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Impact of Backpack Load on Cervical Posture among School Students

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Abstract: ***Background**: Carrying heavy school backpacks has been identified as a major risk factor for musculoskeletal strain and postural deviations in school children. The craniovertebral angle (CVA) is a reliable indicator of forward head posture (FHP), with values less than 50° considered abnormal. Prolonged exposure to heavy loads may lead to postural imbalances, cervical strain, and long term spinal complications like kyphosis, reduced lordosis and have effect in pelvic tilt. Understanding the effect of backpack weight on posture is essential to formulate safe schoolbag weight guidelines and prevent early onset of musculoskeletal issues. **Objective**: To determine the impact of different backpack loads (0%, 10%, and 15% of body weight) on craniovertebral angle and forward head posture among school children, and to analyze gender-based differences. **Methodology**: A cross-sectional study was conducted on 80 school children (40 boys and 40 girls) aged 10–12 years. Posture was assessed by measuring craniovertebral angle (CVA) using a digital goniometric method under three conditions: without backpack, with 10% body weight load, and with 15% body weight load. Students with CVA < 50° were considered to have forward head posture (FHP). **Outcome measures**: 1) Craniovertebral Angle (CVA) **Results**: At baseline (0% load), no students exhibited FHP. With 10% body weight load, 30 students (37.5%) showed FHP, including 16 girls (40%) and 14 boys (35%). With 15% body weight load, 54 students (67.5%) were affected, with boys (82.5%) showing higher prevalence compared to girls (52.5%). Statistical analysis demonstrated a significant association between backpack load and postural deviation ($p < 0.05$). **Conclusion**: The study concluded that backpack loads exceeding 10% of body weight cause significant postural deviations in school children, with boys being more affected than girls. A safe threshold for schoolbag weight should be set at or below 10% of body weight to prevent forward head posture and long-term musculoskeletal problems.*

Keywords: Backpack load, Craniovertebral angle, Forward head posture, School children, Posture

1. Introduction

Posture is a fundamental aspect of human biomechanics that reflects the alignment and balance of body segments during both static and dynamic activities. Good posture is essential for maintaining musculoskeletal health, ensuring efficiency of movement, and preventing undue stress on anatomical structures. Among the various regions of the body, the cervical spine plays a particularly important role, as it supports the head, facilitates mobility, and maintains the orientation of sensory structures such as the eyes and ears. Alterations in cervical posture can influence not only musculoskeletal well-being but also the overall quality of life, especially in growing children whose bodies are still developing [1,2].

In the modern era, the issue of backpack use among school children has emerged as a significant factor affecting posture. School-going children are required to carry their bags for prolonged periods, often loaded with textbooks, notebooks, and other academic materials. Research indicates that excessive backpack weight and improper carrying methods are strongly associated with the development of postural deviations [3,4]. Since children are in a critical period of musculoskeletal growth, even small deviations, when repeated daily, may have long-term consequences on their spinal alignment, including the cervical region. Thus, investigating the impact of backpack load on cervical posture in children becomes highly relevant [5].

The cervical spine, consisting of seven vertebrae, is uniquely designed to balance the head and allow multidirectional movements such as flexion, extension, rotation, and lateral bending. Proper neck posture ensures that the head is aligned vertically with minimal muscular effort, reducing the strain on surrounding soft tissues. However, forward head posture (FHP), one of the most common postural deviations, has become increasingly prevalent in school children [6]. This condition occurs when the head protrudes anteriorly relative to the body, shifting the line of gravity forward. Prolonged forward head posture may lead to musculoskeletal pain, muscle imbalance, headaches, and even impaired respiratory efficiency [7].

Studies have linked forward head posture in children to factors such as extended screen time, lack of ergonomic awareness, and, most importantly, the habitual carrying of heavy backpacks [8]. The cervical spine, being more mobile and less stable compared to the thoracic and lumbar regions, is particularly vulnerable to mechanical stress. As a result, monitoring and evaluating neck posture in school children is crucial for both preventive and rehabilitative measures [9].

Carrying a heavy backpack alters the biomechanics of the spine by shifting the center of gravity posteriorly. To compensate, children often lean forward or adopt an altered cervical posture, which over time leads to adaptive changes in spinal alignment [3]. Prolonged use of such compensatory strategies places increased demand on cervical extensor muscles, accelerates muscular fatigue, and contributes to structural adaptations such as reduced craniovertebral angle (CVA) [10]. Literature suggests that schoolchildren who regularly carry backpacks weighing more than 10–15% of their body weight are more prone to postural deviations, discomfort, and musculoskeletal disorders [4,5]. Therefore, studying the relationship between backpack load and cervical posture in children is essential to prevent the early onset of musculoskeletal problems.

One of the most reliable and widely accepted methods for assessing cervical posture is the measurement of the craniovertebral angle (CVA). The CVA is defined as the angle formed between a horizontal line through the spinous process of the seventh cervical vertebra (C7) and a line connecting C7 to the tragus of the ear [11]. A smaller CVA indicates a more pronounced forward head posture, while a larger angle suggests a more neutral cervical alignment.

