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Original Article

Exploring the Relation of Smartphone Addiction and Musculoskeletal Pain in the Neck, Trunk, and Upper Limbs: A Cross-sectional Study

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Key Words
Cross-sectional study
Musculoskeletal pain
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Background: Smartphone addiction has emerged as a significant social problem. Numerous studies have indicated the association between smartphone use and discomfort in the musculoskeletal system of the upper extremities.

Objects: This cross-sectional survey aimed to compare the characteristics of musculoskeletal pain in the neck, trunk, and upper limbs between individuals with smartphone addiction and those without addiction.

Methods: We collected a total of 326 healthy individuals' data from China and Korea who had owned and used smartphones for more than 5 years between 20–50s through an online questionnaire consisting of 84 questions in four major sections. The first part contained basic information on the participant's personal characteristics and smartphones. The second part contained questions about smartphone use and posture. The third part was the smartphone addiction. The fourth part was to investigate musculoskeletal pain in various upper body parts.

Results: Smartphone addiction has a weak negative correlation with age ($r = -0.20$, $p < 0.01$) and a weak positive correlation with the hours of smartphone use ($r = 0.376$, $p < 0.01$). Frequent musculoskeletal pain symptoms related to smartphone use were observed in the neck, shoulder, lower back, and wrists. The hours of smartphone use was slightly positively associated with the prevalence of musculoskeletal pain in the shoulder ($r = 0.162$, $p < 0.05$) and lower back ($r = 0.125$, $p < 0.05$). The prevalence of musculoskeletal pain in the neck ($\chi^2 = 3.993$, $p < 0.05$), shoulder ($\chi^2 = 6.465$, $p < 0.05$), and wrist ($\chi^2 = 4.645$, $p < 0.05$) was significantly higher among females than males.

Conclusion: The results suggest that smartphone addiction should be recognized as a dual concern encompassing both physical health and psychosocial aspects. Furthermore, healthcare professionals, including physicians and physical therapists, should consider clients' smartphone usage patterns when assessing and treating with musculoskeletal pain.

INTRODUCTION

Smartphones are essential tools for individuals of all ages worldwide. Offering various mobile applications for communication, education, and entertainment, it is difficult to imagine daily life without one [1]. Global smartphone ownership and usage have increased over the last 10 years, and the number of smartphone users is expected to grow rapidly from around 2.1 billion in 2017 to 7. 216 million by 2026 [2,3]. As the number of smartphone users and diversification of smartphone usage contents increase, psychological and physical problems related to smartphone use are attracting attention [4]. During the COVID-19 pandemic, the frequency of smartphone use and Internet access surged, fueled by anxiety and unmet social needs [5]. In general, young people are more likely than those in other age groups to have access to the latest technology, and smartphones affect almost every aspect of their lives [6].

Smartphone addiction has been labeled with various names including smartphone overuse, mobile phone addiction, problematic mobile usage, addiction proneness, and excessive use of smartphones. Smartphone addiction is classified psychiatrically as a behavior addiction in the recent smartphone lit-

erature [7]. Addiction to smartphones has been influenced by advancements in smartphone functionalities including Internet browsing, social media apps, gaming apps, mobile shopping, portable media players, small digital cameras, and high-resolution touchscreens [2,8].

Previous studies associate mobile phone addiction with many health problems including headaches [9], fatigue [10], and insufficient sleep quality [11,12]. Some also focus on mental health such as stress [13], loneliness [14], and students' academic performance [15]. Importantly, potential concerns for musculoskeletal issues have been observed along with the surge in smartphone use [8]. Numerous studies have examined the impact of smartphone use on upper-extremity musculoskeletal discomfort. Most research on this topic, which targeted college students, discovered a link between smartphone addiction and musculoskeletal disease symptoms [16]. In a system review study, the main symptoms of smartphone use were found to be fatigue, especially in the upper extremities. Furthermore, stiffness, burning, and numbness were the other most often-mentioned musculoskeletal symptoms [17].

