International Journal of
Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Estimation of Intrinsic And Extrinsic Hand Muscle Performance in Chronic Smartphone Users

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Date of submission: 11.01.2023
Date of acceptance: 23.04.2024
Date of publication: 01.07.2024

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v14i3.50212

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ABSTRACT

Introduction: In recent years, smartphone use has significantly expanded, and the majority of daily tasks are now completed with the help of smartphones. Therefore, excessive use results in improper posture, which then results in several musculoskeletal pains. Hence, it is crucial to assess the relationship between smartphone addiction and musculoskeletal pain. Similarly, the length-tension relationship between the intrinsic and extrinsic hand muscles might also get altered due to the repetitive movement of the hand muscles.

Methods: A cross sectional study was conducted in the Karad region and depending on the inclusion and exclusion criteria, 80 participants were selected for the study. The study was carried out from 10th August 2022 to 12th February 2023. The information that was gathered included demographic data, smartphone usage patterns, hand grip strength, and length-tension relationships. Followed by this, the received data was then compared to the baseline normative values of each of the outcome measure that was used and results were obtained.

Results: The findings of this study demonstrated that 50 (62.5%) of them were in the 25– 30 age group, whereas 30 (12.5%) were in the 31-35 range. Amongst them, 69 (86.25%) were right-handed, while 11 (13.75%) were left-handed. Results also revealed that extrinsic muscles showed higher involvement as compared to the intrinsic muscles of hand. Hand grip strength was reduced in dominant as well as non- dominant hand.

Conclusion: -This research concluded that, there is a link between smartphone use and the musculoskeletal pain as well as the length tension of the hand muscles. The subjects who used cell phones frequently showed changes in the length-tension relation of the hand muscles, which in turn resulted in a reduction in hand grip strength.

Keywords: Extrinsic muscles, Hand grip strength, Intrinsic muscles, Smartphone Addiction Scale, Smartphone use

Introduction

As time has passed, a growing number of individuals have adopted the use of smartphones. People used telephones, landlines, or transmitters in the past. People only communicated and kept in touch with one another through mobile phones in the past. Yet, cellular phones evolved into smartphones as the technology advanced.

Smartphones have emerged as one of the most important aspects, of practically everyone's life. Also, they are used for gaming, socializing, and internet browsing in addition to communication. The number of smart phone users was widely predicted to reach 2.87 billion in 2020.[1] Younger adults account for the highest total user count,

according to the findings.[2] According to the reports, individuals who use their phones for more than 3.5 hours per day get pain at the base of their thumbs.[3]

Even though, a smartphone's design allows for two-handed operation, most individuals still prefer to hold and operate their devices with just one hand. The constant flexion and extension movements cause pain in the wrist and fingers. Due to the use of smartphones, the thumb and index finger are the two most overworked digits of the hand.[4] Smartphone use has several disadvantages and negative consequences, including eye dryness, neck, shoulder, and computer vision issues.[4] The thumb and index finger, which are constantly moving in an upward and downward motion and laterally, are used to scroll the screen, play games, or browse the internet for work. This causes the muscles in the wrist and fingers to weaken.[4]

In everyday life, the hand has distinct characteristics similar to any other organ of the body, and functional impairment of the hand can affect daily life and, ultimately, quality of life. The human hand is made up of the thumb, index, middle, ring, and little fingers, as well as the palm. The fingers are made up of nineteen bones, including distal phalanges, intermediate phalanges, proximal phalanges, and the metacarpal bone. The hamate, pisiform, triquetral, capitate, lunate, trapezium, trapezius, and scaphoid bones make up the wrist. The hand includes 27 bones and 28 muscles in total. The hand grip and pinch grasp are vital and fundamental functions for a variety of activities. Individuals who use their smartphones more regularly are more likely to have an expanded median nerve and decreased hand capabilities.[5]

The inflammation of the extensor pollicis brevis and *abductor pollicis longus* tendons, results in pain and exhaustion from strenuous movements, and the most noticed effect is, reduced hand performance. This leads to decreased hand function, which also reduces the quality of life of that individual. Similarly, continuous use of hands for the operation of smartphone shows that hand grip strength is also lowered which results in decreased hand performance.[6] Also, since the hand muscles weaken, it is crucial to monitor the length and tension of both the intrinsic as well as extrinsic muscles, as this might result in pain if the muscle length is reduced.

