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Physiology

EFFECT OF SMARTPHONE USAGE ON NECK MUSCLE AND HAND GRIP STRENGTH

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ABSTRACT **Introduction:** Smartphones have become ubiquitous in modern society, influencing daily life and raising concerns about their effects on musculoskeletal health. Prolonged smartphone use often involves sustained forward head flexion, leading to strain on the neck muscles. Despite the documented effects on neck muscles, fewer studies have evaluated their impact on hand grip strength, and even fewer have assessed both together. Henceforth this study was conducted. **Aim** : To analyse the neck muscle and hand grip strength in smartphone users. **Material And Methods:** This cross-sectional study included 230 young Indian smartphone users aged 18-40 years. Participants completed the Smartphone Addiction Scale-Short Version to determine addiction status. Neck muscle strength was assessed using the Deep Neck Flexor Endurance Test (DNFET) and the Cervical Extensor Endurance Test (CEET). Hand grip strength (HGS) was evaluated using a dynamometer. Statistical analyses included the Kolmogorov-Smirnov test, chi-square test, and Mann-Whitney U test. **Results:** There were significant differences found between addicted and non-addicted users in weekly screen time (p=0.006), neck flexor time (p=0.002), neck extensor time (p=0.000) , and both dominant (p=0.000) and non-dominant hand grip strength (p=0.002) among males. While in females, significant differences were observed only in neck extensor time (p=0.000). Mobile phone addicted males have lower neck flexor (29.94±10.37 seconds) and extensor (38.22±11.57 seconds) muscle time in comparison to females having neck flexor (28.14±10.06 seconds) and extensor (40.31±14.54 seconds) muscle time. In case of dominant and non-dominant hand grip strength, males with smartphone addiction have (29.74±8.05 kgs.) and (30.41±7.69 kgs.) respectively whereas females with smartphone addiction have (22.09±4.10 kgs.) and (21.39±4.10 kgs.) for dominant and non-dominant hand grip strength respectively. **Conclusion:** Smartphone addiction significantly impacts neck muscle endurance and weekly screen time, particularly among males. Despite extensive device use, no significant influence on hand grip strength was observed. Gender disparities highlight males' higher dependence on smartphones and greater musculoskeletal issues. Awareness and moderation in device usage are crucial to mitigate adverse health effects.

KEYWORDS : Smartphone addiction, musculoskeletal health, neck muscle endurance, hand grip strength, gender differences.

INTRODUCTION

Smartphone usage has become a daily habit, with people spending hours on them for communication, work, and entertainment. However, prolonged use raises concerns about its impact on physical health, particularly the musculoskeletal system.[1] Poor posture, such as forward head positioning and rounded shoulders, can strain neck muscles and cause discomfort. Constant typing, scrolling, and gripping can also affect hand muscles and grip strength, leading to muscle fatigue or weakness. Prolonged smartphone use often involves sustained forward head flexion, which can strain deep neck flexor muscles, leading to disorders like text neck syndrome. [2] The cervical spine's intricate structure, comprising ligaments, muscles, and vertebrae, is designed to support the head's weight and allow for movement. However, prolonged forward head flexion can alter the cervical spine's curvature, flatten the lordotic curve, and potentially compress nerve roots, leading to numbness and discomfort. [3] Additionally, consistent smartphone use can result in asymmetries and stiffness in the DNFs, reducing blood flow and delaying muscle recovery, thereby perpetuating a cycle of discomfort and reduced function. [4-6] According to reports, among smartphone users, neck pain is prevalent between 17.3% and 67.8% of the time, with a lifetime frequency of 55.8%. [6] Beyond the neck, smartphone use also affects hand grip strength, an essential measure of upper limb function and overall musculoskeletal health. The prevalence of smartphone usage has led to increased reliance on thumb and finger movements for touchscreen interactions, potentially impacting hand grip strength and dexterity. [7,8] Repetitive tapping and swiping can lead to fatigue and decreased grip strength over time. [9] Given that grip strength is a strong predictor of overall health, weakened grip due to smartphone overuse could increase the risk of falls, fractures, and disability, particularly in older adults. [10-12] This study examines the impact of smartphone usage on neck muscle strength and hand grip strength, focusing on neck muscle fatigue and reduced grip strength. It aims to identify potential risks associated with excessive smartphone use and provide insights into the correlation between smartphone habits and musculoskeletal disorders. The study aims to help healthcare practitioners create targeted guidelines and preventive measures to mitigate these negative effects and develop ergonomic guidelines and preventive strategies.