CVA has been extensively used in clinical and research settings as a quantitative indicator of forward head posture [11,12]. It is non-invasive, objective, and provides reproducible results when measured accurately using tools such as goniometers or software-based imaging methods. In the context of children carrying backpacks, reduction in CVA is considered a key marker of cervical postural stress. By evaluating the craniovertebral angle in children with and without backpacks, it becomes possible to determine the degree of postural alteration induced by backpack load [6].

2. Relevance of the Study

Children aged 10 to 12 years are at a sensitive stage of physical development. They experience rapid musculoskeletal growth, and external stressors such as heavy backpacks can easily influence their posture. Since habits and adaptations formed during this stage often persist into adulthood, early identification of postural deviations is vital [5,9]. Investigating the relationship between backpack load and cervical posture not only contributes to scientific understanding but also has practical implications for parents, teachers, physiotherapists, and policymakers in developing ergonomic guidelines for schoolbag use [3,8].

This study specifically focuses on measuring the craniovertebral angle in schoolchildren aged 10– 12 years, both with and without backpacks, to assess the degree of cervical postural changes. By employing a goniometer for direct measurement, the study ensures simplicity, reliability, and feasibility within the school environment.

In summary, posture, particularly cervical posture, is a vital aspect of musculoskeletal health. Schoolbags are an unavoidable part of daily life for children, yet improper load distribution and excessive weight can significantly affect cervical alignment. The craniovertebral angle serves as an objective marker to evaluate these changes, making it a valuable tool in identifying forward head posture. This study aims to bridge the gap between daily backpack use and its impact on cervical posture among children, thereby emphasizing the importance of awareness and preventive strategies in school health programs [1,3,5,10].

3. Need of the Study

The rising concerns regarding musculoskeletal health in children highlight the importance of investigating modifiable risk factors such as backpack usage. While many studies have focused on low back pain and lumbar posture, cervical posture has received comparatively less attention despite its significant clinical consequences. Forward head posture, reflected by reduced CVA, is an early and sensitive indicator of postural deviation that can be objectively measured. Identifying the association between backpack load and cervical posture in schoolaged children can provide crucial insights for preventive strategies.

Children between the ages of 10 and 12 years are at a critical stage of growth, where spinal alignment is still developing, and musculoskeletal structures are highly adaptable. This makes them particularly vulnerable to postural deviations arising from external stressors. At the same time, this period also provides an opportunity for corrective interventions through awareness, ergonomic modifications, and health education. Therefore, understanding the impact of backpack load on cervical posture in this age group is highly relevant.

Clinical Significance

The findings from this study have direct implications for physiotherapists, pediatricians, school health professionals, and policy-makers. Clinically, identifying postural deviations early through CVA measurement can help in instituting timely corrective strategies, such as ergonomic education, posture correction exercises, and load reduction guidelines. The results can also inform school policies regarding the permissible weight of schoolbags, locker facilities, and awareness campaigns for students and parents. From a rehabilitation perspective, physiotherapists can use this evidence to design targeted exercise programs to improve cervical posture and prevent the progression of musculoskeletal complaints in children.

Aim

To evaluate the impact of backpack load on cervical posture, assessed using Cervical Vertebral Angle (CVA), in school students aged 10 to 12 years.

4. Methodology

Study Design: Descriptive study.

Study Setting: Bharathi School of Excellence.

Study Population: School children aged 10–12 years.

Inclusion Criteria
- Age: 10–12 years (middle school/pre-adolescent).
- Regular school attendance (daily).
- Use of double-strap backpacks.
- Backpack usage ≥ 5 days/week.
- Minimum backpack load: ≥ 10% of body weight.
- Physically able to maintain upright posture independently.
- Healthy posture at baseline (no spinal/postural abnormalities).
- Willing to participate.

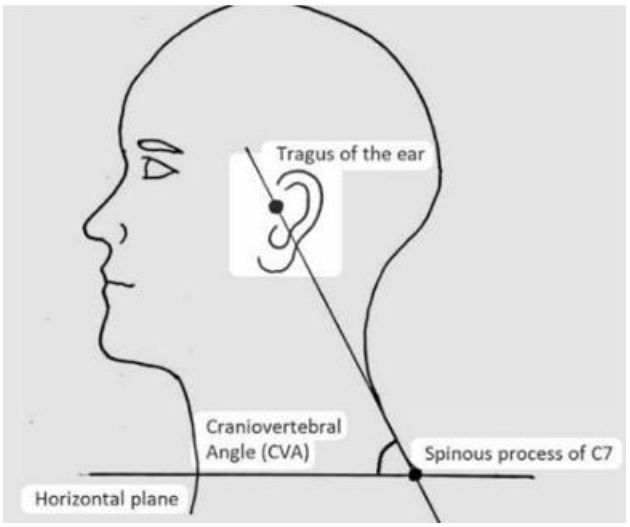
Exclusion Criteria
- Use of single-strap or trolley bags.
- Pre-existing musculoskeletal deformities (scoliosis, kyphosis, etc.).
- Neurological disorders (cerebral palsy, muscular dystrophy, etc.).
- Recent injury/surgery in past 6 months affecting back, neck, or shoulders.
- Abnormal BMI (underweight/obese).
- Use of sling/cross-body bags.
- Cardio respiratory disorders (asthma, congenital heart disease).
- Cognitive/behavioral impairments (ADHD, autism).
- Children not attending regular school.
- Visual/hearing impairments affecting balance/posture.
- Inability to complete CVA measurement.
- Use of orthotics/walking aids.
- Current physiotherapy, braces, or prior treatment for postural issues.

