INTRODUCTION

The smartphones are containing multiple sophisticated features and became an inherent part of human life. It allows users to keep personal information, health and financial data, pictures and memories. Smartphones also became an integral part of modern telecommunications facilities, knowledge and multiple learning options to users, and becomes source of daily activities. The use of smart phone has increased in the last decade, and there is a great debate among people that
whether smart phones have facilitated their daily
tasks and have made every day life’s needs more
convenient.1,2

The literature shows that mobile phones can
negatively affect the human health.3,4 The World
Health Organization (WHO) revealed that exposure
to Radiofrequency Electromagnetic Field Radiation
(RF-EMFR) generated from mobile phones
increases body core temperature and can cause
cognition functions impairment.5 The children who
are exposed to RF-EMF radiation exhibit decreased
motor skills as well as attention span and working
memory,6 poor attention and concentrations.7,8
Moreover, literature also acknowledge the adverse
effects of smartphone.9-13

Although limited research has been conducted
concerning the potential cognitive impacts of
smartphone use in the Saudi society, the present
study aim was to determine the association of use
of smart mobile phone with cognitive function
impairment in Saudi adult population.

METHODS

The present cross-sectional study was conducted
in the Department of Physiology, College of
Medicine, King Saud University, Riyadh, Saudi
Arabia during September 2019 to January 2020.
A total of 251 Saudi adult volunteers aged from
15-65 years using mobile phones were invited
to participate in this study. Knowledge, attitude
and practices were assessed by interview using
a specially designed questionnaire in Arabic or
English languages. Three questions were designed
to determine the awareness of participants about
mobile phone hazards. The Montreal Cognitive
Assessment (MOCA) was used to assess cognition.
From all the participants, a written consent was
obtained who voluntarily agreed to join the
research project, where they have the opportunity
to read the research objectives and join or
withdraw from the research at any time, without
any profits or penalties. Subjects were recruited
through convenience sampling technique. MOCA
scores range between 0 and 30, score of 26 or over
was considered normal, lower scores <26 indicate
mild cognitive impairment (MCI).14

Selection Criteria: Mobile phone users with
history of known psychiatric disorders, central
nervous system disorders, living near high voltage
electricity towers, and subjects with chronic
debilitating disorder such as diabetes mellitus,
cardiac failure, malignancy were not included
in the study. Participants who were below 15 or
above 65 were excluded. Mobile phone users who
smoke cigarette, shisha were also excluded. One
investigator interviewed 251 volunteer male and
female mobile phone users and a detailed clinical
history was obtained, participant demographic and
other characteristics were obtained (Table-I and II).

Ethics Statement: This study was executed in
harmony with the “Declaration of Helsinki,” and
the protocol was approved by the “Institutional
Review Board, Ethics Committee,” College of
Medicine Research Centre, King Saud University
(E-19-4232).

Statistical Analysis: The data were entered into
the computer, SPSS V. 22 and Microsoft Windows
was used. Continuous variables were expressed
as the mean ± standard deviation and descriptive
data were expressed as percentages (%). Variables
were compared between different groups by one-
way ANOVA regarding all variables of knowledge,
attitude and different practices of smart mobile
phone users. Proportions were compared between
different groups using Chi-square test. A p value
<0.05 was considered significant.

RESULTS

More than 61% of the participants used the mobile
phone for more than 10 years Table-I. More than 80%
of the participants used the mobile phone for more

Table-I: Demographic characteristics of all
participants and MOCA Scores (n=251).

| Characteristics of participants | Mean   | SD     | Minimum | Maximum |
|---------------------------------|--------|--------|---------|---------|
| Age                             | 32.43  | 12.80  | 15      | 65      |
| Starting age for use            | 19.71  | 9.16   | 7       | 53      |
| Age at using reading glasses    | 32.73  | 14.95  |         |         |
| Educational Level: n(%)         |        |        | 97 (38.6)|        |
| Secondary                       | 97 (38.6)|        |        |
| Bachelor                        | 134 (53.4)|        |        |
| Higher                          | 20 (8.0)|        |        |
| Type of mobile phone: n(%)      |        |        | 159 (63.3)|        |
| Iphone                          | 159 (63.3)|        |        |
| Samsung                         | 45 (17.9)|        |        |
| Huawei                          | 44 (17.5)|        |        |
| Other                           | 3 (1.2)|        |        |
| Years of usage: n(%)            |        |        | 36 (14.3)|        |
| 1-5                             | 36 (14.3)|        |        |
| 6-10                            | 60 (23.9)|        |        |
| >10                             | 154 (61.4)|        |        |
| MOCA                            | 25.02  | 2.49   | 17      | 30      |

