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Effect of smart phone using duration and gender on dynamic balance

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ABSTRACT

Smart phones are constantly used for extended periods while looking at the visual display terminals this may causes musculoskeletal problems. So, the purpose of this study was to investigate effect of smart phone using duration and gender on dynamic balance.

***Subjects:** Sixty normal subjects included in this study their age ranged from 20 years to 35 years were divided into three groups, A not using smart phone, B using smart phone less than 4 h per day, C using smart phone more than 4 h per day.*

***Methods:** Biodex Stability System was utilized to assess dynamic balance; 3 trials were performed from which the mean value was calculated.*

***Results:** there is a significant decrease in all balance directions for group B and C (using smart phone) with favor reduction for group C (using smart phone more than 4 h per day) and there is a significant difference between male and female subjects as dynamic balance decreased more in female subjects more than male subjects.*

***Conclusion:** Long duration of smart phone using affect negatively the balance ability especially in females, so we should develop preventive programs to alleviate its negative effects.*

Keywords: Smartphone, using duration, gender, dynamic balance

INTRODUCTION

In the last few years, smartphone users number have progressively increased worldwide [1]. With the increasing use of smartphone, researchers have also enhanced to investigate the musculoskeletal problems associated with the prolonged use of smartphone. Recent studies have shown that smartphone users attend to have pain in the neck, and upper limb, and as the time of the Smartphone using increases the severity of the symptoms increases [2]. Prolonged use of smart phone lead to musculoskeletal problems due to faulty posture of the user such as forward neck posture, rounded shoulders, or slouched posture [3]. Prolonged forward neck posture can lead to injury to the structure and ligaments of the cervical and lumbar spine [4,5]. These structural problems caused by faulty posture can also lead to decrease proprioception and so decrease balance ability.

Smart phones are used frequently in daily life, and affect users both physically and psychologically. Longer duration of smart phone using causes continuous mechanical stress on the muscles and tendons, which can produce musculoskeletal symptoms as pain in the neck and shoulders due to increased stress caused by a continuously forward neck posture [6-8]. 18.8% of the subjects have musculoskeletal symptoms at least at one of body parts. Specifically, 8.1% of the subjects have musculoskeletal symptoms at neck, 5.6% at shoulder, 4.1% at elbow and 11.3% at hand. The severity of symptoms was also associated with time for daily using of smart phone. The results of the study provided a good basis in order to remove or reduce the risks associated with musculoskeletal symptoms due to duration of smart phone usage [9].

The maintenance of balance is essential in the prevention of injuries and this ability depends on proprioceptive input from mechanoreceptors in the capsule, ligament, muscle, and tendon, in addition to vestibular and visual input to the central nervous system [10-12]. This input is used to provide the appropriate neuromuscular response [12,13]. Alterations in any of these inputs would disturb balance and increase the risk of injury [14].

The ability to maintain balance in a static or dynamic situation is the basis for functional activities while performing various ordinary activities [15]. The dynamic balance necessary for functional activities is the result of interaction among the ankle joints, knee joints, hip joints and their surrounding muscles, and shoulder joints and their surrounding muscles. Dynamic balance is also associated with cognitive ability. Unfortunately, smart phone using during walking, such as listening to music, sending a message, web surfing, or playing a game, is considered to affect the dynamic balance ability necessary for functional activities by reducing cognitive ability [16].

Balance ability is measured by evaluating the time taken to maintain a fixed posture or center of gravity (COG) according to postural sway, changes in muscle action potential and joint angle, or motion analysis [17]. Postural sway evaluation is most excessively used for testing balance control and provides information on sensory changes during vision block or according to changes in standing surface, this measurement allows to determine balance control based on sway of COG of the body [18]. Muscle activity is increased, when the COG of the body change from its normal position, to recover from this unstable position [19].

Regarding gender, the findings are conflicting. In many studies, it has been found that girls have higher scores than boys even at the preschool age, on balance tasks [20-25]. On the other hand, several researchers revealed no significant differences between boys and girls in balance ability [26-29]. So, the aim of our research was to investigate effect of smart phone using duration and gender on dynamic balance ability.

