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Association between bag weight, carrying style and low back pain and spinal curvatures among school children in Accra, Ghana

Jonathan Quartey [1*], Nana Akosua Boatemaa Baidoo[2], Samuel Koranteng Kwakye[3], John Ahenkorah[2]

[1]Department of Physiotherapy, School of Biomedical and Allied Health Sciences, College of Health Sciences, University of Ghana, Accra, Ghana. [2]Department of Anatomy, University of Ghana Medical School, College of Health Sciences, University of Ghana, Accra, Ghana.
[3]West Africa Football Academy, Sogakope, Ghana.

*Corresponding author: neeayree@googlemail.com

Abstract

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Background: Carrying school bags forms part of the daily routine of school children in the Accra Metropolis. Carrying of these heavy school bags has been found to have negative musculoskeletal effects on developing children. We set out to determine the association between bag weight, carrying style and deviations in the normal curvature as well as low back pain among school children.

Methods: This cross-sectional study involved school children who were selected from 20 public and private schools, in Ablekuma South. Participants and school bags were weighed using a weighing scale. The vertical plumb line was used to screen for sagittal and frontal curvatures and the backpack questionnaire was used to obtain data. Chi square and one-way ANOVA were used to determine the association between the relative weights of the bags, the carrying style, spinal curvature and low back pain among the school children.

Results: Out of 624 participants recruited, 90.2% used backpacks as school bags. There was a significant association between the carrying style and spinal curvatures – frontal and sagittal curvature ($p = 0.005$ & 0.003 respectively), but not low back pain ($p = 0.962$). The bag weight was significantly associated with sagittal curvature ($p = 0.000$) but not for frontal curvature ($p = 0.784$) and low back pain ($p = 0.914$).

Conclusion: Carrying of heavy school bags consequently affects forward deviation of the spine in the sagittal plane. The carrying style also has an effect on the spinal curvature. However, the bag weight and carrying style have no significant effect on the occurrence of low back pain.

Keywords: *bag weight, carrying style, spinal curvatures, low back pain*

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INTRODUCTION

The daily carriage of school bags has become the most popular means employed by students to organize and transport essential items to and from school [1]. Commonly used schoolbags among school children include backpacks, single strap bags and handheld bags, designed to meet different individual needs [2]. A single strap school bag results in considerable differences in both spinal lateral deviation and shoulder elevation compared to the use of double strap bags [3&4]. The spine should normally be straight in the frontal plane, while in the sagittal plane a series of curvatures confer the natural stable shape of the spine [5&6], however, the spine of a child, varies from that of an adult [7]. Ages 11 to 14 are a key time for spinal growth, which is believed to cause the adolescent spine to be less able to withstand stresses that are normal for the adult spine [8]. Rodríguez-Oviedo et al, [2] also reported that most of the school bags used by the school children do not have the required standard features and may also be heavy [9].

It has however been shown that adolescent idiopathic scoliosis is a common disease with an overall prevalence of 0.47 – 5.2 % [10]. Adolescent idiopathic scoliosis is a structural lateral curvature of the spine evident in the late juvenile or adolescent period in otherwise normal individuals. There are different views and findings in relation to the issue of school bags and back pain. Some believe that there is no relationship between the carrying of school bags and low back pain among children [11], while others believe there is [12&13]. Jones et al, [14] and Watson et al, [15] also demonstrated the lack of significant association between low back pain and either the type of school bag, the method of carrying or the percentage weight of the bag carried compared to the individual's body weight. Chow and colleagues [6] reported that asymmetrical load produced a modification in all the anatomical planes, whereas the symmetrical did not. In a study of 140 New Zealand high school students (mean age 13.6 years), musculoskeletal symptoms due to school bag carriage were experienced by 77.1% of the students and the symptoms were most prevalent in the neck, shoulder, upper back and low back, respectively [16].

However, in Ghana quantitative studies related to the effects of different backpack weights and carrying methods on spine curvature and low back pain are still limited and therefore require further probing. Excessive loading due to carrying heavy school bags might result in adaptive structural changes in the normal spinal curvature and also induce stress across the joint which consequently increases the risk of developing low back pain [17]. Forjuoh [18] reported in a study conducted among school children in Ghana, Guatemala and the United States that Ghanaian school children averagely carried 7.7% of their body weight in school bags and further revealed that, 42.7% of the Ghanaian school children walked to school and none used wheeled bags. This outcome indicates that most school load was carried at the back or over the shoulders in convenient transporters known as school bags. The tendency is that, during the entire development phase of the child, the spine of a school going Ghanaian child may be loaded carrying a school bag.

