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Backpack Weight and Forward Head Posture: A Cross-Sectional Study in Junior High School Students

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Abstract

Introduction: Excessive backpack weight exceeding 10% of body mass is linked to postural deviations, including forward head posture (FHP). The prevalence of FHP among adolescents aged 12–16 years is estimated at 63%, potentially increasing the risk of musculoskeletal disorders and reduced quality of life. This study aimed to investigate the association between backpack weight and FHP in junior high school students.

Methods: A cross-sectional study was conducted from 24 February to 8 March 2024 at SMP-IT Ar-Rahmah, Makassar, using purposive sampling. A total of 121 students who met the inclusion criteria were enrolled. Backpack weight was measured with a digital scale, and the average weekly load was calculated. FHP was assessed by measuring the craniovertebral angle (CVA) using the On Protractor application. Fisher's exact test was used to analyze associations.

Results: Seven students (5.8%) carried backpacks exceeding the recommended limit, while 114 students (94.2%) carried loads within the normal range. Four students (3.3%) exhibited severe FHP, 97 students (80.2%) had mild FHP, and 20 students (16.5%) demonstrated normal CVA values. Statistical analysis showed no significant association between backpack weight and FHP ($p = 0.326$).

Conclusion: In this population, the average weekly backpack weight was not significantly associated with forward head posture. Nonetheless, preventive strategies and postural education remain crucial to minimize musculoskeletal risks in adolescents.

Keywords

Backpack weight, Craniovertebral angle, Forward head posture, Adolescents, Posture

Introduction

One of the most common postural disorders among adolescents is forward head posture (FHP), a condition in which the head protrudes forward beyond the body's gravitational midline, increasing pressure on cervical structures such as the facet joints and ligaments[1]. The prevalence of FHP in students aged 12–16 years has been reported to be 63%[2]. FHP is characterized by anterior displacement of the head relative to the body's center of gravity, leading to misalignment between the ear and shoulder.[3]

A previous study comparing two age groups—children (9–11 years) and adolescents (12–15 years)—concluded that adolescents aged 12–15 years are more susceptible to FHP than children aged 9–11 years.[4] Research in Taiwan found that daily use of heavy backpacks contributes to the development of FHP, as the body compensates for the added load[5]. However, few studies have specifically examined the relationship between backpack load and FHP among school-aged adolescents.

FHP has been linked to headaches, reduced respiratory capacity, and poor balance[6]. Anatomical changes in the cervical spine due to FHP alter the body's center of gravity, affecting balance and causing muscle imbalances. Cervical flexor muscles tend to contract excessively, while the antagonistic and postural muscles become weakened. Synergistic activity of postural muscles is essential for maintaining balance[7]. Alterations in head position in FHP reduce the craniovertebral angle (CVA), an indicator of FHP severity[8].

The CVA is formed by two lines: a horizontal line through the spinous process of C7 and an oblique line connecting the spinous process of C7 to the tragus of the ear. A CVA greater than 50° is considered normal, 30°–50° indicates mild FHP, and less than 30° indicates severe FHP. The smaller the CVA, the more severe the FHP[9].

Carrying an excessively heavy backpack is one contributing factor to FHP, as it imposes additional load on the spine, affecting balance and overall posture. Excessive load on the spinal column shifts the body's center of gravity, leading to compensatory forward inclination of the head and trunk[10]. This forward head position helps counterbalance the load on the back[11]. Over time, repeated exposure to such posture may result in habitual forward head positioning, reducing the CVA and indicating the presence of FHP[12].

To date, limited research in Indonesia, particularly in Makassar, has evaluated the association between backpack load and FHP among adolescents. This is important because adolescence is a critical period for postural development, and carrying heavy backpacks is a common practice among students. Therefore, this study aimed to analyze the relationship between backpack load and FHP, as measured by the craniovertebral angle, among junior high school students at SMP-IT Ar-Rahmah, Makassar.

Methods

This study employed a correlational design with a cross-sectional, descriptive–analytic approach. The study population comprised all students of SMP-IT Ar-Rahmah in Makassar City. Data collection was conducted at SMP-IT Ar-Rahmah between February and March 2025 over five consecutive school days.

