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ORIGINAL ARTICLE

Effect of Smartphone Addiction Level on Manual and Finger Dexterity, Hand Grip Strength, Pinch Grip Strength, and Thumb Pressure Pain Threshold in University Students

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Main Points

- In undergraduate students, smartphone addiction did not negatively affect the hand and pinch grip strength, pressure pain threshold, and manual dexterity.
- Excessive smartphone use may affect dexterity parameters and palmar pinch strength in males.
- Hand functions and strength can be preserved despite excessive smartphone use.

Abstract

This study examined smartphone addiction's effect on manual and finger dexterity, hand and pinch grip strength, and thumb pressure pain threshold in university students. The study included 127 university students aged 19 – 25 years. Smartphone usage level was assessed with the Smartphone Addiction Scale Short Form, pressure pain threshold with an algometer, pinch grip strength with a pinch meter, hand grip strength with a hand dynamometer, and dexterity with the Purdue pegboard test and the Minnesota manual dexterity test. The groups had no difference in hand and pinch grip strength, thumb pressure pain threshold, and dexterity ($p > .05$). Females with and without smartphone addiction had similar results ($p > .05$), and males with smartphone addiction showed differences in some dexterity parameters and palmar pinch strength ($p < .05$). In undergraduate students, smartphone addiction was not found to have any adverse effect on hand and pinch grip strength, pressure pain threshold, and dexterity. Excessive smartphone use by males may affect some dexterity parameters and palmar pinch strength. Future studies are needed to investigate the long-term effects of excessive smartphone use regarding gender differences and different age groups.
Keywords: Dexterity, hand grip strength, pain threshold, pinch grip strength, smartphone addiction

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Introduction

The Turkish Statistics Institute indicated that Internet usage was 82.6% in 2021 and 85.0% in 2022 among individuals aged 16 – 74. Smartphone use was 95.8% for the general population, 93.7% for females, and 98% for males. Among 16 – 24-year-olds, smartphone use was 94.5% overall, 92.2% for females, and 96.7% for males (TUIK, 2022). In 2021, mobile users were 7.1 billion worldwide, while forecasts predicted it would increase to 7.26 billion in 2022 (Statista, 2023). Smartphones and the Internet are mainly used for shopping, social media, education, and entertainment, and its usage is increasing (TUIK, 2022).

Internet addiction, Ivan Goldberg first defined in 1996 as a result of excessive use of the Internet and smartphones (Bozkurt et al., 2016), was later included in the Diagnostic and Statistical Manual

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of Mental Disorders (APA, 2017; Regier et al., 2013). Social media, smartphone, and games addiction are among the types of addiction with the common factor of Internet use, but Internet addiction that defined as an entire anyway of addictive applications (Savcı & Aysan, 2017).

With the increasing use of smartphones, the psychological effects of smartphone addiction (Thomée et al., 2011) and its impact on the musculoskeletal system have started to be revealed (Kim et al., 2015). It was stated that musculoskeletal pain, such as the upper back, neck, shoulders, and hands, is higher in smartphone addiction (Ahmed et al., 2021; Mustafaoğlu et al., 2021). Neck muscle endurance has also been affected together with musculoskeletal pain (Alshahrani et al., 2021). Although it has been reported that smartphone addiction caused pain in the thumb, all the studies which have evaluated thumb pain have been conducted using a questionnaire (Alshahrani et al., 2021; Berolo et al., 2011; Jain et al., 2022; Mustafaoğlu et al., 2021). Inal et al. (2015) used ultrasonography and stated that the pain in the thumb might be due to the enlargement of the median nerve. The literature stated that excessive smartphone usage affected finger dexterity but not manual dexterity (Oberoi et al., 2019; Shetty et al., 2019). However, some studies found that smartphone addiction negatively affected hand grip and pinch grip strength (Osailan, 2021; Radwan et al., 2020), while others have found no effect (Alshahrani et al., 2021; Tidke et al., 2019).

