Posture and musculoskeletal implications for students using mobile phones because of learning at home policy

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Abstract
There is an increasing trend of awkward postures due to smartphone use among students learning from home. Previous research in several countries has shown that the use of smartphones during a pandemic impacts musculoskeletal complaints. This study aimed to determine the postures performed by the students when using mobile phones and their implications for musculoskeletal complaints. A total of 709 students who learned from home voluntarily completed an online questionnaire regarding identity, work posture, and duration, while muscle and bone complaints experienced when using mobile phones were obtained through the Nordic Musculoskeletal Questionnaire. Furthermore, a bivariate analysis of body postures was carried out to identify perceived complaints using the chi-square method. The results showed a significant relationship between standing and leaning on a table posture (p-value: 0.026) with elbow, knee, and ankle complaints.

Keywords
Mobile phone, student, learning from home policy, musculoskeletal

Background
The use of technology is rapidly increasing, and data from Statista show that smartphone ownership is expected to rise from 3.7 billion in 2016 to approximately 6.3 billion in 2021. In Indonesia, smartphone users have reached 167 million, with the majority being young people between the ages of 25 to 34 years. Before the pandemic, studies in several countries showed that smartphone use caused musculoskeletal complaints, especially in the neck, shoulders, and upper back. This condition triggers the occurrence of musculoskeletal disorders later in life.

At the beginning of the pandemic, the Indonesian government implemented a policy of working and studying from home to prevent the transmission of the virus. Most of the activities carried out face-to-face were forced to switch to online, including teaching and learning activities in universities. With the increase in activities carried out online, direct communication device uses also increased. A study shows that online learning increases screen time so that static posture in some parts of the body also increases. Based on the integrated model proposed by Karsh, work posture causes physical strain, such as tissue loads, which then causes physiological changes (muscle tension, tissue deformation, and muscle fatigue) and ultimately causes work-related musculoskeletal disorders. However, this is still influenced by several individual factors, such as physical capacity, psychological capacity, genetics, fatigue tolerance, coping, ageing, and gender.

Previous research in several countries has shown that the use of smartphones during a pandemic impacts musculoskeletal complaints. However, most studies only focus on the distribution of musculoskeletal complaints in certain body parts. A study reveals that postures of
smartphone use only focus on neck complaints. In fact, studying from home has implications for static postures in some parts of the body that are performed at the same time. There is little research to identify various body postures when learning to use a smartphone. In addition, research on the posture of smartphone use among Indonesian students during the pandemic is still limited. Therefore, this study aimed to explain the postures performed by Indonesian university students while using smartphones during the pandemic and the associated musculoskeletal complaints (Figure 1).

Methods

Sample population

This study targeted active students pursuing diplomas, bachelor’s, master’s, doctoral, and professional education at an Indonesian university. This research includes students who are still registered (not on leave), use smartphones to study online, and are willing to be respondents. The minimum sample required was calculated using Slovin’s formula with a 95% confidence interval and 1% standard error (e) as follows:

$$n = \frac{N}{1 + Ne^2}$$

We consider that the student population registered reached 39,791 (N) in the 2019/2020 session. Therefore, the results indicated a minimum sample (n) is 655, but 709 respondents were successfully recruited for this study.

Data collection

The respondents were chosen by stratified random sampling to ensure that the number of vocational, bachelor’s, master’s, doctoral, and professional students from all faculty was still proportionate. The online questionnaire was distributed to all students through the university’s

| **Table 1. Sociodemography of respondents.** | Frequency | Percentage (%) |
|---------------------------------------------|-----------|----------------|
| **Gender**                                  |           |                |
| Male                                        | 227       | 32.0           |
| Female                                      | 482       | 68.0           |
| **Age**                                     |           |                |
| ≤20 years                                   | 338       | 47.7           |
| 21–30 years                                 | 273       | 38.5           |
| 31–40 years                                 | 74        | 10.4           |
| 41–50 years                                 | 21        | 3.0            |
| 51–60 years                                 | 3         | 0.4            |
| >61 years                                   | 0         | 0.0            |
| **Programme**                               |           |                |
| Vocational                                  | 19        | 2.7            |
| Bachelor                                    | 473       | 67.4           |
| Master                                      | 178       | 25.4           |
| Doctoral                                    | 16        | 2.3            |
| Profession                                  | 16        | 2.3            |
| **Usage period**                            |           |                |
| ≤5 years                                    | 54        | 7.6            |
| 6–10 years                                  | 343       | 48.4           |
| >10 years                                   | 309       | 43.6           |
Table 2. Bivariate analysis of body posture’s frequency and the subjective complaints.

