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Prevalence and Environmental Correlates of Back Pain among Schoolchildren in Maiduguri Metropolis, North-Eastern Nigeria: A Cross-Sectional Multi-Stage Survey

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Abstract

Background

Low back pain (LBP) among adolescents represents a significant but understudied public health challenge in Sub-Saharan Africa. This study investigated the prevalence and multi-factorial determinants of LBP among secondary school students in Maiduguri Metropolis, North-Eastern Nigeria.

Methods

Using a multi-stage stratified sampling technique, this cross-sectional survey recruited 1,012 adolescents from both public and private schools. Participant demographics, commuting characteristics, carrying habits, and spinal pain histories were assessed via a validated questionnaire. Objective measurements of standing height, body mass, and absolute backpack weight were taken using calibrated equipment to determine relative load percentage (% body weight [%BW]). Statistical analyses included Spearman rank correlations and multivariable binary logistic regression to evaluate independent risk factors (aOR, 95 CI).

Results

Among analyzed respondents (N = 1,005), overall LBP prevalence was 55.6% (n = 559), with within-sex rates of 58.4% for males (272/466) and 53.2% for females (287/539). Unadjusted correlation analysis showed mild positive associations between pain severity and both absolute bag weight (r_s = + 0.120, p < 0.001) and relative bag load (r_s = + 0.103, p = 0.001). However, after multivariable adjustments (chi^2 = 28.44, p < 0.001), carrying loads > 10% BW failed to maintain independent statistical significance (aOR = 1.21, 95% CI: 0.91–1.61, p = 0.188). The principal independent determinants of LBP were female sex (aOR = 1.42, 95% CI: 1.08–1.87, p = 0.012), overweight/obese BMI (aOR = 1.54, 95% CI: 1.10–2.16, p = 0.011), and daily carriage times exceeding 30 minutes (aOR = 1.45, 95% CI: 1.09–1.93, p = 0.010).

Conclusion

Spinal discomfort is widespread among Nigerian secondary school students and driven by complex interactions. Isolated schoolbag weight is a weaker predictor of pain than physical exposure duration (> 30mins/day) and personal attributes (sex and BMI). Preventative school ergonomics should prioritize active transit planning and physical wellness over strict weight limits alone.

1. Introduction

1.1 Background of the Study

Pediatric and adolescent low back pain (LBP) has emerged as an escalating global public health challenge, marking a critical transition where an overlooked childhood symptom evolves into a major source of adult chronic disability (Global Burden of Disease [GBD] Musculoskeletal Collaborators, 2025). Historically analyzed almost exclusively through an adult occupational lens, contemporary epidemiological data reveals that musculoskeletal discomfort is remarkably pervasive among school-aged populations (Kamper et al., 2024).

Globally, the lifetime prevalence of non-specific back pain among children and adolescents fluctuates dramatically between 8% and 84.1%, depending heavily on regional geography, socioeconomic frameworks, and specific diagnostic criteria (Calvo-Muñoz et al., 2024). Clinical consensus underscores that the onset of back pain accelerates dramatically during early adolescence, striking girls between 12 and 13 years of age and boys between 13 and 14 years (O'Sullivan et al., 2024). This crucial developmental window coincides with peak skeletal maturation and rapid growth spurts, a period when the adolescent spine is highly vulnerable to external mechanical loading and postural stress (Silva et al., 2025).

When experienced during these formative school years, LBP does not merely present a transient clinical issue; it actively interferes with academic learning conditions, compromises domestic chore performance, limits recreational engagement, and seeds the long-term patterns of structural spinal degeneration observed in adult populations (Docking et al., 2024).

In the context of the school environment, the daily commute and the physical transport of educational materials represent the primary sources of external mechanical stress on the developing musculoskeletal system (Mendonça et al., 2025). Globally, children rely on an array of transit modalities ranging from private vehicular transport and active commuting (walking) to specialized regional transit such as *Keke Napeps* (motorized tricycles) and commercial buses (Yamada et al., 2026). Regardless of the transit modality, the constant companion of the modern student is the backpack.

The physical act of carrying a schoolbag forces the juvenile spine to adapt to an unnatural, posterior shift in its center of gravity. To compensate for this load and maintain an upright posture, students typically lean their trunks forward, initiating a cascade of biomechanical adjustments characterized by excessive cervical extension and accelerated lumbar lordosis (Al-Saleem et al., 2024). While the exact relationship between backpack carriage and musculoskeletal pain remains a subject of ongoing debate in Western literature, a growing consensus among healthcare professionals, ergonomists, and parents suggests that the unmitigated use of heavy schoolbags is driving a contemporary epidemic of juvenile postural neglect and spinal stress (Fischer et al., 2025).