Although how smartphone addiction affects the musculoskeletal system has been investigated in the literature, the effects on the hand and pinch grip strength are controversial. In addition, thumb pain and hand functions have only been evaluated by the questionnaire. Therefore, this study aimed to objectively examine smartphone addiction's effect on dexterity, hand and pinch grip strength, and thumb pressure pain threshold in university students.

Material and Methods

Study Design and Participants

This study was designed as cross-sectional and was conducted at Bandırma Onyedi Eylül University, Faculty of Health Sciences, Physiotherapy and Rehabilitation Department, between April 2021 and November 2021. One hundred thirty undergraduate students aged 18 – 25 were included who were approved to participate and met the inclusion criteria. The study exclusion criteria were defined as follows: refusal to participate in the study; a history of any operation within the past 6 months; being a pathological Internet user; having any congenital deformities; having any history of diagnosed diseases; or using any psychiatric medication. According to the Internet addiction test results, three participants were excluded. Finally, 127 undergraduate students were included.

Data Collection and Measurements

The Turkish version of Internet addiction test (IAT) was used to assess Internet addiction levels. The test includes the individual's Internet usage habits, their thoughts about the Internet, and the impact of internet use on their lives. The test includes 20 items, and internet addiction is graded as Continuous (5), Very Often (4), Often (3), Occasionally (2), Rarely (1), and Never (0). The maximum score is 100, with the Internet addiction level classified as "No Symptom" if the score was ≤ 49, "Limited Symptom" if the score was between 50 and 79, and "Pathological Internet User" if the score was between 80 and 100 (Yaraşir, 2018). This test was used to exclude pathological Internet users from the study.

The Turkish version of the Smartphone Addiction Scale Short Form (SAS-SF) was used to assess the smartphone addiction level (Kwon et al., 2013; Noyan et al., 2015). The SAS-SF consists of 10 items. Higher scores obtained in the test indicate an increased risk of addiction (Noyan et al., 2015).

Pressure pain threshold was measured with a Baseline algometer with a 1 cm^2 diameter head (Marques et al., 2008). The value was recorded in kilogram per centrimeter square when the feeling of pressure became a painful sensation (Gökoğlu et al., 2001; Marques et al., 2008). The pressure pain threshold measurements were made from four regions, including the right and left side carpometacarpal joint and the adductor pollicis muscle. Measurements were taken three times for each region and the average was calculated for use in the analyses.

Hand grip strength was measured with a hand dynamometer (Baseline). The standard test position of the American Hand Therapists Association was applied. The subject was instructed to grip the dynamometer as strongly as possible and leave it completely loose. Measurements were taken three times for both hands, and the average of the values obtained was calculated.

Pinch grip strength was measured with a pinch meter (Baseline). The pinch strength was evaluated by measuring pinch, tip, and tripod grip positions. Pinch grip strength was evaluated with the thumb and forefinger, lateral grip strength was evaluated with the radial surface of the thumb and index finger, and triple grip strength was evaluated with the thumb, index, and middle fingers (Akel & Öksüz, 2016). Measurements were taken three times in both hands, and the average of the values obtained was calculated

The Minnesota manual dexterity test (MMDT) measures gross skill, coordination, and speed (Desrosiers et al., 1997). The Minnesota manual dexterity test, a new test with two sub-parameters of the turning test and the placing test, was used in this study (Akel & Öksüz, 2016; Desrosiers et al., 1997).

In the placing test, the board was removed from the discs and placed in front of the patient parallel to the discs. In the test where the time is calculated for both hands, the subject was instructed to start from the dominant column if starting with the dominant hand and from the column on the non-dominant side if starting with the non-dominant hand. The lowest disc in the column in which the test was started was placed in the top hole, and when the column was completed, the next was started. When all the columns were completed, the test was finished, and the time was recorded (Akel & Öksüz, 2016).