MATERIALAND METHODS

This was a cross-sectional observational study conducted in the Department of Physiology at King George's Medical University, Lucknow, over a period of one year. The study was approved by the Institutional Ethics Committee (IEC Ref. Code. XIII-PGTSC-IIA/P28 Date 21.01.2023), and written informed consent was obtained from all participants prior to their inclusion in the study.

Inclusion criteria involved young, Total 225 healthy Indian adults aged 18-40 years who were regular smartphone users. The exclusion criteria included individuals with congenital deformities of the upper extremities or neck, those with a history of neurological, rheumatic, or musculoskeletal disorders, any prior neck or upper limb surgery, neck pain with or without radiating symptoms, and individuals who exercised regularly.

A procedure was adopted to collect data from smartphone users, focusing on their neck muscle and hand grip strength. Initially,

participants completed the Smartphone Addiction Scale-Short Version (SAS-SV), developed by Kwon et al. [13] This questionnaire comprised ten questions scored on a Likert scale from 1 to 6, with 1 indicating "strongly disagree" and 6 indicating "strongly agree"[3] Based on their scores, participants were divided into two groups: Group A (smartphone addicts) and Group B (non-addicts). The threshold scores for smartphone addiction were 33/60 for women and 31/60 for men [3]. Participants scoring above these thresholds were classified as smartphone addicts, while those scoring below or equal to these values were classified as non-addicts. Neck muscle strength was assessed using the Deep Neck Flexor Endurance Test (DNFET) [14] and the Cervical Extensor Endurance Test (CEET). [15] For the DNFET, participants lay in a hook-lying position with their hands on their abdomen, tucked their chin maximally, and lifted their head 2.5 cm off the table. The average endurance times were 39 seconds for men and 29 seconds for women. [3,14] The cervical flexors tested included the rectus capitis anterior, lateralis, longus coli (upper cervical flexors), and sternocleidomastoid (lower cervical flexor).

The CEET assessed the upper and lower cervical extensor muscles, including the rectus capitis posterior major, posterior minor, oblique capitis superior, inferior, splenius capitis, and cervicis. Participants lay prone with their neck and head off the table, stabilizing their cervicothoracic junction. Sebastian et al. conducted a study in which participants held their chin tuck-in for 60 seconds. Any increase in chin length or inability to maintain the tuck indicated potential smartphone addiction[15,3]. Hand grip strength (HGS) was evaluated using the Baseline Digital Hand Dynamometer (CAMRY). Participants sat comfortably with their shoulders neutrally rotated and adducted, elbows flexed at 90 degrees, and wrists and forearms in a neutral position. They performed the grip test with both dominant and non-dominant hands, gripping the dynamometer with maximal effort under verbal encouragement. Each grip strength measurement was repeated three times with a one-minute rest between trials, and the average result was recorded. Grip strength Normal, Weak, or Strong decided by CAMRY hand dynamometer manual given with instrument[16].

The sample was analyzed using various statistical methods. The Kolmogorov-Smirnov (K-S) test was utilized to assess the data distribution. The K-S test is a normality test that determines whether the data points follow a normal distribution and works best in case of large samples. The normality-check step is essential since it forms the foundation of choosing an appropriate test. A non-normal data corresponds to a non-parametric test, whereas a normal data corresponds to a parametric test. The categorical data were presented in form of frequency distributions which mostly requires percentages and compared using the Chi-square test of independence and odds ratio (OR). The continuous data were presented as mean and standard deviation (SD) and compared using the Mann-Whitney U non-parametric test. P-values less than 0.05 were considered significant. Additionally, graphical representations were provided wherever necessary. The analysis was performed using IBM SPSS Statistics Version 27.0 software.

RESULTS

The study included participants aged 18 to 32 years, with an average age of 20.41±2.45 years and a mean BMI of 22.80 kg/m². On average, participants reported using smartphones for 4.81 years, with a weekly screen time of 5.14 hours. Their average SAS score was 31.89. [Table-1] Most patients were males (120, 52.2%), right-handed (215, 93.5%), and addicted (118, 51.3%).

