The Effect of Smartphone Usage on the Upper Extremity Performance among Saudi Youth, Kingdom of Saudi Arabia

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Abstract: The current study aims to investigate the effect of smartphones usage on the upper extremity performance among Saudi youth. A goniometer to measure the Range of Motion (ROM), the Smartphone Addiction Scale (SAS), McGill Pain scale and Chattanooga stabilizer were used to perform the current study on a sample of 300 university students from Al-Imam Mohammed bin Saud University. Results had shown that smartphone addiction is negatively correlated to the elbow flexion, shoulder flexion, shoulder extension, shoulder abduction, shoulder adduction, and both shoulder internal and external rotation. Furthermore, results had shown that McGill pain scores were positively correlated to elbow flexion, shoulder flexion, shoulder extension, shoulder abduction, shoulder adduction, and both shoulder internal and external rotation. The study had concluded that smartphone usage among Saudi youth is negatively affecting the upper extremity and causing a significant increase in the pain intensity. The study had recommended that there is an urgent need for a significant awareness campaign to warn the community regarding the impact of using smartphones for long periods of time.

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1. Introduction:

Smartphones are considered as the natural evolution of computers, which have contributed significantly to reduce the popularity of these devices after several decades of dominance. Smartphones had pushed the path towards the development of tablet PCs, which is a compromise between a smartphone and personal computers (Sarwar & Soomro, 2013).

Smartphones differ from traditional phones in that it provides a number of functions, advanced computing capabilities and advanced communication along with other traditional phone functions (Mokoena, 2012).

Smartphones evolve day after day, their capacities and capabilities are increasing spectacularly, some of these phones had become equipped to use the fingerprint, for example, as a kind of safety to unlock the phone. On the other hand, some of them use the technique of the eyes movement, to surf the internet or view the images by just performing an aerobic pointing by the hand (Shahzad *et al*., 2013). In general, almost all the functions of the smartphones require the individuals to stare sharply downwards or to hold their arms out in front of them to view the screen (AlAbdulwahab *et al*., 2017).

Smartphones utilization is growing exponentially in the world, especially in Saudi Arabia (Poushter, 2016).

According to a study performed by Nielsen Holding, it had been indicated that about 67% of the Kingdom population above sixteen years old use a smartphone. Investigating the youth category, the study reported that 73% are using smartphones are under the age of 15. In a study conducted by Alhassan *et al.* (2015) it had been indicated that 52.7% of the males and 46.9% of the females ranging in age between 18 and 23 are addicted on using smartphones. In a more recent study conducted by Alosaimi *et al.* (2016), it had been reported that 27.2% of the individuals ranging in age between 20 to 24 are using their smartphones more than 8 hours (Holdings, 2017).

Several studies had examined the impact of smartphones on the musculoskeletal system. For example, Alabdulwahab *et al.* (2017) had performed a cross-sectional study entitled as " smartphone use addiction can cause neck disability" that aimed to identify the level of smartphones addiction and its correlation to the neck function. The study sample was composed of 78 healthy young adults that were subjected to a Smartphone

Addiction Scale (SAS) and Neck Disability Index (NDI). Findings showed that there is a strong association between smartphone use and different degrees of neck problems among the participants (Alabdulwahab *et al.* 2017).

Earlier in 2011, Berolo *et al.* had conducted a study that aimed to investigate the musculoskeletal symptoms among mobile hand-held devices users and their relationship to device users. The study sample was composed of 140 university students, staff and faculty members. Results had shown that 84% of the study participants reported pain in at least one body part. The right-hand pain was most common at the base of the right thumb. Moreover, there was a strong association between the total time spent using a mobile device and neck pain and the right shoulder and (Berolo *et al*., 2011).

In a retrospective study conducted by Sharan *et al.* (2014), that aimed to describe the risk factors and clinical features of the musculoskeletal disorders arising due to the use of hand-held devices, the study sample was composed of 70 subjects characterized by having musculoskeletal disorders affecting the upper extremities. Results had shown that all the study participants reported pain in the thumb and forearm with associated burning, numbness and tingling around the thenar aspect of the hand. The study had reported that there is a correlation between mobile design and anthropometry of the user in causing discomfort and fatigue in hand, elbow, and shoulder while using hand-held devices (Sharan *et al*., 2014).

