Effects of Various Smart Device on Postural Control

Byeong-Ho Jeong, Ji-WonKim, Young-Jin Lim

Abstract Background/Objectives: The purpose of this study was examine the effects of performing dual task while using a smart device (smart watch, smart phone, and smart pad) on static and dynamic postural stability.

Methods/Statistical analysis: Thirty-six subjects were asked to stand on a force plate and then instructed to perform a balance task while talking on the mobile phone, balance task while sending text massage, and balance task while playing game. We used the BioResue to measure postural sway for static postural stability and Y-balance test was used to measure dynamic postural stability. A one- way ANOVA with repeated measures was used.

Findings: In static postural stability, smart watch was significantly decreased than smart phone and smart pad during game task and conversation task. In dynamic stability, smart watch was significantly decreased than smart pad and smart during game task.

Improvements/Applications: This finding suggest that performing dual task using smart watch decreased static and dynamic stability compare with smart pad and smart phone. Therefore, it requires more attention to maintain static and dynamic balance while using smart watch.

Keywords: Balance, Smart pad, smart phone, smart watch, Y-balance

I. INTRODUCTION

In Korea, smartphone users continue to increase after the introduction of the iPhone in November 2009, and the smartphone market is expected to exceed the current level of 8 ~ 990 million units by 2015. The spread of the smartphone market is expected to accelerate globally. A smart phone is a mobile phone terminal that has evolved from a conventional mobile phone focused on voice and text messaging and has a close effect on our lives, which is easy to carry and can install and use a desired application such as internet, game, multimedia function [1].

Due to the rapid development of information and communication technology (ICT) and electronic devices, smart phones have had a considerable impact on the overall life of people from business to leisure, and smart devices such as smart pads and smart watches have become commonplace [2]. Smart pad is a device that can be operated by touching the screen directly with your fingers without the need of a separate keyboard, and has the advantage of being convenient to carry [3]. Gartner predicts that consumers will be more interested in Smart watch as product design improves in the future, and 40% of wrist wear market share by 2016 is smart location of the total.

According to the Pew research Center (2012), the average daily smartphone usage time is 5.1 hours and the weekend is 5.6 hours. This is because smart devices are small in size and have good portability and are easy to operate, so they can be used anytime and anywhere and can be interlocked with users. A survey of 494 smartphone users showed that the most frequently used applications were games with 25.5%, followed by news 21.9% and web browsers 18.4%. As a result of analyzing by age group, 20s responded to game, messenger, SNS, 30s to game, SNS, 40s to news, finance, traffic information. Smartphones are like ordinary PCs,By installing and installing the software, it has infinite scalability and can utilize various applications.

Today, modern people often use smartphones in a complex environment where many people are driving and crowded, and the problem of exposure to safety hazards is increasing because they are concentrated on smart devices. According to the traffic safety survey results, it is reported that the number of pedestrian traffic accidents caused by smart phones increased sharply from 400 in 2009 to 1000 in 2014 because of the increase in the number of people who do not look around and concentrate on smart devices.

When using smart devices, it is often necessary to perform one or more tasks at the same time. The task to perform both tasks simultaneously is called the dual task [4]. The dual task is to require the exercise task for posture control as one task and the cognitive task as the second task and to perform both tasks simultaneously. For example, walking with a friend, taking a phone call and watching a chapter. In general, when placed in a double task condition compared to a single task, it results in loss of balance and physical impairment such as falls [5].

When the exercise task and the cognitive task are performed at the same time, the exercise ability decreases because the cognition and concentration plays an important role in the exercise control. Pellecchia (2003) investigated postural fluctuations by adding cognitive tasks such as inverted speaking, numbering, and inverse calculation simultaneously in standing postures on adults [6]. As a result, postural fluctuation was the greatest when reverse calculation of the number task because of the

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most difficult task. Weon investigated in contrast to the single task of postural control alone, the ability to send a text message and to control the posture diminish the dynamic balance ability in the double task.

Since smartphone users concentrate on a small screen when using a smartphone, the amount of visual information they receive when walking is gradually reduced. In addition, when cognitive task is performed simultaneously with walking, attention is distributed and significant influence is given to walking. Especially when using a smartphone and walking, the most dangerous thing is the fall that can not avoid obstacles at the foot.

As described above, only the study on the mobile phone was the study of posture control related to the double task. Therefore, the purpose of this study was to investigate the static and dynamic posture control according to the tasks (telephone conversation, text, game) between smart devices. Based on the existing research, the hypothesis of this study is that the ability to control the posture among the smart devices (dynamic, static) will be different.

II. MATERIALS AND METHODS

2.1. Subjects

Subjects were 36 healthy adults. All subjects had no orthopedic or neurological disease. All subjects were given sufficient explanations about the purpose and method of this study, and the experiment was conducted only for those who agreed to the study. The general characteristics of the study subjects are as follows[Table 1].

