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Smartphone Addiction and Manual Coordination, Strength and Hand Pain in Normal Teenage Students: A Cross-Sectional Study

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ABSTRACT

Background: These days, we can't imagine living without our smartphones. Physical functions of your hands and fingers like dexterity and coordination could be impaired from too much time spent on your smartphone due to the constant grasping and tapping of its screen.

Objective: The purpose of this study was to look into how smartphone addiction affects normal adolescent students' manual coordination (manual dexterity and upper limb coordination), grip strength, pinch strength, and wrist and hand pain.

Subjects and Methods: An observational cross-sectional study for governmental and private preparatory and secondary schools at Ashmoun educational administration, Menoufia Governorate, Egypt was done. The study included one hundred normal teenage students (54 girls and 46 boys), aged from 12 to 18years. The Bruininks-Oseretsky Test of Motor Proficiency was employed to evaluate manual coordination (manual dexterity and upper limb coordination) (BOT-2). A hand dynamometer and a pinch meter were used to measure grip and pinch strength. The PRWHE questionnaire was used to assess wrist and hand pain as reported by participants.

Results: Research found a significant positive association between smartphone addiction ratings and pain in the wrist and hand ($r = 0.304$, $P = 0.002$). Scores on a scale measuring smart phone addiction were not significantly correlated with any of the other characteristics studied.

Conclusion: In a typical sample of adolescent students, researchers observed a significant positive association between smartphone use and wrist/hand pain. This finding indicates that the heavy usage of smartphones is considered a risk factor that leads to wrist/hand pain.

Keywords: Hand pain, Manual coordination, Manual strength, Smartphone addiction, Teenage students.

INTRODUCTION

Smartphones are now available all over the world; more than one third of the human mankind has mobile access to the internet [(1)]. A large number of young adults, teenagers, and children are addicted to their smartphones, which is a well-known problem. Addiction to smartphones is defined as a behavioral addiction characterized by loss of control due to excessive immersion and obsessions with smartphones, disruption of daily functioning due to nervousness and anxiety, and a preference for the virtual world that is more enjoyable with smartphone than with friends[(2)].

Forty percent of both teenagers and adults report using their phones for more than four hours a day, mostly for communication purposes. In addition, they had more behavioral, interpersonal, and physiological issues than individuals who used their phones for less than four hours daily[(3)]. The function of hands is the most important tool to connect with the world, it includes a variety of functions such as dexterity, coordination, grip and endurance, the most important function in manipulating or performing things with agility is dexterity, which is the main physical function of smartphone use [(4)].

Problems with your wrists and neck aren't the only ones you can experience if you use your phone all the time. Constantly holding your phone can put a lot of strain on your hands, which can cause pain and other issues with your thumb and fingers[(5)]. Everyday life is undoubtedly altered by the ever-increasing prevalence of smartphone use, and this fact should be taken into account when gauging the influence of smartphone use on manual dexterity[(6)]. Constant use of a smartphone without breaks can lead to repetitive stress injuries in the head, neck, shoulders, hands and wrists. Because smartphones often demand thumb and finger interactions with the screen, they may contribute to these illnesses. Overuse injuries to the wrist, hand, and finger joints are common among those who use their smartphones for long periods of time while maintaining an unnatural grip on the device[(7)]. Pain and muscle weariness can be brought on by repetitive static motion of the hands because blood supply is cut off and nutrients aren't being given to the muscles[(8)].

Upper limb (UL) work that is performed repeatedly can create discomfort in the neck, shoulders, arms, wrists, and fingers, as well as mild to moderate damage to the UL's muscles, nerves, joints, and blood vessels. The research on how much time teenagers spend on their smartphones may affect their manual coordination, such as their manual dexterity and UL coordination, is limited and often contradictory[(9)].

The purpose of this study was to examine the effects of smartphone addiction on manual coordination, hand-grip and pinch strength, and wrist/hand pain in healthy adolescent students.

