance (Straube et al., 1990; Van Asten et al., 1988). In this context, one study reported that using a smartphone could restrict visual information and weaken postural balance (Laatar et al., 2017).

According to a study by Jeon et al. (2016), the use of smartphones during gait was related to a reduction in walking speed by up to 41.69% depending on the tasks being conducted on the smartphone. The decrease in walking speed concurrently increased the support time for both legs by 111.11%, suggesting that it would lead to a gait pattern that is different from the normal pattern of the user. In such situations, individuals continue to walk by relying on the memory of the target seen temporarily, instead of keeping an eye on the target. As the visual attention is focused on the smartphone, the direction of the target captured by transient sight is perceived as farther than it actually is. This is called the attentional repulsion effect (Au et al., 2013). In addition, maintaining the observed target in one's cognition weakens when vision is limited. Due to this limitation, participants in Au et al.'s study (2013) experienced visual distortion and poor estimation of space, thereby contributing to the deviation in the direction of gait. This, in turn, made it difficult for them to be aware of surrounding circumstances, resulting in losing directionality, in which the length of forward progression becomes longer than originally anticipated. Other studies reported that the use of smartphones may limit visual information and weaken postural balance (Laatar et al., 2017), somatosensory, vestibular, and visual inputs to minimize body sway (Berg & Norman, 1996; Della Volpe et al., 2006). It is thus possible that an imbalance in any of the three sensory systems will affect postural alignment (Della Volpe et al., 2006). Poor balance in the standing posture can limit functional activities of daily living (Schmitt & Kressig, 2008). There are two types of balance, namely, static balance and dynamic balance. Static balance pertains to maintaining the equilibrium in one's body position, while dynamic balance pertains to maintaining equilibrium while in motion (Schmitt & Kressig, 2008). Thus, losing balance would affect human gait and result in reducing the energy consumption of the whole body (Ohsato, 1993).

However, the problems mentioned above may be related to dynamic balance because they occur when the body is in motion. There is still a lack of research on static balance after the use of a smartphone game for a long time in a sitting position, as experienced in daily life. In addition, visual information has a substantial influence on balance, and little research has examined the symptoms of dizziness caused by such smartphone use (Straube et al., 1990; Van Asten et al., 1988). Therefore, the present study aimed to investigate the effect of playing a smartphone game on balance and dizziness in healthy adults.

MATERIALS AND METHODS

Participants

After making an announcement about the purpose and methods of this study through a bulletin board in Kyungnam University, volunteers who were willing to participate in the study were recruited. Participants were selected using the following criteria: 1) not having any disease of the musculoskeletal or nervous system; 2) not having any congenital deformity in the extremities; 3) not having any open injury or inflammatory disease in the extremities; 4) not having any cognitive damage, mental disease, or record of alcohol or drug abuse; 5) being healthy adults in their twenties. A total of 30 volunteers were recruited and 24 participants were selected based on the criteria. The general characteristics of the participants have been presented in Table 1.

The participants were thoroughly informed about the purpose and procedures of the study before they voluntarily signed the consent form. This study was conducted after receiving the approval of the Kyungnam University Ethics Judging Committee.

Table 1. General information of the subject

Group	Age	Height (cm)	Weight (kg)	BMI (kg/m2)	%Fat
10 group(n=12)	21.58±1.88	169.35±7.24	67.43±15.59	23.40±4.26	23.98±9.47
20 group(n=12)	21.50±2.27	167.37±5.21	62.32±6.96	22.20±1.93	23.26±7.29
p	0.923	0.450	0.311	0.383	0.835

Values are means±SD

Procedure

Prior to the commencement of the experiment, data on the general characteristics of the participants, such as sex, age, height, weight, and body mass index (BMI) were collected. The experiment was conducted in a quiet and spacious physiotherapy practice room, to minimize any effects of the external environment. The balance ability of the participants was measured using the Wii Balance Board (WBB) before having them play smartphone games. After the participants were asked to play games on a smartphone in a random order, their balance ability was measured. After playing games for the specific duration according to their respective conditions, participants were asked to stand on the WBB, to measure their balance. Additionally, an assessment of their dizziness level and oculomotor function was conducted using the Simulator Sickness Questionnaire. Balance ability was measured prior to using any smartphone game and after using the smartphone for 10 or 20 minutes, according to the study group. Dizziness was assessed using the SSQ after having the participants use the smartphone for 10 and 20 minutes, respectively The smartphone was used in a sitting position. However, the balance was measured in a standing position after using the smartphone. The reason we measured balance for 30 seconds after sitting and standing was most often the viewing situation. Thus, they participants were divided into the 10-minute and 20-minute group based on the duration of smartphone use, and their balance and dizziness were measured after they played the smartphone game. The smartphone game was a car racing game called Asphalt 8: Airborne (Asphalt 8: Airborne ver.3.51b, Gameloft, Paris, France). The Samsung Galaxy S7 (SM-G930S, SAMSUNG Electronics Inc., Suwon, Korea) was used for the experiment and its size was 142.4 * 69.6 * 7.9 mm (length * width * thickness).