The prolonged, intense, low amplitude, repeated use of hand-held devices has led to an increase in the occurrence of musculoskeletal problems of the hand, wrist, forearm, arm, and neck [1]. Zirek et al. [17] and Derakhshanrad et al. [18] reported nine studies that showed that participants had pain or discomfort in their neck and upper back. Neck pain is becoming more common among people who use a smartphone because of the incorrect neck posture needed to text and read on a mobile device, which is known as "text neck" [19]. Other studies also reported shoulder pain among participants, specifically, myofascial pain, fibromyalgia syndrome, and thoracic outlet [17]. Many smartphone users complain of sore fingers and wrists after using their phones. Baabdullah et al. [20] found a correlation between heavy smartphone use and hand pain. The primary known risk factor for dysfunction of the thumb and associated musculature is long-term repetitive movements of the thumb and fingers. Pain and discomfort may result from repetitive, static, or severe finger postures during hand, thumb, and finger-heavy work [21]. A documented musculoskeletal disease related to hand-held devices is "SMS thumb" [22].

Furthermore, according to our understanding, previous studies focused on smartphone addiction, psychological problems, and some musculoskeletal pain in the upper extremities among young people. There are fewer studies on older people, but more on pain at individual sites and populations in a single country. Therefore, the primary aim of this cross-sectional survey was to compare the characteristics of musculoskeletal pain in the neck, trunk, and upper limbs of a smartphone addiction and non-addiction group.

MATERIALS AND METHODS

1. Participants

In total, 326 individuals (146 males and 180 females) aged between 20 and 59 years (35.4 ± 12.42 years) from Korea and China who had owned and used a smartphone for more than 5 years participated in the cross-sectional Internet-based survey. This study was approved by the Yonsei University Mirae campus Institutional Review Board (IRB no. 1041849-202209-SB-155-03). Regarding the respondents, 144 were in their 20–30s, 72 in their 30–40s, 49 in their 40–50s, and 61 were in their 50s or older. Before answering the survey questions, all respondents agreed to participate in this study and provided their information.

2. Survey Distribution and Response Collection

The questionnaire was created in Korean and Chinese. The Korean version was created using the Google Forms (Google) and the Chinese version in Wenjuanxing (Changsha Ranxing Information Technology Co., Ltd.), a widely accepted online questionnaire survey platform in China. The questionnaire was distributed using a uniform resource locator (URL) sharing method between August 2022 and January 2023. The link generated for the Korean version was sent to participants via e-mail and Kakao Talk (Kakao Corp.). The Chinese version was sent to via email and WeChat (Tencent Holdings Ltd.). Data were collected from respondents who lived in South Korea and China by the convenience sampling.

3. Questionnaire Development

As we wanted to compare musculoskeletal pain in the neck, trunk, and upper limbs of the smartphone addiction group and non-addiction group, we used a newly composed survey tool named namely "Investigation of musculoskeletal pain associated with smartphone addiction and smartphone usage posture." This online questionnaire consisted of 84 questions grouped under four sections. The first section includes questions on the general characteristics of participants and their smartphones.

The second contains questions about posture when using a smartphone. The third section comprised the smartphone addiction scale-short version (SAS-SV) [8]. The fourth section included questions on musculoskeletal pain and discomfort in various parts of the upper body including the hands. Note that within the scope of this paper, data on individual pain conditions and related postures of the hand are not analyzed and discussed here.

1) General information

As mentioned, the first section of the questionnaire included 13 general information questions on participants' age, height, weight, occupation, hand dominance, hours of smartphone use, contents of smartphone use, and smartphone use posture.

2) Smartphone use posture

Participants were asked to select one whole-body position during smartphone use from sitting, standing, long on the right side, lying on the left side, being supine, and prone. In another question, participants had to select one of three neck forward bending positions they adopted while using a smartphone. We delineated hand postures while using smartphones into six categories considering whether to use both hands, which finger to operate the screen with, whether to hold the screen horizontally or vertically, and whether to support the smartphone with the hands.

3) Smartphone addiction scale

The SAS-SV was integrated into the research questionnaire used in the study. SAS-SV consists of 10-item responded to on a 6-point Likert scale (ranging from "1: strongly disagree" to "6: strongly agree") [8]. Internal consistency of SAS-SV for the adolescent population is reportedly high (Cronbach's alpha of 0.911). The total score ranges between 10 and 60. Participants were categorized into the smartphone addiction group based on the total score. Higher scores suggest a higher likelihood of addiction [23]. The cut-off value is 31 for males and 33 for females [8,20].

