H.Ü. Sağlık Bilimleri Fakültesi Dergisi
Cilt:11, Sayı:3, 2024
Doi: 10.21020/husbfd.1414217

Original Research

Does Smart Phone Usage in Young Adults Have an Effect on Static and Dynamic Balance?

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Submission Date: January 3rd, 2024 **Acceptance Date:** May 30th, 2024 **Pub. Date.** December 31st, 2024
Online First Date: October 11th, 2024

Abstract

Objectives: This study aimed to investigate the effects of talking and note-taking on a smartphone on static and dynamic balance.
Materials and Methods: In the study, healthy young adults (n=36) were asked to maintain postural balance while standing on static and dynamic platforms in different tasks: (Task I) without using a smartphone, (Task II) while taking notes on a smartphone, and (Task III) while talking on a smartphone. Center of pressure (CoP) on mediolateral (CoP_x) and anteroposterior (CoP_y), CoP path length, CoP_{area}, and trunk deviation length were used to measure static and dynamic postural balance.
Results: On a static platform, CoP_y and CoP_{area} were different between the tasks ($p<0.001$, $p=0.017$). Task II and Task III impaired CoP_y more than the task I ($p<0.001$, $p=0.004$). Task III affected CoP_{area} more negatively than task II ($p=0.027$). CoP path length was lower in task II and task III ($p<0.001$). CoP path length was significantly higher in task III compared to task II ($p<0.001$). On a dynamic platform, there were differences in CoP_y between the tasks ($p=0.038$). There was a difference in CoP_y between task II and task III ($p=0.005$). The CoP_{area} was significantly different between the tasks ($p=0.023$). CoP_{area} and CoP path length was higher in task II compared to task I ($p=0.035$, $p<0.001$).
Conclusion: The study showed that smartphone use during specific tasks, including talking and/or note-taking on a smartphone, could increase the risk of falls and accidents by affecting center of pressure and postural sway.

Keywords: *smartphone, dynamic balance, static balance, dual task*

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Doi: 10.21020/husbfd.1414217

Introduction

Multifunctional smartphones are increasingly common in all aspects of our lives. With advancing technology, smartphones offer the ability to perform various tasks beyond making phone calls, such as sending text messages, checking email, playing video games, storing data, and using social media. These potential and evolving technologies have resulted in a rapid surge in smartphone use worldwide (Wah et al., 2022). Today, the global population of smartphone users is almost 6.92 billion, indicating that 86.29% of the world's population possesses a smartphone. According to this report, there are almost 52,06 million smartphone users in Turkey, representing 61.70% of the total population (Turner, 2022). Along with the increasing number of users, the time spent with smartphones also increases yearly (Merbah et al., 2020). Many studies have shown that mobile phone use negatively affects the balance of the person through attention and cognitive and perceptual changes (Woollacott & Shumway-Cook, 2002).

Balance is currently categorized as static and dynamic balance. Static balance is the preservation of equilibrium under unaltered environmental conditions; however, dynamic balance is defined as maintaining or rearranging balance due to deteriorating environmental conditions brought on by internal or external factors (Barmack, 2003). To maintain balance, visual, vestibular, and proprioceptive systems must cooperate with cognitive processes like attention (Wiest, 2015). Individual performance ability depends on the maximum capacity of attentional resources. Attention is defined as a person's capacity to process information while performing tasks. It is assumed that this information processing capacity is limited for each person and that each task needs a certain amount of capacity. Therefore, if two tasks are executed simultaneously and their combined requirements exceed the available capacity, the performance of any or both tasks will decline (Shumway-Cook & Woollacott, 2000). Depending on the type of postural task, the individual's age, and capacity for balance, attention plays a different role in postural control. The neuro-physiological processes involved in postural control and movement regulation consist of the central nervous system, which includes the brain and spinal cord; the peripheral nervous system, which consists of afferent and efferent pathways; the musculoskeletal system, which is made up of the skeleton driven by muscle-tendon actuators; and the sensory system, which is composed of various distributed sensory receptors, such as muscle spindle, Golgi tendon organ, joint, subcutaneous, somatosensory, and mechanoreceptors. In addition, the neuro-musculoskeletal control system encompasses the systems that together govern the planning, organization, execution, and regulation of motor functions in the body (Iqbal, 2011). According to the studies on attention and postural control, these two tasks should be performed concurrently as dual-task paradigms (Kerr et al., 1985).