Procedure
- Prerequisites
- Measurement of Height using stadiometer.
- Measurement of Weight using digital weighing scale.
- Calculation of BMI = Weight (kg) / Height² (m²).
- Backpack load measured to confirm ≥10% body weight.

Test Name
- Craniovertebral Angle (CVA) Assessment using goniometer.

Position
- Child standing upright in relaxed natural posture.
- Arms resting by the side.
- Head in natural position (not corrected).
- Backpack worn properly with double straps.
- CVA measured with backpack and without backpack for comparison.

Procedure
- Identify anatomical landmarks: tragus of ear and C7 spinous process.
- Place the axis of goniometer over C7.
- Align stationary arm horizontally parallel to the ground.
- Align movable arm with a line drawn from C7 to tragus of ear.
- Record the angle formed = Craniovertebral Angle (CVA).
- Take three readings and calculate mean CVA for accuracy.



Scoring
- Normal CVA: >50° (indicates good cervical posture).
- Reduced CVA: <50° (indicates forward head posture).
- Comparison made between CVA with backpack vs without backpack.

Data Collection
- Duration: 6 months.
- Sample size: 80 students (40 boys, 40 girls).
- Only CVA used as outcome measure.

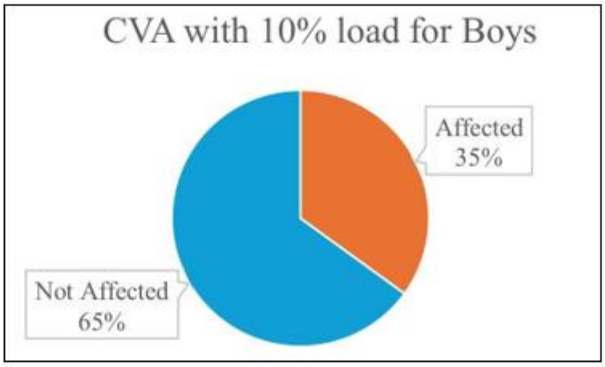
Ethics:
- Ethical clearance obtained from Institutional Ethics Committee, BET Health Sciences, Bharathinagara.
- Consent from parents has been taken before conducting the study.
- Confidentiality of data has been maintained.

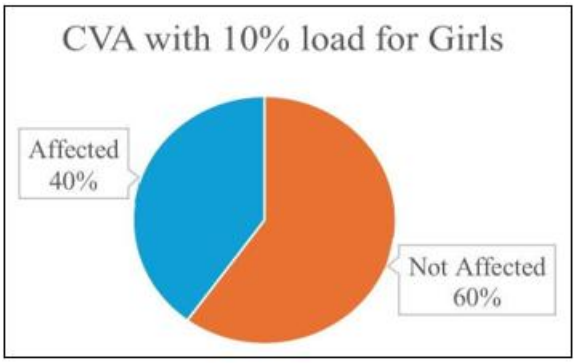
5. Results

Final Results: Impact of Backpack Load on Posture [CVA]

Table 1: Impact of backpack load on craniovertebral angle (cva)

Load Condition	Boys Affected	% Boys	Girls Affected	% Girls	Total Affected	% Total
0% (No Load)	0 / 40	0%	0 / 40	0%	0 / 80	0%
10% BW	14 / 40	35%	16 / 40	40%	30 / 80	37.50%
15% BW	33 / 40	82.50%	21 / 40	52.50%	54 / 80	67.50%



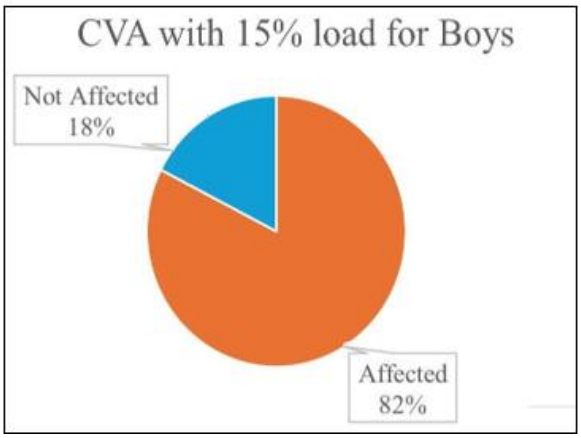


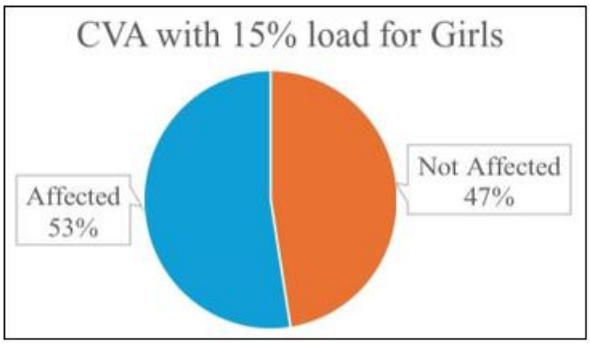
The pie charts illustrate the effect of backpack load on posture (CVA). At 10% body weight, around one-third of boys (35%) and two-fifths of girls (40%) were affected. At 15% body weight, posture deviation rose sharply, with 82.5% of boys and 52.5% of girls affected.

