

## ORIGINAL STUDY

# The effect of smartphone usage on the upper extremity performance among Saudi Youth, KSA

**Mohammed Khalid Alruzayhi, Muath Salman Almuahini, Akrm Ibrahim Alwassel, Osama Mansour Alateeq**

College of Medicine, Al-Imam Mohammed Bin Saud Islamic University, Riyadh, Kingdom of Saudi Arabia

## ABSTRACT

The current study aims to investigate the effect of smartphone 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. The results have 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, the results have 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 has concluded that smartphone usage among Saudi youth negatively affects the upper extremity and causes a significant increase in the pain intensity. The study has 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.

**KEYWORDS:** smartphones, range of motion, upper extremity.

## INTRODUCTION

Smartphones are considered to be the natural evolution of computers, which have contributed significantly to reduce the popularity of these devices after several decades of dominance. Smartphones have pushed the path towards the development of tablet PCs, which is a compromise between a smart phone and personal computers<sup>1</sup>.

Smartphones differ from traditional phones in that they provide a number of functions, advanced computing capabilities and advanced communication along with other traditional phone functions<sup>2</sup>.

Smartphones evolve day after day, their capacities and capabilities increasing spectacularly. Some of these phones have 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 following the eyes movement to surf the internet or view the images by just performing an aerobic pointing by the hand<sup>3</sup>. 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<sup>4</sup>.

Smartphone utilization is growing exponentially in the world, especially in Saudi Arabia<sup>5</sup>. According to a

study performed by Nielsen Holding, it has 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% of those using smartphones are under the age of 15. In a study conducted by Alhassan et al. in 2016 it has been indicated that 52.7% of the males and 46.9% of the females ranging in age between 18 and 23 are addicted to using smartphones<sup>6</sup>. In a more recent study conducted by Alosaimi et al. it has been reported that 27.2% of the individuals ranging in age between 20 to 24 use their smartphones more than 8 hours<sup>7,8</sup>.

Several studies examined the impact of smartphones on the musculoskeletal system. For example, Alabdulwahab et al. performed a cross-sectional study entitled "smartphone use addiction can cause neck disability", that aimed to identify the level of smartphone addiction and its correlation to the neck function<sup>4</sup>. The study sample was composed of 78 healthy young adults that were subjected to a Smartphone Addiction Scale (SAS) and Neck Disability Index (NDI). The findings have shown that there is a strong association between smartphone use and different degrees of neck problems among the participants<sup>4</sup>.

Earlier in 2011, Berolo et al. conducted a study that aimed to investigate the musculoskeletal symp-

toms among mobile hand-held device users and their relationship to device users<sup>9</sup>. The study sample was composed of 140 university students, staff and faculty members. The results showed that 84% of the study participants reported pain in at least one body part. The right hand pain was the 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 and right shoulder pain<sup>9</sup>.

In a retrospective study conducted by Sharan et al.<sup>10</sup>, that aimed to describe the risk factors and clinical features of the musculoskeletal disorders arising due to the usage of hand-held devices, the study sample was composed of 70 subjects characterized by having a musculoskeletal disorder affecting the upper extremities. The results showed that all the study participants reported pain in the thumb and forearm with associated burning, numbness and tingling around the thenar eminence of the hand. The study has 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<sup>10</sup>.

Although there are a number of studies investigating the impact of hand-held devices on the musculoskeletal system, there is still a clear shortage in data and responses regarding their impact. Studies have varied among the cross-sectional, retrospective and experimental designs, which indicate 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 will be 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 to 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 on-going 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 smartphone usage on the upper extremity performance among Saudi youth.

## MATERIAL AND METHODS

### Research design

A cross-sectional study – observational study

### Study setting

Al-Imam Mohammed Bin Abdul Aziz University.

### Study Subject

The study sample will include 300 students enrolled in Al-Imam Mohammed Bin Saud University.

### Inclusion criteria

- Age 18 – 25
- Voluntary participation
- Students enrolled in Al-Imam Mohammed Bin Saud University.
- Acceptable level in English (Speaking, reading and writing)

### Exclusion criteria

- Non-student individuals
- Pregnant females

### Study instruments

#### 1. Goniometer

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

Steps to using a Goniometer:

1. Align the fulcrum of the device with the fulcrum or the joint to be measured.
2. Align the stationary arm of the device with the limb being measured.
3. Hold the arms of the goniometer in place while the joint is moved through its range of motion.
4. The degree between the endpoints represents the entire range of motion.

Assessment of elbow range of motion steps:

- Sitting study participant on a chair
- (Arm position): Arms are supported on the table
- Shoulder flexion (90 degrees)
- Then measure the range of motion

Assessment of shoulder range of motion<sup>11</sup>:

- Trace arc while reaching forward with elbow straight (forward flexion).
- Should be able to move hand to position over head - 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 position with hand above their head.