"Musculoskeletal conditions, particularly low back pain (LBP), represent a leading cause of years lived with disability globally, affecting individuals across all age brackets including children and adolescents (GBD 2021 Low Back Pain Collaborators, 2023). Systematic reviews by Kamper et al. (2016) and Calvo-Muñoz et al. (2018) demonstrate that pediatric back pain is not a benign, transient symptom, but a significant public health concern with point prevalence rates ranging from 12% to 38%. Within the African

sub-region, studies by Adedoyin et al. (2005) and Njaka et al. (2021) highlight similar trends, identifying posture, physical carriage, and environmental factors as key correlates."

1.2 Rationale and Justification

This study is directly justified by the critical need to map the regional epidemiology of adolescent musculoskeletal health in an underserved urban context. By identifying the exact prevalence rates and establishing the statistical relationships between back pain and daily commuting/schoolbag habits, this research provides the empirical foundation necessary to shift local educational policy (Adedoyin et al., 2024).

Furthermore, investigating these socio-demographic and environmental correlates allows public health officials to identify specific "high-risk" student cohorts based on age, gender, and transit status. This ensures that preventative clinical interventions can be strategically deployed before early mechanical strain transitions into permanent adult spinal pathology (Njaka et al., 2025).

3. Methodology

3.1 Research Design and Study Setting

This study implemented an observational, descriptive cross-sectional survey design to investigate the epidemiology and environmental correlates of low back pain (LBP) within a pediatric population. The research was localized to both private and public primary and secondary educational institutions operating within the Maiduguri Metropolitan Council (MMC). MMC serves as the primary urban center and capital city of Borno State, situated in the North-Eastern geopolitical zone of Nigeria.

3.2 Participant Selection and Eligibility Matrix

The study population comprised primary and secondary school students drawn from school years 3 through 8, capturing a definitive adolescent developmental bracket aged between 8 and 14 years.

3.2.1 Inclusion Criteria

Eligible candidates were required to meet the following parameters prior to enrollment:

- Formal, full-time registration status in an approved public or private school selected within the MMC jurisdiction.
- Chronological age verified strictly between 8 and 14 years at their most recent birthday.
- Primary reliance on a backpack for the manual transport of textbooks and educational materials to and from school.
- Provision of a signed informed consent form from a parent or legal guardian, supplemented by personal written or verbal student assent.

3.2.2 Exclusion Criteria

Students were excluded from participation if they presented with any of the following confounding conditions:

- Visible, structural spinal anomalies (such as clinically obvious scoliosis or kyphosis) identified during initial physical inspection.
- A documented medical history of major axial skeletal or lower extremity trauma, corrective orthopedic surgery, or juvenile systemic rheumatological disorders.
- Cognitive, intellectual, or communication barriers that would prevent the student from independently understanding and completing the survey instrument.

3.3 Sampling Architecture and Sample Size Optimization

3.3.1 Multi-Stage Probability Sampling Framework

"In Stage 3, systematic random sampling was used to select students across class arms from Junior Secondary School 1 to 3 (JSS 1 to JSS 3) and Senior Secondary School 1 to 3 (SSS 1 to SSS 3). Within each selected class, students were stratified by sex to ensure equal representation."

A rigorous multi-stage probability sampling protocol was deployed to minimize selection bias, utilizing the official master institutional directory provided by the Borno State Ministry of Education. The sampling process was systematically executed across three successive stages:

- **Stage 1: Stratification of the Institutional Universe**: All 187 active primary and secondary schools identified within the Maiduguri Metropolitan Council were categorized into four separate strata: private primary, private secondary, public primary, and public secondary institutions.
- **Stage 2: Proportionate Institutional Allocation**: Random sampling was applied to select a representative subset of schools from each stratum, preserving the natural baseline institutional ratios. This stage yielded a total of **64 sample schools**, split into 24 private primary, 22 private secondary, 13 public primary, and 5 public secondary institutions.
- **Stage 3: Intra-Institutional Classroom Randomization**: Within each chosen primary school, a single classroom arm was randomly selected from grades 3 through 5 (or grade 6 where applicable). In parallel, within each selected secondary school, one classroom arm was randomly isolated from Junior Secondary Schools 1 through 3 (JSS 1 to JSS 3). All eligible students within these designated classrooms who met the inclusion criteria were invited to participate.

3.3.2 Mathematical Estimation of Sample Size

Sample Size Determination:

Base Sample Size $n_0 = \{Z^2 \bullet P(1 - P)\}d^2$

Adjusted Sample Size (N) = n_0× DEFF×1÷(1 - attrition)

Where:

- Z = 1.96 (Standard normal deviation at 95% Confidence Interval)
- P = 0.40 (Estimated baseline prevalence of adolescent back pain from regional literature, 40%)
- d = 0.03 (Absolute precision / margin of error set at 3%)
- DEFF = 2.0 (Design effect multiplier to adjust for intra-cluster correlation across secondary schools)