Figure 1. Smartphone (Samsung Galaxy S7)

Figure 2. Asphalt 8: Airborne

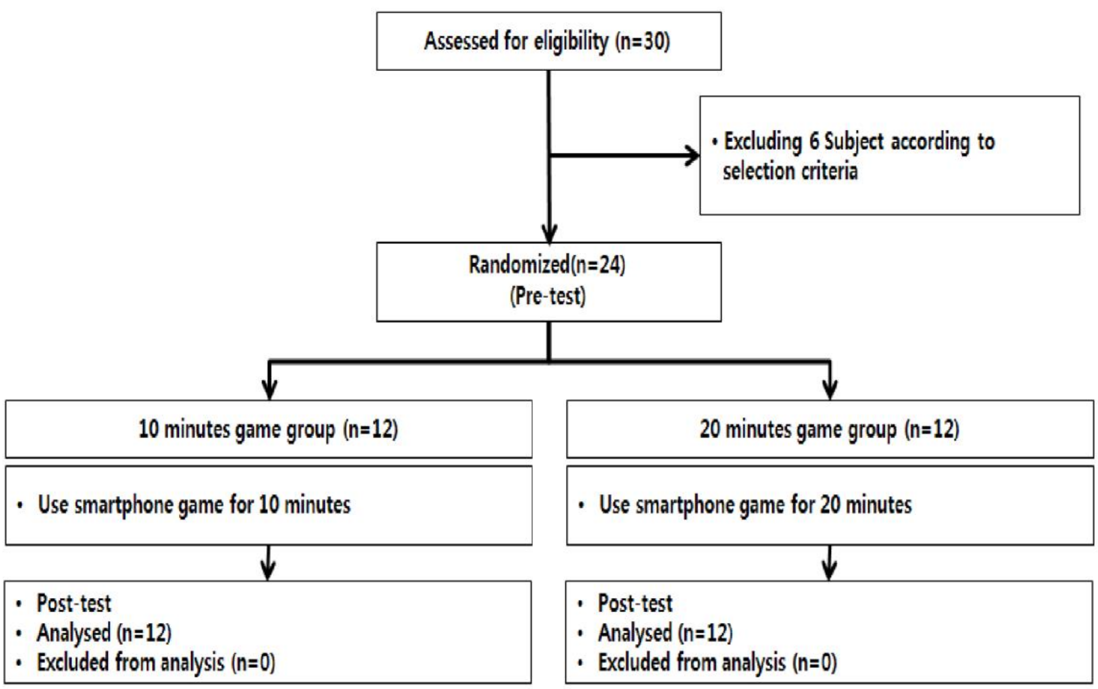

Figure 3. Flow chart

Outcome Measurements

The Nintendo WBB was used as the force plate for measuring static balance. Similar to a force plate, WBB is widely used these days because of its portability (Park & Lee, 2014). Through the load cells located on its four corners, a WBB sequentially collects information on the centre of pressure (COP), which is then transmitted to a computer connected via Bluetooth. The measured data were extracted using the Balancia software ver. 2.0 (Mintosys, Korea). All data were extracted at a sampling rate of 50 Hz and a low-pass filter frequency of 10 Hz. The participants were asked to step on the force plate with their bare feet and to place their feet in the most comfortable position. Each participant's foot position was marked so that the same position was used when remeasuring balance after smartphone gaming. Additionally, participants were asked to keep their arms by their sides, in a comfortable manner. The inter-tester reliability of this experiment was ICC = .89–.79, while its intra-tester reliability was ICC = .70–.92. Validity of this experiment was ICC = .73–.87 (Park & Lee, 2014).

Dizziness was examined using the SSQ (Kennedy et al., 1993), a self-report tool for examining dizziness and oculomotor function. It consists of 30 questions about experiences related to nausea, oculomotor function, and anaesthesia. For the present study, only 16 questions about dizziness and oculomotor-related experiences, such as eye strain, blurred vision, and difficulty concentrating were used (Bouchard et al., 2011). The highest possible score for the 9 questions related to dizziness was 27, while that for the 7 questions on oculomotor function was 21. Higher SSQ scores indicate higher dizziness level, and higher manifestation of nausea, blurred vision, and eye strain.

Statistical Analysis

In this study, SPSS 18.0 software was used for conducting the statistical analyses. The general characteristics of the participants were expressed in frequencies or means (with standard deviations). The balance variables at different measurement points were compared among participants in each group using the Paired t-test and independent t-test, respectively. The dizziness levels of the participants were expressed in frequencies or means (with standard deviations). Statistical significance was set at $p = 0.05$.

RESULTS

Balance Test

Table 2 shows the results of analysing the balance change measured by the Nintendo WBB according to the smartphone usage groups. Results of the analysis of sway velocity and sway length in the in-group pre-post comparison revealed that both groups showed statistically significant differences ($p < 0.05$) but there was no significant difference in (independent) the group comparison ($p > 0.05$).

Dizziness Test

Table 3 shows the results of analysing the dizziness level (SSQ score) according to the smartphone usage time. The difference in the dizziness level before and after smartphone use was 6.75 points in the 10-minute group and 10.08 points in the 20-minute group.

