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Research Paper

# Investigation of the effect of smartphone addiction on upper extremity functions in healthy adults in Turkey: A cross-sectional study

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ABSTRACT

*Background:* Turkey has a high rate of average daily phone usage time.
*Purpose:* The study was planned to investigate the effect of smartphone addiction on upper extremity function in healthy adults in Turkey.
*Study Design:* The study was designed as a cross-sectional study.
*Methods:* The study was conducted between January to May 2025 with university students studying at a university in Turkey. Addiction level was evaluated using the Smartphone Addiction Scale-Short Version (SAS-SV); muscle strength was evaluated using Hydraulic Hand Dynamometer and Mechanical Pinch Gauge; and hand-eye coordination was evaluated using Minnesota Manual Dexterity Test (MMDT). Quick Disabilities Of The Arm, Shoulder, and Hand Questionnaire (Quick-DASH) was used for upper extremity functioning and Neck Disability Index (NDI) was used for neck disabilities.
*Results:* Our study was completed with 213 participants. 79.7% ($n$ = 166) of the participants were female with a mean age of 20.99 ± 3.95 years. Smartphone addiction was 47.9%. In the turning test of the sub-dimension of the MMDT, participants with smartphone addiction demonstrated lower performance ($p < 0.05$). In addition, Quick-DASH and NDI scores were significantly higher among addicts compared to non-addicts ($p < 0.05$). Correlation analysis revealed a positive correlation between SAS-SV scores and the turning test, daily smartphone usage time, Quick-DASH, and NDI scores ($p = 0.014$, r = 0.17; $p < 0.001$, r = 0.31; $p < 0.001$, r = 0.28; and $p < 0.001$, r = 0.35, respectively). Furthermore, as cervical flexion posture increased during phone use, both Quick-DASH and NDI scores also increased ($p < 0.05$).
*Conclusions:* Smartphone addiction and increased flexion posture in the cervical region negatively affect hand-eye coordination, upper extremity and cervical spine health in users. Physiotherapists should take the lead in developing healthy posture habits and body awareness in adults who use smartphones intensively.


## Introduction

In the report published in April 2025, it was indicated that approximately 90% (7.21 billion) of the world population uses smartphones and the average daily usage time is 3 hours 43 minutes. The report emphasizes that Turkey is the only country in Europe with an average daily phone usage time above the world average. The average daily smartphone usage time in Turkey is 4 hours and 16 minutes.[1]

Since 2016, there has been a 50% increase in smartphone users.[1] The high number of users has encouraged scientists to investigate the effects of smartphone use on different parameters. When these studies are evaluated, it is seen that different results have been observed. Din and Hafeez found that smartphone addiction reduced hand grip strength and impaired upper extremity functionality.[2] In contrast, in other studies it was reported that smartphone addiction did not cause a significant change in upper extremity muscle strength.[3,4]

Research on how smartphone use effects dexterity and upper limb coordination in adults is inadequate and often conflicting.[5] Akçay et al reported that smartphone addiction did not affect manual dexterity and coordination in university students, while Aswathappa et al showed that upper extremity coordination was significantly lower in smartphone addicts.[6,7]

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The relationship between smartphone addiction and cervical spine and upper extremity symptoms complicates individuals' activities of daily living.[8,9] Previous study showed that smartphone addiction was significantly associated with upper limb functionality and daily smartphone usage time.[10] Topçu et al found that there was a positive relationship between smartphone usage time and neck disability level; in contrast, there was no relationship between smartphone usage time and upper extremity functionality.[11] Studies in Thailand and China have shown that excessive flexion posture in the cervical spine and prolonged smartphone use increase the risk of musculoskeletal problems such as spondylosis and disc degeneration in adults.[12,13]

Considering the negative effects of smartphone use on the musculoskeletal system in healthy adults, physiotherapy assessment and intervention become important. According to 2025 data, 97% of individuals aged 18-49 in the world use smartphones. In this data, Turkey's results on smartphone use and addiction are also interesting,[1] We believe that the fact that Turkey is among the risky countries in smartphone addiction necessitates the importance of studies and results that reveal the effects of smartphone use in this country. For this reason, we aimed to conduct our study in the age group (18-49) that uses smartphones most intensively in the world. The current study was planned to determine the level of smartphone addiction in healthy adults in Turkey and to investigate its effects on upper extremity functions.

