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Original Paper

Investigating the Relationship between Postural Abnormalities and Adolescent Musculoskeletal Pain Through Biostatistical and Orthopedic Approaches: A Cross-Sectional Biostatistical and Orthopedic Investigation

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Abstract

The development of postural abnormalities is now identified as a contributor to adolescents' musculoskeletal pain experience, although strong biostatistical evidence to support the association is sparse. This cross-sectional study investigated the relationship between postural abnormalities and musculoskeletal pain among 341 school-going adolescents (180 males, 52.8%; 161 females, 47.2%; mean age 14.25 ± 1.32 years) using a structured 20-item self-administered questionnaire combined with orthopedic assessment frameworks. Association of postural risk indicators with pain outcomes was analyzed using descriptive statistics, Pearson correlation, chi-square tests of independence and binary logistic regression analyses. Forward head posture was the most common postural abnormality (81.5%) and the overall prevalence of musculoskeletal pain was 78.9%, with a mean composite musculoskeletal pain score of 4.27/5. There was a moderate to strong correlation between the composite postural and pain scores ($r = 0.646$, $p < 0.001$), and the postural abnormality accounted for 41.7% of the variance in the pain scores ($R^2 = 0.417$). Taking the other extreme, high postural abnormality was significantly correlated with high pain classification as detected by Chi-square analysis ($\chi^2 = 47.79$, $p < 0.001$). Logistic regression identified forward head posture (OR = 3.84), prolonged static neck posture (OR = 3.12), backpack overload (OR = 2.74), prolonged sitting (OR = 2.41), and hard pillow use/sleep posture (OR = 1.96) as independent predictors of high pain risk, while gender was not significant. These results suggest that postural deformities are modifiable and clinically relevant risk factors for adolescent musculoskeletal pain and justify incorporating early postural assessment, ergonomic education and

physical activity programs that focus on postural improvements into school health promotion initiatives.

Keywords

Postural abnormalities, Musculoskeletal pain, Adolescents, Forward head posture, Biostatistical analysis, Orthopedic assessment, Cross-sectional study

1. Introduction

1.1 Background of the Study

The alignment or positioning of the body in relation to the base of support, the centre of mass and gravity is called Posture. Mechanical stress on the musculoskeletal system and efficient performance of neuromusculoskeletal system are minimised when the body is in optimum posture (Ozdemir et al., 2021). Disruption of this alignment causes postural abnormalities, which lead to pathological loading across joints, muscle and intervertebral discs (pathological loading patterns) which when sustained over time have a significant contribution to pain and functional limitation.

The most common postural problems reported in adolescents are forward head posture (FHP), rounded shoulders, thoracic hyperkyphosis, lumbar hyperlordosis and scoliosis. FHP places anterior stress on the head in relationship to the cervical spine, elevating the stress in the cervical extensors and increasing compression in the facet joints and intervertebral discs. The effective cervical load increases by approximately 4.5kg for every anterior head movement of 1cm (Pacheco et al., 2018). In addition, the rounded shoulders and thoracic kyphosis change the biomechanics of both the glenohumeral and also scapulothoracic joint, putting the adolescent at risk for pain in the shoulder and upper back.

Increasing postural deviations in adolescents are associated with increased use of digital technology and lack of physical activity. Adolescents spend a lot of time sitting in mostly static, unsupported positions, typically 4 to 6 hours daily. Bučan Nenadić et al (2022) conducted a systematic review in 2022 and found strong associations between excessive amounts of screen time and musculoskeletal pain in youths over a study period of two hours a day. Adopting elongated static positions, inactivity and the school bag combined, subject occupants to a complex of risk factors that require intensive investigation.

1.2 Problem Statement

Musculoskeletal pain in school-going adolescents is now acknowledged as a major health burden in many countries around the world, but is often ignored, underestimated or trivialised as a passing discomfort. Epidemiological studies show that life-time prevalence of neck pain in adolescents varies between 20% and 70% and cross-sectional studies have demonstrated that the prevalence of back, shoulder and cervical pain is also high among children younger than 14 years old (Minghelli, 2020). This is worrying as adolescent musculoskeletal pain is a significant risk factor for adult musculoskeletal pain, affecting quality of life, school attendance and performance and physical function.

