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How does the use of smartphones affect cervical region structures?

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ABSTRACT

Postural changes occurring during prolonged smartphone usage may be associated with impaired proprioception, altered musculoskeletal dynamics, and structural alterations in the cervical region. This study aimed to investigate the association between smartphone addictive use and cervical paraspinal muscles morphology and vertebral degeneration in patients with chronic neck pain (NP). This study included 119 patients with chronic NP. The cross-sectional areas (CSA) of the paraspinal muscles were quantified from magnetic resonance imaging (MRI) slices using the software program ImageJ 1.53. The relationship between the Smartphone Addiction Scale-Short Version (SAS-SV) and cervical paraspinal CSAs as well as cervical intervertebral disc degeneration was analyzed. A weak positive correlation was observed between SAS-SV scores and degeneration at C2-C3, C3-C4, C4-C5, C5-C6, and C6-C7 ($p<0.05$). Conversely, a weak negative correlation existed between SAS-SV and the CSAs of the sternocleidomastoid (SCM), trapezius, scalene muscles (anterior, middle, posterior), multifidus, multifidus+semispinalis, levator scapulae muscles and the posterolateral, lateral, and anterior muscle groups ($p<0.05$). Prolonged smartphone use may be associated with subtle reductions in cervical paraspinal muscle CSA and increased disc degeneration; however, these associations remain modest and should be interpreted cautiously. Given the prevalence of smartphones in contemporary lifestyles, individuals with neck pain may benefit from limiting continuous device use and incorporating postural breaks. Patients may also benefit from appropriately designed exercise programs aimed at improving cervical stability, reducing pain, and preserving paraspinal muscle integrity and function.

Keywords: neck pain, smartphone, paraspinal muscle, magnetic resonance imaging.

INTRODUCTION

Smartphones have gained extensive popularity as integral technological devices worldwide, offering a variety of applications for communication, education, and entertainment[1]. Han et al. reported that more than 65% of smartphone users in the USA engage with these devices daily, typically for at least 1-2 hours[2]. Furthermore, research indicates that users spend more than 20 hours per week on activities such as texting, emailing, and social networking[3].

Consequent to this widespread adoption, smartphone engagement has been associated with a range of health-related concerns. In addition to psychological implications such as depression, anxiety, and sleep disorders, musculoskeletal complaints are also prevalent among users[4]. Musculoskeletal disorders affecting the hand, wrist, forearm, arm, and neck are increasingly observed[1]. A previous study reported that neck pain (NP) is the most frequent musculoskeletal problem in this population[1,5].

During smartphone interaction, users typically maintain sustained cervical flexion while viewing the device screen. In addition to this flexed posture, users frequently exhibit a forward head position[6]. Postural adjustments occurring during prolonged smartphone use may induce impaired proprioception, abnormal musculoskeletal movements, and alterations in the peripheral cervical structures[7]. Prolonged neck flexion has been suggested to correlate with an excessive anterior curve in the lower cervical vertebrae and an excessive posterior curve in the upper thoracic vertebrae, which may diminish cervical lordosis[8]. In the flexed position, the mechanical load on the cervical region increases compared with the neutral position, necessitating increased activity of the paraspinal muscles to provide segmental stability[5].

Previous studies have examined changes in pain intensity, pain-related disability, and cervical lordosis in relation to smartphone use in patients with chronic NP[8,9]. However, to the best of our knowledge, the effects of smartphone dependency on cervical intervertebral discs and paraspinal muscles in patients with chronic NP have not yet been fully elucidated.

The present study aimed to investigate the association between smartphone use and cervical paraspinal muscle morphology, as well as intervertebral disc degeneration, in patients with chronic NP. We hypothesized that higher levels of smartphone use may be associated with differences in cervical intervertebral disc degeneration and paraspinal muscle morphology.

