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ĆGSHIFTER: A METHOD TO SHIFT CENTRE OF GRAVITY TO REDUCE SCHOOL BAG STRESS ON CHILDREN BODY

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Abstract:
Increasing weight of backpacks of school going students and its adverse effect on children's body is shown through survey of Indore city. Outcome of survey shows that the average of ratio of backpack weight to body weight of school children was 20.62% which is higher than acceptable limit. It gives a method to reduce the impact of schoolbag on spinal cord of children body. In this paper, the effect of center of gravity of schoolbag on human body is observed which is shifted in a position which lowers the effect of schoolbag stress by applying CGSHIFTER method.

Keywords:
Adverse effect on children's body, Backpack weight to body ratio, Centre of Gravity, Schoolbag stress, Spinal cord.

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1. INTRODUCTION

Backpack is one of several forms of manual load carriage and is often used of school students as schoolbag acceptable limit which is recommended for schoolbag weight is 10-15% of child's body weight [1]. Regular use of heavy schoolbag is inappropriate carrying methods can case the risk of musculoskeletal problems [2], shoulder and neck injuries, muscle strain [3], deformation of spinal cord [4], chronic back and neck pain [5] and also change the body posture [6]. Primary school children are adolescents who are experienced a period of accelerated growth and development of skeletal and soft tissues of body [7]. There spinal structure is marked different from those of adults. Growth of spinal structure takes a longer period of time than the other tissues and any incongruities in rate of tissue development can pose a threat to the posture of children's body, moreover external force such as load carrying may also influence the growth, development and maintenance of the alignment of body [8].

Intensity of schoolbag stress impact is comparatively higher as girl child because of the body structural differences [9]. Impact of schoolbag is not only related with its stress on body but also with the alignment of centre of gravity (CG) of it [10]. If CG schoolbag is not properly aligned then there may be a spinal deformation and positioning error occurs in body [11]. In this paper, a

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cross sectional study has been done on the basis of survey. Participants are 643 school children from 5 different primary schools of Indore city (India). Result shows that children's schoolbag weight exceeds the acceptable limit of 10 to 15% of body weight. Section 3 specifies the effect and position of CG on human body because of schoolbag. Section 4 shows the details of materials and methods used in CGSHIFTER method.

2. SURVEY

A cross sectional study has been done on the basis of a survey, participants are 643(375 boys, 268 girls) school children aged 6 to 12 years from 5 different primary school of Indore city (India). The duration of this survey is 12 December 2014 to 31 December 2014. A digital weighing scales (CAEG Electrolux ABS 408E China) and electronic body scale (TCS-200-RT, China) was used 70 electronically measure the weight and height of the participants. The questionnaire consists of two sections; the first section includes the demographic information (name, age, height, weight and schoolbag weight). The second section of the questionnaire includes four questions, two questions about school bag type and way of carrying and two questions about the presence of pain in different body areas and location of pain. Outcomes from the survey are categorized into three sections. In first section mode of transport, method of carriage and time spent by children carrying school bag is shown in table 1, in section 2, Pain characteristics of participated children is shown in table 2 and section 3 is about characteristics of children and their schoolbags which are described in table 3.

Table 1: Mode of transport, method of carriage and time spent carrying the school bag.

Mode of Transport	**Boys (n=375)**	**Girls (n=268)**
Bus	153 (40.8%)	124 (46.26%)
Auto	89 (23.73%)	85 (31.71%)
Cycle	48 (12.8%)	26 (9.70%)
Walking	41 (10.93%)	19 (7.08%)
Two wheeler (with parents)	26 (6.94%)	12 (4.47%)
Four wheeler (with parents)	18 (4.8%)	22 (8.20%)
Method of Carriage	**Boys (n=375)**	**Girls (n=268)**
Two strap (Both shoulders)	289 (77.08%)	219 (81.72%)
Single Strap (One Shoulder)	86 (22.92%)	49 (18.28%)

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Approximate Duration of Carrying School Bag	Boys (n=375)	Girls (n=268)
<10 minutes	29 (7.73%)	41 (15.29%)
10-20 minutes	46 (12.26%)	36 (13.43%)
20-40 minutes	97 (25.86%)	62 (23.13%)
40-60 minutes	203 (54.13%)	129 (48.13%)