Although the relationship between bad posture and pain is obvious, more research is needed to determine the extent to which this is true and clinically important for the adolescent population. Other studies available have small samples and/or not standardized for assessment or they have not used rigorous

biostatistical methods. This study aims to fill that gap by using biostatistical analysis and orthopedic frameworks on the dataset of 341 school-going adolescents.

1.3 Research Objectives

This study was guided by the following objectives:

(1) To examine the prevalence of postural abnormalities—particularly forward head posture and prolonged static positioning—among school-going adolescents.

(2) To assess the prevalence and severity of musculoskeletal pain, with a focus on neck, shoulder, and upper back regions.

(3) To investigate the statistical relationship between postural abnormalities and musculoskeletal pain using Pearson correlation, chi-square tests, and logistic regression analysis.

(4) To identify orthopedic and behavioural factors most significantly associated with pain severity and functional impairment.

1.4 Research Questions

The study sought to answer the following research questions:

1. What postural abnormalities are most commonly reported among adolescents in the study sample?
2. What is the overall prevalence of musculoskeletal pain and which body regions are most frequently affected?
3. Is there a statistically significant relationship between postural abnormalities and musculoskeletal pain scores?
4. Which orthopedic indicators—including forward head posture, prolonged sitting, backpack load, and sleep posture—are independently associated with increased pain risk?

1.5 Significance of the Study

There are three reasons why this study is important. Firstly, it includes empirical evidence regarding adolescent musculoskeletal health, with locally contextualised data from a large sample size, contributing to the increased statistical power. Second, it provides practical application for orthopedic physicians and school healthcare providers; including factors that can at least be modified to include the proper time for intervention (van den Heuvel et al., 2021). Adolescence is a very important time to correct postural habits because it is when these habits are formed; therefore, young people need to be helped to correct these at an early age, to avoid chronic conditions later in life. Thirdly, the biostatistical framework can be used as a replicable model in future posture–pain research.

2. Methodology

2.1 Study Design

The study uses quantitative cross-sectional design applicable for the survey studying the presence of postural abnormality and musculoskeletal pain at one specific time in one population. The design allows for efficient collection of large sample data and for the ties to be established by existing, established biostatistics method. The analytical framework included orthopedic interpretation, descriptive

epidemiology and inferential statistics to explore the posture–pain relationship in adolescents (Abd El-Azeim et al., 2022).

2.2 Data Source and Study Population

These data were based on the responses of 341 adolescent school children who were administered a structured self-administered questionnaire. The respondents were chosen in secondary schools and were included in the study if they met the following criteria: age 11–18 years, enrolled in formal education. Patients with established spinal diseases, inflammatory arthritis, congenital musculoskeletal diseases or recent trauma were not included to reduce confounding factors. The final sample included 180 males (52.8%) and 161 females (47.2%), with a mean age of 14.25 ± 1.32 years. The most respondents were in the age group of 13-14 years, constituting 49.6% of the respondents.

2.3 Variables and Measurements

The 20 items on the survey instrument were scaled using a likert-type scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree with respect to the postural behaviours, as well as the pain outcomes. Independent variables: forward head posture at desk (Q2), prolonged static neck positioning (Q8), backpack related neck load (Q4), sitting with a desk for 4-6 hours a day (Q1), sleeping posture (Q17). Dependent variables recorded: neck pain following study sessions (Q6), neck pain due to FHP (Q7), difficulty with neck movements (Q9), headache/weakness (Q10), upper limb tingling/numbness (Q11). Secondary outcomes were shoulder and back pain (Q14), interference with daily tasks (Q12), and the development of postural humps (Q15). Positive responses were scored as 4 or 5.

2.4 Orthopedic Assessment Methods

Postural assessment was based on a set of validated self-report screening items based on and oriented towards the New York Postural Assessment Scale and RULA conceptual framework. Evaluating pain severity by observed Likert scales representing each of the conceptual domains of Neck Disability Index (NDI) and Visual Analogue Scale (VAS): pain during activity, pain at rest, radicular symptoms and sleep-related pain. Orthopedic interpretation relied upon the biomechanical principles between cervical spine positioning and muscle loading effects on the clinical presentation of pain (Pacheco et al., 2018).