Overall, heavier backpack loads significantly impact posture, with boys more vulnerable than girls.

Table 2: CVA Reduction at 15% Body Weight Load

Load Condition	Boys Affected	% Boys	Girls Affected	% Girls	Total Affected	% Total
0% (No Load)	0 / 40	0%	0 / 40	0%	0 / 80	0%
10% BW	14 / 40	35%	16 / 40	40%	30 / 80	37.5%
15% BW	33 / 40	82.5%	21 / 40	52.5%	54 / 80	67.5%



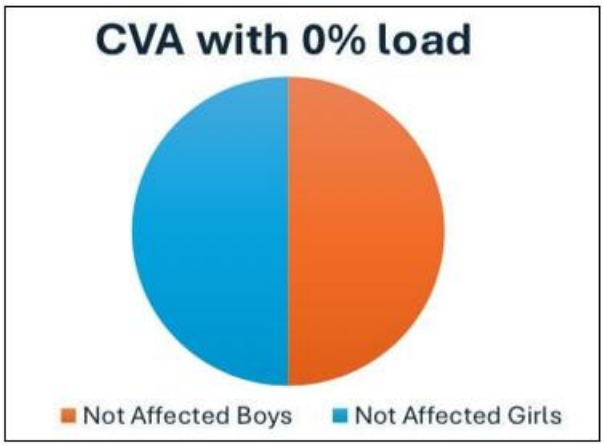


The pie charts illustrate the effect of a 15% body weight backpack load on posture.

A much higher proportion of boys (82.5%) were affected compared to girls (52.5%), indicating a statistically significant difference. Overall, more than two- thirds of students (67.5%) showed reduced CVA, confirming that heavier loads substantially increase the risk of Forward Head Posture.

Table 3: CVA at 0% Body Weight Load

Group	Affected (n)	% Affected	Not Affected (n)	% Not Affected
Boys (n=40)	0	0%	40	100%
Girls (n=40)	0	0%	40	100%
Total (n=80)	0	0%	80	100%

