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Biomechanical analysis of posture and its relationship to musculoskeletal complaints in university students who frequently use mobile phones

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ABSTRACT

Background: Prolonged and excessive use of mobile phones in non-ergonomic postures, particularly those involving a forward head position that increases cervical spine loading and demands sustained neck muscle stabilization, may lead to musculoskeletal complaints involving the neck, shoulders, upper back, and arms. Therefore, this literature review aimed to examine studies related to the biomechanics of posture during mobile phone use and their impact on the musculoskeletal system.

Methods: This study employed a literature review method, which analyzed secondary data obtained from journals accessed through the PubMed and Google Scholar databases, using the keywords: "biomechanics," "smartphone addiction," and "musculoskeletal disorder. The article criteria were original research with an observational design, and available as open-access full-text articles.

Results: Based on the reviewed literature, non-ergonomic mobile phone usage postures were possibly associated with musculoskeletal complaints among students.

Conclusion: Mobile phone use in poor ergonomic postures was possibly associated with musculoskeletal disorders among college students. This literature review emphasizes the importance of ergonomics education and the implementation of preventive strategies in physiotherapy practice, particularly within student populations. Furthermore, the findings are expected to serve as a foundation for developing effective approaches to prevent musculoskeletal disorders related to mobile phone use among students.

Keywords: Biomechanics, musculoskeletal disorder, smartphone addiction

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Introduction

In today's technological era, mobile phones have become one of the most widely used communication tools. They are frequently utilized to access information, facilitate communication, and support academic activities. For students, mobile phones play a crucial role in literature searches and the learning process. Along with increasing academic demands, the duration of mobile phone use among students also tends to be high. Globally, prolonged smartphone use has been recognized as an emerging public health concern, particularly among young adults and students, due to its strong association with musculoskeletal disorders (MSDs) that affect posture, productivity, and overall well-being.[1]

Ergonomics is the scientific study of the interaction between humans and their work environment, with a focus on creating conditions that promote health, comfort, and performance.[2] Musculoskeletal disorders related to frequent mobile phone use are most commonly reported as neck pain, with prevalence ranging from 17.3% to 67.8% across different studies.[3] A study conducted at Gondar University, Ethiopia, reported that 47.4% of students who used mobile phones experienced neck pain within the past year.[3] Other studies have shown that the prevalence of musculoskeletal disorders

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associated with mobile phone use ranges from 8.2% to 89.9%, with common complaints including pain in the upper back, hands, neck, and shoulders.[4]

From a biomechanical perspective, prolonged flexion of the neck and forward head posture while using mobile phones significantly increase the mechanical load on the cervical spine and alter scapular kinematics.[5] These postural changes require sustained activation of the upper trapezius and levator scapulae muscles, which decreases local muscle perfusion, causes metabolite accumulation, and contributes to muscle fatigue and discomfort. Such mechanisms have been described as mobile phone head and neck syndrome, reflecting the physiological strain that develops from prolonged static posture during device use.[6]

Although numerous studies have examined the impact of mobile phone use on musculoskeletal disorders among students in various countries, few have quantitatively analyzed the biomechanical aspects of posture. Physiotherapy students, who are extensively trained in musculoskeletal health, are ironically also at risk of developing postural strain due to academic workloads and prolonged digital activities. This highlights a clear research gap concerning the biomechanical evaluation of posture during mobile phone use among physiotherapy students.

Therefore, this literature review aims to examine studies related to the biomechanics of posture during mobile phone use and their impact on the musculoskeletal system. The scope focuses on ergonomic aspects of the shoulder, neck, and upper back, with particular attention to musculoskeletal complaints among young adults and college students who frequently use mobile phones.