In the bargain, daily tasks become more challenging as a result of diminished strength. Given how pervasive smartphones have grown in people's lives, this is one of the most crucial subject to be discussed. The purpose of this research is to learn more about the issues individuals encounter as a result of their continued use of smartphones.

Methods

This cross-sectional study was undertaken in Karad wherein a survey was carried out about smartphone addiction and around 322 individuals were found to be addicted to smartphones. The sample size was calculated using $n = \frac{Z^2P\,(1-P)}{d^2}$ formula [7] and also by using the prevalence of smartphone addiction.[8] 80 individuals were recruited by simple random sampling from the 322 individuals based on the inclusion and exclusion criteria. The inclusion criteria were both male and female smartphone users within the age group of 25-35 years who have been using smartphones for more than 3 hours per day for 2 years, the phone's display size was more than 4 inches, and the weight of the smartphone was more than 130 gm. Subjects using their phones in odd or abnormal positions, e.g., using smartphones in bed, etc., and those willing to participate were considered.[9] Individuals having surgical histories of the median nerve, tendon lesions of the thumb or hand, prior fractures of the hand or wrist, neurological diseases, or any history of hand or wrist injuries were all excluded. Verbal requests for participation in the study were made to participants, and those who were addressed on the spot were given full study details. A written consent document was offered for signature, after which the researcher filled out an assessment form only after the participant agreed to participate in the study.

Then, the subjects were required to complete the "Smartphone Addiction Scale-Short Version" (SAS-SV) chronic smartphone user scale. The assessment form was filled up using demographic information followed by hand grip power assessment. The name of the digital hand dynamometer that was used was the Constant Electric Hand Dynamometer manufactured by Nitrous Stores. Three measurements using the digital hand dynamometer were made, and the average of those readings was computed. The technique began with the dominant hand first, followed by the non-dominant hand.

For assessing the length-tension of hand muscles following measures were taken into consideration: If the muscle length is normal, the passive range will be fully extended, and the final feel will be that of a normal joint tissue stretch. If the muscles are tight, the range of motion is restricted and the

end feel is muscle strain rather than tissue or capsular stretch. The patient was placed in a supine lying position with the elbow extended to evaluate the length of the long wrist extensors. The examiner passively flexed the fingers first, followed by the wrist. If the wrist muscles are tight, wrist flexion will be limited. Then, the patient was placed in a supine reclining position with the elbow extended to evaluate the length of the wrist flexors. The examiner stretched the wrist after passively extending the fingers. Wrist extension was restricted by tense muscles.[10]

The study was carried out from 10th August 2022 to 12th February 2023. The statistical analysis was done manually by using the statistics software SPSS (version 21.0 for Windows; SPSS, Inc., Chicago, USA). We employed the Pearson Chi-Square Test and Linear-By-Linear Association for analyzing the data and deriving the results. The final results were calculated as percentages.

Outcome variables:

The subjects were given the smartphone addiction scale prior to the hand grip strength test. After responses were collected, a score was generated, wherein anything above the baseline score for females which was >33, and for males >31 was considered. According to each participant's age and gender, the hand grip dynamometer was adjusted and the subject was instructed to maintain a neutral wrist and an elbow flexed at 90 degrees while standing. Participants were instructed to squeeze the handle three times as hard as they could; each squeeze lasted for five seconds, with a 30-second break in between each squeeze. The three trials' average was then converted into kg.

Results

The results of socio-demographic data, Pain Scale, Chronic Smartphone use, Dominant Hand Grip strength, Non-Dominant Hand Grip strength and Length-Tension Relationship of the intrinsic and extrinsic muscles is mentioned in table no. 1-6.

After analyzing the data, it was found that 85% of people who used smartphones, as measured by the "SMART PHONE ADDICTION SCALE," were devoted users. All of the inclusion criteria were also taken into consideration. There were 80 samples collected in all, 68 of which were regular smartphone users. The hand grip strength was assessed after the subjects underwent a scale screening to determine the strength of their hand muscles.[5,11] The outcome for hand grip strength was identical to the scale, with 68 of them having hand muscular weakness. The sociodemographic data, pain scale and chronic smartphone use and dominance are mentioned in Table No. 1-3.

