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RULA-Based Ergonomic Assessment of Sitting Posture as a Risk Factor for Neck Pain in Students

Indri Seta Septadina[1*)], Wardiansah[1], Tri Suciati[1], Msy Rulan Adnindya[1], Sima Asmara Dewa Marya Mahardika Putri[1], Legiran[1], Putri Malahayati[2], Muhammad Ramadhan Odiesta[1,] Alfian Hasbi[3]

[1] Department of Anatomy, Faculty of Medicine, Universitas Sriwijaya, Palembang
[2] Medical Doctor Study Programme, Faculty of Medicine, Universitas Sriwijaya, Palembang
[3] Department of Physiology, Faculty of Medicine, Universitas Sriwijaya, Palembang

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**) corresponding author*

Indri Seta Septadina

Email:
indrisetaseptadina@fk.unsri.ac.id
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ABSTRACT

Research on ergonomic risk factors for neck pain among Islamic boarding school students remains scarce, despite their prolonged study and Qur′an memorization activities in static sitting postures. Non-neutral body posture during learning may increase the risk of musculoskeletal disorders (MSDs), particularly neck pain, which can impair concentration and quality of life. This analytic cross-sectional study aimed to assess students′ body posture during study and memorization activities and to examine its association with neck pain. A total of 72 boarding and non-boarding students participated. Data were collected using questionnaires and the Rapid Upper Limb Assessment (RULA), and analyzed with chi-square tests and logistic regression to obtain prevalence ratios (PR) and p-values. Neck pain was reported by 63.9% of respondents; 72.2% exhibited poor sitting posture, and 80.6% reported moderate-to-severe stress. Bivariate analysis showed a significant association between stress level and neck pain ($p = 0.033$; PR = 2.19; 95% CI: 1.25–3.83). In multivariate logistic regression, no variable reached conventional statistical significance; however, students with moderate-to-severe stress had a 3.81-fold higher risk of neck pain ($p = 0.057$). These findings underscore the need for integrated ergonomic and psychosocial interventions in Islamic boarding school settings to reduce neck pain risk among students.

INTRODUCTION

Neck pain is a prevalent musculoskeletal issue that affects people of all ages, from teenagers to adults (Jahre et al., 2020). This condition not only impairs physical health but also contributes significantly to global disability rates (Kazeminasab et al., 2022). The primary cause of neck pain is the prolonged maintenance of non-ergonomic postures, such as sitting with poor neck alignment for long periods. Sustained static posture forces continuous activation of neck muscles, which leads to muscle fatigue, microtrauma, and pain. Over time, these conditions may interfere with daily activities, limit mobility, impair sleep quality, and decrease learning performance (Zapponi, 2023).

In 2020, global data indicated that over 203 million individuals suffered from neck pain, with projections suggesting a 32% rise to 266 million cases by 2050. Among adolescents aged 15–19, neck pain ranks as the 8th most frequent complaint (Jahre et al., 2020). A study found that up to 87% of children and adolescents aged 8–17 years have experienced neck discomfort. Students, including those in Islamic boarding schools, are particularly susceptible to neck pain due to their intensive formal and informal educational activities, which include schoolwork, religious studies, Quran memorization, and classical text learning. These activities often involve prolonged sitting without ergonomic support, which exacerbates poor posture and increases the risk of pain (Zapponi, 2023). Such environments increase the risk of static muscular strain and neck discomfort.

Maintaining a fixed posture for extended periods results in continuous low-level muscle contraction, which reduces blood flow to the working muscles. This diminished oxygen supply accelerates fatigue, leading to discomfort and pain. This theory provides a crucial framework for understanding how prolonged sitting and neck flexion among students can contribute to musculoskeletal disorders. (Coutaux, 2017).

Extended neck flexion can lead to muscle spasms, disrupted muscle function, and damage to supporting tissues, such as ligaments, resulting in chronic pain (Coglianese, 2024). However, there is a scarcity of research specifically examining the neck posture of students and its link to neck pain, especially using standardized ergonomic assessments. RULA is particularly suited for assessing static upper body postures, including the neck, shoulders, and arms, during sedentary activities such as studying or reading. Unlike REBA and OWAS, which are more applicable to dynamic or industrial work settings, RULA provides a focused assessment of postural load in seated or repetitive tasks, making it particularly suitable for student populations.(Kakaraparthi, 2022).