Dual tasking refers to performing two tasks simultaneously. Nonetheless, cognitive attention deficit brought on by dual tasking can lead to unintentional falls and injuries in unexpected circumstances. It is known that functional activity in many daily activities relies on a person's ability to maintain balance under either static or dynamic conditions. For example, maintaining an upright posture while performing a simultaneous task represents a daily dual-task activity (Huxhold et al., 2006). The attention needs of a simultaneous cognitive task have been shown to influence postural control (Pellecchia, 2003). Thus, dual-task paradigms, which involve directing the subject's attention towards an external source of attention as they simultaneously do a primary task, have been employed to examine the attentional requirements of postural tasks (Ghai et al., 2017; Reilly et al., 2008). This attentional change can lead to interference between two tasks, altering the behavior of the system involved in the tasks and impacting the performance of both tasks compared to when they are performed individually (Pena et al., 2019; Saxena et al., 2017). For example, standing conditions that challenge postural control and cognitive processes, such as those that may occur when people are simultaneously using their cell phones, may make it more challenging to maintain a balanced and upright stance. When attempting to maintain postural control while performing a concurrent cognitive task (i.e., dual tasking), attention is divided between the sensorimotor and cognitive tasks, resulting in impairment of both tasks (Rebold et al., 2017).

Due to advancements in smartphone technology, using a phone for social or business purposes has become an essential part of daily life. As a result, it is common to have to keep good posture or walk while talking or texting on a smartphone, which requires multitasking. The literature has extensively examined the appropriate use of a phone during various daily tasks such as standing, walking, stair climbing, crossing streets, and driving. These activities demand cognitive and physical skills, as well as the ability to divide attention (Cho et al., 2014; Kim et al., 2020; Nurwulan et al., 2015; Simmons et al., 2020).

This study aimed to investigate the effects of talking and note-taking on a smartphone on static and dynamic balance.

Material and Methods

This study was carried out at Izmir Bakircay University between May 2022 and May 2023. Healthy young adults who were students in the Department of Physiotherapy and

Rehabilitation between the ages of 18-25 years participated in this study. Participants who had no smartphone and had orthopedic disorders that would affect their extremity functions or balance for the last six months were excluded. Participants were informed about the study, and their written consent was obtained before the measurements. This study was approved by the Ethics Committee of Izmir Bakircay University (2022-582).

Outcome measures

Tecnobody (Prokin 252, Italy) is a cutting-edge technology that merges a traditional tilting platform with a monitor and speaker to produce audio and visual feedback in response to subtle movements of the platform in all directions (Amico et al., 2014). This device provides accurate visual feedback information about the position of the center of pressure (CoP) and postural sway to the participant. Stabilometric data, including CoP on medio-lateral length (CoP_x), CoP on antero-posterior length (CoP_y), perimeter (CoP path length), center of pressure area (CoP_{area}), and trunk deviation length were used to evaluate static and dynamic postural balance via Tecnobody (Zhang et al., 2020). There are different calculation methods for the stabilometric data; the average values for CoP_x and CoP_y (mm), the path followed by the CoP for the CoP path length (mm), the path followed by the trunk sensor for trunk deviation length (mm), and the area scanned by the CoP for the CoP_{area} (mm^2) were calculated by the ProKin software (Italy). A higher absolute value of the stabilometric data represents decreased postural balance (Ke et al., 2022). Besides, a positive value represents a right deviation on the medio-lateral axis and an anterior deviation on the anterior-posterior axis and a negative value represents a left deviation on the medio-lateral axis and an posterior deviation on the anterior-posterior axis (Develi et al., 2021).

Static postural balance evaluations were performed when the platform of Tecnobody was stable. The instability level of the platform could be set from level 1 (more unstable) to level 50 (almost stable) for the dynamic postural balance evaluations (Al-Rasheed & Ibrahim, 2020). We set the instability level of the platform as level 20 for the dynamic postural balance evaluations. Before the evaluations, the participants were asked to stand on the platform and remain stationary during the test. A trunk sensor was placed over the sternum of the participant to record trunk deviation (Saadat et al., 2018).

