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Does alteration in backpack load affects posture of school children?

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Abstract *: AIM: The aim of this study was to assess the extent of backpack load on postural changes in school children who were carrying school bags.*

Materials And Methods: *87 normal healthy school children out of these 40 girls and 47 boys from CBSE school were tested in upright erect posture. Depending on % of schoolbag weight of their total body weight, they were divided into three groups - Group I-(<10%), Group II (10-20%) and Group III (20-30%) Postural angles such as Craniohorizontal(CHA),Craniovertebral angle (CVA) and shoulder saggital posture were measured in three groups.*

Results: *With increasing schoolbag load from less than10% to 30% BW, CVA progressively increased significantly while CHA and shoulder saggital angle was decreased significantly as magnitude of backpack load increases. These results indicate a limitation on the ventilatory pump caused by load carriage which is directly related to the load carried and characteristic of restrictive disease of the respiratory system.*

Conclusion: *The present study demonstrates the increased forward head posture observed in children while carrying loaded backpacks are associated with backpack weight. The greatest differences were noted as the magnitude of backpack loads goes on increasing. Further analyses of the changes in forward head posture suggest that the condition as well as the weight of backpack loads markedly affect forward head posture and present a risk for neck pain in children.*

Keywords: school children, backpack load, CVA, CHA, shouldser saggital posture.

I. Introduction

Within developed nations, backpack use amongst schoolchildren has become the most popular means of transporting belongings to and from school. However ,there is a growing public concern that overloaded children's and adolescent's backpacks may lead to the development of back pain and other musculoskeletal injuries.[(1)] In recent years, school health has been the object of attention in the scientific community, especially with regard to postural changes of the spine and back pain in children and teenagers. Due to the great number of spinal disorders in adults, researchers investigate children and adolescents to find the possible causes for these disorders. Backpacks are commonly used by students of all ages with more than 90% of schoolchildren carrying backpacks worldwide. Children are introduced to the concept of carrying a backpack as early as 2 years of age. Decreased availability of school lockers as a result of vandalism and security concerns, increased homework, larger textbooks, and other objects being carried to school has prompted the increase use of backpack by school children which in turn, has lead to both an increase in weight and duration of backpack carriage.[(2)] The carrying of a backpack alters upright posture and results in postural responses that require a complex interaction of trunk and limb adjustments to accommodate to the new stressor and maintain upright equilibrium.[(3)] The backpack is an appropriate way to load the spine closely and symmetrically, while maintaining stability.[(4)] There is a widespread belief that repeated carrying of heavy loads, such as school backpacks, place additional stress on rapidly growing adolescent spinal structures, making them prone to postural change[(5)] Moreover, external forces such as load carrying in the form of heavy bags may influence the normal growth, development of children and adolescents and also maintenance of alignment of their bodies. Probably, for this reason school children experience a period of accelerated growth and development of skeletal and soft tissues. Hence the spinal structures are quite different from those of adults. As the growth of the spinal structures continues over the long period of time than the other skeletal structures, there are dissimilarities in the rate of tissue development, which can pose a threat to postural integrity. Therefore, load carrying along with irregular spinal growth pattern can affect the adolescent posture and make the adolescent more susceptible to injury [(6)] Effectively, the relative load carried by school children expressed as percentage of body weight (% BW) in these studies represents a range between 10% and 22% BW. The relative load carried by schoolchildren (expressed as % BW) has been considered in ergonomic studies as one of the contributory factors for developing musculoskeletal problems among this age group. A school bag weight limit of 10% to 15% of body weight has been suggested as a maximum load for school students [(7)] However, a recent study conducted on school bag carriage among 13-14 year old children, found significant changes in body posture, rating of perceived exertion (PRE) and muscular strain when school bag load reached 10% of their body weight, and therefore the authors suggested that a school bag weight limit of 15% of body weight might be excessive [(8)] Furthermore, it has been noted that carrying loads exceeding 10% of body weight should be avoided as these loads induce significant changes in electromyography, kinematics and subjective assessments [(9).]Few Indian researchers have focussed on the impact of load carriage on postural angles in high school children. But there is scarcity of information regarding % of backpack load carried by children on posture in India. Thus, the present study was undertaken with the objective of determining the effect of increasing magnitude of load on postural angles and to compare the different % of backpack load with unloaded condition.