Despite the increasing prevalence of musculoskeletal complaints among students, there is a scarcity of research examining neck posture and associated risk factors in Islamic boarding school settings, particularly in Southeast Asia. Therefore, this study aims to analyze the relationship between body posture and neck pain among Islamic boarding and non-boarding students using the RULA method. The findings are expected to provide a scientific basis for developing ergonomic education and preventive strategies tailored to Islamic educational institutions.

METHOD

This study was an observational analytic quantitative study with a cross-sectional design, aimed to determine the relationship between upper body posture, analyzed using the Rapid Upper Limb Assessment (RULA) method, and complaints of neck pain among students of SMA IT Izzuddin Palembang. The research was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines to ensure methodological transparency.

The population in this study consisted of all students at SMA IT Izzuddin Palembang. The sampling technique used was proportional random sampling, in which students were divided into several strata based on class level and gender, then selected proportionally from each stratum. The inclusion criteria were: (1) students aged 15–18 years who actively participated in daily learning activities; (2) students who had at least six hours of sitting or studying activity per day; and (3) students willing to participate by signing informed consent. The exclusion criteria included: (1) a history of neck or back injury; (2) congenital spinal deformities or neurological disorders; and (3) students who refused or were unable to complete the questionnaire and posture examination.

This study used primary data collected directly from respondents. Prior to data collection, identification was conducted to ensure that respondents met the inclusion and exclusion criteria. Each respondent received an explanation about the research and signed an informed consent form before participating. Posture analysis was carried out using the RULA instrument (Kakaraparthi, 2022). The neck angle was measured using a universal goniometer to objectively quantify neck flexion during study activities. The dependent variable, neck pain, was assessed using the Nordic Body Map (NBM) questionnaire to identify the location of pain, and the Visual Analogue Scale (VAS) to measure pain intensity. Respondents were given instructions before completing the questionnaire to ensure accurate responses.

The data were processed and analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics were used to present frequency and percentage distributions. The relationship between posture (RULA score) and neck pain was analyzed using the chi-square test, while logistic regression was employed to determine the strength of association and calculate prevalence ratios (PR) with 95% confidence intervals (CI). The significance threshold was set at $p < 0.05$. This research obtained ethical approval from the Health Research Ethics Committee, Faculty of Medicine, Universitas Sriwijaya (No. 338/KEPKK/2025).

RESULTS OF STUDY

Based on Table 1, a total of 72 students participated in this study with a relatively balanced distribution across grade levels. Most respondents were from class XII Ibnu Khaldun (33.33%) and XII Ibnu Sina (25.00%), followed by XI Al Biruni (22.22%) and XI Ibnu Batuta (19.44%). The gender composition was equally distributed between males and females, each accounting for 50.00%, allowing for a more objective analysis of potential differences in risk between the two groups. In terms of age, the majority of respondents were 16 years old (55.56%), followed by 17 years old (26.39%), while those aged 15 years (13.89%) and 18 years (4.17%) represented smaller proportions. This indicates that most respondents were in middle adolescence, a developmental phase typically characterized by increased academic demands and intensive learning activities.

Table 1. Distribution of Respondent Characteristics

Characteristic	Amount	Percentage (%)
Class		
XI Al Biruni	16	22.22
XI Ibnu Batuta	14	19.44
XII Ibnu Khaldun	24	33.33
XII Ibnu Sina	18	25.00
Gender		
Male	36	50.00
Female	36	50.00
Age		
15 Years	10	13.89
16 Years	40	55.56
17 Years	19	26.39
18 Years	3	4.17

Table 2 presents the distribution of categorical variables related to ergonomic risk and musculoskeletal complaints. Neck pain was reported by 63.89% of students, indicating a high prevalence of musculoskeletal disorders in this population. Most respondents had a normal body mass index (63.89%), while 16.67% were underweight and 19.44% were overweight/obese, suggesting that, overall, nutritional status does not appear to be the dominant factor disrupting the normal distribution. Exposure to static sitting posture was high, as reflected by 84.72% of students reporting a sitting duration of ≥ 8 hours per day. In addition, 72.22% of students were assessed as having an incorrect sitting position, and 88.89% fell into the ergonomic risk category based on RULA scores, indicating that the majority of students were in working postures that potentially impose excessive load on the musculoskeletal system. From a psychosocial perspective, 80.56% of respondents reported moderate to severe stress levels, which theoretically may contribute to increased muscle tension and pain perception.