MOCA: Montreal cognition assessment.
Values are expressed in mean and standard deviation.
than two hours daily. Table-II. In addition, more than 61% of participants used handheld mode for calling rather than placing the mobile phone away from body in order to minimize the radiation effect (Table-III). About 54% of the participants placed their mobile phone near their heads while sleeping. About 61% of the participants were not aware of the side effect of the radiation of the mobile phone.

Table-II: Attitude and practices of mobile phone users.

| Categories                          | Number (%) |
|-------------------------------------|------------|
| Daily usage                         |            |
| <1 hour                             | 12(4.8)*   |
| 1-2 hour                            | 36(14.3)   |
| >2 hours                            | 203(80.9)  |
| How do you use your mobile?         |            |
| Handheld                            | 155(61.8)* |
| Earphone                            | 47(18.7)   |
| Speaker                             | 39(15.5)   |
| Bluetooth                           | 10(4.0)    |
| Do you live near mobile tower?      |            |
| Yes                                 | 46(18.3)*  |
| No                                  | 205(81.7)  |
| Do you live near high voltage tower?|            |
| Yes                                 |            |
| No                                  | 251(100)   |
| Do you use reading glasses?         |            |
| Yes                                 | 62(24.7)*  |
| No                                  | 189(75.3)  |
| Where do you put your mobile while sleeping? |        |
| Near pillow                         | 136(54.2)* |
| Inside bedroom                      | 99(39.4)   |
| Outside bedroom                     | 16(6.4)    |
| What is your dominant hand?         |            |
| Right                               | 228(90.8)* |
| Left                                | 23(9.2)    |
| Where do you put the mobile while calling? |        |
| Right ear                           | 178(70.9)* |
| Left ear                            | 39(15.5)   |
| Variable                            | 34(13.5)   |
| Where do you put the mobile when not used? |         |
| Upper pocket                        | 8(3.2)*    |
| Lower pocket                        | 126(50.2)  |
| Away from pocket                    | 66(26.3)   |
| Variable                            | 51(20.3)   |
| Do you think you are dependent on mobile? |        |
| Yes                                 | 141(56.2)* |
| To some extent                      | 81(32.3)   |
| No                                  | 29(11.6)   |
| Do you want to quit using mobile?   |            |
| Yes                                 | 30(12)*    |
| To some extent                      | 62(24.7)   |
| No                                  | 159(63.3)  |

ANOVA comparison *P <0.001.

Table-III: Awareness of mobile phone side effects in all participants.

| Categories                                      | Number (%) |
|------------------------------------------------|------------|
| Aware of putting the mobile 5 CM away from your body reduces the radiation effect four times |            |
| Do not know                                     | 154 (61.4) |
| To some extent                                  | 47 (18.7)  |
| Know                                            | 50 (19.9)  |
| WHO announcement (mobile phone is a possible cause of cancer)                |            |
| Do not know                                     | 158 (62.9) |
| To some extent                                  | 59 (23.5)  |
| Know                                            | 34 (13.5)  |
| ACS announcement (mobile phone is a possible cause of brain cancer)          |            |
| Do not know                                     | 173 (68.9) |
| To some extent                                  | 50 (19.9)  |
| Know                                            | 28 (11.2)  |

WHO: world health organization. ACS: American cancer society.
The participants who exceeded two hours of daily usage, in them MOCA score decreased below normal (Fig. 1). It also showed a significant difference between groups in the MOCA score except between those who used the mobile less than one hour and two hours.

