

Ergonomic risk factors for wrist pain among smartphone-using university students: A cross-sectional study

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ABSTRACT

Introduction: Smartphone use has become integral to university students' academic and social activities, but prolonged use combined with non-ergonomic wrist positions and body postures may increase biomechanical strain and contribute to wrist pain. This study examined ergonomic risk factors associated with wrist pain among smartphone-using university students.

Methods: A quantitative observational cross-sectional study was conducted from June to July 2026 among undergraduate Public Health students at Universitas Tamalatea Makassar. A total of 78 students were recruited using accidental sampling from a population of 336 students. Smartphone use, wrist position, and body posture were assessed using an ergonomics-based questionnaire referring to Rapid Upper Limb Assessment principles, while wrist pain was measured using the Numeric Rating Scale. Associations were analyzed using Pearson's Chi-square test, with odds ratios (ORs) and 95% confidence intervals (CIs) estimated from the 2×2 contingency tables.

Results: Wrist pain was reported by 64 students (82.1%). High smartphone use was associated with greater odds of wrist pain than low use (OR=3.44; 95% CI: 1.03–11.51; p=0.038). A non-ergonomic wrist position showed the strongest association with wrist pain (OR=10.14; 95% CI: 2.52–40.78; p<0.001). Non-ergonomic body posture was also significantly associated with wrist pain (OR=4.77; 95% CI: 1.34–16.98; p=0.011).

Conclusion: Smartphone-related ergonomic exposures were significantly associated with wrist pain among university students, particularly non-neutral wrist positioning. Campus-based ergonomic education should emphasize neutral wrist alignment, appropriate posture, reduced prolonged smartphone use, and regular rest breaks to minimize musculoskeletal strain.

Keywords: ergonomics; musculoskeletal pain; posture; smartphone; wrist.

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Highlight:

- Wrist pain affected 82.1% of smartphone-using university students.
- High smartphone use was associated with higher odds of wrist pain.
- Non-ergonomic wrist position showed the strongest association with wrist pain.
- Poor body posture significantly increased the likelihood of wrist pain.
- Ergonomic education and regular breaks may reduce smartphone-related wrist strain..

INTRODUCTION

Smartphone use has become embedded in university learning, communication, and leisure, creating a pattern of prolonged handheld-device exposure that has implications beyond screen time alone. From an ergonomic perspective, the concern is the combination of duration, repetitive thumb and finger movements, sustained gripping, non-neutral wrist alignment, and static upper-body posture^{1,2}. These exposures can increase mechanical loading on muscles, tendons, joints, and neural structures of the upper extremity. University students represent a particularly relevant population because smartphone use frequently extends across both academic and non-academic activities. In Indonesia, high levels of mobile-device engagement further increase the relevance of identifying modifiable ergonomic exposures before transient discomfort develops into persistent musculoskeletal problems^{3,4}. Within the study population, preliminary observations indicated smartphone use of approximately 5–8 hours per day, accompanied by reports of wrist pain, soreness, tingling, and discomfort after prolonged use.

Existing evidence suggests that smartphone-related musculoskeletal symptoms are not attributable to a single exposure. Prolonged device use can involve repetitive movements and sustained static loading, while one-handed operation and prolonged gripping may further increase stress on the wrist and hand. The biomechanical consequences become more pronounced when the wrist deviates from a neutral position^{5,6}. Flexion, extension, or deviation maintained during scrolling, typing, and gripping can alter muscle recruitment and increase loading of the structures surrounding the wrist. Similarly, poor body posture may indirectly influence upper-extremity loading. A flexed neck, rounded shoulders, unsupported arms, and prolonged static sitting can modify the kinetic chain through which the upper limb supports and operates the device^{7,8}. Thus, smartphone-related wrist pain should be considered within an integrated ergonomic framework involving exposure duration, local wrist mechanics, and whole-body posture rather than as an isolated consequence of device use.

However, the current literature remains fragmented in several respects. Previous studies have frequently concentrated on smartphone addiction, overall screen time, or musculoskeletal symptoms involving the neck, shoulders, and upper back. Wrist-specific outcomes have received comparatively less attention. Moreover, studies examining hand and wrist symptoms often focus on a single dimension, such as duration of smartphone use or repetitive thumb activity, without simultaneously considering wrist alignment and body posture^{9,10}. This distinction is important because similar durations of smartphone exposure may impose different biomechanical loads depending on how the device is held and how the upper extremity is positioned¹¹. The source study therefore conceptualized smartphone use, wrist position, and body posture as interconnected exposures potentially associated with wrist pain.