Although there is a number of studies investigating the impact of hand-held devices on the musculoskeletal system, still there is a clear shortage of data and responses regarding their impact. Studies had been varied among the cross-sectional, retrospective and experimental designs, which indicates the absence of a fixed research approach to achieve the study aim of identifying the musculoskeletal disorders resulted from hand-held devices.

Furthermore, the majority of the studies did not include a rehabilitation protocol that could help the individuals to recover completely from the symptoms of the musculoskeletal disorders.

In the context of Saudi Arabia, there is a clear shortage of studies and data insufficiency regarding the musculoskeletal disorders caused by using the hand-held devices.

In the light of the studies shortage, the current study was conducted to identify the impact of smartphone devices on the musculoskeletal disorders among a randomly selected sample of the community members varying in age range. Moreover, this study will contribute efficiently in enriching the available literature review concerning the musculoskeletal disorders due to the usage of smartphones as it is a growing problem that has a large impact globally.

Finally, the ongoing study proposes an effective sequenced rehabilitation program that helps in the recovery of the affected individuals.

The current study aims to investigate the effect of the smartphones usage on the upper extremity performance among Saudi youth.

2. Methodology:

2.1. Research design

A cross-sectional study- observational study

2.2. Study setting

Al-Imam Mohammed Bin Abdul Aziz University.

2.3. Study Subject

The study sample was 300 students enrolled at Al-Imam Mohammed Bin Saud University. Inclusion criteria were the following: Students enrolled in Al-Imam Mohammed Bin Saud University, Acceptable level in English (Speaking, reading, and writing) Age 18 – 25, and Voluntary participation. **Exclusion criteria were** Nonstudent individuals and Pregnant females. The study was performed under the institutional research and ethics committee

2.4. Study instruments

2.4.1. Goniometer

A goniometer is usually made of plastic and is often transparent. Occasionally goniometers are made of metal. There are two "arms" of the goniometer: the stationary arm and the movable arm. Each arm is positioned at specific points on the body and the center of the goniometer is aligned at the joint to be measured.

Steps of using a Goniometer are the following: Align the fulcrum of the device with the fulcrum or the joint to be measured, Align the stationary arm of the device with the limb being measured, Hold the arms of the goniometer in place while the joint is moved through its range of motion, and The degree between the endpoints represents the entire range of motion.

Assessment of elbow range of motion steps is the following: Sitting study participant on a chair, (Arm position): Arms are supported on the table, Shoulder flexion (90 degrees), and Then measure the range of motion.

Assessment of shoulder range of motion (Armestrong *et al*.,1998): Trace arc while reaching forward with the elbow straight (forward flexion), Should be able to move the hand to position overhead - normal range is 0 to 180 degrees, Reverse direction & trace arc backwards (extension), Should be able to position hand behind their back, Direct patient to abduct their arm to a position with the hand above their head, Movement should be smooth and painless, and the normal range is 0 to 180.

2.4.2. The Smartphone Addiction Scale (Kwon *et al.*, 2013)

Assessment will include Duration of smartphone use on a typical day, Frequency of smartphone use on a typical day, Duration of time until first smartphone use in the morning upon waking. The smartphone function with the most personal relevance

Smartphone addiction was assessed using the SAS. 10- item self-report instrument

The SAS addresses the following 5 content areas**:**

daily-life disturbance, withdrawal, cyberspace-oriented relationship, overuse, and tolerance.

2.4.3. McGill Pain Scale (Metzack, 1987)

A scale of rating pain developed at McGill University by Melzack and Torgerson is a self-report questionnaire

How to use: Users first select a single word from each group that best reflects their pain, Users then review the list and select the three words from groups 1–10 that best describe their pain, Two words from groups 11–15, A single word from group 16, and then one word from groups 17–20. Users can use some words more than once

2.4.4. Chattanooga stabilizer pressure biofeedback Muscle isometric contraction

Muscle isometric contraction was tested with Chattanooga stabilizer pressure biofeedback.