A total of 121 students were recruited using purposive sampling. The inclusion criteria were: (1) aged 12–15 years, (2) using a backpack, and (3) attending all measurement sessions during the study period. Exclusion criteria included the presence of musculoskeletal disorders or a history of neck or back injury.

Data collection involved measuring both backpack load and craniovertebral angle (CVA). Backpack load was measured in kilograms using a digital scale each morning for five consecutive school days, and the mean value was calculated to determine the daily average backpack load. Students' body weight was also measured to assess whether the backpack load exceeded 10% of body weight. Backpack load was categorized as normal (≤10% of body weight) or excessive (>10%).

Forward head posture was assessed using the CVA, categorized as normal (>50°), mild FHP (30°–50°), and severe FHP (<30°). Measurements were performed in a standing position with the participant looking straight ahead, and photographs were taken from the lateral view. CVA analysis was conducted using the On Protractor application by a trained investigator. To minimize measurement bias, all CVA assessments were performed by the same researcher following standardized procedures.

Data analysis was performed using SPSS version 29. The association between backpack load (≤10% vs. >10% of body weight) and FHP (normal, mild, severe) was evaluated using the chi-square test or Fisher's exact test when chi-square assumptions were not met. Statistical significance was set at $p < 0.05$. This study received ethical approval from the Ethics Committee of the Faculty of Nursing, Universitas Hasanuddin (Approval No. 479/UN4.18.3/TP.01.02/2024).

Results

This study was conducted from 24 February to 8 March 2024 at SMP-IT Ar Rahmah, Makassar City, involving a population of 162 students from regular classes in grades 7 to 9. A total of 121 students met the inclusion criteria and participated as the study sample. Forty-one students were absent consecutively during data collection, and their data were therefore excluded from analysis without imputation. Primary data were obtained directly from respondents through the measurement of schoolbag weight over one week using a digital hanging scale, and the measurement of the craniovertebral angle (CVA) using a protractor application. Table 1 presents the demographic and general characteristics of the respondents, providing an overview of the study population. Table 2 summarizes the mean, minimum, and maximum values of the respondents' characteristics, offering a descriptive overview of the data distribution.

Table 1. Characteristics of Respondents

Characteristics	Frequency (n)	Percentage (%)
Age		
12 years	13	10.7
13 years	45	37.2
14 years	44	36.4
15 years	18	14.9
16 years	1	0.8
Total	121	100.0
Class		
Grade VII Male	18	14.9
Grade VII Female	20	16.5
Grade VIII Male	18	14.9
Grade VIII Female	21	17.4
Grade IX Male	17	14.0
Grade IX Female	27	22.3
Total	121	100.0
Body weight		
29–39 kg	24	19.8
40–50 kg	48	39.7
51–61 kg	27	22.3
62–72 kg	16	13.2
>73 kg	6	5.0
Total	121	100.0
Sex		
Male	53	43.8
Female	68	56.2
Total	121	100.0

Table 1 (Continued). Characteristics of Respondents

Characteristics	Frequency (n)	Percentage (%)
Backpack weight		
0–2 kg	11	9.1
2.1–3 kg	58	47.9
3.1–4 kg	40	33.1
>4 kg	12	9.9
Total	121	100.0
CVA category		
Normal (>50°)	20	16.5
Mild (30°–50°)	97	80.2
Severe (<30°)	4	3.3
Total	121	100.0

Table 2. Mean, Minimum, and Maximum of Respondent Characteristics

Variable	Mean	Min	Max
Age	13.1 years	12 years	16 years
Body weight	51 kg	29 kg	111 kg
Backpack weight	3 kg	0.97 kg	5.58 kg
CVA	43.5°	25.4°	61.9°

General Characteristics of Respondents

The majority of respondents were 13 years old (37.2%), followed by 14 years old (36.4%). Among 13-year-olds, there were 28 males and 17 females. The largest group by class was Grade IX female (22.3%), mostly aged 14 years. Body weight ranged from 29 kg to 111 kg (SD ±14.013), with one extreme value (111 kg) retained as valid. Average schoolbag weight over five school days was 3.05 kg. Table 3 displays the distribution of respondents according to their backpack weight categories.

