Evaluation of cervical posture and smartphone use in young adults

Avaliação da postura cervical e do uso de smartphone em adultos jovens

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Abstract

Introduction: The smartphone, a popular mobile device, has become attractive because it is easy to use and due to it multifunctionality. Its prolonged use, with anterior flexion of the neck and repetitive movements of the upper limbs, contributes to musculoskeletal symptoms. **Objective:** To evaluate changes in cervical posture due to smartphone use in adults, as well as verify the association of posture with health-related factors. **Methods:** Cross-sectional study, carried out at two universities in Fortaleza, Ceará, Brasil, between 2018 and 2019. A total of 769 adults (>18 years old) who routinely used smartphones participated. Data on socioeconomic variables, health conditions and smartphone use were collected. The cervical postural alignment was assessed, with the vertical head alignment (VHA) being measured using photogrammetry, in the anatomical position (baseline) and while typing on the smartphone. **Results:** The mean age was 23 years (± 6.7), with a higher proportion of females (72.1%; n = 559) and an average of 7.9h (± 4.4) using the device. Smartphone use led to the forward head movement related to males ($p < 0.05$ by ΔVHA), time spent using the device ($p < 0.05$ by ΔVHA), functional disability in the cervical region ($p < 0.05$ by ΔVHA) and not sleeping well ($p = 0.019$ by ΔVHA on the R side). **Conclusion:** Using a smartphone in the typing position causes the head to tilt forward, being related to longer usage time, male gender, cervical region dysfunction and sleep.

Keywords: Cervical. Posture. Risk factors. Smartphone.

Resumo

Introdução: *O smartphone, dispositivo móvel e popular, tornou-se atrativo pela facilidade de utilização e multifuncionalidade. Seu uso prolongado, com flexão anterior do pescoço e movimentos repetitivos dos membros superiores, contribui para sintomas musculoesqueléticos.* ***Objetivo:*** *Avaliar as alterações da postura cervical pelo uso do smartphone em adultos, bem como verificar a associação da postura com fatores relacionados à saúde.* **Métodos:** *Estudo transversal, em duas universidades em Fortaleza, Ceará, Brasil, entre 2018 e 2019. Participaram 769 adultos (>18 anos) que usavam rotineiramente o smartphone. Foram coletadas variáveis socioeconômicas, condições de saúde e uso do smartphone. Realizou-se a avaliação do alinhamento postural da cervical, sendo mensurado o alinhamento vertical da cabeça (AVC) pela fotogrametria, na posição anatômica (*baseline*) e digitando no smartphone.* ***Resultados:*** *A idade média foi de 23 anos (± 6,7), com maior proporção do sexo feminino (72,1 %; n = 559) e média de 7,9h (± 4,4) utilizando o dispositivo. O uso do smartphone gerou anteriorização de cabeça relacionada ao sexo masculino (p < 0,05 pelo ΔAVC), tempo de uso do dispositivo (p < 0,05 pela ΔAVC), incapacidade funcional na região cervical (p < 0,05 pela ΔAVC) e não dormir bem (p = 0,019 pela ΔAVC lado D).* ***Conclusão:*** *O uso do smartphone na posição de digitação causa anteriorização de cabeça, estando relacionado ao maior tempo de uso, ao sexo masculino, à disfunção da região cervical e ao sono.*

Palavra-chave: *Cervical. Postura. Fatores de risco. Smartphone.*

Introduction

The smartphone is a mobile and popular technological device, which over the years has become increasingly attractive because it is easy to use and due to its multifunctionality, resulting in longer usage time and greater dependence on the device.[1] There are more than five billion users of mobile phones worldwide and more than four billion internet users. In Brazil, 94% of the population owns a smartphone, with a density of 108 devices per 100 inhabitants. In the world ranking, the country occupies third place in time spent on the internet, around 9 hours a day, and fifth place in time spent on smartphones, where users spend more than 4 hours a day sending text messages, emails and using social networks.[2]