The participant was tested while moving the upper limb, the therapist will resist the movement using the stabilizer with his arm against the wall to prevent the substitution of the subject

2.4.5. Statistical analysis

Data were presented as a mean and standard deviation, minimum and maximum values. Spearman and Pearson correlation coefficients were used for assessing the relationship between different variables

3. Results:

Results shown in Table 1 represents the mean and standard deviation scores of the study variables

Table 1: *The mean and standard deviation scores of the study variables*

Variable	Mean	Standard deviation
Elbow flexion	133.33	19.84
Elbow extension	3.76	5.12
Shoulder flexion	164.55	7.34
Shoulder extension	42.24	7.35

Results show that the mean score for the elbow flexion was 133.33±19.84, for the elbow extension was 3.76±5.12, for the shoulder flexion was 164.55±7.34 and for the shoulder, the extension was 42.24±7.35.

Table (2) shows the Spearman's rho correlation factor values between the participants BMI and their elbow flexion, extension, and shoulder flexion and extension

Results show that:

BMI is negatively correlated to elbow flexion (-0.159), shoulder flexion (-0.342) and shoulder extension (-0.235).

There is a weak positive correlation between participants' BMI and their elbow extension (0.011)

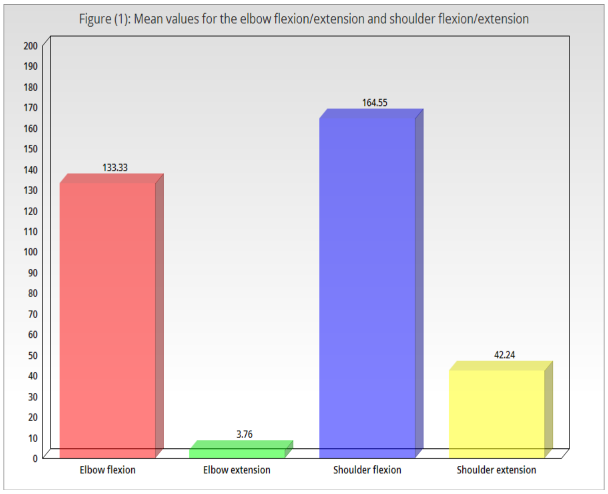
Table 2: *Spearman's rho correlation results*

	BMI	Elbow flexion	Elbow extension	Shoulder flexion	Shoulder extension
BMI	1.00	-0.159	0.11	-0.342	-0.235

Correlation between elbow flexion/extension and shoulder flexion/extension to the smartphone addiction scale and McGill pain scale

Table 3: *Spearman's' rho correlation coefficient values among smartphone addiction, pain intensity, and elbow shoulder and wrist ROM.*

Measurement	Smartphone Addiction	McGill pain score
Elbow flexion/extension	-0.146	0.206
Shoulder Ext/Flex	-0.107	0.137



Results presented in table 3 indicate that smartphone addiction is negatively correlated to the elbow flexion, elbow extension, shoulder flexion and shoulder extension.

On the other hand, results indicate that McGill pain responses had been positively correlated with the elbow flexion/extension and shoulder flexion/ extension. Measurements of the shoulder abduction, adduction, internal and external rotation had yielded mean score equals to 165.6, 11.3, 83.4 and 84.2, respectively.

Table (4): Mean and standard deviation values for the shoulder abduction, adduction, internal and external rotation

	Mean	Standard deviation
Shoulder abduction	165.6	19.9
Shoulder adduction	11.3	7.00
Internal rotation	83.4	4.8
External rotation	84.2	13.1

Investigation of BMI correlation to the shoulder abduction, adduction, internal and external rotation had shown that BMI is negatively correlated to the shoulder abduction and external rotation, while it was positively correlated to the shoulder adduction and the internal rotation Table 4.

Table (5): correlation coefficient values among BMI and the wrist flexion/ extension, and ulnar/radial deviation

	BMI
Shoulder abduction	-0.087
Shoulder adduction	0.074
Internal rotation	0.374
External rotation	-0.052

Results shown in table 3 indicates that smartphones addiction is negatively correlated to Shoulder Abdu/Add and Shoulder In/Ex rotation.

On the other hand, McGill pain score was positively correlated Shoulder Abdu/Add and Shoulder In/Ex rotation measurements (Table 6).