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SUBJECTS AND METHODS

The research design was a cross-sectional observational study. One hundred teenage students were selected randomly from both governmental and private preparatory and secondary schools at Ashmoun Educational Administration, Menoufia Governorate, Egypt. Normal teenage students from both sexes were eligible to be enrolled in the study if their age ranged from 12 to 18 years, with smartphone addiction score ranged from 31 to 60 points for boys and from 33 to 60 points for girls on smartphone addiction scale [10]. Students were excluded if they had congenital hand abnormalities or medical conditions as previous hand burn, musculoskeletal problems such as previous or recent orthopedic surgery, fractures, abnormalities of sight and hearing, mental retardation, and physical impairments such as missing fingers, arms, or shoulders.

The students' smartphone addiction was measured using the Smartphone addiction Scale-Short Version (SAS-SV). Each of the 10 items on this reliable self-report scale was assigned a score between 1 (strongly disagree) and 6 (strongly agree). For men, the cutoff was reported to be 31, and for women, it was 33. Higher ratings indicated a greater propensity toward smart phone dependency and addiction[11].

Assessment of manual coordination was done with the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) (manual dexterity and UL coordination). A youngster is directly observed and evaluated using this reliable norm-referenced scale as they complete various tasks[12]. The BOT-2 assesses stability, mobility, strength, coordination, and object manipulation using a subtest and composite framework. It has 8 different subtests within it, with a total of 53 questions: fine motor precision and integration, manual dexterity, bilateral coordination, balance, speed and agility in running, coordination and strength of the UL.

Reaching, grasping, and bimanual coordination with small items are all utilised in the goal-oriented tasks that make up the Manual Dexterity subtest. Accuracy is highly valued. To further separate skill levels, the items are timed. Items in the set include: Making Dots in Circles with red pencil, Transferring coins, inserting Pegs into a Pegboard, Sorting Cards and Stringing Blocks.

The Upper-Limb Coordination subtest includes drills that evaluate eye-hand coordination while following a moving target. Among its contents are: Skills covered include: catching a tossed ball with both hands, catching a dropped ball with one hand, dribbling a ball with one hand, dribbling with both hands, and throwing a ball at a target.

Following the attached conversion table, raw scores were transformed into point totals for the dexterity and UL coordination subtests, next to each item in the record form. Subtest total point score was then calculated by summing the point score from each individual item. Total point score for each subtest was converted to scale score by looking at conversion tables divided according to student age and sex. Then, standard score was calculated for each student for manual coordination domain by adding dexterity scale score to UL coordination scale score and the sum was converted to manual coordination standard score by looking at conversion tables divided according to student age and sex.

For the purpose of measuring hand-grip and pinch strength, a hand dynamometer and Pinch-meter were utilized. With the help of a hand dynamometer, we were able to determine the maximum isometric strength of our hand muscles[13]. The pinch meter is very reliable in terms of test-retest consistency, as well as inter- and intra-rater consistency. Strength of the thumb muscle was evaluated with its use[14].

Participants sat with their arms in a position recommended by the American Society for Hand Therapists, which included a neutrally rotated and adducted shoulder, an elbow flexed to 90 degrees, and a forearm and wrist in a neutral position. Each person held the dynamometer's handle with as much force as they could muster for a set period of time. Three trials were conducted, each separated by 30 seconds. The results of the three trials were averaged. Weakened grip and pinch strength was reflected by lower ratings[15]. The same trunk and arm postures were used to evaluate pinch strength as were used to test grip strength; the pinch meter was positioned laterally (with the forearm neutral) to evaluate the key pinch, and it was held upright with the forearm pronated to evaluate the tip and palmer pinches.[14].

The patient-rated wrist and hand evaluation (PRWHE) scale [16], a 15-item self-report questionnaire, was used to evaluate wrist and hand pain. It has a pain subscale (consisting of 5 items) and a function subscale (10 items). On a scale from 0 to 10, with 0 representing no discomfort at all and 10 representing the worst suffering imaginable, we evaluate each item. In order to get a total score out of 100, you add the functional scores together, divide by 2, then add the pain scores. With a lower score, function and pain are both improved[17].