Methods

This study employed a literature review approach by analyzing secondary data from journals accessed through the PubMed and Google Scholar databases using the keywords: “biomechanics,” “smartphone addiction,” and “musculoskeletal disorder.” The selected journals were screened using predetermined inclusion and exclusion criteria. The inclusion criteria consisted of original research with an observational design, published in English, involving young adults and/or student populations, and published within the last five years (January 2020–May 2025). The exclusion criteria were studies that did not focus on the relationship between mobile phone users’ biomechanical posture and musculoskeletal complaints, studies not indexed in Sinta or Scopus, and those not available as open-access full-text articles. After the selection process, five journals were found to meet the inclusion criteria.

Results

After reviewing the five journals (Table 1), similarities were found regarding excessive mobile phone use and non-ergonomic postures, both of which significantly contribute to musculoskeletal complaints. Ayhualem et al. reported that 47.4% of students experienced neck pain within the past year, with a higher risk observed among fifth and sixth xyear students (AOR = 3.907 and 2.93; $p < 0.05$), indicating a significant association between year of study and neck pain.[3] Maayah et al. found that predictors of neck pain included sex, duration of mobile phone use, study hours, and history of previous pain (all significant, $p \leq 0.018$). Specifically, pain history and the hand used for writing significantly affected the severity of pain ($p < 0.001$).[7]

Susilowati et al. reported that 70.5% of an Indonesian university community working from home experienced musculoskeletal complaints, particularly in the neck (86.4%), lower back (75.9%), and shoulders (76.2%).[8]

Mustafaoglu et al. showed that the most common musculoskeletal complaints were neck pain (65.9%), upper back pain (70.3%), and hand pain (68.7%), with significant associations observed for daily smartphone use duration ($p = 0.001$), length of ownership ($p = 0.027$), and SAS score ($p = 0.002, 0.001, 0.033$), all of which increased the risk of pain.[9] Finally, Torkamani et al. found significant differences in SAS-SV, CVA, and FHD scores between addicted and non-addicted groups ($p < 0.001$). Neck extensor muscle endurance also differed significantly before Bonferroni correction ($p = 0.010$), but not after correction. No significant differences were observed in neck flexor endurance, joint position errors, or SA and SHA parameters ($p > 0.05$).[10]

Discussion

The reviewed journals consistently demonstrated that non-ergonomic mobile phone postures among students significantly contribute to musculoskeletal complaints. Across various studies, similar risk factors were identified, indicating that this problem arises from a combination of biomechanical stress and behavioral factors. These findings align with the broader understanding that sustained static postures and repetitive micro-movements during smartphone use can induce cumulative muscular strain and postural imbalance, leading to chronic discomfort if not addressed through preventive strategies.[11]

One study reported that 47.4% of students experienced neck pain within the past year, with contributing factors including mobile phone use for more than six hours per day, lack of rest breaks during prolonged use, and intensive mobile gaming. Students living in urban areas were found to be more vulnerable due to higher exposure compared to those in rural areas. Furthermore, lack of physical activity and smoking were identified as additional risk factors, as both negatively affect blood circulation and muscle health.3 This highlights that not only ergonomic but also lifestyle-related variables play a role in exacerbating musculoskeletal symptoms among young adults.[12]

Another study identified female gender, a history of previous pain, and long study hours using mobile phones as significant predictors of musculoskeletal complaints. Neck pain was associated with forward head posture and repetitive loading on the trapezius muscles. Clinical factors such as dehydration and lack of sleep were also associated with a lower pain threshold and delayed muscle recovery.[7] From a physiological standpoint, repetitive strain and insufficient

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Table 1. Results summary of the biomechanical analysis of posture and its relationship to musculoskeletal complaints in university students who frequently use mobile phones

