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ORIGINAL ARTICLE

EFFECT OF SMARTPHONE USE ON NECK AND TRUNK MUSCLE ENDURANCE AND SPINAL POSTURE IN YOUNG ADULT - A COMPARATIVE ANALYSIS

Saram Mufeeda P. V., Harsha M. Naik

Yenepoya Physiotherapy College, Yenepoya (Deemed to be University), University Road, Deralakatte, Mangalore, Karnataka, India

Corresponding author's e-mail: harshamnaik@yenepoya.edu.in

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LEVEL OF EVIDENCE: 2C

ABSTRACT

Background: The rapid integration of smartphones into daily life—driven by accessibility, affordability, and functionality—has raised concerns about smartphone addiction and its potential biomechanical consequences. Prolonged usage is associated with muscle imbalance, altered posture, and reduced proprioceptive awareness. Understanding how addiction influences physical health may guide future ergonomic and rehabilitative interventions.

Purpose: To compare trunk and neck muscle endurance, as well as spinal posture, between young adults with and without smartphone addiction.

Method: A cross-sectional study was conducted on 146 medical students aged 18–25 years. Participants were categorized into smartphone addiction and non-addiction groups using the smartphone addiction scale–short version. Assessments included the McGill Torso endurance battery, deep neck flexor endurance test, cervical extensor endurance test, scapular muscle endurance test, craniovertebral angle (CVA), lumbar lordosis angle (LLA), and thoracic kyphosis angle (TKA).

Results: The non-addiction group demonstrated significantly higher endurance in trunk muscles (excluding right lateral flexors), as well as significantly better craniovertebral and lumbar lordosis angles. Although differences in neck and scapular muscle endurance, and thoracic kyphosis, were not statistically significant, they were descriptively higher in the non-addiction group.

Discussion: Smartphone addiction was associated with reduced endurance in specific trunk muscle groups and greater deviations in spinal posture, particularly forward head posture and lumbar alignment. These findings suggest that smartphone addiction may contribute to early postural deterioration and musculoskeletal strain in young adults, underlining the need for preventive education and targeted interventions.

KEYWORDS

Neck, physical endurance, posture, smartphone addiction, torso

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INTRODUCTION

The rapid advancement in technology, with smartphones being a leading one and their fascinating features, has greatly influenced the lives of today's generation[1]. Hence, the term "smartphone addiction" has become a new health disorder impacting physical and mental well-being, with musculoskeletal issues being the most prominent[2]. A systematic review of problematic smartphone usage, prevalence, and patterns among college students conducted in 2023 found that the percentage of university students ranged from 36.5 to 67%[1]. Another study analyzing problematic smartphone use across different age groups concluded that individuals aged 20–34 years had the highest scores[3]. Smartphone use in awkward postures for prolonged periods can lead to pain and discomfort in the neck, back, shoulder, wrist, elbow, and thumb, with higher prevalence in the neck and back[4]. Rounded shoulders and forward head posture are also observed in heavy smartphone users, with the latter causing loss of cervical extension and a decrease in the craniovertebral angle[5]. Different head angles change the amount of weight borne by the cervical spine, which affects children more due to their proportionally larger heads[6].

Prolonged head-hung posture can cause neck pain, leading to "text neck syndrome," characterized by reduced muscle activity and difficulty maintaining posture[7]. The position of the head alters muscle activity throughout the spine, affecting postural control and emphasizing its importance in thoracic and lumbar alignment[8]. Sustained faulty posture with improper activation of spinal musculature leads to localized fatigue and increases the risk of injury[9]. Poor posture causes musculoskeletal imbalance, highlighting the need to assess spinal posture in smartphone users[7].

Adequate endurance in the neck flexors and extensors is crucial for stabilizing the cervical spine. A decrease in endurance makes stabilization difficult, and prolonged faulty posture may increase discomfort and reduce muscle endurance. Weak neck muscles have an impaired ability to maintain postural stability, leading to abnormal spinal forces, pain, and reduced proprioception[10]. Therefore, assessing neck muscle endurance is vital, especially since individuals with smartphone addiction often exhibit forward head posture associated with neck pain. Studies have also reported a correlation between slumped sitting posture and back muscle activity[11].