Table 3. Distribution of Backpack Weight Categories

Category	n	%
Normal	114	94.2
Excessive	7	5.8
Total	121	100.0

Distribution of Backpack Weight

Most respondents carried backpacks within the recommended limit (<10% of body weight), with only 7 students (5.8%) exceeding this threshold. The highest number of excessive loads occurred on Fridays (13 students). Males and females had similar proportions, though females were noted to carry additional personal items (e.g., skincare products) absent among males. Excessive load was more common among students aged 12–14 years (2 students in each group). Students with lower body weight proportionally carried heavier loads relative to body mass, increasing musculoskeletal risk. The heaviest mean daily load occurred on Tuesdays (3.31 kg; range: 0.92–6.91 kg), varying by class schedule. Table 4 shows the frequency distribution of respondents based on their Forward Head Posture (FHP) categories.

Table 4. Distribution of Forward Head Posture (FHP) Categories

FHP Category (CVA)	n	%
Normal (>50°)	20	16.5
Mild (30°–50°)	97	80.2
Severe (<30°)	4	3.3
Total	121	100.0

Four respondents had severe FHP (CVA: 25.4°, 28°, 28.5°, 28.6°). Most students had mild FHP (30°–50°).

FHP Distribution by Sex

Among males, 16 had normal posture, 37 had mild FHP, and none had severe FHP. Among females, 4 were normal, 60 had mild FHP, and 4 had severe FHP. Females exhibited higher FHP prevalence, consistent with studies showing greater cervical flexion angles in females, likely due to biological differences in body size, muscle capacity, and hormonal factors. Table 5 presents the distribution of craniovertebral angle (CVA) measurements according to backpack weight categories.

Table 5. CVA Distribution by Backpack Weight Category

Backpack weight	CVA >50°	CVA 30–50°	CVA <30°	Total
Normal	18 (14.9%)	92 (76.0%)	4 (3.3%)	114 (94.2%)
Excessive	2 (1.7%)	5 (4.1%)	0 (0.0%)	7 (5.8%)
Total	20 (16.5%)	97 (80.2%)	4 (3.3%)	121 (100.0%)

Association Between Backpack Weight and FHP

Chi-square analysis with a 2×3 contingency table showed >50% of cells with expected counts <5, prompting cell merging into a 2×2 table. As expected counts <5 remained, Fisher's exact test was used. The association between mean weekly backpack weight and FHP was not significant (p=0.326). Spearman's rho correlation revealed significant, inverse associations on Tuesdays, Wednesdays, and Fridays. Mean CVA was 43.50° ± 7.1654; mean backpack weights were 3.18 ± 0.97 kg (Tuesday), 3.57 ± 1.17 kg (Wednesday), and 3.56 ± 1.12 kg (Friday).

Sex-specific Fisher's exact tests found no significant associations between backpack weight and FHP (males: p=0.213; females: p=1.000). However, odds ratio analysis indicated females were 6.92 times more likely to have mild-to-severe FHP than males (p=0.00045; OR=6.92), with prevalence rates of 94.1% and 69.8%, respectively. No significant correlation was found between age and CVA (ρ = –0.050; p=0.587), likely due to similar activity p atterns, posture habits, and smartphone use across ages 12–16.

Discussion

This study aimed to investigate the relationship between backpack load and forward head posture (FHP) among students at SMP-IT Ar-Rahmah. Based on the analysis, no significant association was found between the two variables. Among the 121 participants, 7 students carried backpacks with excessive loads, while 114 carried backpacks within the normal weight range. Regarding FHP severity, 4 students exhibited severe FHP, 97 had mild FHP, and 20 were classified as having normal posture.

A chi-square correlation test with a 2×3 contingency table was initially performed at a significance level of 0.05. The results showed that 50% of the expected cell counts were less than 5, violating the test assumptions. Therefore, cells were merged, and the analysis was repeated with a 2×2 contingency table. However, some cells still had expected counts of less than 5, prompting the use of Fisher's exact test. The Fisher's exact test between the average weekly backpack load and FHP yielded a p-value of 0.326 (>0.05), indicating no statistically significant relationship between the variables. Gender-stratified analysis using Fisher's exact test also revealed no significant association. The p-values for male and female students were 0.213 and 1.000, respectively (both >0.05).