In the turning test, the red or black side is placed on the board, 2.5 cm in front of the person so that the discs are the same colors. The person takes the disc from the right corner of the top row with his left hand, places it in his right hand, then puts the disc in place with the right hand, and continues until the top row is finished. When the top row was completed and the left corner of the second row was reached, the disc was removed with the right hand, placed in the left hand, and replaced with the left hand, and this process was continued until the end. The next row was completed like the first row, and the last row was like the second row. The time was recorded when the test was completed (Akel & Öksüz, 2016).

The Purdue pegboard test is used to test fine finger dexterity and speed. The test includes a test board, pegs, washers, and collars. The test evaluates fine dexterity unilaterally and bilaterally; it consists of four sub-parameter sections: dominant hand, non-dominant hand, both hands, and assemblies (Akel & Öksüz, 2016; Tiffin & Asher, 1948). At the end of each test, the number of materials inserted by the participant is recorded.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) for Windows version 23.0 software (IBM SPSS Corp.; Armonk, NY, USA) was used for statistical analyses of the study. The Shapiro – Wilk test was used to examine the conformity of the data to normal distribution. Results were stated as mean ± SD values if normally distributed, and as median (minimum – maximum) values for data not showing normal distribution. To compare the dependent variables between groups, the independent sample *t*-test was used for data with normal distribution and the Mann – Whitney *U* test for those without normal distribution. A value of $p < .05$ was accepted as the level of statistical significance for all tests.

Ethics

The ethics approval for the study was obtained from the Non-interventional Ethics Committee of Bandırma Onyedi Eylül University (Number: 2019-04-05). All participants were informed, and written informed consent was obtained.

Results

The study was completed with 127 undergraduate students, comprising 96 females and 31 males, with a median age of 21 (19 – 25 years). According to the students' statements, the dominant hand was right side in 123 cases (96.9%) and left side in 4 (3.1%).

The demographic characteristics, smartphone addiction levels, thumb pressure pain threshold, hand and pinch grip strength, and manual and finger dexterity test results of all the study participants are given in Table 1.

The results of the SAS-SF showed that 44.1% ($n = 56$) of the participants were evaluated as addiction and 55.9% ($n = 71$) as non-addiction. All the data were analyzed between these two groups of addiction and non-addiction. There was no significant difference observed between the two sub-groups of smartphone addiction and non-addiction in respect of the pressure pain threshold, hand grip strength, and hand skills ($p > .05$) (Table 1).

Both groups were similar in terms of demographic characteristics (BMI) ($p > .05$). In the separate comparisons of the genders regarding smartphone addiction, the effect of smartphone addiction on pressure pain threshold, hand grip strength, and hand dexterity was similar in females with high or low smartphone addiction ($p > .05$). In males with high smartphone addiction, the Minnesota test parameters of the non-dominant hand in the placing test and turning test and the Purdue pegboard test parameter of assembly were statistically significantly higher than those of the non-addicted group ($p < .05$). Palmar pinch grip strength in the non-dominant hand was also lower in the male subjects in the smartphone addiction group (Table 2).

Discussion

The aim of this study was to examine the effect of the degree of smartphone addiction on the thumb pressure pain threshold, hand grip strength, pinch grip strength, and manual and finger dexterity in 127 university students. The study's results demonstrated no differences between the groups in respect of the thumb pressure pain threshold, hand grip strength, pinch grip strength, and dexterity values. However, it was observed that although the smartphone addiction status of females did not affect hand strength, dexterity, and pain parameters, the smartphone addiction status of males showed differences in some hand dexterity parameters and palmar pinch strength.

The human hand performs a wide range of activities, from those requiring fine dexterity to those requiring great force (Chan, 2000). Therefore, it will be important to determine the effects of smartphone usage on manual and finger dexterity. In Shetty et al., study evaluating finger dexterity with the Purdue pegboard test, it was found that excessive smartphone usage had a negative effect on finger dexterity (Shetty et al., 2019). On the other hand, in another study using the MMDT for manual dexterity, it was found that smartphone addiction did not affect the results (Oberoi et al., 2019). However, in both of these studies, no gender-based evaluation was made. The current study found that the degree of smartphone addiction level did not affect manual and finger dexterity. However, when participants were analyzed according to gender, the female's manual and finger dexterity were unaffected.