Prolonged inappropriate sitting posture also impacts trunk musculature, leading to muscle overactivity and fatigue[4,9]. Normally, lumbar muscles contribute to postural stability and reduce stress on passive structures, but prolonged awkward sitting reduces spinal proprioception and increases load on these structures[11]. The resulting disuse and altered motor patterns decrease muscle endurance.

However, the lack of studies comparing trunk and neck muscle endurance and spinal posture between smartphone "addiction" and "non-addiction" groups prompted this study. The objective was to determine the effect of trunk and neck muscle endurance and spinal posture between these groups. The research question was whether there is any significant difference between them. The null hypothesis states that there is no difference between the groups, while the alternative hypothesis states that there is a significant difference.

METHODS

Study design

This was a cross-sectional comparative study conducted in the Physiotherapy OPD. This research study was approved by the Yenepoya Ethics Committee (YEC2/2024/089) on 14th May 2024, after which data collection was started in September 2024; the study duration was from May 2024 to April 2025. Clinical Trials Registry: India registration number CTRI/2024/09/073745 All participants signed an informed consent form, and the study was pre-registered in the clinical trial registry to prevent reporting bias. All procedures were conducted in accordance with the Declaration of Helsinki.

Study participants

Using the G*power version with regard to the t-test a 5% level of significance, power of 85%, and an anticipated effect size of 0.05, the sample size was 146 with 11 dependent variables. 146 healthy adult participants including both male and female were recruited conveniently to prevent gender bias. They were screened based on the inclusion criteria and exclusion criteria. The inclusion criteria were 1) undergraduate and postgraduate student in Yenepoya (Deemed to be University) and 2) age group (18-25). The exclusion criteria were 1) person with history of neck pain, back pain, radicular pain, neurological symptoms and 2) person with medical condition or undergone surgery. They were categorized into two groups based on the smartphone addiction scale-short version (SAS-SV), with the cut-off value (male (n >31), female (n >33). Participants (n = 72; female = 41, male = 31) were in the smartphone-addicted group (SAG) and (n = 74; female = 43, male = 31) were in the smartphone non-addicted group (SNAG). Participants were given an explanation regarding the study, and demographic details were obtained.

Initially, the examiner screened the participants against the eligibility criteria and explained the study procedures, after obtaining consent; the participants were initially given a data collection form for the demographic details of age, sex and hand dominance; then the assessment of endurance was taken initially with recording in the stopwatch, followed by the posture evaluation, which was recorded with the flexiruler and APECS app.

Procedure

Biering–Sorensen endurance test

In the trunk extensor endurance test, the subjects were

made to lie prone on the couch with the ASIS of the pelvis at the edge. The lower limbs were strapped using a belt. They were asked to cross their arms to the opposite shoulder and align their shoulders with the pelvis while holding the position. The holding time was recorded with a stopwatch by the therapist[12] *(Fig. 1)*.

Trunk flexor endurance test

The trunk flexor endurance test was performed by asking the participant to sit on the couch with the hips and knees bent at 90°, aligned with the hip and second toe. They folded their arms across the chest to the opposite shoulder and leaned on a wedge placed at 60° with a neutral head. The position was held after removing the wedge, maintaining a 60° hip angle and engaging abdominal muscles to prevent lumbar arching. The toes were anchored by the therapist when needed. The holding time was recorded using a stopwatch[12] *(Fig. 2)*.

Lateral flexor endurance test

The participant lay on the side to be tested, aligning the legs in a heel-to-toe position. The lower arm was placed below the body and the upper arm by the side. They lifted the hip and knee with the elbow supporting the table, keeping it aligned with the shoulder. The position was held while time was recorded with a stopwatch by the therapist[12] *(Fig. 3)*.