A pilot study with 44 individuals was used to determine the optimal sample size. Using a two-tail exact correlation bivariate normal model and a significance level (α)) of 0.05, a sample size of 100 participants would yield 80% power, a correlation coefficient (r) = 0.276, and a coefficient of determination (r2): 0.076. G Power and Sample Size Calculations, version 3.0.11 for Microsoft Windows, was used for the sample size calculation.

Ethical consent:

The Physical Therapy Department of Cairo University's Ethical Committee gave their support to this work (No: P.T.REC/012/003440) and was registered on Clinical Trials.gov registry database

with approval number (NCT05260632). Also, an approval from Educational District in Ashmoun city to conduct this study among preparatory and secondary schools' students at Ashmoun Educational Administration. All participants' parents gave their permission after being fully informed. All procedures involving human participants in this study have been performed in conformity with the principles outlined in the World Medical Association's Declaration of Helsinki.

Statistical analysis

This study utilized SPSS Version 28 for statistical analysis (IBM, Armonk, New York, United States). The Kolmogorov-Smirnov test, the Shapiro-Wilk test, and direct data visualization were utilized to examine the distribution of the quantitative data. Means and standard deviations or medians and ranges were calculated from the numerical data after normality testing was performed. Statistics and percentages were used to summaries the categorical data. Pearson's and Spearman's correlation coefficients were used to analyze the relationships between variables. Significant results were reported for P values lower than 0.05.

RESULTS

In Table (**1**) general characteristics of the participants and the results of the measured variables were seen. Data were presented as mean ±SD, number and percentage, and median (min-max).

Table (1): General characteristics of the participants and results of the measured variables

General characteristics (N=100)		
Age (years) (mean± SD)		14.5 ±2
Gender (N & %)	**Boys**	46 (46 %)
	Girls	54 (54 %)
Dominant Hand (N & %)	**Right**	97 (97%)
	Left	3 (3%)
Usage hours (hours/ day)		5 (0.5 - 15)
Usage years (median)		3 (1 - 9)
Measured variables		**Mean± SD**
SAS score		49 ±8
PRWHE score (%)		28.5 ±6.8
Manual dexterity subtest score		6 ±1
UL Coordination subtest score		9 ±2.1
Manual coordination standard score		33 ±3
Hand-grip strength (pound)		10.4 ±2.4
Pinch strength (pound)		4.4±1

SAS: Smartphone addiction scale; **PRWHE:** Patient rated wrist/hand evaluation; **UL:** Upper limb; ***significant**

Smartphone addiction (SAS) scores displayed a positive connection with patient-reported measures of wrist and hand pain (r=0.304, P=0.002). No significant relationships were found between the SAS and the other measures including manual dexterity scale score (r=0.024, P=0.810), UL coordination scale score (r=0.086, P=0.395), manual coordination standard score (r=-0.025, P=0.807), hand-grip strength (r=0.125, P=0.215), and pinch strength (r=0.05, P=0.623) (Table 2 & Figure **1**).

Table (2): Correlation of Smart phone addiction scale Scores with measured variables.

	SAS	
	R	**P**
Wrist and hand pain (PRWHE (%))	0.304*	0.002
Manual dexterity scale score	0.024	0.810
UL coordination scale score	0.086	0.395
Manual coordination standard score	-0.025	0.807
Pinch strength (pound)	0.05	0.623
Handgrip strength (pound)	0.125	0.215

SAS: Smartphone addiction scale; **PRWHE:** Patient rated wrist/hand evaluation; **r:** correlation coefficient; ***significant**

