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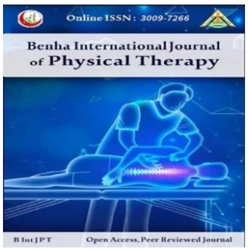

Original research

Effect of smartphone overuse on hand strength and function in physical therapy students.

Nouran M Saad Zaghloul [1*], Hanaa k Atta[2], Noran A Elbehary.[3].

1. Basic Science Department, Faculty of physical therapy cairo university.

2. Assitant professor at Basic Science Department, Faculty of physical therapy Cairo university.

3. Assitant professor at Basic Science Department, Faculty of physical therapy Cairo university.

Correspondene to:** ***Nouran M Saad Zaghloul, Basic Science Department, Faculty of physical therapy cairo university.
E-mail: nouran_saad93@yahoo.com
Tel: 01028241351 .+

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Abstract:
Background: Smartphones have evolved to the point where they are now an essential part of contemporary lifestyles. On the other hand, it has also had a detrimental effect on our way of life. **Purpose:** The study was made to investigate the effect of smartphone overuse on peak torque of wrist flexors and extensors, handgrip strength and functional performance of hand in physical therapy students. **Methods:** A total of 60 students aged between 18 and 25 assigned into two groups: Group A (high-frequency smartphone users) and Group B (low-frequency smartphone users) using stratified random method. Levels of smartphone use were determined using the smartphone addiction scale-short version. An isokinetic dynamometer was utilized to measure the peak torque of wrist flexors and extensors. Then, hand-held dynamometer was utilized to measure handgrip strength. The evaluated hand is the dominant hand. Functional abilities of the upper limb and hand were determined via the Patient Rated Wrist and Hand Evaluation questionnaire (PRWHE). **Results:** Group A had significant reduction in wrist extensor and flexor peak torque relative to group B ($p < 0.01$). Group A had significant reduction in hand grip strength relative to group B ($p < 0.05$). Compared to group B, group A demonstrated a significant increase in both pain and functional limitation scores ($p < 0.01$). **Conclusions:** Excessive smartphone use led to a reduction in peak torque of wrist flexors and extensors. Also, the hand grip strength was decreased by increasing the level of smartphone use. Hand functions were decreased while wrist pain was increased in high frequency smartphone users.

Key Words: Hand-Grip strength, Patient Rated Wrist and Hand Evaluation, Peak torque, Smartphone addiction, Smartphone addiction scale.

Introduction

Currently, technology is essential to daily existence. It entails staying up to date with the quick changes occurring in the communication technology space. Therefore, cellphones have evolved into indispensable tools for social interaction as well as communication.[1,2]

Because of its powerful attraction, youths are particularly more vulnerable to smartphone addiction. Numerous people view smartphones as a "second self." Numerous smartphone users indicated a dependence on their devices for daily functioning.[3]

Excessive smartphone usage without incorporating sufficient breaks contributes to repetitive stress injuries in the hands, wrists, shoulders, and neck. Because using a smartphone normally necessitates touching the screen with the thumb and finger, several problems could arise.[4]

According to reports, prolonged smartphone use combined with suboptimal wrist positioning is likely to result in repetitive stress conditions involving the wrist joints, especially if the fingers, hands, and wrist are overworked.[5]

Only in the last few years, studies exploring smartphone-related musculoskeletal diseases have come to light. Nonetheless, a few studies have suggested that thumb motions, repeated pushing motions, and gripping are risk factors for upper limb dysfunction.[6,7]

Ming et al. (2006)[2] revealed that people with upper limb musculoskeletal diseases used smartphones for longer than three years. Carpal tunnel syndrome is a result of the carpal tunnel narrowing caused by repetitive wrist movements during excessive smartphone use. Furthermore, Connections exist between the number of strokes and hand conditions involving De Quervain disease and the first carpometacarpal degeneration.

Many university students (about 859 students), who use mobile phones, were watched by Gold et al. for their postures and typing habits, and it was shown that the majority (more than 90%) assumed incorrect wrist posture, shoulder protraction, and neck flexion when texting.[8]

Gustafsson et al. (2011)[9] investigated the kinematics of the neck, thumb, and shoulder, in addition to the muscular engagement in the cervical region, shoulders, and forearms among those who used keypad phones. The study concluded that test subjects in the experimental group had an elevated likelihood of having bad body mechanics and greater muscular activation during mobile texting. Doing repetitive upper extremity exercises would cause little harm to the blood vessels, muscles, nerves, and joints, in addition to paresthesia and persistent discomfort in the arms, fingers, wrists, shoulders, and neck.[7]

Despite the worldwide use of smartphones, its potential impact on hand strength and function remains poorly understood. The current study explores the influence of smartphone overuse on peak torque of wrist flexors and extensors.