| Body posture | Frequency per day | Subjective musculoskeletal complaint | Yes | %  | No. | %  | P-value |
|--------------|------------------|--------------------------------------|-----|----|-----|----|---------|
|              |                  |                                      | N   |    | N   |    |         |
|              |                  |                                      |     |    |     |    |         |
| Never        | 14               | Yes                                  | 73.68 | 14 | 26.32 | 5  | 0.138   |
|              | 59               | No                                   | 70.24 | 59 | 29.76 | 25 |         |
|              | 90               |                                       | 73.77 | 90 | 26.23 | 32 |         |
|              | 217              |                                       | 76.68 | 217| 23.32 | 66 |         |
|              | 161              |                                       | 82.99 | 161| 17.01 | 33 |         |
| <30 min      | 239              | Yes                                  | 76.85 | 239| 23.15 | 72 | 0.026*  |
|              | 239              | No                                   | 80.47 | 239| 19.53 | 58 |         |
|              | 50               |                                       | 70.42 | 50 | 29.58 | 21 |         |
|              | 0                |                                       | 0  | 0  | 0    | 0  |         |
|              | 13               |                                       | 56.52 | 13 | 43.48 | 10 |         |
| 30 min to 1 h| 133              | Yes                                  | 78.70 | 133| 21.30 | 36 | 0.306   |
|              | 294              | No                                   | 79.03 | 294| 20.97 | 78 |         |
|              | 74               |                                       | 69.81 | 74 | 30.19 | 32 |         |
|              | 37               |                                       | 72.55 | 37 | 27.45 | 14 |         |
|              | 3                |                                       | 75.00 | 3  | 25.00 | 1  |         |
| 1–3 h        | 61               | Yes                                  | 75.31 | 61 | 24.69 | 20 | 0.622   |
|              | 120              | No                                   | 73.17 | 120| 26.83 | 44 |         |
|              | 154              |                                       | 79.79 | 154| 20.21 | 39 |         |
|              | 154              |                                       | 78.57 | 154| 21.43 | 42 |         |
|              | 52               |                                       | 76.47 | 52 | 23.53 | 16 |         |
| >3 h         | 48               | Yes                                  | 75.00 | 48 | 25.00 | 16 | 0.887   |
|              | 135              | No                                   | 78.49 | 135| 21.51 | 37 |         |
|              | 143              |                                       | 74.87 | 143| 25.13 | 48 |         |

(continued)
internal occupational health, safety, and environment unit. All respondents gave their informed consent before they completed the questionnaire.

**Instruments**

The data collection was carried out with instruments adapted from the University of Queensland in Australia, which were developed from the previous studies and consisted of demographic and smartphone information. Furthermore, the duration of smartphone use in relation to work and posture were the independent variables and the skeletal symptoms were the dependent variables. After testing the questionnaire, each question item was tested using the item validity method. All questions were considered valid with an Rtable of 108 (df = N – 2) because the Rcount value was greater than the Rtable (0.108). Meanwhile, reliability was obtained through a Cronbach’s alpha value of 0.798. Hence, the questionnaire was reliable because the value was greater than the Rtable, 0.189. Furthermore, for data on musculoskeletal complaints, the Nordic Musculoskeletal Questionnaire (NMQ) was used.

**Data analysis**

Bivariate analysis was performed by performing a chi-square test on body and hand posture variables that have been categorised for musculoskeletal complaints in Table 2.