Table 1:General characteristics of subjects (M±SD)

	Male(n=15)	female(n=21)	Total
Age (years)	20.3±1.0	20.5±0.6	20.4±0.8
Height (cm)	174.7±7.3	161.5±5.5	167.0±9.1
Weight (kg)	74.8±17.3	55.8±10.5	63.7±16.5
BMI(kg/m^2)	24.4±4.8	21.4±3.3	22.7±4.2

2.2.Methods

2.2.1. BioRescue

To determine the static posture control ability, posture fluctuation was measured using BioRescue[Figure 1, Figure 2].

Figure 1. BioRescue

Figure 2. Force plate

2.2.2 Y-balance test

To determine the dynamic posture control ability, we measured using a Y-balance kit.The Y-balance test is a measurement method designed to increase the repeatability of the Star excursion balance test (SEBT), which is commonly used to measure leg strength, flexibility, and proprioceptive sensation[Figure 3].

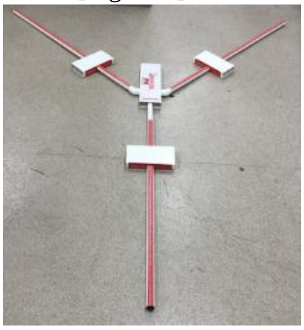

Figure 3. Y-balance kit

2.2.3 Smart device models and tasks

The iPhone 6S, iPad, and Apple Watch were provided to perform the balancing tasks associated with the conversation task. The iPhone 6S and iPad were provided to perform the balancing tasks related to sending texts, because Apple Watch does not have character capabilities. The iPhone 6S, iPad, and AppleWatch were provided to perform the balancing tasks associated with performance of the games.

2.3 Tasks

Subjects wore elastic short sleeves and shorts. The sequence of task performance was performed randomly to rule out learning effects. The conversation task was conducted by using a dominant hand to talk to a friend via a smart phone. The text task was to input Hangul into the smart device using the dominant hand. The task of playing the game was to perform the RULE game using the dominant hand.

2.3.1Static balance

During each task, posture perturbation were measured to confirm the static posture control. The measurement method is to maintain the same posture for 60 seconds without moving while keeping the line of sight fixed to the display point in the monitor[Figure 4].

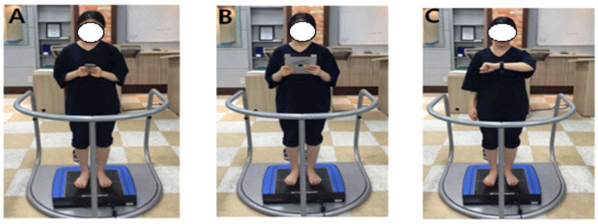

Figure 4. Static balance
(A) Smart Phone task (B) Smart Pad task (C) Smart Watch task

2.3.2 Dynamic balance

Y-Balance was used to identify dynamic control during each task. In this study, the anterior, posteomedial, and posterolateral were measured three times each with the dominent leg and the Composite Score was analyzed using the formula. If the foot was touched to the ground or could not return to the starting position, it was considered a failure and remeasured [Figure 5].

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Figure 5. Dynamic Balance
(A) Anterior (B) Posteromedial (C) Posterolateral

2.4Analysis

One-way ANOVA with repeated measurements was used to check the balance ability of tasks (conversation task, games) using various smart devices (smartphone, smart pad, smart watch).Bonferroni Correlation was performed to confirm the difference according to the task. Paired t-test was used to confirm the balance ability according to the text task.

III. RESULTS AND DISCUSSION

3.1 Results

3.1.1Static posture control

There was a significant difference between the three devices during the game[Table 2]. .

As a result of the post test, there was a significant difference between smart watch and smart phone, smart watch and smart pad, and smart phone and smart pad. There was a significant difference between the devices during telephone conversation. As a result of the post test, there was a significant difference between smart watch and smart pad.

Table 2: Comparison of change in balance function in static condition

	Task	Smart watch	Smart phone	Smart pad	F	P
Sway area (mm2)	Game	67.82±82.89	35.82±36.21	28.48±30.3	12.353	.000*
	conversatio n	83.42±130.25	58.30±74.58	40.89±48.7	3.904	.03*
Sway length (mm)	Game	15.51±5.79	13.63±3.93	16.94±23.98	.132	.719
	conversatio n	17.91±10.13	16.14±7.46	15.30±7.98	3.949	.055

There was a significant difference between the smartphone and the smart pad in the text task [Table 3].