Methods

An observational cross-sectional study was carried out the isokinetic lab at the Faculty of Physical Therapy, Cairo University, Egypt, to explore the relationship between smartphone addiction and the strength, function of the hand and wrist muscles in adult persons

Sample Size calculation:

Sample size estimation was conducted through G*POWER statistical software (version 3.1.9.2), utilizing previously published handgrip strength data.11 It indicated a requirement of 30 participants per group, with calculations employing a significance level of α=0.05, statistical power of 80%, effect size of 0.74, and a 1:1 allocation ratio between groups.

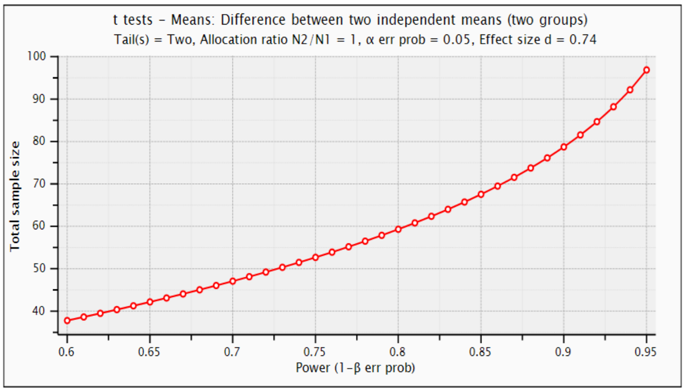

Figure 1. Sample size calculation

Participants:

A total of 60 persons, including male and female subjects, were included in the study. They were 27 females and 33 males. Prior to the study, every participant had been using smartphones for at least two years. If a participant had experienced neurological or orthopedic issues in their upper extremities within the previous four months, or if they had hearing, visual, or perceptual impairments, they were not allowed to participate in the study.

Ethics approval and consent to participate:

The study was carried out in accordance with the 1964 Declaration of Helsinki's ethical criteria and was authorized by the Faculty of Physical Therapy, Cairo University, Egypt's ethical committee (No:P.T.REC/012/005125).

Procedures:

The evaluated hand was the dominant hand. The Arabic version of the smartphone addiction scale (short version) was used to evaluate the participants for smartphone addiction. The handgrip strength was measured using the hand-held Dynamometer. The wrist flexor and extensor peak torque were measured by the isokinetic dynamometer. Hand Pain and Function were measured using the Patient Rated Wrist and Hand Evaluation (PRWHE) questionnaire. First of all,

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the participants were given the Arabic version of the smartphone addiction scale (short version) to fill it out. Then, they were asked if they were suffering from any medical, musculoskeletal or neurological condition. Before taking the participants to evaluation, they were asked to fill out a consent form confirming their willingness to share in the study. The outcomes of assessment were not said to the participants until the end of the study.

Inclusion criteria:

Sixty healthy participants of both sexes. Their ages range from 18 to 25. The Body Mass Indices (BMIs) ranges from 18 but less than 25 kg/m2. All were right dominant handed, from the faculty of physical therapy, Cairo university. Participants were divided into two equal groups, based on how frequently they used smartphones. Group A, was for high-frequency smartphone users, which is the experimental group. While Group B, was for low-frequency smartphone users, which is the control group. The smartphone addiction scale-short version (SAS-SV) was utilized to assess use levels.

Exclusion criteria:

If a participant had experienced neurological or orthopedic issues affecting the upper limbs over the previous four months, or if there was hearing, visual, or perceptual impairments, presence of mental disability, presence of anatomical defects, deformities, anomalies, or motor/sensory deficits involving the upper limbs, the participant would have been excluded from the study. Presence of neuromuscular or tendon-related pathologies in the upper extremity, history of upper limb fractures, presence of asymmetrical measurements of the arm or hand (hand girth, digit length, forearm size, etc.) and high-performance athletes were contraindicated in the study. Also, there are some factors contraindicating grip strength testing such as open skin injuries, severe osteoporotic subjects, regular use of vitamins D or B and any burn-related injury located on or adjacent to the hand region involved in dynamometer placement.[10]

Smartphone Addiction Assessment:

A validated questionnaire called the Smartphone Addiction Scale Short Version (SAS-SV) is utilized to evaluate children's addiction to smartphone.12 It exhibits internal consistency (Cronbach's alpha 0.91), concurrent validity, and content validity.[13] Ten questions concerning daily activities (such as interruption, pleasant expectation, departure, internet-based communication, excessive use, and patience) made up the questionnaire. A dimensional scale ranging from 1 to 6 was used to grade each question. In other words, respondents indicated how much they agreed or disagreed with the questions (6 being highly agree, 5 being agree, 1 indicates strongly disagreeing, 2 disagree, 3 disagree, and 4 indicate somewhat agreeing.[14] Cut-off values for identifying frequent smartphone usage were determined by gender-specific normative scores, 31 for males and 33 for females, on a 60-point scale.[14]

Hand Pain and Function Assessment:

Upper Extremity functional assessment was done using the Patient Rated Wrist and Hand Evaluation (PRWHE) questionnaire. A patient-reported outcome measure called the Patient-Rated Wrist Evaluation (PRWE) is designed to determine how much pain and disability a patient feels as a result of wrist disorders.[15] More than 150 studies have employed PRWE, which is advised as a fundamental metric for assessing results in distal radius fractures (DRFs).[16]

Although the PRWE questionnaire was initially created to assess distal radial fractures, the rating guidelines (though the individual items remained unchanged) were eventually changed to assess hand and wrist issues as part of the PRWHE.[16]

The PRWE assessment tool comprises 15 items across three distinct subscales: pain, particular activities, and regular activities, assessing both pain and impairment. The five items on the pain subscale scored from 0 (reflecting pain absence) to 10 (representing the highest pain level). Functional capability evaluation encompasses ten questions, six examining specific movements and four addressing routine activities—with scores ranging from 0 (perfect ability) to 10 (complete disability). Pain and impairment (function) values are equally evaluated in the final PRWE score. The straightforward scoring method adds the functional scores, divides them by two, and then adds them to the pain scores to produce an overall score out of 100.[17]

Handgrip Strength Assessment:

The same physiotherapist, who was unaware of the participants' SAS-SV scores, assessed each participant's grip strength in their dominant hands. Kilogram grip strength was assessed utilizing a JAMAR hand dynamometer (Sammons Preston Inc., Bolingbrook, IL, USA). The Handgrip

Assessment approach demonstrated strong inter-rater and intra-rater reliability as well as test-retest reliability.[18,19]

Subjects were positioned with their shoulders close to the body and in a neutral rotation, based on the American Society of Hand Therapists' guidelines for measuring handgrip. The elbow on the assessed side was bent at a 90° angle, with the wrist and forearm placed in standard neutral positioning. Subjects were then instructed to apply maximum pressure on the dynamometer handle while exerting their strongest grip. There were three trials with half-minute rest intervals in between. Each participant's mean score from the three trials was noted.18,19

Wrist Strength Assessment (Peak Torque of wrist Flexors and Extensors):

Wrist flexor and extensor peak torque evaluation were performed utilizing the isokinetic dynamometer. The Biodex MultiJoint System 3 dynamometer (Biodex Medical System, Shirley, New York, USA) was utilized to conduct wrist strength testing.

As directed by the manufacturer, dynamometer calibration was conducted before every test.20 The same examiner assessed each individual. On the dominant limb, the peak concentric torque of the wrist flexors and extensors was measured. The full name, sex, birthdate, height, body mass, and hand dominance were input into the system prior to the evaluations. Strength measurement was done while the elbow is bent at a right angle, the forearm turned palm-up, and the participant seated upright. Proper alignment between the dynamometer's rotational axis and the diagonal axis connecting the distal radial tuberculum and ulnar head was established (HUMAC norm, model 502140; Computer Sports Medicine, Inc, Stoughton, MA).

Throughout the evaluation, participants maintained 90 degrees of elbow flexion, with forearm stabilization achieved using a securing strap. Therefore, there is immobility in the biceps and triceps, eliminating their contribution to wrist movement. When adjusting the wrist joint, it will be put in a standard neutral position using a goniometer. The neutral position represents the baseline configuration of the dynamometer. For each participant, the wrist's neutral (zero-degree) position on the dynamometer was recorded to ensure consistent alignment during the second evaluation. To minimize unnecessary wrist movement, the device's motion was restricted to 80 degrees, 40 degrees in flexion and 40 degrees in extension.[21]

Accordingly, a concentric wrist flexion and extension strength test was conducted at an angular velocity of 90°/s, involving three sets of three repetitions each. A 60-second rest period was provided between sets. The same verbal and visual cues were given to every participant. Participants were encouraged to do better each time. Average highest peak torque was recorded in each trial and since they are three trials so the average peak torque is recorded three times in flexion and three times in extension.