Neck position during learning was predominantly at a flexion angle of ≤ 15° (65.28%), although 34.72% of students had a flexion angle > 15°, which biomechanically increases axial load on the cervical spine when maintained for prolonged periods. Overall, the combination of long sitting duration, non-ergonomic sitting posture, high ergonomic risk according to RULA, and elevated stress levels suggests that these students are in a highly vulnerable situation for developing neck pain.

Table 2. Distribution of Categorical Variables

Category	Amount (n)	Percentage (%)
Neck Pain		
(+)	46	63.89
(-)	26	36.11
Gender		
Male	36	50.00
Female	36	50.00
Body Mass Index (BMI)		
Thin	12	16.67
Normal	46	63.89
Overweight/Obesity	14	19.44
Sitting Duration		
≥ 8 hours	61	84.72
< 8 hours	11	15.28
Sitting Position		
Incorrect	52	72.22
Correct	20	27.78
Stress Level		
Moderate/severe	58	80.56
Mild	14	19.44
Neck Position		
>15°	25	34.72
≤ 15°	47	65.28
RULA		
Risky	64	88.89
Safe	8	11.11

Based on Table 3, the bivariate analysis shows that only stress level has a statistically significant association with the incidence of neck pain. Students with moderate-to-severe stress had a neck pain prevalence of 70.69%, which was markedly higher than that of students with mild stress (35.71%), with a PR = 2.19 (95% CI: 1.25–3.83; p = 0.033). This indicates that students with moderate-to-severe stress are approximately twice as likely to experience neck pain compared to those with mild stress, and the confidence interval not crossing 1 suggests that this association is statistically robust.

For the other variables, no statistically significant relationships with neck pain were observed, although some showed a risk tendency. For gender, 75.00% of female students reported neck pain compared to 52.77% of male students, with PR = 1.88 (95% CI: 0.97–3.99; p = 0.086). The p-value close to 0.05 and the lower bound of the confidence interval approaching 1 suggest a trend that females may be at higher risk, although this has not reached statistical significance. Sitting duration showed a similar pattern: students who sat for ≥ 8 hours per day had a neck pain prevalence of 67.21% compared to 45.45% among those who sat for < 8 hours, with PR = 1.66 (95% CI: 0.87–3.18; p = 0.149). However, the wide confidence interval that includes 1 indicates that this effect is not statistically strong.

Nutritional status (BMI), sitting position, neck position, and RULA risk category did not show meaningful associations with neck pain. For BMI, both the underweight category (PR = 1.66; 95% CI: 0.30–9.15; p = 0.557) and the overweight/obesity category (PR = 0.86; 95% CI: 0.24–2.99; p = 0.818) had very wide confidence intervals crossing 1, indicating uncertainty in the estimates, likely due to small subgroup sizes. Similarly, students with incorrect sitting position (63.46% neck pain) and neck flexion angle >15° (72.00% neck pain) appeared to have higher proportions of neck pain than their reference groups, but the corresponding PR values (0.95 and 1.44) and p-values (1.000 and 0.431, respectively) provide no statistical evidence of association. Notably, although 88.89% of students were classified as at ergonomic risk according to RULA, the comparison between the "risky" and "safe" categories did not reveal a significant difference (PR = 1.04; 95% CI: 0.40–2.70; p = 0.608). Overall, these findings suggest that, in the bivariate analysis, the psychosocial factor of stress appears to be a more consistent predictor of neck pain than the ergonomic factors measured, although the risk patterns observed for gender and sitting duration remain relevant for further investigation with larger samples.