MATERIAL AND METHODS

Ethical Statement

This study was approved by the local Institutional Ethics Committee of our hospital (Approval date: 05.05.2021; Approval number: E2-21-253) and was conducted in accordance with the Declaration of Helsinki guidelines. All participants provided written informed consent prior to data collection.

Study setting and participants

In this cross-sectional study, 119 patients presenting to our physical medicine and rehabilitation outpatient clinic with chronic NP (duration >3 months) between June 2021 and December 2021 were included. The participants were between 18 and 65 years of age and had experienced NP for more than 3 months. Those who had a history of cervical surgery, serious trauma, metabolic or inflammatory disease, progressive or non-progressive neurological disease, known psychiatric disease, cancer, pregnancy, and who had received physical therapy and/or injection therapy for the neck were excluded from the study.

Evaluation parameters

Demographic and clinical data, including age, sex, educational level, occupation, comorbidities, and pain duration were documented. Occupational status was categorized as housewife, blue collar, and white collar. If the patient worked in a desk job that did not require physical labor, the patient was classified as white-collar; if the patient worked in a job that required physical labor, the patient was classified as blue-collar. Comorbidity was defined as any chronic condition requiring regular medication for at least 3 months.

The intensity of NP was quantified using a 0-100 mm visual analog scale (VAS). Functional impairment was determined via the Neck Disability Index (NDI). The NDI is a self-administered 10-item questionnaire and assesses the extent to which life activities (including both work and lifestyle activities) are affected by NP. Each item is scored from 0 (no disability) to 5 (complete disability), with total scores ranging from 0 to 50.10

To evaluate the extent of smartphone dependency, the Smartphone Addiction Scale-Short Version (SAS-SV) was employed. Extant literature suggests a strong correlation between usage patterns and addiction levels[11-14]. This self-report 6-point Likert-type scale consists of 10 questions ranging from 1 to 6 (1: strongly disagree, 2: disagree, 3: weakly disagree, 4: weakly agree, 5: agree, 6: strongly agree). The total scores obtained from the SAS-SV range from 10 to 60. Higher scores indicate a higher risk of addiction[15]. In a study conducted in the Korean population, the cut-off value for addiction was determined to be 33 for women and 31 for men[16].

Cervical paraspinal muscle cross-sectional areas (CSA) were measured at the C4-C5 intervertebral disc level using magnetic resonance imaging (MRI). To ensure consistency across segmental levels, all measurements were standardized to this midpoint. MRI sequences were acquired on a 1.5-T unit (MAGNETOM, Siemens AG, Germany) utilizing sagittal T1 and T2-weighted turbo spin echo, along with axial T1-weighted protocols. During imaging, the head was maintained in a neutral position to prevent rotation, lateral flexion, or exaggerated lordosis.

Axial slices were aligned parallel to the C4-C5 intervertebral disc, ensuring a vertical intersection for precise CSA measurement. Using ImageJ 1.53 software (developed by Wayne Rasband, National Institutes of Health, Bethesda, MD, USA), the areas of the sternocleidomastoid (SCM), trapezius, scalene muscles (anterior, middle, posterior), levator scapulae, splenius capitis, multifidus, multifidus+semispinalis capitis and cervicis, and longus colli/capitis were calculated according to established anatomical atlases[17]. Additionally, muscles were clustered into anterior (longus colli and capitis), lateral (SCM and scalene muscles), posterior (multifidus, semispinalis capitis and cervicis, and splenius capitis), and posterolateral (levator scapulae and longissimus colli and capitis) groups (Figure 1).