| Body posture | Frequency per day | Subjective musculoskeletal complaint |
|--------------|------------------|-------------------------------------|
|              |                  | Yes | % | No. | % | P-value |
|              |                 | N   | % | N   | % |
| 1–3 h        | 150              | 77.72 | 43 | 22.28 |
| >3 h         | 65               | 79.27 | 17 | 20.73 |
| Never        | 74               | 74.00 | 26 | 26.00 | 0.634 |
| <30 min      | 185              | 75.20 | 61 | 24.80 |
| 30 min to 1 h | 149              | 77.60 | 43 | 22.40 |
| 1–3 h        | 104              | 81.25 | 24 | 18.75 |
| >3 h         | 29               | 80.56 | 7  | 19.44 |
| Never        | 91               | 71.65 | 36 | 28.35 | 0.275 |
| <30 min      | 178              | 77.73 | 51 | 22.27 |
| 30 min to 1 h | 113              | 74.83 | 38 | 25.17 |
| 1–3 h        | 111              | 80.43 | 27 | 19.57 |
| >3 h         | 48               | 84.21 | 9  | 15.79 |
| Never        | 159              | 75.36 | 52 | 24.64 | 0.427 |
| <30 min      | 297              | 78.57 | 81 | 21.43 |
| 30 min to 1 h | 66               | 76.74 | 20 | 23.26 |
| 1–3 h        | 15               | 65.22 | 8  | 34.78 |
| >3 h         | 4                | 100.00 | 0  | 0.00 |

* means the p-value is under 0.05 that showed the significant relationship.
After obtaining a posture that has a significant relationship to musculoskeletal complaints in general, further chi-square testing is carried out on specific body parts that experience musculoskeletal complaints. Data analysis was performed using IBM SPSS version 25.

### Results

**Sociodemographic factors**

Based on the results, 68% of the respondents were female. The majority (47.7%) were below 20 years old, while...
47.7% were 21 to 30 years old. In addition, the majority were undergraduates (67.4%), while 48.4% had been using mobile phones for 6 to 10 years (Table 1).

**Body and hand posture analysis**

The bivariate analysis results (Table 2) showed a statistically significant relationship between the use of smartphones while standing and leaning on a table posture (p-value: 0.026). Table 3 shows that the grasping posture of holding the phone with both hands and thumbs was significantly associated with subjective musculoskeletal complaints (p-value: 0.041).

Further analyses showed that there was a significant relationship between standing and leaning on a table posture with musculoskeletal complaints in the elbow (p-value: 0.001), knee (p-value: 0.003), and ankle (p-value: 0.038). Meanwhile, gripping posture had no significant relationship with specific complaints (Table 4).

Comparing the duration of the postures (Table 5), those using smartphones more than 3 h per day tended to have 6.5 times the risk of elbow complaints and 3.2 times the risk of knee complaints than respondents who had never performed these postures. Meanwhile, using a smartphone for 30 min to 1 h carried 2.4 times the risk of an ankle complaint.

**Discussion**

In general, smartphone use contributes to increased musculoskeletal complaints, especially in the neck, shoulders, and upper back. However, this study showed different results, as explained below.

**Standing posture with table**

The results indicate that a standing posture by leaning on a table is significantly associated with elbow complaints. This is

| Posture | Neck | Shoulder | Upper back | Elbow | Lower back | Wrist | Knee | Ankle |
|---------|------|----------|------------|-------|------------|-------|------|-------|
| N       | 64   | 121      | 136        | 363   | 129        | 195   | 372  | 365   |
| %       | 11.83| 22.37    | 25.14      | 67.10 | 23.84      | 36.04 | 68.76| 67.47 |
| P-value | 0.339| 0.146    | 0.222      | 0.001*| 0.666      | 0.796 | 0.003*| 0.038*|

Table 4. Follow-up analysis.
because while using a smartphone with this body posture, the body weight is supported by the elbow with the forearm. Furthermore, Padua et al. showed that the ulnar nerve function is modified when using a smartphone with flexed elbows.

There was also a significant relationship between standing posture by leaning on a table and knee and ankle complaints. Previous studies have shown that a foot volume factor affects the compressive strength and floor temperature related to complex thermoregulation in the foot area.

Table 5. Comparison of duration per day and subjective musculoskeletal complaint.