In contrast, some but not all sub-parameters of manual and finger dexterity were affected in males with smartphone addiction. These differences should be determined more clearly, and the source of these differences should be examined in future studies. In addition, the difference in the turning test and assembly test suggests that as smartphone use increases, the dexterity that requires the use of both hands in the male may be affected by the non-dominant hand. On the other hand, it was found that there was a decrease in non-dominant hand placing test and non-dominant tripod pinch grip strength in males with smartphone addiction compared to those without smartphone addiction. This may be due to the similar hand-holding positions of both tests.

In recent years, smartphone use for different purposes has increased significantly worldwide. Smartphones have become popular, particularly among young people, for many uses besides communication, including playing games and surfing the Internet. Many studies in the literature have investigated the effects of smartphone usage on the musculoskeletal system, focusing on the grip and pinch strength, the endurance of neck muscles, and pain, but the results of these studies are contradictory (Alshahrani et al., 2021; İnal et al., 2015; Lee et al., 2016; Mustafaoglu et al., 2021; Osailan, 2021; Radwan et al., 2020; Tidke et al., 2019). Some studies have investigated the effect of smartphones on hand and pinch grip strength as there is intense hand use in phone operations. Osailan (2021) reported that the extended use of smartphones was related to weaker hand and pinch grip in

Table 1.
The Participants' Demographic Characteristics, Smartphone Addiction Levels, Manual and Finger Dexterity, Hand Grip Strength, Pinch Grip Strength, and Thumb Pressure Pain Threshold Results

	Total (*n* = 127)	Smartphone Addiction Group (*n* = 56)	Smartphone Non-Addiction Group (*n* = 71)	*P*
Age (years)	21 (19 – 25)	21 (19 – 25)	21 (19 – 25)	.870[a]
BMI (kg/m^2)	21.48 (15.41 – 34.01)	21.31 (16.30 – 34.01)	21.97 (15.41 – 31.07)	.263[a]
Female/male, *n* (%)	96 (75.6)/31 (24.4)	44 (78.6)/12 (21.4)	52 (73.2)/19 (26.8)	.487
Smartphone usage (weekly/h)	35.88 (7 – 112)	35.88 (7 – 112)	35.88 (7 – 70)	.164[a]
Internet usage (weekly/h)	33.32 (7 – 110)	33.32 (8 – 110)	33.32 (7 – 70)	.024[a]
Minnesota manual dexterity test				
Dominant hand placing test	62.38 ± 4.87	61.82 (54.36 – 75.87)	61.52 (52.39 – 76.62)	.436[a]
Non-dominant hand placing test	66.84 ± 5.68	67.25 ± 6.37	66.51 ± 5.09	.468[b]
Turning test	53.78 ± 8.33	53.31 ± 8.52	54.14 ± 8.22	.579[b]
Purdue pegboard test				
Dominant hand	15 (11 – 20)	15 (11 – 20)	16 (11 – 19)	.912[a]
Non-dominant hand	14 (9 – 19)	15 (10 – 19)	14 (9 – 19)	.102[a]
Both hands	24 (12 – 38)	24 (12 – 38)	24 (14 – 30)	.402[a]
Dominant plus non-dominant plus both hands	41.79 ± 4.48	42 (31 – 51)	42 (32 – 51)	.713[a]
Assembly	30 (20 – 51)	29.5 (20 – 48)	31 (20 – 51)	.329[a]
Hand grip strength				
Dominant hand	25.67 (13 – 54.33)	25.17 (16 – 53)	26.33 (13 – 54.33)	.300[a]
Non-dominant hand	23.33 (14.67 – 57)	22.33 (14.67 – 57)	25.33 (14.67 – 48.67)	.053[a]
Pinch grip strength				
Dominant hand lateral pinch	6.58 (4.42 – 13)	6.46 (4.42 – 13)	6.67 (4.50 – 11.33)	.252[a]
Non-dominant hand lateral pinch	6 (3.83 – 14)	5.83 (4 – 14)	6.33 (3.83 – 10.83)	.242[a]
Dominant hand tip pinch	4.08 (1.17 – 10.83)	4 (2.08 – 10.83)	4.17 (1.17 – 6.67)	.598[a]
Non-dominant hand tip pinch	3.83 (1.17 – 10.33)	3.63 (2.33 – 10.33)	3.92 (1.17 – 6.08)	.575[a]
Dominant hand tripod pinch	5.83 (2.83 – 14)	5.75 (3.25 – 14)	6 (2.83 – 9.33)	.397[a]
Non-dominant hand tripod pinch	5.33 (3 – 15.17)	5.13 (3 – 15.17)	5.5 (3 – 8.33)	.177[a]
Thumb pressure pain threshold				
Dominant hand CMC joint	3.42 (1.60 – 7.67)	3.49 ± 1.05	3.58 ± 1.21	.657[b]
Non-dominant hand CMC joint	3.73 (1.70 – 8)	3.67 (1.70 – 6.50)	3.80 (1.80 – 8)	.646[a]
Dominant hand adductor muscle	3.50 (1.40 – 8)	3.52 (1.50 – 7.17)	3.50 (1.40 – 8)	.732[a]
Non-dominant hand adductor muscle	3.63 (1.53 – 8.50)	3.65 (1.53 – 6.67)	3.63 (1.77 – 8.50)	.719[a]