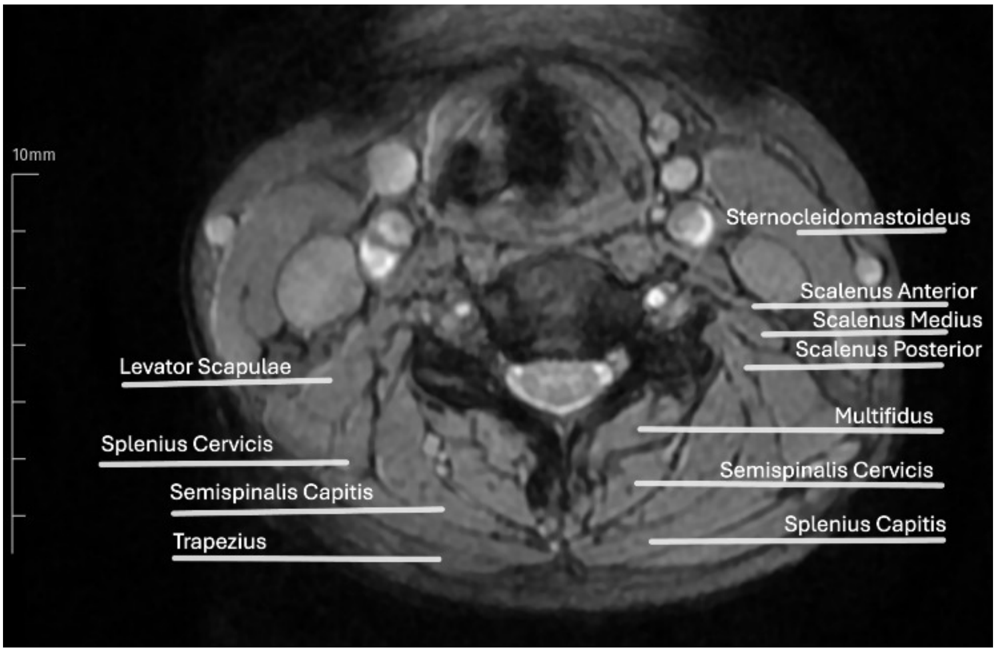

Fig. 1 — A measurement trace around the cross-sectional areas of the paraspinal muscles at the C4-5 level of Magnetic Resonance Imaging slice using ImageJ 1.53 software program (produced by Wayne Rasband, United States National Institutes of Health, Bethesda, MD).

Degenerative changes in the cervical vertebrae (C2-C7) were graded according to the Kellgren-Lawrence classification (0: normal to 4: severe)[18].

Statistical analysis

The Statistical Package for the Social Sciences (SPSS version 20.0 for Windows) software package was used for data analysis. Variables were investigated using visual methods (histograms, probability plots) and analytical methods (Kolmogorov–Smirnov test) to determine whether they were normally distributed. Descriptive statistics were expressed as mean ± standard deviation (SD) for normally distributed continuous and ordinal variables median (minimum-maximum) for non-normally distributed continuous variables, and frequency and percentage (%) for nominal and categorical variables. Correlations were analyzed using Pearson or Spearman correlation tests, as appropriate. Correlation coefficients (r) were interpreted according to standard thresholds: values below 0.30 indicate weak correlations, values between 0.30 and 0.60 indicate moderate correlations, and values above 0.60 indicate strong correlations. Models adjusted for age, sex, VAS, pain duration, NDI, and SAS-SV were analyzed using multiple regression analyses (backward modeling) to determine the significant effect of SAS-SV on the CSAs of cervical muscles including the SCM, trapezius, scalene (anterior, middle, posterior), levator scapulae, multifidus, semispinalis capitis and cervicis, longus colli and capitis, and the anterior, lateral, posterior, and posterolateral muscle groups. Statistical significance was defined as $p<0.05$, with a confidence level of 95%.

RESULTS

The study cohort comprised 119 individuals with chronic NP, consisting of 99 women (83.2%) and 20 men (16.8%). Table I presents the demographic and clinical characteristics of the participants.

Regarding muscle morphology, male participants exhibited significantly larger CSAs for the SCM, trapezius, splenius capitis, scalene muscles (anterior, middle, posterior), multifidus, and levator scapulae, as well as the posterior, posterolateral, and anterior muscle regions ($p=0.001$, $p=0.001$, $p<0.001$, $p=0.004$, $p=0.001$, $p<0.001$, $p<0.001$, $p=0.001$, and $p=0.008$, respectively). Conversely, no significant sex-based variance was detected for the multifidus + semispinalis CSA ($p = 0.066$) (Table II).

