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Assessment of postural risks in adolescents aged 12-19 during smartphone use

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ABSTRACT

In contemporary times, the use of smartphones has become an essential requirement for daily life in the digital era. The prevalent consequences of smartphone usage include the development of poor posture and behaviors. This study aimed to assess the risk of musculoskeletal disorders (MSD) among smartphone users, focusing on adolescents aged 12 to 19 years. A sample of 82 students (79.3% female and 20.7% male, with an average age of 15.7 ± 2 years and a normal BMI of 76.8%) in the West Lombok district of the West Nusa Tenggara Province in Indonesia was measured. Data collection through simple random sampling involved distributing questionnaires to participants and requesting them to provide responses based on their personal experiences. The present study employs a chi-square analysis to examine the association between smartphone usage, posture behavior, and the highest values of MSD complaints. The findings indicate that the neck (46.3%) and back (45.1%) were the body regions with the most prevalent complaints of MSD. The participants frequently engaged in standing without support and walking as their posture behaviors. There was a significant correlation between the level of neck pain and posture during walking. The use of smartphones among adolescents has an impact on the risk level of experiencing MSD complaints, thereby increasing the potential for illness and abnormalities. Hence, it is necessary to exercise sufficient control over the routine usage of smartphones to mitigate the negative impacts incurred.

1. Introduction

In contemporary times, the use of smartphones has become an essential requirement for daily life in the digital era. Indonesia ranks fourth in terms of active smartphone users worldwide, with China, India, and the United States taking the top three spots [1]. Individuals who use smartphones are distributed among various demographic categories, including but not limited to age, gender, and occupation. Nevertheless, imbalanced and improper usage of smartphones can significantly affect the health of the user. Excessive usage and dependence on smartphones have been found to negatively impact an individual's concentration, personality, social interactions, and physical well-being [2, 3]. The present investigation focused on examining the effects of smartphone usage on the physical well-being of individuals.

The physical health of an individual plays a significant role in enhancing their ability to perform work-related tasks effectively [4, 5]. The prevalent consequences of smartphone usage include the development of poor posture and behaviors. Using a smartphone typically involves maintaining a static posture, which carries a higher level of risk compared to dynamic work. Prolonged maintenance of a single body position results in a disparity between the physical and mental aspects of the body [6]. Using a smartphone in a non-ergonomic posture can result in abnormal cervical function [2]. Prolonged smartphone usage leads to a decrease in the cranio-cervical angle and the cervical-thorax angle, as well as an increase in the degree of forward flexion of the neck [7]. Musculoskeletal disorders (MSD) refer to health issues related to bones, joints, and muscles that arise due to non-ergonomic working postures [6, 8].

The control of body posture is an important indicator in assessing overall body balance. Regarding the usage of smartphones, various factors such as hand and arm positioning in relation to the device, the condition of the neck in relation to screen distance, and even postural considerations during operation while sitting, standing, or walking may come into effect [6, 9, 10]. Utilizing a smartphone in both upright and seated

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postures results in the flexion of the neck and a subsequent lowering of the screen by an angle ranging from 45 to 65 degrees [7]. This positioning places a considerable amount of pressure, approximately 50 to 60 pounds, on the neck region, which can lead to prolonged discomfort and pain [7, 11]. Empirical evidence indicates that the duration of smartphone usage can exceed 5 hours per day, and a positive correlation exists between prolonged usage and an escalation in MSD complaints [12, 13].

Numerous prior research studies have demonstrated that children and adolescents are particularly at risk for MSD [14, 15]. This issue necessitates the need for additional investigation to acquire current and relevant data. This study focuses on the examination of the possible indications of musculoskeletal disorders (MSD) among adolescents residing in Indonesia. Indonesia ranks as the fourth largest global consumer of smartphones [16]. This statement highlights the importance of conducting research on the subject matter, while also providing an understanding of the potential risks associated with the usage of smartphones among adolescents.