## Methods

### Participants and study design

The study was conducted between January and May 2025 with university students from a university in Turkey who met the inclusion criteria and their social group. It was designed as a cross-sectional study. The University Ethics Committee approved the study (Protocol No: 2024/587). Participants were informed about the study's procedures, and signed consent forms were obtained. The study was conducted according to the 2024 Declaration of Helsinki.

The study included adults between the ages of 18-49, who had been using smartphones for the last year, who had not had any upper extremity injury in the last 6 months, who could communicate easily, and who accepted to participate in the study. Individuals with upper extremity deformities, functional limitations, upper extremity amputation, chronic diseases, hearing problems that could not be corrected with hearing implants, and vision problems that could not be corrected with glasses or lenses were excluded from the study.

### Outcome variables

#### Evaluation questions

In the evaluation questions, participants were asked about their demographic information, phone usage, and cervical posture habits. A cloth tape measure was used to measure the screen size of the phone. For participants who used a phone case, measurements were taken with the case on. Because it was thought that the case could also affect manual dexterity when using the phone. In this case, the short and long sides of the phone were measured in centimeters. The screen area size was recorded in $cm^2$ on the evaluation form.

#### Smartphone addiction

Smartphone addiction was evaluated with the Smartphone Addiction Scale-Short Version (SAS-SV). The scale designed by Kwon et al consists of 10 questions and is in six-likert style. An increase in the total score indicates a high level of addiction. When determining addiction, the reference cut-off value for the total score is 31 for men and 33 for women. The scale was adapted to the Turkish population by Noyan et al.[14,15]

#### Muscle strength

Hand grip, pinch and lateral grip muscle strength were measured in a comfortable sitting position in a chair without back support with the shoulder in adduction, elbow flexed 90 degrees, forearm in semi-supination and wrist in neutral position.[16,17] During the evaluation, verbal encouragement and prompts were given to the participants to reach maximum muscle strength. The measurements were repeated three times with 1 minute rest intervals and performed only on the dominant limb. The mean value of three tests was recorded in kilograms. Baseline Grip strength is measured by the hydraulic hand dynamometer (Baseline Hydraulic Hand Dynamometer, Product 12-0240, SN 04200898, White Plains, NY) and pinch strength by the mechanical pinch gauge (Baseline Mechanical Pinch Gauge, 30 Ib, Product 12-0200, SN 00201942, White Plains, NY).

#### Hand-eye coordination

The Minnesota Manual Dexterity Test (MMDT) is a test battery that evaluates upper extremity performance and endurance as well as gross and fine motor skills and hand-eye coordination. It consists of placing and turning tests with discs painted black and red on the lower surfaces.[18,19]

*Placing test:* The wooden platform was empty and the discs were lined up parallel to the wooden platform. The participant was requested to start from the right column for the right hand placing test. The disc at the lowest part of the column was placed in the top hole of the wooden platform and followed by the bottom row. The participant was asked to place the discs in all columns, moving to the next column as the column ended. The time was stopped on the stopwatch and recorded on the evaluation form. The left hand placing test was similar.[18]

*Turning test:* On the board placed 2.5 cm in front of the individual, the discs were placed in the same color (all red or all black). The individual took the disc from the right corner of the first row with his/her left hand, turned it over and placed it in his/her right hand, and placed the disc with his/her right hand to complete the top row. After the first row was finished, the disc placed in the left corner of the second row was turned over with the right hand and placed in the left hand, and then the second row was started to be placed. After the wooden platform was completed with the discs, the time was stopped on the stopwatch and recorded on the evaluation form. The third and fourth rows of discs were also placed according to the instructions given above.[20]

For each test, three trials were performed and the average of the three trials was recorded in seconds.