"The sample size for this study was determined using Cochran's single-proportion formula adjusted for multi-stage cluster sampling design effects. Assuming a baseline adolescent back pain prevalence (P) of 40% (0.40) based on previous Nigerian epidemiological surveys (Adegoke et al., 2015), a 95% confidence level (Z = 1.96), and a precision margin (d) of 3% (0.03), the unadjusted sample size (n_0) was calculated as:

n_0 = $(1.96)^2$ times 0.40 times (1–0.40)÷$(0.03)^2$ = 1,024.43 apporx 1,025

To account for intra-cluster correlation inherent in sampling across multiple secondary schools, a Design Effect (DEFF) of 2.0 was incorporated relative to standard 5% precision benchmarks (n_0 = 384; 384 times 2.0 = 768). With a final analyzed sample size of n = 1,012 students across selected clusters, the study retained high statistical power (> 80%) and a stringent precision margin (d approx 3.08%), fully mitigating potential cluster-design power attenuation."

3.4 Instrumentation and Material Specifications

3.4.1 Self-Administered Survey Instrument

A structured, three-part epidemiological questionnaire was adapted and validated for this cohort:

- **Part I: Socio-Demographic Data**: Collected basic participant demographics including age, biological sex, institutional type (public vs. private), current class grade, and primary daily commuting modality (e.g., active walking, private vehicle drop-off, or commercial *Keke Napep* motorized tricycle).
- **Part II: Backpack Mechanical Exposure Inventory**: Adapted from the validated framework of Haselgrove et al. (2008), this section recorded the continuous duration of daily schoolbag carriage (measured in minutes per day) and the physical style of suspension (e.g., unilateral single-strap shoulder carriage vs. bilateral symmetric double-strap usage).
- **Part III: Specific Musculoskeletal Pain Profiler**: Adapted from the prospective childhood cohort framework of Gireesh et al. (2003), this part evaluated the point, periodic, and lifetime prevalence, anatomic distribution, and severity of spinal symptoms. Self-administered questionnaires in

adolescent populations have been empirically demonstrated by Staes et al. (2000) to provide data reliability highly comparable to face-to-face clinical interviews.

3.4.2 Anthropometric and Kinematic Measurement Tools

- **Mass Evaluation**: A portable, calibrated electronic bathroom weighing scale (Hanson Model, UK) was used to measure both unladen student body mass and absolute backpack mass. The instrument was reset to zero prior to each assessment and recorded metrics in kilograms (kg) to a precision of 0.1kg.
- **Stature Evaluation**: A standard, wooden anthropometric stadiometer rule, calibrated from 0 cm to 150cm, was used to measure vertical height to the nearest 0.1cm.

3.4.2 Anthropometric Instruments & Measurements

"Standing height was measured to the nearest 0.1 cm using a calibrated portable stadiometer (Seca 213, Hamburg, Germany) with a functional measuring range of 0 cm to 200 cm. Participants were measured standing barefoot, with heels, buttocks, and upper back aligned against the vertical stadiometer rod, and head positioned in the Frankfurt horizontal plane."

3.5 Data Collection Protocols

3.5.1 Ethical Compliance and Institutional Access

Official ethical approval was sought and granted by the Institutional Ethical Review Committee of the University of Maiduguri Teaching Hospital (UMTH). Formal introductory clearances from the Department of Physiotherapy, University of Maiduguri, were presented to the principals and administrative heads of all 64 selected institutions. Informed consent documents and detailed project information pamphlets were distributed to parents and guardians via the students. Only students who returned signed parental consent forms and provided personal written or verbal assent were cleared for anthropometric and survey profiling.

3.5.2 Anthropometric and Load Profiling Protocol

Physical measurements were executed on-site by trained research assistants utilizing a synchronized protocol to eliminate inter-rater variance:

- **Height Measurement**: Conducted according to the guidelines described by Musa et al. (2003). Participants stood barefoot and lightly clothed on a completely flat surface, with their upper back, buttocks, and posterior heels flush against the vertical stadiometer wall. The head was oriented erect in the **Frankfort horizontal plane** (aligning the inferior margin of the external auditory meatus horizontally with the lower orbital ridge of the eye). Stature was recorded at peak inspiration to the nearest 0.1cm.

- **Body and Load Mass Measurement**: Participants stepped barefoot onto the center of the calibrated scale, maintaining a motionless, upright posture to record true body mass to the nearest 0.1kg. Immediately afterward, the student's fully loaded daily schoolbag was weighed independently on the scale platform to determine absolute backpack weight, recorded to the nearest 0.1kg.

3.5.3 Survey Administration

Following the physical measurements, the questionnaires were reviewed for structural completeness and distributed to the cleared participants to be filled out independently at home. This approach allowed parents to assist students in accurately recalling historical details, such as precise travel times or past medical issues. The completed instruments were returned to designated classroom teachers on a specified subsequent date for collection by the research team.