Data are presented as mean ± SD, non-normally distributed continuous data are presented as median (minimum – maximum). BMI, body mass index; CMC, carpometacarpal.
[a]Mann – Whitney *U*-test.[b]Independent samples *t*-test.

male participants with a mean age of 21. Radwan et al. (2020) also found that hand and pinch grip strength decreased in the dominant hands of excessive smartphone users in participants aged 9 – 15. İnal et al. (2015) examined the median nerve and the flexor pollicis longus tendon with ultrasonography to evaluate the effects of smartphone addiction on the hands. Although grip and pinch strength values were similar, it was stated that excessive smartphone use resulted in enlargement of the median nerve and decreased pinch strength and hand functions.

Contrary to those studies (Osailan, 2021; Radwan et al., 2020), the current study results showed that the hand and pinch grip strength values were similar in the groups with and without smartphone addiction. Tidke et al. (2019) conducted a study with participants in a similar age range (18 – 24 years) to that of the current study, and reported no difference in pinch grip strength between the groups with and without smartphone addiction. When Alshahrani et al. (2021) examined only females, similar grip and pinch strength results were also obtained. Alshahrani et al. (2021) reported decreased neck flexor endurance but no difference in neck extensor muscle endurance, hand and pinch grip strength in men with smartphone addiction. The current study results demonstrated that the smartphone addiction status of females did not affect the hand and pinch grip strength, and it

Table 2.
The Participants' Demographic Characteristics, Smartphone Addiction Levels, Internet Addiction Levels, Manual and Finger Dexterity, Hand Grip Strength, Pinch Grip Strength, and Thumb Pressure Pain Threshold Results by Gender