A further methodological issue concerns how ergonomic exposure and pain are operationalized. Reliance exclusively on duration may obscure the mechanical characteristics of smartphone use, whereas assessment of posture without a defined pain outcome may provide limited information about its clinical relevance. In the present study, ergonomic characteristics were assessed using a questionnaire informed by the principles of the Rapid Upper Limb Assessment (RULA), while wrist pain was evaluated using the Numeric Rating Scale (NRS). The NRS distinguished students reporting no wrist pain from those experiencing pain during or after smartphone use, thereby providing a specific musculoskeletal outcome for evaluating ergonomic exposures.

The research gap addressed by this study is therefore the limited evidence examining smartphone exposure, wrist position, and body posture concurrently in relation to wrist-specific

pain among university students, particularly in an Indonesian university setting. Rather than treating smartphone use as a stand-alone behavioral exposure, this study evaluates whether the way students position their wrists and bodies provides additional ergonomic information relevant to wrist symptoms.

The novelty of this study lies in its integrated ergonomic perspective. It combines a behavioral exposure smartphone use with two modifiable biomechanical factors wrist position and body posture and evaluates their associations with a clearly defined wrist-pain outcome within the same student population. This approach provides a more functionally relevant framework for identifying targets for preventive interventions than screen-time assessment alone. Accordingly, this study aimed to examine the associations of smartphone use, wrist position, and body posture with wrist pain among undergraduate public health students at Universitas Tamalatea Makassar. By identifying modifiable ergonomic factors associated with wrist symptoms, the findings are expected to inform practical campus-based strategies emphasizing appropriate smartphone-use patterns, neutral wrist positioning, postural support, and periodic recovery from sustained device use.

RESEARCH METHODOLOGY

Study Design

This study employed an analytical observational cross-sectional design to examine the associations between smartphone use, wrist position, body posture, and wrist pain among university students. The cross-sectional approach was appropriate because exposure variables and wrist-pain outcomes were measured within the same observation period, allowing the study to estimate the prevalence of wrist pain and evaluate associations between ergonomic exposures and the outcome without manipulating participants' behavior.

Setting and Participants

The study was conducted at Universitas Tamalatea Makassar, Indonesia, from June to July 2026. The source population comprised 336 active undergraduate students enrolled in the Public Health Study Program. Eligible participants were active undergraduate Public Health students who were using a smartphone when approached, agreed to participate, and completed the study questionnaire. Students who declined participation or returned incomplete or unusable questionnaires were excluded. Participants were recruited using accidental sampling, a non-probability sampling technique in which eligible students encountered at the study site were invited to participate until the required sample size was reached. The minimum sample size was calculated using the Slovin formula: This calculation yielded approximately 77 participants, which was rounded to a final sample of 78 students. The original manuscript specifies a 10% margin of error for the sample-size calculation.

Variables and Measurement

The primary outcome was wrist pain, defined as pain or discomfort in the wrist experienced during or after smartphone use. Pain intensity was assessed using the Numeric Rating Scale (NRS) ranging from 0 to 10. For the categorical analysis, a score of 0 represented no wrist pain, whereas scores of 1–10 were classified as the presence of wrist pain. Three exposure variables were evaluated. Smartphone use reflected the duration and pattern of daily smartphone use and was categorized as high or low use. In the operational definition used in the study, high use referred to smartphone use exceeding 4 hours per day or use without adequate rest breaks, whereas low use referred to ≤ 4 hours per day with rest periods.

Wrist position represented wrist alignment during smartphone use. An ergonomic position was characterized by predominantly neutral wrist alignment, whereas a non-ergonomic position involved predominant flexion, extension, or deviation from neutral alignment. Assessment included behaviors such as wrist bending, sustained non-neutral positioning, prolonged one-handed use, and static hand positioning. Body posture reflected upper-body positioning during smartphone use. The assessment considered trunk flexion, downward head position, prolonged static posture, smartphone use while lying down, and unsupported arm positioning. Posture was subsequently classified as ergonomic or non-ergonomic according to the study criteria. Exposure assessment was conducted using a structured questionnaire developed according to the study variables and informed by ergonomic principles of the Rapid Upper Limb Assessment (RULA). The manuscript, however, does not report empirical validity coefficients, reliability statistics such as Cronbach's alpha, or a separate psychometric validation procedure for the study-specific questionnaire. These parameters should therefore not be claimed unless supporting validation data are available. Primary data consisted of participants' questionnaire responses. Secondary data concerning the number of eligible students were obtained from the university academic administration (BAAK) and were used to establish the study population.