There seems to be substantial lack of systematic data on the average weight of bags carried by school children in Ghana on daily basis. The direct and indirect effects of loaded school bags on the developing body of a Ghanaian school going child therefore appears not to have been adequately captured in literature. Since school bag carriage forms a part of the daily routine of school going children in the Accra Metropolis, this study primarily sought to determine the association between school bag weights, style of carrying and deviations in the frontal and sagittal curvature and low back pain among these school children.

MATERIALS AND METHODS

A cross sectional study was carried out in 10 public and 10 private randomly selected schools from Ablekuma South in the Accra Metropolis of Ghana. The study was conducted among male and female school children, from classes 6 to junior high school 2 (JHS 2), whose ages ranged from 12 to 16 years. The study included school children who carried school bags that weighed 10% or more of their body weight [19] to school at least three times in the school week. The study exempted any school child with any form of identifiable or obvious form of musculoskeletal disorders. Six hundred (600) school children were recruited for this study.

The Backpack questionnaire was used to obtain information about the backpack features; time spent carrying the backpack, activity after school, medical conditions and symptoms. The backpack features were physically and visually assessed by the researchers for clarity. The vertical inelastic plumb line was used to

determine the deviation of the spinal curvature, in the sagittal plane and frontally from the ideal, whiles the Camry weighing scale was used to weigh the participants and the school bags. A data capturing form was used to obtain general demographics of the participants and to record the results of the screening of the frontal and spinal curvatures with and without the bag. Ethical approval was sought from the Ethics and Protocol Review Committee of School of Biomedical and Allied Health Sciences, University of Ghana. Permission was sought from the Ghana Education Service Accra Sub metro office. The rationale and procedure of the study was explained to parents and guardians via information sheets. Prior information, in the form of letters and consent forms were given to the school heads, parents and teachers. Following the approval, convenient dates and times were scheduled to collect data.

Written and signed consent was obtained from the parents or guardians of each participating school child. Assent was also obtained from each participating child.

Subsequently, the school children as well as their school bags were weighed and requested to complete the self-administered backpack questionnaire. Measurements were taken in a room designated for the study by the researchers at each school to ensure privacy of each participant and the screening was performed by researchers with the same gender as participants. The participants were required to remove their school uniforms and shoes and wear a polyester sewn robe which exposed the vital reference points required for the screening. This was to ensure accuracy and uniformity in the weights of participants. The participants were then asked to stand on a mark indicated on the ground, approximately 10 centimeters (cm) from the vertical inelastic string (plumb line) hung from a height. The posture of the participants was then assessed with a plumb line, which is often used as a reference of alignment for the body when examining posture [20]. The string of the plumb line was suspended overhead with a plumb bob (small weight), attached at the end, near the floor and participants were positioned behind the line 10 cm from a specified mark in such a way that the body is bisected by the plumb line. The screening was done in standing position, first with the participant wearing or carrying the school bag and then the process repeated without the school bag. The plumb line screening was assessed from the posterior and lateral views and the feet of the school children used as reference point. In the lateral or sagittal view, the standard is described as when the plumb line cuts through the middle of earlobe, the acromion, the greater trochanter, anterior of the knees and anterior of the lateral malleolus. In the posterior or frontal view, the standard is described as when the plumb line cuts through the middle of the occiput, thoracic and lumbar spinous process, the buttocks and the knee. Shoulder deviations were also used to ascertain the direction of the deviation in the frontal view. The findings were recorded on a data capturing form.

Data analysis

Data obtained from the study was analyzed using SPSS version 20. Chi square and one-way ANOVA were used to determine the association between the relative weights of the bags expressed as a percentage of the body weight as well as the carrying style and spinal curvature and low back pain in the school children. One-way ANOVA was also used to determine the association between the relative weights of the school bags and the perceived weights.

RESULTS

Participant's demographic characteristics

A total of 624 (331 males and 293 females) school children participated in this study. This consisted of 312 each from public and private schools recruited between classes 6 and JHS 2. Domains of the questionnaire that did not have complete data were not included in the analysis. A significantly greater number 563 (90.2%) of the school children used backpacks. Table 1 shows the frequencies of the type of bags commonly used by the school children in both private and the public schools. Table 1 shows features of the school bags and the frequency of their usage by the school children.