MATERIALS AND METHODS

Design of the study

Cross sectional observational study. The study was carried out in the Balance Laboratory at Faculty of Physical Therapy, Cairo University in the period from June 2016 to September 2016 to investigate the effect of smart phone using duration and gender on dynamic balance.

Ethical considerations

This study was approved by the Faculty of Physical Therapy Ethical Committee under unique identification number for the study is P.T.REC/012/001372. Before participating in this study, the aims were explained to all subjects and they signed a confirmed consent form before participation in the study.

Subjects

Sixty normal subjects from faculty of physical therapy were included in this study, their age ranged from 20 to 35 years. All subjects were healthy, the subjects were excluded from the study if they had auditory, visual, or perceptual deficits, deformities of the lower limbs and spine, surgical operations in the lower limbs, deep sensory loss, history of epilepsy, history of cerebral concussions, diabetic or smoker, and any diseases affecting balance and neuromuscular control.

Subjects were divided into 3 groups. Group A, 20 subjects 10 males and 10 female subjects not using smart phone. Group B, 20 subjects 10 males and 10 female subjects using smart phone less than 4 h per day. Group C, 20 subjects 10 males and 10 female subjects using smart phone more than 4 h per day.

Biodex stability system (BSS)

The device used in this study (Biodex Medical Systems Inc., Shirley, New York, USA) was a foot platform (circular in shape with a diameter of 21.5′ and a height of 8′ above the floor, which permits up to 20° tilting from horizontal in all directions), support rails that were adjustable from 25′ to 36.5′ above the platform, and could be swung away if desired, a display module whose height was adjustable from 51′ to 68′ above the platform and angle was adjustable from vertical back to 45°, with a display viewing area of 122 mm × 92 mm and a display resolution of 320 pixels × 240 pixels, and a printer. This testing machine with a multiaxial standing platform, allowing up to 20° of surface tilt, creates a dynamic situation similar to actual functional activities that result in instability.

BSS has eight stability levels dynamic postural stability measures can vary depending on the adjustment level of the Biodex platform. Shaking of the platform is the most on the 1st stage which has the highest instability, and the shaking is the least in the 8th stage which has the highest stability. In the present study, 7th stage was utilized, 3 trials were performed, from which the mean value was calculated.

Dynamic balance measurement procedure

Each participant received a verbal explanation about the test steps. The weight and height of the participant were recorded. Each subject stands upright posture looking forward on the center of the "locked" platform with arms relaxed beside his body and assuming comfortable erect posture. The subject's weight, height, and age were entered in the balance Biodex system, the subject's eyes were open. The subject was asked to stand on the locked platform. Then the platform was unlocked and display screen showed a circle with a central cursor. The subject was tried to be in centered position by shifting his feet position and correspondingly the cursor. Once centering was achieved and the cursor was in the center of the display screen, each subject was instructed to maintain his feet position constant until the end of the testing procedures. Then we locked the platform. Then we recorded feet angles and heels coordinate from the platform. After introducing feet angles and heels coordinate into the BBS, the test then began. As the platform advanced to an unstable state, the subject was instructed to focus on the visual feedback screen directly in front (while standing with both arms at the side of the body without grasping the handrails) and attempt to maintain the cursor in the middle of the bull's eye on the screen. At the end of each test trial, a print copy of report was obtained by the printer.

Data analysis

All statistical measures were performed through the statistical package for social studies (SPSS) version 19 for windows. Descriptive statistics and t-test were used for comparison of the mean age, height, weight, and body mass index "BMI" between both groups. Analysis of Variance "ANOVA" test was used to investigate duration effect of using smart phone on dynamic balance in both gender. The level of significance for all statistical tests was set at $p<0.05$. followed by least significant difference test for comparisons in case of significance. The level of significance for all statistical tests was set at P-value less than 0.05. The sample size estimation was based on power analysis in a pilot study with 15 subjects (mean difference 26.87 and SD 5.64). G*power 3.1 software (University of Dusseldorf, Dusseldorf, Germany) was used in the present study. With power 80% and probability 0.05.