Data Collection and Quality Control

Data were collected directly from eligible students using the structured questionnaire. After confirming eligibility and willingness to participate, respondents completed questions concerning smartphone use, wrist position, body posture, and wrist pain. Data quality was maintained through sequential editing, coding, data entry, and cleaning procedures. Completed questionnaires were initially reviewed for completeness and clarity. Responses were subsequently coded to facilitate quantitative processing. The coded data were entered into Microsoft Excel before statistical analysis. Data cleaning was performed to identify entry errors, duplicate observations, and incomplete records before the analytical dataset was finalized.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 25. Descriptive analysis summarized participant characteristics and study variables using frequencies and percentages. The prevalence of high smartphone use, non-ergonomic wrist position, non-ergonomic body posture, and wrist pain was subsequently reported. Bivariate associations between each exposure variable and wrist pain were evaluated using the Pearson Chi-square test. Statistical significance was defined at a two-sided $\alpha = 0.05$, corresponding to a 95% confidence level. For effect-size reporting, crude odds ratios (ORs) with 95% confidence intervals (CIs) can be calculated from the 2×2 contingency tables. This provides a more informative estimate of the magnitude and direction of each association than the *p*-value alone.

Ethical Approval

Participation was voluntary, and the eligibility criteria specified that students were included only after agreeing to participate in the study.

RESULT

Participant Characteristics

A total of 78 undergraduate Public Health students participated in the study. Women accounted for 51.3% of the sample and men for 48.7%. More than half of the participants were aged 18–20 years (51.3%), followed by those aged 21–23 years (44.9%), while only 3.8% were aged 24–26 years. Participants represented four academic cohorts, with the largest proportion coming from the 2022 cohort (32.1%).

Table 1. Characteristics and ergonomic profiles of study participants (n = 78)

Characteristics	Category	n	%
Sex	Male	38	48.7
	Female	40	51.3
Age (years)	18–20	40	51.3
	21–23	35	44.9
	24–26	3	3.8
Academic cohort	2022	25	32.1
	2023	14	17.9
	2024	23	29.5
	2025	16	20.5
Smartphone use	High	47	60.3
	Low	31	39.7
Wrist position	Non-ergonomic	50	64.1
	Ergonomic	28	35.9
Body posture	Non-ergonomic	46	59.0
	Ergonomic	32	41.0
Wrist pain	Yes	64	82.1
	No	14	17.9

Source: Primary data, 2026.

The ergonomic profile showed substantial exposure to potentially unfavorable smartphone-use behaviors. High smartphone use was reported by 60.3% of participants, while 64.1% used smartphones with a non-ergonomic wrist position and 59.0% adopted a non-ergonomic body posture. Wrist pain was reported by 64 of 78 students (82.1%), indicating a high symptom burden within the study population. All three ergonomic exposures were significantly associated with wrist pain in the bivariate analysis. Among students with high smartphone use, 42 of 47 (89.4%) reported wrist pain, compared with 22 of 31 (71.0%) students with low smartphone use. The corresponding crude OR was 3.44 (95% CI: 1.03–11.51; $p = 0.038$). The largest effect estimate was observed for wrist position. Wrist pain occurred in 47 of 50 students (94.0%) with a non-ergonomic wrist position compared with 17 of 28 (60.7%) students maintaining an ergonomic position. Students with a non-ergonomic wrist position had approximately ten times the odds of reporting wrist pain (OR = 10.14; 95% CI: 2.52–40.78; $p < 0.001$). Non-ergonomic body posture was also associated with wrist pain. Pain was reported by 42 of 46 students (91.3%) with non-ergonomic posture compared with 22 of 32 students (68.8%) with ergonomic posture. The crude OR was 4.77 (95% CI: 1.34–16.98; $p = 0.011$).