Thus, the need to connect and communicate with other people contributes to excessive or dependent use of smartphones, which despite not being considered a disease, causes harmful effects on the users' health, resulting in social, behavioral, mental and physical changes,[3] with the emergence of musculoskeletal disorders. It is considered one of the biggest addictions of the century regardless of the age group, affecting the work environment and interpersonal relationships.[2]

The relationship between non-traumatic musculoskeletal dysfunction in the cervical region and excessive smartphone use has been widely investigated.[4-6] The use of this mobile device generally requires anterior flexion of the neck, which, associated with the maintenance of this posture for a prolonged period of time and repeated movements of the upper limbs has contributed to the incidence of musculoskeletal disorders,[4] such as decreased range of motion in the cervical region, muscle fatigue, reduced local circulation, muscle activation,[5] pain and discomfort.[6]

In this context, it is understood that it is essential to identify the biomechanical risk factors for neck discomfort resulting from smartphone use. Therefore, the present study aimed to evaluate changes in cervical posture due to smartphone use in adults, as well as verify the association of posture with health-related factors, through a hierarchical model, providing support for increasing the discussion on this topic regarding the factors related to this outcome.

Methods

This is a cross-sectional study, originating from a research section entitled "Study of the relationship between myoarticular dysfunction in the cervical region and the use of mobile devices in different age groups", carried out at two universities (private and public) in the city of Fortaleza, state of Ceará, Brazil. The recruitment of participants and data collection took place in 2018 and 2019 in three distinct collection periods.

Study population

The study included 769 adults, aged between 18 and 59 years, who were university students and employees at both universities, regardless of socioeconomic characteristics and who routinely used smartphones.

Additionally, 52 participants were removed due to not completing all the questionnaires or not having postural alignment assessed using photogrammetry. The exclusion criteria adopted were diagnoses of discopathies, fractures or degenerative injuries in the cervical spine, fibromyalgia and head/neck surgeries self-reported at recruitment, due to the influence of these dysfunctions on the functionality of the cervical region. Pregnant women and physically disabled people were excluded due to the non-adaptability of the data collection instruments used in the research.

A total of 227 participants were estimated for each period of collection, using as parameters a finite population (n = 1,436,575) according to the age pyramid of Fortaleza, prevalence of 18% of neck pain in users of mobile devices,[7] accuracy of 5% and 95% confidence interval.

The participants were recruited by public call and by direct invitation during breaks in undergraduate courses at both institutions. This study was approved by the Research Ethics Committees of the University of Fortaleza, under opinion number 2,144,930, and the Federal University of Ceará, under opinion number 2,266,752. All participants authorized their inclusion in the study by signing the free and informed consent form.

Collection procedures and variables

Three self-administered instruments were used. The first questionnaire investigated the socioeconomic profile (age, sex, marital status, remunerated activity and social class), health conditions (sleep, complaints of neck pain, physical activity and functional disability in the cervical region), smartphone usage time (hours/day) and device brand (to check device weight).

To assess physical activity, the short version of the International Physical Activity Questionnaire (IPAQ) was used. This instrument has eight questions to estimate the time spent weekly and the intensity of physical activity at different times: work, transport, domestic activities and leisure.[8] In this study, physical activity was categorized into: active (very active, active and insufficiently active) and not active to classify the practice of physical activity.

