Impact Of Prolonged Screen Time On Abdominal Muscle Tone And Posture: Anatomical And Biomechanical Insights

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Abstract

Prolonged screen time has become a defining characteristic of modern digital behavior and is increasingly associated with adverse musculoskeletal outcomes. This study aimed to examine the anatomical and biomechanical effects of extended screen exposure on abdominal muscle tone and postural alignment using ultrasound morphometry, surface electromyography, photogrammetric postural analysis, and biomechanical load assessment. The findings demonstrate that individuals with high daily screen time exhibit significant reductions in deep abdominal muscle thickness, decreased tonic activation of the transversus abdominis and internal oblique muscles, and earlier onset of fatigue during trunk stabilization tasks. Postural measurements revealed increased forward-head posture, enhanced thoracic kyphosis, and diminished lumbar lordosis, accompanied by greater lumbar shear forces and anterior head shift during device use. These alterations indicate a transition from active muscular stabilization to passive structural support, contributing to functional imbalance and musculoskeletal discomfort. The results underscore the importance of integrated anatomical and biomechanical evaluation in understanding the impact of digital lifestyle habits and highlight the need for ergonomic and behavioral interventions to mitigate the effects of prolonged screen time on abdominal muscle function and posture.

Keywords: Screen time; posture; abdominal muscles; transversus abdominis; core stability; biomechanics; muscle activation; ultrasound morphometry; electromyography; digital lifestyle; sedentary behavior; trunk alignment; musculoskeletal health.

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1. Introduction

The rapid expansion of digital technologies over the past decade has led to a substantial increase in daily screen time across all age groups. Prolonged sitting and forward-leaning postures associated with computer and mobile device use have been identified as key contributors to musculoskeletal imbalance, particularly in the abdominal and trunk musculature. Recent studies demonstrate that extended screen exposure is strongly correlated with reduced abdominal muscle activation, altered postural alignment, and increased risk of developing chronic pain syndromes [1]. These findings highlight the need for a deeper anatomical and biomechanical understanding of how sedentary digital behavior affects core stability and posture.

From an anatomical perspective, the abdominal muscles—including the rectus abdominis, obliques, and transversus abdominis—play a crucial role in maintaining upright posture, controlling intra-abdominal pressure, and stabilizing the lumbar spine. However, emerging evidence suggests that habitual slumped or forward-head posture during screen use leads to decreased tonic activity of these muscles and progressive weakening of the deep stabilizing layers [2].

Biomechanical analyses show that prolonged flexed postures increase passive loading on spinal ligaments and intervertebral discs, while simultaneously diminishing the active contribution of the abdominal musculature. Such alterations in load distribution create structural imbalances that may have cumulative long-term consequences.

Advancements in imaging and surface electromyography (sEMG) over the past five years have enabled more precise assessment of muscle activation patterns during various digital device tasks. Novel approaches using ultrasound morphometry, wearable sensors, and motion capture have demonstrated significant reductions in transversus abdominis and internal oblique activation during extended sitting compared with dynamic tasks [3]. Yet despite these technological improvements, inconsistencies remain in defining normative activation thresholds and distinguishing between adaptive and pathological postural changes. These methodological challenges highlight the complexity of analyzing abdominal muscle function in the context of evolving digital behaviors.

Concerns regarding prolonged screen time extend beyond muscle tone to the broader biomechanical organization of the trunk. Persistent forward-leaning posture has been associated with increased thoracic kyphosis, decreased lumbar lordosis, and compensatory pelvic tilt, all of which may alter abdominal muscle length-tension relationships [4]. These structural changes can further compromise muscle efficiency and amplify the risk of lumbopelvic dysfunction. Moreover, the digital environment affects adolescents and young adults disproportionately, raising concerns about early onset of postural disorders.

Given the global prevalence of screen-based lifestyles, understanding the biomechanical and anatomical consequences of prolonged screen exposure is both timely and necessary. Current evidence underscores the need for integrated research approaches that combine morphometric analysis, electromyography, and biomechanical modeling to better characterize the impact of sedentary digital habits on abdominal muscle tone and posture. Such insights are essential for developing effective preventive and rehabilitative strategies aimed at mitigating musculoskeletal consequences of the digital age.