#### Upper extremity functional evaluation

The Quick Disabilities Of The Arm, Shoulder, and Hand Questionnaire (Quick-DASH) was used in the upper extremity functional evaluation of the participants. The Turkish version of the scale by Koldas et al evaluates the level of difficulty in upper extremity function, the severity of pain and pinching, and problems with socialization, daily tasks, and sleep due to pain.[21] The questionnaire contains 11 questions and each question is scored between 1 and 5. The total score ranges from 0 (no disability) to 100 (high level of disability).[22]

#### Neck disability level

The Neck Disability Index (NDI) The scale reveals neck pain that limits the activities of daily living of individuals. It consists of 10 questions in a six-likert scale. As a result of the test, 0-4 points: no disability; 5-14 points: mild disability; 15-24 points: moderate disability; 25-34 points: severe disability; 35 and above indicate complete disability, developed by Howard[23] and validated in Turkish by Telci et al, was used to determine the neck disability level of the participants.[24]

*Sample size*

A post-hoc power analysis was performed, using G*Power version 3.1.9.7. The power of the study was calculated as 99% with a margin of error of 0.05 and an effect size of 0.66 in the calculation made by considering the NDI value (addicted group: 10.91+5.31; non-addicted group: 7.77+3.99) in the groups with and without smartphone addiction.

*Statistical analysis*

SPSS Statistics software (Version 22.0; IBM Corp, Armonk, NY) package program was used for data analysis. After the Shapiro-Wilk test for normality (data showing a normal distribution: Right-placing test, Left-placing, / non-normally distributed data: Hand grip, Hand pinch, Lateral grip, Turning test, Quick-DASH, NDI) data with normal distribution were analyzed using the independent t-test, while non-normally distributed data were analyzed using the Mann-Whitney U and Kruskal-Wallis tests. Post-hoc analysis was used to determine the difference in multiple group comparisons. Chi-square test was used to analyze categorical variables and Spearman rho test was used for correlation analysis. The level of association was determined according to the correlation coefficient. The correlation coefficient was evaluated as low correlation between 0.05-0.3, moderate correlation between 0.3-0.7 and high correlation between 0.7-1.0.[25] A $p$-value of $< 0.05$ was considered statistically significant.

## Results

In our study, 230 individuals were evaluated. Nine individuals were excluded because they did not meet the inclusion criteria. Five individuals stopped participating in the study while the evaluation was in progress. It was observed that three evaluated individuals answered the scale questions blank. Study was completed with 213 participants (Fig. 1).

When the groups with and without smartphone addiction were compared in terms of demographic and descriptive characteristics, the duration of smartphone use (years) and average daily use (hours) were different in the groups. The duration of smartphone use and average daily usage time were higher in the addicted group. The cervical spine angle during smartphone use was found to be significant in the groups ($p < 0.05$) In addition, categorical classification based on NDI scores revealed that neck disability was significantly higher in smartphone addicts ($p < 0.001$) (Table 1).

Upper extremity muscle strength (hand grip, pinch, lateral grip) was similar in the groups ($p > 0.05$). On the other hand, the turning test time, which is a sub-dimension of the MMDT was significantly higher in the group with smartphone addiction ($p < 0.05$) (Table 2).

Quick-DASH and NDI scores were significantly higher in those with smartphone addiction ($p < 0.05$) (Table 2).

When the participants were categorized in terms of cervical flexion posture; Quick-DASH and NDI scores were found to be significant in the groups ($p < 0.05$). According to the results of analysis of variance, the Quick-DASH and NDI scores of those who used smartphones at 45 degrees cervical flexion were higher than those who used smartphones at 15 and 30 degrees cervical flexion ($p < 0.05$) (Table 3).

According to the results of the correlation analysis, it was determined that there was no significant correlation between phone usage time, average usage time and screen size and muscle strength, hand-eye coordination, upper extremity functionality and neck disability level ($p > 0.05$) (Table 4).