Table 3: Comparison of change in balance function in static condition

	Smart Phone	Smart Pad	t	P
Sway length (mm)	14.29±4.08	12.82±2.87	-3.0 8	.004 *
Sway area (mm2)	34.99±42.52	33.74±21.64	-.18 7	.853

3.1.2 Dynamic posture control

There was a significant difference between the three devices duringgametask. As a result of the post test, there was a significant difference between smart watch and smart pad, and there was a significant difference between smart phone and smart pad. There was a significant difference between the three devicesduring conversation task. There was a significant difference between smart watch and smart phone [Table 4].

Table 4: Comparison of change in balance function in dynamic condition

	Smart watch	Smart Phone	Smart Pad	F	P
Game	78.53±12.77	80.54±12.67	84.89±12.81	12.57	.000 *
conversatio n	80.60±13.74	83.43±13.1	82.83±13.26	15.085	.000 *

There was a significant difference between the smartphone and the smart pad in text task [Table 5].

Table 5: Comparison of change in balance function in dynamic condition

	Smart Phone	Smart Pad	t	P
text	80.39±12.05	83.19±12.95	-2.862	.007

*

3.2Discussion

In this study, we measured the static and dynamic posture control ability of telephone conversation, text, and game tasks using various smart devices. There was a significant difference between the three devices in

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the dual tasks using smart devices. Static balance ability decreased when smart watch was worn in comparison with smart phone and smart pad during game task. The reason is thought to be the result of the screen size of the smart device. The sizes of smart devices used in this study were 9.7 inches for smart pads, 4.7 inches for smart phones, and 1.7 inches for smart watches. The smart device screen size was significantly smaller than that of smartphones and smart pads. Yoon (2016) investigated the effect of the size of the smartphone screen on user's work processes [7]. He argued that smartphones with larger screens are more effective than smartphones with smaller screens because the target is bigger on the big screen smartphone and the processing time is reduced as the time to recognize the information isshortened. In this study, static balance ability of smart watch was decreased than smart pad and smartphone because the readability decreased as the size of the screen became smaller, and the time to recognize the information increased, resulting in a difference in the balance ability. Park (2011) reported that the readability of the touch screen increases as the size of the screen increases [8].

In the telephone conversation task, static balance was reduced when smart watches were worn as compared to smart phones and smart pads. This included the manual task of placing a smart watch on the wrist and placing a smart watch in front of the mouth when using a smart watch. In addition, the position of the arm and the hand moved to the front of the body compared to other tasks, and the control of the posture would have been reduced. Patla et al. (2002) reported that when the arm moved 90 degrees forward, the pressure center of the body shifted toward the front edge of the basal plane [9].In this study, the posture of the arm moved to the front side of the body, and the pressure center point of the body moved from the center of the basal plane toward the front edge.

Static balance was reduced when using smart phone compared to smart pad during text task. The reason is that the touch pad of smart pad is larger than the touch pad of smart phone. Kim et al. (2011) reported that smartphone users are experiencing inconveniences due to the high rate of mistakes that come from pressing small buttons [10]. The keypad of smartpad used in this research is larger than the keypad of smartphone, so it is likely that the mistake rate is low and it is easy to input characters. Kimet al. (2012) reported that the larger the touch key size, the lower the error rate and the better the performance of the smartphone touch keypad [11].

In this study, the Y-balance test used to confirm the dynamic postural control ability is a measurement tool with high reliability (intralass correlation = .85 ~ .91) as a tool supplementing the repeatability of SEBT. In this study, dynamic balance was decreased when smart watch was worn in comparison with smart phone and smart pad during game task, and dynamic balance was reduced when smart phone was used in telephone conversation task compared to smart watch and smart pad. Plisky et al. (2006) found that subjects who had a difference of more than 4cm between the left and right legs reached 2.5 times higher than those of the subjects who had both legs of 235 high school basketball players ($p < .05$), and the female reaching the composite reach distance less than 94% of the leg length was 6.5 times higher than that of the leg.

In this study, it is considered that the risk of injury is high in smart watch because the total reach of smartwatch is lower than the total reach of smart phone and smart pad. Compared with smart pad, dynamic balance in text task was reduced when using smart phone. Weon (2012) reported that when performing a double task using a mobile phone, the ability to control the dynamic postural control in a text task is reduced compared to a single task, a monetary task, and a listening task [12].

The limitation of this study is that firstly, the position and the posture of the hand were not controlled equally during the three tasks. For example, smartpads and smartphones performed tasks with both hands, while smartwatch performed tasks with one hand. In the next study, it is necessary to control posture through motion analysis. Second, since the age groups are in their early 20s, this result cannot be generalized to all ages. Since people of all ages use smart devices in their daily lives, researches should be conducted for various age groups.

IV. CONCLUSION

Both the static posture control and the dynamic posture control decreased significantly in the order of smart watch, smart phone, and smart pad. This result shows that the dynamic and static posture control ability is decreased when the task is performed using a smart device having a smaller screen size than a smart device having a large screen size.

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