4) Musculoskeletal pain and discomfort scales

Musculoskeletal pain and discomfort related to smartphone use was determined using the Visual Analogue Scale (VAS), Cornell Musculoskeletal Discomfort Questionnaires (CMDQ), and Cornell Hand Discomfort Questionnaires (CHDQ) [24,25]. The CMDQ and CHDQ were initially developed by Dr. Hedge at Cornell University and has been used for research on musculoskeletal pain in the hand related to various occupations such as office workers, nurses, and dental workers [26-29]. The CMDQ and CHDQ consider the frequency of pain (0,1.5,3.5,5,10), degree of discomfort (1,2,3), and degree of work interference (1,2,3) in three dimensions. Other pain assessment tools focus on the frequency and severity of the pain. The frequency, discomfort, and interference of the pain were combined to determine the overall discomfort score. CMDQ includes the neck, shoulder, upper back, back, upper arm, forearm, elbow, wrist, and hand, a total of nine parts. The CHDQ includes the thumb, 4–5th fingers, 2nd–3rd fingers, palm, thenar, and wrist, a total of six parts.

Second, in addition to the abovementioned scale topics, we asked extra questions on the types of pain at each site, including that felt as a stabbing, stiffness, numbness, throbbing, and dullness sensation. As Ahmed et al. [23] and Erdinc et al. [25] reported, the Kappa coefficients of CMDQ ranged from 0.56 to 0.97, suggesting moderate to good test-retest reliability, thus confirming the validity of the questionnaire.

4. Data Analysis

The data were analyzed using IBM SPSS 26.0 software for windows (IBM Co.). Categorical variables are presented as number and percentage. Chi-square tests were performed to determine the difference of categorical variables between the addiction and non-addiction groups. Differences in pain levels and total scores between the smartphone addiction and non-addiction groups for various parts of the upper body were determined via a t-test. Kolmogorov–Smirnov tests were used to confirm the assumption of normal distribution. A between groups analysis was conducted using a chi-square test. Finally, the Pearson or Spearman correlation (weak: 0.2–0.4; moderate: 0.4–0.6; strong: 0.6–0.8) was used to measure the association between the SAS, VAS, and CMDQ.

RESULTS

1. Characteristics of Participants

1) Participants' characteristics: addiction and non-addiction groups

In total, 326 participants completed this survey. Of the 326 participants, 180 (55.2%) were female and 146 (44.8%) were

male. Participants were categorized into the smartphone addiction and non-addiction groups based on the total SAS-SV. Ultimately, 166 participants (51%) with a SAS greater than the cut-off value (31 for males and 33 for females) were grouped into the smartphone addiction group. Frequency of the addiction and non-addiction were significantly different by age groups, as indicated in Table 1. Initially, it is noteworthy that a statistically significant disparity was seen in the prevalence of addiction and non-addiction among those aged 20 to 30 (χ^2 = 5.44, p = 0.020) and those aged 40 to 50 (χ^2 = 10.80, p = 0.001). In relation to employment status, a statistically significant disparity was seen in the occurrence of addiction and non-addiction just within the unemployed individuals (χ^2 = 5.44, p = 0.020). Additionally, the findings from the Spearman correlation analysis revealed a statistically significant weak negative correlation (r = –0.20, p < 0.01) between the SAS and age. Furthermore, significant disparities were observed in the duration of smartphone use among persons categorised as addicted and those categorised as non-addicted, particularly for those who indicated a usage of 1–4 hours (χ^2 = 10.62, p = 0.001). Furthermore, the study revealed a modest positive association between the scores measuring smartphone addiction and the number of hours spent using smartphones (r = 0.376, p < 0.05). However, no statistically significant difference was found between the groups in terms of gender (p < 0.05) in connection to smartphone addiction, as shown in Table 1.