Regarding dominant hand grip, (131,57.0%) had a normal grip, while for the non-dominant hand, (114,49.6%) had normal and weak grip. [Table-2] The distribution of smartphone addiction between sexes showed a statistically significant difference ($\chi^2 = 3.855$, OR = 1.68, $p < 0.05$). In our data, 69(57.5%) males and 49(44.5%) females had smartphone addiction and 51(42.5%) males, and 61(55.5%) females had no smartphone addiction. [Fig-1] Among males, significant differences were observed in weekly screen time, neck muscle flexor time, neck muscle extensor time, dominant hand grip strength, and non-dominant hand grip strength. However, for females, significant differences were found only in neck muscle extensor time. [Table-3] The distribution of parameters, including neck muscle, hand grip strength, years of smartphone use, and weekly screen time, differed significantly between individuals with and without smartphone addiction (all $p < 0.05$). [Table-4] Comparing individuals with and without smartphone addiction, significant differences were found in weekly screen time ($p = 0.009$), neck muscle flexor time ($p = 0.011$), and neck muscle extensor time ($p = 0.000$). Those with addiction spent more time on screens (5.44 ± 1.68 hours) compared to non-addicts (4.82 ± 1.43 hours). No significant differences were observed in years of smartphone use, dominant hand grip strength, or non-dominant hand grip strength between the two groups (all $p > 0.05$). These findings suggest that smartphone addiction may correlate with increased screen time and altered neck muscle function, but not necessarily with smartphone use duration or hand grip strength. [Table-5; Fig-2 and -3] Our study found males, with around 6 hours of weekly mobile phone use, are more likely addicted to smartphones compared to females. This affects their neck muscle time and hand grip strength. However, addicted females only showed significant differences in neck extensor muscle time. Overall, hand grip strength did not significantly differ between addicted and non-addicted users, while neck muscle time and weekly screen time were significantly affected in addicted users.

DISCUSSION

In this research, we analyzed neck muscle strength and hand grip among smartphone users aged 18 to 32 years. Younger individuals are increasingly reliant on smartphones due to their eagerness for new technologies and leisure activities like social media and gaming. Similar findings are evident in previous studies. For instance, a study in Saudi Arabia assessed smartphone addiction's impact on hand grip and neck muscle among 40 male college students [3]. Another study in Saudi Arabia explored the relationship between smartphone use and hand grip strength among 100 young men [12]. Widjaja et al. (2022) conducted a study involving 110 teenagers and examined the correlation between smartphone use duration and hand grip strength among girls. [17] The findings reveal that smartphone addiction and sex are interrelated, with a larger likelihood of smartphone addiction in men than in women. [18] An Iranian study investigated neck range of motion and muscle endurance in relation to smartphone addiction among 60 college students. Similar conclusions can be drawn from my research, which showed that men outperformed women in SAS-SV scores. [19] Another study also found that smartphone addiction is more common in men. [20] Nonetheless, certain research indicate that women are more prone to smartphone addiction. [21,22] In addition, men who were hooked to cell phones used screens more frequently than non-dependent individuals each week, while women's screen usage varied negligibly each week. Similar findings from my study revealed that males have more screen time than females. [23] Further, the neck muscle endurance and hand grip strength varied significantly in addiction versus non-addiction group for males.

Further, the neck extensor endurance time was significantly lower in smartphone addicted females. However, the neck flexor endurance time and hand grip strength did not vary significantly across addicted and non-addicted smartphone female users.

The primary findings of the research showed that those with smartphone addiction spend more time on screens than people without addiction. Similarly, researchers demonstrated in their research that average screen time is higher for smartphone addicts. [24] A study found that utilizing a phone for less than two hours a day lowers the risk of developing a smartphone addiction. [25] On the other hand, using a phone for five hours or more a day increases the likelihood of developing a smartphone addiction by a factor of 2.5. The COVID-19 pandemic led to widespread screen overuse, with academic and business activities shifting to mobile devices. Increased screen time for both work and leisure, including social media browsing and impulsive purchases, resulted in heightened anxiety levels, poor sleep quality, and deteriorating posture. Weekly screen use rose significantly during lockdown, particularly on platforms like Instagram, Twitter, YouTube, and TikTok. [26] Prolonged internet surfing in poor posture contributed to neck, shoulder, and spine pain. Mustafaoglu et al., showed that during past one year the highest prevalence of pain was recorded in upper back (70.3%), neck (65.9%), wrists/hands (68.7%), and shoulders (56.6%). [27] However, during the past one-week pain symptoms were observed in wrists/hands (58.2%), upper back (51.0%), and neck (22.5%). 74.3 percent of high school students who use smartphones report having cervical pain, with girls being more affected than boys. [28] Another study conducted by Kim & Kim [29] revealed that university students who use smartphones have complained of neck and shoulder ache. Furthermore, there was a correlation between the amount of time spent using digital devices and bending the neck when sitting or standing. [28] A study by Toh et al.