2. Material and method

The research sampled both male and female individuals aged 12 to 19. Data distribution was conducted using simple random sampling, with the sample consisting of students from the West Lombok district of the West Nusa Tenggara Province in Indonesia. The study was conducted in March and April 2023.

Respondents needed to meet specific criteria, including owning a personal smartphone, a minimum usage period of 12 months, and no symptoms of stress, dizziness, or uncorrected visual impairment (not corrected by glasses). They should also have no prior surgical intervention for cervical or musculoskeletal abnormalities.

Data collection involved participants who met the specified criteria filling out a questionnaire. Each participant was allocated 5-10 minutes. The questionnaire included demographic data, usage history information, and reports of MSD complaints encountered during smartphone usage. The collected data was analyzed using statistical methods, including descriptive statistics to examine participant attributes and the Chi-square test to detect relationships between outcomes and posture/MSD complaints. The statistical test applied in this study used a significance level of $p < 0.05$.

3. Results and discussions

3.1. Characteristics of respondents

The study's collection consisted of 79.3% female and 20.7% male participants. The study reports that the participants had a mean age of 15.7 ± 2 years, with an age range of 12-19 years. The average body weight was 48.3 ± 9.8 kg, ranging from 30 to 90 kg, and the mean height was 155.1 ± 10 cm, ranging from 125 to 180 cm. The findings indicate that a significant proportion of the subjects exhibited certain traits, such as possessing a normal BMI (76.8%), never smoking (92.7%), refraining from alcohol consumption (97.6%), rarely exercising (81.7%), having never been ill in the last month (79.3%), no history of MSD complaints (100%), sleeping for 4-6 hours per day (40.2%), and experiencing mild levels of stress (51.2%). Table 1 and 2 show the characteristics of respondents.

3.2. Smartphone useage

According to Table 3, most respondents reported using smartphones for one to three years (40.2%). Additionally, they reported a daily usage frequency of three to four hours (37.8%).

Table 1.
Age, weight, and height of respondents

No	Characteristics	Interval	Min-max
1	Age (years old)	15.7±2	12-19
2	Weight (kilograms)	48.3±9.8	30-90
3	Height (centimeters)	155.1±10	125-180

Table 2.
Other characteristics of respondents

No	Characteristics	*N* (%)
1	Gender	
	Male	17 (20.7)
	Female	65 (79.3)
2	Body Mass Index (kg/m^2)	
	Underweight (≤ 18.5)	12 (14.6)
	Normal	63 (76.8)
	Overweight (≥ 25)	7 (8.5)
3	Smoking behaviour	
	Current smoker	4 (4.9)
	Former smoker	2 (2.4)
	Never smoker	76 (92.7)
4	Alcohol drinking behaviour	
	Current drinker	0 (0.0)
	Former drinker	2 (2.4)
	Never drinker	80 (97.6)
5	Exercise behaviour	
	Never	3 (3.7)
	Sometime	67 (81.7)
	Always	12 (14.6)
6	Sick history (per month)	
	Never	65 (79.3)
	Yes	17 (20.7)
7	MSD history	
	No	82 (100.0)
	Yes	0 (0.0)
8	Sleep frequency (hours/day)	
	Less than 3 hours	15 (18.3)
	4-6 hours	33 (40.2)
	7-8 hours	28 (34.1)
	More than 8 hours	6 (7.3)
9	Stress level	
	No stress	26 (31.7)
	Mild stress	42 (51.2)
	Moderate stress	13 (15.9)
	Severe stress	1 (1.2)

Table 3.
Smartphone usage

No	Characteristics	N = 82	Percentage (%)
1	Duration using smartphone (years)		
	less than 3 years	13	15.9
	1-3 years	33	40.2
	4-6 years	27	32.9
	More than 6 years	9	11.0
2	Duration using smartphone (hours/day)		
	Less than 1 hours/day	2	2.4
	1-2 hours/day	16	19.5
	3-4 hours/day	31	37.8
	5-6 hours/day	14	17.1
	More than 6 hours/day	19	23.2
3	Operating time		
	01.00-04.59 WITA	3	3.7
	05.00-10.59 WITA	12	14.6
	11.00-18.59 WITA	40	48.8
	19.00-00.59 WITA	27	32.9
4	Resting frequency (hours/day)		
	less than 3 hours	15	18.3
	4-6 hours	33	40.2
	7-8 hours	28	34.1
	More than 8 hours	6	7.3
5	Objective of usage		
	Entertainment (Video, Comic, Novel)	15	18.3
	Games	10	12.2
	Social Networking (WA, FB, IG)	57	69.5

