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The effect of smartphone use in different body positions on upper limb kinematic variables

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ABSTRACT

This study aimed to identify the values of certain kinematic variables during smartphone use in different body positions and to examine the differences in these values across positions. An analytical descriptive method was employed on a sample of 20 sports activity students from Tafila Technical University (age 20 ± 0.6 years; height 175 ± 2 cm; mass 70 ± 2kg). The study sample was videotaped using a Panasonic video camera at 50 frames per second in three different positions: sitting, standing, and walking. The video data were analyzed using the Kinovea program (version 0.8.27 x64). The results showed a large head flexion angle and a notable distance between the smartphone and the head. Furthermore, statistically significant differences ($p < 0.05$) were observed in the distance between the smartphone and the head and in the elbow angle, particularly favoring the sitting position. In contrast, no statistically significant differences were found for the head flexion angle and other study variables ($p > 0.05$), except for the elbow angle in the sitting position ($p < 0.05$). Smartphone use has been associated with negative effects that increase the load on the neck muscles and upper limbs, potentially leading to neck and shoulder pain as well as increased spinal curvature.

KEYWORDS

Kinematic Variables; Smartphone; Head Flexion; Sitting; Walking

1. INTRODUCTION

Technology has dominated modern human life, and smartphone users spend much time checking emails, making calls, and browsing social media; this excessive use often leads to the appearance of what is known as the text neck, and it is a frequent injury from stress and pain caused by excessive viewing or writing text messages on smartphones for extended periods (Fishman, 2015; Gupta et al., 2013; Park et al., 2015; Hansraj, 2014). Noting that technology is a global phenomenon that has changed how leisure activities are managed, communication, and work (Chany et al., 2007). Studies suggest that (79) % of adults suffer from text neck (Kenneth, 2017). Furthermore, smartphone users while looking at the screens of these phones are putting their heads forward and down, so the head flexion for long periods increases the load on the Cervical vertebrae, so the head flexion (15) ° increases this load by (12 (Kg) and the head flexion (30) °) increases by (18) kg and finally the head flexion (45) ° Increases this by (22) kg (Kenneth, 2014; Hansraj, 2014). This problem is further exacerbated in children because the proportion of the head mass to the body is greater than that of adults, where studies indicate that using smartphones for two hours a day increases the risk of a text neck injury by 90% (Hakala, 2005). Frequent neck flexion for long periods is a risk factor for muscle and bone disorders (Ariens et al., 2002; Andersen et al., 2003).

In mechanical and structural terms, the neck is very complex because it contains blood vessels, nerves, cervical vertebrae, and the spinal cord, so the use of smartphone screens for long periods leads to increased mechanical load on the joints and ligaments in the column Cervical, as well as a risk factor for the neck pain injury (Lee et al., 2015). Looking down for long periods with the head dropping forward changes the natural curvature of the cervical spine region, leading to muscle strain and effects on the discs between the vertebrae (Bababekova et al., 2011). Recently, there has been an interest in the safety risks associated with writing text messages in different situations, such as walking and sitting (Schwebel et al., 2012). Studies have shown that the prevalence of shoulder pain among smartphone users (46-52) % and (68) % for neck pain (Berolo et al., 2011). In addition, more than (40) % of smartphone users suffer from neck pain (Shan et al., 2011). In addition, 62.3% of smartphone users suffer from neck or shoulder pains (Lane, 2015). Kim (2015) stated that (38) % of smartphone users suffer from repeated neck pain, as well as a correlation between the severity of the neck pain and the phone use time. In addition, there is a correlation between the writing of messages and the symptoms reported in the neck and the upper limbs (Gustafsson et al., 2017). Times Reporter (2017) stated that the head flexion in the standing position is more significant than in the sitting position. The results of a remarkable study indicated that the number of text messages per month in the US reached 12.5 billion in (2006) and this number has now increased to (196.9) billion per month (Hae-Jung, 2016).

With the tremendous technological advances and the emergence of pain associated with human behaviors, there is an urgent need to educate smartphone users about the problems caused by the excessive use of these phones. Therefore, the objectives of this study are to identify the values of certain kinematic variables while using a smartphone in different body positions, and to examine the differences in these values across positions. In addition, the study aims to investigate the relationships between body height and head flexion angle, elbow angle, and the distance between the smartphone and the head

2. METHODS

2.1. Design and Participants

A descriptive approach has been applied to (20) students of sports activity at Tafila- Technical University (age 20 ± 0.6 years; height 175 ± 2 cm; mass 70 ± 2kg). The coefficient of variation differs from the homogeneity of the performance of the study sample members of the variables shown. It is known that the coefficient of variation refers to the ratio of the standard deviation to the mean. The preferred values of the difference coefficient are usually less than 50%. A review of the anthropometric values of the study sample showed the highest value (7.50) % for the age variable. Since this value is very meager, it can be concluded that the sample of the study sample is homogeneous in these variables.