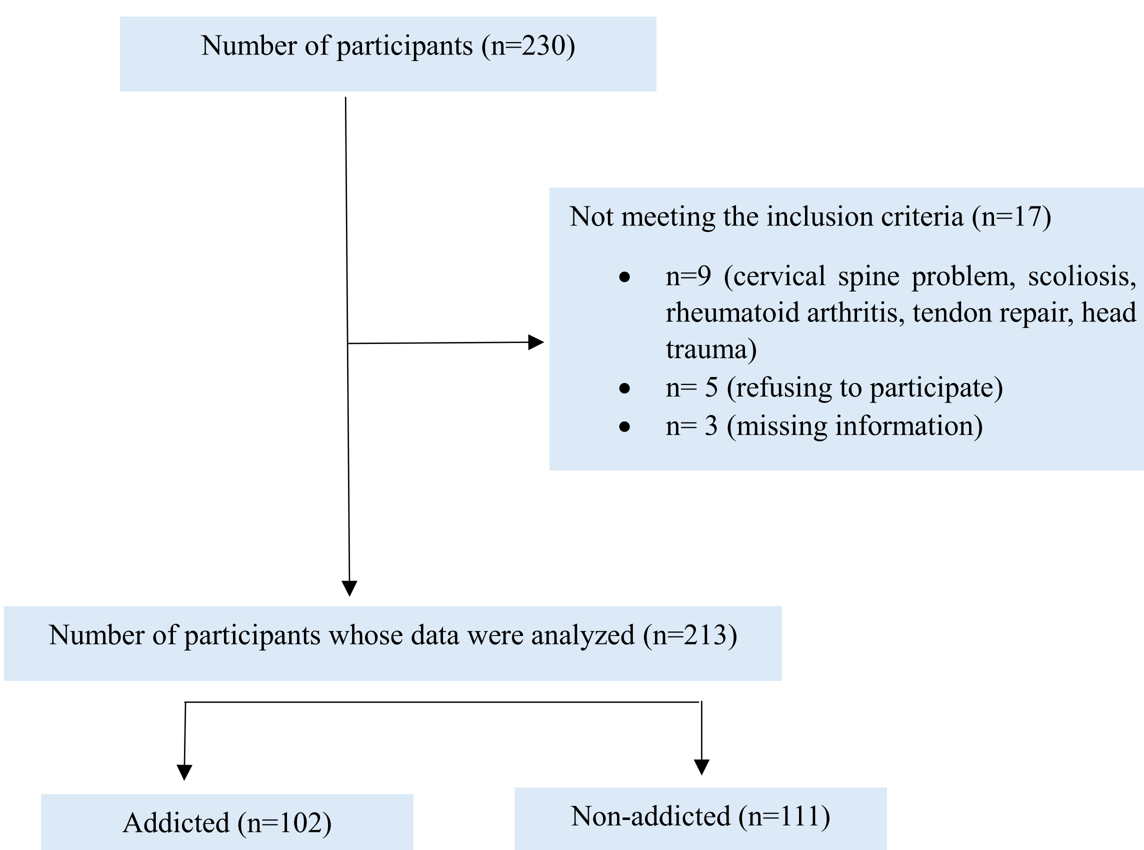


**Fig. 1.** Participant flow diagram.

**Table 1**
Demographic and descriptive information about the groups and their phone usage habits

| Characteristics | | Addicted (*n* = 102) | | Non-addicted (*n* = 111) | | Statistic |
|---|---|---|---|---|---|---|
| | | m ± SS | Min; Max | m ± SS | Min; Max | *p* |
| Age (y) | | 21.1 ± 4.4 | 18; 42 | 20.9 ± 3.5 | 18; 45 | 0.4 |
| BMI (kg/cm$^2$) | | 23 ± 4.4 | 15.8; 41.7 | 22.6 ± 3.9 | 15.4; 37 | 0.64 |
| SAS-SV | | 40.3 ± 5.7 | 27; 56 | 25.2 ± 4.9 | 10; 32 | **< 0.001**[*] |
| Duration of phone use (y) | | 7.7 ± 3 | 2; 20 | 6.8 ± 2.8 | 1.5; 16 | **0.045**[*] |
| Duration of daily use (h) | | 5.3 ± 2.4 | 1.5; 15 | 4.4 ± 1.8 | 1.5; 10 | **0.009**[*] |
| Screen size (cm$^2$) | | 126.7 ± 14.3 | 94.2; 157.5 | 129.4 ± 12.3 | 94.2; 153 | 0.18 |
| Duration of current phone use (y) | | 1.9 ± 1.4 | 0.1; 6 | 1.9 ± 1.6 | 0.1;6 | 0.62 |
| | | *n* | % | *n* | % | |
| Gender | Female | 84 | 82.4 | 82 | 73.9 | 0.13 |
| | Male | 18 | 17.6 | 29 | 26.1 | |
| Dominant extremity | Right | 92 | 90.2 | 105 | 94.6 | 0.22 |
| | Left | 10 | 9.8 | 6 | 5.4 | |
| Hand preference in phone usage | Dominant hand | 68 | 66.7 | 77 | 69.4 | 0.67 |
| | Double hand | 34 | 33.3 | 34 | 30.6 | |
| Neck posture | 15 degree flexion | 7 | 6.9 | 21 | 18.9 | **0.001**[†] |
| | 30 degree flexion | 40 | 39.2 | 59 | 53.2 | |
| | 45 degree flexion | 47 | 46.1 | 27 | 24.3 | |
| | 60 degree flexion | 8 | 7.8 | 4 | 3.6 | |
| Exercise habits | Yes | 31 | 30.4 | 38 | 34.2 | 0.54 |
| | No | 71 | 69.6 | 73 | 65.8 | |
| Cigarette smoking | Yes | 30 | 29.4 | 32 | 28.8 | 0.92 |
| | No | 72 | 70.6 | 79 | 71.2 | |
| Alcohol consumption | Yes | 11 | 10.8 | 10 | 9 | 0.66 |
| | No | 91 | 89.2 | 101 | 91 | |
| Neck disability status | No disability | 8 | 7.8 | 21 | 18.9 | **< 0.001**[†] |
| | Mild disability | 69 | 67.6 | 85 | 76.6 | |
| | Moderate disability | 24 | 23.5 | 5 | 4.5 | |
| | Severe disability | 1 | 1 | - | - | |