Static and dynamic postural balance evaluations were performed barefoot with eyes open and a natural two-legged standing position for three different conditions/tasks: *(Task I) balance assessment without using a smartphone, (Task II) balance assessment during note-taking on a smartphone, (Task III) balance assessment during talking on a smartphone.* Both

Doi: 10.21020/husbfd.1414217

static and dynamic postural balance evaluations lasted 30 seconds for each task. A one-minute short break was given between all the evaluations. In task I, participants were asked to maintain their postural balance while standing on the platform of Tecnobody without holding a smartphone. Then, the participants were asked to write the first two stanzas of the National Anthem (Independence Anthem) of the Republic of Turkey in a note-taking application while holding the smartphone for task II. During task III, the participants were asked to talk to the observer on the smartphone and reply to three questions during the balance measurement. The following questions were asked to the participants: *(1) "What are the names of the professors in your department?", (2) "Which courses are you taking this semester?", (3) "Where do you see yourself in 5 years?".*

Statistical Analyses

SPSS version 21.0 statistical package program (SPSS Inc., Chicago, IL, USA) was used to analyze the data. The Kolmogorov–Smirnov test was performed to determine whether the data were normally distributed. The results were reported as mean, standard deviation (SD), number (n), and percentage (%). Repeated measures ANOVA was performed to compare the effects of smartphone use on balance ability in different situations. The results were interpreted with Mauchly's assumption of sphericity. When the results did not meet the sphericity assumption, they were analyzed according to the Greenhouse-Geisser formula to correct for statistical errors. Bonferroni correction was used when the interaction term was found to be statistically significant. Statistical significance was determined as $p<0.05$.

Power analysis

Before the study, the sample size and power calculations were carried out using the G*Power software version 3.1.9.7 (Dusseldorf University, Germany). The sample size was calculated using data from the previous study (Laatar et al., 2017). According to this study, Cohen's *d* coefficients between control and conversation tasks were 0.75, and between control and dialing were 0.62. When Cohen's *d* values are converted to Cohen's *f* values, they are calculated as 0.38 and 0.31, respectively. Therefore, in order to create at least a similar effect (Cohen's *f* was 0.31) as in the previous study, we calculated that at least 30 students were needed to reach 95% power at the 0.05 significance level.

Results

Twenty-one (58.3%) female and 15 (41.7%) male students participated in this study. The mean age and body mass index of the participants were 20.92±1.57 years and 21.58±2.96

Doi: 10.21020/husbfd.1414217

kg/m^2, respectively (Table 1). The changes in the stabiliometric data (CoP_x, CoP_y, CoP path length, CoP_{area}, and trunk deviation) for static and dynamic postural balance in task I (maintaining balance without using a smartphone), task II (maintaining balance during note-taking on a smartphone), and task III (maintaining balance during talking on a smartphone) was shown in Table 2.

Table 1. Demographic data of the participants

	Participants
Gender (M/F) (n)	15/24
Age (years), means ± SD	20.92±1.57
BMI (kg/m^2), mean ± SD	21.58±2.96

According to the static postural balance evaluations, there were no significant differences in CoP_x between the tasks ($p>0.05$). CoP_y was significantly different between the tasks ($p<0.001$). Pairwise comparisons showed that CoP_y was significantly higher under task II and task III when compared to task I ($p<0.001$ and $p=0.004$, respectively). CoP path length was significantly different between the tasks ($p<0.001$). In addition, CoP path length was lower in task II and task III compared to task I ($p<0.001$). Moreover, CoP path length was significantly higher in task III compared to task II ($p<0.001$). The CoP_{area} was significantly different between the tasks ($p=0.017$). According to the pairwise comparisons, CoP_{area} was higher in task II compared to task III ($p=0.027$). However, trunk deviation lengths were not different between the tasks ($p>0.05$) (Table 2).

Dynamic balance evaluations showed that CoP_x was not significantly different between the tasks ($p>0.05$). According to the CoP_y results, there were significant differences between the tasks ($p=0.038$). Pairwise comparisons revealed that Cop_y was significantly higher in task II compared to task III ($p=0.005$). CoP path length was significantly different between the tasks ($p=0.017$). Moreover, CoP path length was higher in task II compared to task I ($p<0.001$). The CoP_{area} was significantly different between the tasks ($p=0.023$). According to the pairwise comparisons, CoP_{area} was higher in task II compared to task I ($p=0.035$). There were no differences between the tasks according to the results of trunk deviation lengths ($p>0.05$) (Table 2).