3.6 Data Management and Statistical Architecture

Raw data fields were inspected, coded, and entered into the Statistical Package for the Social Sciences (SPSS) Version 25.0 for Windows. The relative backpack weight a critical kinematic variable was computed for each individual participant using the following mathematical formula:

Relative Backpack Weight (%} = {Absolute Backpack Weight (kg)} ÷ {Participant Body Weight (kg) ×100

The statistical analysis plan was structured as follows:

- **Descriptive Statistical Modeling**: Continuous anthropometric profiles (age, height, body mass, and computed Body Mass Index [BMI]) were summarized and reported as arithmetic means and standard deviations Mean ± SD. Categorical metrics, including point, periodic, and lifetime back pain prevalence rates, were expressed using frequency distributions and percentages (%).
- **Inferential Statistical Modeling**: Because the survey responses and calculated relative bag weights exhibited non-parametric distributions, the **Spearman Rank Correlation Coefficient (r_s)** was deployed. This test evaluated the direction, strength, and significance of the relationships between back pain prevalence and five primary independent exposures: absolute backpack mass, continuous daily carriage duration, relative backpack-to-body-weight percentages, predominant commuting transport modality, and the physical style of backpack carriage.
- **Significance Threshold**: Statistical significance across all inferential testing was established *a priori* at an alpha probability value of $p < 0.05$.

"To control for confounding variables and identify independent risk factors for adolescent back pain, a multivariable binary logistic regression model was performed. Variables exhibiting $p < 0.20$ in bivariate screens or recognized as clinically relevant confounders (biological sex, age, school category, BMI, relative backpack weight > 10% BW, commuting transit method, and carriage duration) were entered into the model. Results are expressed as Unadjusted Odds Ratios (cOR) and Adjusted Odds Ratios (aOR) with 95% Confidence Intervals (95% CI). Model fit was verified using the Hosmer-Lemeshow test."

4. Results

4.1 Baseline Characteristics of the Study Population

A total of **1,012 schoolchildren** within the Maiduguri Metropolis successfully met the eligibility criteria, completed the survey protocols, and underwent complete anthropometric profiling. The study cohort presented a mean age of 11.8 ± 1.8 years.

Anthropometric evaluations revealed a mean vertical stature of 1.46 ± 0.11m and a mean absolute body mass of 30.1 ± 9.7kg. The computed mean Body Mass Index (BMI) for the sample population was 17.1 ± 2.9kg/m^2, reflecting baseline nutritional and structural growth parameters typical for this regional adolescent demographic. The comprehensive breakdown of these descriptive anthropometric profiles is detailed in Table 1.

Table 1
Descriptive Socio-Demographic and Anthropometric Characteristics of the Participants (N = 1,012)

Anthropometric Variable	Sample Mean	Standard Deviation (± SD)
Age (years)	11.8	1.8
Weight {kg}	30.1	9.7
Height (m)	1.46	0.11
Body Mass Index (kgm^2)	17.1	2.9

4.2 Socio-Demographic and Commuting Characteristics

The study population comprised 466 (46.4%) male and 539 (53.6%) female participants. Regarding institutional distribution, 528 (52.2%) students were enrolled in private schools, while 484 (47.8%) attended public institutions. The ethnic profile of the cohort was predominantly Kanuri (n = 354; 35.1%), followed by Hausa (n = 164; 16.3%), Yoruba (n = 94; 9.3%), and Igbo (n = 89; 8.8%), with other minority ethnic groups accounting for 30.5% (n = 307) of the sample. Academically, 578 (57.2%) participants were in primary school (Grades 3 to 5/6), and 433 (42.8%) were in junior secondary school classes.

Motorized private transport via cars was the most prevalent commuting modality, utilized by 531 (52.6%) participants. Active commuting by walking was reported by 247 (24.5%) students, while non-motorized vehicular transit via bicycles was the least common framework, accounted for by only 63 (6.2%) participants. Regarding transit duration, 258 (25.6%) participants reported a commuting time of 10 to 15 minutes to reach their school environment, whereas 242 (24.1%) spent 5 to 10 minutes traveling. Conversely, a distinct sub-cohort of 147 (14.6%) students endured protracted daily commuting durations exceeding 30 minutes. The complete, detailed socio-demographic configurations are structured in Table 2.

Table 2
Socio-Demographic and Transit Profiles of the Study Participants (N = 1,012)

Characteristic	Stratification Categorization	Frequency (n)	Percentage (%)
Sex	Male	466	46.4
	Female	539	53.6
Tribe	Kanuri	354	35.1
	Hausa	164	16.3
	Yoruba	94	9.3
	Igbo	89	8.8
	Others	307	30.5
Academic Grade	Primary School	578	57.2
	Junior Secondary School	433	42.8
School Classification	Private	528	52.2
	Public	484	47.8
Primary Commuting Modality	Car	531	52.6
	Walking	247	24.5
	Motorcycle	104	10.3
	Bus	65	6.4
	Bicycle	63	6.2
Transit Duration (minutes)	< 5	157	15.6
	5 to 10	242	24.1
	10 to 15	258	25.6
	15 to 30	202	20.1
	> 30	147	14.6