All endurance tests were assessed in seconds and terminated when there was any deviation from the position.

Cervical extensor endurance test

Subjects lay prone with the head hanging over the end of the table and arms by the side. The thorax was stabilized with straps. They maintained a neutral head position, and the test ended when deviation occurred. Time was recorded in seconds[13] *(Fig. 4)*.

Neck flexor endurance test

Subjects lay in a hook-lying position, retracting the chin and lifting the head 2.5 cm from the couch to maintain the position. The therapist's hand was kept below the head, and the test was terminated when the head touched it. The duration was measured using a stopwatch[13] *(Fig. 5)*.

Scapular endurance test

Participants remained prone and abducted the arm to 135°, holding 1% of their body weight. They maintained this position as the therapist recorded the time using a stopwatch[14] *(Figure 6)*.

Craniovertebral angle – APECS application

The craniovertebral angle was assessed by asking the subjects to sit comfortably after moving their neck in flexion and extension, then look forward. A marker was placed at the C7 spinous process. A lateral photograph was taken and analyzed in the APECS app. Three landmarks were



Figure 1. *Biering–Sorensen endurance test.*



Figure 2. *Trunk flexor endurance test.*



Figure 3. *Lateral flexor endurance test.*



Figure 4. *Cervical extensor endurance test.*



Figure 5. *Neck flexor endurance test.*



Figure 6. *Scapular endurance test.*

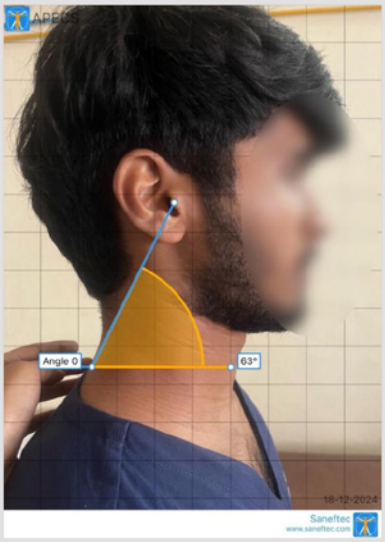


Figure 7. *Craniovertebral angle measurement using APECS application.*

identified: tragus, C7 spinous process, and a horizontal line at C7. The angle was then assessed[13] *(Fig. 7)*.

Lumbar lordosis and thoracic kyphosis – flexiruler

Thoracic kyphosis and lumbar lordosis angles were assessed using a 60 cm flexiruler. Participants stood comfortably, holding their hands in front to relax the posture. The spinous processes of C7, T12/L1, and L5 were marked. The flexiruler was molded along the spine from C7 to L5 and traced on 80 mm graph paper with marked landmarks.

Thoracic kyphosis was measured between C7–T12 and lumbar lordosis between L1–L5. The angle was calculated using:

Angle (θ) = 4 arctan (2 h/l)

where l = length of the curve and h = height of the curve[15] *(Fig. 8–11)*.

Outcome measures

The primary outcome measure were the McGill torso endurance battery test, the deep neck flexor endurance test, the cervical extensor endurance test, and the scapular endurance test with good to excellent reliability are used to measure the trunk, neck and scapular muscle endurance[16-19] and secondary outcome measures were the cranio-vertebral angle (CVA) measured using APECS App, lumbar lordosis angle and thoracic kyphosis angle using flexiruler which is highly reliable and valid with high reproducibility measurement tool for assessing spinal posture[15].