RESULTS

Base line and demographic data

There were no statistically significant differences between subjects in all groups concerning age, weight, height, BMI ($p>0.05$) as shown in Table 1. There was a significant decrease in stability index, anteroposterior and mediolateral balance in groups B and C in comparing with group A subjects $p<0.0001$, this significant reduction in favour of group C. This significant reduction of balance in dynamic balance measures in female subjects in group B, C more than male subjects $p<0.0001$ as presented in Table 2. Least significant difference test indicates there was significant difference between male and female in dynamic balance in all direction as shown in Tables 3-5.

DISCUSSION

The results of this study showed that there is a significant decrease in all balance directions for group B and C (using smart phone) with favor reduction for group C (using smart phone more than 4 h per day) and there is a significant difference between male and female subjects as dynamic balance decreased more in female subjects more than male subjects.

Table 1 General characteristics of subjects in the study groups

General characteristics		Age (years) Mean ± SD	Weight (kg) Mean ± SD	Height (cm) Mean ± SD	BMI (kg/m²) Mean ± SD
Group A	F	27.8 ± 3.85	63 ± 10.8	163.4 ± 8.4	23 ± 1.8
	M	25.2 ± 3.73	60.6 ± 6.7	161.6 ± 6.9	22.6 ± 1.1
Group B	F	30.4 ± 5.9	64.2 ± 6.3	163 ± 6.4	23.8 ± 0.8
	M	28 ± 5.33	63.8 ± 8.6	163.8 ± 7.5	23.6 ± 1.7
Group C	F	27.8 ± 4.82	56 ± 7.7	159.8 ± 4.7	21.6 ± 2.4
	M	27.8 ± 4.82	62.8 ± 6.5	164.2 ± 6.15	23 ± 1.8
Comparison	F-value	1.398	1.49	0.642	1.567
	p-value	0.24	0.207	0.669	0.185
Significance		NS	NS	NS	NS

SD: standard deviation, P: probability, NS: non-significant

Table 2 Results of ANOVA among the groups for stability index, anteroposterior and mediolateral balance

Balance		Stability index Mean ± SD	Anteroposterior Mean ± SD	Mediolateral Mean ± SD
Group A	F	1.5 ± 0.24	1.1 ± 0.1	0.78 ± 0.13
	M	1.1 ± 0.34	1.14 ± 0.05	0.88 ± 0.12
Group B	F	2.62 ± 0.57	2.34 ± 0.45	1.68 ± 0.36
	M	2.2 ± 0.21	1.9 ± 0.33	1.46 ± 0.11
Group C	F	4.48 ± 0.41	3.4 ± 0.45	2.6±0.4
	M	3.52 ± 0.33	2.9 ± 0.34	2.54 ± 0.35
Comparison	F-value	131.47	79.49	78.08
	p-value	0	0	0
Significance		S	S	S

SD: standard deviation, P: probability, S: significant

Table 3 LSD test between groups for stability index

Stability index		Mean difference	p-value	Significant
LSD	Group AF vs. Group BF	-1.12	0	S
	Group AF vs. Group CF	-2.98	0	S
	Group BF vs. Group CF	-1.86	0	S
	Group AM vs. Group BM	-1.1	0	S
	Group AM vs. Group CM	-2.42	0	S
	Group BM vs. Group CM	-1.32	0	S

Table 4 LSD test between groups for anteroposterior

Anteroposterior index		Mean difference	P-value	Significant
LSD	Group AF vs. Group BF	-1.24	0.789	NS
	Group AF vs. Group CF	-2.3	0	S
	Group BF vs. Group CF	-1.06	0	S
	Group AM vs. Group BM	-0.76	0	S
	Group AM vs. Group CM	-1.78	0	S
	Group BM vs. Group CM	-1.02	0	S

S: significant NS: non-significant

Table 5 LSD test between groups for mediolateral

Mediolateral index		Mean difference	p-value	Significant
LSD	Group AF vs. Group BF	-0.892	0.466	NS
	Group AF vs. Group CF	-1.812	0	S
	Group BF vs. Group CF	-0.92	0	S
	Group AM vs. Group BM	-0.58	0	S
	Group AM vs. Group CM	-1.66	0	S
	Group BM vs. Group CM	-1.08	0	S

S: significant NS: non-significant

Smart phone is used at anytime and anyplace as it is easy to carry and use. Smart phone use in a static position and with an unsupported arm could bring about abnormal alignment of the neck and shoulders. Because smart phones have small monitors that are typically held downward near the laps, users must bend their heads to see the screens, increasing activity in the neck extensor muscles overloading the neck and shoulders increases muscle fatigue, decreases work capacity, and affects the musculoskeletal system [30,31]. Using smart phones for long duration of time cause repetitive use of certain muscles, resulting in muscle fiber injury, and cumulative damage from acute trauma, to the muscles of neck and shoulders [32].