Table 2. Bivariate associations between ergonomic risk factors and wrist pain

Risk factor	Category	Wrist pain n (%)	No wrist pain n (%)	Crude OR (95% CI)	p-value
Smartphone use	High	42 (89.4)	5 (10.6)	3.44 (1.03–11.51)	0.038
	Low	22 (71.0)	9 (29.0)	Reference	
Wrist position	Non-ergonomic	47 (94.0)	3 (6.0)	10.14 (2.52–40.78)	<0.001
	Ergonomic	17 (60.7)	11 (39.3)	Reference	
Body posture	Non-ergonomic	42 (91.3)	4 (8.7)	4.77 (1.34–16.98)	0.011
	Ergonomic	22 (68.8)	10 (31.3)	Reference	

OR = odds ratio; CI = confidence interval. ORs and 95% CIs were calculated from the 2×2 contingency tables reported in the original dataset. p-values are those reported from Pearson's Chi-square tests in the source manuscript.

The magnitude of the crude associations suggests a gradient across the ergonomic exposures. Non-ergonomic wrist position produced the largest effect estimate, followed by non-ergonomic body posture and high smartphone use. However, the wide confidence intervals, particularly for wrist position, indicate substantial statistical uncertainty, consistent with the relatively small sample and the limited number of participants without wrist pain. These estimates should therefore be interpreted as measures of association rather than evidence of causality. The findings indicate that wrist pain among smartphone-using university students may reflect an interconnected ergonomic exposure pattern rather than smartphone duration alone. Although high smartphone use was associated with increased odds of wrist pain, the substantially larger effect estimate for non-ergonomic wrist positioning suggests that how a smartphone is used may be at least as important as how long it is used. The coexistence of high smartphone exposure, non-neutral wrist positioning, and poor body posture may generate sustained and repetitive biomechanical loading across the upper extremity.

This distinction has practical implications for prevention. Strategies limited to reducing screen time may overlook modifiable mechanical behaviors occurring during necessary academic smartphone use. University-based interventions could therefore combine scheduled microbreaks with education on neutral wrist alignment, bilateral device handling, forearm support, and avoidance of prolonged unsupported or flexed postures. The high prevalence of wrist pain (82.1%) further suggests that ergonomic screening could be incorporated into student health promotion initiatives. Nevertheless, the cross-sectional design prevents determination of temporal sequence, and the crude associations may be influenced by confounding. Prospective studies incorporating objective exposure measurements and multivariable modeling are needed to determine whether modification of these ergonomic behaviors reduces subsequent wrist symptoms.

DISCUSSION

This study indicates that wrist pain among university students is better understood as the result of an interconnected ergonomic exposure pattern rather than as a consequence of smartphone duration alone. Wrist pain was reported by 82.1% of participants, while high smartphone use, non-ergonomic wrist positioning, and non-ergonomic body posture were each significantly associated with the outcome. The pattern of effect estimates is particularly informative. High smartphone use was associated with greater odds of wrist pain, but the magnitude of association was larger for non-ergonomic body posture and strongest for non-ergonomic wrist position. This suggests that the mechanical conditions under which smartphones are used may be as important as the amount of time spent using them.

The strong association observed for wrist position is biomechanically plausible. Smartphone interaction requires repeated gripping, scrolling, tapping, and typing, often while the wrist is maintained outside a neutral position. In this study, wrist ergonomics were assessed through indicators such as wrist bending, sustained non-neutral alignment, prolonged one-handed use, and static hand positioning. These behaviors may increase localized mechanical loading on muscles, tendons, and surrounding soft tissues. The finding that 94.0% of students with a non-ergonomic wrist position reported pain, compared with 60.7% of those with an ergonomic position, reinforces the relevance of wrist alignment in smartphone-related musculoskeletal complaints. Even so, this pattern should be interpreted as an association because exposure and outcome were measured at the same time^{12,13}.

Body posture also appears to contribute to the overall ergonomic burden. Smartphone use involves coordinated positioning of the head, trunk, shoulders, arms, and wrists. The study assessed several postural behaviors, including trunk flexion, downward head positioning, prolonged static posture, smartphone use while lying down, and unsupported arm positioning¹⁴. The association between non-ergonomic posture and wrist pain suggests that distal symptoms may be influenced by the organization of the entire upper-body kinetic chain. Unsupported arms may increase the muscular effort needed to stabilize the device, while flexed or asymmetrical postures may alter the way mechanical loads are transmitted through the forearm and wrist¹⁵.