Table 4.
Posture during smartphone use

No	Characteristics	N = 82	Percentage (%)
1	Data entry method		
	Both hands to hold the device and both fingers to operate the screen	61	74.4
	Right hands to hold the device and left fingers to operate the screen	0	0.0
	Right hands to hold the device and right fingers to operate the screen	15	18.3
	Left hands to hold the device and right fingers to operate the screen	3	3.7
	Left hands to hold the device and left fingers to operate the screen	3	3.7
2	Laying down		
	Never	2	2.4
	Less than 30 minutes	18	22.0
	Between 30-60 minutes	33	40.2
	Between 1-3 hours	18	22.0
	More than 3 hours	11	13.4
3	Operating while standing without support		
	Never	20	24.4
	Less than 30 minutes	45	54.9
	Between 30-60 minutes	13	15.9
	Between 1-3 hours	4	4.9
	More than 3 hours	0	0.0
4	Standing with support		
	Never	21	25.6
	Less than 30 minutes	37	45.1
	Between 30-60 minutes	19	23.2
	Between 1-3 hours	3	3.7
	More than 3 hours	2	2.4
5	Sitting with support		
	Never	12	14.6
	Less than 30 minutes	37	45.1
	Between 30-60 minutes	25	30.5
	Between 1-3 hours	5	6.1
	More than 3 hours	3	3.7
6	Sitting with support		
	Never	3	3.7
	Less than 30 minutes	34	41.5
	Between 30-60 minutes	31	37.8
	Between 1-3 hours	10	12.2
	More than 3 hours	4	4.9

Table 4.
Posture during smartphone use (*continued*)

No	Characteristics	N = 82	Percentage (%)
7	Walking		
	Never	12	14.6
	Less than 30 minutes	38	46.3
	Between 30-60 minutes	16	19.5
	Between 1-3 hours	6	7.3
	More than 3 hours	10	12.2

Table 5.
Correlation between smartphone usage and posture during smartphone use and MSD complaints

Variables	MSD Complaints					
	Neck			Back		
	Pearson χ^2	*df*	*p*-value	Pearson χ^2	*df*	*p*-value
Usage of smartphone						
Duration using smartphone (years)	1.240	2	0.538	2.031	2	0.362
Duration using smartphone (hours/day)	6.351	4	0.174	1.858	4	0.762
Operating time	1.383	3	0.710	1.400	3	0.705
Resting time	4.166	3	0.244	2.971	3	0.396
Objective of usage	1.795	2	0.408	0.551	2	0.759
Posture behavior						
Standing without support	5.715	3	0.126	2.319	3	0.509
Walking	8.753	3	0.033	1.347	3	0.718

The utilization of time typically occurs during the midday to afternoon period, specifically between 11:00 and 18:59 WITA (48.8%). This timeframe is commonly reserved for relaxation activities following a day of academic responsibility. Social networks such as WhatsApp, Facebook, and Instagram are the most frequently used applications, accounting for 69.5% of usage.

3.3. Posture during smartphone use

Table 4 shows posture during smartphone use. The dominant hand and finger posture observed during smartphone use involves the utilization of both hands to hold the device and both fingers to operate the screen (74.4%). The findings indicate that most participants engaged in standing postures for less than 30 minutes, with a preference for unsupported standing (54.9%) and walking (46.3%). Standing with support (45.1%) and sitting with support (45.1%) are also commonly assumed postures.