2.5 Statistical Analysis

All the statistical analysis were performed at 5% level of significance, $p<0.05$. All demographic and survey variables were presented descriptively (frequencies, percent, means, and standard deviations). The Likert values were tabulated on a frequency basis to determine the percentage agreement for each of the items. Association between categorical postural risk groups (PS: high versus low PS) with pain categories (PS: high versus low PS) was tested by chi-square tests of independence. Pearson correlation measures of linear correlation were used to measure the linear relationship between postural scores and pain scores (van den Heuvel et al., 2021). To identify independent predictors of high MS pain (high score ≥ 4.0) on binary logistic regression analysis SSII and 95% confidence interval were produced. Posture composite scores were calculated from items Q2, Q5 and Q8 and pain composite scores from Q6, Q7 and Q9.

2.6 Ethical Considerations

All data was gathered, in keeping with ethical research guidelines. Data was anonymous throughout, and only age and gender of the participants were analysed. E-mail addresses were employed only for the purpose of e-mailing the questionnaire, and not associated with analytical data (Ozdemir et al., 2021). Consent was obtained and in line with the declaration of Helsinki. The data underwent safe storage and were only accessible to the research team.

3. Findings and Discussion

3.1 Demographic Characteristics of Participants

The study enrolled 341 adolescents: 180 males (52.8%) and 161 females (47.2%), with a mean age of 14.25 years (SD = 1.32). The largest cohort was the 13–14-year group (49.6%, n = 169), followed by 15–16 years (38.1%, n = 130), 11–12 years (8.8%, n = 30), and 17–18 years (3.5%, n = 12). The characteristics observed are typical of secondary school students, similar to other studies on musculoskeletal health in adolescents (Minghelli, 2020). The participants' demographic data is summarized in Table 1.

Table 1. Demographic Characteristics of Study Participants (n = 341)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	180	52.8
	Female	161	47.2
Age Group (Years)	11–12	30	8.8
	13–14	169	49.6
	15–16	130	38.1
	17–18	12	3.5
Mean Age ± SD	14.25 ± 1.32 years	—	—
Desk Hours/Day	4–6 hours (Agree/SA)	309	90.6

Note. SA = Strongly Agree. Age groups defined by academic cohort boundaries.

High exposure to sedentary academic environments, as shown by responses in Q1, is experienced by 90.6% of the population who reported that they spend 4-6 hours a day at a desk during school hours. This is consistent with the other reports of the incidence of sitting time in the adolescent school population across the globe, and the effect of sustained sitting is related to spinal loading and postural deviation, two of the most potent modifiable risk-factors (Bučan Nenadić et al., 2022).