Table 1: Percentage values of Sociodemographic Variables

Variables	**Frequency n (%)**
Gender	
Males	24(30%)
Females	56(70%)
Age distribution	
25-30	50(62.5%)
31-35	30(37.5%)
Dominance	
Right	69(86.25%)
Left	11(13.75%)
BMI (kg/mt²)	
<18.5	0(0%)
18.5-24.9	22(27.5%)
25-29.9	0(0%)
30-34.9	42(52.5%)
35-39.9	14(17.5%)
>40	2(2.5%)

Table 2 : Visual Analogue Scale for Pain Assessment and the percentage values

Pain Assessment using Visual Analogue Scale (VAS)	Frequency (n) %
No pain	8(10%)
<5	11(13.75%)
>5	61(76.25%)

Table 3.: Percentage values of the participant's Smart phone addiction scale score

SMARTPHONE ADDICTION SCORE	TOTAL PARTICIPANTS (%)
Yes	85%
No	15%

Table 1 shows the description of sociodemographic data according to gender, age, hand dominance, and BMI. The table depicts that among 80 individuals 30% were males and 70% were females, 62.5% were from the 25-30 age group and 37.5% were from the 31-35 age group, 69% were right-handed and 11% were left-handed. The BMI of the individuals was also considered in 6 categories namely <18.5, 18.5-24.9, 25-29.9, 30-34.9, 35-39.9 and >40 (kg/mt^2) and 0%,27.5%, 0%, 52.5%,17.5% and 2.5% were the percentage values of individuals that participated in the study respectively.

Table 2 shows that around 8(10%) individuals didn't complain of any pain, 11(13.75%) showed <5 pain score whereas 61(76.25%) is the maximum percentile from the sample size showed a pain score of more than 5.

Table 3, showed that when 80 individuals, were assessed on the iOS system and the smartphone addiction scale ("SAS-SV"), 85% of individuals showed smartphone addiction and 15% of the individuals did not show smartphone addiction.

Table 4 : Percentage values of the Grip strength of the dominant hand

DOMINANT HAND GRIP STRENGTH	
Ranges	Total Participants (%)
10-16.5	13.75%
16.5-23	23.75%
23-29.5	12.5%
29.5-36	35%
36-42.5	15%

Table 5: Percentage values of participants regarding Grip strength of Non-Dominant hand

NON-DOMINANT HAND GRIP STRENGTH	
Ranges	Total Participants (%)
14-20.4	20%
20.4-26.8	23.75%
26.8-33.2	26.25%
33.2-39.6	23.75%
39.6-46	6.25%

Table 4 depicts the percentage values of the participants and ranges of the grip strength.

Individuals having grip strength of less than 36 had weak grip strength. so among 80 individuals, 85% had weak grip strength and the remaining 15% had normal or strong grip strength.

Table 5 shows the percentage values of the ranges of grip strength of Non-dominant hands and several individuals in that particular range. The range 14-20.4 consisted of 20%, 20.4-26.8 of 23.75% 26.8-33.2 of 26.75%, 33.2-39.6 of 23.75%, and 39.6-46 of 6.25% respectively.

As per table 6: it depicts the number of individuals having changes in length and tension of intrinsic and extrinsic hand muscles due to overuse of the particular hand while using a smartphone. Among 80 individuals 17(21.25%) had changes in the intrinsic muscles, 51(63.75%) had changes in extrinsic muscles, 7(8.75%) had changes in both intrinsic and extrinsic muscles whereas 5(6.25%) showed normal ranges. The length of the extrinsic muscles is reduced due to restricted extension movement which leads to increase in the tension of the muscle.

Table 6 : Percentage value of intrinsic and extrinsic muscles involvement and its severity.