3.4. Potential for MSD when using a smartphone

The analysis revealed that most MSD complaints during smartphone use were concentrated on the neck area (46.3%) and back (45.1%). The less frequently affected body parts include the buttocks (28.0%), shoulders (28.0%), hands (24.4%), legs (24.4%), arms (20.7%), thighs (14.6%), and knees (12.2%).

3.5. Discussions

The present investigation reports that 46.3% of the participants included in the study reported MSD in the cervical region. This finding is consistent with previous research, where the prevalence of MSD in the neck ranged from 46% to 48% [13, 17]. According to another study, the incidence of MSD related to excessive smartphone use in the neck region was reported to be between 86% and 90% [4, 9, 18]. Sarraf and Varmazyar classified the pain levels experienced as moderate and severe [19]. MSD complaints arise due to the forward and downward bending of the neck or flexion towards the smartphone screen. Prolonged exposure to such postures can significantly increase the likelihood of experiencing pain and bodily abnormalities [7, 13, 20].

The study's findings indicate a statistically significant association between MSD complaints in the neck region and the posture adopted while using a smartphone while walking. Posture is a significant factor contributing to the level of MSD experienced by individuals [2, 14, 21]. When assuming a standing position, an angle of neck flexion measuring 27.50°±14.05° is generated, which subsequently rises to 32.03°±10.03° during walking. This observation suggests that the neck is subjected to greater pressure depending on the type of physical activity being performed [11].

Participants reported the second highest prevalence of MSD complaints in the back region, accounting for 45.1% of the total, with another study reporting a range of 63%-67% [17, 22]. Excessive smartphone use has been found to impact MSD complaints, specifically in the upper and lower back regions [23, 24]. The incidence of back pain complaints appears to be influenced by poor user habits during smartphone usage, which can result in compromised posture [17, 22]. The duration of usage seems to have a minimal effect on the increased discomfort experienced in the lumbar region [25].

Research conducted by Kurniawati & Murti elucidates that prolonged smartphone use, specifically for a duration of ≥6 hours/day, is significantly associated with an increase in back pain [26].

According to the results presented in Table 5, the analysis of the interrelationship between the variables revealed that only the walking posture exhibited a statistically significant association with MSD grievances in the neck area (0.033 ≤ 0.05). The statistical significance of the variable's relationship is indicated by the p-value being less than or equal to 0.05. Numerous studies have reported neck complaints among smartphone users, which may be attributed to factors such as poor neck posture, cervical position, spine abnormality, and craniovertebral angle [2, 7]. Other variables, including neck-standing without support, have a *p*-value greater than or equal to 0.05, indicating the absence of a statistically significant relationship. Therefore, additional investigation is required for these variables to enhance the comprehensiveness of the findings. Future research should consider various factors such as age, posture variation, and the specific focus region of MSD complaints.

4. Conclusions

Based on the results of various articles on the VSM method, it is found to be effective in identifying each production flow layout and information flow needed by the production process. Among the 42 national and international papers we reviewed spanning from 2017 to 2022, VSM was found to be particularly effective in the manufacturing industry. The VSM method has been applied in several sectors such as automotive, garment, handicraft, and other industries. Therefore, VSM is influential in the world of the manufacturing industry, as it can improve efficiency in companies by increasing production yields, identifying production flow issues or errors, improving quality, and reducing time wastage.

Declaration statement

Fikrihadi Kurnia: **Conceptualization, Methodology, Supervision, Project administration, Writing - Original Draft**. Anak Agung Alit Triadi: **Statistical Analysis, Writing - Review & Editing**. I Made Suartika: **Resources, Validation, Formal analysis**. Made Wijana: **Resources, Visualization, Investigation**. Maharsa Pradityatama: **Data curation, Validation**.

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The authors report there are no competing interests to declare.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, [FK], upon reasonable request.

References

[1] J. Howarth, "How many people own smartphones (2023-2028)." Accessed: Mar. 27, 2023. [Online]. Available: https://explodingtopics.com/blog/smartphone-stats.