*n* = number of participants; m ± SD = mean ± standart deviation; min = minimum; max = maximum; SAS-SV = Smartphone Addiction Scale-Short Version; Quick-DASH = Quick Disabilities of the Arm, Shoulder, and Hand; NDI = Neck Disability Index; BMI = Body Mass Index.
Bold value indicates statistically significance ($p < 0.05$).
[*] Mann Whitney U test.
[†] Chi-square test.

On the other hand, there was a low positive correlation between smartphone addiction and MMDT sub-dimensions of turning test duration and Quick-DASH scores ($p = 0.014$; $r = 0.17$/$p < 0.001$; $r = 0.28$, respectively). There was a moderate positive correlation between smartphone addiction and daily usage time and NDI ($p < 0.001$; $r = 0.35$/$p < 0.001$; $r = 0.31$, respectively) (Table 4).

## Discussion

The findings of this study showed that smartphone addiction is associated with poorer hand-eye coordination, upper extremity function and higher neck disability. According to the correlation analysis results, it was determined that there was a positive relationship between smartphone addiction and hand-eye coordination, upper extremity functionality and neck disability level.

Kurtaran, in a study involving university students, reported that 38.4% of smartphone addiction and 69.5% of addicts were female.[10] In the 2019 study by Alsalameh et al smartphone addiction was found to be 60.3%.[26] In comparison, the prevalence of smartphone addiction in our study was higher than that reported by Kurtaran, but lower than the rate found by Alsalameh et al. Torkamani et al found that the daily smartphone usage time was 6.5 hours and the

**Table 2**
Comparison of muscle strength, hand-eye coordination, upper extremity functionality, and neck disability level in groups

| Measurements | | Addicted (*n* = 102) | | Non-addicted (*n* = 111) | | Test statistic |
|---|---|---|---|---|---|---|
| | | Median | IQR | Median | IQR | *p* |
| Muscle strength | Hand grip | 25.3 | 9.3 | 24.7 | 11.7 | 0.46 |
| | Hand pinch | 5.5 | 1.5 | 5.7 | 1.7 | 0.82 |
| | Lateral grip | 7.5 | 2.0 | 7.7 | 2.3 | 0.49 |
| Evaluations | Quick-DASH | 18.2 | 15.9 | 11.4 | 9.1 | **0.001**[†] |
| | NDI | 11 | 8 | 7 | 5 | **< 0.001**[†] |
| MMDT | Turning test | 52.7 | 7.2 | 51 | 7 | **0.021**[*] |
| | | m + SD | Min;Max | m + SD | Min;Max | |
| | Right-placing test | 61.9 + 5.6 | 50.3;78 | 61.1 + 4.9 | 45.3;73 | 0.25 |
| | Left-placing test | 66.4 + 6.4 | 47;82.7 | 65.2 + 6 | 54;80.3 | 0.17 |

*n* = number of participants; m ± SD = mean ± standart deviation; min = minimum; max = maximum; IQR = interquartile range; *p* = significance level; MMDT = Minnesota Manual Dexterity Test; Quick-DASH = Quick Disabilities of the Arm, Shoulder, and Hand; NDI = Neck Disability Index.
Bold value indicates statistically significance ($p < 0.05$).
[*] Mann-Whitney U test.
[†] Independent samples t-test.