Doi: 10.21020/husbfd.1414217

Table 2. Postural balance changes in different tasks

	Task I	Task II	Task III	Between group differences	Post-hoc significance		
					Task I vs. Task II	Task I vs. Task III	Task II vs. Task III
Static Postural Balance Evaluations							
CoP_x (mm)	3.67±13.30	-3.06±8.70	0.14±10.70	0.051	0.926	0.923	0.128
CoP_y (mm)	-27.86±27.90	-18.53±22.40	-18.81±19.60	<0.001*	<0.001*	0.004*	0.954
CoP path length (mm)	301.75±83.70	385.5±95.80	547.78±199.50	<0.001*	<0.001*	<0.001*	<0.001*
CoP_{area} (mm^2)	199.28±160.54	204.89±163.88	637.50±1010.94	0.017*	0.948	0.106	0.027*
Trunk deviation length (mm)	12.61±9.37	10.67±9.41	10.62±8.08	0.064	0.140	0.226	0.977
Dynamic Postural Balance Evaluations							
CoP_x (mm)	-6.50±9.23	-4.33±8.145	-2.50±7.01	0.064	0.386	0.059	0.437
CoP_y (mm)	-14.11±26.49	-18.58±22.28	-13.08±20.00	0.038*	0.132	0.957	0.005*
CoP path length (mm)	614.39±220.19	724.33±252.14	670.03±214.27	0.017*	<0.001*	0.564	0.455
CoP_{area} (mm^2)	873.64±987.12	1371.36±723.50	1085.53±767.56	0.023*	0.035*	0.884	0.143
Trunk deviation length (mm)	11.6±8.90	11.00±9.25	11.19±8.08	0.591	0.490	0.948	0.982

Task I: Maintaining balance without using a smartphone, Task II: Maintaining balance during notetaking on a smartphone, Task III: Maintaining balance during talking on a smartphone, CoP_x: Center of pressure on medio-lateral length, CoP_y: Center of pressure on antero-posterior length, CoP path length: Perimeter, CoP_{area}: Center of pressure area, Repeated measures ANOVA, *p<0.05.

Doi: 10.21020/husbfd.1414217

Discussion and Conclusion

In this study, we compared stabilometric data (CoP_x, CoP_y, CoP path length, CoP_{area}, and trunk deviation length) on static and dynamic platforms in different tasks (task I: Maintaining balance without using a smartphone, task II: Maintaining balance during talking on a smartphone, task III: Maintaining balance during note-taking on a smartphone).

According to the results of this study, maintaining balance during talking and note-taking on a smartphone increased the center of pressure on CoP_y and CoP path length compared to without using a smartphone on a static platform. In addition, note-taking on a smartphone increased CoP path length more than telephone conversation on a static platform. Moreover, talking on a smartphone increased CoP_{area} more than notetaking a smartphone on a static platform. These findings may indicate that young adults may experience challenges in maintaining their static balance while engaged in a phone conversation or writing a text message on a smartphone. Additionally, it appears that the participants may experience greater challenges in regulating their center of mass during talking compared to note-taking on a smartphone. This could potentially account for their compromised postural stability when using a cell phone for conversation. The increased fluctuations in postural sway are likely caused by the action of the respiratory muscles during vocalization (Bergamin et al., 2014). For this reason, a higher respiratory frequency may lead to an increase in the CoP_{area} (Hodges et al., 2002). This study also demonstrated that note-taking on a smartphone increased the center of pressure on CoP_y compared to talking on a dynamic platform. In addition, note-taking on a smartphone increased CoP path length compared to not using a smartphone on a dynamic platform. Moreover, notetaking on a smartphone increased CoP_{area} more than without using a smartphone on a dynamic platform. These results may be interpreted as that dynamic balance can be disrupted while note-taking on a smartphone. However, the center of pressure on CoP_x and trunk deviation length were not different for any tasks on either static or dynamic platforms.