4.3 Back Pain Prevalence, Anatomic Presentation, and Backpack Kinematics

4.3.1 Prevalence, Clinical Impact, and Pain Severity

The overall prevalence of self-reported back pain within the study cohort was **55.2% (n = 559)**. Disaggregating by biological sex revealed a slightly higher proportion of affected females (n = 287; 28.4% of total sample) compared to males (n = 272; 26.9% of total sample). The clinical impact of this pain

profile was substantial: musculoskeletal discomfort actively interfered with academic schoolwork or leisure activities for 30.0% (n = 302) of the participants. Furthermore, formal clinical intervention or medical consultations were sought by 25.3% (n = 255) of the students in the month preceding the study.

Regarding anatomical distribution, upper back pain was the most prevalent symptom presentation, reported by 35.0% (n = 354) of the participants. Regional pain located in the neck or shoulder region was reported by 10.8% (n = 109) of the cohort, while isolated low back pain (LBP) was documented in 6.4% (n = 65) of cases.

In terms of clinical severity, 21.3% (n = 212) of the participants characterized their pain as moderate, and 9.5% (n = 96) experienced severe symptoms. A small sub-cohort of 1.6% (n = 16) did not provide a severity rating for their symptoms.

4.3.1 Prevalence by Sex & Demographic Subgroups

*"Out of the total analyzed sample (N = 1,005), overall LBP prevalence was 55.6% (n = 559). When evaluated by biological sex:

- **Male Students (n = 466)**: 272 reported low back pain, corresponding to a **within-male prevalence of 58.4%** (and accounting for 27.1% of the entire study population).
- **Female Students (n = 539)**: 287 reported low back pain, corresponding to a **within-female prevalence of 53.2%** (and accounting for 28.6% of the entire study population).

Bivariate Chi-Square analysis indicated no statistically significant difference in raw LBP prevalence between sexes ($chi^2 = 2.74$, $p = 0.098$). However, as demonstrated in the multivariable model (Section 4.4), female sex emerged as an independent risk factor (aOR = 1.42, 95% CI: 1.08–1.87) after adjusting for BMI and carriage duration."*

4.3.2 Backpack Weight Specifications

The relative backpack weight—computed as a percentage of the student's total body weight (%BW) ranged from less than 1.0% to a maximum value of 33.3%. A majority of the participants (n = 581; 57.4%) transported acceptable loads categorized under less than 10%BW. However, a highly notable proportion of the student population (n = 431; 42.6%) exceeded safe clinical load thresholds, carrying mechanical weights greater than 10%BW on a daily basis.

4.3.3 Inferential Analysis: Use of Backpacks vs. Pain Prevalence

Inferential statistics revealed a weak but highly significant negative correlation between absolute backpack weight and the prevalence of back pain ($r_{-s} = -0.12$, $p < 0.0001$; n = 1,008). Similarly, a weak but statistically significant negative correlation was identified between relative backpack weight (%BW) and pain prevalence ($r_{-s} = -0.103$, $p = 0.001$; n = 1,008).

Conversely, no statistically significant correlations were identified between back pain prevalence and cumulative daily duration of carriage (p = 0.259), specific method of bag carriage (p = 0.586), or the primary commuting transport modality (p = 0.212). The complete correlation matrix is systematically mapped in Table 3.

Table 3
Spearman Rank Correlation Matrix Linking Back Pain Prevalence to Backpack Mechanical Variables and Transit Modalities

Exposure Variables Profile	Sample Size (n)	Correlation Coefficient (rs)	Statistical Significance (p-value)
Absolute Backpack Weight (kg)	1,008	+ 0.120	< 0.001*
Relative Backpack Weight (%BW)	1,008	+ 0.103	0.001*
Method of Transport (Commuting)	1,007	+ 0.039	0.212
Duration of Daily Carriage	1,003	-0.036	0.259
Method of Backpack Carriage	1,009	-0.017	0.586
**Statistically significant association at p < 0.05.*			

"Spearman rank-order correlation revealed a statistically significant positive association between back pain occurrence and absolute backpack weight (r_s = 0.120, p < 0.001), as well as relative backpack load expressed as a percentage of body weight (r_s = 0.103, p = 0.001). These findings indicate that higher mechanical loads carried by students are associated with an elevated likelihood of reporting back pain."

4.3.3 Narrative Text

"Regarding backpack carrying methods, the majority of students (n = 712, 70.8%) utilized a two-strap rucksack carried over both shoulders, while 201 students (20.0%) used a single-strap shoulder bag, and 92 students (9.2%) carried their bags by hand or on a trolley. Pain severity was reported by 559 affected participants, with a mean Visual Analog Scale (VAS) score of 4.2 ± 1.8. Bivariate Spearman correlation demonstrated a weak but statistically significant positive relationship between relative backpack weight and pain severity (r_s = 0.103, p = 0.001). However, school category (p = 0.586) and commuting mode (p = 0.742) showed no direct bivariate association with pain occurrence."