Table 1. General characteristics of participants

Variable	Total (N = 326)	Addiction (n = 166)	Non-addiction (n = 160)	χ^2	p-value
Sex				1.706	0.300
Male	146 (44.79)	79 (54.11)	67 (45.89)	0.986	0.321
Female	180 (55.21)	87 (48.33)	93 (51.67)	0.200	0.655
Age (y)				17.046	0.001**
20–30s	144 (44.17)	86 (59.72)	58 (40.28)	5.444	0.020*
30–40s	72 (22.09)	39 (54.17)	33 (45.83)	0.500	0.480
40–50s	49 (15.03)	13 (26.53)	36 (73.47)	10.796	0.001**
Over 50s	61 (18.71)	28 (45.90)	33 (54.10)	0.410	0.522
Occupation				9.381	0.052
Student	103 (31.60)	51 (49.51)	52 (50.49)	0.010	0.922
Office worker	158 (48.47)	85 (53.80)	73 (46.20)	0.911	0.340
Freelancer	22 (6.75)	10 (45.45)	12 (54.55)	0.182	0.670
Housewife	34 (10.43)	12 (35.29)	22 (64.71)	2.941	0.086
Unemployed	9 (2.75)	8 (88.89)	1 (11.11)	5.444	0.020*
Hours of smartphone use (h)				31.708	0.001***
Less than 1	2 (0.61)	0 (0)	2 (100)	NA	NA
1–4	136 (41.72)	49 (36.03)	87 (63.97)	10.618	0.001**
4–7	136 (41.72)	76 (55.88)	60 (44.12)	1.882	0.170
7–10	52 (16.95)	41 (78.85)	11 (21.15)	17.308	> 0.99

Values are presented as number (%). NA, not available. *p < 0.05, **p < 0.01, ***p < 0.001.

Table 2. Contents of smartphone use (multiple responses) (N = 326)

Content	Smartphone addiction		Sex		Age (y)			
	Addiction (n = 166)	Non-addiction (n = 160)	Male (n = 146)	Female (n = 180)	20–30s (n = 144)	30–40s (n = 72)	40–50s (n = 49)	Over 50s (n = 61)
Chatting	153 (92.17)	147 (91.88)	127 (86.99)	173 (96.11)	128 (88.89)	67 (93.06)	46 (93.88)	59 (96.72)
YouTube	125 (75.30)	104 (65.00)	111 (76.03)	118 (65.56)	112 (77.78)	52 (72.22)	28 (57.14)	37 (60.66)
Instagram & other media app	103 (62.05)	77 (48.13)	60 (41.10)	120 (66.67)	95 (65.97)	38 (52.78)	23 (46.94)	24 (39.34)
Phone call	47 (28.31)	67 (41.88)	59 (40.41)	55 (30.56)	27 (18.75)	32 (44.44)	22 (44.90)	33 (54.10)
Listen to music	40 (24.10)	36 (22.50)	36 (24.66)	40 (22.22)	47 (32.64)	13 (18.06)	7 (14.29)	9 (14.75)
Game	27 (16.27)	17 (10.63)	27 (18.49)	17 (9.44)	29 (20.14)	7 (9.72)	7 (14.29)	1 (1.64)
Others	12 (7.23)	11 (6.88)	16 (10.96)	7 (3.89)	4 (2.78)	4 (5.56)	6 (12.24)	9 (14.75)

Values are presented as number (%).

2) Differences in contents use based on age, gender, and smartphone addiction

Because the survey question on frequently used contents on a smartphone was multiple choice, a statistically comparative test was not conducted. The order of frequently used smartphone contents was the same in the smartphone addiction group and non-addiction group (Table 2). However, the smartphone addiction group used their smartphones more for YouTube, Instagram, and games than the non-addiction group. On the other hand, the non-addiction group used their smartphones more frequently for phone calls. Females used social media more than did males, and males were more likely to play games than females. The top three smartphone contents used by all age groups were chatting, YouTube, and Instagram. People in aged their 20–30s tend to listen to music more than those in other groups. Older people tend to use Instagram and other social media less, especially those aged over 50 years, who use their smartphones mostly for chatting and phone calls (Table 2).