The association of placement of the mobile phone while sleeping on cognition scores was also assessed (Fig. 2). It was noticed that MOCA score was higher while users placed the mobile phone away while sleeping. Even though the effect of the placement of the mobile phone during sleep did not bring the scores to the normal level, but there was a significant effect on the scores. Fig. 2 also shows significant difference between the effect of the placement of the mobile phone near the pillow and placing it inside the bedroom or outside on the MOCA score, but there was no significant difference between placing the mobile phone near the pillow and inside the bedroom versus outside the bedroom. However, there was no effect of the placement of the mobile phone while not calling on the scores (Table-IV).

### DISCUSSION

Exposure to Radiofrequency Electromagnetic Field Radiation (RF-EMFR) has various effects on human health including fatigue, headache, tension, sleep disturbance, hearing and vision complaints, and risk of type 2 diabetes mellitus. Extensive fixing of mobile phone base station towers (MPBSTs) in densely populated commercial, residential areas, and school buildings has started community concerns about adverse effects on human health, mainly on brain functions.

To the best of our knowledge, this is the first study that investigate the relation between the knowledge, attitude and practices of mobile phone usage with cognitive impairment in Saudi adult population. In this study, it was identified that the cognitive functions were deteriorated with the increase daily usage of mobile phone. The present study results are in line with the results of other studies published in different countries. In the present study, the deterioration of cognitive function due to mobile usage was consistent with the conclusion of earlier published literature.

Arns et al. reported that decrease in brain activity was associated with the use of mobile phone. In addition, Kalafatak et al. found that mobile phone usage has a significant negative impact on working memory performance. The effect was noticed even after the 5-minutes use of mobile phone.

It has also been reported that continuous using or checking of the smart phone screen was associated with cognitive function impairment. The present study has explored how performance was affected among individuals who use their phones to take

| MOCA         | Mean  | Std. Deviation |
|--------------|-------|----------------|
| Upper Pocket | 8(3.2)* | 23.38          |
| Lower Pocket | 126(50.2) | 25.01          |
| Away        | 66(26.3) | 24.88          |
| Variable    | 51(20.3) | 25.08          |
| Total       | 24.94  | 2.853          |
a break from job tasks. The data showed that individuals who took break on their phones have shown cognition decline which was evident on their weak performance.\textsuperscript{21} Moreover, sleep disorders have been associated with excessive use of smart phones.\textsuperscript{22} Consequently, less sleep duration can lead to impairments in cognition functions. In addition to the daily usage, deterioration of cognition was associated with placement of mobile phone while sleeping and subsequently cognitive deterioration. The present study results are in consistent with other studies which concluded that mobile phones can affect cognition functions as a result of sleep disturbance.\textsuperscript{23,24}

The general population need to be educated and counselled on the proper usage and practices of mobile phones. They need to be compelled to ensure mobile phone usage only for essential tasks and should be organized so it will not affect the performance of the students and the employees. Paul et al.\textsuperscript{25} suggested that it is highly needed to teach people to be educated and structured, to know when to have the cell phone on, and to avoid becoming the slave of technology instead of its mastery. In addition, media has to come to frontline to educate the public about the side effects of the improper usage of such device.

**Strengths of the study:** This is the first study to investigate the effect of mobile phone usage on cognition functions in Saudi adult population. The study exclusion criteria were highly standardized.

**Limitations of the study:** It includes its cross-sectional design and small number of sample size. It was very difficult to find participants who use mobile phone less than one hour daily which reflected that it has become a known habit in the society. The reason to find more participants who used mobile phone for less than two hours was the attempt to increase the sample size. The difficulties to find non-smoking participants, without any debilitating disorders or central nervous systems disorders, and not living near high voltage electricity towers to eliminates the effects of these factors on the results should be countered. Further studies with larger sample size are essential to confirm the current evidence of the role of mobile related disturbance to cognition.

**CONCLUSIONS**

Excessive use of mobile phone is associated with cognitive function impairment assessed by Montreal cognitive Assessment (MOCA) score. The health authorities should employ strict policies regarding mobile phones in order to minimize their hazardous effects on human health including cognitive functions impairment. The media has to be on the forefront in educating the public about the proper usage of mobile phone.

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