Data Analysis

To compare baseline characteristics between groups, an unpaired t-test was utilized, and sex distribution was examined using the Chi-square test. The Shapiro-Wilk test assessed normality of distribution, while Levene's test verified variance homogeneity across groups. Further comparisons of wrist extensor/flexor peak torque, hand grip strength, and PRWHE scores between groups were conducted using unpaired t-tests. A significance level of $p < 0.05$ was adopted for all statistical tests, which were conducted utilizing the statistical package for social sciences (SPSS) version 25 (Windows).

Results

Subject characteristics:

Table 1 displays the demographic characteristics of participants in both groups. Statistical analysis revealed insignificant differences between groups regarding age, weight, height, BMI, and sex distribution ($p > 0.05$). Conversely, group A recorded a significantly higher SAS-SV score than group B ($p < 0.001$).

Table 1. Basic characteristics of participants.

	Group A	Group B	p-value
	Mean ± SD	Mean ± SD	
Age (years)	19.20 ± 1.03	18.97 ± 1.19	0.42
Weight (kg)	66.83 ± 10.51	65.40 ± 9.38	0.58
Height (cm)	70.± 10 40.171	± 10.22 171.83	0.87
BMI (kg/m²)	22.66 ± 2.11	22.08 ± 1.69	0.25
SAS	39.23 ± 5.21	± 2.73 28.10	0.001
Sex, n (%)			
Females	(43%) 13	(47%) 14	0.79
Males	17 (57%)	(53%) 16	

SD, standard deviation; p-value, level of significance

Effect of smartphone overuse on wrist extensors and flexors peak torque, hand grip strength and PRWHE:

A significant reduction in wrist extensor and flexor peak torque was observed in group A relative to group B ($p < 0.01$)

A significant reduction in hand grip strength was noted in group A relative to group B ($p < 0.05$).

Compared to group B, group A demonstrated a significant increase in both pain and functional limitation scores ($p < 0.01$) (table 2).

Table 2. Mean hand grip strength and PRWHE of group A and group B:

	Group A	Group B			
	Mean ± SD	Mean ± SD	MD	t- value	p value
Wrist extensors peak torque (Nm)	37.± 1 98.2	26.± 1 85.3	87.-0	54.-2	0.01
Wrist flexors peak torque (Nm)	3.23 ± 0.92	± 0.89 4.17	94.-0	-4.05	0.001
Hand grip strength (lb)	± 19.82 13.61	72.17 ± 15.95	04.-11	37.-2	0.02
PRWHE					
Pain	86.± 6 17.14	± 6.12 20.9	4.97	96.2	0.004
Function	12.25 ± 3.64	5.43 ± 2.90	6.82	03.8	0.001

SD, standard deviation; MD, mean difference; p-value, probability value

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Discussion

The present study explored how smartphone addiction influences wrist muscular strength, hand grip strength and upper limb impairment within the young adult population.

The findings of the current study indicate that increased smartphone usage is linked to a reduced hand grip strength along with an increased upper limb impairment.

The distribution by sex was 57% male and 43% female in Group A, and 43% male and 57% female in Group B. The mean age taken was 19.2 for group A, while 18.97 for group B. Mean Smart phone addiction score found was 39.23 for group A, while 29.3 for group B out of total 60. Another PRWHE questionnaire was utilized to measure upper extremity functional limitations. It is subdivided into two subscales which are pain and function. Mean pain score in PRWHE was 14.17 for group A, and 9.2 for group B. The score is out of 50. Mean function score in PRWHE was 12.25 for group A, and 5.43 for group B. The score is out of 50, as well. So, Participants had had mild to moderate level of disability when they overuse their smartphones. Mean of flexors peak torque was 3.23 for group A, and 4.17 for group B. Mean of extensors peak torque was 2.98 for group A, and 3.85 for group B.

The unpaired t test showed that both groups were comparable in age, weight, height, BMI, and sex distribution ($p > 0.05$). Group A exhibited a significantly higher SAS-SV score than group B ($p < 0.001$). Group A also demonstrated significant reductions in wrist extensor and flexor peak torque ($p < 0.01$) and hand grip strength ($p < 0.05$) relative to group B. In addition, pain and function scores exhibited a significant increase in group A as opposed to group B ($p < 0.01$).