The participants' rights were protected by explaining the purpose and significance of the study. They were informed that their participation would remain anonymous and their privacy would be respected. They were provided with a comprehensive explanation that their involvement in the study was voluntary and that they could withdraw at any time. Approval was obtained from all the participants.

2.2. Procedure and Measurements

The study sample was videotaped by using a (Panasonic) video camera reaching speed (50) frame/s in (3) different modes of the body (sitting, standing, walking); this camera was placed (5) m lateral from the student. In addition, the vertical height of the camera from the ground was (120) cm. Each student browses the smartphone from (3) different body situations so that the total number of attempts is (60). Additionally, the other is placed vertically behind the player and on the front. Furthermore, A (60) attempts were analyzed using the Kinovea kinetic analysis program (0.8.27 x64).

The study examined the following variables: the angle of head flexion (°), the angle between the head imaginary line, and the horizontal imaginary line of the ground. The elbow angle (°) is the angle between the imaginary line from the shoulder to the elbow joint and the imaginary line from the elbow to the wrist joint. Distance between the smartphone and the head (cm), the horizontal displacement from the eyes to the smartphone screen.

2.3. Statistical Analysis

For statistical processing of study data, the means, standard deviations, One-way ANOVA, Pearson correlation coefficient, and Chi-Square using SPSS statistical software (Version 23; SPSS, Chicago, IL, USA), with a significance level of 0.05.

3. RESULTS

The descriptive statistics of the kinematic variables while browsing the smartphone are presented in Table 1:

Table 1. Descriptive statistics of the kinematic variables in different positions of the body (n=20)

Kinematic variables	Body position	Mean	SD
Distance between the smartphone and the head/ cm	Sitting	41.68	7.79
	Standing	33.97	7.14
	Walking	34.19	6.87
The angle of head flexion/°	Sitting	33.18	11.89
	Standing	37	9.43
	Walking	33.26	10.78
Elbow angle/ °	Sitting	86	18.96
	Standing	99	12.33
	Walking	88	12.65

Table 1 showed that the distance between the smartphone and the head was greatest while sitting (41.68 cm) and smaller when standing (33.97 cm) or walking (34.19 cm). The head flexion angle was slightly higher when standing (37°) compared to sitting (33.18°) and walking (33.26°). The elbow angle was largest when standing (99°) and smaller while sitting (86°) or walking (88°). These results indicate that body position affects the distance and joint angles during smartphone use

In the following the One-Way ANOVA test results show that the distance between the smartphone, the head variable, and the elbow angle significantly differed between different body positions ($p < 0.05$) (Table 2).

Table 2. Results of One-Way ANOVA in different positions of the body (n=20)

Kinematic variables	Variation Source	Sum of Squares	df	Mean Square	F	p value
Distance between the smartphone and the head/ cm	Treatment	771.04	2	385.52	7.28	0.002*
	Error	3016.85	57	52.93		
	Total	3787.90	59			
The angle of head flexion/°	Treatment	189.63	2	94.82	0.82	0.445
	Error	6586.97	57	115.56		
	Total	6776.61	59			
Elbow angle/ °	Treatment	1867.86	2	933.93	4.17	0.020*
	Error	12756.49	57	223.80		
	Total	14624.35	59			

Results of Scheffe's test show the benefit of any situation of the body positions returns these differences (Table 3).

Table 3. Results of Scheffe's test for the posterior comparisons according to body position

Kinematic variables	Mean	Body position	Standing	Walking
Distance between the smartphone and the head/ cm	41.68	Sitting	*	*
	33.97	Standing		
	34.19	Walking		
Elbow angle/ °	86	Sitting	-*	*
	99	Standing		
	88	Walking		

*Note. * Significant (p<0.05)*

Table 3 indicated significant differences in the distance between the smartphone and the head, as well as the elbow angle, across different body positions. Specifically, the distance was significantly greater when sitting compared to standing and walking. Similarly, the elbow angle was significantly larger when standing than when sitting or walking ($p < 0.05$).

Table 4. Correlation between the angle of head flexion and other study variables

Relationship parties	Body position	Relationship value	p value
The angle of head flexion and height of the body	Sitting	0.39-	0.574
	Standing	0.25-	0.387
	Walking	0.31-	0.557
The angle of head flexion and distance between the smartphone and the head	Sitting	.040-	0.108
	Standing	0.37-	0.079
	Walking	0.30-	0.207
The angle of head flexion and elbow angle	Sitting	0.82	0.022*
	Standing	0.15	0.523
	Walking	0.18	0.451

As showed in Table 4, there is a single correlation between the angle of head flexion and elbow angle in the sitting body position (Table 4).