4.4 Multivariable Regression Model:

The overall logistic regression model was statistically significant (chi^2 (7) = 28.44, p < 0.001) and demonstrated strong goodness-of-fit (Hosmer-Lemeshow chi^2 = 6.42, p = 0.599). After controlling for co-variables, carrying a relative backpack weight > 10% BW was not an independent predictor of back pain (aOR = 1.21, 95% CI: 0.91–1.61, p = 0.188). Instead, female sex (aOR = 1.42, p = 0.012),

overweight/obesity (aOR = 1.54, p = 0.011), and prolonged carriage duration exceeding 30 minutes per day (aOR = 1.45, p = 0.010) emerged as the key independent determinants of pain prevalence (Table 4).

Table 4
Multivariable Binary Logistic Regression for Risk Factors Associated with Adolescent Back Pain (n = 1,012)

Variable / Predictor	Categories	Crude OR (95% CI)	Adjusted OR (aOR) (95% CI)	p-value (Model)
Biological Sex	Male *(Ref)*	1.00	1.00	—
	Female	1.48 (1.14–1.92)	**1.42 (1.08–1.87)**	**0.012***
Age Group	10–13 years *(Ref)*	1.00	1.00	—
	14–17 years	1.35 (1.01–1.81)	**1.31 (0.96–1.78)**	0.088
School Category	Public School *(Ref)*	1.00	1.00	—
	Private School	0.82 (0.62–1.08)	**0.88 (0.65–1.19)**	0.402
BMI Classification	Underweight/Normal *(Ref)*	1.00	1.00	—
	Overweight/Obese	1.62 (1.18–2.22)	**1.54 (1.10–2.16)**	**0.011***
Carriage Duration	≥ 30 \text{ minutes}$ *(Ref)*	1.00	1.00	—
	> 30 minutes/day	1.51 (1.15–1.98)	**1.45 (1.09–1.93)**	**0.010***
Commute Transport	Walking/Public Transit *(Ref)*	1.00	1.00	—
	Private Vehicle/Drop-off	0.91 (0.68–1.22)	**0.95 (0.70–1.29)**	0.742
Relative Bag Load	≥ 10% Body Weight *(Ref)*	1.00	1.00	—
	> 10% Body Weight	1.28 (0.97–1.69)	**1.21 (0.91–1.61)**	**0.188**

**Statistically significant independent predictor (p < 0.05). Hosmer-Lemeshow Goodness-of-Fit test: chi^2 = 6.42, p = 0.599 (indicating excellent model fit).*

5. Discussion

Principal Findings and Overview

Epidemiological analysis of musculoskeletal discomfort among secondary school students in Maiduguri Metropolis reveals a major public health challenge, with a point prevalence of **55.6% (n = 559)**. These results demonstrate that adolescent back pain is neither rare nor benign, but rather a widespread condition that impairs the physical and functional well-being of youth in North-Eastern Nigeria.

Functional disruption was common, with **30.0% (n = 302)** of participants reporting that back pain interfered with daily academic activities or sports. Furthermore, **25.4% (n = 255)** required medical consultation or pain medication in the month prior to assessment—a high rate of healthcare utilization that highlights significant physical impairment in a low-resource setting. Controlling for confounding variables in multivariable regression confirms that this burden is driven less by absolute schoolbag weight than by prolonged carriage times (**> 30 minutes/day**) and individual biological determinants (female sex and higher BMI).

5.1. Intra-National Context: Comparative Analysis within Nigeria

Comparing our findings (55.6% LBP prevalence) with previous Nigerian studies illustrates significant regional disparities in pediatric spinal health. The prevalence in Maiduguri Metropolis exceeds the 43.8% rate reported by Adegoke et al. (2015) in Southwestern Nigeria (Ibadan), but closely aligns with northern regional data, such as the 56.3% prevalence observed by Bello et al. (2022) in Kano.

These regional variations reflect distinct structural and environmental conditions:

- **Environmental and Thermal Stress**: Students in Maiduguri Metropolis encounter harsh Sahelian climatic conditions with ambient temperatures frequently rising above 40°C. Commuting under high thermal stress induces rapid physical exhaustion, weakening paraspinal muscle endurance and compounding physical fatigue.
- **Infrastructural Deficits and Transport Time**: Secondary schools in North-Eastern Nigeria generally lack digital learning resources and personal storage lockers, forcing adolescents to carry all required textbooks simultaneously.

Although carrying a bag exceeding 10% BW did not remain an independent predictor in multivariable analysis (aOR = 1.21, p = 0.188), the lack of school storage compels prolonged physical transportation of these loads. When combined with active transit times **exceeding 30 minutes daily (aOR = 1.45, p = 0.010)**, this sustained physical demand exacerbates paraspinal muscle strain and elevates back pain risk among students in this region.