Gender	Female (n = 96)			Male (n = 31)		
	Smartphone Addiction Group (n = 44)	Smartphone Non-Addiction Group (n = 52)	*p*	Smartphone Addiction Group (n = 12)	Smartphone Non-Addiction Group (n = 19)	*p*
Age (year)	21 (19 – 24)	21 (19 – 25)	.951[a]	21.50 (19 – 25)	21 (20 – 25)	.921[a]
BMI (kg/m²)	21.24 (16.30 – 34.01)	21.09 (15.41 – 31.07)	.956[a]	21.48 (17.36 – 29.32)	23.67 (17.51 – 30.86)	.028[a]
Minnesota manual dexterity test						
Dominant hand placing test	61.24 (54.36 – 75.87)	60.92 (52.39 – 76.62)	.944[a]	66.63 (60.23 – 72.16)	61.94 (54.34 – 71.15)	.092[a]
Non-dominant hand placing test	65.95 (56.32 – 87.06)	66.20 (57.81 – 78.02)	.431[a]	72.54 (60.12 – 81.04)	65.34 (54.19 – 73.55)	.037[a]
Turning test	48.80 (41.49 – 73.56)	53.12 (40.37 – 87.03)	.122[a]	59.95 (51.30 – 71.59)	54.22 (47.72 – 67.24)	.043[a]
Purdue pegboard test						
Dominant hand	15 (11 – 20)	16 (11 – 19)	.852[a]	15 (12 – 18)	15 (11 – 18)	.951[a]
Non-dominant hand	15 (10 – 19)	14 (9 – 19)	.065[a]	13 (11 – 15)	13 (11 – 18)	.680[a]
Both hands	24 (12 – 38)	24 (14 – 30)	.408[a]	23 (18 – 28)	22 (18 – 30)	.695[a]
Dominant plus non-dominant plus both hands	42.5 (31 – 51)	43 (33 – 51)	.693[a]	38.5 (32 – 45)	39 (32 – 50)	.792[a]
Assemblies	31 (20 – 48)	30.50 (20 – 51)	.833[a]	26.5 (21 – 35)	31 (22 – 38)	.046[a]
Hand grip strength						
Dominant hand	23.87 ± 3.47	24.30 ± 4.62	.613[b]	36.67 (23.33 – 53.00)	41.33 (28.67 – 54.33)	.372[a]
Non-dominant hand	22.10 ± 3.47	23.21 ± 4.45	.181[b]	37.83 (19 – 57)	37 (24.33 – 48.67)	.919[a]
Pinch grip strength						
Dominant hand lateral pinch	6.08 (4.42 – 12.83)	6.33 (4.50 – 9.08)	.383[a]	8.17 (6 – 13)	8.50 (6.67 – 11.33)	.968[a]
Non-dominant hand lateral pinch	5.67 (4 – 14)	5.83 (3.83 – 9.50)	.412[a]	8.33 (4.50 – 11.33)	8.50 (5.50 – 10.83)	.792[a]
Dominant hand tip pinch	3.83 (2.08 – 10.83)	3.96 (1.17 – 6.67)	.609[a]	5.13 (3.50 – 6.33)	4.67 (2.75 – 6)	.641[a]
Non-dominant hand tip pinch	3.46 (2.33 – 10.33)	3.67 (1.17 – 5.90)	.892[a]	4.17 (3 – 6.17)	4.67 (2.58 – 6.08)	.570[a]
Dominant hand tripod pinch	5.67 (3.25 – 14)	5.63 (2.83 – 9.33)	.909[a]	6.50 (4.92 – 9.08)	7.33 (4.25 – 8.83)	.118[a]
Non-dominant hand tripod pinch	5 (3 – 15.17)	5.33 (3 – 7.50)	.638[a]	5.42(4.67 – 6.83)	6.75 (3.58 – 8.33)	.028[a]
Thumb pressure pain threshold						
Dominant hand CMC joint	3.07 (1.60 – 6.17)	3.40 (1.67 – 6.57)	.561[a]	4.17 (2.57 – 6.20)	4 (2 – 7.67)	.441[a]
Non-dominant hand CMC joint	3.59 ± 0.95	3.70 ± 1.06	.617[b]	5.73 (2.57 – 6.50)	4.77 (2.73 – 8)	.556[a]
Dominant hand adductor muscle	3.36 ± 0.78	3.43 ± 0.06	.688[b]	4.46 (2.07 – 7.17)	4.50 (2.20 – 8)	.919[a]
Non-dominant hand adductor muscle	3.42 ± 0.80	3.49 ± 0.94	.717[b]	4.17 (1.60 – 6.67)	4.20 (2.37 – 8.50)	.903[a]

Data are presented as mean ± SD, non-normally distributed continuous data are presented as median (minimum – maximum).
BMI, body mass index; CMC carpometacarpal.
[a]Mann – Whitney *U*-test.[b]Independent sample *t*-test.

only decreased palmar pinch strength in the non-dominant hand in males. Alshahrani et al. (2021) stated that more research is needed to analyze the relationship between excessive smartphone use and its impact on hand function and the risk of developing neuromusculoskeletal dysfunction.