**Table 3**
Comparison of upper extremity functionality and neck disability level according to cervical flexion posture ($n$ = 213)

| Evaluations | 15 degree flexion[1] (n=28) | | 30 degree flexion[2] (n=99) | | 45 degree flexion[3] (n=74) | | 60 degree flexion[4] (n=12) | | Test statistic |
|---|---|---|---|---|---|---|---|---|---|
| | Median | IQR | Median | IQR | Median | IQR | Median | IQR | p |
| **Quick-DASH** | 10.22 | 11.36 | 11.36 | 12.37 | 18.18 | 15.91 | 18.17 | 22.72 | **0.005** |
| *Post-Hoc* | $p^{1-2}$=0.52 | **$p^{1-3}$=0.041** | $p^{1-4}$=0.16 | | **$p^{2-3}$=0.042** | $p^{2-4}$=0.05 | $p^{3-4}$=0.55 | | |
| **NDI** | **7** | 7 | 8 | 6 | 10 | 8 | 10.50 | 6 | **0.015** |
| *Post-Hoc* | $p^{1-2}$=0.99 | **$p^{1-3}$=0.035** | $p^{1-4}$=0.18 | | **$p^{2-3}$=0.039** | $p^{2-4}$=0.13 | $p^{3-4}$=0.93 | | |

$n$ = number of participants; Quick-DASH = Quick Disabilities of the Arm, Shoulder, and Hand; NDI = Neck Disability Index; IQR = interquartile range; $p$ = significance level.
Bold value indicates statistically significance ($p < 0.05$).

**Table 4**
The relationship between smartphone addiction and duration of phone use (years), duration of daily use (hours), muscle strength, hand-eye coordination, upper extremity functionality and neck disability index

| Evaluations | SAS-SV | | Duration of phone use (y) | | Duration of daily use (h) | | Screen size (cm²) | |
|---|---|---|---|---|---|---|---|---|
| | Test statistic | | | | | | | |
| | *p* | r | *p* | r | *p* | r | *p* | r |
| Muscle strength | | | | | | | | |
| Hand grip | 0.08 | -0.11 | 0.27 | 0.07 | 0.45 | 0.05 | 0.64 | -0.03 |
| Hand pinch | 0.35 | -0.06 | 0.32 | 0.06 | 0.13 | 0.1 | 0.77 | 0.02 |
| Lateral grip | 0.18 | -0.09 | 0.08 | 0.11 | 0.15 | 0.09 | 0.82 | 0.01 |
| MMDT | | | | | | | | |
| Right-placing test | 0.5 | 0.04 | 0.88 | -0.01 | 0.91 | 0.01 | 0.80 | -0.01 |
| Left-placing test | 0.09 | 0.11 | 0.78 | -0.01 | 0.38 | -0.06 | 0.96 | 0.01 |
| Turning test | **0.014** | **0.17** | 0.89 | 0.01 | 0.58 | 0.03 | 0.55 | -0.04 |
| SAS-SV | | | 0.14 | 0.1 | **< 0.001** | **0.31** | 0.67 | -0.02 |
| Quick-DASH | **< 0.001** | **0.28** | 0.29 | -0.07 | 0.21 | 0.08 | 0.88 | -0.01 |
| NDI | **< 0.001** | **0.35** | 0.71 | -0.02 | 0.16 | 0.09 | 0.11 | 0.1 |

SAS-SV = Smartphone Addiction Scale-Short Version; MMDT = Minnesota Manual Dexterity Test; Quick-DASH = Quick Disabilities of the Arm, Shoulder, and Hand; NDI = Neck Disability Index; IQR = interquartile range; $p$ = significance level; r = Spearman rho correlation (low correlation: 0.05-0.3, moderate: 0.3-0.7, high: 0.7-1.0).
Bold value indicates statistically significance ($p < 0.05$).