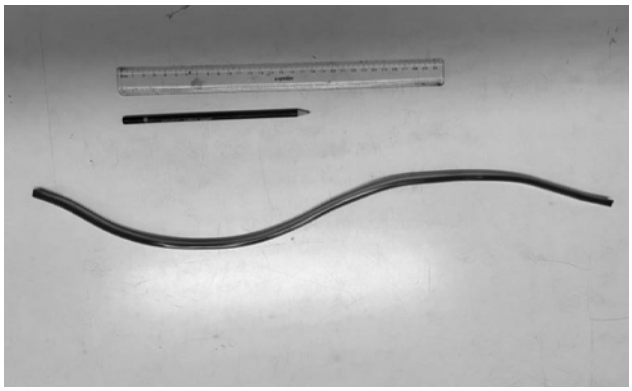


Figure 8. *Materials used for spinal posture assessment.*



Figure 9. *Flexiruler assessment in participants.*

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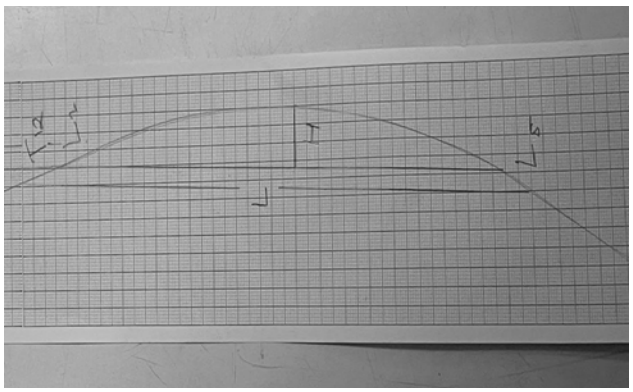


Figure 10. *Flexiruler tracing in graph (lumbar lordosis).*

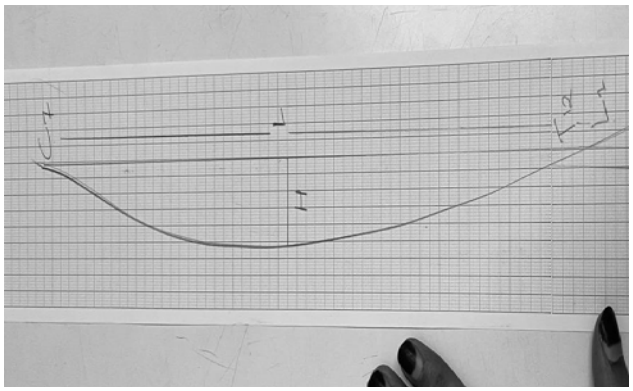


Figure 11. *Flexiruler tracing in graph (thoracic kyphosis).*

Statistical analysis

The sample size for the study was estimated using an independent t-test with G*Power. The anticipated effect size is 0.05, which indicates that the average difference in neck flexor endurance among smartphone-addicted and non-addicted individuals is 50% of the pooled standard deviation. To detect the anticipated difference with 85% power and 5% level of significance, 146 subjects were included in the study, and all statistical analyses were performed using the SPSS Statistics 27 package. Descriptive statistics, including means and standard deviation, were used to summarize the data. The normality of the data was assessed using the Kolmogorov-Smirnov test. In cases of normal distribution, an independent t-test was used, whereas the Mann-Whitney U test was applied in cases of abnormal distribution. Statistically significance was set at $p < 0.05$. Cohen's d was used to determine practical significance between the groups. A Cohen's d of 0.2 is (small effect), 0.5 (moderate effect), and 0.8 or greater (large effect).

RESULTS

A total of 150 participants were recruited, of which four were excluded and then 146 were categorized into two groups based on the smartphone addiction scale-short version. Data from all 146 participants were analyzed. The smartphone addiction group (SAG) had significantly higher SAS-SV scores (mean = 38.96, SD = 5.94) than the smartphone non-addiction group (SNAG) (mean = 23.99, SD = 5.52), confirming effective classification *(Table 2)*. The addiction group also showed a more pronounced positive skew (skewness = 1.09) than the non-addiction group (-0.299), *Figure 12*.