Table 6: *correlation coefficient values among smartphone addiction, pain intensity, and elbow, shoulder, and wrist ROM*

Measurement	Smartphone Addiction	McGill pain score
Shoulder Abdu'/Add'	-0.213	0.183
Shoulder In/Ex rotation	-0.171	0.246

Findings shown in table 7 indicate that 65% of the study sample were within the addicted category, while 35% of the female students were within the non-addicted smartphone users.

Mean and standard deviation scores had shown that the total SAS score for addicted users was 38.31±3.16. on the other hand, the total SAS score for the non-addicted user was 22.71±1.29.

Table 7: *total score of SAS responses*

	N	%	Mean	SD	Total SAS score
Addicted users	13	65%	1.22	0.73	38.31±3.16
Non-addicted users	7	35%	1.01	0.39	22.71±1.29

Results shown in table 8 indicates that there is a significant positive correlation between smartphones and shoulder abduction among the study participants.

Table 8: *correlation coefficient values among SAS scores and ROM of shoulder and elbow.*

	Shoulder flexion	Shoulder extension	Shoulder abduction	Shoulder adduction	Shoulder external rotation	Shoulder internal rotation	Elbow flex
SAS	0.22448	0.11094	0.45852*	0.10415	0.2719	0.01992	0.09088
	Elbow extension	Wrist flexion	Wrist extension	Wrist radial deviation	Wrist ulnar deviation	BMI	MA
SAS	0.24931	0.3622	0.17414	0.12911	0.18811	0.16629	0.24669

Measurements of the wrist flexion, extension, ulnar deviation and radial deviation had yielded mean score equals to 72.85, 68.93, 42.56 and 31.60, respectively. Investigation of BMI correlation to the wrist flexion/ extension and ulnar/radial deviation had shown that BMI is negatively correlated to the wrist flexion, extension, ulnar deviation and wrist radial deviation (Table 9).

Table 9: *Mean and standard deviation values for the wrist flexion/ extension, and ulnar/radial deviation.*

	Mean	Standard deviation
Wrist flexion	72.85	28.95558
Wrist extension	68.93	16.77814
Ulnar deviation	42.56	7.5893249
Radial deviation	31.60	8.503987

Table 10: *correlation coefficient values among BMI and the wrist flexion/ extension, and ulnar/radial deviation.*

	BMI
Wrist flexion	-0.077
Wrist extension	-0.562
Ulnar deviation	-0.261
Radial deviation	-0.264

Results shown in table 10 indicates that smartphones addiction is negatively correlated to wrist flexion, and extension, and both ulnar and radial deviation.

On the other hand, McGill pain score was positively correlated to the previously mentioned measurements.

Table 11: correlation coefficient values among smartphone addiction, pain intensity, and elbow, shoulder, and wrist ROM

Measurement	Smartphone Addiction	McGill pain score
Wrist Flex/Ext	-0.231	0.381
U/R radiation	-0.136	0.163

Results presented in (Table 11) show that study participants were divided into four subgroups according to McGill pain questionnaire responses. Moderate pain group had constituted 45% of the total study sample, followed by Mild pain group that represented 35%, severe pain subgroup (15%), and finally, no pain subgroup which constituted 5% of the total study sample

Table 12: *mean and standard deviation values for the McGill pain questionnaire responses.*

Pain subgroup	N	%	Mean	SD
No Pain	1	5%	0.81	0.39
Mild Pain	7	35%	1.16	0.76
Moderate Pain	9	45%	2.07	0.63
Severe Pain	3	15%	2.89	0.71

Table 12 shows the correlation results among the McGill pain scores and elbow, shoulder and wrist ROM McGill pain score was positively correlated to the Elbow flex/ext., Shoulder Ext/Flex, Shoulder Abdu/Add, Shoulder In/Ex rotation, and Wrist Flex/Ext (Table 13).

Table 13: *correlation coefficient values among pain intensity, and elbow, shoulder and wrist ROM.*

Measurement	McGill pain score
Elbow flex/ext.	0.206
Shoulder Ext/Flex	0.137
Shoulder Abdu/Add	0.183
Shoulder In/Ex rotation	0.246
Wrist Flex/Ext	0.381
U/R radiation	0.163

4. Discussion:

Results are consistent with Golden *et al.* (2008) results which indicated that BMI was negatively correlated with elbow range of motion, elbow flexion. As well as they are in accordance with Wong *et al* (2014) study results which reported that BMI is significantly correlated to the wrist flexion and extension.