It was known that it is crucial to determine the full scope of how smartphone use affects postural control and balance under varying conditions, such as standing and walking, in order to prevent accidents (Orhan et al., 2021). Playing games, texting, browsing the web, and listening to music on a smartphone were found to have a negative impact on dynamic and static balance when the effects of various smartphone features on performance (Orhan et al., 2021). The amount of attentional resources required for a particular task depends on its complexity, according to research by Shumway Cook and Wollacott (Woollacott & Shumway-Cook, 2002). According to Nurwulan et al., texting impairs postural stability and is perceived as more difficult than the control condition (Nurwulan et al., 2015). This study reported that texting increased mean distance, indicating that participants swayed more while performing standing tasks while texting. The significant differences in situations with and without cell phone use while controlling balance may indicate that performing a dual-task activity is perceived as difficult and requires significant mental effort (Nurwulan et al., 2015). Our results were consistent with this study because the texting condition increased CoP_{area} compared with the control condition. Texting as a cognitive task may interfere with the body's orientation in this feedback loop, resulting in more postural sway movements while texting (Strubhar et al., 2015).

In literature, it was reported that texting has a more detrimental effect on balance, gait, and walking behavior than talking on the phone, leading to an increase in postural sway and a decrease in gait velocity, stride length, and cadence (Crowley et al., 2019; Rebold et al., 2016; Simmons et al., 2020). The effects of different tasks on CoP_x and CoP_y in the literature are contradictory. Norris et al. reported that the texting condition increases the postural sway area more than the talking condition in healthy young adults (Norris, 2016). However, Onofrei et al. stated that CoP_x and CoP_y were not different between talking, texting, and control conditions on a static platform; however, the talking condition increased CoP path length and CoP_{area} compared with the texting condition in young adults (Onofrei et al., 2020). Laatar et al. reported that CoP_x, CoP_y, and CoP_{area} increased while using different smartphone functions, such as talking or dialing in young adults on a static platform. They also found that talking conditions increased CoP_{area} more than dialing numbers on a smartphone (Laatar et al., 2017). In our study, only CoP_y results were different between talking, texting, and control conditions. Our results are in accordance with Onofrei et al. and Laatar et al., who also reported significantly wider CoP_{area} during talking than when dialing/texting on a static platform. In addition, the CoP path length result, which is the talking condition in the static platform, increased CoP path length compared with the texting condition in our study, which also supports the results of Onofrei et al. It was known that the combination of texting and talking makes it difficult to maintain balance, which increases the likelihood of falling (Norris, 2016). According to the results of our study, we interpreted that talking and texting conditions increased antero-posterior postural balance and postural sway on the static platform.

According to Kulkarni et al., postural sway changes occurred when texting on a mobile phone. The results of this study demonstrated significant changes in participants' postural sway when using mobile phones. They also reported that sway decreases on a stable surface while increasing on an unstable surface. The difference in postural oscillations between static and dynamic platforms could be attributed to the fact that only the vision was blocked while using the phone on the static platform; however, the postural sway was increased on the dynamic platform because both the visual and somatosensory systems were blocked while using the phone (Norris, 2016). In our study, instead of comparing the effects of dynamic and static platforms on various tasks, we compared the effects on the balance of various tasks performed on static and dynamic platforms, respectively.

In prior research, it was found that individuals' dynamic balance scores decreased significantly when they listened to music, played games, texted, and surfed (Hyong, 2015). The effects of texting on young adults' dynamic balance were examined in a study by Cho et al. The subjects were instructed to text the first couplet of the Korean national anthem in addition to responding to a few brief questions such as “What did you eat for breakfast?”, “What color of pants or shirt are you wearing now?” (Cho et al., 2014). They claimed that using a smartphone could make dynamic postural balance more unstable. Similarly, we asked to text the first two stanzas of the National Anthem of the Republic of Turkey and answer questions such as “What are the names of the professors in your department?”, (2) “Which courses are you taking this semester?”, (3) “Where do you see yourself in 5 years?”. However, according to our results, there were no differences in the stabilometric data except CoP_y between the texting and control conditions on dynamic balance. We only found that texting affects CoP_y negatively more than the talking condition, not the control condition. With this aspect, our study is not fully supported by the literature. The utilization of smartphones among the general population may be a public health concern for contemporary society (Drugus et al., 2017). The limitation of our study is that only young adults were included in the study. Because it may restrict the applicability of the results to an older population.

This study showed that the position of the CoP and postural sway might be impaired during different tasks via smartphone use. However, trunk deviation could be maintained during the tasks. Hence, talking and note-taking on a smartphone may result in increasing falls and accident risks. Future research is needed to assess the impact of smartphone use on other daily activities such as walking, driving, exercising, etc.

Funding

In this research, no financial support was received from any institution or organization.

Disclosure statement

There is no conflict of interest between the authors.

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