II. Material And Method

2.1 subjects

The present study was based on selection of 87 normal healthy primary school including 40 girls and 47 boys, aged between 9 and 14 years, who were in grades four to eight (based on Indian primary education system of central board) participated in the study. Children were randomly selected from elementary schools located in the city of Pune (Maharashtra state) in western part India. All children were given a written consent form to be approved by their parents. Both parental and child written consent was obtained before participation in the study. Permission for carrying out the research was granted from the school authorities involved. The Ethics Committee of our Institute approved the study.

2.2 Selection criteria for students

87 Students (47 boys and 40 girls) are selected. Then, investigators arranged with individual schools and visited each participating school for data collection. Data collection was carried out on an unscheduled day so that children could not alter their school bag weight. All subjects were free from neuromuscular disorders at the time of testing and none had history of chronic low back pain, current or past cardio-pulmonary disorders, children with any orthopaedic problem, recent upper respiratory tract infection, history of recent or past ear ,nose or throat surgery. Prior to Data collection, measurements of height(cm), weight(Kg), weight of school bag(kg) and % of backpack weight (%WB) were recorded(details in Table No.1). Height was measured using a physician's scale, while weight of children and schoolbag was measured using digital scale, measuring to 0.01kg. Children are divided into three groups depending on % of schoolbag weight as a backpack load they carried of their total body weight.

Table No.1 showing physical characteristics of school children. (N=87)

characteristics	Group I (<10%BW) (n=11)	Group II (10-20%) (n=49)	Group III (20-30%) (n=27)
Age (yrs)	11.25 ±1.08	10.24 ±1.11	10.33 ± 1.00
Height(cm)	139.5 ± 8.31	133.9 ± 6.02	131.08 ± 7.36
Weight (kg)	49.58 ± 10,72	37.46 ± 7.23	29.63 ± 5.89
Schoolbag weight(kg)	4.51 ± 0.99	5.67 ± 1.18	6.85 ± 1.15

2.3 Postural angles measurements

With the subjects in standing position, adhesive photo reflective markers were placed on the right-sided lateral landmarks, which included the lateral canthus of the right eye, right tragus, a mid point between greater tuberosity of humerous and posterior aspect of acromion process of right shoulder spinous process of C7. [(10).] The subjects were instructed to stand comfortably in a normal standing position and to look straight ahead at a predetermined point on the foot template. To allow for visualization of the greater trochanter marker, the subjects were instructed to move the elbows forward but still touching the body and with minimal shoulder movement. The position was then checked prior to taking the photograph. The photograph was taken within 5 seconds after attaining the position. Sony 8 mega pixels digital camera was attached to an adjustable tripod stand, which was placed at a distance of 3 m from the subject's right side and was positioned perpendicular to the ground. Photographs of the subject were taken from the right lateral view with backpack.

In order to evaluate posture of the cervical and the shoulder region, three postural angles were measured, the detail of which as follows:-

i) **Craniohorizontal angle:** The angle formed at the intersection of a horizontal line through the tragus of ear and a line joining the tragus of ear and the external canthus of the eye was measured. It is believed to provide an estimation of head on neck angle or position of upper cervical spine [(11)]

ii) **Craniovertebral angle:** This angle was defined by Wickens and Kipath [(12)]. It is the angle termed at the intersection of a horizontal line through the spinous process of C7 and a line to the tragus of the ear. This is believed to provide an estimation of neck on upper trunk positioning .a small angle indicates more forward head posture.

iii) Saggital shoulder posture: The angle formed by the intersection of a horizontal line through C7 and a line between the mid-point of the greater tuberosity of humerus and posterior aspect of the acromion, was measured. This angle provides a measurement of forward shoulder position .a smaller angle indicates that theshoulder is further forward in relation to C7 – in other words a more rounded shoulder [11] The angles were measured by software AutoCAD 2007.

2.4 Statistical Analysis

ANOVA test was used to statistical compare the postural angles obtained during the three load carriage conditions in boys and girls. Tukey's Post hoc test was used to locate significant difference among the three groups. Statistical tests were considered significant if $p < 0.05$.