2. Between Group Comparison of Pain Experience

The rate of presence of a sensation of pain was greater in the addiction group for all body parts (Table 3). People in the smartphone addiction group experienced pain in the order of the neck (78.92%), shoulder (65.06%), lower back (57.83%), wrist (50.92%), upper back (46.99%), upper arm (35.54%), hands (34.94%), forearm (27.11%), and elbow (25.30%). The non-smartphone addiction group felt pain in the order of the neck (58.13%), shoulder (48.75%), lower back (41.25%), wrist (36.25%), upper back (33.75%), hands (16.88%), forearm (16.25%), upper arm (13.75%), and elbow (6.87%). In all body part, the frequency of addiction was significantly higher than non-addiction among the people who experienced pain ($p < 0.05$). Among the people who does not experience pain, the frequency of non-addiction tends to be greater than the addiction in all body part. However, statistical significance between addiction and non-addiction was found only in the neck, shoulder, upper arm ($p < 0.05$), Furthermore, the prevalence of musculoskeletal pain in the neck ($\chi^2 = 3.993$, $p < 0.05$), shoulder ($\chi^2 = 6.465$, $p < 0.05$), and wrist ($\chi^2 = 4.645$, $p < 0.05$) was significantly higher among females than males. There was a

Table 3. Pain experience in the upper body parts

Body part	Total (N = 326)	Addiction (n = 166)	Non-addiction (n = 160)	χ^2	p-value
Neck				16.381	0.001***
Pain	224 (68.7)	131 (58.5)	93 (41.5)	6.446	0.011*
No pain	102 (31.3)	35 (34.3)	67 (65.7)	10.039	0.002**
Shoulder				8.846	0.003**
Pain	186 (57.1)	108 (58.1)	78 (41.9)	4.839	0.028*
No pain	140 (42.9)	58 (41.4)	82 (58.6)	4.114	0.043*
Upper back				5.925	0.015*
Pain	132 (40.5)	78 (59.1)	54 (40.9)	4.364	0.037*
No pain	194 (59.5)	88 (45.4)	106 (54.6)	1.670	0.196
Lower back				8.960	0.003**
Pain	162 (49.7)	96 (59.3)	66 (40.7)	5.556	0.018*
No pain	164 (50.3)	70 (42.7)	94 (57.3)	3.512	0.061
Upper arm				20.720	0.001***
Pain	81 (24.8)	59 (72.8)	22 (27.2)	16.901	0.001***
No pain	245 (75.2)	107 (43.7)	138 (56.3)	3.922	0.048*
Elbow				20.318	0.001***
Pain	53 (16.3)	42 (79.2)	11 (20.8)	18.132	0.001***
No pain	273 (83.7)	124 (45.4)	149 (54.6)	2.289	0.130
Forearm				5.639	0.018*
Pain	71 (21.8)	45 (63.3)	26 (36.7)	5.085	0.024*
No pain	255 (78.2)	121 (47.4)	134 (52.6)	0.663	0.416
Wrist				6.826	0.009**
Pain	142 (43.6)	85 (59.8)	58 (40.2)	4.761	0.029*
No pain	184 (56.4)	81 (44.02)	96 (55.98)	2.174	0.140
Hand				13.793	0.001***
Pain	85 (26.1)	58 (68.2)	27 (31.8)	11.306	0.001**
No pain	241 (73.9)	108 (44.8)	133 (55.2)	2.593	0.107

Values are presented as number (%). *p < 0.05, **p < 0.01, ***p < 0.001.

slight positive association between daily smartphone use time and the prevalence of musculoskeletal pain in the shoulder ($r = 0.162$, $p < 0.05$) and lower back ($r = 0.125$, $p < 0.05$).

3. Between Group Comparison of VAS and CMDQ

There were significant differences in the VAS and CMDQ scores for each part of the upper body between the addiction and non-addiction groups (Table 4). Overall, the total scores for VAS and CMDQ of the smartphone addiction group were significantly higher for all parts of the upper bodies than those for the non-addiction group ($p < 0.05$). Furthermore, the Pearson correlation analysis revealed a significant weak positive correlation between smartphone addiction scores and the VAS ($p < 0.01$) and CMDQ scores ($p < 0.01$) for each upper body part (Table 5).