The most significant complication linked to smartphone usage is weakness of hand and wrist. Consequently, prolonged usage may lead to uncomfortable and suboptimal postures of the upper limb. Therefore, experiencing musculoskeletal difficulties.[23]

To the best of our knowledge no one used the isokinetic dynamometer for measurement of effect of smartphone overuse. Only some studies mentioned the reliability of isokinetic dynamometer in measuring wrist strength. Also, another study differentiated between using hand-held dynamometer and using isokinetic dynamometer in measuring wrist strength. Moreover, the isokinetic dynamometer is regarded as the most accurate tool for evaluating muscle performance.[24] Also, dynamometry is used to quantify fatigue in repetitive tasks. So, it was decided to use it in the study.

The effect of smartphone overuse is evident here and in many other studies and it can be interpreted through the following.

Firstly, Excessive smartphone use can lead to hand pain through several mechanisms. The first one is increasing muscle activity. It appears in the increased activity of the neck extensor, erector spinae and upper trapezius musculature.[25] The second mechanism is the Repetitive Strain Injury (RSI), which is performing repetitive movements, such as typing or swiping on a smartphone, can negatively impact the muscular, tendinous, and nervous components of the hand. Such overuse can produce pain, tingling, numbness, and weakness, which may worsen over time if not addressed.[26] Also, carpal tunnel syndrome (CTS) might be a cause for hand pain. Using a smartphone increases the incidence of carpal tunnel syndrome and therefore increases susceptibility of pain.[27]

Frequent smartphone use compels users to assume an unnatural posture, resulting in a heightened likelihood of musculoskeletal complications and discomfort. The aim of the study is to perform a systematic review of evaluating the impact of smartphone usage on pain and musculoskeletal disorders. The findings indicate that muscular activity in the neck extensor muscles, erector spinae, and upper trapezius is elevated, alongside an increase in forward head displacement, head tilt angle, and head flexion angle when interacting with smartphones. Furthermore, utilizing a smartphone while seated appears to induce a greater alteration in the head-neck angle compared to when standing. The utilization of smartphones may result in musculoskeletal disorders. The conclusions drawn from the reviewed studies should be interpreted cautiously, considering the concerns raised by the moderate quality assessment ratings.[25]

Another study was done by Al shahrani et al. (2021)26. The aim was to evaluate the correlation between smartphone usage and the onset of carpal tunnel syndrome (CTS).[26] It was found that Carpal Tunnel Syndrome adversely affects daily living tasks and occupational performance. The authors' findings demonstrated that a greater duration of

smartphone usage correlates with the onset of Carpal Tunnel Syndrome (CTS).[27]
Secondly, it was obvious that hand weakness and deminished grip strength with functional impairments were evident in case of smartphone overuse. The hand weakness can be due to Median Nerve Enlargement and Compression. Prolonged and repetitive smartphone activities, such as typing and swiping, can cause the median nerve to enlarge. The median nerve enlargement increases pressure within the carpal tunnel, potentially resulting in nerve compression. Such compression may result in reduced grip and pinch strength, contributing to hand weakness.[28] Also, it may be due to Muscle Fatigue and Overuse. Persistent static contractions of the upper extremity musculature, particularly without adequate rest, can lead to muscle fatigue. The overuse affects muscles like the upper trapezius, abductor pollicis, and extensor pollicis longus, resulting in lowered hand strength and function.[11]
Another reason could be Repetitive Stress Injuries. Frequent and repetitive thumb and wrist movements induced by smartphone utilization may lead to disorders like De Quervain's tenosynovitis and tendinitis. Such conditions cause inflammation and pain in the tendons, leading to weakened hand muscles and reduced functional capacity.[26] Moreover, the hand weakness could be due to poor ergonomic postures. Holding smartphones in awkward positions, such as with unsupported elbows or extreme wrist flexion, places additional strain on the musculoskeletal system. These poor postures can exacerbate muscle fatigue and contribute to nerve compression, further diminishing hand strength.[29]
An observational study was previously conducted by Kim et al. (2014)[11]. The composition includes two groups of children, aged 9 and 15. One group contains heavy smartphone users and other groups include users of smartphones with low frequency of use. The present study focused on examining how smartphone use influences hand grip and pinch strength. The findings indicate that elevated smartphone use leads to reductions in grip and pinch strength.[11] Comparing the previous study with current study, the previous one uses the quick DASH questionnaire, but present study uses the PRWHE questionnaire. The previous one was done on participants with smaller age as it was done on children with age 9 to 15 while the present one was done on adults from 18 to 25. The previous one explored how intensive smartphone use impacts handgrip and pinch strengths, while the current one focused on assessing the consequences of smartphone use on wrist flexor and extensor peak torque, handgrip strength and hand pain and function.
Another study come in accordance with the study, Soliman et al. (2020)30 carried out a cross-sectional analysis involving 420 Egyptian physical therapy students who investigated the link between smartphone overuse and musculoskeletal discomfort. The results indicated a substantial correlation between excessive smartphone use and reported aches and pains in musculoskeletal areas among the participants.[30]