The Neck Disability Index (NDI-BR), adapted and validated for Portuguese,[9] assesses functional disability in the cervical region using 10 items, with each item consisting of six response options, with a score ranging from zero to five. The instrument total score was obtained by adding the scores of all items. In this study, a dichotomous classification was used: absence (≤ 4 points) and presence of functional disability in the cervical region (> 4 points).[10]

Subsequently, the participants underwent assessment of the postural alignment of the cervical region using photogrammetry, in two positions: anatomical, considered as baseline, and the position while typing on the smartphone, holding the device with both hands. The photos were recorded using a digital camera (Canon EOS Rebel T3) positioned on a tripod (Canon Nikon Sony) three meters away and at a height of approximately half the participant's height. Markers (20 mm diameter Styrofoam balls) were used at nine anatomical points: glabella, mental process, manubrium, right (R) and left (L) tragus, acromion (R and L) and spinous processes of C7 and T1 vertebrae. The participants were instructed to remain in the standing position, with their eyes open, in the abovementioned positions, and the photographic record was taken in the R and L anterior and lateral views.[11]

To evaluate postural alignment, the angle was generated by the Postural Analysis Software (SAPO) in the lateral view: vertical head alignment (VHA), which identifies the forward head position (the greater the angle value). Bilateral photogrammetry was necessary due to possible angular changes resulting from upper limb dominance.[6]

Statistical analysis

Two outcomes were adopted: postural alignment, measured from three angles and evaluated in two positions (typing on the smartphone and baseline), and changes in postural alignment caused by the use of the smartphone, represented by the difference between the position while typing and the anatomical position (Δ = typing position - anatomical).

The related factors were divided into three hierarchical levels: proximal (sociodemographic variables); intermediate 1 (time of use and device weight) and 2 (complaint of neck pain and functional disability in the cervical region); and distal (health conditions).

Univariate analyses were applied to each outcome, using the SPSS Statistics software, version 23.0. For the first, the difference between the angles obtained when typing on the smartphone was evaluated in comparison to the anatomical position (baseline) by applying the t test.

For the second, t-tests and ANOVA were applied to verify the differences between changes in postural alignments caused by smartphone use and the sociodemographic variables, health conditions and physical activity. To analyze the correlation between the outcome and the variables age, hours of sleep, smartphone usage time, device weight and functional disability in the cervical region, Pearson's correlation test was applied. The parametric tests applied were in accordance with the Kolmogorov-Smirnov normality test.

Next, the hierarchical multiple linear regression was applied to each change in postural alignment caused by smartphone use, initially selecting analyses with $p < 0.20$ at each level (proximal, intermediate and distal). For the final model, only variables with a significance of 5% remained in the model and adjusted coefficients (β) were calculated. The criteria of absence of multicollinearity and homoscedasticity were also analyzed.

Results

Regarding the socioeconomic profile of the participants, the mean age was 23.5 years, with a higher proportion of females (72.1%) and no remunerated work (69.3%). Regarding health conditions, 23.1% did not sleep well, 52% practiced physical activity, 60.8% complained of neck pain and 62.7% had functional disability in the cervical region. Furthermore, the mean duration of smartphone use per day was 7.9 hours (± 4.4) (Table 1).

Regarding the outcome of changes in postural alignment, there was an increase in head forward due to VHA ($p = 0.000$, R and L sides) in the position typing on the smartphone compared to the anatomical position (Table 2).

In the univariate analysis of changes in postural alignment caused by smartphone use in the anterior view, it was observed that the increase in head anteriorization associated with smartphone use was more related to males ($p < 0.05$ by ΔVHA on the R and L sides) and not sleeping well ($p < 0.005$ by ΔVHA on the R and L sides) (Table 3). It was also found that increased head position anteriorization was associated with fewer hours of sleep ($p < 0.05$ by ΔVHA R and EL side), greater functional disability in the cervical region ($p < 0.05$ by ΔVHA R side) and longer smartphone usage time ($p < 0.05$ by ΔVHA R and L sides) (Table 4).