mean SAS-SV score was 43.9.[27] Kurtaran detected that the average duration of smartphone use of adults was 7.2 and the average SAS-SV score was 39.8.[10] Alshahrani et al define smartphone use for more than 4 hours on average per day as intensive use.[28] Previous studies have shown that more than 70% of adults use smartphones for more than 4 hours daily. [29,30] In this study, the mean SAS-SV score of those with smartphone addiction was similar to previous studies. Although the average daily smartphone usage time of healthy adults was lower than in the literature, it was determined that all of the adults had intensive smartphone use and the intensity of daily smartphone use was even higher in addicted adults. Similar to the literature, the majority of the adults who participated in our study were female and the level of addiction was higher in females.

### *Muscle strength*

Although there are many studies in the literature investigating whether smartphone use and addiction effects upper extremity muscle strength, the results are controversial. Din and Hafeez found that smartphone addiction decreased hand grip strength in a study published in 2021.[2] In contrast to this study, Alshahrani et al found no difference in hand grip and pinch strength in youth with and without smartphone addiction.[3] Our study is similar to the study of Alshahrani et al. In our study, we found that smartphone addiction did not affect upper hand grip, pinch and lateral grip strength in healthy adults. Similarly, another study showed that high-frequency and low-frequency smartphone use did not make a difference in pinch strength in adults.[4] The asymptomatic status of the adult participants in our study may have caused these results. When the average age of the participants in our study is taken into consideration, smartphone use may not have affected the strength of the distal segments, as the duration of phone use is expected to be shorter than middle or older age. We think that the similar exercise habits of the participants in the groups may be another reason for the similar upper extremity muscle strength in the groups.

Osailan reported a slight negative correlation between duration of smartphone use and hand grip and pinch strength.[31] In our study, there was no relationship between average daily smartphone usage time and upper extremity muscle strength. In our study, the average daily smartphone usage time was recorded according to the participants' reports. In his study, Osailan recorded the duration of phone use through a feature on the phones. This method may have provided a more objective evaluation of the time spent by adults in the last week in front of the phone. Therefore, the results of our study may have been different from Osailan's study. In addition, in our study, it is seen that adults prefer one-handed use more during phone use, as previously stated in the literatüre.[32] One-handed use, which is preferred during smartphone use, is primarily based on thumb movement and it is also known that the remaining parts of the hand are used in grasping.[33] The role of the thumb in grasping and the similarity of the preferred hand use of the healthy adults in the groups in our study during phone use support our results.

### *Hand-eye coordination*

Research on how the time spent with smartphones effects hand dexterity and coordination and upper extremity coordination of adults is limited and the results are often controversial.[5] In one study, participants' manual dexterity was evaluated with MMDT and it was found that smartphone addiction did not affect dexterity functions.[34] Similarly, Akçay et al used MMDT for hand dexterity and coordination in their study with university students. In the study, it was indicated that smartphone addiction did not have a negative effect on hand dexterity.[6]

In the studies realized with younger age group adolescents, the results are similar to the studies of Akçay et al and Oberoi et al.[35] In contrast, Shetty et al evaluated finger dexterity with the Purdue pegboard test and found that heavy smartphone use had a negative impact on finger dexterity.[36] Aswathappa et al also reported that smartphone addicts had significantly lower upper extremity coordination compared to non-addicts in a study involving 100 students aged 18-25 years.[7] The results of our study are relatively similar to this study. We found that those with smartphone addiction completed the turning test time, a sub-dimension of the MMDT, in a longer time, which indicates a lower performance. Similarly, our study shows that there is a positive correlation between smartphone addiction and turning test duration. In our study, we did not question whether the participants had a hobby (painting, playing a musical instrument, etc) that they realized by using their hands. In addition, the majority of healthy adults are university students. It is expected that university students generally do activities that require fine motor activity such as writing and using computers. Such differences may have affected the results of the study. This may have a limited effect on hand-eye coordination performance.