Trunk muscle endurance was significantly lower in the smartphone addiction group for the trunk flexor, trunk extensor, and left lateral flexor endurance tests, whereas no significant difference was observed for the right lateral flexor test ($p = 0.091$). The Trunk Flexor Endurance Test showed significantly lower endurance in the smartphone addiction group (61.45 ± 33.24 sec) than in the smartphone non-addiction group (90.54 ± 62.59 sec), with a moderate to large effect size ($Z = -3.321$, $p < 0.001$, $d = 0.578$). Trunk Extensor Endurance was also significantly reduced in the smartphone addiction group (50.96 ± 27.92 sec) than in the smartphone non-addiction group (74.62 ± 47.95 sec) ($d = 0.601$, $p = 0.002$). Left lateral flexor endurance was significantly lower in the smartphone addiction group (45.87 ± 25.81 sec) than in the smartphone non-addiction group (58.94 ± 33.56 sec) ($p = 0.016$, $d = 0.407$). The right lateral flexor showed no significant difference ($p = 0.091$, $d = 0.318$), although mean endurance was lower in the smartphone addiction group (50.32 ± 29.41 sec) than in the smartphone non-addiction group (59.87 ± 31.26 sec), *Figure 13*.

The Kolmogorov-Smirnov test indicated non-normal distributions for most endurance tests. The Mann-Whitney U test was used, except for the left lateral flexor test where an independent t-test was used.

The neck flexor endurance test results showed a normal distribution ($p = 0.200$), allowing for parametric analysis. No significant difference was found ($t = 0.574$, $p = 0.567$, $d = 0.096$) between the smartphone addiction group (56.27 ±

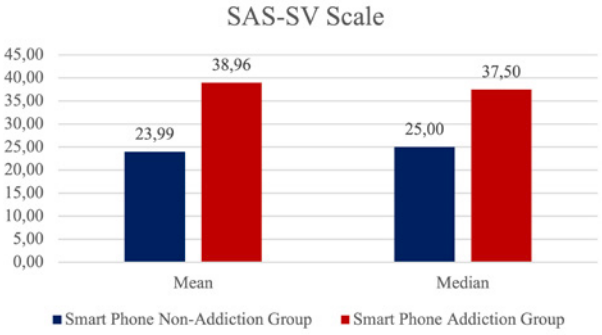


Figure 12. *Distribution of SAS-SV scores in the smartphone addiction (SAG) and non-addiction (SNAG) groups.*

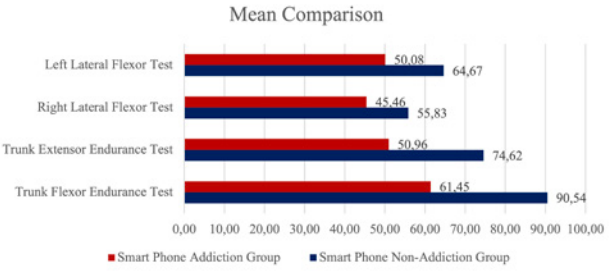


Figure 13. *Mean comparison of trunk muscle endurance between the smartphone addiction and non-addiction group.*

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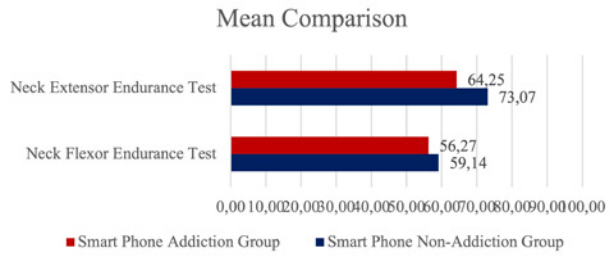


Figure 14. *Mean comparison of neck muscle endurance between the smartphone addiction and non-addiction group.*

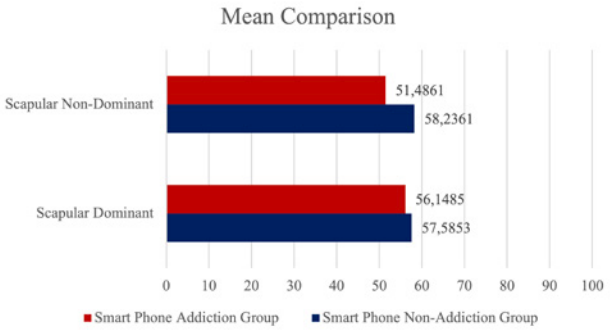


Figure 15. *Mean comparison of scapular muscle endurance between the smartphone addiction and non-addiction group.*