Based on Table 4, the multivariate logistic regression analysis shows that none of the variables reached conventional statistical significance (p < 0.05) as an independent predictor of neck pain, although some clinical risk patterns are apparent. Among all variables included in the model, moderate-to-severe stress emerged as the numerically strongest factor, with B = 1.34 and Exp(B) = 3.81 (p = 0.057; 95% CI: 0.96–15.09). This indicates that, after adjusting for gender, BMI, sitting duration, sitting position, neck position, and RULA score, students with moderate-to-severe stress had approximately 3.8 times higher odds of experiencing neck pain compared to those with mild stress; however, the wide confidence interval crossing 1 reflects limited precision of this estimate, likely due to the relatively small sample size (n = 72). The other variables showed weaker effect sizes and very wide confidence intervals, so their interpretation must be made with caution. For example, gender had Exp(B) = 2.22 (p = 0.190; 95% CI: 0.67–7.32), suggesting a higher likelihood of neck pain in one category relative to the reference, but the substantial uncertainty precludes concluding it as an independent risk factor. Similarly, sitting duration ≥ 8 hours (Exp(B) = 1.59; p = 0.561), incorrect sitting position (Exp(B) = 1.02; p = 0.972), neck flexion < 15° (Exp(B) = 1.48; p = 0.534), and risky RULA category (Exp(B) = 0.61; p = 0.580) did not demonstrate significant associations, indicating that when ergonomic variables are entered simultaneously, none stands out as an independent predictor. For BMI, both the underweight category (Exp(B) = 0.59; p = 0.517; 95% CI: 0.12–2.92) and overweight/obesity (Exp(B) = 1.00; p = 0.997; 95% CI: 0.15–6.79) had very wide confidence intervals including 1, suggesting no strong evidence for a role of nutritional status in determining neck pain within this model.

Overall, the 2 Log Likelihood value of 83.93 and Nagelkerke R^2 of 18.17% indicate that the model explains only about one-fifth of the variance in neck pain, implying that a substantial proportion of the variance may be attributable to unmeasured factors such as sleep quality, device use habits, physical activity outside study hours, or other psychosocial variables. Thus, these regression results reinforce the bivariate findings that stress is the most important candidate predictor, while also highlighting the limited explanatory power of the model and the need for further research with larger sample sizes and more selective variable modeling (e.g., reducing collinearity among ergonomic variables) to more accurately estimate the relative contributions of psychosocial and ergonomic factors to neck pain.

Table 3 The Relationship between Risk Factors and the Incidence of Neck Pain (n=72)

Variabel	Neck Pain (=) n (%)	Neck Pain (-) n (%)	Amount (n)	PR (CI 95%)	P-value
Gender					
Male	19 (52.77)	17 (47.23)	36	1.88 (0.97–3.99)	0.086
Female	27 (75.00)	9 (25.00)	36	Reference	–
BMI					
Thin	9 (75.00)	3 (25.00)	12	1.66 (0.30–9.15)	0.557
Normal	28 (60.87)	18 (39.13)	46	Reference	–
Overweight/obesity	9 (35.71)	5 (64.29)	14	0.86 (0.24–2.99)	0.818
Sitting Duration					
≥ 8 hours	41 (67.21)	20 (32.79)	61	1.66 (0.87–3.18)	0.149
< 8 hours	5 (45.45)	6 (54.55)	11	Reference	–
Sitting Position					
Incorrect	33 (63.46)	19 (36.54)	52	0.95 (0.47–1.92)	1.000
Correct	13 (65.00)	7 (35.00)	20	Reference	–
Stress Level					
Moderate/severe	41 (70.69)	9 (29.31)	50	2.19 (1.25–3.83)	0.033
Mild	5 (35.71)	17 (64.29)	22	Reference	–
Neck Position					
>15°	18 (72.00)	7 (28.00)	25	1.44 (0.70–2.96)	0.431
≤ 15°	28 (59.57)	19 (40.43)	47	Reference	–
RULA					
Risky	41 (64.06)	23 (35.94)	64	1.04 (0.40–2.70)	0.608
Safe	5 (62.50)	3 (37.50)	8	Reference	–

