

# **Association of Musculoskeletal Disorders among Higher Secondary School Students Undergoing E-Learning as a Mode of Education**

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## **I. Introduction**

On January 30th, 2020, the Coronavirus (COVID-19) outbreak was declared a global pandemic by the World Health Organization (WHO) [1]. The rapid spread of the virus fundamentally disrupted nearly all aspects of human life. Governments worldwide imposed lockdowns and quarantines on billions of people as a preventive measure against uncontrolled infection rates. By the middle of 2020, more than 3 billion people were living under some form of restriction [2]. The direct health threat was severe, but the indirect social and educational effects were also unprecedented. Individuals of all age groups were forced to restructure their daily routines. Physical activity decreased substantially, while screen time for work, education, and leisure surged. One of the most significant transformations occurred in the education sector. Traditional classroom-based learning, which has been the cornerstone of education for centuries, was disrupted almost overnight. Schools and colleges closed in response to public health guidelines, leaving institutions scrambling to continue their operations. The solution, widely adopted across the globe, was a rapid shift to remote learning and e-learning modalities [3]. This shift ensured continuity of education but simultaneously introduced new challenges. Students, particularly at the school level, had to adapt to prolonged hours of digital engagement through laptops, smartphones, and tablets, often without prior preparation or adequate ergonomic guidance. E-learning refers to the use of digital platforms and the internet to deliver structured educational content to learners at remote locations. The attractiveness of e-learning lies in its flexibility, cost-effectiveness, and ability to transcend geographical barriers. Even prior to the pandemic, online learning was gaining ground as a complementary educational approach through blended classrooms and flipped teaching models. However, the pandemic accelerated its adoption, pushing both teachers and students to rely heavily on technology, often without time to assess or mitigate the associated risks [64,65]. While online learning created opportunities for lifelong learning and equitable access in some contexts, its sudden imposition revealed the vulnerabilities of students who were unprepared for extended sedentary screen time.

One of the most critical consequences of this change is its impact on physical health, particularly musculoskeletal health. Adolescents, who are already in a dynamic stage of physical growth, are highly susceptible to postural strain, repetitive stress, and musculoskeletal discomfort when subjected to improper ergonomics and sedentary routines [9,12]. Previous studies have consistently documented a strong association between excessive computer use and musculoskeletal complaints, particularly involving the neck, shoulders, and back [13,15]. Such findings highlight the urgent need to examine the broader health implications of the e-learning era.

## **II. Methodology**

This study employed a cross-sectional design to explore the association of musculoskeletal disorders among higher secondary school students engaged in e-learning. A total of 320 students participated, drawn from St. Stephen's School, Sector 45 Chandigarh, and Chandigarh Baptist School, Sector 45 Chandigarh. Convenience sampling was adopted due to feasibility constraints imposed by COVID-19 restrictions. Students in grades 10–12, aged 15–17 years, with access to laptops, desktops or smartphones.

### **Procedure**

A structured data collection sheet was developed by the researcher under supervision of a guide to investigate research questions. Demographic data including age, gender, height, and weight were collected, along with detailed information on social media usage (for learning, leisure, and communication). Device type (laptop, computer, smartphone) was documented.

The Nordic Musculoskeletal Questionnaire-Extended version (NMQ-E) was utilized to assess musculoskeletal problems across nine anatomical regions. The tool's reliability and validity in adolescent populations have been demonstrated in multiple studies [72,74,75]. In addition, participants rated their pain intensity using the Numeric Rating Scale (NRS), ranging from 0 ("no pain") to 10 ("worst imaginable pain").

These self-reports enabled both prevalence and severity assessment. Consent was obtained from students and their guardians via a Google Form (<https://forms.gle/8bM6v9dY68jFm87M6>). Data was collected using Google Forms (<https://forms.gle/z4cUcU3PPDRHTCYT7>), with links disseminated by class coordinators. A Zoom orientation session was held to explain procedures and clarify queries. Out of 325 submissions, 5 duplicates were excluded, leaving 320 valid responses for final analysis.

**Ethical Considerations**

Approval was obtained from institutional review authorities. Participation was voluntary, with informed consent ensured. Data anonymity and confidentiality were maintained throughout. Students with systemic illnesses, congenital deformities, or prior spine/neuromuscular disorders were excluded to reduce confounding factors.

**III. Results and Discussion**

The findings highlight a high prevalence of musculoskeletal pain among adolescents engaged in prolonged e-learning. NMQ-E responses indicated significant discomfort in multiple regions, with neck, upper back, and shoulders most affected, followed by wrists/hands, hips, thighs, and knees. Pain intensity varied, with several students reporting moderate-to-severe discomfort on the NRS.

These findings resonate with global studies documenting a surge in MSD prevalence among adolescents during the COVID-19 pandemic [2,50,56]. The sudden digital transformation heightened ergonomic risks, with students relying on suboptimal setups such as smartphones or poorly positioned laptops. Improper posture, prolonged sitting, and reduced physical activity were identified as contributing factors [13,15,55].

The current study reinforces evidence that adolescents are not immune to health burdens typically associated with adult office workers [21,24]. The dose-response relationship between screen exposure and MSDs has been highlighted in prior studies [9,12,23].

Our findings corroborate this trend, with higher daily e-learning hours correlating with more frequent and severe complaints. Comparative studies also reveal gender differences, with female students often reporting higher prevalence of neck and shoulder pain [18,24]. While our dataset did not explicitly stratify results by gender, anecdotal observation aligns with these trends. Future studies should examine sex-specific vulnerabilities more closely.

Psychological stress, increased academic workload, and diminished social interaction during quarantine may have compounded the problem. Literature shows that academic stress interacts with musculoskeletal discomfort, intensifying perception of pain [25]. Hence, interventions must address not only ergonomic corrections but also mental well-being.

This study relied on self-reported data, introducing recall bias, particularly for screen exposure durations. Absence of clinical examinations limited diagnostic confirmation. Convenience sampling from two schools in Chandigarh restricts generalizability.

Despite these limitations, the study offers crucial baseline data for adolescent musculoskeletal health in the Indian context.

**IV. Conclusion and Recommendations:**

This study demonstrates a significant association between e-learning and musculoskeletal disorders among higher secondary school students. Prolonged digital engagement, poor ergonomics, and reduced physical activity were key contributors to pain in regions such as the neck, shoulders, and lower back.

**IV. Recommendations include:**

1. Schools should integrate ergonomics training and awareness sessions for students and parents.
2. Students should be encouraged to follow the “20-20-20 rule” (20-second breaks every 20 minutes, with eyes focused 20 feet away) to reduce visual and musculoskeletal strain.
3. Incorporation of structured physical activity and stretching routines into daily schedules should be promoted.
4. Policymakers must prioritize ergonomic infrastructure for students, especially in contexts where online learning remains prevalent.
5. Future longitudinal studies are recommended to track musculoskeletal outcomes and evaluate interventions in adolescent populations.

By addressing these factors early, stakeholders can mitigate long-term health risks and promote sustainable, healthy digital learning environments for students transitioning to adulthood.

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