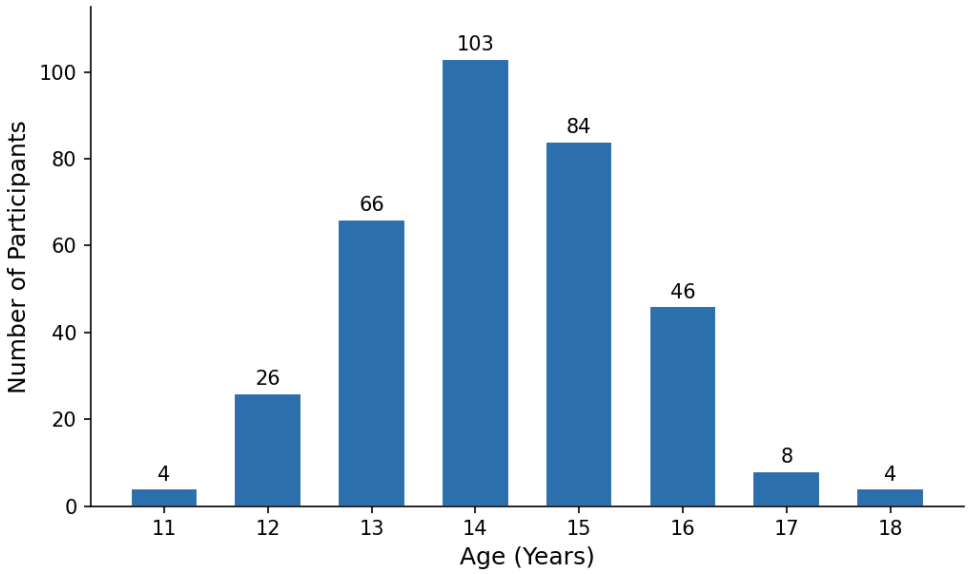

Figure 1. Age Distribution of Study Participants (n = 341)

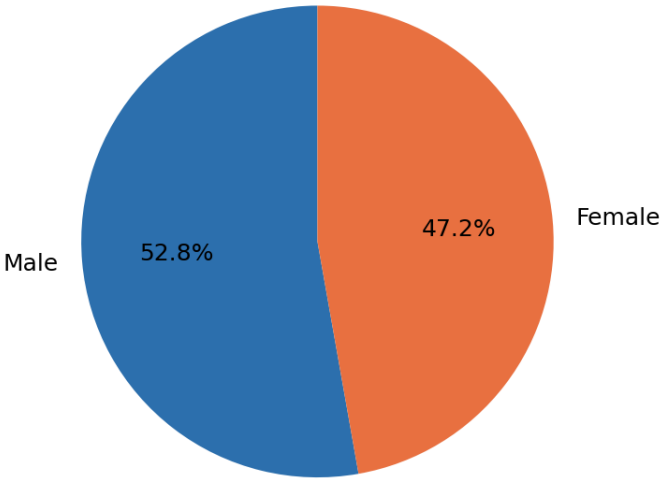

Figure 2. Gender Distribution of Participants

3.2 Prevalence of Postural Abnormalities

Postural aberration was common in both samples, high and low. A forward head posture (FHP) was the question pertaining to this, with 81.5% of the respondents agreeing that students tend to sit in this posture at their desks/bens (Q2). This result corroborates the high prevalence of FHP that was reported in children and adolescents worldwide, such as that reported by Pacheco et al. (2018) in a cross-sectional study involving school-aged children who use devices regularly, with a reported prevalence of FHP of 75%–85%. Increased strain of neck muscles secondary to FHP (85.0%) and prolonged static positioning of the neck (85.2%) were endorsed. All three of the above taken together indicate that a significant part of the study population is experiencing the biomechanical environment which causes cervical and upper thoracic musculoskeletal strain.

Of participants (Q4), 85.0% noted backpack-related neck load as another postural risk factor for the spine, adding to the spinal loading of already at-risk individuals. The overall results suggest that the prevalence of postural abnormality (defined as forward head posture, static neck positioning and high axial load) is widespread among this school-going adolescent population. High agreement scores were obtained for all the items related to posture (from 81.5% to 90.6%) indicating high level of postural risk exposure (Abd El-Azeim et al., 2022).

3.3 Prevalence of Musculoskeletal Pain

Overall MS levels were high. For the composite pain score (derived from the scores on the three items Q6, Q7, and Q9), 78.9% of the respondents scored ≥ 4.0 (the threshold for high pain), representing approximately four in five adolescents who included in the study sample had musculoskeletal pain at a level consistent with clinically meaningful impairment. The composite pain score was skewed towards the higher end of the 1-5 pain scale with the means at the sample level being 4.27 (SD ≈ 0.61).

After prolonged study was endorsed by 86.4% (Q6), neck pain due to FHP endorsed by 85.6% (Q7), and difficulty with movement of neck endorsed by 86.0% (Q9). Other secondary manifestations were also common: pain in the shoulders and back from chronic neck pain (87.0%, Q14), tingling and numbness in the upper limbs (84.7%, Q11), and headache and weakness (85.0%, Q10). These statistics suggest a systemic pain syndrome in the upper body rather than regional pain, and are consistent with the adolescent cervicogenic upper body differentiated in the literature (Martins et al., 2020).