Table III summarizes the associations between clinical variables, smartphone usage, and paraspinal muscle CSAs. Age displayed weak negative correlations with the CSAs of the splenius capitis, multifidus + semispinalis, and posterior paraspinal regions ($r=-0.238$, $p=0.010$; $r=-0.265$, $p=0.004$; $r=-0.264$, $p=0.004$, respectively). Similarly, both VAS and NDI scores yielded weak inverse correlations with the splenius capitis and posterior paraspinal

Table I. — Demographic characteristics and disease characteristics of the patients.

	N=119
Age (years)(mean±SD)	40.4±11.31
Sex n (%) Female Male	 99 (83.2) 20 (16.8)
Education status n (%) Illiterate Primary school Middle school High school University	 4 (3.4) 36 (30.3) 33 (27.7) 25 (21.0) 21 (17.6)
Occupation n (%) Housewife White collar Blue collar	 70 (58.8) 14 (11.8) 35 (29.4)
Presence of comorbidity n (%)	56 (47.1)
Duration of pain (months)median (minimum-maximum)	6.0 (4.0-140.0)
VAS (0-100 mm) (mean±SD)	60.37±10.11
NDI (mean±SD)	17.49±7.04
SAS-SV (mean±SD)	22.61±9.12

SD: Standard Deviation, VAS: Visual Analog Scale, NDI: Neck Disability Index, SAS-SV: Smartphone Addiction Scale-Short Version.

Table II. — Comparison of Cervical Paraspinal Cross-Sectional Areas Between Sexes.

	Female Median (IQR)	Male Median (IQR)	p
SCM CSA	734.89 (234.73)	1003.25 (455.17)	<0.01
Trapezius CSA	423.10 (210.40)	642.43 (415.93)	<0.01
Scalene muscles CSA	271.47 (96.76)	371.88 (195.22)	0.01
Splenius capitis CSA	293.48 (138.88)	496.56 (173.42)	<0.01
Multifidus CSA	164.77 (68.94)	227.11 (86.03)	0.04
Multifidus+semispinalis CSA	618.06 (184.65)	731.06 (466.87)	0.03
Levator scapulae CSA	485.46 (169.70)	718.82 (380.82)	<0.01
Posterior CSA	941.96 (261.45)	1443.96 (562.76)	<0.01
Posterolateral CSA	636.36 (211.91)	882.52 (349.73)	0.01
Anterior CSA	216.64 (75.92)	267.86 (147.72)	0.01

SCM: Sternocleidomastoid, CSA: Cross-Sectional Area, IQR: Interquartile Range, p-value calculated with Mann Whitney U test, bold values show statistical significance (p<0.05).

CSAs ($p<0.05$). Pain duration was further identified as having a weak negative association with the multifidus CSA ($r=-0.201$, $p=0.036$). Furthermore, SAS-SV scores inversely correlated with the CSAs across a broad spectrum of muscles, including the SCM, trapezius, scalene muscules, levator scapulae, multifidus, semispinalis capitis/cervicis, longus colli/capitis, and the anterior, lateral, and posterolateral muscle groups ($p<0.05$).

A weak but consistent positive correlation was observed between SAS-SV scores and degenerative changes across all examined cervical segments, from C2-C3 through C6-C7 ($r=0.229$, $p=0.014$; $r=0.326$, $p=0.001$; $r=0.296$, $p=0.001$; $r=0.299$, $p=0.001$; $r=0.327$, $p=0.001$, respectively) (Table IV).