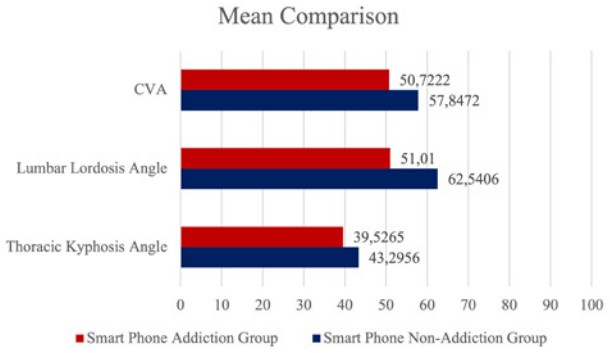


Figure 16. *Mean comparison of spinal posture between the smartphone addiction and non-addiction group.*

31.60 sec) and the smartphone non-addiction group (59.13 ± 28.23 sec). Neck Extensor Endurance and Scapular Endurance Tests were non-normally distributed and Mann-Whitney U tests were used. No significant difference was observed in neck extensor endurance ($Z = -0.743$, $p = 0.457$, $d = 0.198$). Scapular dominant endurance ($Z = -0.476$, $p = 0.634$, $d = 0.043$) and scapular non-dominant endurance ($Z = -1.688$, $p = 0.091$, $d = 0.215$) were similar between the groups, *Figure 14 and 15*.

Thoracic kyphosis and lumbar lordosis angles showed right-skewed distributions and the CVA was symmetric. The Thoracic Kyphosis Angle did not differ significantly between the groups ($t = 1.661$, $p = 0.099$, $d = 0.30$). The lumbar lordosis angle was significantly lower in the smartphone addiction group (51.01 ± 18.77°) than in the smartphone non-addiction group (62.54 ± 20.13°) ($t = 3.554$, $p < 0.001$, $d = 0.592$). CVA was significantly smaller in smartphone addiction group (50.72 ± 5.62°) than smartphone non-addiction group (57.84 ± 5.70°), indicating greater forward head posture ($t = 7.541$, $p < 0.001$, $d = 1.257$). Normality checks supported the use of parametric tests for all spinal posture variables, *Figure 16*.

DISCUSSION

The purpose of this study was to investigate the difference between the neck, scapula, trunk muscle endurance and spinal posture between the smartphone addicted and non-addicted individuals and found that trunk muscle endurance was significantly increased in the non-addicted group than in the addicted group, while neck and scapula muscle endurance descriptively increased in the non-addicted group but not statistically significant. The spinal posture also revealed decreased craniovertebral angle and lumbar lordosis angle in the smartphone addiction group, while thoracic kyphosis did not show any statistically significant difference.

Trunk muscle endurance was significantly higher in the non-addicted group, consistent with the results of Hussin et al.[20], who reported that increased lumbar lordosis and altered activation patterns in the core musculature among addicted users may compromise trunk stability. Prolonged static postures, commonly associated with smartphone use, contribute to muscle fatigue and subsequently reduce endurance over time.

Core stabilizers, such as the transverse abdominis (TrA) and multifidus (MULT), play a critical role in maintaining spinal and pelvic stability, along with the superficial trunk muscles. A previous study found significantly reduced TrA thickness in individuals with sway-back posture compared to those with a neutral lumbopelvic alignment, reinforcing the notion that posture directly influences muscle performance. This phenomenon is linked to both positive and negative outcomes in individuals with low back pain, and endurance assessments are increasingly recognized as predictive indicators of the risk of future low back pain. Moreover, a cohort study on young adults reported reduced TrA thickness compared with MULT, suggesting that prolonged static postures may result in inadequately protected spinal segments. These findings support the observed negative correlation between trunk muscle endurance and lumbopelvic posture[21].