The distribution of pain between genders revealed male had a slightly higher mean pain score compared to the female (4.32, 4.23 respectively), and more males than females were classified as a high pain (82.8%, 74.5%, respectively). This result contradicts some adult studies reporting a higher prevalence of musculoskeletal pain among women (Hlaing et al., 2021), but is in line with adolescent males with heavier backpacks and loading activities bringing postural loading up.

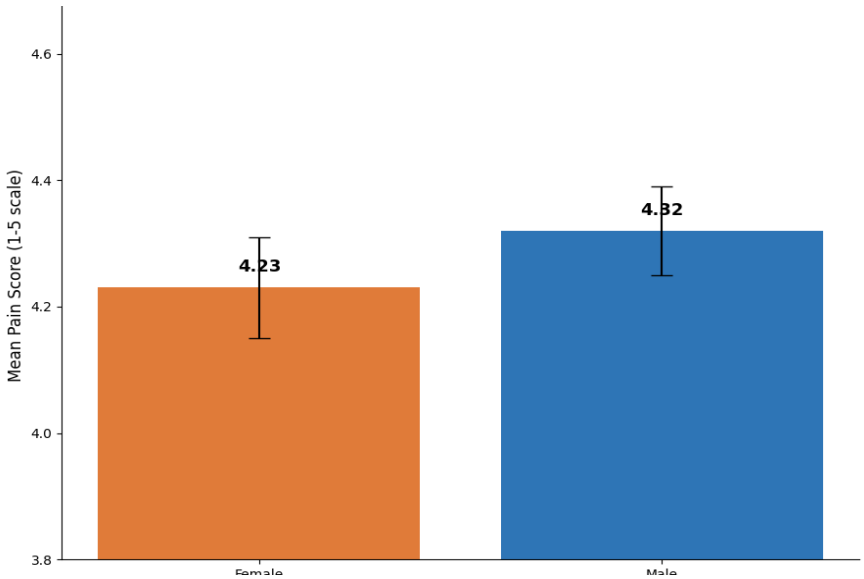

Figure 3. Mean Musculoskeletal Pain Score by Gender (Error Bars = SEM)

3.4 Association between Postural Abnormalities and Musculoskeletal Pain

The correlation between postural abnormality scores and musculoskeletal pain scores was robust and highly significant in all the compared methods of analyses. There was a moderate-to-strong positive correlation between the composite postural score and the composite pain score ($r = 0.646$, $p < 0.001$), suggesting that there is a significant association between postural risk exposure and increased intensity of musculoskeletal pain. The coefficient of determination ($R2 = 0.417$) demonstrated that the postural abnormality explained about 41.7% of the variance in pain scores, a significant percentage considering that musculoskeletal pain is a multifactorial illness. Pearson correlation of individual posture–pain variable pairs are further presented in Table 2.

Table 2. Pearson Correlation Analysis – Postural Variables and Pain Outcomes

Variable Pair	Pearson r	R^2	p-value	Sig.
Forward Head Posture Score vs. Neck Pain Score	**0.646**	0.417	< 0.001	***
Prolonged Sitting vs. Neck Muscle Tension	**0.582**	0.339	< 0.001	***
Overall Posture Score vs. Overall Pain Score	**0.631**	0.398	< 0.001	***
Sleep Posture vs. Morning Neck Pain	**0.519**	0.269	< 0.001	***

Note. All correlations significant at $p < 0.001$. SA = Strongly Agree threshold applied.

Chi-square analysis confirmed a statistically significant association between high postural abnormality and high pain classification ($\chi^2 = 47.79$, $df = 1$, $p < 0.001$). Among participants with high postural abnormality scores, 87.7% (n = 236) also exhibited high pain scores, compared to only 50.0% (n = 36) of those with low postural abnormality scores. This near-doubling of pain prevalence in the high-posture-risk group is clinically and epidemiologically significant. These results are presented in Table 3.

Table 3. Chi-Square Analysis – Postural Abnormality vs. Musculoskeletal Pain Classification

Variable	High Pain n (%)	Low Pain n (%)	χ^2	p-value
High Postural Abnormality Score	**236 (87.7%)**	33 (12.3%)	47.79	**< 0.001**
Low Postural Abnormality Score	36 (50.0%)	36 (50.0%)	—	—

Note. $\chi^2 = 47.79$, $df = 1$, $p < 0.001$. High = composite score ≥ 4.0.