Furthermore, smart phone users are vulnerable to having severe musculoskeletal disorders as the duration of using increased, the symptoms of which can include fatigue and pains in the upper extremities, such as the neck, shoulders, arms, wrists, back of the hand, and fingers, in addition to pain in the waist. repeated static motion of the users decreases blood circulation, prevents nutrients from being supplied to muscles, and lead to small amounts of pain and fatigue. The musculoskeletal problems that often occur are caused by repeated motions and minimal muscle tension of the subject due to long hours of using smart phone. In addition, poor postures lead to fatigue, which can have negative effects, such as reduced physiological function, disruption of the autonomic nervous system, creation of problems in daily life, and affects both the visual and the musculoskeletal systems, leading to headaches and stress [3,33]. Revel, et al. [34] study concluded that neck pain and muscle tension can change the sensitivity of neck proprioception, which affect dynamic balance ability. The musculoskeletal problems related to using of smart phone include muscle fatigue and increase loading of the neck and shoulder muscles, due to the repeated motions of hands, wrists, and arms [35-37].

Schieppati, et al. [38] studied the effects of cervical muscle fatigue on balance during quiet upright stance on 18 healthy subjects, the results support the fact that fatigue of cervical muscular affects balance as fatigue causes decrease in the dynamic postural balance ability. The first explanation was that balance is controlled by the CNS through the integration of sensory information from the vestibular, somatosensory, and visual systems and when the muscles that control balance are fatigued, these systems would be affected, thus inhibiting proper balance control [39]. Second explanation, muscle fatigue enhances the muscle spindle discharge, which obstructs the afferent feedback input to CNS that causes alterations in proprioceptive and kinesthetic properties of joints, which has a negative effect on postural control ability [40-52].

Gandevia [53] and Gosselin, et al. [54] studies showed that the main cause of changing balance following isometric contraction of neck muscle appears to be proprioceptive interference and may be central fatigue which in turn increases the velocity of sway during quiet stance. Another researchers suggested that fatigue of sub-occipital muscles could alter balance due to the activation of tonic gamma motor neurons due to build-up of metabolites during muscle contraction. The consequence of such an accumulation (of K^+, arachidonic and lactic acids) lead to advancement of group III and IV afferent signals, leading to positive feedback and more excitation of muscle spindles and gamma motor system hyperactivity [55-58].

Our results agree with Hyounk [16] and Sung-Hak, et al. [59] they found the use of smart phone can increase the instability of dynamic postural balance which can be a cause of full or injury.

Also, our results revealed that increase duration use of smart phone increase its negative effects due to faulty posture, pain, and muscle fatigue. These results supported by studies conducted by Kim and Koo [60], Hyo-Jeong and Jin-Seop [61], Um [62], and Berolo, et al. [2] as they found that pain and muscle fatigue increased with longer duration of smart phone use.

Corresponding difference between male and female subjects our results revealed that females are more affected than males as muscle strength of males who are involved in more physical activity increases, which affects their balance performance positively and this results agreed with Oya, et al. [63] the results have shown that bilateral and unilateral balance ability of boys were better than the girls. In contrast Fotini and Antonis [64] found no difference between male and female subjects in balance tasks.

The limitations for our study may be small sample, assessment of dynamic balance only. So, our recommendation to apply further studies on both dynamic and static balance, examine changes in muscle activity and biomechanics due to long duration use of smart phones.

CONCLUSION

The result of this study showed that prolonged duration of using a smart phone could negatively affect dynamic balance ability, and there is a significant difference between male and female subjects, as female subjects had significantly decreased dynamic balance ability. These results may be used to promote awareness about smart phone using duration and developing programs to decrease its effects on balance ability especially female subjects.

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