[2] A. Alonazi, N. Daher, A. Alismail, R. Nelson, W. Almutairi, and G. Bains, "The effects of smartphone addiction on children's cervical posture and range of motion," *Int. J. Physiother.*, vol. 6, no. 2, 2019, doi: 10.15621/ijphy/2019/v6i2/181910.

[3] M. O. Pratama, D. Harinitha, S. Indriani, B. Denov, and D. Mahayana, "Influence factors of social media and gadget addiction of adolescent in Indonesia," *J. Sist. Inf.*, vol. 16, no. 1, pp. 16–24, Apr. 2020, doi: 10.21609/jsi.v16i1.918.

[4] S. Namwongsa, R. Puntumetakul, M. S. Neubert, S. Chaiklieng, and R. Boucaut, "Ergonomic risk assessment of smartphone users using the Rapid Upper Limb Assessment (RULA) tool," *PLoS One*, vol. 13, no. 8, pp. 1–16, 2018, doi: 10.1371/journal.pone.0203394.

[5] M. Betsch *et al.*, "The influence of smartphone use on spinal posture – A laboratory study," *Gait Posture*, vol. 85, pp. 298–303, Mar. 2021, doi: 10.1016/j.gaitpost.2021.02.018.

[6] J. Jasik-Ślęzak and N. Baryshnikova, "The effect of static physical work on work safety," *Syst. Saf. Hum. - Tech. Facil. - Environ.*, vol. 2, no. 1, pp. 47–54, Mar. 2020, doi: 10.2478/czoto-2020-0007.

[7] R. Ojha, B. Sindhu, and S. Sen, "Effects of smartphone addiction on sitting neck posture & hand discomfort," *Int. J. Health Sci. (Qassim).*, vol. 6, no. March, pp. 13642–13650, 2022, doi: 10.53730/ijhs.v6ns2.8595.

[8] E. Timurtaş, E. E. Avcı, K. Mate, N. Karabacak, M. G. Polat, and İ. Demirbüken, "A mobile application tool for standing posture analysis: development, validity, and reliability," *Ir. J. Med. Sci.*, vol. 191, no. 5, pp. 2123–2131, 2022, doi: 10.1007/s11845-021-02827-5.

[9] B. P. Hasiholan and I. H. Susilowati, "Posture and musculoskeletal implications for students using mobile phones because of learning at home policy," *Digit. Heal.*, vol. 8, p. 205520762211063, Jan. 2022, doi: 10.1177/20552076221106345.

[10] J. Mongkonkansai, U. Madardam, and S. Veerasakul, "Smartphone Usage Posture (Sitting and Lying Down) and Musculoskeletal Symptoms among school-aged children (6-12 years old) in Nakhon Si Thammarat, Thailand," *Walailak Univ.*, pp. 1–18, 2020.

[11] J. Fercho *et al.*, "Kinematic analysis of the forward head posture associated with smartphone use," *Symmetry (Basel).*, vol. 15, no. 3, p. 667, Mar. 2023, doi: 10.3390/sym15030667.

[12] L. Bertozzi *et al.*, "Posture and time spent using a smartphone are not correlated with neck pain and disability in young adults: A cross-sectional study," *J. Bodyw. Mov. Ther.*, vol. 26, pp. 220–226, Apr. 2021, doi: 10.1016/j.jbmt.2020.09.006.

[13] M. S. Sirajudeen *et al.*, "Prevalence of text neck posture, smartphone addiction, and its association with neck disorders among university students in the Kingdom of Saudi Arabia during the COVID-19 pandemic," *PeerJ*, vol. 10, p. e14443, Dec. 2022, doi: 10.7717/peerj.14443.

[14] S. M. H. Tsang, G. L. Y. Cheing, and J. W. K. Chan, "Severity of slouched posture during smartphone use is associated with the musculoskeletal discomfort, daily usage, and school year among adolescents," *Ergonomics*, pp. 1–14, Nov. 2022, doi: 10.1080/00140139.2022.2146208.