Authors	Title	Methods	Results
Ayhualem et al., (2021)[3]	Burden of neck pain and associated factors among smart phone user students in University of Gondar, Ethiopia	Study design: Cross-sectional Participants: 845 university students Measuring instrument: a questionnaire developed by the researchers and adapted from the Nordic Musculoskeletal Questionnaire (NMQ). Inclusion criteria: students who have been using mobile phones for at least one year and who provided written informed consent after being informed about the benefits and purpose of the study Exclusion criteria: students with a history of musculoskeletal disorders and students who have undergone head or neck surgery	The study results showed that 47.4% of students experienced neck pain in the past year, with a higher risk observed among 5th- and 6th-year students (AOR 3.907 and 2.93; $p < 0.05$), indicating a significant relationship between year of study and neck pain
Maayah et al., (2023)[7]	Neck pain associated with smartphone usage among university students	Study design: Cross-sectional Participants: 867 university students Measuring instruments: The researchers used an online questionnaire, which was distributed through social media Inclusion criteria: Students over 18 years old who routinely use mobile phones Exclusion criteria: Students with chronic musculoskeletal conditions	Factors predicting neck pain included gender, duration of mobile phone use and study time, as well as a history of previous pain (all significant, $p \leq 0.018$). Pain and a history of hand-side discomfort while writing specifically influenced the severity of pain ($p < 0.001$)
Susilowati et al., (2022)[8]	The prevalence of bad posture and musculoskeletal symptoms originating from the use of gadgets as an impact of the work from home program of the university community	Study design: Cross-sectional Participants: 1083 university students Measuring instruments: Researchers used an online questionnaire distributed through social media	Study results show that approximately 70.5% of members of the university community in Indonesia who engaged in WFH experienced musculoskeletal complaints, particularly in the

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		Inclusion and exclusion criteria: Not explicitly explained	neck (86.4%), lower back (75.9%), and shoulders (76.2%)
Mustafaoglu et al., (2021)[9]	The relationship between smartphone addiction and musculoskeletal pain prevalence among young population: a cross- sectional study	Study design: Cross-sectional Participants: 249 university students Measuring instruments: The researchers used a questionnaire consisting of demographic information, the Smartphone Addiction Scale, and the Modified Nordic Musculoskeletal Questionnaire Inclusion criteria: Students aged 18–25 years, active mobile phone users for at least the past 6 months, and without chronic musculoskeletal disorders Exclusion criteria: Participants with a history of trauma or surgery in the musculoskeletal system within the past 6 months, and those reporting mental or neurological conditions that may affect pain perception	Study results show that musculoskeletal pain was most commonly reported in the neck (65.9%), upper back (70.3%), and hands (68.7%). Significant associations were found with longer daily smartphone use (p = 0.001), longer duration of smartphone ownership (p = 0.027), and higher SAS scores (p = 0.002, p = 0.001, p = 0.033), all of which increased the risk of pain in these areas
Torkamani et al., (2023)[10]	Relationships between cervical sagittal posture, muscle endurance, joint position sense, range of motion and level of smartphone addiction	Study design: Cross-sectional Participants: 60 university students Measuring instruments: Researchers used the Smartphone Addiction Scale – Short Version (SAS-SV) to assess the level of smartphone addiction, as well as neck flexor and extensor muscle endurance tests (NFMET and NEMET) to measure muscle strength. In addition, cervical range of motion was measured using a goniometer, and image analysis tools were employed to assess head flexibility and	Results show that SAS-SV, CVA, and FHD scores were significantly different between the addictive and non-addictive groups (p < 0.001). Neck extensor muscle endurance also showed significant differences before Bonferroni correction (p = 0.010), but not after the correction. No significant differences were found in neck flexor muscle endurance, joint position error, as well as in SA and SHA parameters (p > 0.05)

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	posture parameters, including craniovertebral angle (CVA), shoulder angle (SA), sagittal head angle (SHA), and forward head distance (FHD) Inclusion and exclusion criteria: Not explicitly explained

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recovery periods may accelerate the onset of muscle fatigue and microtrauma in cervical and scapular stabilizers, thereby worsening pain perception.[13]

In addition, poor postures such as sitting on the floor without proper support while using mobile devices were major contributors to musculoskeletal complaints among students.[14] Other contributing factors included insufficient rest, lack of stretching, and limited physical activity. Psychological stress from academic demands was also found to exacerbate muscle tension, thereby worsening musculoskeletal symptoms.8 Psychosocial stress is known to increase sympathetic nervous system activity, promoting muscle hypertonicity and reducing relaxation capacity, which can further intensify perceived pain levels.[15]