Taken together, the findings support an integrated ergonomic exposure model in which duration, wrist mechanics, and whole-body posture operate as interrelated dimensions. Prolonged smartphone use creates the duration of exposure, while wrist and body positioning determine the biomechanical quality of that exposure¹⁶. This distinction has practical value because smartphone use cannot realistically be eliminated from university life¹⁷. The more relevant prevention question is not simply whether students should reduce smartphone use, but whether necessary smartphone use can be reorganized in ways that lower cumulative mechanical strain.

The present findings are broadly consistent with previous evidence discussed in the source manuscript. Earlier studies have linked prolonged smartphone use with upper-extremity musculoskeletal complaints, including symptoms affecting the hand and wrist. The manuscript also identifies repetitive gripping, scrolling, and prolonged static loading as possible mechanisms through which muscular fatigue and soft-tissue stress may develop. In the current sample, 42 of 47 students with high smartphone use experienced wrist pain, and the Chi-square test showed a significant association between smartphone-use category and wrist symptoms. This pattern supports the idea that repetitive smartphone activity performed without adequate recovery may contribute to musculoskeletal discomfort^{18,19}.

The findings also align with previous work emphasizing wrist alignment. The literature cited in the manuscript identifies wrist position during smartphone gripping as an important factor related to pain and carpal tunnel-related symptoms. The current study extends that perspective by examining wrist position alongside smartphone exposure and body posture in the same analytical framework. This is important because duration alone may provide an incomplete picture of ergonomic risk^{20,21}. Two students may use smartphones for similar periods but experience very different mechanical demands if one maintains a relatively neutral wrist with arm support while the other uses the device one-handed with sustained wrist deviation.

The relationship between body posture and wrist pain is also compatible with previous observations on smartphone-related postural adaptation. The source manuscript describes forward head posture, downward head positioning, shoulder flexion, and prolonged static posture as common features of smartphone use and notes their relationship with increased musculoskeletal loading. Previous work cited in the manuscript has also examined smartphone use in relation to forward head posture and hand pain among university students^{22,23}. The current findings suggest that the consequences of poor smartphone posture may not be limited to the neck and shoulders but may extend to the distal upper extremity.

A notable contribution of this study is its simultaneous consideration of three related exposures. Much of the earlier literature summarized in the manuscript focuses on individual dimensions of smartphone behavior or on specific musculoskeletal regions^{24,25}. The research gap identified in the source document was the limited simultaneous assessment of smartphone use, wrist positioning, and body posture in relation to wrist pain. The present findings address that gap

by showing that all three dimensions are relevant at the bivariate level and should be considered together when developing an ergonomic explanation of smartphone-associated wrist symptoms.

However, the findings should not be interpreted as proving that wrist position is definitively more important than duration or body posture. Although the crude odds ratio for non-ergonomic wrist position was substantially larger, the confidence interval was wide, indicating statistical imprecision^{26,27}. The three exposures may also be correlated. Students who use smartphones for longer periods may simultaneously spend more time in non-neutral wrist positions and unsupported body postures. Because the original analysis did not include multivariable adjustment, the independent contribution of each exposure cannot be separated from the shared behavioral pattern. The conceptual contribution of this study is therefore stronger than any claim of causal hierarchy: smartphone-related musculoskeletal risk appears multidimensional.

Several limitations should be considered when interpreting the results. First, the cross-sectional design measured exposures and wrist pain within the same study period. This means that temporality cannot be established²⁸. It is possible that non-ergonomic smartphone behavior preceded pain, but it is also possible that students with existing wrist discomfort changed how they held or used their devices. For this reason, causal terms such as effect, cause, or predictor should be used cautiously.

Second, participants were recruited using accidental sampling rather than a probability-based approach. Although this method was practical, it may have introduced selection bias and limits the generalizability of the findings. The sample was drawn from a single undergraduate Public Health program at one university, so smartphone-use behaviors and ergonomic environments may differ from those found in other faculties, universities, or regions.

Third, the sample size was modest, with 78 participants, and only 14 students were classified as not having wrist pain. This imbalance contributes to the wide confidence intervals observed for several odds ratios, particularly the estimate for wrist position. The large crude effect size for non-ergonomic wrist position should therefore be interpreted as a signal of association rather than a precise estimate of risk magnitude.

Fourth, the exposure variables were based largely on questionnaire responses. Although the questionnaire was informed by RULA ergonomic principles and wrist pain was assessed using the NRS, the manuscript does not report validity coefficients or reliability statistics for the study-specific instrument. Smartphone duration was also not measured using objective device logs, and posture was not assessed through continuous observation or sensor-based recording. Recall bias and exposure misclassification therefore remain possible.