While no statistically significant difference was observed in neck muscle endurance between the addicted and non-addicted groups, mean endurance time was higher in the non-addicted group. This trend corresponds with previous research indicating a negative association between extended smartphone use and endurance of neck extensor muscles. Although not statistically significant in our study, the flexed neck posture commonly adopted during smartphone use can place sustained stress on cervical extensors, predisposing them to fatigue. Further studies with larger sample sizes are required to validate these findings[12].

Scapular muscle endurance also showed no significant group difference; however, the non-addicted group had

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	Smartphone non-addiction group		Smartphone addiction group	
Variable	**K-S**	**p value**	**K-S**	**p value**
Trunk flexor endurance (s)	0.178	<0.001*	0.13	0.004*
Trunk extensor endurance (s)	0.142	0.001*	0.112	0.025*
Right lateral flexor (s)	0.112	0.026*	0.153	<0.001*
Left lateral flexor (s)	0.098	0.081	0.097	0.091
Neck flexor endurance (s)	0.093	0.2	0.093	0.2
Neck extensor endurance (s)	0.124	0.008*	0.144	<0.001*
Scapular dominant endurance (s)	0.1	0.074	0.121	0.011*
Scapular non-dominant endurance (s)	0.09	0.2	0.116	0.018*
Thoracic kyphosis angle (°)	0.104	0.054	0.092	0.2
Lumbar lordosis angle (°)	0.065	0.2	0.1	0.074
Cranio-vertebral angle (°)	0.087	0.2	0.079	0.2

Table 1. *Descriptive statistics of all the variables and testing of normality.*
The normality of each variable is assessed using Kolmogorov-Smirnov test, p <0.05 indicate deviation from normal distribution.
**p <0.05 significant difference; K-S, Kolmogorov-Smirnov statistic value.*

Variable	SAG (mean ± SD)	SNAG (mean ± SD)	Test statistic	p value	Effect size (d)
Trunk flexor endurance	61.45 ± 33.24	90.54 ± 62.59	Z = -3.321	<0.001*	0.578
Trunk extensor endurance	50.96 ± 27.92	74.62 ± 47.95	Z = -3.152	0.002*	0.601
Left lateral flexor endurance	45.87 ± 25.81	58.94 ± 33.56	Z = -2.407	0.016*	0.407
Right lateral flexor endurance	50.32 ± 29.41	59.87 ± 31.26	Z = -1.690	0.091	0.318
Neck flexor endurance	56.27 ± 31.60	59.13 ± 28.23	t = 0.574	0.567	0.096
Neck extensor endurance	64.25 ± 35.74	73.06 ± 51.53	Z = -0.743	0.457	0.198
Scapular dominant endurance	56.14 ± 34.72	57.58 ± 32.38	Z = -0.476	0.634	0.043
Scapular non-dominant endurance	51.48 ± 32.70	58.23 ± 29.99	Z = -1.688	0.091	0.215
Thoracic kyphosis angle	39.52 ± 12.62	43.29 ± 14.53	t = 1.661	0.099	0.300
Lumbar lordosis angle	51.01 ± 18.77	62.54 ± 20.13	t = 3.554	<0.001*	0.592
Cranio-vertebral angle	50.72 ± 5.62	57.84 ± 5.70	t = 7.541	<0.001*	1.257

Table 2. *Between group comparison of all the outcome measures and it's effect size.*
Inferential statistics of all outcome measure using the parametric and non parametric test.
Abbreviations: Z, Z-Mann Whitney U test statistic; t, t-Independent t test statistic; SAG, smartphone addiction group, SNAG, smartphone non-addiction group; SD, standard deviation; p <0.05, significant*

a higher mean endurance time. The scapula is integral to upper-body posture and provides dynamic stability during neck and shoulder movements. Prolonged forward head posture, often adopted by smartphone users, negatively impacts scapulothoracic biomechanics, which may lead to overuse of compensatory muscles, such as the trapezius and rhomboids, exacerbating fatigue. This results in overactivation of the upper trapezius and inhibition of the lower trapezius and serratus anterior, ultimately contributing to muscle imbalance and scapular dyskinesia[22].