In the multivariate regression analysis, SAS-SV scores emerged as an independent predictor of diminished CSA across multiple cervical muscle groups. Higher SAS-SV scores were independently associated with smaller CSAs of the SCM ($B=-5.63$, $p=0.012$), trapezius ($B=-6.74$, $p=0.001$), scalene muscles ($B=-2.81$, $p=0.004$), multifidus ($B=-1.39$, $p=0.009$), and levator scapulae ($B = -3.41$, $p = 0.021$). SAS-SV also independently predicted decreased

Table III. — The relationship between disease characteristics and smartphone use and paraspinal cross-sectional area.

	Age	VAS	NDI	SAS-SV	Pain duration
	r / p				
SCM CSA	-0.092/0.35	-0.060/0.54	-0.078/0.43	-0.243/0.02	-0.051/0.38
Trapezius CSA	-0.007/0.95	-0.091/0.34	-0.047/0.62	-0.324/0.01	-0.088/0.38
Scalene muscles CSA	0.066/0.49	-0.120/0.20	-0.009/0.93	-0.215/0.03	-0.086/0.37
Splenius capitis CSA	-0.238/0.01*	-0.205/0.03*	-0.239/0.01	-0.202/0.04	-0.123/0.21
Multifidus CSA	-0.142/0.13	-0.110/0.25	-0.147/0.12	-0.255/0.01	-0.201/0.04
Multifidus+semispinalis CSA	-0.265/0.01*	-0.166/0.08	-0.090/0.34	-0.222/0.03	-0.061/0.53
Levator scapulae CSA	-0.045/0.64	-0.157/0.06	-0.102/0.28	-0.220/0.03	-0.040/0.68
Posterior CSA	-0.264/0.01*	-0.256/0.01*	-0.275/0.01	-0.131/0.18	-0.073/0.46
Posterolateral CSA	-0.006/0.96	-0.123/0.20	-0.057/0.55	-0.202/0.04	-0.070/0.48
Lateral CSA	0.092/0.33	0.002/0.99	-0.062/0.57	-0.233/0.02	-0.072/0.51
Anterior CSA	0.017/0.88	0.070/0.99	-0.014/0.88	-0.265/0.02	-0.072/0.51

SCM: Sternocleidomastoid, CSA: Cross-Sectional Area, VAS: Visual Analog Scale, NDI: Neck Disability Index, SAS-SV: Smartphone Addiction Scale-Short Version.

Table IV. — Relationship between Degree of Cervical Disc Degeneration and Smartphone Use.

	C2-3 r / p	C3-4 r / p	C4-5 r / p	C5-6 r / p	C6-7 r / p
SAS-SV	0.229/0.014	0.326/0.001	0.296/0.001	0.299/0.001	0.327/0.001

SAS-SV: Smartphone Addiction Scale-Short Version, bold values show statistical significance (p<0.05).

Table V. — Results of multivariate regression analyses.

		Multivariate (Backward modeling)			
		ß (95% Cl)	P	B	Standard error B
SCM CSA	Sex	-0.386 (-315.78/-111.65)	<0.01	-213.72	51.4
	SAS-SV	-0.239 (-9.97/-1.29)	0.02	-5.63	2.19
Trapezius CSA	Sex	-0.371 (-279.70/-101.16)	<0.01	-190.43	44.99
	SAS-SV	-0.310 (-10.52/-2.96)	0.02	-6.74	1.91
Splenius capitis CSA	Age	-0.249 (-4.59/-0.96)	0.01	-2.77	0.92
	Sex	-0.420 (-188.06/-82.80)	<0.01	-135.43	26.57
Scalene Muscles CSA	Sex	-0.349 (-127.19/-44.57)	<0.01	-85.88	20.86
	SAS-SV	-0.274 (-4.70/-0.92)	0.01	-2.81	0.96
Multifidus CSA	Sex	-0.296 (-68.29/18.01)	0.02	-43.15	12.70
	SAS-SV	-0.230 (2.44/-0.34)	0.01	-1.39	0.53
Multifidus+semispinalis CSA	Age	-0.272 (-8.15/-1.83)	0.01	-4.99	1.59
	Sex	-0.273 (-236.01/-53.09)	0.01	-144.55	46.17
Levator scapulae CSA	Sex	-0.468 (-271.48/-132.65)	<0.01	-202.07	35.04
	SAS-SV	-0.190 (-6.29/-0.52)	0.03	-3.41	1.46
Posterior CSA	Age	-0.261 (-15.15/-3.67)	0.01	-9.41	2.89
	Sex	-0.406 (-591.61/-254.28)	<0.01	-422.95	85.12
Posterolateral CSA	Sex	-0.388 (-290.88/-115/12)	<0.01	-202.99	44.36
	SAS-SV	-0.195 (-7.91/-0.59)	0.03	-0.43	1.85
Lateral CSA	Sex	-0.442(-449.59/-185.82)	<0.01	-317.70	66.35
	SAS-SV	-0.258 (-13.93/-2.34)	0.01	-8.14	2.92
Anterior CSA	Age	-0.214 (-2.73/-0.21)	0.03	-1.47	0.63
	Sex	-0.307 (-93.98/-27.38)	<0.01	-60.68	16.81
	SAS-SV	-0.315 (-4.12/-1.08)	0.01	-2.59	0.77