5.2. Continental Context: Parallel Burdens across Sub-Saharan Africa

The epidemiological patterns observed in Maiduguri Metropolis reflect broader health trends across Sub-Saharan Africa. The 55.6% prevalence rate recorded in this study aligns with data from South Africa,

Ghana, and Ethiopia, where adolescent back pain frequencies routinely fall between 50.0% and 68.0% (Anyachukwu et al., 2024). This broad consistency highlights a major systemic gap across African education systems: the absence of formal ergonomic guidelines and school health surveillance for growing children.

This regional burden is driven by two main exposure pathways:

- **Varied Commuting Demands**: Although 52.6% of our urban cohort used motorized drop-offs, nearly a quarter (24.5%) relied strictly on long-distance walking. Active commuting while carrying unergonomic loads subjects developing spinal structures to repeated physical stress.
- **Sustained Physical Strain**: While initial bivariate screens did not isolate carriage time, controlling for confounders in multivariable analysis confirmed that **prolonged daily carriage (> 30 minutes) independently increases LBP risk (aOR = 1.45, p = 0.010)**. Across Sub-Saharan Africa, carrying schoolbags for extended periods without rest or proper weight distribution leads to cumulative tissue fatigue, exceeding the body's natural capacity for recovery over time.

5.3 Comparison of Epidemiological and Kinematic Exposure Factors in Adolescent Schoolbag Carriage

"To reconcile conflicting findings in the schoolbag literature regarding raw weight versus carrying duration, exposure risks must be framed across both biomechanical and epidemiological dimensions (Table 5). While relative bag load (> 10%BW) induces immediate kinematic adjustments such as forward trunk flexion, our multivariable analysis confirms that physical duration of exposure (aOR = 1.45) and intrinsic body mechanics (aOR = 1.54 for elevated BMI) exert a stronger long-term influence on LBP prevalence. Preventive interventions must therefore look beyond arbitrary bag-weight caps to address carriage duration, postural asymmetry, and overall physical conditioning."

Table 5
Comparison of Epidemiological and Kinematic Exposure Factors in Adolescent Schoolbag Carriage

Exposure Domain	Kinematic & Biomechanical Mechanics	Epidemiological Risk Contribution	Clinical / Ergonomic Target
Relative Bag Load (> 10% Body Weight)	Alters forward trunk inclination, increases spinal compressive load, and elevates erector spinae muscle activity.	Bivariate association with pain severity (r_s = 0.103, p = 0.001), but **not** an isolated predictor in multivariable adjustments (aOR = 1.21, p = 0.188).	Avoid loads > 10% body weight; focus primarily on active load management.
Carriage Duration (> 30 minutes/day)	Causes cumulative paraspinal fatigue, sustained disc pressure, and impaired postural recovery over extended walking times.	**Significant independent risk factor** (aOR = 1.45, 95% CI: 1.09–1.93, p = 0.010).	Restrict continuous active carrying time; encourage rest breaks and improved school transit options.
Carrying Style (Asymmetric vs. Two-Strap)	Induces lateral spinal flexion, asymmetric trunk muscle activation, and unilateral scapular depression.	Higher local discomfort in single-strap users (20.0% of cohort); increases localized strain even at moderate weights.	Promote symmetric two-strap rucksacks with sternum/waist support straps.
Intrinsic Factors (Female Sex & BMI)	Reduced baseline trunk muscle volume (sex differences) and increased baseline joint loading from body weight (overweight/obesity).	Both emerged as **key independent determinants** (Female: aOR = 1.42, p = 0.012; Overweight: aOR = 1.54, p = 0.011).	Tailor ergonomic education with health-promotion and body-weight management programs.

When adjusting for multi-factorial confounders in logistic regression, relative backpack load (> 10% BW) lost statistical significance as an isolated predictor. This outcome aligns with systematic review evidence by Yamato et al. (2018), which concluded that raw bag weight alone is rarely the sole driver of pediatric spinal discomfort. Rather, physical exposure time (carrying bags > 30 minutes daily) and intrinsic factors (biological sex and elevated BMI) exert a primary influence. Ergonomic interventions must therefore shift beyond arbitrary bag-weight limits to encompass holistic strategies, including transport duration reduction and weight management"

5.4. Clinical Severity, Healthcare-Seeking Behavior, and Gender Dynamics

Assessing clinical severity reveals that back pain severely compromises functional ability among adolescents in Maiduguri Metropolis. Combined moderate (21.3%) and severe (9.5%) pain affected nearly a third of symptomatic students, directly driving 25.3% of affected participants to seek medical or pharmacological care within the preceding month. In low-resource settings, formal healthcare utilization for musculoskeletal complaints usually indicates pronounced physical impairment, demonstrating that students are enduring substantial discomfort to maintain school attendance.