A recent study has emphasized the effectiveness of

scapular stabilization exercises in reducing neck pain and restoring normal muscle activation. These exercises decreased upper trapezius activity while promoting the activation of the lower trapezius and serratus anterior muscles. Incorporating abdominal core feedback further enhances scapulothoracic alignment and reduces postural discomfort. This supports the observed reduction in scapular endurance in the addicted group, as altered scapulothoracic alignment is frequently associated with cervical dysfunction and rounded shoulders in habitual smartphone users[23].

The craniovertebral angle was significantly lower in the addiction group than in the non-addicted group, with the mean normal range of 57°. Frequent neck flexion during smartphone use is likely to increase cervical lordosis, and prolonged postural strain contributes to structural adaptation. Several studies confirm a positive relationship between smartphone use and cervical postural abnormalities, reinforcing the significance of our findings[12,24].

The decreased lumbar lordosis observed in the addicted group may reflect a compensatory mechanism to maintain postural balance in response to forward-head posture, adding additional stress on the spinal muscles and passive structures, potentially causing discomfort. Although thoracic kyphosis was also lower in the addiction group, the difference was not statistically significant. Nonetheless, such subtle postural shifts may still contribute to musculoskeletal strain over time[25]. Our findings are consistent with existing research reporting increased lumbar lordosis and thoracic kyphosis angles among frequent smartphone users, supporting postural adaptations associated with smartphone addiction[26].

It has been observed from the study that forward head posture has a linkage to the trunk muscle endurance as the most commonly adopted slumped posture is causing increased activation of neck extensor muscle and decrease activation of the lumbar erector spinae muscle and internal oblique muscle. The extension of the upper cervical region and flexion of the lower cervical region are affecting the pattern for the trunk muscle activation. A study conducted for different head posture influence on trunk has observed that flexed posture in neck can lead to activation of the abdominals. Multifidus activation is increased in neck extension and activation of lumbar erector spinae & external obliques in retracted neck posture. These points are also justified by the other studies which reported that Biering-Sorensen test endurance in children can be increased by adding neck extension component and adding neck flexion in plank increase abdominal endurance. The side bridge test significant improvement in smartphone non-addiction state that the quadratus lumborum, being the major spinal stabilizer have a major influence on smartphone use which in turn can affect the spinal postural control[12].

This study helps establish biomechanical consequences of addiction, informing both ergonomic practices and future interventions. This study contributes by integrating multiple objective physical measures in relation to smartphone addiction, demonstrating patterns that, while partially non-significant, consistently point toward postural and endurance compromise.

This study explores the impact of smartphone addiction on neck and trunk muscle endurance and spinal posture in young adults. Strengths include a clear research question, robust methodology, and practical implications for physiotherapy rehabilitation, awareness and preventive care. However, limitations include a narrow sample (medical students only), cross-sectional design, and lack of control for confounding factors. Future studies should control for confounders such as daily smartphone usage duration (hours/day), physical activity levels, ergonomic habits to strengthen causal inference, broader demographics, longitudinal designs, and objective usage data.

CONCLUSION

It was concluded that smartphone addiction significantly affects spinal posture and muscle endurance, indicating potential long-term musculoskeletal complications due to muscle fatigue and imbalance. Trunk muscle endurance, craniovertebral angle, and lumbar lordosis were significantly altered in the smartphone addiction group, while other variables, though not statistically significant, remain important for postural stability.

Implication on physiotherapy practice

This study investigates the impact of smartphone addiction on trunk and neck muscle endurance and found significant differences in specific muscle groups between addicted and non-addicted individuals, highlighting postural and muscular implications. These findings underscore the need for early preventive strategies, ergonomic education and postural awareness among frequent smartphone users.

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