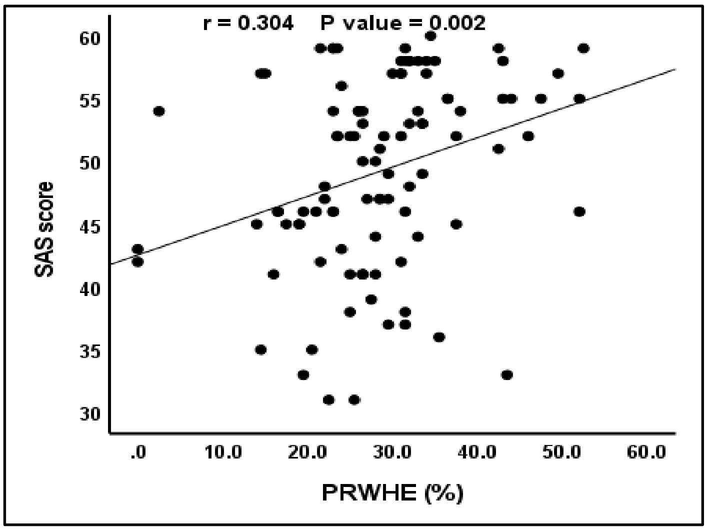

Figure (1): Correlation between SAS scores and wrist/hand pain.

DISCUSSION

Smartphone use has been increased in teenage students' life; they use it for participating on social media, entertaining, searching and learning. Until recently, the effects of prolonged smartphone use on motor skills like hand-eye coordination, dexterity, and strength were largely unknown. Adolescents with smart phone heavy usage are more likely to ignore symptoms of overuse, which may affect their hands [15].

The purpose of this study was to examine if and how smartphone use affects manual dexterity, UL coordination, hand-grip and pinch strengths and wrist/hand pain in normal teenage students.

The results showed a statistically significant positive connection between smartphone addiction and aching wrists and hands among healthy adolescent participants. While no significant correlations were observed between smartphone addiction and other measured variables, including manual dexterity, UL coordination, manual coordination and hand-grip and pinch strengths.

Similar results were found by **Elserty *et al.*** [18], who looked at the relationship between smartphone addiction and musculoskeletal pain among physical therapy students in Egypt. They discovered that smartphone use, especially for lengthy periods of time, negatively affected the joints in the fingers, particularly the thumb and the wrist. Our findings are consistent with those of a study by **Ahmed *et al.*** [19], which found that 29.2 percent of physiotherapy students experienced thumb pain as a result of excessive usage of smartphones.

The results of this study come in agreement with that of **Mustafaoglu *et al.*** [20] who found that spending over six hours a day on a smartphone was significantly associated with high musculoskeletal pain prevalence in the neck, shoulders, and wrists/hands. It was recommended that continuous gaming time should be kept below 20 min and the player should find a way to play the game that reduces their dependence on thumb movements [21]. The study conducted by **Baabdullah *et al.*** [22] concluded that students who are heavy users of smartphone have mild pain and stiffness in thumb\wrist and 20.4% of all participants reported pain in the thumb/wrist. In a study from China, 43.4% of participants experienced thumb/ wrist pain due to the use of different electronic devices [23]. Another study from Pakistan, revealed that 42% of adolescents reported pain in the thumb/wrist due to smartphone use [24].

Nobody in our study has ever suffered a serious hand injury. Consistent with the findings published by **Bahathiq *et al.*** [25] this study has a plausible rationale that the rising phenomenon of smartphone addiction is associated with musculoskeletal pain in the hand, wrist, and thumb from excessive smartphone use. Researchers **Wang *et al.*** [21] discovered a statistically significant rise in pain levels after 30 minutes of playing a smartphone game, suggesting that this activity is damaging to the muscles involved in thumb movements. **Kim and Kim** [9] and **Radwan *et al.*** [26] studies have shown that using a smartphone too much might lead to injury to the joints in your wrist because it necessitates the usage of your thumbs and fingers. Constant flexion for the smartphone's grabbing and typing functions causes the palmar fascia to contract, and the thenar and hypothenar eminence, along with the underlying muscles, are positioned more superficially, resulting in weaker muscle activation. Tendonitis develops from overuse due to frequent thumb adduction, abduction, and opposition. [27]. Constant pain in the hands and fingers could result, as could a decrease in blood flow and the delivery of nutrients to the muscles. It was stated by **Ahmed *et al.*** [19] that texting in a stationary position for lengthy periods of time strains the hand muscles, causing pain.