Table 4 Analysis of the Most Influential Risk Factors for Neck Pain

Variables	B	Exp (B)	*p*	CI (95%) Lower	CI (95%) Upper
Gender	0.80	2.22	0.190	0.67	7.32
BMI (thin)	-0.53	0.59	0.517	0.12	2.92
BMI (overweight/obesity)	0.00	1.00	0.997	0.15	6.79
Duration of sitting (≥ 8 h)	0.47	1.59	0.561	0.33	7.67
Sitting Position (incorrect)	0.02	1.02	0.972	0.27	3.92
Stress (Moderate/severe)	1.34	3.81	0.057	0.96	15.09
Neck Position (<15°)	0.39	1.48	0.534	0.43	5.06
RULA (Risky)	-0.49	0.61	0.580	0.11	3.45
N observasi	72				
2 Log Likelihood	83.93				
Nagelkerke R2	18.17%				

DISCUSSION

The study's findings revealed that a significant portion of participants, 63.89%, reported experiencing neck pain. This suggests that musculoskeletal issues in the neck area remain prevalent among individuals who spend extended periods sitting. This aligns with earlier research indicating that maintaining a static posture, particularly in non-ergonomic seating, is a primary contributor to muscle tension in the neck and shoulders (Alhakami et al, 2022). Maintaining a fixed posture for extended periods—especially without sufficient muscular recovery—causes continuous contraction of specific muscle groups, reducing local blood flow and oxygen supply. This leads to fatigue, discomfort, and ultimately musculoskeletal pain, particularly in the cervical region.

Gender distribution was balanced in this study, yet the prevalence of neck pain was higher among female respondents. Although this finding was not statistically significant, it aligns with prior studies indicating that women may be more susceptible to musculoskeletal complaints due to hormonal influences, differences in muscle strength, and psychosocial stressors (Punnett, L., & Wegman, 2004). This supports the biopsychosocial model, which posits that musculoskeletal pain is not purely biomechanical but influenced by psychological and social dimensions such as stress perception, workload, and coping mechanisms. (Cagnie, B., 2007).

BMI distribution in this study showed no significant relationship with neck pain, although both underweight and overweight respondents displayed higher pain proportions than those with normal BMI. This pattern reflects the biomechanical imbalance where excess weight increases axial loading on the spine, while insufficient body mass may be linked to weaker postural support muscles. Both extremes can exacerbate static muscle strain during prolonged sitting (Shiri et al, 2014). Therefore, extreme nutritional statuses in either direction may influence the occurrence of neck pain complaints.

Long sitting durations (≥8 hours/day) were associated with a higher prevalence of neck pain (67.21%) compared to shorter durations, consistent with previous findings among office workers (Cagnie, 2007; Jung et al., 2020). Extended sitting time promotes sustained static load on postural muscles, in line with the static load theory, where immobile positions increase intramuscular pressure and reduce blood perfusion, thereby heightening the risk of pain and stiffness (Cagnie, 2007). Extended periods of sitting result in decreased blood circulation to the neck and shoulder muscles, as well as increased static pressure on the musculoskeletal structures. This finding is consistent with studies by (Cagnie, 2007) and (Jung et al, 2020)Studies have shown that office workers who sit for more than 7 hours per day have a higher risk of experiencing neck pain.

Most respondents (72.22%) adopted non-ergonomic sitting postures, characterized by neck flexion and forward-leaning positions. Such postures disrupt muscle balance and elevate mechanical strain on the cervical spine (Ariëns, 2001). Interestingly, neck position and RULA scores were not found to be significantly associated with neck pain. This may be explained by the homogeneity of study activities among Islamic boarding school students, who generally share similar learning patterns and sitting environments, leading to minimal variation in RULA risk scores. Furthermore, the potential for observational bias in posture assessment could have attenuated the relationship between RULA scores and pain outcomes, as the majority of participants were already classified within the "moderate to high risk" category. RULA remains an effective screening tool, but may be less sensitive in relatively homogeneous populations with comparable activity patterns (Ariëns, 2001).