- Movement should be smooth and painless.
- Normal range is 0 to 180.

## 2. The Smartphone Addiction Scale (SAS)<sup>12</sup>

The assessment will include:

1. Duration of smartphone use on a typical day.
2. Frequency of smartphone use on a typical day.
3. Duration of time until first smartphone use in the morning upon waking.
4. The smartphone function with the most personal relevance.

Smartphone addiction will be 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
- tolerance

## 3. McGill Pain Scale (Melzack, 1987)<sup>13</sup>

- A scale of rating pain developed at McGill University by Melzack and Torgerson
- 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.

## 4. Chattanooga stabilizer pressure biofeedback – Muscle isometric contraction

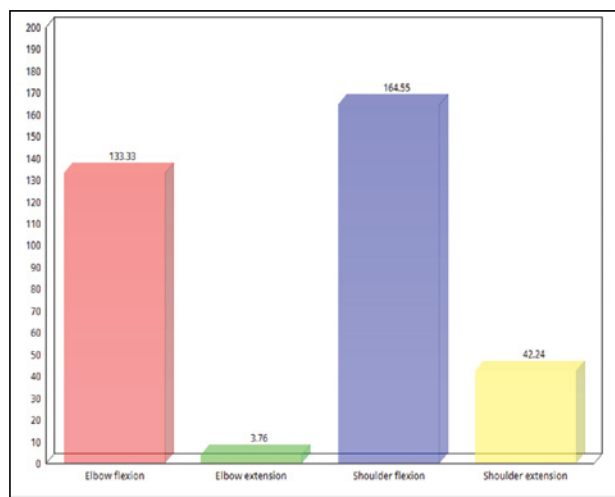
Muscle isometric contraction will be tested with Chattanooga stabilizer pressure biofeedback. The participant will be tested while moving the upper limb; the therapist will resist the movement using the stabilizer with his arm against the wall to prevent the substitution of the subject.

### Statistical analysis

Data will be presented as mean and standard deviation, minimum and maximum values. Spearman and Pearson correlation coefficients will be used for assessing the relation between different variables.

## RESULTS

Results shown in Table 1 represent the mean and standard deviation scores of the study variables. The same variable can be seen also in Figure 1.



**Figure 1** Mean values for the elbow flexion/extension and shoulder flexion/extension

**Table 1**

**Mean and standard deviation scores of the variables evaluated in the study.**

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  $133.33 \pm 19.84$ , for the elbow extension was  $3.76 \pm 5.12$ , for the shoulder flexion was  $164.55 \pm 7.34$  and for the shoulder extension was  $42.24 \pm 7.35$ .

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

The 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 (0.11).

**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

The correlation between elbow flexion/extension and shoulder flexion/extension to the smartphone addiction scale and McGill pain scale indicate that smartphone addiction is negatively correlated to the elbow flexion, elbow extension, shoulder flexion and shoulder extension (Table 3). On the other hand, results indicate that McGill pain responses have been positively correlated to the elbow flexion/extension and shoulder flexion/extension.

**Table 3**  
**Spearman's rho correlation coefficient values among smartphone addiction, pain intensity, and elbow, shoulder and wrist range of motion (ROM).**

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

Measurements of the shoulder abduction, adduction, internal and external rotation have yielded a mean score equal to 165.6, 11.3, 83.4 and 84.2, respectively (Table 4).

**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

The investigation of BMI correlation to the shoulder abduction, adduction, internal and external rotation has shown that BMI was negatively correlated to the shoulder abduction and external rotation, while it was positively correlated to the shoulder adduction and the internal rotation (Table 5).

**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 5 indicate that smartphone addiction is negatively correlated to shoulder abduction/adduction and shoulder internal/external rotation.

On the other hand, the McGill pain score was positively correlated with shoulder abduction/adduction and shoulder internal/external 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 abduction/adduction	-0.213	0.183
Shoulder internal/external rotation	-0.171	0.246

Findings shown in Table 7 indicate that 65% of the study samples were within the addicted category, while 35% of the female students were within the non-addicted smartphone users. Mean and standard deviation scores have shown that the total SAS score for addicted users was  $38.31 \pm 3.16$ , on the other hand, the total SAS score for the non-addicted user was  $22.71 \pm 1.29$ .

**Table 7**  
**Total score of SAS responses.**

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

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

Measurements of the wrist flexion, extension, ulnar deviation and radial deviation have yielded a mean score equal to 72.85, 68.93, 42.56 and 31.60, respectively (Table 9).