Table 1 - Distribution of the socioeconomic profile, health conditions and smartphone use among adults (Fortaleza, CE, Brazil, 2018-2019)

Variables	n = 769
Socioeconomic profile	
Age (years)*	23.5 ± 6.7 (18 - 59)
Female sex	559 (72.1)
Marital status	
Single	668 (86.2)
Married	94 (12.1)
Divorced/Separate	11 (1.4)
Widowed	2 (0.3)
Remunerated activity (no)	537 (69.3)
Social class	
E/D/C	570 (73.7)
B/A	204 (26.3)
Health conditions	
Hours of sleep*	6.5 ± 1.2 (4 - 11)
Sleeps well (no)	179 (23.1)
Complaints of cervical pain (yes)	471 (60.8)
Physical activity practice (yes)	403 (52.0)
Functional disability in the cervical region*	486 (62.7) 6.4 ± 4.2 (0 - 29)
Smartphone use	
Time of usage (hours/day)*	7.9 ± 4.4 (1 - 20)
Device weight (g)*	151.7 ± 22.4 (96 - 210)

Note: *Data expressed as mean ± standard deviation (minimum - maximum); for the other variables: n (%).

Table 2 - Analysis of postural alignment of the cervical region using the Postural Analysis Software (SAPO) while using a smartphone in adults (Fortaleza, CE, Brazil, 2018-2019)

VHA (in degrees)	Position*		p-value
	Anatomic	Typing at the smartphone	
Right	17.2 ± 8.9	39.0 ± 12.2	0.000
Left	18.2 ± 8.2	39.9 ± 11.9	0.000

Note: VHA = vertical head alignment (higher values represent greater head anteriorization). *Data expressed as mean ± standard deviation.

Table 3 - Analysis of the relationship between changes in postural alignment (mean ± SD) caused by smartphone use and sociodemographic variables and health conditions in adults (Fortaleza, CE, Brazil, 2018-2019)

Variables	Right ΔVHA	p-value	Left ΔVHA	p-value
Sex				
Male	25.8 ± 10.7	0.000*	26.3 ± 10.5	0.000*
Female	20.0 ± 9.2		20.0 ± 9.3	
Remunerated activity				
No	22.2 ± 9.9	0.097	22.0 ± 10.2	0.283
Yes	20.9 ± 10.1		21.1 ± 9.7	
Sleeps well				
No	24.1 ± 9.9	0.001*	23.2 ± 9.5	0.031*
Yes	21.2 ± 9.9		21.3 ± 10.2	
Physical activity practice				
No	21.2 ± 9.6	0.112	21.4 ± 9.6	0.452
Yes	22.4 ± 10.3		22.0 ± 10.5	
Complaint of cervical pain				
No	21.3 ± 9.9	0.216	21.2 ± 10.1	0.223
Yes	22.2 ± 10.0		22.1 ± 10.1	

Note: SD = standard deviation; VHA = vertical head alignment (higher values represent greater head anteriorization). Δ represents the differences between the typing position on the smartphone and the anatomical position (baseline) for each variable analyzed in the table. *p < 0.05 by t test.

Table 4 - Correlation between changes in postural alignment caused by smartphone use and the variables age, hours of sleep, cervical functional disability and smartphone use in adults (Fortaleza, CE, Brazil, 2018-2019)

Variables	Right ΔVHA		Left ΔVHA	
	r	p-value	r	p-value
Age (years)	-0.063	0.083	-0.042	0.243
Hours of sleep	-0.086	0.017*	-0.082	0.023*
FD in cervical region	0.088	0.015*	0.059	0.100[a]
TSU (hours/day)	0.117	0.001*	0.110	0.002*
Device weight (g)	-0.028	0.432	-0.069	0.057

Note: FD = functional disability; TSU = time of smartphone use; VHA = vertical head alignment. Δ represents the differences between the positions typing on the smartphone and anatomical (baseline) for each variable analyzed in the table. r = Pearson's correlation and *p < 0.05.

In the multivariate analysis, it was evident that head anteriorization caused by smartphone use remained related to male sex (p < 0.05), time of use of the device (p < 0.05), functional disability in the cervical region (p < 0.05) and not sleeping well (p = 0.019 by ΔVHA on the R side) (Table 5).