The psychological dimension of the biopsychosocial model was supported by the significant association between stress levels and neck pain. Respondents with moderate to severe stress were 2.19 times more likely to experience neck pain than those with mild stress. Chronic psychological stress activates the sympathetic nervous system and increases muscle tone, particularly in the neck and shoulders (Waersted, M., Hanvold, T. N., & Veiersted, 2020). Prolonged sympathetic activation can lead to sustained muscle contraction and reduced microcirculation, reinforcing the physical manifestation of psychological strain. Similar findings have been reported in studies linking occupational stress to musculoskeletal disorders among office workers (Ariëns, 2001).

In terms of neck position, as many as 34.72% of respondents had a neck inclination angle >15°, indicating excessive static load on the cervical muscles. Biomechanical studies indicate that each increase in neck flexion angle results in an exponential increase in the load on the cervical spine (Hansraj, 2014). As many as 72.00% of respondents with a neck position >15° experienced neck pain, compared to 59.57% at a position of ≤15°. Although not statistically significant (p = 0.431), this result suggests a tendency toward increased risk with greater neck flexion angles. According to (Hansraj, 2014), a 15° increase in flexion angle can more than double the load on the cervical spine compared to the weight of a normal head, which, in the long term, leads to muscle tension and chronic pain.

The results of the RULA (Rapid Upper Limb Assessment) evaluation show that most respondents (88.89%) fall into the at-risk category, indicating the need for immediate ergonomic intervention. RULA is an effective tool for assessing the risk of working posture on the musculoskeletal system, and a high score indicates unsafe working positions that can potentially cause neck and shoulder muscle disorders. Analysis shows that respondents with a high-risk RULA score had a neck pain prevalence of 64.06%, compared to 62.50% in the safe category. However, this relationship is not significant (p = 0.608). This lack of significance is likely due to the homogeneity of work activities among respondents, most of whom are already in the moderate to high ergonomic risk category. RULA is an effective screening tool for evaluating posture risks to the musculoskeletal system, but the results need to be combined with field observations and work activity analysis to obtain a more accurate picture.

Overall, the results of this study confirm that ergonomic factors (sitting position, neck position, and sitting duration) and psychological factors (stress level) play significant roles in the development of neck pain complaints. Preventive efforts can be made through ergonomic education, workstation adjustments, regular stretching, and stress management in the workplace. Stress level was the only variable showing a significant relationship with the incidence of neck pain (p = 0.033; PR = 2.19; 95% CI: 1.25–3.83). Respondents with moderate–severe stress had a 2.19 times higher risk of experiencing neck pain than respondents with mild stress. This finding strengthens the evidence that psychological factors make an important contribution to the occurrence of musculoskeletal pain. Stress causes activation of the sympathetic nervous system, which triggers an increase in muscle tone, particularly in the neck and shoulder areas (Arvidsson I., Dahlqvist C., Enquist H., Nordander C., 2021). As a result, muscle spasms can occur, causing pain or stiffness. This finding is consistent with those of (Sohrabi, MS., Babamiri M., 2021), who reported a significant relationship between work stress and neck pain complaints among administrative workers.

This study extends the application of the biopsychosocial model and static load theory within an educational ergonomics context—specifically among Islamic boarding school students, a population rarely examined in ergonomic research. The findings suggest that musculoskeletal health in student populations must be understood through an integrated lens combining posture mechanics, psychological stress, and sociocultural learning environments.

CONCLUSIONS AND RECOMMENDATION

This study contributes to the growing body of educational ergonomics literature by demonstrating that psychological stress plays a significant role in the development of neck pain among students in boarding school settings. While ergonomic factors such as gender, BMI, sitting duration, sitting posture, neck position, and RULA score were not statistically significant, they still showed trends indicating potential risk. These findings support the biopsychosocial framework, emphasizing that musculoskeletal complaints are shaped by both physical and psychological demands in academic environments.

The main limitation of this study lies in its cross-sectional design, which limits causal inference, and the relatively homogeneous characteristics of the study population, which may reduce variability in ergonomic exposure. Future studies should employ longitudinal designs or intervention-based approaches to better establish causal relationships and evaluate the effectiveness of ergonomic and psychosocial interventions in educational settings.