[30] found that while individuals stared at their phones, the angle between neck flex and head increased to 23.54 degrees, indicating a flexed neck position. The most common position for prolonged smartphone use, neck flexion, can lead to neck pain. [3,31] Screen size may also affect neck position, with smaller screens contributing to increased forward bending. [32] Previous studies found no significant differences in neck muscle endurance between addicted and non-addicted smartphone users [3], and those with neck pain did not perform better on endurance tests. [15] However, our study showed that smartphone-dependent individuals struggle to maintain proper neck position, with lower neck flexor muscle endurance compared to non-addicted users.

Sl No.	Author's name and year	Place of study	Number of subjects	Objective	Parameters assessed	(Conclusion)
1.	Min Kwon/2013	South Korea	540	Investigate	The Smartphone Addiction Scale - Development of a short version for adolescents	SAS-SV showed good reliability & validity for the assessment of smartphone addiction.
2.	Deepak Sebastian /2014	Livonia	30	The presence of weakness of the neck extensor has been described to cause pain & dysfunction in cervical region	Neck extensor endurance test	Neck extensor endurance test simple , effective test to determine the presence of weakness of neck extensors & differentiate the weakness between superficial &deep neck extensor in symptomatic population.
3.	Adel Alshahrani/2021	Saudi Arabia	40	To explore the effects of smartphone addiction on neck muscle (flexor & extensors)endurance, hand grip,& pinch strength among healthy college students who used smartphones for various periods of time	Neck muscle endurance & Hand grip &Pinch strength	smartphone addiction can negatively affect neck flexor endurance ,but not hand grip & pinch strength in young healthy male college students.
4.	Manuel A. /2023	Texas	126	Average hold time for the deep neck flexors (DNF) endurance test in subjects without neck pain or pathology.	Deep neck flexor endurance test	Asymptomatic men displayed greater DNF endurance than women

Additionally, addicted users exhibited lower neck extensor muscle endurance compared to non-addicted users. Furthermore, outcomes showed that using a smartphone had no effect on the strength of the dominant and non-dominant hand grip. To put it briefly, individuals with and without a mobile phone addiction exhibit comparable average grip strengths for both dominant and non-dominant hands. This can be explained by the fact that most of the participants were young medical students, between the ages of 18 and 20, and that they might have been engaged in different hand activities like typing on computer, and writing that necessitate continuous muscle contractions, thus preserving the strength of hand muscles. Similar results have been found in earlier studies.[3,33] Furthermore, hand grip was linked in certain studies to the amount of time spent using mobile phones. [3,34,35] Long-term use of mobile devices can cause damage to the thumb, forearm, and fingers, as demonstrated by earlier research. [36-38] Additionally, heat and sensation around the thenar side of the palm are linked to prolonged smartphone use. [36] However, we did not observe the effects of prolonged mobile phone use in our investigation, which could account for our insignificant results. In conclusion, the simplicity and portability of handheld devices have made young people completely reliant on them in the modern era. This dependency has been worse since the COVID-19 pandemic started. Yet, the proverb "excess of everything is bad" suggests that when individuals rely too much on these harmful devices, it affects their psychological and physiological functions. Consequently, this study sheds light on a few crucial topics that the public frequently ignores when utilizing mobile phones.

It's essential for future research to prioritize larger, diverse samples and dedicate sufficient time to data collection to gain more deep insights. This approach will enhance our understanding of how smartphone addiction impacts musculoskeletal health.

CONCLUSION

In conclusion, my study highlights the significant impact of smartphone addiction on neck muscle endurance and weekly screen time, particularly among male users. Despite the extensive use of handheld devices, no significant influence on handgrip strength was observed. Gender disparities were evident, with males showing higher dependence on smartphones and experiencing greater decreases in neck muscle endurance and hand grip strength compared to females. The transition to modern culture, accelerated by the COVID-19 pandemic, has intensified reliance on smartphones, leading to increased screen time and potential musculoskeletal issues. Chronic musculoskeletal pain and poor posture associated with prolonged smartphone use underscore the need for awareness and moderation in device usage to mitigate adverse health effects. Ultimately, this research provides insight into the societal shift towards smartphone reliance and emphasizes the importance of addressing its implications on both physical and mental well-being.

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Tables And Figures

Table 1: Descriptive analysis of smartphone users.