III. Results

Table 1 shows the demographic characteristics of the sample of school children participated in the study and the weight of school bags and school bag weight expressed as % BW.

Values of Craniovertrebal angle (CVA) obtained in boys and girls with three loaded conditions are shown in Fig No.1 and it was found that CVA was decreased as load increased. The post hoc test showed that there was a significant decrease in CVA between Group I and Group II as well as Group I and Group III. There was non significant decrement in CVA between Group II and Group III. The reductions were approximately proportional to the magnitude of load carried in boys and girls.

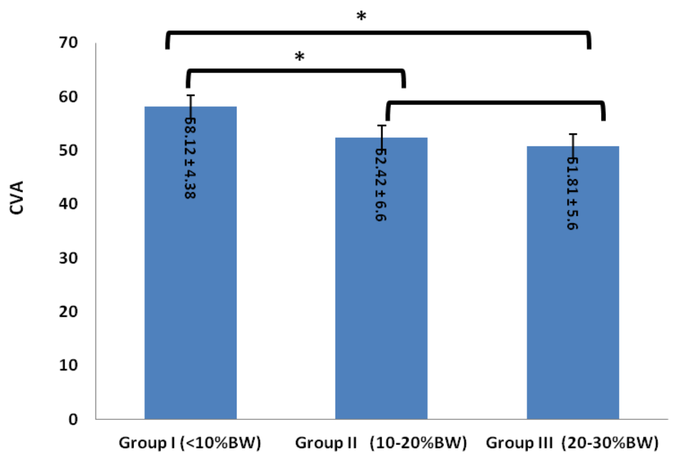

Fig.1 comparison of CVA (mean± SD) in children depending on % of load they carried
*** indicates significant (p<0.05) difference**

In Fig.2, the Craniohorizontal angle (CHA) was also found to be increased in proportion with the backpack load in both boys and girls. CHA was increased significantly when Group I was compared with Group III and Group II was compared with Group III, while there was non significant increase between Group I and Group II.

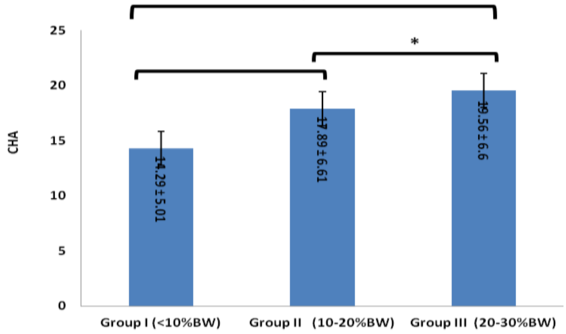

Fig.2comparision of CHA (mean± SD) in children depending on % of load they carried.
*** indicates significant (p<0.05) difference**

The results of the shoulder saggital posture is presented in Fig.3. The shoulder saggital posture was significantly increased in school children as % of backpack load goes on increasing. The shoulder saggital posture was increased significantly when Group I was compared with Group II and III and when group II was compared with group III.

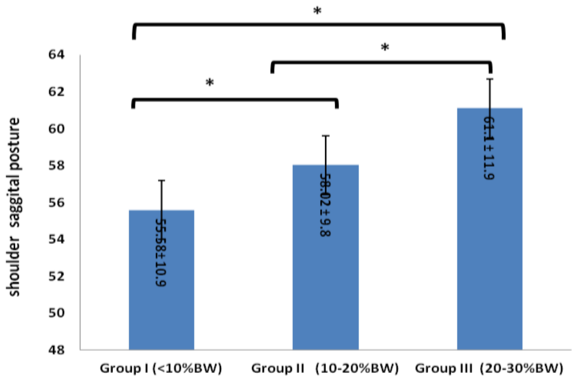

Fig.1 comparision of shoulder saggital posture (mean± SD) in school children depending on % of BW they carried. * indicates significant ($p<0.05$) difference

IV. Discussion

The purpose of this study was to examine the effects of carrying a weighted backpack on forward head position and subjective complaints of pain in elementary schoolchildren. This study identified a unique relationship between various backpack weights, condition and the forward head postural compensation in schoolchildren ages 9 and 13 years of age.