SCM: sternocleidomastoid, CSA: cross-sectional area, VAS: visual analog scale, NDI: neck disability index, SAS-SV: smartphone addiction scale-short version.

CSA in the posterolateral (B = −0.43, p = 0.023), lateral (B =−8.14, p= 0.006), and anterior (B=−2.59, p=0.010) muscle groups. Concurrently, male sex was consistently linked to significantly larger CSA values across nearly all muscle groups, including the SCM (B=−213.72, p<0.01), trapezius (B=−190.43, p<0.01), scalene muscles (B=−85.88, p<0.01), splenius capitis (B=−135.43, p<0.01), multifidus (B=−43.15, p=0.02), multifidus + semispinalis (B=−144.55, p=0.01), levator scapulae (B=−202.07, p<0.01), posterior muscle group (B=−422.95, p<0.01), posterolateral group (B=−202.99, p<0.01), lateral group (B=−317.70, p<0.01), and anterior muscle group (B=−60.68, p<0.01). Age also emerged as an independent predictor for several muscle groups. Increasing age was associated with reduced CSA in the splenius capitis (B=−2.77, p=0.01), multifidus + semispinalis (B=−4.99, p=0.01), posterior paraspinal muscles (B=−9.41, p=0.01), and the anterior muscle group (B=−1.47, p=0.03) (Table V).

DISCUSSION

The current investigation examined the relationship between smartphone utilization and cervical structural integrity in patients with chronic NP. Multivariate analysis revealed that every incremental unit increase in SAS-SV score was independently linked to a reduction of 5.63 mm^2 in SCM CSA, 6.74 mm^2 in trapezius CSA, 2.81 mm^2 in scalene muscle CSA, 1.39 mm^2 in multifidus CSA, 3.41 mm^2 in levator scapulae CSA, 0.43 mm^2 in posterolateral CSA, 8.14 mm^2 in lateral CSA, and 2.59 mm^2 in anterior CSA. Higher SAS-SV scores demonstrated a weak association with greater cervical disc degeneration.

Correlation analyses indicated that these relationships were weak (r < 0.30), suggesting that smartphone addiction accounts for only a limited proportion of the variance in cervical muscle morphology and disc health. Although these findings partially align with our initial hypothesis, the weak effect sizes underscore the necessity of cautious interpretation and do not imply a strong predictive value or direct causality.

Paraspinal muscles are dynamic and static stabilizers of the cervical spine and play an important role in the pathophysiology of chronic NP[19]. Recently, research has increasingly focused on quantifying morphological changes in these muscles using advanced imaging[20-22]. Previous studies have shown an increase in CSAs in superficial flexor muscles and a decrease in CSAs in deep flexor, superficial extensor, and deep extensor muscles in individuals with idiopathic NP[18]. Changes in CSA have been reported to be associated with changes in muscle strength, and these alterations may reflect underlying muscle atrophy[23,24]. Such findings have also been suggested to reflect altered muscle composition[23,24].