Table 2. Changes of Balance in each group

Variables		10 group(n=12)	20 group(n=12)	*p*
Sway Velocity	pre	2.15±0.39	2.25±0.25	0.565
	post	2.30±0.49	2.39±0.26	
	change	-0.15±0.19	-0.14±0.12	
	t	-2.851*	-4.174*	
Path length	pre	64.32±11.71	67.50±7.43	0.564
	post	68.95±14.81	71.79±7.94	
	change	-4.64±5.64	-4.30±3.57	
	t	-2.846*	-4.166*	

NOTE: Values are means±SD, *Significant differences when compared to condition before and after ($p<0.05$)

Table 3. Differences of SSQ in each group

Variables	10 group(n=19)	20 group(n=17)
SSQ	6.75±4.47	10.08±7.87

NOTE: Values are means±SD, SSQ; Simulator Sickness Questionnaire

DISCUSSION

The smartphone penetration rate is the highest among individuals in their 20s, which is the most influential on balance (Straube et al., 1990; Van Asten et al., 1988). Therefore, in the present study, we investigated the effects of smartphone game usage duration on balance and dizziness in healthy adults in their twenties. Findings revealed significant differences in the pre-post comparison of balance in the 10-minute and 20-minute smartphone gaming groups. However, there was no significant difference between these two groups.

In a study by Cho et al. (2014), standing balance was measured during smartphone usage in healthy adults in their 20s and 30s. Since a smartphone is portable and easy to use, they used it in a standing position to reproduce the feature that smartphones can be used anytime and anywhere. Their findings revealed that greater engagement in smartphone usage had a stronger impact on Negative impact of balance. Similarly, in the present study, balance was measured before and after using a smartphone, and smartphone use was found to have an effect on balance. However, there were some differences in the way balance was measured in these two studies. Specifically, in the present study, the balance was measured after standing on a bench while using a smartphone. Differences in balance measurement were based on situations that occur frequently in everyday life. As a result, both the 10-minute group and the 20-minute group exhibited higher effects on balance as compared to normal standing. This reduction in the ability to maintain a standing posture may have been influenced by a visual problem. In a study by Park et al. (2017) visual fatigue and posture control ability were measured after smartphone usage. Visual fatigue was found to affect posture control ability significantly after smartphone usage (Shen et al., 2003). Therefore, the results of the present study also seem to indicate the effect of visual problems on balance.

However, there was no significant difference between the 10- and 20-minute smartphone usage groups. A study by Gratton et al. (1990) found that work at a close distance leads to a change in visual control and, when continuous near-field work is done, it reduces visual control. Work at a close range leads to changes in phoria, and this type of stress can cause severe visual fatigue (Gratton et al., 1990). Park et al. (2012) observed a change in eye material for 5 minutes after smartphone use for 20 minutes. Further, the largest change in near-near material phoria was observed between 5 and 10 minutes. These results suggest that the visual fatigue caused by 10-minute long smartphone use can be sufficient for affecting balance. Like previous research, both groups in the present study used smartphones for more than 10 minutes. Therefore, both groups may have experienced visual fatigue.

The present study also revealed that the dizziness score was 6.75 points (minimal symptoms) in the 10-minute smartphone use group, while it was 10.08 points (significant symptoms) the 20-minute group. The SSQ is a dizziness evaluation questionnaire that was created by a three-symptom factor analysis to characterize the measurement standards clearly (Lane et al., 1988).

The three main symptoms in the SSQ are Nausea, Oculomotor function disturbance, and Disorientation. Scores on the nausea subscale are based on the report of symptoms that relate to gastrointestinal distress such as nausea, stomach awareness, salivation, and burping. Scores on the oculomotor function subscale relate to eyestrain, difficulty in focusing, blurred vision, and headache. Scores on the disorientation subscale are related to vestibular disturbances such as dizziness and vertigo (Kennedy et al., 2003). In the present study, participants who engaged in smartphone usage for 20 minutes in a sitting position showed significant symptoms. These results suggest that smartphone usage for more than 20 minutes may cause symptoms like nausea, oculomotor function disturbance, and disorientation. These problems possibly lead to more dangerous accidents like falls. Therefore, it seems necessary that individuals rest sufficiently after using a smartphone for a long time, rather than engaging in movement immediately.

In the present study, the result of analysing differences in balance and dizziness among smartphone usage duration groups revealed that smartphone usage affects balance and dizziness. However, as the present participants were young and healthy adults, and the sample size was small, these findings have limited generalizability. In addition, we only examined balance and dizziness after smartphone usage but did not identify the recommended rest duration necessary after smartphone use. Thus, subsequent studies should address these limitations to supplement the present findings.

CONCLUSION

The present study examined the effect of smartphone game usage in a sitting position on balance and dizziness in 24 healthy male and female adults in their 20s. Findings revealed that smartphone use had a significant influence on balance and dizziness. Based on these results, it is recommended that, when individuals use a smartphone for more than 10 minutes, they should take enough rest before moving, in order to enable their body to cope with the changes in balance and dizziness caused by the smartphone use.

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