The investigation of BMI correlation with the wrist flexion/extension and ulnar/radial deviation has shown that BMI is negatively correlated with the wrist flexion, extension, ulnar deviation and wrist radial deviation, as shown in Table 10.

**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

**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 indicate that smartphone addiction is negatively correlated with wrist flexion and extension, and both ulnar and radial deviation.

On the other hand, the McGill pain score was positively correlated with the previously mentioned measurements (Table 11).

**Table 11**  
Mean and standard deviation values for the wrist flexion/extension, and ulnar/radial deviation.

Measurement	Smartphone Addiction	McGill pain score
Wrist flexion/extension	-0.231	0.381
Ulnar/Radial deviation	-0.136	0.163

Results presented in Table 12 show that study participants were divided into four subgroups according to the McGill pain questionnaire responses. The mod-

erate pain group constituted 45% of the total study sample, followed by the mild pain group that represented 35%, the severe pain subgroup (15%), and finally the no pain subgroup that 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 13 shows the correlation results among the McGill pain scores and elbow, shoulder and wrist ROM. McGill pain score was positively correlated with the elbow flexion/extension, shoulder extension/flexion, shoulder abduction/adduction, shoulder internal/external rotation and wrist flexion/extension (Table 13).

**Table 13**  
Correlation coefficient values among BMI and the wrist flexion/extension and ulnar/radial deviation.

Measurement	McGill pain score
Elbow flexion/extension	0.206
Shoulder extension/flexion	0.137
Shoulder abduction/adduction	0.183
Shoulder internal/external rotation	0.246
Wrist flexion/extension	0.381
Ulnar/Radial deviation	0.163

## DISCUSSIONS

Results are consistent with Golden et al.<sup>14</sup> results which indicated that BMI was negatively correlated with the elbow range of motion, elbow flexion. Also,



they are in accordance with Wong et al. study results which reported that BMI is significantly correlated with the wrist flexion and extension<sup>15</sup>.

Moreover, the current study results are consistent with the results of Gill et al.<sup>16</sup> 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.<sup>17</sup> results that reported that the severity of the symptoms in the upper extremity is significantly associated with time for daily using of smartphones, and revealed that an increased duration of 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 Al Jouf University female students, by studying a random sample composed of 20 female students. The results showed that 65% of the studied female students were addicted smartphone user.

Moreover, our results are consistent with Berolo et al. and Um who found that pain and muscle fatigue increased with longer duration of smartphone usage<sup>9,18</sup>.

By comparing our results to the previously performed studies results, the current study results were inconsistent with Alhassan et al. findings, which reported that 26.7% of the medical students are addicted to smartphone usage<sup>6</sup>.

Moreover, results are not in accordance with Alo-saimi et al. who reported that 27.2% of the university students spend more than 8 hours per day using their smartphones<sup>7</sup>.

The findings have indicated that wrist flexion and extension are negatively correlated with the smartphone addiction scale scores, and positively correlated with McGill pain scores. In 2015, Inal et al. reported that wrist flexion or extension is linked to increased carpal tunnel pressure, and it also decreases the amount of space available for the median nerve in the carpal tunnel<sup>19</sup>. 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 high smartphone users. According to them, the extensive flexion/extension of the thumb and wrist occurs when an individual uses a smartphone. Placing thumbs and wrists in static postures will likely lead to an increased load on these joints, associated with a decreased strength of muscles and tendons. These findings could explain the positive correlation between smartphone usage and the McGill pain scores<sup>19</sup>.

The current study findings are consistent with Inal et al.<sup>19</sup> who found that Visual Analogue Scale (VAS)

pain in movement was also found to be significantly higher in the high smartphone-user group than in the lower smartphone-user group.

In 2006, Woo et al. found that ulnar and radial deviations are negatively affected by the prolonged usage of smartphones<sup>20</sup>. They have reported that the gradual reduction in the cross sectional area of the median nerve, with thumb opposition together with the wrist in ulnar deviation, cause the greatest extent of deformation of the median nerve.

Our study results have been consistent with Cote et al. findings which indicated that pain intensity measured using the McGill pain scale was positively correlated with the shoulder and wrist range of motion<sup>21</sup>.

At the same time, our findings are in accordance with Inal et al. study results that have reported a significant correlation between pain intensity and upper extremity ROM among smartphone users<sup>19</sup>.

**Conflict of interest:** The authors have no conflict of interest.

**Contribution of authors:** All authors have equally contributed to this work.

**Ethical Approval:** The study was performed under the institutional research and ethics committee.

**Acknowledgements:** Authors acknowledge the unlimited support and encouragement of the colleagues in the medicine department and the administration of Al-Imam Mohammad Bin Saud Islamic University for facilitating the current study.

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