| Posture | Frequency per day | Subjective musculoskeletal complaint | No | % | Yes | % | P-value | OR (95% CI) |
|---------|------------------|-------------------------------------|----|---|-----|---|---------|-------------|
| Elbow   |                  |                                     |    |   |      |   |         |             |
| Never   | 178              | 74.48                               | 61 | 25.52 | 1 |
| <30 min | 151              | 63.45                               | 87 | 36.55 | 0.01* | 1.670 (1.128–2.473) |
| 30 min to 1 h | 29 | 58.00 | 21 | 42.00 | 0.02* | 2.113 (1.123–3.977) |
| >3 h     | 4                | 30.77                               | 9  | 69.23 | 0.002* | 6.566 (1.952–22.087) |
| Knee    |                  |                                     |    |   |      |   |         |             |
| Never   | 176              | 73.64                               | 63 | 26.36 | 1 |
| <30 min | 165              | 69.04                               | 74 | 30.96 | 0.266 | 1.253 (0.842–1.864) |
| 30 min to 1 h | 25 | 50.00 | 25 | 50.00 | 0.001* | 2.794 (1.496–5.217) |
| >3 h     | 6                | 46.15                               | 7  | 53.85 | 0.04* | 3.259 (1.055–10.067) |
| Ankle   |                  |                                     |    |   |      |   |         |             |
| Never   | 173              | 72.38                               | 66 | 27.62 | 1 |
| <30 min | 157              | 65.69                               | 82 | 34.31 | 0.114 | 1.369 (0.927–2.021) |
| 30 min to 1 h | 26 | 52.00 | 24 | 48.00 | 0.005* | 2.420 (1.298–4.512) |
| >3 h     | 9                | 69.23                               | 4  | 30.77 | 0.805 | 1.165 (0.347–3.912) |

Grip posture with two hands

There was a significant association between grip posture with two hands and general musculoskeletal complaints. However, this study did not find a significant association in specific body areas because the NMQ does not consider the findings of specific finger complaints. This condition was supported by previous studies, which stated that grip posture with two hands tends to increase complaints in specific areas, such as the thumb and wrist, due to higher...
muscle pull than when using one hand.\textsuperscript{25} However, previous studies have also shown that this grip posture correlates with improved performance.\textsuperscript{25}

\textbf{Duration of posture}

The duration of smartphone use also contributes to the emergence of musculoskeletal complaints. Previous studies on duration and musculoskeletal complaints stated that pain and fatigue worsened with extended use.\textsuperscript{26}

The results of this study were in line with Karsh’s integrated model\textsuperscript{6} that the musculoskeletal complaints felt by students were influenced by their posture while using smartphones. Work postures, such as standing with a table, affect the pressure on the elbows, knees, and ankles, leading to musculoskeletal complaints. The appearance of complaints is caused by physical strain in the tissue load, followed by physiological changes. The same goes for the smartphone gripping posture.

\textbf{Limitations of the study}

This study cannot determine causality because the study design is cross-sectional. Then, it did not consider the confounding factors such as the history of injury and illness, additional work, and gender differences outside of learning activities because the focus was on posture in the general student population. Based on the previous literature, those confounding had a significant relationship with musculoskeletal discomfort.\textsuperscript{27–29} This study also did not consider the differences in faculties and study programmes at the university, which might have different duration of smartphone use. The musculoskeletal complaints felt by the respondents in this study may not only be caused by smartphones because sometimes they also use laptops, tablets, and computers simultaneously when learning online. Therefore, research with a specific population with specific gadgets should be carried out so that it can be more comprehensive.

\textbf{Implications}

Online learning forces many students to do bad postures because the study equipment (tables, chairs, etc.) used at home is not designed for learning. Moreover, the results of this study also show a significant relationship between learning posture and complaints in several body parts, such as the elbow, knee, and ankle. This study complements previous studies that found a significant association between back and neck. This proves that musculoskeletal complaints are getting wider in other body areas. This result makes sense because not all students have a specially designed and the same place to study as on campus. As illustrated in this study, they learn with various postures to suit their respective environments, whether on a bed, sofa, desk, and others. Musculoskeletal complaints will be more diverse with various learning postures and environments, not limited to the neck and back. Therefore, the policy regarding online learning needs to be reviewed, especially in terms of the duration of screen time and short breaks during online lectures. Students also need to pay attention to posture while using smartphones, prepare comfortable learning equipment, and a conducive condition of a learning environment.

\textbf{Conclusion}

Students using smartphones perform various postures in many variations, whether sitting, standing, supine, or prone. Based on this study, the postures of using a smartphone while leaning on a table are significantly related and have implications for the appearance of musculoskeletal complaints in the elbows, knees, and ankles. Likewise, holding the phone with both hands also has implications for musculoskeletal complaints. Therefore, students need to pay attention to body posture when using smartphones to minimise the physical strain experienced by the body. In addition, students need to pay attention to the duration of smartphone use because it also affects the incidence of musculoskeletal complaints. All students studying from home should be advised, where possible, to create an ergonomic workplace or study to minimise musculoskeletal complaints.

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