Further evidence highlighted poor posture habits, such as forward head position and rounded shoulders during mobile phone use, as significant contributors to musculoskeletal discomfort.[16] Intensive activities such as prolonged gaming or typing were associated with higher risk, and female students were found to be more vulnerable than males, likely due to biomechanical differences such as lower muscle strength and longer durations of mobile phone use. The combination of poor posture, prolonged duration, and repetitive activities creates excessive stress on muscles and joints, ultimately provoking pain and discomfort.[9] These results reinforce the importance of understanding gender-specific ergonomic risks and muscle endurance capacity when developing targeted preventive interventions in academic settings.[17]

Students categorized as addicted to mobile phones showed significant changes in neck posture, including reduced craniovertebral angle and increased forward head deviation.[18] These changes were attributed to sustained forward head posture, which increases cervical spine loading. Neck extensor muscle endurance was also lower among the addicted group, suggesting muscle fatigue resulting from prolonged use. Lack of physical activity and daily use exceeding six hours further worsened the condition. Additionally, static postures and repetitive movements during mobile phone use may provoke microtrauma in the soft tissues of the neck, leading to musculoskeletal pain.[10] Biomechanically, such sustained loading may alter cervical curvature and disrupt proprioceptive control, contributing not only to pain but also to impaired postural stability over time.[19]

Several strengths can be identified from the reviewed studies, including the use of cross-sectional designs and validated measurement instruments such as the smartphone addiction scale and the nordic musculoskeletal questionnaire. Large sample sizes with student populations also enhance the credibility and generalizability of the findings to the broader student community.[20] However, certain limitations should be acknowledged. This review relied primarily on open-access sources, excluding closed-access journals that may contain higher-quality studies.[21] Limited access to paid databases may have restricted the comprehensiveness of the findings. Furthermore, the lack of experimental biomechanical testing in most studies prevented an in-depth and objective analysis of muscle load and postural angles. Lastly, the inclusion and exclusion criteria were based only on topic relevance and publication year, without applying a systematic framework such as population, intervention, comparison, outcome (PICO).

Overall, the findings from the reviewed studies demonstrate that prolonged and non-ergonomic smartphone use imposes excessive biomechanical strain on the cervical and shoulder regions through sustained muscle contraction, postural deviation, and repetitive loading. Integrating these findings into physiotherapy education and practice can help enhance ergonomic awareness and promote early intervention strategies to prevent chronic musculoskeletal dysfunction. These mechanisms highlight the importance of ergonomic education, postural correction, and preventive physiotherapy strategies to reduce the risk of musculoskeletal complaints among students.

Conclusions

This study demonstrates that non-ergonomic mobile phone usage is significantly associated with musculoskeletal complaints among students who are active users. It also highlights the importance of ergonomics education and the implementation of preventive approaches within physiotherapy practice, particularly for student populations. Future research is recommended to employ observational designs with stronger methodologies, larger and more representative samples, in order to enhance the validity of findings, broaden the generalizability of results, and minimize potential biases. Hopefully, this study can serve as a foundation for developing preventive strategies against musculoskeletal disorders caused by mobile phone use.

Conflict of interest

The authors declare that there are no potential conflicts of interest, financial or otherwise, that could be construed as influencing the research, the preparation of the manuscript, or the publication and dissemination of this manuscript. All authors affirm that their participation in this study and the preparation of this manuscript were conducted with the highest scientific integrity and without external pressures or personal interests that could compromise the objectivity or validity of the reported findings.

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Author contributions

MSAAR developed the study design, conducted data collection, and prepared the initial manuscript; IPYPP and IPGSA were responsible for data collection and provided revisions to the manuscript.

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Ethical clearance

This review study utilized publicly available published articles, so informed consent and ethical approval were unnecessary.

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