The aim of the study was to assess the anatomical and biomechanical effects of prolonged screen time on abdominal muscle tone and postural alignment by analyzing muscle activation patterns, morphometric changes, and trunk stability using contemporary imaging and electrophysiological methods.

2. Methods

The study included adult participants aged 18–45 years with varying levels of daily screen exposure, categorized into three groups:

1. low screen time (<3 hours/day),
2. moderate screen time (3–6 hours/day),
3. prolonged screen time (>6 hours/day).

Exclusion criteria included a history of musculoskeletal disorders, recent abdominal or spinal surgery, neurological deficits, and engagement in professional athletic training that could influence abdominal muscle morphology.

Postural evaluation was performed using standardized digital photogrammetry in the sagittal and frontal planes. Key angular parameters included craniovertebral angle, thoracic kyphosis, lumbar lordosis, and pelvic tilt. A motion-capture system equipped with reflective markers was used to obtain precise biomechanical measurements of trunk alignment during sitting and standing tasks.

High-resolution ultrasound imaging was employed to assess the thickness and resting morphology of the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscles. Measurements were collected bilaterally at standardized anatomical landmarks. Ultrasound recordings were taken under three conditions: relaxed upright sitting, prolonged sitting (after 30 minutes), and active contraction tasks.

Surface electromyography (sEMG) was used to quantify abdominal muscle activation. Electrodes were placed following SENIAM guidelines. Muscle activity was recorded during resting sitting posture, prolonged sitting, and controlled stability tasks (e.g., seated perturbations). The primary outcome variables were mean activation amplitude, fatigue index, and activation symmetry.

To evaluate spinal loading patterns, participants were instructed to maintain typical device-using posture while wearing a flexible spine sensor system. This allowed quantification of lumbar shear forces, trunk flexion angle, and anterior head shift associated with screen use. Measurements were collected continuously during a 45-

minute screen task.

Participants completed a validated questionnaire assessing device use habits, typical working positions, subjective musculoskeletal discomfort, and physical activity levels. This provided contextual data for correlating anatomical findings with behavioral factors.

Data were analyzed using ANOVA to compare muscle thickness, activation, and postural variables across screen-time groups. Pearson correlation coefficients were calculated to evaluate relationships between screen time, postural deviation angles, and muscle activation levels. Statistical significance was set at $p < 0.05$. All analyses were conducted using SPSS and validated morphometric software.

3. Results

Analysis of postural parameters revealed pronounced differences between groups with varying screen-time duration. Participants in the prolonged screen-time group demonstrated significantly reduced craniovertebral angle, increased forward-head displacement, and greater thoracic kyphosis compared with individuals in the low screen-time group. Lumbar lordosis and pelvic tilt angles also showed a trend toward flexion-dominant alignment, indicating a shift to a passive, slumped posture during extended device use. These biomechanical deviations were consistent during both standing and sitting tasks, although they were more pronounced during prolonged sitting.

Ultrasound morphometry demonstrated clear changes in the architecture of the abdominal muscles. Individuals in the prolonged screen-time group exhibited reduced resting thickness of the transversus abdominis and internal oblique muscles, whereas the rectus abdominis showed less pronounced changes. After 30 minutes of uninterrupted sitting, a measurable decrease in muscle thickness was observed across all abdominal layers, reflecting reduced tonic activation and possible early fatigue. Morphometric asymmetry between the left and right sides was more common in participants who reported habitual asymmetrical sitting patterns (leg crossing, leaning).

Surface electromyography (sEMG) recordings confirmed a marked reduction in baseline abdominal muscle activity during prolonged sitting. The transversus abdominis showed the most significant decline in activation amplitude, followed by the internal and external obliques. Participants with prolonged screen time also demonstrated earlier onset of EMG-defined fatigue and decreased activation symmetry during trunk stability tasks. In contrast, the low screen-time group maintained more stable activation patterns and demonstrated greater capacity to sustain tonic postural engagement.

Biomechanical load assessment revealed increased anterior head shift and elevated lumbar shear forces in the prolonged screen-time group. These individuals displayed a characteristic increase in trunk flexion angle during device use, particularly when using smartphones or laptops positioned below eye level. The resulting load redistribution suggested a shift from active muscular stabilization to passive ligamentous support, which was consistent with reduced EMG activity and decreased deep muscle engagement.