Another important limitation is that the original analysis was restricted to univariate and bivariate statistics. The odds ratios reported in this manuscript are crude estimates and do not show whether smartphone use, wrist position, and body posture remain independently associated with wrist pain after adjustment for one another or for potential confounders. This is particularly important because ergonomic behaviors are likely to cluster within the same individual. Future research should move beyond cross-sectional association toward longitudinal exposure assessment. Prospective cohort studies could clarify whether high smartphone exposure and non-neutral ergonomic patterns precede the onset or worsening of wrist symptoms. Repeated measurement would also help distinguish transient discomfort from persistent musculoskeletal problems and determine whether changes in smartphone-use behavior are followed by meaningful changes in symptoms.

Future studies should also improve exposure measurement. Smartphone operating-system logs or validated screen-time applications could provide more objective estimates of duration and

frequency of use. Wearable sensors, photographs, video-based ergonomic assessment, or motion analysis could be used to characterize wrist angles, forearm support, trunk inclination, and sustained posture. Combining objective exposure measures with validated pain and functional outcomes would reduce dependence on self-report and strengthen the assessment of dose-response relationships.

Larger multicenter studies are needed to allow more robust multivariable modeling. Binary logistic regression or other appropriate generalized models could estimate adjusted associations while accounting for demographic characteristics and relevant behavioral or ergonomic covariates. Interaction analyses would also be useful to determine whether prolonged smartphone use becomes particularly problematic when combined with non-neutral wrist positioning or poor body posture. Such analyses would move the field away from isolated risk-factor identification toward the study of ergonomic exposure configurations.

Intervention studies are also warranted. Strategies such as maintaining neutral wrist alignment, using both hands, supporting the forearms, avoiding prolonged static positions, incorporating short breaks, and performing periodic stretching are consistent with the preventive recommendations described in the source manuscript. At the institutional level, universities could integrate digital ergonomics into student health promotion, orientation activities, learning-space design, and guidance for mobile learning. The broader implication of this study is not that smartphones should be regarded as inherently harmful, but that the ergonomic organization of intensive digital activity is a modifiable component of student health. Addressing that component may offer a practical and sustainable approach to reducing musculoskeletal complaints in increasingly digital academic environments.

CONCLUSION

This study demonstrates that smartphone-related ergonomic factors are significantly associated with wrist pain among university students. Wrist pain was reported by 82.1% of participants, indicating a substantial musculoskeletal burden in this population. High smartphone use, non-ergonomic wrist positioning, and non-ergonomic body posture were each associated with higher odds of wrist pain, with non-ergonomic wrist position showing the strongest crude association. These findings suggest that wrist symptoms are related not only to the duration of smartphone exposure but also to the biomechanical conditions under which devices are used. Given the cross-sectional design and absence of multivariable adjustment, these associations should not be interpreted as causal. Universities should incorporate digital ergonomics into student health promotion by encouraging neutral wrist positioning, appropriate arm support, balanced body posture, regular microbreaks, and avoidance of prolonged uninterrupted smartphone use. Future multicenter prospective studies using objective smartphone-use and postural measurements, validated ergonomic instruments, and adjusted multivariable models are needed to confirm these relationships and evaluate whether targeted ergonomic interventions can reduce wrist pain among university students.

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Conflict of Interest

The author(s) declare no financial, professional, or personal relationships that could have influenced the design, conduct, analysis, interpretation, or reporting of this study.

Authors' Contributions

M. Shoadiqin: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, and Writing – Original Draft.

Hendrik: Methodology, Validation, Supervision, and Writing – Review & Editing.

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Declaration of Generative AI Use

During manuscript preparation, generative artificial intelligence tools were used only to assist with language refinement, organization, and improvement of academic readability. The authors critically reviewed and revised all AI-assisted content and remain fully responsible for the accuracy, interpretation, originality, and integrity of the manuscript. Generative AI was not used to generate, alter, or fabricate research data, statistical results, participants, or primary research findings.

Data Availability Statement

The data supporting the findings of this study were obtained from primary questionnaire responses collected from participating students. Because the dataset contains participant-level research information, it is not publicly deposited. De-identified data may be made available by the corresponding author upon reasonable request, subject to institutional requirements and appropriate safeguards for participant confidentiality.

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