Table 1: Features of the Bag

Features	Unavailable n (%)	Never n (%)	Sometimes n (%)	Always n (%)
Waist belt	441 (70.9)	40 (6.4)	102 (16.4)	39 (6.3)
Chest strap	527 (85.0)	42 (6.8)	36 (5.8)	15 (2.4)
Adjustable shoulder straps	83 (13.4)	12 (1.9)	178 (28.8)	345 (55.8)
Padded shoulder straps	144 (23.4)	18 (2.9)	38 (6.2)	416 (67.5)
Wheels(optional)	554 (89.6)	27 (4.4)	19 (3.1)	18 (2.9)

A little over half, 170 (54.7%) of the school children in the private school claimed that their bags were heavy, whereas 186 (59.6%) of their counterparts from the public schools reported same. Table 2 shows the association between the carrying style and the frontal curvature and Table 3 highlights the results of the effects of carrying style on sagittal curvature among the school children. Majority 276 (44.3%) of the school children showed no deviation in spinal curvature in the frontal plane for carrying school bags, whereas 190 (30.5%) showed deviation to the left while carrying their school bags. Two hundred and ninety-five (47.3%) school children showed forward deviation even without carrying the school bag whereas a significantly high number 467 (74.8%) showed forward deviation in the sagittal curvature while carrying the school bag.

Table 2: Carrying style against frontal curvature

		Frontal Curvature				
	No deviation	Deviation to the left	Deviation to the right	Total		
	n (%)	n (%)	n (%)	n (%)	X^2	P-value
Over both shoulders	256(47.0)	159(29.2)	130(23.8)	545(100)		
Over right shoulder	11(26.8)	17(41.5)	13(31.7)	41(100)		
In right hand	1(14.3)	3(42.9)	3(42.9)	7(100)		
Rolled	0(0)	0(0)	1(100)	1(100)	31.5	0.005
In front using both hands	5(83.3)	1(16.7)	0(0)	6(100)		
Over the left shoulder	3(18.8)	8(50.0)	5(31.2)	16(100)		
In the left hand	0(0)	2(40.0)	3(60)	5(100)		
Other	0(0)	0(0)	2(100)	2(100)		

Table 3: Carrying style against sagittal curvature

	Sagittal curvature				
Carrying style	**No deviation**	**Forward deviation**	**Total**		
	n (%)	**n (%)**	**n (%)**	**X^2**	**P-value**
Over both shoulders	124(22.8)	421(77.2)	545(100)		
Over right shoulder	21(51.2)	20(48.8)	41(100)		
In the right hand	1(14.3)	6(85.7)	7(100)		
Rolled	0(0)	1(100)	1(100)	21.2	0.003
In front using both hands	2(33.3)	4(66.7)	6(100)		
Over the left shoulder	7(43.8)	9(56.2)	16(100)		
In the left hand	1(20.0)	4(80.0)	5(100)		
Other	0(0)	2(100)	2(100)		

Table 4 shows the frequencies of the school children who responded either yes or no to having low back pain related to school bag use and the means of their relative school bag weights. The most commonly reported physical pain symptoms among the school children was neck; 192 (31.3%), upper back; 190 (30.9%), lower back; 160 (26.1%) and arm 130 (21.1%). The rest were tingling in the arms and legs; 76 (12.4%), muscle soreness; 70 (11.4%) and leg pain; 62 (10.1%). Table 5 depicts the results of the association between carrying style and low back pain. Three hundred and ninety-seven (74.1%) of the school children who carried their school bags over both shoulders indicated that they did not have low back pain as a result of that carrying style. There was a significant association (p = 0.000) between bag weight and the forward deviation in the sagittal plane among the school children however, there was no association (p = 0.9) between bag weight and low back pain. Results not show.

Table 4: Carrying style and low back pain

Carrying style	**Low back pain**		**Total**		
	No	**yes**			
	n (%)	**n (%)**	**n (%)**	**X^2**	**p-value**
Over both shoulders	397(74.1)	139(25.9)	536(100)		
Over right shoulder	28(68.3)	13(31.7)	41(100)		
In the right hand	6(85.7)	1(14.3)	7(100)		
Rolled	1(100)	0(0)	1(100)	2.514	0.926
In front using both hand	4(66.7)	2(33.3)	6(100)		
Over the left shoulder	12(75.0)	4(25.0)	16(100)		
In the left hand	4(80.0)	1(20.0)	5(100)		
Other	2(100)	0(0)	2(100)		

Table 5: Association between bag weight and frontal curvature

Frontal curvature	Without Bag			With Bag		
	n	Mean %	Standard Deviation	n	Mean %	Standard Deviation
no deviation	376	12.3	2.5	276	12.3	2.4
deviation to the left	139	12.5	2.6	190	12.3	2.7
deviation to the right	108	12.5	2.9	157	12.5	2.6
Total	623	12.3	2.6	623	12.3	2.6
P value		0.797			0.784	

DISCUSSION

The most commonly used type of bag by both private and public-school children was the backpack. However, only a handful of the backpacks had features that made it a bag ideal for school children. The use of the double strap backpack even without all the ergonomic detail, serves as the most comfortable means of transporting school items. The adjustable and padded shoulder straps appeared to be the most employed feature of the school bags used irrespective of the type. Similar findings were reported by Rodríguez-Oviedo et al, [2] in Spain.