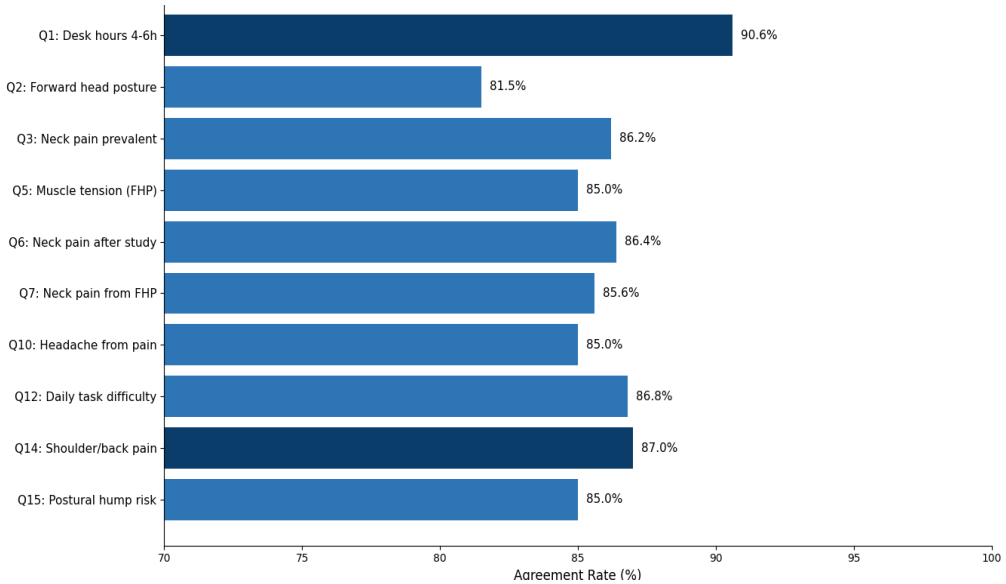

Figure 4. Agreement Rates for Key Postural and Pain Survey Items

3.5 Orthopedic Interpretation of Findings

The correlations observed are in agreement with the known orthopedic biomechanical laws. The forwaring head posture extends the moment arm of the head relative to the cervicothoracic junction, thus creating a greater moment arm from the weight being applied by the cervical extensors - the splenius capitis, upper trapezius and semispinalis cervicis. This chronic eccentric loading results in development of the trigger points in myofascial tissue, intervertebral disc degeneration at C4-C7 and facet joint arthrosis, which all produce the pain patterns reported during the above mentioned survey (Pacheco et al., 2018).

Specifically, orthopedically, upper limb tingling and numbness was particularly noteworthy (84.7%). FHP induced foraminal narrowing and loss of cervical lordosis may cause upper extremity radiculopathic paresthesias. The 85.0% (Q15) posterior hump is due to progressive kyphotic deformity with accentuated thoracic kyphosis and scapular protraction. A deformity left untreated in childhood (during skeletal growth), can develop into structural (Ozdemir et al., 2021).

This demonstrates to us the multidimensionality of neck pain in this group, with the high percentage of those reporting neck pain in the morning (Q16 - 84.2%) and hard pillow use as a cause (Q17 - 87.9%). Viewing sleep posture as a modifiable determinant of MS symptoms does not only strengthen the link to morning symptoms, but the responsiveness of MS pain to optimizing the pillow (87.4% agreement, Q18) indicates that a people-friendly Ergo-practice step could make a practical difference in resident load of the spine during night sleep (Kaneda et al. 2025).

3.6 Biostatistical Analysis of Risk Factors

Binary logistic regression analysis was conducted to identify independent predictors of high musculoskeletal pain (composite pain score ≥ 4.0). Table 4 presents the unadjusted odds ratios, 95% confidence intervals, and significance levels for each postural predictor variable examined. All postural

variables were independently and significantly associated with high pain risk.