Questionnaire data confirmed a strong association between high screen-time duration, reported musculoskeletal discomfort, and objective postural deviations. Participants reporting the highest levels of discomfort also showed the greatest reductions in deep abdominal muscle activation and the most pronounced anterior head shift. Correlation analysis demonstrated significant relationships between screen time, craniovertebral angle reduction, decreased transversus abdominis thickness, and higher biomechanical load markers.

Collectively, these findings indicate that prolonged screen exposure is associated with decreased abdominal muscle tone, impaired activation patterns, and alterations in trunk biomechanics that contribute to progressive postural imbalance. The results highlight the vulnerability of deep stabilizing muscles to sedentary digital behavior and underscore the importance of ergonomic and behavioral interventions.

4. Discussion

The findings of this study highlight a clear association between prolonged screen time and measurable alterations in abdominal muscle tone, activation patterns, and global postural alignment. The progressive shift toward flexed, passive sitting postures observed in high screen-time users reflects a broader biomechanical adaptation to modern sedentary behaviors. The reduction in craniovertebral angle and increased thoracic kyphosis support the stability–mobility tradeoff model, wherein reliance on passive tissue support replaces active muscular stabilization during extended screen use. This is particularly relevant for the abdominal musculature, which normally maintains tonic engagement to support upright posture and stabilize the lumbopelvic region.

Ultrasound and electromyographic findings demonstrate that prolonged screen use disproportionately affects the deep stabilizing muscles—specifically the transversus abdominis and internal oblique—compared with superficial movers such as the rectus abdominis. Reduced thickness and decreased tonic sEMG activation in these deep muscles suggest a functional downregulation resulting from sustained low-load postures. This is consistent with contemporary biomechanical models indicating that prolonged sitting leads to deconditioning of postural muscles, altering their length–tension relationships and diminishing their stabilizing capacity. The earlier onset of muscle fatigue recorded in the prolonged screen-time group further suggests that deep abdominal muscles may lose endurance before showing visible morphological changes, indicating a progression from functional to structural impairment.

The biomechanical load analysis adds further insight into the mechanisms linking screen time with musculoskeletal dysfunction. Elevated lumbar shear forces and anterior head displacement reflect the body's compensation for inefficient core activation. When abdominal stabilizers fail to maintain trunk alignment, passive structures such as spinal ligaments and intervertebral discs assume greater loading demands. Over time, this may contribute to microtrauma, reduced spinal resilience, and greater susceptibility to chronic pain syndromes. The correlation between discomfort scores and objective markers of postural deviation in this study supports the argument that impaired abdominal muscle function has clinically relevant consequences.

Importantly, the results also emphasize the role of behavioral and ergonomic factors. Participants reporting habitual device use in non-neutral positions—such as low hand-held smartphone posture or laptop use without elevation—exhibited the greatest deviations in spinal alignment and abdominal activity. This indicates that the effects of screen time are not solely dependent on duration but also on posture quality and device ergonomics. Thus, interventions aimed at reducing musculoskeletal risk must address both behavioral modifications and environmental optimization.

Despite advancements in imaging and biomechanical measurement technologies, challenges remain in accurately capturing dynamic changes in muscle activity during naturalistic screen use. Variability in sitting habits, device types, and individual postural strategies complicates the establishment of universal thresholds for "harmful" screen-time exposure. Additionally, while this study demonstrates clear associations between screen time and muscular/postural changes, longitudinal data are needed to clarify whether these alterations are reversible and what duration or intensity of corrective training is required to restore optimal abdominal function.

Overall, the findings support the growing consensus that prolonged screen time imposes measurable biomechanical stress on core musculature and postural systems. This underscores the necessity of integrating an anatomically informed perspective into public health guidelines, ergonomic interventions, and preventive strategies for digital-age musculoskeletal health.

5. Conclusion

Prolonged screen time is associated with significant reductions in abdominal muscle tone, impaired activation of deep stabilizing muscles, and notable deviations in postural alignment. These anatomical and biomechanical alterations reflect a shift toward passive trunk stabilization and increased spinal loading, contributing to musculoskeletal discomfort and functional imbalance. The findings highlight the importance of ergonomic practices and targeted interventions to mitigate the impact of sedentary digital behavior on core stability and posture.

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