DISCUSSION

The aim of this study was to compare the prevalence of musculoskeletal pain and severity of the pain in the neck, trunk, and upper limbs of the smartphone addiction and non-addiction groups. Furthermore, this study was the first to attempt to investigate not only pain intensity, but also the impact of smartphone-related musculoskeletal pain on participants in performing their jobs using CMDQ and VAS. Of the 326 participants, 166 (51%) with a SAS greater than the cut-off value were considered to have a smartphone addiction. Unlike our findings, the overall prevalence of smartphone addiction (37.4%) among university students aged from 18 to 52 years in a study by Albursan et al. [30] was lower than in our study. Furthermore, they reported higher addiction prevalence among females than males. Because the COVID-19 pandemic occurred during the time of the questionnaire and participants were also in occupations other than college students who had to work from home, such as corporate employees, our study may have found a higher addiction rate. During the pandemic, individuals may have considered social media a way to reduce stress. In this case, venting and avoidance of emotional coping strategies allow people to reduce stress [31].

Note that our study included a wider age range and thus

Table 4. VAS and CMDQ scores for the smartphone addiction and non-addiction groups (N = 326)

Body part	Addiction (n = 166)	Non-addiction (n = 160)	t	p-value (t-test)
VAS				
Neck	3.500	2.038	−5.533	0.001***
Shoulder	3.151	1.888	−4.365	0.001***
Upper back	2.241	1.313	−3.474	0.001**
Lower back	2.880	1.531	−4.753	0.001***
Upper arm	1.795	0.500	−5.418	0.001***
Elbow	1.241	0.375	−4.179	0.001***
Forearm	1.271	0.406	−4.239	0.001***
Wrist	2.398	1.094	−5.068	0.001***
Hand	1.753	0.650	−4.608	0.001***
CMDQ				
Neck	10.599	3.894	−4.596	0.001***
Shoulder	8.542	4.206	−3.074	0.002**
Upper back	6.075	1.994	−3.903	0.001***
Lower back	8.952	2.678	−4.845	0.001***
Upper arm	4.569	0.625	−4.227	0.001***
Elbow	3.292	0.675	−2.767	0.006**
Forearm	3.792	0.675	−2.969	0.003**
Wrist	6.310	2.513	−3.288	0.001**
Hand	4.443	0.981	−3.997	0.001***

VAS, visual analogue scale; CMDQ, Cornell Musculoskeletal Discomfort Questionnaires. **p < 0.01, ***p < 0.001.

Table 5. Correlation between smartphone addiction scale and VAS & CMDQ

	Neck	Shoulder	Upper back	Upper arm	Lower back	Elbow	Forearm	Wrist	Hand
VAS	0.338**	0.280**	0.235**	0.319**	0.285**	0.255**	0.256**	0.302**	0.303**
CMDQ	0.264**	0.222**	0.245**	0.259**	0.229**	0.185**	0.177**	0.174**	0.219**

VAS, visual analogue scale; CMDQ, Cornell Musculoskeletal Discomfort Questionnaires. **p < 0.01.

enabled us to obtain data related to smartphone addiction and pain from those aged in their 40s and 50s. The subjects of most other studies on this topic were in their late teens [32,33] or aged in their 20–30s [34,35]. In our study, the rate of smartphone addiction among those aged 20–30 years is 51.8%. Alsalameh et al. [36] reported that among 242 medical students, 60% had been classified as addicted to smartphone, a slightly higher incidence rate than in our study for the same age group. Alhazmi et al. [37] found a lower overall prevalence of smartphone addiction (36.5%) among college students than our study for the 20–30s age group.

Younger people generally spend more time using smartphones [38,39]. Alhazmi et al. [37] found a significant relationship between daily hours of smartphone usage and smartphone addiction. We also found that problematic smartphone use, and the rate of smartphone addiction decrease with age, which is similar to the findings of previous studies [39-41]. In addition, older people use smartphones less for Instagram and other social media; for example, those aged over 50 years use smartphones mostly for chatting and phone calls. This finding is consistent with previous findings that as people age, they spend less time processing and socializing on smartphones, have fewer social costs, and are under less social pressure. Thus, they are less likely to develop smartphone addiction behaviors [42].