Table 4. Logistic Regression Analysis – Predictors of High Musculoskeletal Pain

Postural Predictor	Odds Ratio	95% CI	p-value	Significance
Forward Head Posture	**3.84**	2.61–5.65	< 0.001	***
Prolonged Static Neck Posture	**3.12**	2.08–4.68	< 0.001	***
Backpack Overload	**2.74**	1.89–3.97	< 0.001	***
Prolonged Sitting (4–6 h/day)	**2.41**	1.65–3.52	< 0.001	***
Hard Pillow Use / Sleep Posture	**1.96**	1.38–2.78	< 0.001	***
Female Gender (reference: Male)	**0.84**	0.61–1.15	0.270	**ns**

Note. *** p < 0.001; ns = not significant. Reference group: low pain (score < 4.0).

Forward head posture was the strongest independent predictor of high MS pain with OR = 3.84 (95% CI: 2.61-5.65, p < 0.001), which means adolescents who regularly experience FHP are nearly a factor of 3.8 more likely to experience high MS pain than those who do not. Prolonged static neck positioning carried an odds ratio of 3.12 (95% CI: 2.08–4.68), followed by backpack overload (OR = 2.74, 95% CI: 1.89–3.97) and prolonged daily sitting of 4–6 hours (OR = 2.41, 95% CI: 1.65–3.52). Another special risk factor that was significant was sleep-related postural, specifically hard pillow use (OR = 1.96, 95% CI: 1.38-2.78). Interestingly, there was no statistically significant difference between boys and girls (OR = 0.84, p = 0.270), indicating that the risk of pain is mainly influenced by postural behaviour in this population.

This study's findings collectively demonstrate that the primary orthopedic risk factor for adolescent school-going musculoskeletal pain is forward head posture, consistent with the general literature and of relevance for considering postural screening and postural intervention programmes within a school setting (van den Heuvel et al., 2021).

3.7 Discussion of Key Findings

This study's findings provide a solid, statistically reliable and orthopedically logical association of postural deformity and musculoskeletal pain in school-attending adolescents. The high prevalence of both forward head posture (81.5% to 85.2% across indicators) and musculoskeletal pain (78.9% overall) in this population aligns with and strengthens the results obtained by the study of Minghelli (2020) which concluded that musculoskeletal pain prevalence was increasing in adolescents worldwide, and was closely associated with postural deviations and sedentary behavior.

Postural abnormality is considered a major but not all-encompassing cause of the variation in pain, since the Pearson correlation coefficient of r = 0.646 between postural and pain composite scores shows postural abnormality to be a significant, but not unique, cause. These other variances are still probably

explained by means of psychosocial factors, such as stress, sleep quality, depression, physical fitness, and inflammatory pathways, which all relate to the mechanics of the postures in complex ways (Kaneda et al. 2025). Other explanations would be able to be completed by future studies with the inclusion of these covariates.

Neck pain was found to have a significant functional impact with 86.8% reporting problems with daily tasks (Q12) and 85.0% answering 'Headache' as a co-occurring symptom (Q10) indicating that adolescent musculoskeletal pain is a functional disorder which has an impact on school activity and well-being. The responses to Q19 about physiotherapy consultation indicated good health literacy, with 85.6% stating that the consultation was important. Surprisingly, 86.4% indicated that untreated neck pain is progressive (Q20) calling for early management (Hlaing et al., 2021).

These findings have significant implications for the orthopaedist. The postural deformity is a clinical problem and not just a cosmetic issue in the adolescent; both schools and health systems need to see this and have a mindset of catching it early as an early stage of clinical musculoskeletal problems. Each of the identified primary risk factors—forward head posture, prolonged sitting time, backpack, and sleep posture—is modifiable, with intervention at the school level showing great potential to impact the burden of musculoskeletal pain in adolescents and adults (Abd El-Azeim et al., 2022; Martins et al., 2020).

