The effect of maximum voluntary neck flexion on neck muscle activity during smartphone usage

Rounak Bhattacharya [1], Laureb Rao[2], Mahshida Hamid[3], Anoop Chawla[1,2,3], Kaushik Mukherjee[1,2,3]
[1]School of Interdisciplinary Research, Indian Institute of Technology Delhi, New Delhi, India
[2]Transportation Research and Injury Prevention Centre, Indian Institute of Technology Delhi, New Delhi, India
[3]Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi, India
Email: srz208258@iitd.ac.in

Summary

Excessive forward neck flexion during smartphone use imposes a significant strain on neck muscles, heightening the likelihood of chronic neck pain and musculoskeletal issues. The primary aim of the study was to examine how maximum voluntary neck flexion impacts neck muscle activity during smartphone usage through subject-specific musculoskeletal modelling. The results indicated that forward neck flexion during smartphone use increased muscle activity in the SP, SS, and CES muscles relative to a neutral neck position.

Introduction

Smartphones have become deeply embedded in modern life, playing critical roles in both personal and professional activities. Studies across multiple nations indicate a steady increase in smartphone usage, with average daily use exceeding 2.4 hours and many people spending over 5 hours per day [1]. While smartphones offer significant convenience, its prolonged use imposes considerable physical strain on the neck, shoulders, and upper back muscles [2]. Many users unconsciously adopt extreme forward head postures during smartphone use, leading to high stresses on the neck muscles. This forward flexion, especially during texting, elevates neck muscle activity and heightens the risk of chronic neck pain and musculoskeletal disorders [2]. Therefore, ergonomic recommendations are essential to reduce the neck muscle strain and prevent injury during smartphone use. The primary aim of this study was to investigate the effect of maximum voluntary neck flexion on neck muscle activity while using smartphones through subject-specific musculoskeletal modelling.

Methods

One healthy adult male (age: 31 years; height: 1.78 m; weight: 76 kg) was recruited for this study following approval from the institutional ethics committee. The participant was right-handed, used a smartphone for at least 2 hours daily, and had no history of musculoskeletal symptoms in the neck or upper extremities. The participant performed texting on a smartphone using both hands in a voluntary forward neck flexion posture while standing. Ten trials were conducted, each lasting for 1.5 minutes. Anatomical landmarks were palpated, and retroreflective markers were attached to the skin with double-adhesive tape. Head motion was tracked using a headband with four markers, along with additional markers placed on the C7, sternum, and both acromions. The three-dimensional positions of the markers were captured using a 12-camera motion capture system (Oqus 300, Qualisys, Sweden) with a sampling frequency of 100 Hz. Surface electrodes (Ultium EMG, Noraxon USA Inc., Scottsdale, AZ) were bilaterally placed on the Cervical Erector Spinae (CES) and Upper Trapezius (UT) muscles, with the acquisition frequency set at 2,000 Hz. An OpenSim-based head-neck musculoskeletal model [3] was scaled to match the subject's anthropometry. An inverse dynamics based static optimization was performed to estimate the muscle activations. The optimization routine minimized the sum of squared muscle activations.

Results and Discussion

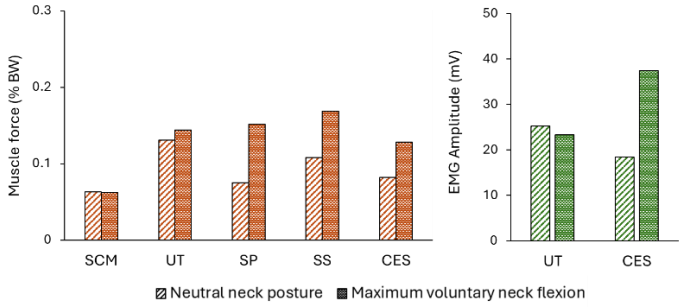

***Figure 1**: (a) OpenSim predicted (b) EMG measured muscle activity. Abbreviations: Sternocleidomastoid (SCM); Upper Trapezius (UT); Splenius (SP); Semispinalis (SS), Cervical Erector Spinae (CES)*

Forward neck flexion during smartphone usage increased muscle activity compared to a neutral neck posture [Fig. 1]. Specifically, predicted muscle activity for the SP, SS, and CES muscles was significantly higher during flexion than in a neutral posture. Additionally, EMG-measured CES muscle activity increased with greater neck flexion angles.

Conclusions

Using a smartphone in a near-maximum neck flexion posture significantly increases neck muscle loading, potentially raising the risk of neck pain and musculoskeletal disorders. Moreover, using smartphones in such postures for a longer duration may worsen neck problems. Future research should focus on muscle fatigue from long-duration smartphone usage in various postures to help develop recommendations for optimal smartphone usage posture.

References

[1] Chen, YL et al. (2024). *Sci. Rep*., **14.1**: 12994.
[2] Tapanya, W et al. (2021). *Int. J. Ind. Ergon*., **85**: 103175.
[3] Mortensen, JD et al. (2018). *PLOS One*, **13.6**: e01999.