From a practical perspective, the results highlight the importance of integrating health promotion strategies in schools that combine ergonomic education, periodic posture assessments, and stress management programs. Incorporating ergonomic awareness and mental health training into teacher development and student health policies may help reduce musculoskeletal complaints and enhance overall well-being in the learning environment.

DECLARATION

Ethics approval and consent to participate

Ethics approval and consent to participate were confirmed by the Ethical Committee, Faculty of Medicine, Sriwijaya University, No. No. 338/KEPKK/2025 and declared that the research protocol has been granted exempt status.

Consent for publication

Consent for publication of the findings was obtained from all participants.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request

Conflicts of Interest Statement

The authors declare that they have no conflict of interest

Statement on the Use of Artificial Intelligence (AI)

Not Applicable

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AUTHORS' CONTRIBUTIONS

Indri Seta Septadina, Conceptualization, Supervision, methodology, and manuscript review, and corresponding author

Wardiansah, developed the review protocol, conducted literature search, performed data analysis

Tri Suciati, Field study coordination, data collection,

Msy Rulan Adnindya, Field study coordination, data collection,

Sima Asmara, Data analysis, statistical interpretation, and manuscript drafting

Legiran· Data analysis, statistical interpretation, and manuscript drafting

Putri Malahayati, ideas, field study coordination, data collection

Muhammad Ramadhan Odiesta, collecting data, prepared the manuscript for publication

Alfian Hasbi, field study coordination, data collection

ABOUT THE AUTHORS

Indri Seta Septadina –Currently serves as the Head of the Anatomy Department at the Medical Faculty of Universitas Sriwijaya, Palembang. She completed her MD at Sriwijaya University, Palembang, and her Magister at Padjadjaran University, Bandung.

Wardiansah – Born in Palembang on September 8, 1984. Presently holds the position of lecturer in the Anatomy Department in the Medical Faculty of Universitas Sriwijaya, Palembang. He obtained his MD from Sriwijaya University in Palembang and his Master's degree from Universitas Indonesia in Jakarta.

Tri Suciati –Currently serves as a lecturer at Department of Anatomy at the Medical Faculty of Universitas Sriwijaya, Palembang. She completed her Medical Doctor (MD) at Sriwijaya University, Palembang, and her Master's'degree at Padjajaran University, Bandung

Msy Rulan Adnindya –Presently holds the position of lecturer in the Anatomy Department in the Medical Faculty of Universitas Sriwijaya, Palembang. He obtained her MD from Sriwijaya University in Palembang and his Master's degree from the Universitas Indonesia in Jakarta.

Sima Asmara Dewa Marya Mahardika Putri - She is currently a lecturer in the Department of Anatomy, Faculty of Medicine, Sriwijaya University, Palembang. She obtained her Bachelor′s degree from the University of Muhammadiyah Malang, her Professional Education from the Health Polytechnic of the Ministry of Health in Surakarta, and her Master′s degree from Sebelas Maret University.

Legiran –Currently serves as a lecturer in the Anatomy Department at the Medical Faculty of Universitas Sriwijaya, Palembang. He completed his MD at Sriwijaya University, Palembang, his Magister at Gadjah Mada University, Yogyakarta, and his Doctoral Programme at Padjajaran University, Bandung

Putri Malahayati-Currently as an active student in Medical Faculty of Universitas Sriwijaya Palembang.

Muhammad Ramadhandie Odiesta –Currently serves as a lecturer at the Department of Anatomy, Faculty of Medicine, Universitas Sriwijaya. He finished his Medical Doctor (MD) degree from Universitas Sriwijaya, Palembang, and completed his Neurology Residency (Sp.N) from Universitas Sriwijaya, Palembang.

Alfian Hasbi –Currently serves as the staff of the Physiology Department at the Medical Faculty of Universitas Sriwijaya, Palembang. He completed his MD at Sriwijaya University in Palembang and specialized in Radiology at Airlangga University in Surabaya.

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Correspondence All inquiries and requests for additional materials should be directed to the Corresponding Author.

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