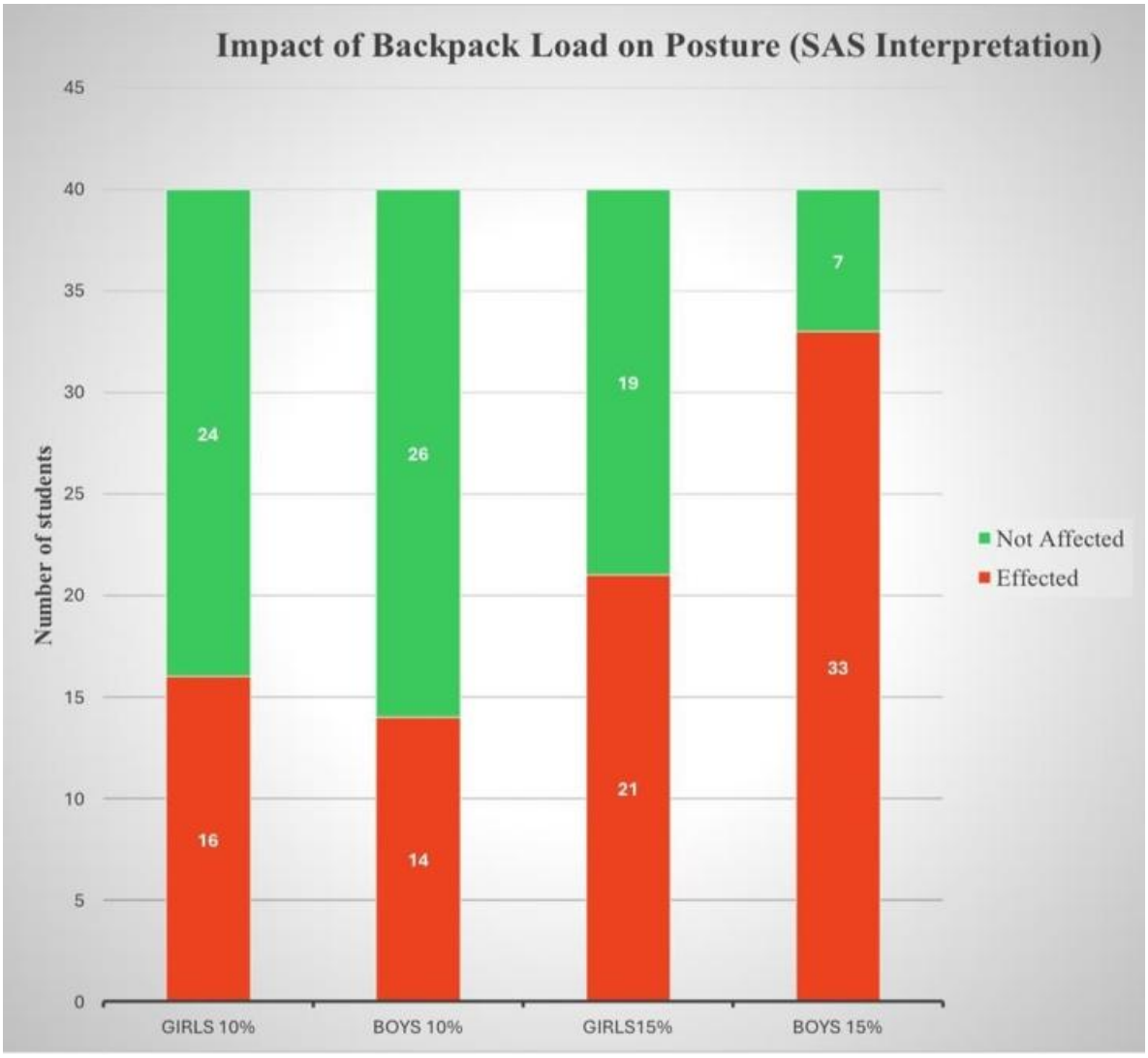


The pie chart shows Craniovertebral Angle (CVA) status without backpack load (0%). None of the students, either boys or girls, exhibited posture deviation.

Baseline posture was normal in all participants.

Table 4: SAS interpretation of CVA

Group	Total (n)	Affected @10% (n, %)	Not Affected @10% (n, %)	Affected @15% (n, %)	Not Affected @15% (n, %)
Girls	40	16 (40%)	24 (60%)	21 (52.5%)	19 (47.5%)
Boys	40	14 (35%)	26 (65%)	33 (82.5%)	7 (17.5%)
Total	80	30 (37.5%)	50 (62.5%)	54 (67.5%)	26 (32.5%)



The bar chart illustrates the effect of backpack load (10% and 15% bodyweight) on posture, measured by the number of students showing reduced Craniovertebral Angle (CVA).

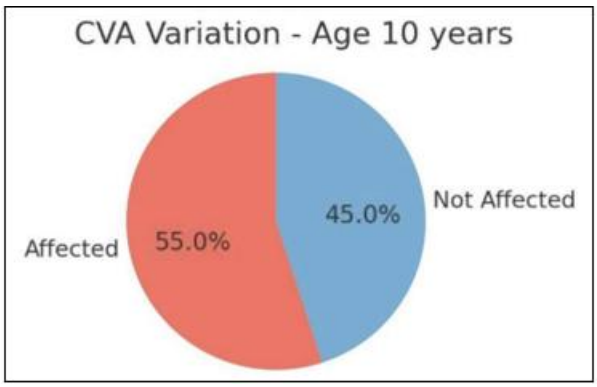
At 10% load:
16 girls (40%) and 14 boys (35%) were affected, while the remaining majority maintained normal posture. This indicates that posture deviation begins to appear even at moderate loads, but less than half of students are impacted.

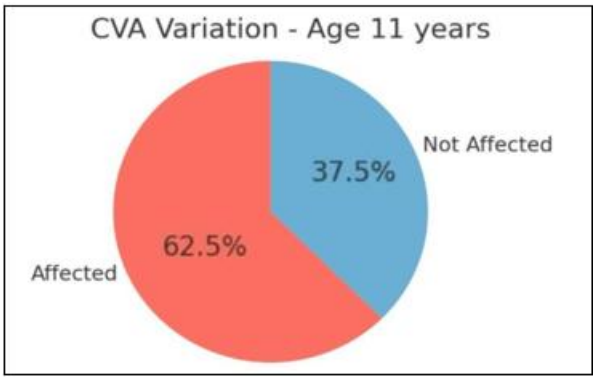
At 15% load:
21 girls (52.5%) and 33 boys (82.5%) were affected. A sharp increase in prevalence is evident, especially in boys, where over four-fifths demonstrated forward head posture. Girls also showed increased prevalence, though to a lesser degree than boys.

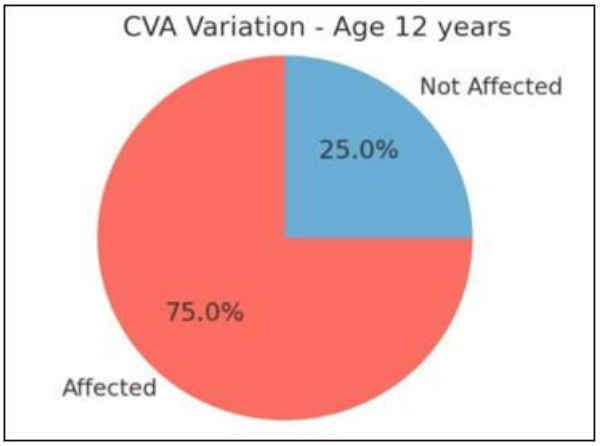
Interpretation
There is a clear dose–response relationship between backpack load and postural deviation. While both genders are affected, boys show a significantly higher prevalence at 15% load, indicating possible gender differences in bio mechanical tolerance to backpack stress.