[15] D. David, C. Giannini, F. Chiarelli, and A. Mohn, "Text neck syndrome in children and adolescents," *Int. J. Environ. Res. Public Health*, vol. 18, no. 4, p. 1565, Feb. 2021, doi: 10.3390/ijerph18041565.

[16] S. Sadya, "Pengguna smartphone indonesia terbesar keempat dunia pada 2022." Accessed: Mar. 14, 2023. [Online]. Available: https://dataindonesia.id/digital/detail/pengguna-smartphone-indonesia-terbesar-keempat-dunia-pada-2022

[17] C. O. Adesola *et al.*, "Musculoskeletal pain and postural abnormalities among smartphone-using digital natives," *J. Musculoskelet. Disord. Treat.*, vol. 6, no. 3, pp. 1–12, Dec. 2020, doi: 10.23937/2572-3243.1510089.

[18] I. H. Susilowati, L. M. Kurniawidjaja, S. Nugraha, S. M. Nasri, I. Pujiriani, and B. P. Hasiholan, "The prevalence of bad posture and musculoskeletal symptoms originating from the use of gadgets as an impact of the work from home program of the university community," *Heliyon*, vol. 8, no. 10, p. e11059, 2022, doi: 10.1016/j.heliyon.2022.e11059.

[19] F. Sarraf and S. Varmazyar, "Comparing the effect of the posture of using smartphones on head and neck angles among college students," *Ergonomics*, vol. 65, no. 12, pp. 1631–1638, Dec. 2022, doi: 10.1080/00140139.2022.2047229.

[20] F. Al-Hadidi *et al.*, "Association between mobile phone use and neck pain in university students: A cross-sectional study using numeric rating scale for evaluation of neck pain," *PLoS One*, vol. 14, no. 5, p. e0217231, May 2019, doi: 10.1371/journal.pone.0217231.

[21] S. Ayhualem, A. Alamer, S. D. Dabi, K. G. Bogale, A. B. Abebe, and M. B. Chala, "Burden of neck pain and associated factors among smart phone user students in University of Gondar, Ethiopia," *PLoS One*, vol. 16, no. 9, p. e0256794, Sep. 2021, doi: 10.1371/journal.pone.0256794.

[22] B. N. da Rosa *et al.*, "Back pain and body posture evaluation instrument for children and adolescents (BackPEI-CA): Expansion, content validation, and reliability," *Int. J. Environ. Res. Public Health*, vol. 19, no. 3, 2022, doi: 10.3390/ijerph19031398.

[23] A. Alsalameh, M. Harisi, M. Alduayji, A. Almutham, and F. Mahmood, "Evaluating the relationship between smartphone addiction/overuse and musculoskeletal pain among medical students at Qassim University," *J. Fam. Med. Prim. Care*, vol. 8, no. 9, p. 2953, 2019, doi: 10.4103/jfmpc.jfmpc_665_19.

[24] E. Kaur, P. Delir Haghighi, F. M. Cicuttini, and D. M. Urquhart, "Smartphone-Based Ecological Momentary Assessment for Collecting Pain and Function Data for Those with Low Back Pain," *Sensors*, vol. 22, no. 18, p. 7095, Sep. 2022, doi: 10.3390/s22187095.

[25] R. Mustafaoglu, Z. Yasaci, E. Zirek, M. D. Griffiths, and A. R. Ozdincler, "The relationship between smartphone addiction and musculoskeletal pain prevalence among young population: a cross-sectional study," *Korean J. Pain*, vol. 34, no. 1, pp. 72–81, Jan. 2021, doi: 10.3344/kjp.2021.34.1.72.

[26] Y. Kurniawati and B. Murti, "Meta-Analysis: The effect of smartphone use on the incidence of low back pain in adolescents," in *Developing a Global Pandemic Exit Strategy and Framework for Global Health Security*, Masters Program in Public Health, Universitas Sebelas Maret, 2021, pp. 48, doi: 10.26911/AB.Epidemiology.ICPH.08.2021.28.