Table 2: Pain characteristics of the participants

Type of Pain	Boys (n=375)	Girls (n=268)
Pain atleast in one part of body	242 (64.53%)	185 (69.02%)
Neck pain	26.3%	22.4%
Shoulder pain	32.4%	35.8%
Back pain	36.8%	34.1%
Elbow pain	12.9%	14.8%
Hand and Wrist pain	11.2%	9.3%
Thigh pain	16.2%	12.9%
Knee pain	9.7%	8.1%
Foot and ankle pain	7.3%	9.8%

Table 3: Characteristics of children and their schoolbags

Characteristics	Boys		Girls	
	Range	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$
Age (years)	6-12	8.72±1.21	6-12	8.14 ± 2.74
Height (cm)	105-150	124.8 ± 3.2	105-150	121.39 ± 4.7
Body weight (Kg)	25-60	33.48 ± 5.3	20-50	31.7 ± 3.8

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Weight of schoolbag(Kg)	4.5- 13.5	7.4 ± 1.98	4.5- 13.5	7.2 ± 4.3

$\bar{x}$ Implies mean and SD implies Standard Deviation.

The purpose of this study is to document health effect, back and musculoskeletal pains and describe their relationship with schoolbag weight. Carrying a heavy schoolbag for long periods of time could result in repetitive stress injuries to growing body.

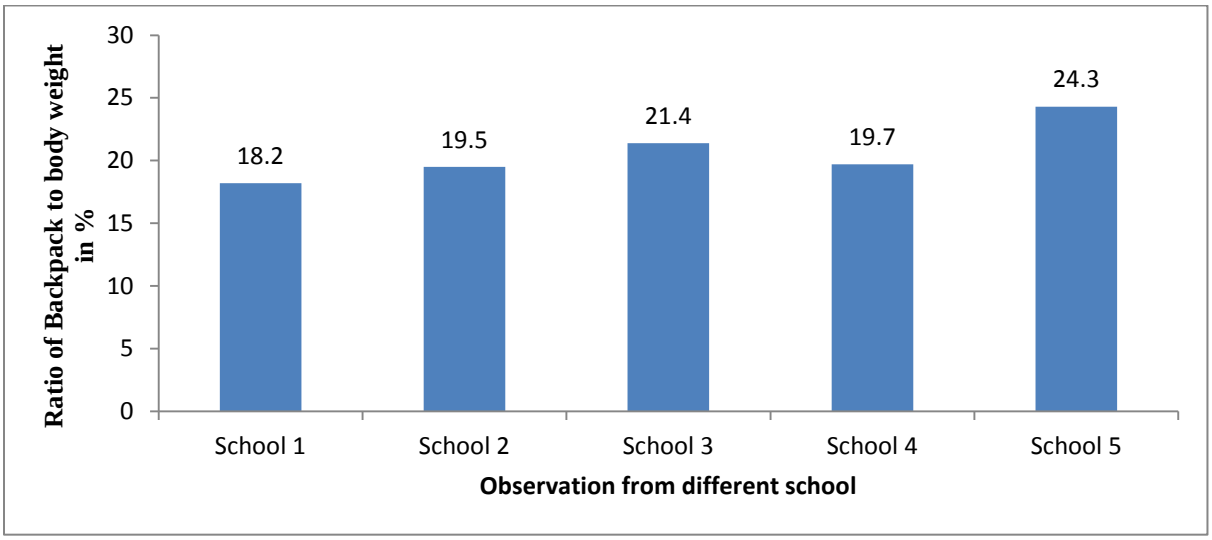

Figure1: Ratio of school bag weight to the body weight of children in percentage

Fig.1 shows the result of study for the ratio of schoolbag weight to the body weight of children in percentage and this was a school wise comparison. The average of ratio of schoolbag weight to body of 643 children in percentage and its value was observed 20.62%. Percentage ratio was higher for every school (under study) and it crosses the acceptable limit of schoolbag weight which should not be more than 10 to 15% of body weight [1]. The effect of this exceeded ratio on health in such a way that, increase in energy consumption of body [12], increase trunk forward lean [13] and result in decreased lung volumes [14]. These three factors lead to reduce the oxygen partial pressure (PO_2) resulting in an aerobic respiration and eventual fatigue [12].

3. LOCATION OF CG AND ITS EFFECT ON CHILDREN BODY

In addition to the stress of schoolbag, the effect of placement of the center of gravity (CG) of the load at the different vertical levels and the anteroposterior positions relative to the body are also important consideration. For this purpose, an experiment has been done in which the effects of

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the schoolbag. CG level on spinal region and muscle activity are determined. These findings revealed that human posture and spine muscles were significantly affected by load carriage of different CG locations. A schoolbag of dimension (17x13x6 cm) is selected it is filled with weight of 7.5 kg in different manner as to vary the location of CG of the body shifts from location from P_1 to P_5 which is shown in fig.2 of participants. Points P_1 to P_5 includes spinal curvatures of the cervical, upper and lower thoracic, upper and lower lumbar regions and pelvic tilt.