This study's findings that normal adolescent students' smartphone use is not correlated with their manual dexterity are corroborated by those of **Petrigna *et al.*** [28], who found that the amount of time young adults spend using smartphones did not affect their performance on the Peg Board Test. **Jayaram *et al.*** [29] studied 220 medical students and found that active smartphone use (texting and scrolling) for long periods of time does not negatively impact hand dexterity. **Ernsting *et al.*** [30] matching our findings, which showed no connection between finger dexterity and smartphone use even while students' dexterity was lower than average.

Our results regarding smartphone addiction and manual dexterity contradicted with **Lin** [31] who compared the visual perception and fine motor skills of preschoolers who used tablets to those who did not and found that the children who did not use tablets performed better on all subtests. This included visual discrimination, visual memory, spatial relationships, form constancy, visual figure ground, fine motor precision, fine motor integration, and manual dexterity.

No link was seen between smartphone use and either UL coordination or manual coordination in this sample of healthy adolescent pupils. Our results contradicted with **Aswathappa *et al.*** [32] who studied 100 students aged 18-25 years and reported that in comparison to non-addicts, smartphone addicts had significantly lower UL coordination. This contradiction can be explained by difference in our younger sample ages (12-18 years); thus they spent less period of smartphone use and their coordination skills are not affected yet.

Actually, our results regarding the correlation between smart phone addiction and dexterity or coordination can be explained by some reasons like that our study was conducted in a rural region even if the participants were collected from private and governmental schools, they are not living a very comfortable life. They are very active. They participate always in house and field chores. Most of these daily chores need high level of dexterity and coordination such as cooking, tree pruning, fruit picking and packing. Most of them also practice sports usually in gymnasium.

Although our study revealed no statistically significant correlations between smartphone addiction and dexterity or coordination, we observed that students with higher addiction scores had lower performance during physical assessment. All students also had below normal scores of dexterity and coordination when compared to BOT-2 norms.

The results of the current study revealed that there was no correlation between smart phone addiction and hand-grip or pinch strengths. This result is supported by **Samaan *et al.*** [33] who found that adolescents who used their phones for lengthy periods of time developed a more flexed posture at the neck and experienced pain without any impact on hand-grip strength. Our result also comes in agreement with **Alshahrani *et al.*** [34] who looked at 40 healthy male college students and how frequently they used smartphones affected their grip and pinch strength. SAS-SV ratings indicated no significant difference between the addicted and non-addicted groups in hand-grip and pinch strengths.

This study results contradicted with **Osailan** [35] and **Radwan *et al.*** [26] who showed that Hand-grip and pinch strengths decreased with increased smartphone use, and this was explained by the modified position of the hand and thumb while holding the device The median nerve supplies the muscles used to grasp and pinch, hence overusing those muscles might weaken your grip and pinch.

This cross-sectional study was a trial to fill the gap of research regarding the relation between smartphone addiction in normal teenage students and hand functions and wrist/hand pain; in order to find the impact of smartphone overuse on this population.

Limitation of the study:

It was limited to 100 teenage students from both governmental and private schools in a rural area, their age ranged from 12 to 18 years old. Future studies may be conducted on larger sample, in different areas, using more objective methods for manual skills evaluation. Future cohort study also is recommended to investigate the long-term effects of smartphone addiction on students.

CONCLUSION

The significant positive correlation that was found between smartphone addiction and hand pain in normal teenage students indicates that the heavy usage of smartphones is considered a risk factor that leads to hand pain. Therefore, essential issues are required to reduce and prevent the risks of overusing smartphones. We recommend future studies investigating the safe period of time for smart phone use per day. It is also recommended for the parents and school managers to guide and control smartphone use in this population to avoid its risk.

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