Table 5: CVA interpretation based on different age

Age Group	Affected (n)	% Affected	Not Affected (n)	% Not Affected	Total Students
10 yrs	22	55.00%	18	45.00%	40
11 yrs	25	62.50%	15	37.50%	40
12 yrs	30	75.00%	10	25.00%	40
Total	77	64.20%	43	35.80%	120







Age 10 Years:
55% of students were affected, while 45% maintained normal CVA. Younger children already show noticeable posture deviation under backpack load.

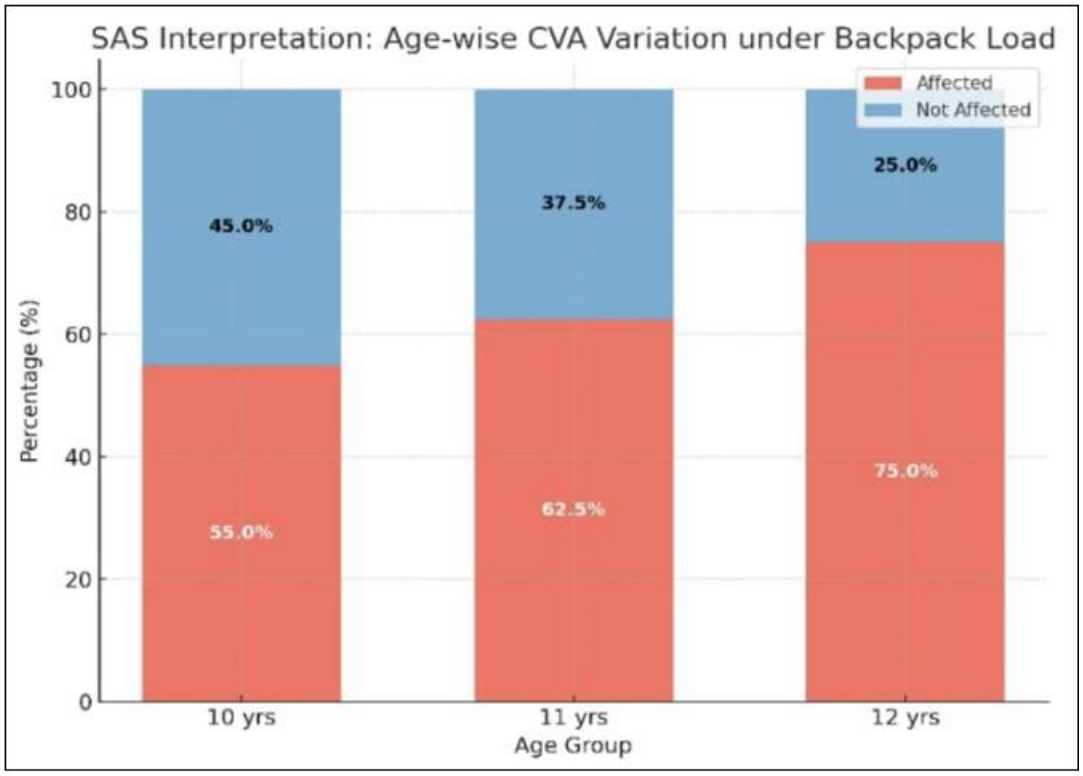
Age 11 Years:
62.5% were affected showing an increase compared to10 years. Indicates a progressive trend with age.

Age 12 Years:
75% were affected, the highest among all groups. Suggests older students are most vulnerable to forward head posture when carrying heavy backpacks.

Overall Summary

- Postural deviation increase with age under similar backpack load
- 10 year old: more than half affected
- 11 year old: nearly two thirds affected
- 12 year old: three fourths affected
- Clear evidence of an age related progression, reinforcing that school bag loads should not exceed 10% body weight to protect posture across all ages

Age Group	Total Students	Affected (n)	% Affected	Not Affected (n)	% Not Affected
10 yrs	40	22	55.00%	18	45.00%
11 yrs	40	25	62.50%	15	37.50%
12 yrs	40	30	75.00%	10	25.00%
Total	120	77	64.20%	43	35.80%



The stacked bar chart demonstrates that the percentage of students with reduced CVA increases progressively with age. At 10 year, 55% were affected; at 11 years 62.5%; and at 12 years, 75%. This confirms an age-related trend, with older children more prone to forward head posture under backpack load.

Overall Interpretation

1) **No deviation at baseline (0%load)**
- At 10% body weight ,37.5% of students showed postural deviation (FHP).
- At 15% load, this rose to 67.5% of students.