There are many ways to grasp and use smartphones, and the thumb is most commonly used to touch the screen surface (Lee et al., 2016). Therefore, the effect of smartphone addiction on hand grip strength and thumb pain is a subject of interest. In the current literature, studies using questionnaires have shown that smartphone addiction is positively related to musculoskeletal pain. In the Ahmed et al. (2021) study, which included 326 participants aged 18 – 30 years, the pain level was evaluated with questionnaires, and from the results, it was concluded that smartphone addiction has a negative impact and is positively related to musculoskeletal pain. Mustafaoğlu et al. (2021) observed that the SAS-SF scores correlated with smartphone usage duration and prevalence of musculoskeletal pain. It has been reported that more than half of mobile device users (56%) have hand/wrist complaints (Jain et al., 2022). While 84% of participants documented pain in at least one body part, the most commonly expressed was the thumb pain on the right hand (Berole et al., 2011). Since many smartphone users experience thumb/wrist pain, Baabdullah et al. (2020) examined the condition of the extensor pollicis brevis and abductor pollicis longus tendons. Of the total study participants, 66.4% were smartphone addicts, and 19.1% of these were determined with Finkelstein test positivity. In contrast to previous studies (Ahmed et al., 2021; Berolo et al., 2011; Jain et al., 2022; Mustafaoglu et al., 2021), the pain level and localization of the upper extremity or musculoskeletal system were not evaluated in the current study with questionnaires. For the first time in literature, the thumb pressure pain threshold was evaluated with objective measurements taken over the carpometacarpal joint and adductor pollicis muscle. Current study results stated no difference in the pressure pain threshold between the groups with and without smartphone addiction or between the genders.

İnal et al. (2015) stated that excessive use of a smartphone enlarges the median nerve and may cause thumb pain. In that study by İnal et al., no change was observed in the flexor pollicis longus tendon, and as in the current study, there was no change in the pain threshold on the thumb muscle and joint. In light of the current study results and the previous literature, there is a clear need for further studies to investigate which tissues are the source of pain in excessive smartphone use.

The results of this study demonstrated that smartphone addiction has no adverse effect on hand and pinch grip strength, pressure pain threshold, and dexterity in undergraduate students. In males, excessive smartphone use may affect some dexterity parameters and palmar pinch strength. Hand functions and strength, which are important in daily life, can be preserved despite excessive smartphone use. However, future studies are needed to investigate the long-term effects of smartphone use according to gender and different age groups.

Limitations and Directions/Suggestions for Future Research

There were some limitations in the current study, primarily the unequal distribution of the groups. In addition, only a young adult population was evaluated, and it can therefore be recommended that future studies include participants from all age groups. The lower number of male participants meant that the effects of smartphone use in relation to gender could not be clearly demonstrated. It would be useful for future studies to define the change in the effects of smartphone use according to gender and to clarify from which tissues the pain originates. To see the effect of smartphone use on hand functions more clearly, a control group that does not use smartphones is needed, but this is not possible for all age groups today, not only for young people. The most powerful aspect of this study was that hand-related measurements were made with valid and reliable objective evaluation methods. Therefore, the study can be considered of value in contributing to the literature, especially on the effect of smartphone addiction on hand dexterity. Another strength of the study was that an objective method was used for the first time, especially in pain evaluation. In previous studies in the literature, the pain has been evaluated with questionnaires, and therefore, if a questionnaire had been used in addition to the objective measurement of pain in this study, more results about pain could have been determined. There remains a need for future studies to investigate the effects of smartphone use by questioning daily life habits to reveal the clinical implications more clearly.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of University of Bandırma Onyedi Eylül (Approval no: 2019-04-05, Date: 14.04.2019).

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