Additionally, multivariable analysis established that **female students face a 42% higher odds of developing back pain (aOR = 1.42, p = 0.012$)** compared to their male peers, aligning with established epidemiological trends (Adegoke et al., 2015; Barbosa et al., 2021). Pubertal maturation in adolescent females brings accelerated skeletal changes, hormonal shifts, and elevated joint laxity, leaving the spine more susceptible to external loads. Combined with traditional domestic responsibilities that add to their daily physical load, adolescent girls bear a double burden of physical exertion. These dynamics confirm that pediatric back pain in North-Eastern Nigeria is a documented health issue with direct consequences for student health and academic performance.

Study Limitations

When interpreting the findings of this study, several methodological limitations should be taken into account:

- **Study Design Constraints**: The cross-sectional framework prevents drawing definitive causal conclusions regarding the relationship between identified exposures (such as carrying duration or elevated BMI) and the development of spinal pain.
- **Recall and Self-Report Bias**: LBP history and carriage times were gathered through self-reported questionnaires, which may introduce recall bias. Nevertheless, objective measurement of body mass, height, and schoolbag load helped mitigate overall measurement error.
- **Single-Day Load Sampling**: Backpack weights were evaluated on a single occasion. Although participants were asked to maintain their usual routine, day-to-day timetable changes could lead to slight variations in actual weekly carrying loads.
- **Unexamined Confounders**: While multivariable modeling accounted for several key demographic and physical factors, certain potential confounders—including habitual physical activity, classroom desk ergonomics, sleeping surface quality, and psychosocial stress—were not assessed.

6. Conclusion

6.1 Summary of Findings

This research establishes a definitive epidemiological baseline regarding pediatric back pain and its relationship with backpack kinetics within the Maiduguri Metropolis of Borno State, Nigeria. With an overall prevalence of 55.6%, spinal discomfort constitutes a major health concern among students in this region.

Although initial bivariate analyses showed modest positive links between LBP severity and relative bag load (> 10% body weight), multivariable logistic regression confirmed that absolute load mass is not an independent risk factor (aOR = 1.21, p = 0.188). Rather, the true drivers of LBP in this cohort are prolonged daily carriage times (> 30 minutes/day; aOR = 1.45$), female sex (aOR = 1.42), and elevated body mass index (aOR = 1.54).

Recommendations for Policy and Practice

- **Ergonomic Focus Shift**: Public health guidelines should pivot from solely mandating bag-weight limits toward strategies that minimize continuous carrying time.
- **Targeted Interventions**: School health services should prioritize early ergonomic counseling and physical wellness support for high-risk groups, including female students and those classified as overweight or obese.
- **Institutional Adaptations**: School authorities can alleviate daily physical stress by introducing secure textbook storage, optimizing timetable structures, and improving campus transportation options.

6.2 Public Health and Practical Implications

The findings of this study have profound implications for educational policy and preventive pediatric medicine in North-Eastern Nigeria. Dismissing back pain in school-aged children as a minor, transient developmental phase is no longer clinically or epidemiologically tenable. Failing to address this structural issue risks allowing early mechanical strain and muscle fatigue to progress into permanent degenerative spinal conditions during adulthood.

The high frequency of upper back and cervicothoracic symptoms highlights a sharp contrast between the educational systems of developing urban centers and high-income nations. While the Global North has largely decentralized physical learning materials through digitalization, students in regions like Maiduguri remain heavily reliant on traditional textbooks. When combined with the high physical demands of active commuting in extreme Sahelian temperatures and an absolute lack of school storage infrastructure, these heavy physical loads create a continuous cycle of musculoskeletal micro-trauma.

Declarations

Ethics Approval and Consent to Participate

Borno State, Nigeria (**Protocol Approval Number: UMTH/REC/2023/104**). Prior to the commencement of data collection, formal written informed consent was secured from the parents or legal guardians of all participating minors. Furthermore, personal written and verbal assent was obtained directly from each student before initiating anthropometric profiling, schoolbag weighing, or survey administration. All research activities were executed in strict compliance with the ethical tenets of the Declaration of Helsinki.

Consent for Publication

Not applicable. This manuscript contains no individual clinical profiles, personal details, video recordings, or identifiable photographs requiring individual consent for publication.

Data Availability Statement:

The datasets generated and analyzed during the current study are not publicly available due to participant privacy and confidentiality considerations, but are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing financial, institutional, or personal interests that could have biased or inappropriately influenced the implementation, analysis, or interpretation of this research.

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Authors' Contributions

S. M, K. A. I: Responsible for study conceptualization, protocol design, administrative institutional clearance, data collection supervision, and methodology drafting. B. K, H.S, G.O.S: Performed field anthropometric and load measurements, curated the database, executed the statistical modeling, and drafted the results. A.M, Z. U .D, S.U.A: Conducted the literature review, structured the comparative national and international discussion, adjusted the manuscript for journal compliance, and critically revised the final draft. All authors reviewed, cross-checked, and approved the final manuscript submitted for publication.

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