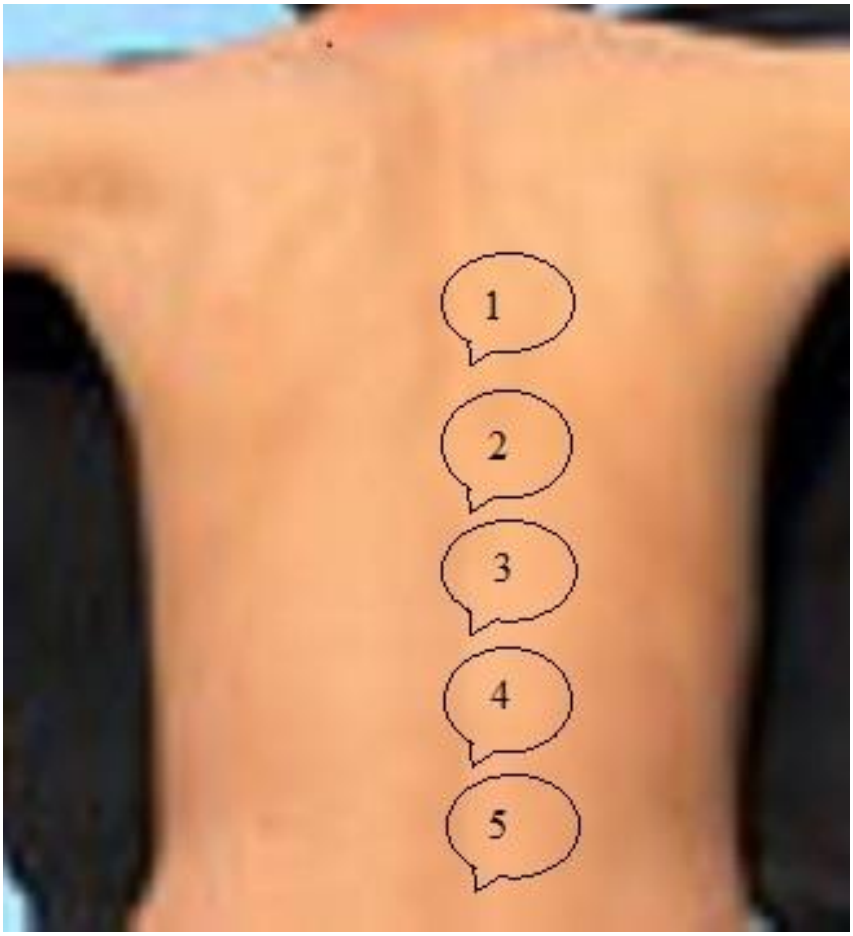

Figure 2: Location of CG on child's body

Stress calculation at these 5 different positions has been done when CG of schoolbag was in contact with body of participants. Stress exerted by schoolbag weight is mainly responsible for health problems related to children and it is equals to the force (weight) per unit area acting

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normal to its cross section. If the weight of particular part of schoolbag is W (Newton) and is acts on the cross sectional area of body A (m^2). This stress σ is defined as

$$\sigma = \frac{W}{A}$$

It has dimensions of force per unit area (SI unit N/m^2).

Fig.3 shows the magnitude of stress at different points from P_1 to P_5 when the location of CG of schoolbag changes on spinal cord. From the experiment it is observed that the effect of schoolbag stress is more when CG of bag is found in the region P_1 to P_3 and it is highest on P_3. Stress impact was less when CG found in this region P_4 &P_5 and it is least at point P_4.