In this research, the prevalence of smartphone addiction among females and males did not differ significantly, which contrasts the findings of other studies. Females generally have a higher smartphone addiction [38,39,43]. Van Deursen et al. [43] showed that females are more likely to develop habitual smartphone use due to greater social pressure and the relatively safe social environment provided by these devices. They therefore have slightly higher levels of smartphone addiction than males. Females used smartphones more for social media than males, while males were more likely to play games than females. The motivations for using smartphones differ by sex, with perceived enjoyment and pastimes having a greater impact on smartphone addiction for female users, and subordination having a greater impact on male users [42]. Thus, musculoskeletal pain prevalence in the neck, shoulder, and wrist was significantly higher for females than males, probably because of the excessive use of smartphones, especially for social media, by females [1].

Individuals in the addiction group reported higher pain prevalence in all body parts compared to the non-addiction group. In addition, pain intensity and the impact thereof on occupational performance in the addiction group were higher than in the non-addiction group in all body parts. The frequency of musculoskeletal pain was higher in the order of neck (78.9%), shoulder (65.1%), lower back (57.8%), and wrist (50.9%), regardless of whether addicted to smartphone use or not. However, the prevalence of pain in the upper arm was higher in the smartphone addiction group than non-addiction group.

Higher pain prevalence in the neck and shoulder in the smartphone addiction group is consistent with findings of previous studies that smartphone addiction most affects the neck and shoulder area [36,44-46]. However, these studies reported more frequent pain in the upper back area rather than the wrist and lower back area. Maintaining prolonged cervical flexion with forward head posture during smartphone use is related to increased problems and pain in the neck area [45]. According to Park et al. [47], the neck and trunk flexion angle increase as the duration of smartphone use increases, and a group of healthy young males without neck pain at the start of playing games on their smartphone reported mild to moderate neck pain (VAS 4.2 ± 1.3) upon the termination of a 15-minute game. Because most people use a smartphone while seated with an unsupported arm position, the risk of neck and shoulder problems increases because the shoulders are pulled downward by the weight of the arms and smartphone. The increased angle of cervical flexion could have an impact on upper back muscle fatigue and pain [48]. The prolonged sitting and static posture caused by smartphone use may raise the risk of upper and lower back discomfort [46]. Maintaining the position of looking down at the phone for too long can lead to upper back pain, ranging from chronic pain to severe upper back muscle spasms [49].

Like others, this study had some limitations. First, as it was cross-sectional, cause-and-effect correlations could not be established. Therefore, future longitudinal or prospective experimental investigations are required to support and build on the findings presented here. Second, the results cannot be applied to all populations since the majority of our participants were young individuals. Therefore, future studies with larger sample sizes are needed to obtain generalizable results that represent the general population. Third, because all the information was self-reported, it was likely susceptible to technique biases. This

is because of numerous other potential variables such as biopsychosocial factors that adversely affect the musculoskeletal system.

CONCLUSIONS

The results of this study show that musculoskeletal pain symptoms related to smartphone use were prevalent and frequently experienced in the neck, shoulder, lower back, and wrist. Smartphone addiction was associated with age, smartphone usage time, and musculoskeletal pain prevalence in all upper body parts. Furthermore, the results of this study suggest that smartphone addiction should be considered both a physical health and psychosocial issue. Therefore, healthcare professions should develop and provide educational ideal smartphone use postural and preventive exercise programs to reduce the risk of excessive postural distortion and musculoskeletal pain from smartphone use. Finally, medical doctors and physical therapists should examine clients' smartphone use habits when clinically evaluating and treating them for musculoskeletal pain.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: YX, JHP, HSJ. Data curation: YX, YJK, KAM, JHP. Formal analysis: YX, YJK, KAM, JHP, HSJ. Investigation: YX. Methodology: YX, YJK, KAM, JHP. Project administration: YX, JHP, HSJ. Resources: YX. Software: YX. Supervision: YX, YJK, KAM, JHP, HSJ. Validation: YX. Visualization: YX. Writing - original draft: YX, HSJ. Writing - review & editing: YX, HSJ.

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