*Upper extremity function and neck disability*

Studies have reported that smartphone addiction and daily usage time are associated with neck, shoulder and upper extremity musculoskeletal pain, while intensive phone use causes difficulties in performing daily life activities.[8,9,37] Topçu et al found that there was no relationship between DASH score and duration of smartphone use.[11] In contrast, Kurtaran found a significant relationship between daily smartphone usage time and Quick-DASH score in his study.[10] Our study is partially similar to the study of Topçu et al. Our results show that there is no relationship between average daily smartphone usage time and NDI and Quick-DASH score. Din and Hafeez found that smartphone addiction decreased upper extremity functionality in their study.[2] In this study, the Quick-DASH score was higher in the group with smartphone addiction. In addition, as the level of smartphone addiction increased, the participants' upper extremity functionality decreased indirectly.

Among smartphone users, the posture in which the neck is flexed forward or the chin is moved forward is a poor posture often adopted during use.[38] The neck is flexed forward and this condition continues for a long time and contributes to musculoskeletal problems in the upper extremities.[39] A study in adults in Thailand showed that flexion movements of more than 20 degrees in the cervical spine during cell phone use were associated with musculoskeletal disorders of the neck, trunk and lower extremities.[12] In our study, similar to the literature, Quick-DASH and NDI scores increased with increasing cervical flexion angle. In addition, in our study, the majority of the participants reported that the angle in the cervical spine was between 30 and 45 degrees of flexion during smartphone use. We suggest that the degree of flexion in the cervical region is affected by smartphone screen size. With smaller screen sizes, the phone user adaptively flexes their neck more to reduce the distance between the screen and the eye.[40] In our study, the relatively lower screen size in the smartphone addicted group compared to the non-addicted group may have led to this result.

Studies have reported that heavy use of smartphones causes more stress on the neck and weakness in the neck muscles.[41] Abdel-aziem et al found that the risk of developing functional neck disability was much higher in those with smartphone addiction than in those without.[42] Yağcı et al found that the level of neck disability was higher in adults with smartphone addiction compared to those who were not addicted.[30] The results of our study were similar to the literature. In another recent study, Baah et al found a significant and positive correlation between smartphone addiction and Copenhagen Neck Functional Disability Scale.[43] In our study, there was a moderate positive relationship between smartphone addiction and neck disability level. However, Topçu et al reported a positive relationship between smartphone usage time and NDI.[11] In contrast to this study, Bertozzi et al results that there is no relationship between average daily smartphone usage time and NDI.[44] In our study, as in the study of Bertozzi et al no correlation was found between average daily smartphone usage time and NDI. It is possible to see that the screen size of smartphones is effective in eliciting symptoms. However, it is seen that the participants in our study have been using their current phones for 2 years in both groups. During this time, users may have developed different adaptations. In addition, long-term use of the phone in a static position may not only affects muscular structures. For this reason, we believe that future studies should focus on a neuromusculoskeletal-oriented integrative approach to reveal smartphone effects in the upper extremity.

*Strengths*

One of the strengths of our study is that participants were selected from the 18-49 age group, which is the most common smartphone user group. Mobile phone cases may affect the way you hold your phone and the functionality of your fingers. Examining the screen size in this respect and comparing the data in terms of the parameters determined in our study and analyzing the relationship is different from the previously published studies in this respect. Another strength that makes our results significant is that the study was conducted with healthy adults who are heavy users of smartphones.

*Limitations*

Our study was designed as a cross-sectional study, so we think that our results are limited in terms of causality and causal relationship. Another limitation was that the evaluations of smartphone habits in our study were based on subjective data.

## Conclusion

The current research shows that smartphone addiction and increased flexion posture in the cervical spine negatively affect hand-eye coordination, upper extremity and cervical spine health in users. Determining the effects of smartphone use in healthy adults is extremely important for healthy and more comfortable aging in later life. Early detection of risks and dysfunctions can prevent possible musculoskeletal problems that may develop. Hand therapists should play a leading role in educating adults, especially those who lead lifestyles involving intensive use of smartphones, on developing correct posture habits and increasing body awareness.

## Ethical approval and informed consent

Ethics committee permission was obtained from the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee dated 14.03.2024/02-587 with decision number 2024-587 research code.

## Author contributions

**Ali Ceylan**: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ertuğrul Demirdel**: Writing – review & editing, Validation, Supervision, Project administration, Formal analysis, Conceptualization.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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