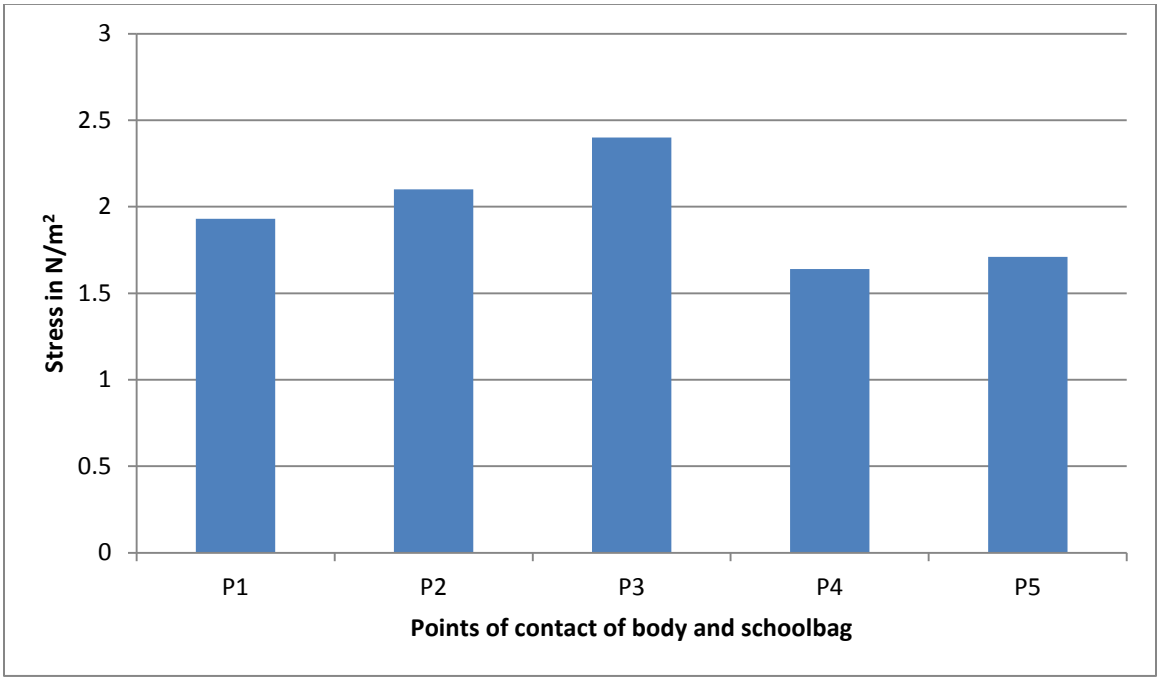

Figure 3: Magnitude of stress at different points (P_1 to $P_{5)}$ when the location of CG of schoolbag changes on spinal cord

4. MATERIAL AND METHOD

From the previous experiment, it is clear that for reducing the impact of schoolbag weight stress on the weight of children, this CG of schoolbag should not lie in the region from P_1 to P_3 which is generally occurred for every schoolbag. CG of schoolbag must be shifted in the region P_4 & P_5 where less stress effect is observed. CGSHIFTER method is applied on normal schoolbag to shift the CG of weight to the P_4. The center of gravity is defined as the balancing, equilibrium or pivoting point if the body. It is the point where the sum of all the forces and force movements

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acting on the body is zero and at which all the weight of the body may be considered to be concentrated and about which all the parts exactly balance. To lower the position of CG of schoolbag, it is necessary to add some weight at the lower part of it. For this purpose, air packets are used. Structure of a normal schoolbag of dimension (17x13x6 cm) is modified by using CGSHIFTER method. Air packets are used in the method which is shown in fig 4. It is a Kind of small airbags made by light weight rubber materials that can be inflated with air or gas and posses' better strength like durability and air retention properties.

Figure 4: Air packets

Air packets are covered by nylon clothing and further wrapped with sponge materials. Location of air packets installations are shown in fig 5. In CGSHIFTER method, whole schoolbag structure is divided into 3 sections. The CG of schoolbag from the region (P_1, P_2, and P_3) is to be shown in section. For the stress reduction, 14 air packets of size (6x4x2 cm) are installed in lower part of section 2 and 10 air packets of size (6x8x2 cm) are installed in section 3.