Variables	Minimum	Maximum	Mean	Std. Deviation
Age	18.00	32.00	20.41	2.45
BMI	14.95	35.09	22.80	3.56
Years' use of smartphone	1	15	4.81	2.16
Weekly screen time	2	11	5.14	1.59
SAS score	14	54	31.89	8.45
NM Flexor Time	10.00	67.00	32.35	14.10
NM Extensor Time	18.00	100.00	50.93	19.38
Dominant Hand Grip Strength	11.80	45.00	27.21	8.70
Non-dominant Hand Grip Strength	11.80	44.40	26.85	8.39

Table 2: Frequency distribution of clinical variables.

Variables	Frequency (N = 230)	Percentage
Sex		
Male	120	52.2
Female	110	47.8
Hand Dominance		
Left	15	6.5
Right	215	93.5
Dominant Hand Grip		
Weak	96	41.7
Normal	131	57.0
Strong	3	1.3
Non-dominant Hand Grip		
Weak	114	49.6
Normal	114	49.6
Strong	2	0.9
Group		
Addicted	118	51.3
Non-addicted	112	48.7

Table 3: Association between group and sex

Group		Sex		Chi-square statistic (p-value)
		Male	Female	
No Addiction	Count	51	61	3.855* **(0.050)**
	% within Group	45.5%	54.5%	
	% within Sex	42.5%	55.5%	
Addiction	Count	69	49	
	% within Group	58.5%	41.5%	
	% within Sex	57.5%	44.5%	

Table 4: Comparison of various parameters across the categories of group by sex.

Parameters	Group				Mann-Whitney U statistic (p-value)
	No Addiction		Addiction		
	Mean	Standard Deviation	Mean	Standard Deviation	
Male					
Year's use of smartphone	5.00	2.23	5.15	2.29	1669.500 (0.629)
Weekly screen time	4.83	1.45	5.64	1.65	1248.500* (0.006)
NM Flexor Time	39.53	16.77	29.94	10.37	1166.500* (0.002)
NM Extensor Time	63.02	15.99	38.22	11.57	398.500* (0.000)
Dominant Hand Grip	36.14	6.87	29.74	8.05	899.000* (0.000)
Non-dominant Hand Grip	34.67	6.36	30.41	7.69	1188.000* (0.002)
Female					
Year's use of smartphone	4.34	2.10	4.71	1.90	1311.500 (0.264)
Weekly screen time	4.81	1.43	5.15	1.71	1391.500 (0.529)
NM Flexor Time	32.44	16.04	28.14	10.06	1352.500 (0.393)
NM Extensor Time	63.72	18.20	40.31	14.54	460.000* (0.000)
Dominant Hand Grip	20.99	5.17	22.09	4.10	1238.000 (0.123)
Non-dominant Hand Grip	20.68	5.00	21.39	4.10	1302.500 (0.248)

Table 5: Normality test on different parameters by group.

Parameters	Group	Kolmogorov-Smirnov		
		Statistic	N	p-value
NM Flexor Time	No addiction	0.139*	112	< 0.05
	Addiction	0.117*	118	< 0.05
NM Extensor Time	No addiction	0.096*	112	< 0.05
	Addiction	0.100*	118	< 0.05
Dominant Hand Grip Strength	No addiction	0.119*	112	< 0.05
	Addiction	0.083*	118	< 0.05
Non-dominant Hand Grip Strength	No addiction	0.126*	112	< 0.05
	Addiction	0.104*	118	< 0.05
Years' use of smartphone	No addiction	0.152*	112	< 0.05
	Addiction	0.158*	118	< 0.05
Weekly screen time	No addiction	0.157*	112	< 0.05
	Addiction	0.136*	118	< 0.05

Table 6: Comparison of various parameters across the categories of group

Parameters	Group				Mann-Whitney U statistic (p-value)
	No Addiction		Addiction		
	Mean	Standard Deviation	Mean	Standard Deviation	
Years' use of smartphone	4.64	2.17	4.97	2.14	5933.000 (0.175)
Weekly screen time	4.82	1.43	5.44	1.68	5318.000* (0.009)
NM Flexor Time	35.67	16.68	29.19	10.24	5327.000* (0.011)
NM Extensor Time	63.40	17.16	39.08	12.87	1725.500* (0.000)
Dominant Hand Grip Strength	27.89	9.65	26.56	7.67	6210.500 (0.431)
Non-dominant Hand Grip Strength	27.05	8.98	26.66	7.82	6529.500 (0.876)

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