According to Megna et al. (2018)[31] who investigated using a smart phone necessitates a lot of movement and an excessive amount of tension on the distal interphalangeal joints and nails. The objective was to find out more about the effects of addiction to smart phones on the hand joints of young patients suffering from psoriatic arthritis. In each of the subjects, an ultrasonography examination was performed on both of their hands. It was shown that excessive usage of smartphones was associated with inflammation of the musculoskeletal tissues of the hands and joints. Consequently, excessive use can be a factor that contributes to the development of psoriatic arthritis.31 An addiction to smart phones has been shown to have a strong positive correlation with upper limb impairment, in agreement with the current study's findings.
Overuse-related injuries may result from excessive finger activity carried out during extended durations at rapid speed.[32] Hand functional ability and pinch strength were observed to decline as a result of regular usage of smart phones, according to a previous study on hand pain caused by repetitive tasks. The current study's results are corroborated by the findings of Cho et al. (2014)[33], who discovered that frequent usage of intelligent phones leads to reduced hand grip strength and function.[33]
Prolonged tension of upper limb muscles with minimal or no relaxation during smartphone usage leads to muscle fatigue and weakening. The primary upper hand musculature, which are the trapezius, the abductor pollicis, and the extensor pollicis longus, are impacted. These findings align with those by El-Azab et al. (2017)[34], who observed a strong link between extended

smartphone use to the intensity of arm-related complaints, including discomfort, exhaustion, and poor ergonomic alignment, which adversely affect upper extremity functionality.[34]

Another study was done by Goswami et al. (2016)[22], the aim of the study was to explore the influence of utilizing a smartphone on the strength of the hand grip as well as the capability of the hands to perform functional tasks in younger individuals. Excessive smartphone utilization was linked to decreased hand grip strengths and hand functionality, with the dominant hand being more adversely affected.[22]

In accordance with present study, another study was done by Radwan et al. (2021)[28]. The study employed ultrasound imaging to examine the flexor pollicis longus (FPL) tendon and median nerve structures among smartphone users to determine how smartphone addiction affects hand clinical presentation and functional capabilities. It was concluded that Excessive smartphone usage enlarges the median nerve, induces thumb pain, and diminishes pinch strength and hand functionality.[28]

However, in contrast to the findings some studies present differing findings. For instance, a study, published in Addicta: The Turkish Journal on Addictions by Akçay et al. (2023)[35], reported no adverse effects of smartphone addiction on hand and pinch grip strength, pressure pain threshold, or dexterity among undergraduate student populations.[35]

Study authors conducted a study examining the impact of smartphone usage time on cervical flexor and extensor endurance, grip strength, and pinch strength in healthy young college students. The study determined that prolonged smartphone usage may affect neck flexor muscle endurance; however, no significant differences were found in cervical extensor endurance tests or in bilateral hand grasp and pinch strength assessments across groups ($p > 0.05$). [36]

These discrepancies may stem from variations in study populations, methodologies, and definitions of smartphone overuse. Nonetheless, the potential for hand pain and functional impairments due to excessive smartphone use is evident.

Limitations of the study:

The participants varied in age from 18 to 25 years old and were limited to a total of sixty college students from one university. In the future for the purpose of evaluating manual abilities and hand strength, studies might be carried out on a bigger sample size, in a variety of locations. A future cohort is also required in order to evaluate the long-term impacts that students experience as a result of their addiction to smartphones.

Conclusion

It can be concluded from the results presented in the current study that prolonged usage of smartphones induces a reduction in the hand grip strength along with the overall hand-related functionality. In particular, those who used their smartphones frequently experienced a decrease in the strength of their hands on the dominant hand side. Moreover, there is decrease in the peak torque especially that of wrist flexors, besides extensors. Also, with a high or low level of smartphone usage, hand functions were impaired and they experience more pain on the dominant side.

DECLARATIONS

□ **Consent to publish:** I certify that each author has given their consent to submit the work.

□ **Competing interests:** None.

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