More than half of all the sampled school children with a greater number of from private schools reported that their bags were heavy, as similarly reported by Taboltt [10]. However, some school children in this study with perceived relatively heavier bags reported that their bags were light whereas others with perceived comparatively lighter ones indicated that their bags were heavy. This could be ascribed to the relativity of the term 'heavy'. Heuscher *et al*, [12] suggested that increasing reported backpack weight is associated with increased prevalence of annual low back pain [12]. Population based studies have demonstrated that children and adolescents (50.9 % of boys and 69.3 % of girls) often complain of LBP [5]. Further studies conducted in the same population suggested that a postural education program implemented in children can positively influence backpack habits related to LBP [3].

Majority of the school children used the backpack hung over both shoulders which indicates that the remaining school children habitually loaded one shoulder with all the weight meant for both shoulders as similarly found by Chow et al., [6]. As observed the during data collection phase, most of the school children wrongly or unequally adjusted the shoulder straps such that the load was borne maximally on one part of the body for which the school children claimed that, either one of the pair of straps was malfunctioning or that they were simply unaware of the ergonomic functions of the straps. A majority of those who adopted the method of bearing their school bag weight on either of their shoulders presented with lateral deviation away from the load which corroborate the outcomes of Katarzyna et al, [4] for a similar study conducted. This could possibly be related to compensatory adjustment incorporated by the human body when the load carried is heavy in relation to the functional response capacities, which in this instance were the school children. On the contrary, some school children also showed actual deviation to the position of the load. The possible explanation is that gravity acts directly on the weight of the bag over the shoulder creating a direct pull on that part of the body; hence if the bag is over the left shoulder, the deviation is also to the left side of the body.

Appreciable numbers of the recruited school children did not show any deviations irrespective of the fact that they carried their school bags over their right or left shoulders. Reasons may be that, these school children were able to properly adjust their load such that their center line was probably not shifted even with the presence of the school bag load. Others might also have adapted the habit of consistently shifting or

alternating the position of the load on the spine so that the load is not perpetually carried on one side, while others also employed the means of simply strapping their bags across their torso, thus evenly distributing the weight.

The results of this study indicate that the forward deviation in the sagittal plane is affected by the carrying style of the school bag. This may be due to the weight of backpacks carried as part of everyday activity by these school children, which may also be related to the shape of curvatures of their spine, especially when the activity requires taking a specific forced posture [21]. Kotwicki *et al*, [22] also reported that a child carrying a heavy backpack will tend to lean forward to balance their center of gravity, which results in a reduction of lumbar lordosis and increased thoracic kyphosis. Similarly, Walicka-Cupryś [21] reported that wearing a backpack heavier than 10% of one's body weight can cause shallowing of the lumbar lordosis among seven-year school children as shown by the findings of our study and corroborates a similar study conducted among school children by Chow et al, [8].

Some of the school children reported low back pain as a result of the use of their school bags however there was no significant association between the carrying style of school bags and occurrence of low back pain. Skoffer [11], Jones *et al,* [14] and Watson *et al,* [15] reported similar observations in their studies. This observation is however consistent with the possibility that the perception of pain in adolescents is multidimensional in nature and there are many demographic and psychosocial factors associated with the pain. Pain symptoms like low back pain are often cumulative and associated to long term exposure; however, data were collected at the beginning of the school term and could be responsible for the observations made in this study.

This study did not show any association between the bag weight and low back pain. Divergent findings (a significant association between the weight of the school bag and low back pain) were however reported by the American Academy of Orthopedic Surgeons [13] who used a bag weight limit of 20% of body weight, (twice the weight, used in this study) hence, the possible difference in outcomes. Perceptions of low back pain as a result of the school bag weight are not objective and the responses themselves may not reflect current health status.

LIMITATIONS

The outcomes of a study such as ours may require long-term follow-up to assess potential low back pain. The duration for which the school children had been carrying the bag and weight variations were also not captured by this study.

CONCLUSION

This study revealed that deviations in the spinal curvature were predisposed by the carrying style of the school bag. Forward deviation in the sagittal plane of the school children appeared to have been mostly affected by the weight of the school bag but not the side-to-side deviation of the spine in the frontal plane. A longitudinal study may be conducted to ascertain the relationship between the weight of bags, its usage and low back pain of school children.

DECLARATION

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Competing interests There were no competing interests from all authors in this study.

Author contributions JQ and AB contributed to the study design and collected data. JQ, AB, SK and JA contributed in the data analysis, wrote the manuscript and reviewed the manuscript for important intellectual content. JQ, AB, SK and JA revised the draft and approved the final version of the manuscript for submission.

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