	Intrinsic Muscles	**Extrinsic Muscles**	**Both (Intrinsic and Extrinsic)**	**Normal**
Frequency (n)	17	51	7	5
Percentage (%)	21.25%	63.75%	8.75%	6.25%

Discussion

The purpose of this research was to investigate the relationship between smartphone use and hand grip strength in individuals falling in the age group of 25-35 years and using smartphones for a longer period of time. The relationship between factors like hand dominance, socio-demographic variables and intrinsic and extrinsic muscles and its severity of involvement was proven to be highly significant. The results showed that a decreased hand grip strength was related to and contributed by hours or years of continuous phone use. Similarly, a relevant association was seen between smartphone addiction and pain. It was revealed that the higher the smartphone addiction seen, the more the pain. On the other side, the individuals who showed increased pain subsequently showed reduced grip strength on the dominant side.

When comparing high-frequency smartphone users to low-frequency smartphone users, many studies found that hand function was impaired and that there were numerous musculoskeletal issues. A study carried out by Samaan M et al; compared the hand grip strength, neck pain, forward head tilt, and nerve conduction velocity of the ulnar and median nerves to the frequency of smartphone use . This study included 60 subjects with ages ranging from 14 to 18 years were divided randomly into two groups of equal number. Group A represented the control group who use smartphones less than four hours per day and Group B represent the study group who uses smartphone more than four hours per day. Also, Electromyography, Visual Analogue Scale and Universal Goniometer were the outcome measures were used. According to the results,

group B members who use their smartphones more frequently had lower ulnar nerve conduction velocity, more neck pain, and fewer forward head angle movements, although there was no discernible difference in hand grip strength or median nerve conduction velocity.[12]

Another study compared two groups of individuals aged between 9-15 years who overused smartphones based on the smartphone addiction scale with a control group of people who did not use smartphones. It revealed that high-frequency smartphone users had an enlarged median nerve, more pain in the thumb, decreased pinch strength, and impaired hand functions compared to low-frequency smartphone users.[13] Also several studies have proven to establish a link between the median nerve injury and prolonged smartphone use, due to which the inverse relationship between smartphone usage duration and hand-grip strength can be explained.[14] The majority of the musculature in the radial region of the hand, including the abduction of the thumb, flexion of the hand and wrist, and bending of the digital phalanx of the fingers, are all controlled by the median nerve. When holding a smartphone for an extended period of time, the

position of the hand and the thumb may have an impact on the median nerve.[15] The median nerve can also become damaged by excessive thumb use and wrist flexion and extension.[16] The muscles innervated by the median nerve, which are in charge of maintaining the strength of the hand grip, may become weak as a result of the injured median nerve. It is noteworthy to notice that repetitive movements using maximum effort over a brief period can also cause muscle fatigue in the hands.[17] Simultaneously, there are various sorts of exhaustion in relation to the same; which might be either mental or physical fatigue. Central or peripheral weariness are both parts of physical fatigue. The term "mental fatigue" describes how tired one feels mentally and physically after using a smartphone for an extended period. Peripheral exhaustion is the result of alterations in the myoneural junction that lower the muscle's potential to produce contractile force, while central weariness is explained by a decrease in moto-neuronal output from the central nervous system to the muscles.[17] During the evaluation process, which consisted of three trials with a 60-second gap, a study that looked into the effects of peripheral muscle fatigue during the testing of hand grip strength showed a substantial reduction.[18] A prior study carried out by V Mathiowetz in 1990, which included a total of 98 participants divided as 49 in each group which conducted the identical 60-second gap between the three trials to evaluate possible practice or fatigue effects during grip and pinch strength measurements however, it it did not show any significant results.[19]

The measurement of the hand muscles may also be influenced by a variety of other factors, such as the amount of physical activity one engages in, participation in various sports or activities, and occupation. These are a few of the variables that determine hand grip strength, albeit their interaction, particularly with physical activity, has not been well studied.[20] Numerous earlier research could not discover any conclusive effects of these variables on the assessment of the hand muscles.[21] This is due to the dearth of studies examining how physical activity or exercise affects the hand muscles. Without a doubt, including these variables in the current study would provide more information regarding the variables that affected hand grip strength in the sample. This can serve as a goal for subsequent research in the same field or region.