Discussion

The present study focused on an emerging topic in the epidemiological area that investigates smartphone addiction and the possible musculoskeletal effects on the cervical spine and upper limbs. Previous studies highlighted that excessive smartphone use is a risk factor for dysfunction in the cervical region and unhealthy behaviors.[12,13] However, few studies have analyzed postural changes during its use and related factors through a hierarchical model.[14]

Unlike this model, traditional multiple regression analyses with only one hierarchical level may not be the most adequate for situations in which there are mediating variables, as in the case of studies involving risk factors for postural changes. The hierarchical model constitutes a strategy for managing many conceptually related variables existing in epidemiological studies.[1]

Table 5 - Multivariate analysis of the relationship between changes in postural alignment caused by smartphone use using a hierarchical model in adults (Fortaleza, CE, Brazil, 2018-2019)

Variables	r^2	β	p-value	95%CI
ΔVHA right side	0.105	-	-	-
Proximal level				
Sex (male)		-5.953	0.000*	-7.516 - -4.389
Intermediate level				
Time of smartphone usage	-	0.239	0.003*	0.079 - 0.399
Functional disability in the cervical region	-	0.210	0.020*	0.033 - 0.389
Distal level				
Sleeps well (no)	-	2.138	0.019*	0.346 - 3.931
ΔVHA left side	0.110	-	-	-
Proximal level				
Sex (male)	-	-6.691	0.000*	-8.241 - -5.140
Intermediate level				
Time of smartphone usage	-	0.246	0.002*	0.086 - 0.399
Functional disability in the cervical region	-	0.198	0.029*	0.020 - 0.376

Note: VHA = vertical head alignment; Δ represents the differences between the typing position on the smartphone and the anatomical position (baseline) for each variable analyzed in the table. r^2 = coefficient of multiple determination; β = adjusted coefficient; 95% CI = 95% confidence interval and *$p < 0.05$ for the linear regression model variables.

Regarding the postural changes evaluated in this study, using a smartphone with both hands and in the standing position caused cervical anteriorization, showing a variation of around 20°. This position is frequently adopted by the population in everyday situations, such as waiting in lines, on public transportation and when walking.[4] The position adopted with the flexed head is also called "text neck", alluding to the sending of messages, and is considered a risk factor for cervical dysfunction and increased by frequency and time of use.[15,16]

Findings in the literature have highlighted cervical anteriorization, such as a survey carried out in Libya with young adults that found an increase in the neck flexion angle within a few minutes of use and in different positions (standing up, sitting down and sitting with support for the arms).[17] Complementing these findings, research carried out in Thailand with young adults showed, through body sensors and videos, an increase of more than 20° in cervical flexion during the smartphone use, showing the ergonomic risks of using this device and its relationship with musculoskeletal disorders in the neck, trunk and leg regions.[18]

In the multivariate analysis in the hierarchical model, the head anteriorization caused by smartphone use indicated a relationship with the male sex, time of use of this device, functional disability in the cervical region and not sleeping well. Regarding the relationship with males, studies in Africa[17] and Asia[19] found similar results, reinforcing a greater neck flexion angle when compared to females. These results can be explained by differences in height and adoption of an upright posture between the sexes;[19] however, the need for further investigation is emphasized in order to elucidate the role of sex in head and neck posture.

Regarding the influence of time of use on cervical anteriorization, a previous study with South Korean university students revealed that use for more than four hours would cause an increase in cervical anteriorization and shoulder protrusion compared to a shorter period of use.[20] Another study with Brazilian university students found that use equal to or greater than 4-5 hours would cause musculoskeletal symptoms such as pain, tingling and paresthesia.[21] The authors also found a relationship between greater cervical flexion and complaints of pain, through questionnaires.[21]