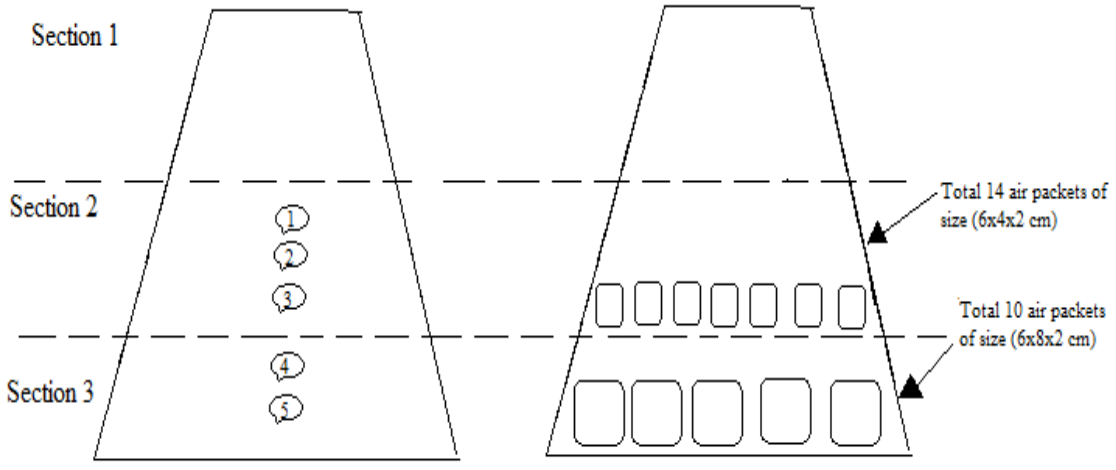

Figure 5: Location of air packets in schoolbag.

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Experiment is performed by using difficult weight ranging from 6 to 9 kg of the schoolbag using CGSHIFTER method. Location of CG is determined which is shown in fig. 6. The location of CG is lower in CGSHIFTER method when compared with normal bag in different weighing conditions and it is near about to point P_4 and P_5 which exerts less stress on the spinal portion of children's body.

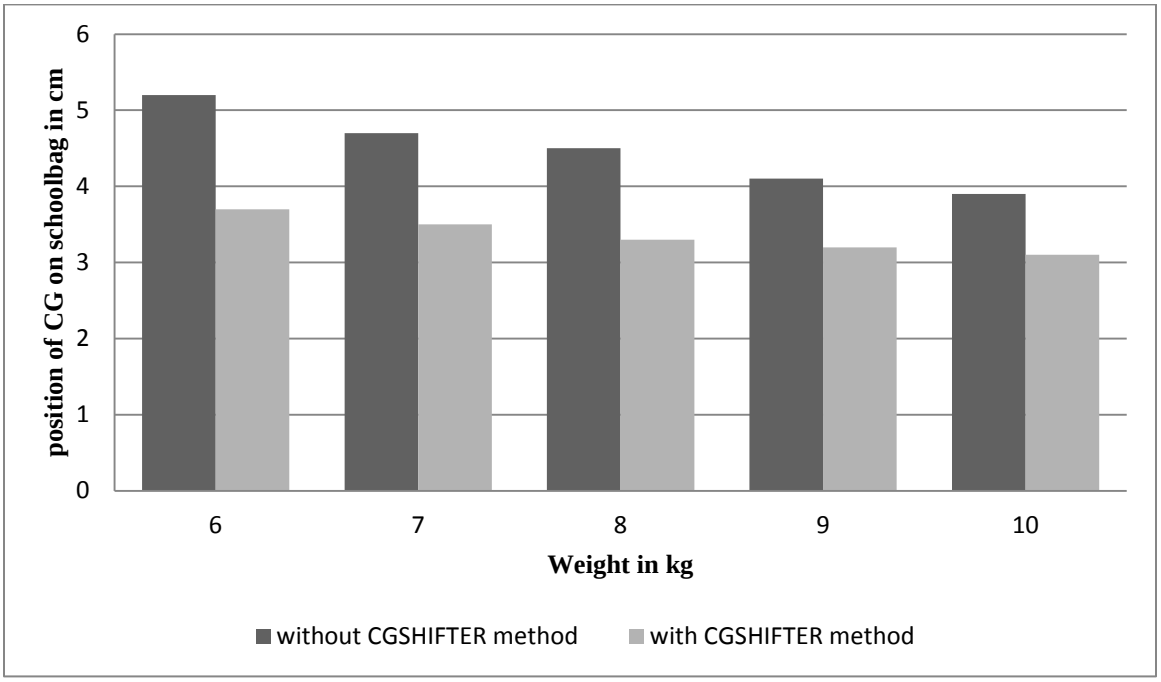

Figure 6: Position of CG with respect to weight.

4. CONCLUSION

This paper shows the survey of around 600 students including both girls and boys which gives the average of ratio of schoolbag weight and student weight is 20.62%. The impact of stress on children body due to position of centre of gravity of schoolbag is decreased by CGSHIFTER method which changes its CG location. It is an efficient method as it is of low cost and with increase in only 200-220 gm of schoolbag weights it reduces the effect of schoolbag on spinal cord.

5. ACKNOWLEDGMENT

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