Moreover, current study results are consistent with the results of Gill *et al* (2006) study results who found that shoulder flexion, abduction, and internal rotation were not significantly affected by body mass index (BMI).

Correlation results regarding the elbow, shoulder, and wrist, the smartphone addiction and pain intensity are compatible with El-Azab *et al.* (2017) results who reported that the severity of the symptoms in the upper extremist is significantly associated with time for daily using of smartphones, and revealed that increase duration use of smartphones increase its negative effects due to faulty posture, pain, and muscle fatigue.

Moreover, results are consistent with Berolo *et al.* (2011) and Um (2013) who found that pain and muscle fatigue increased with longer duration of smartphone usage.

Current study results are consistent with the results of Gill *et al* (2006) study results who found that shoulder abduction and internal rotation were not significantly affected by body mass index (BMI).

Correlation results regarding the elbow, shoulder, and wrist, the smartphone addiction and pain intensity are compatible with El-Azab *et al.* (2017) results who reported that the severity of the symptoms in the upper extremist is significantly associated with time for daily using of smartphones, and revealed that increase duration use of smartphones increase its negative effects due to faulty posture, pain, and muscle fatigue.

The study aimed to investigate the effect of smartphone usage on the upper extremity performance among aljouf university female students, by studying a random sample composed of 20 female students.

Results showed that 65% of the studied female students had been addicted smartphone user.

By comparing our results to the previously performed studies results, current study results were inconsistent with Alhassan *et al.* (2015) findings which reported that 26.7% of the medical students are addicted to smartphone usage.

Moreover, results are not in accordance with Alosaimi *et al.* (2016) who reported that 27.2% of the university students are spending more than 8 hours per day using their smartphones.

Correlation results regarding the elbow, shoulder, and wrist, the smartphone addiction and pain intensity are not compatible with El-Azab *et al.* (2017) results who reported that the severity of the symptoms in the upper extremist is significantly associated with time for daily using of smartphones, and revealed that increase duration use of smartphones increase its negative effects due to faulty posture, pain, and muscle fatigue.

Moreover, results are inconsistent with Berolo *et al.* (2011) and Um (2013) who found that pain and muscle fatigue increased with longer duration of smartphone usage.

Findings had indicated that wrist flexion and extension are negatively correlated to the smartphone addiction scale scores, and positively correlated with McGill pain scores. INal *et al.* (2015) had recently reported that wrist flexion or extension has been linked to increased carpal tunnel pressure, and it also decreases the amount of space available for the median nerve in the carpal tunnel. So, they hypothesized that repetitive wrist flexion and extension during smartphone use may also impact the median nerve, as indicated by larger median nerves in the high smartphone users.

Positive correlation with pain score could be referred as reported by INal *et al.* (2015) that extensive flexion/extension of the thumb and the wrist occurs when an individual uses a smartphone and placing thumbs and wrists in these static postures that will likely lead to increased load on these joints and associated muscles and tendons.

Current study findings are consistent with INal *et al.* (2015) who found that Visual Analogue Scale (VAS) pain in the movement was also found to be significantly higher in the high-smartphone-user group than in the lower smartphone-user group.

Moreover, Woo *et al.* (2016) found that ulnar and radial deviation are negatively affected by the prolonged usage of smartphones. They had reported that the gradual reduction in the cross-sectional area of the median nerve, with thumb opposition together with the wrist in ulnar deviation causing the greatest extent of deformation of the median nerve.

Current study results had been consistent to Cote *et al.* (2005) findings which indicated that pain intensity measured using McGill pain scale was positively correlated to the shoulder and wrist range of motion.

Moreover, our findings are in accordance with INal *et al.* (2015) study results that had reported a significant correlation of pain intensity and upper extremity ROM among smartphone users.

Correlation results regarding the elbow, shoulder, and wrist, the smartphone addiction and pain intensity are compatible with El-Azab *et al.* (2017) results who reported that the severity of the symptoms in the upper extremist is significantly increased among smartphones, and revealed that increase duration use of smartphones increase its negative effects due to faulty posture, pain, and muscle fatigue.

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There are no conflicts of interest among authors.

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