Craniovertebral angle provides an estimation of head on upper back. A small angle indicates more forward head position. Collectively there is flexion of lower cervical spine, extension of upper cervical spine and increased thoracic kyphosis after carrying backpack compared without backpack. Hence students showed forward head with thoracic kyphosis and protracted shoulder with backpack. When the child carries backpack due to the posterior load the centre of gravity moves posterior. Child's body tries to keep centre of mass between the feet, so with a backpack, the trunk is in more forward position. This requires more forward head position and protraction of the shoulders but this would mean looking down. As the head and neck are brought forward, the student is forced to extend the occiput to keep the eyes horizontal. [13,14] This will lead to forward head posture. Students of this age are in adolescent stage exhibits much greater mobility and flexibility than adult. Hence time expanded in faulty posture leads to deleterious effect on the body. Children do many activities while carrying a backpack e.g. walking playing, cycling and travelling to school. Most postural deviation in the growing child fall in the category of developmental deviation but when this pattern become habitual they may result in postural faults. [15]

Chansirinukor found adolescents were unable to maintain an upright standing posture when carrying more than 15% of body weight due to the imposed load.[16] Grimmer examined adolescents carrying backpacks containing 3%, 5% & 10%BW positioned high, low and centred on the back, compared to unloaded standing.84 Backpack loads placed higher on the back produced greater anterior postural shifts at all weights, compared to the loads placed on the center or low back.[17] HolewijnM (1990) examined the pressures placed on the shoulders by backpacks on varying weights. The pressures on the scapula and top of shoulder significantly increased during carriage of a backpack which was supported mainly by the shoulders as compared to a backpack which was designed to support weight on the hips through use of a wide waist belt.[18] These responses are consistent with previous studies identifying decreased CVA measurements with increased backpack loads, indicating a more forward head.[19,20,21] Additionally, Grimmer reported significant associations between heavy backpack weights and complaints of spinal pain in adolescents.[17]Additionally, Lai found that cervical and shoulder postures were influenced by both amount and duration of weight carried by a backpack, suggesting that potential problems may occur from backpack weights greater than 10%.[22] Orloff & Rapp's examination of spinal curvature and load carriage of a 13.8%BW backpack found significant increases in the thoracic & lumbar spinal curvatures as the subjects fatigued while carrying the weighted backpack.[23] The forward head position reported here as a compensatory response to carrying a loaded backpack may have far reaching consequences into adulthood as children are subjected to carrying heavy backpacks on a regular basis for educational purposes. Clinicians and parents should be aware of the amount of weight and time that children spend carrying loaded backpacks, as they may be carrying relatively excessive backpacks loads on their immature spines and consequently biasing these undeveloped bodies for potential injury. Hong et al suggested the altered biomechanics required by children to carry increased loads on a daily basis "might be harmful and influence their normal musculoskeletal developmental growth" and recommended a backpack load limit of 10% body weight "since it causes the least disturbance of metabolic processes."[24] In this study, the 10%BW backpack load affected postural responses the least, while the 15% and 20%BW loads resulted in forward head positions which put the children at risk for headaches. This study supports a backpack load weight limit of 10% body weight for children.

V. Conclusion

The present study demonstrates the increased forward head posture observed in children while carrying loaded backpacks are associated with backpack weight. The greatest differences were noted as the magnitude of backpack loads goes on increasing. Further analyses of the changes in forward head posture suggest that the condition as well as the weight of backpack loads markedly affect forward head posture and present a risk for neck pain in children. Significant change in cervical and shoulder indicated by decrease in craniovertebral angle and increase in sagittal shoulder posture was found as %BW increased. This implies that loading more than 10% of body weight would be too heavy for the child to maintain normal cervical and shoulder posture alignment. It can be say that duration of time spent in carrying school bag has an effect on shoulder and cervical posture. Thus implying that school bag weighing 10% of body weight would be too heavy for the Indian school children aged 9-13 to be able to maintain their normal cervical and shoulder posture alignment. Thus carrying a load of less than 10% of body weight is recommended.

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