- Gender differences:
- Boys: 82.5% affected at 15% load (vs.35% at 10%).
- Girls: 52.5% affected at15%load (vs.40% at 10%). Boys clearly more vulnerable at higher load.

2) **Age differences:**
- 10 years :48.3% affected at 10%→75.9% at 15%.
- 11 years: 25.8% affected at10%→58.0% at 15%.
- 12 years: 40.0% affected at 10%→70.0% at 15%.
- Younger children (10yrs) show the highest risk at 15%, while 11yrs are
- relatively less affected.

3) **Trend:** Clear dose–response relationship higher load=more deviation.

4) **Practical Implication: Backpack**
Should not exceed 10% body weight, with stricter caution for boys and younger student

6. Discussion

The present study investigated the impact of backpack load on cervical posture among school children aged 10–12 years and revealed a significant association between load and the development of forward head posture (FHP).

At baseline (0% body weight load), none of the children demonstrated postural changes.

However, when the load was increased to 10% of body weight, more than one-third (37.5%) of children exhibited FHP, which further rose to two-thirds (67.5%) at 15% of body weight. This clearly establishes a dose-dependent relationship between load magnitude and postural deviation, emphasizing that even modest increases in load beyond recommended thresholds substantially affect cervical alignment.

These findings align with earlier studies which caution against excessive backpack loads in children. Negrini and Carabalona (2002) observed that carrying backpacks exceeding 10–15% of body weight led to postural alterations and musculoskeletal discomfort in school-going children. Similarly, Ramprasad et al. (2010) demonstrated that backpack loads as low as 10% body weight could induce measurable postural deviations in sagittal alignment, including forward head and rounded shoulder posture. Our results strongly support these observations, further reinforcing that 10% of body weight should be considered the upper safe limit to prevent musculoskeletal strain. A gender-based difference was also noted in this study. At 15% body weight load, boys (82.5%) were disproportionately more affected than girls (52.5%). This difference may be explained by anthropometric and biomechanical variations between genders. Previous research by Hong and Cheung (2003) suggested that boys, despite often having greater muscle mass, tend to carry heavier backpacks in practice, which predisposes them to postural adaptations such as FHP. Girls, on the other hand, are reported to adopt different carrying strategies and distribute load more cautiously, potentially accounting for their lower prevalence of FHP in this study.

Another study by Samia Ali El-nagar et al finds out regarding gender, the study showed that male students were four times more likely to suffer from back pain than female students. There was a significant statistical association between male sex and the occurrence of back pain among primary school students (P value = 0.000). This result was inconsistent with several studies showing that gender is a significant factor in the development of back pain among school children. Girls were more likely to report back pain than boys of the same age, which is in contrast to a study reporting that female sex is a predictor of back pain[22]. This may be related to physiological differences between the two sexes. Additionally, another study reported that the occurrence of back pain due to school bags was related to sex, which is inconsistent with our study, as it is common in males. In Spain, a study concluded that girls presented a greater risk of back pain than boys did.

The implications of these findings are particularly concerning because forward head posture in childhood can predispose individuals to long-term musculoskeletal complications. Studies by Ruivo et al. (2014) have shown that persistent FHP is associated with cervical pain, reduced respiratory capacity, and poor postural stability in adolescents and adults. Early onset of such postural deviations during the critical growth phase may therefore contribute to chronic musculoskeletal conditions later in life if corrective measures are not adopted. The study also highlights the importance of adhering to international recommendations regarding schoolbag loads. The American Occupational Therapy Association and the American of Pediatrics both recommend that backpacks should not exceed 10–15% of a child's body weight. Our findings confirm that even at 10%, a considerable number of students already exhibit postural changes, suggesting that for younger school children, the threshold may need to be closer to 10% rather than 15% for safety. This provides strong evidence for revisiting policy guidelines on schoolbag weight limits, especially for children in the 10–12 year age group.

In addition to physical load, carrying behavior and backpack design may also influence the development of FHP. Previous studies by Mackenzie et al. (2003) have highlighted that asymmetrical carrying, such as slinging the backpack over one shoulder, exacerbates lateral spinal deviations, while improper strap adjustments may increase forward lean. Though the present study standardized carrying method with both straps, the influence of carrying style in real-world conditions must be considered, since schoolchildren often adopt asymmetrical patterns in daily life.

Another significant aspect is the potential psychosocial burden caused by heavy backpacks. Research by Grimmer et al. (2006) indicated that children carrying heavier loads reported increased fatigue, reduced concentration in class, and even absenteeism due to musculoskeletal discomfort. While our study primarily focused on biomechanical outcomes, it is reasonable to infer that such psychosocial factors may co-exist in the affected group of children, further amplifying the negative consequences of excessive

load carriage. The strengths of this study include the use of objective observational assessment of cervical posture across graded backpack loads, as well as the focus on a vulnerable age group undergoing rapid musculoskeletal development. However, limitations must also be acknowledged.