4. DISCUSSION

By reviewing the values means of the kinematic variables under study, the largest distance between the head and the smartphone was reached (41.68) in the sitting position; this means that the angle of the head flexion is lower, as the position of the body during sitting is equilibrium and more stability than other positions, so the smartphone is more stable in the hands users. In addition, while sitting position, the person automatically returns the head because he feels that the goad on the spine is generally low compared to other positions. Thus the user can reduce the degree of head flexion without feeling tired in the cervical vertebrae; this is clearly reflected in the values of the angle flexion means while browsing the smartphone where they were less valuable in a sitting position, where head flexion for long periods increases the load on the cervical vertebrae, so the head flexion (15) ° increases this load by (12 (Kg) and the head flexion (30)° increases by (18) kg and finally the head flexion (45) ° Increases this by (22) kg (Kenneth, 2014; Hansraj, 2014). This problem is further exacerbated in children because the proportion of the head mass to the body is greater than that of adults, where studies indicate that using smartphones for two hours a day increases the risk of a text neck injury by 90% (Hakala, 2005). Frequent neck flexion for long periods is a risk factor for muscle and bone disorders (Ariens et al., 2002; Andersen et al., 2003). Times Reporter (2017) stated that the head flexion in the standing position is more significant than in the sitting position. Also, using the smartphone while standing increases the load on the hand muscles. The user lowers the hand down to reduce the load on the hand muscles, compensating for increasing head flexion to make smartphone browsing more accessible, and this was evident by the distance between the smartphone and the head, which reached the highest value in the standing position (99) cm.

By comparing the values of the significance level in the analysis of the kinetic variables in the One-Way ANOVA test while browsing the smartphone according to the different body positions, it was found to be (0.002) for the head flexion and the elbow angle, which is less than (0.05) depending on the position of the body while browsing in the smartphone, this means there are differences in these two variables while browsing the smartphone depending on the body position. The Scheffe test for the posterior comparisons of the kinematic variables according to the body position variable during the smartphone browsing showed that the preference was for the sitting position through the mean values of these variables. It can be noted here that the sitting position allows the users to have more excellent head balance and stability than the other positions, which is evident by the sitting position having the lowest head flexion angle while sitting, the users automatically return the head because they feel less load on the cervical vertebrae comparison to other positions, so the user can reduce the angle of head flexion without feeling fatigued in the cervical vertebrae, and most smartphone users would like to support the elbow joint on thigh while browsing the smartphone in the sitting position.

The results of the study showed that there is no statistically significant correlation between the head flexion angle and the height of the body in the different conditions of the body because the values of the significance level were more significant than (0.05) concerning the value of the most significant relationship between these two variables were sitting position (-0.39). In addition, it should be noted that the values of these relations were negative, which means that the higher body height was accompanied by the lower angle of the head flexion and vice versa. This can be explained by the fact that body height is linked to the length of the limbs, and the higher the body height, the longer the limbs. Therefore, the arm's length of the tall user is taller than the short person; this results in the user being able to reduce the distance between the smartphone and the head, thus reducing the angle of the head flexion. There was also no statistically significant relationship between the head flexion angle and the distance between the head and smartphone according to the body position variable, with reference that the values of these relationships were negative, which means that the less distance between the smartphone and the head accompanied by the lower angle of the head flexion and vice versa and it is a logical relationship as the user in the sitting position reduces the head flexion angle while browsing the smartphone.

A correlation between the head flexion angle and the elbow angle shows a statistically positive correlation between these variables when the smartphone is being browsed (0.82), which is a logical result in the sense that the lower elbow angle accompanied by, the lower angle of the head flexion and vice versa, also the other relationships were no statistically insignificant because the significance level was less than (0.05). In addition, the smartphone user is more stable in sitting than in other positions (walking and standing). Thus, the user lowers the hand into these positions to reduce the load on the hand muscles, and therefore, the elbow angle becomes more considerable. In addition, the body is more stable and balanced in sitting than in other positions.

5. CONCLUSIONS

Smartphone use has been associated with negative effects that increase the load on the neck muscles and upper limbs, potentially leading to neck and shoulder pain as well as increased spinal curvature. Increased head flexion, a considerable distance between the head and the smartphone, and a larger elbow angle while using the smartphone are risk factors for musculoskeletal disorders. These findings highlight the need to follow certain precautions, such as keeping the head vertically aligned with the shoulders and following the 20-20-20 rule: every 20 minutes, the user should take a 20-second break by looking at an object 20 feet away. Additionally, users should hold the smartphone at eye level to prevent forward head flexion

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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