Individuals commonly flex their necks between approximately 33° and 45° and shift their heads into a forward position while viewing the small screen during smartphone use[5]. This posture is commonly referred to as ‘text neck posture’[25]. The impact of smartphone use on cervical structures has also been suggested to be related to the duration of smartphone use. In one study, postural changes were found to begin at the fifth minute of smartphone use and pain began at approximately the sixteenth minute[26].

Although flexed postures are clinically linked to NP, postural factors alone rarely explain symptom development in all smartphone users. To our knowledge, no previous study has examined the relationship between smartphone use and paraspinal muscle characteristics, which represent an important component of NP pathophysiology. Smartphone users with NP exhibit heightened muscle activity compared to asymptomatic individuals, particularly as flexion angles increase[5]. Persistent or repetitive muscle activation may precipitate micro-level muscular strain or cumulative overload[7].

In the present study, higher smartphone addiction scores correlated with reduced paraspinal CSAs. Although effect sizes were limited, these associations may reflect subtle biomechanical and neuromuscular adaptations. Postural changes during sustained device use have been shown to alter cervical loading and may diminish proprioceptive input, potentially contributing to maladaptive movement patterns and increased muscle fatigue. Such mechanisms provide context for the observed CSA reductions, although these pathways remain largely speculative. It is also plausible that sustained low-grade muscle activation leads to micro-fatigue, creating a deleterious cycle where postural shifts undermine stability, further predisposing the individual to additional deviations.

Regarding disc health, higher SAS-SV scores demonstrated a weak association with greater degeneration across the C2–C7 levels. While modest, these associations may stem from the biomechanical toll of prolonged flexion, which increases cervical load by three-to-five-fold compared to a neutral stance. Flexion shifts the gravitational vector, inducing compressive and shear forces that may exacerbate degenerative processes over time[27,28].

This study has several limitations that should be considered when interpreting the findings. Primarily, smartphone use was quantified via a subjective self-report scale (SAS-SV). Objective metrics, such as screen time–tracking applications, may provide more accurate estimates of actual device use. Second, while CSA was measured, intramuscular fat infiltration (i.e., fatty or fibrous infiltration), which may impair muscle function without substantially altering muscle size, was not evaluated. Third, MRI sequences were acquired only in the neutral position; dynamic or kinetic MRI performed during flexion and extension may offer a more comprehensive assessment of cervical muscle and disc behavior under physiological loading conditions.

In addition, several potentially important confounding factors—including physical activity level, occupational and ergonomic exposure, other forms of screen use, and overall sedentary behavior—were not assessed, as each may influence cervical muscle morphology and spinal loading. The absence of these variables limits our ability to determine the specific contribution of smartphone use to the observed associations.

Finally, because the study sample consisted exclusively of patients with chronic NP, the findings cannot be generalized to healthy populations or to smartphone users without neck symptoms.

The strength of this study is that the relationship between smartphone use, cervical paraspinal muscle morphology and disc degeneration was systematically examined for the first time in individuals with NP, building on findings reported in previous studies.

In conclusion, the etiology of NP in smartphone users is likely multifactorial. Our findings suggest that excessive use may be intertwined with subtle paraspinal CSA reductions and disc degeneration. However, these associations were weak and should be interpreted with caution.

CONCLUSION

Given the widespread use of smartphones in modern life, individuals with NP may benefit from limiting prolonged or uninterrupted device use and incorporating regular postural breaks. In addition, exercise programs aimed at improving cervical muscle endurance, proprioception, and overall spinal stability may help to support paraspinal muscle function and reduce symptom burden. Further longitudinal studies incorporating objective measures of smartphone use are needed to clarify the clinical relevance and long-term implications of these associations.

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