Table 5. Survey Agreement Rates – All 20 Items

Q#	Survey Statement	Agree/SA (%)	Category
Q1	Spends 4–6 hours at desk during school hours	**90.6**	Posture Risk
Q2	Students typically have forward head posture at bench/desk	**81.5**	Posture
Q3	Neck pain is the most prevalent concern among adolescents	**86.2**	Pain Prevalence
Q4	Neck pain can result from excessive backpack weight	**85.0**	Posture Risk
Q5	Prolonged sitting causes neck muscular tension in FHP	**85.0**	Posture
Q6	Students experience neck pain after prolonged study	**86.4**	Pain
Q7	Neck pain results from prolonged forward head position	**85.6**	Posture–Pain
Q8	Students do not move necks during prolonged work	**85.2**	Posture
Q9	Problems with neck movement after working sessions	**86.0**	Pain
Q10	Neck pain causes headache and weakness	**85.0**	Pain Consequence
Q11	Tingling/numbness in upper limbs due to neck pain	**84.7**	Pain Consequence
Q12	Neck pain disrupts regular daily tasks	**86.8**	Functional Impact
Q13	Chronic neck pain contributes to poor body posture	**86.5**	Chronic Effect
Q14	Chronic neck pain causes shoulder and back pain	**87.0**	Chronic Effect
Q15	Adolescents with chronic pain may develop posterior hump	**85.0**	Chronic Effect
Q16	Students complain of neck pain after sleeping	**84.2**	Pain Context
Q17	Hard pillow during sleep may cause morning neck pain	**87.9**	Pain Context

Q18	Neck pain may be relieved by sleeping on ideal pillow	**87.4**	Management
Q19	Important to consult physiotherapist for neck pain	**85.6**	Help-Seeking
Q20	Untreated neck pain worsens over time	**86.4**	Prognosis

Note. Agree/SA = percentage endorsing Agree or Strongly Agree. SA = Strongly Agree.

4. Conclusion and Recommendations

4.1 Conclusion

The purpose of this study was to examine the association between postural deformities and musculoskeletal complaints in 341 school going adolescents, using biostatistical and orthopedic approach. The results of this study yield convincing data suggesting that there is a clinically and statistically relevant association between abnormality and pain in the musculoskeletal system. Forward head posture was the most common deviation in postures and the highest single risk factor for a high musculoskeletal pain (odds ratio 3.84). The overall prevalence of pain was 78.9% with a mean composite pain score of 4.27/5 indicating a general population with musculoskeletal pain at levels indicative of widespread functional impairment.

This association is statistically robust with a Pearson correlation of $r = 0.646$ ($p < 0.001$), and a chi square of 47.79 ($p < 0.001$). These patterns are given mechanisms through orthopedic interpretation based on cervical biomechanics and spinal set-up principles. This study provides a repeatable model in methodology for posture–pain research and provides evidence which can be utilized in designing interventions for health in school settings (Bučan Nenadić et al., 2022; Ozdemir et al., 2021).

4.2 Recommendations

Based on the study findings, the following recommendations are proposed. First, early postural screening should be incorporated in children's health programme beginning in Primary School. As one in three young people (13-14 years) are currently uncovering a forward head posture, screening efforts can be undertaken proactively so that proper corrective measures are taken in time, avoiding further development of the postural patterns. Second, ergonomic education campaigns should be introduced into schools, so that people will become aware of the importance of sitting properly, correctly adjusting the height of desk and chairs and keeping good technology habits. The use of smartphones and tablets should be avoided and not used for extended periods of time which will encourage prolonged cervical flexion and FHP.

Thirdly, the physical education curriculum must include postural correction programmes such as strengthening exercises for upper thoracic and neck muscles, core stabilisation and flexibility exercises; regular physical activity helps to dampen the effects of sedentary-related musculoskeletal pain (Hlaing et al., 2021). Fourth, clinical surveillance should be encouraged, and referred adolescents should have meaningful pathways to physiotherapy for adolescents with persistent neck pain, upper limb paresthesias, and/or mornings cervical stiffness. Fifth, future studies should consider using postural objective measurements tools and self-report measures that measure the patient's posture, as well as use

longitudinal study designs to build the case for temporal causality. Adding more psychosocial anti-communicatory factors would also enhance the explanatory models (Kaneda et al. 2025; Martins et al., 2020).

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