Moreover, when evaluating posture through video monitoring during smartphone use with both hands and in a sitting position, a study with Arab university students confirmed an increase in cervical flexion after 20 minutes using the device and, also, a relationship with complaints of pain in the neck, shoulder and hands.[22] The cervical flexion posture adopted when using a smartphone and excessive time of use are the causes of the early onset of spondylosis and disc degeneration in young people, according to the results of a Chinese study with over two thousand volunteers who underwent magnetic resonance examinations.[23]

Regarding the relationship between cervical anteriorization due to smartphone use and not sleeping well found in the present study, there is still a gap to be clarified. However, there is extensive evidence in the literature on the association between excessive smartphone use and negative effects on sleep quality. A study of university students in India revealed high smartphone dependence associated with poor sleep quality, highlighting the importance of early screening for health maintenance.[24] A study with young university students in Turkey elucidates that excessive smartphone use is related to daytime drowsiness, partly linked to a reduction in hours of sleep/rest.[25] This poor quality of sleep can affect mental health, which makes it a public health problem relevant for technologically advanced societies.[25]

Based on the observed results, it is believed that this study can provide useful knowledge for health professionals who treat people with neck pain and who use smartphones, especially adults. Furthermore, educational interventions that address factors related to postural changes and smartphone use should be implemented by health professionals and the media, aiming to reduce impacts on the physical and mental health of the population. According to a study carried out in Asia, these negative impacts create an overload on the health system, due to the increase in the number of medical visits to emergency departments and outpatient clinics.[26]

Some limitations are recognized in the present study, such as the predominance of young adults, impacting the generalization of results to other age groups, and the non-application of a specific instrument to assess the time spent using a smartphone in this population, which could either over- or underestimate its usage time when questioned during data collection. Another limitation involves the failure to assess the posture of the cervical region when using a smartphone in different positions, such as sitting and using only one hand. It is believed, however, that this study will contribute to the discussion of this topic.

Conclusion

Using a smartphone in the typing position causes head anteriorization and is related to longer use of this device, male sex, cervical region dysfunction and sleep.

Authors' contributions

APVA, LKSMR, NKFDM, NRMS, and DGBM were responsible for the study conception and planning, collection, analysis and interpretation of data. All authors participated in the preparation, drafting and review of the manuscript and approved the final version.

References

1. Alsalameh AM, Harisi MJ, Alduayji MA, Almutham AA, Mahmood FM. Evaluating the relationship between smartphone addiction/overuse and musculoskeletal pain among medical students at Qassim University. J Family Med Prim Care. 2019;8(9):2953-9. DOI

2. We Are Social. Special Report - Digital 2020 US: Your ultimate guide to the evolving digital world [cited 2020 Dec 12]. Available from: https://wearesocial.com/us/blog/2020/01/digital-2020-us/

3. Gokce A, Ozer A. The relationship between problematic cell phone use, eating disorders and social anxiety among university students. Pak J Med Sci. 2021;37(4):1201-5. DOI

4. Tapanya W, Puntumetakul R, Neubert MS, Boucaut R. Influence of neck flexion angle on gravitational moment and neck muscle activity when using a smartphone while standing. Ergonomics. 2021;64(7):900-11. DOI

5. Al-Hadidi F, Bsisu I, AlRyalat SA, Al-Zu'bi B, Bsisu R, Hamdan M, 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. 2019;14(5):e0217231. DOI

6. Cochrane ME, Tshabalala MD, Hlatswayo NC, Modipana RM, Makibelo PP, Mashale EP, et al. The short-term effect of smartphone usage on the upper-back postures of university students. Cogent Eng. 2019;6:1627752. DOI

7. Xie Y, Szeto G, Dai J. Prevalence and risk factors associated with musculoskeletal complaints among users of mobile handheld devices: A systematic review. Appl Ergon. 2017;59(Pt A): 132-42. DOI

8. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-country reliability and validity. Med Sci Sport Exerc. 2003; 35(8):1381-95. DOI