Spearman's rho correlation analysis between backpack load and FHP revealed a significant but inverse relationship, particularly on Tuesdays, Wednesdays, and Fridays. The mean craniovertebral angle (CVA) was 43.50 ± 7.1654, with mean backpack weights of 31.7506 ± 96.65491 on Tuesdays, 35.6715 ± 116.99757 on Wednesdays, and 35.5555 ± 111.95154 on Fridays. Although no significant categorical relationship was found, the Spearman's correlation suggested a weak and inconsistent trend across days in which increased backpack weight was associated with a decrease in CVA. Biomechanically, heavier backpacks may cause postural compensation such as cervical dorsiflexion to maintain balance, which over time can reduce the CVA—a finding supported, albeit weakly, in the present correlation analysis.

The occurrence of FHP in this population is likely influenced by other factors, such as repetitive movements outside school and non-ergonomic postures during prolonged smartphone or online gaming use. Most participants reported spending their after-school hours on these activities. Previous studies have demonstrated a significant association between smartphone use and FHP, as users tend to look down toward a small screen, leading to a forward-bent posture[13]. A 2019 study also highlighted the lack of ergonomic education regarding smartphone use as a contributing factor to FHP.[14] Repetitive smartphone and gaming activities performed in non-ergonomic postures can cause the head to gradually tilt forward, and if sustained, this may alter the CVA.

Potential measurement bias should also be considered, including differences in instruments and CVA measurement protocols. For instance, a prior study measured CVA using an inclinometer to assess the effect of backpack weight on cervical angles.[15] In contrast, the present study used a photographic method, maintaining a camera-to-subject distance of 1.5 m, consistent with earlier studies recommending a distance of 150 cm when measuring CVA.[16] Another possible source of bias relates to changes in posture due to participants' gaze direction. One previous study minimized this effect by instructing participants to focus on a mirror positioned directly in front of them during measurement.[17]

This study has several limitations. The cross-sectional design only allows for the assessment of associations at a single time point and cannot establish causality. The small proportion of students carrying excessive backpack loads (5.8%) weakened the group comparison analysis. Additionally, other potentially relevant variables—such as duration of backpack carrying, sitting posture during study, and physical activity levels—were not assessed. The purposive sampling method may also have introduced selection bias, as participants were chosen intentionally based on specific criteria. This could affect the representativeness of the sample and limit the generalizability of findings to all adolescents, particularly since the study population was restricted to one school in Makassar.

Furthermore, direct measurements conducted by the researcher may have introduced observer bias, whereby the presence of the examiner during assessment could influence participants' posture or responses, potentially leading to data that do not fully reflect actual conditions.

Overall, these findings underscore the need for a holistic approach to preventing FHP in students—not solely by regulating backpack weight, but also through ergonomic education and monitoring of smartphone use. Future longitudinal studies incorporating additional contributing variables are warranted to better understand the relationship between backpack load and FHP.

Conclusion

This study demonstrated that there was no significant association between the average weekly backpack load and forward head posture (FHP) among students of SMP-IT Ar-Rahmah in Makassar. The mean weekly backpack

weight among participants was 3.05 kg. The prevalence of severe FHP (CVA <30°) was 3.3%, while mild FHP (CVA 30°–50°) accounted for 80.2% of cases.

Future research may compare craniovertebral angle measurements obtained using a protractor application with those obtained using an inclinometer or goniometer, ensuring that standardized measurement protocols are established. Subsequent studies should also consider additional variables such as duration of gadget use, prolonged sitting habits, and body posture during study at school.

For parents, it is recommended to enhance supervision and provide education regarding posture control during smartphone use at home, including limiting excessive screen time, which may influence craniovertebral angle. Schools are encouraged to take an active role in preventing FHP by implementing posture education programs, arranging classrooms to meet ergonomic standards, and incorporating light stretching exercises into students' daily routines.

Author Contribution

Clarrisa Elisabeth Sumbongi: Conceptualization, data collection, data analysis, manuscript drafting.
Yery Mustari: Methodology, supervision, manuscript review.
Immanuel Maulang: Data analysis, validation, manuscript review.
Asdar Fajrin Multazam: Supervision, critical revision, final approval of manuscript.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study received ethical approval from the Ethics Committee of the Faculty of Nursing, Hasanuddin University (Approval No. 479/UN4.18.3/TP.01.02/2024). Written informed consent was obtained from all participants and their parents or legal guardians prior to data collection, in accordance with the Declaration of Helsinki.

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