The study was cross-sectional in nature and did not assess long-term follow-up of postural changes. Additionally, factors such as duration of daily backpack carriage, extracurricular activities, and ergonomic variables were not included, which may have, influenced outcomes. Future research with longitudinal designs, larger samples, and inclusion of additional biomechanical variables will help clarify the cumulative effects of backpack use. Overall, the findings underscore the urgent need for preventive strategies, including parental and school-based awareness programs, enforcement of backpack weight regulations, and promotion of ergonomic carrying practices.

Physiotherapists and pediatric health professionals should play a proactive role in screening children for early postural changes and implementing corrective exercises to mitigate risks. Ensuring healthy postural development during the school years is crucial, not only for immediate musculoskeletal comfort but also for long-term spinal health

7. Conclusion

- No postural deviation was observed without backpack load (0%).
- At 10% body weight, about one-third of students showed forward head posture (FHP).
- At 15% body weight, more than two-thirds of students were affected.
- Boys (82.5%) were more affected than girls (52.5%) at heavier loads.
- A clear dose–response relationship exists between backpack load and postural deviation.
- Findings reinforce the guideline: schoolbags should not exceed 10% of body weight.
- Preventive strategies (ergonomic backpacks, posture education, and school policies) are essential to safeguard students' musculoskeletal health.

References

[1] Brackley HM, Stevenson JM. Are children's backpack weight limits enough. A critical review of the literature. Spine. 2004;29(19):2184-90.
[2] Negrini S, Carabalona R. Backpacks on Schoolchildren's perceptions of load, associations with back pain and factors determining load compliance. Spine. 2002;27(2):187-95.
[3] Chansirinukor W, Wilson D, Grimmer K, Dansie B. Effects of backpacks on students: Measurement of cervical and shoulder posture. Aust J Physiother. 2001;47(2):110-6.
[4] Grimmer K, Dansie B, Milanese S, Pirunsan U, Trott P. Adolescent standing postural response to backpack loads: A randomized controlled experimental study. BMC MusculoskeletDisord. 2002; 3: 10.
[5] Mackenzie WG, Sampath JS, Kruse RW, Sheir-Neiss GJ. Backpacks in children. ClinOrthopRelat Res. 2003; 409: 78-84.
[6] Goodgold SA, Nielsen D. Effectiveness of a school-based backpack health promotion program. PediatrPhysTher. 2003;15(3):128-35.
[7] Sheir-Neiss GI, Kruse RW, Rahman T, Jacobson LP, Pelli JA. The association of backpack use and back pain in adolescents. Spine. 2003;28(9):922-30.
[8] Sheir-Neiss GI, Kruse RW, Rahman T, Jacobson LP, Pelli JA. The association of backpack use and back pain in adolescents. Spine. 2003;28(9):922-30.
[9] Hong Y, Cheung CK. Gait and posture responses to backpack load in primary schoolchildren. Gait Posture. 2003;17(1):28-33.
[10] Mackie HW, Legg SJ. Postural and discomfort assessment of schoolchildren's backpack loads. Appl Ergon. 2008;39(2):212-20.
[11] Dockrell S, Kane C, O'Keeffe E. Schoolbag carriage and schoolbag-related musculoskeletal discomfort among primary school children. Appl Ergon. 2006;37(3):216-22.
[12] Korovessis P, Koureas G, Zacharatos S. Backpack weight and back pain in schoolchildren: Is there a direct link. Orthopedics. 2004;27(2):187-95.
[13] Grimmer-Somers K, Milanese S, Louw Q. Measurement of cervical posture in the sagittal plane. J Manipulative PhysiolTher. 2008;31(7):509-17.
[14] Neupane S, Ali UT, Mathew A. School children's backpack weight and associated musculoskeletal discomfort. Public Health Front. 2016;4(1):9-13.
[15] Kistner F, Fiebert I, Roach K, Moore J. Postural compensations and subjective complaints due to backpack loads and wear time in schoolchildren. PediatrPhysTher. 2013;25(1):15-24.
[16] Ramprasad M, Alias J, Raghuveer AK. Effect of backpack weight on postural angles in preadolescent children. Indian Pediatr. 2010;47(7):575-80.
[17] Singla D, Veqar Z. Association between forward head, rounded shoulders, and increased thoracic kyphosis: A review of the literature. J Chiropr Med. 2017;16(3):220-9.
[18] Yoon JY, Park JH. Cervical angle and load carriage in school-aged children. J PhysTher Sci. 2017;29(2):213-8.
[19] Grimmer K, Williams M. Gender-age environmental associates of adolescent low back pain. Appl Ergon. 2000;31(5):343-60.
[20] Caneiro JP, O'Sullivan P, Burnett A, Barach A, O'Neil D, Tveit O, Olafsdottir K. The influence of different sitting postures on head/neck posture and muscle activity. Man Ther. 2010;15(1):54-60.
[21] Kistner F, Roach K, Moore J, Fiebert I. Postural compensations and subjective complaints due to backpack loads and wear time in schoolchildren. PediatrPhysTher. 2014;26(1):15-23.
[22] El-Nagar SA, Mady MM. School bag usage, postural and behavioral habits and its effect on back pain occurrence. Among School Child. 2017; 6: 218–31. https://doi.org/10.11648/J.AJNS.20170603.2 0.