9. Cook C, Richardson JK, Braga L, Menezes A, Soler X, Kume P, et al. Cross-cultural adaptation and validation of the Brazilian Portuguese version of the Neck Disability Index and Neck Pain and Disability Scale. Spine (1976). 2006;31(14):1621-7. DOI

10. Vernon H. The Neck Disability Index: state-of-the-art, 1991-2008. J Manipulative Physiol Ther. 2008;31(7):491-502. DOI

11. Paes JL, Piazza L, Tormen L, Libardoni TC, Pasquali T, Santos GM. Confiabilidade intra e interexaminador da avaliação do alinhamento da cabeça nas posições sentado e em pé. Fisioter Pesqui. 2017;24(1):29-39. DOI

12. Metin G, Topuz S, Yagci G. Smartphone use affects gait performance, spinal kinematics and causes spinal musculoskeletal discomfort in young adults. Musculoskelet Sci Pract. 2023;66:102819. DOI

13. Maayah MF, Nawasreh ZH, Gaowgzeh RAM, Neamatallah Z, Alfawaz SS, Alabasi UM. Neck pain associated with smartphone usage among university students. PLoS One. 2023; 18(6):e0285451. DOI

14. Lima S, Carvalho ML, Vasconcelos AGG. Proposta de modelo hierarquizado aplicado à investigação de fatores de risco de óbito infantil neonatal. Cad Saude Publica. 2008;24 (8):1910-6. DOI

15. Xie YF, Szeto G, Madeleine P, Tsang S. Spinal kinematics during smartphone texting – A comparison between young adults with and without chronic neck-shoulder pain. Appl Ergon. 2018;68:160-8. DOI

16. Tsantili AR, Chrysikos D, Troupis T. Text neck syndrome: disentangling a new epidemic. Acta Med Acad. 2022;51(2): 123-7. DOI

17. Alfaitouri S, Altaboli A. The effect of posture and duration of smartphone usage on neck flexion angle. Proc Hum Factors Ergon Soc. 2019;63(1):962-6. DOI

18. Namwongsa S, Puntumetakul R, Neubert MS, Chaiklieng S, Boucaut R. Ergonomic risk assessment of smartphone users using the Rapid Upper Limb Assessment (RULA) tool. PLoS One. 2018;13(8):e0203394. DOI

19. Chen YL, Chen KH, Cheng YC, Chang CC. Field study of postural characteristics of standing and seated smartphone use. Int J Environ Res Public Health. 2022;19(8):4583. DOI

20. Jung SI, Lee NK, Kang KW, Kim K, Lee DY. The effect of smartphone usage time on posture and respiratory function. J Phys Ther Sci. 2016;28(1):186-9. DOI

21. Bueno GR, Garcia LF, Bertolini SMMG, Lucena TFR. The head down generation: musculoskeletal symptoms and the use of smartphones among young university students. Telemed J E Health. 2019;25(11):1049-56. DOI

22. Vahedi Z, Mazlomi A, Sharifnezhad A, Azam K. Examining the effect of smartphone on musculoskeletal disorders and neck kinematic among smartphone users in different postures and tasks. Iran J Ergon. 2019;6(4):58-65. DOI

23. Zhuang L, Wang L, Xu D, Wang Z, Liang R. Association between excessive smartphone use and cervical disc degeneration in young patients suffering from chronic neck pain. J Orthop Sci. 2021;26(1):110-5. DOI

24. Kumar VA, Chandrasekaran V, Brahadeeswari H. Prevalence of smartphone addiction and its effects on sleep quality: A cross-sectional study among medical students. Ind Psychiatry J. 2019;28(1):82-5. DOI

25. Demirci K, Akgönül M, Akpinar A. Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. J Behav Addict. 2015;4(2):85-92. DOI

26. Al-Hadidi F, Bsisu I, AlRyalat SA, Al-Zu'bi B, Bsisu R, Hamdan M, 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. 2019;14(5):e0217231. DOI