A study was conducted by Matthew A. Christensen et al, in the year 2016, in which the technology offered by the smartphone (iOS operating system), enabled the users to keep tabs on their daily use of the smartphone in the form of weekly reports, was used for the first time. The association between screen time on a smartphone and the quality of sleep has already been investigated using this direct measurement of usage length. This study further concluded that exposure to smartphone screens, particularly around bedtime, may negatively impact sleep.[22] While simply browsing on a phone one will need the use of the thumb and the palm to hold the smartphone (e.g.scrolling the page on the screen up and down), screen time can also include the length of just looking at the screen. In contrast to filling out assessments like the smartphone addiction scale, the study allowed the participants to self-monitor their weekly average daily smartphone activity.

A study demonstrated the reliability of self-reported measures of smartphone usage time in compared to data from the devices' logs. It was discovered out of curiosity that users typically overestimate their smartphone screen time by 23 minutes compared to what is actually recorded in the devices' log data.[23] Psychological sciences have also exploited the data from smartphones to gather behavioral information.[24] As a result, the usage of data from smartphones is still evolving and may one day be used to observe and identify different illnesses and abnormalities. Also , a systematic review by Shinde Sandeep B. et al; in the year 2022 focused on the the effects seen on the cervical spine due to excessive smartphone use. The review concluded that excessive use of smartphones led to 'Text Neck Syndrome' which is an upcoming concern as it shows several symptoms ranging from neck pain to hand pain and at the same time has also revealed various postural deviations and possible treatment outcomes for the same syndrome.[25] Another study carried out by Shinde et al; spoke about the effects of spinal extension exercises on mechanical low back pain in work from home IT professionals, which revealed that it is important to incorporate spinal extension exercises as a part of their routine to avoid problems like low back pain which arise due to prolonged sitting. This will then help in stabilizing the back muscles along with proper physical functioning with minimal discomfort.[26] Hence, individuals who tend to also use phone or any other electronic device for longer periods of time may eventually land into similar problems and to avoid those regular assessment of these factors like amount of phone usage, strength of the muscles involved is mandatory.

The results of the current study indicated a

substantial correlation between the amount of time spent using a smartphone and the strength of the hand grip. This association might open up new avenues for research into how using a smartphone affects the strength of the hand muscles. People today are more accustomed to typing, texting, and scrolling online than exercising or performing physical labour, which raises the fear that they have weak hand grips.[27] Researchers in the future are urged to shed more light on the connection between smartphone use and hand muscles. The above-mentioned association is receiving a lot of attention in the current study, which will be useful for such investigations in the future. There was no control group in the current study to compare participant data to and determine whether screen-free individuals have weak hand grip strength.

Additionally, there are different values for hand grip strength for men and women, and they are combined in a way that is descriptive for various age groups. The hand grip strength of the study's participants is subpar. The study's limitations include the fact that only participants in the 25–35 age range were included. Additionally, several of the above-mentioned issues may be considered in subsequent studies. The use of keyboards on laptops or computers, as well as any other action that can have an impact on or involve the base of the thumb and digits of the hand when using a screen, all involve the use of the hand muscles.

The use of smartphones for chatting, shopping, utilizing navigation while driving a car, and viewing favorite shows is also included in the category of screen use, which is added to everything else. Individuals who conduct online business tend to use the phone frequently, especially those between the ages of 25 and 35 years. Women who are not working also use their smartphones for socializing. Future research should focus on addressing additional factors, such as physical exercise, occupational activity, or the nature of the population's employment, that can affect hand grip strength.[11]

The current study's findings indicate an antagonistic relationship between smartphone use and hand muscle weakening. The variables that were left out of the current study should be incorporated into further research.

Conclusions

The findings of the current study concluded that the hand grip strength reduced as the smartphone usage increased. According to the smartphone addiction scale (SAS-SV), 85% of the participants from the study showed smartphone addiction. Also, pain on the Visual Analogue Scale(VAS) revealed that around 76.25% showed severe pain in the hands. Similarly, the length tension relationship of the extrinsic and the intrinsic muscles was altered and subsequently it led to hand grip weakness. So, from these all findings it can be concluded that excessive use of smartphone can lead to decrease hand grip strength.

Acknowledgments

We acknowledge the guidance and constant support provided by KIMSDTU. Also, we express our most humble and profound gratitude to respected Dean Dr. G Varadharajulu, Krishna College Of Physiotherapy, KIMSDTU, for his inspiration, motivation, guidance, and suggestions throughout this review.

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