SRT: A Method for Backpack Stress Reduction

Banti Khan[1] Ashita Goyal[2]

[1]School of Energy and Environment Studies, DAVV, Indore, India
[2]School of computer science and IT, DAVV, Indore, India

Abstract— *In this paper, 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 musculoskeletal effect and stress due to heavy backpack which is named as SRT (Stress Reduction Technique) used to distribute the load and reduce backpack stress on children body.*

Keywords— Adverse effect of backpack, Backpack weight to body weight ratio, Musculoskeletal effect, Stress reduction, Weight of backpacks

I. Introduction

Children uses school bags or back packs to carry load such as books, notebooks, lunchbox, water bottle and other equipment's required from home to school and back to home. The acceptable limit recommended for backpack weight is 10%-15% of child's body weight [1]. Many school children carry backpacks weighing beyond the acceptable limit which leads to the health injuries to them [2]. Regular use of heavy backpack and inappropriate carrying method can put children to the risk of musculoskeletal problems [3], shoulder and neck injury, muscle strain [4], effect on spinal cord [5], chronic back and neck pain [6] and also change the body posture [7]. The daily physical stresses associated with carrying heavy backpacks causes' significant forward lean of head and trunk of children's body and also develop the risk for short term as well as long term health issues. A study revealed that, there is higher risk of spinal symptoms to the children carrying heavy backpack loads during the stair use, especially when ascending a staircase, which is more physically demanding compared to the level walking [8].

Primary school children are adolescents who experienced a period of accelerated growth and development skeletal and soft tissues of body [9]. There spinal structure is markedly different from those of adults. Growth of spinal structure takes a longer period of time than 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 [10]. Change in alignment of neck can produce strain at cervical joints and soft tissues and imbalance the muscle performance [11]. Intensity of backpack stress impact is comparatively higher for the girl child because of body structural differences [12].

The use of backpack with physical exposure to the body is determined not only the weight of bag but also by the duration and method of carriage and its impact is measured in terms of stress[13]. In this paper a cross sectional study has been done on the basis of a survey, participants are 643 school children from 5 different primary school of Indore city (India). Result shows that children's backpack weight exceeds the acceptable limit of 10% to 15% of body weight. Section IV shows the experimental determination of various stress point by the backpack of child's body. Section V gives the solution of reducing the impact of backpack stress by using stress reduction technique (SRT) and material used for developing this model.

II. 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 backpacks which are described in table 3.

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%)
Approximate Duration of Carrying School Bag	**Boys (n=375)**	**Girls (n=268)**
<10 minutes	29 (7.73%)	41 (15.29%)
10-20 minutes	46	36

	(12.26%)	(13.43%)
20-40 minutes	97 (25.86%)	62 (23.13%)
40-60 minutes	203 (54.13%)	129 (48.13%)

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

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 2: Pain characteristics of the participants

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

Table 3: Characteristics of children and their backpacks
$\bar{x}$ 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 backpack weight. Carrying a heavy backpack for long periods of time could result in repetitive stress injuries to growing body. Fig.1 shows the result of study for the ratio of backpack weight to the body weight of children in percentage and this was a school wise comparison. The average of ratio of backpack 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 backpack 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 [14], increase trunk forward lean [15] and result in decreased lung volumes [16]. These three factors lead to reduce the oxygen partial pressure (PO_2) resulting in an aerobic respiration and eventual fatigue [14].

III. Effect of Stress on Body

Stress exerted by backpack weight is mainly responsible for health problems related to children. Stress is equals to the force (weight) per unit area acting normal to its cross section. If the weight of particular part of backpack is W (Newton) and it acts on the cross sectional area of body A (square metre), the stress σ is defined as;

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

It has dimensions of force per unit area (SI unit Nm^{-2}).

For the stress measurement a school bag (two straps) was taken and filled with books and other items of a school going children up to 7.84 kg as shown in fig.2.With the help of vertical weighing machine, individual weight of different points was taken. Cross sectional area of respective points which were generally in contact with body was measured.

After the measurement of stress, some points where maximum stress found were marked shown in fig. 3. Magnitude of stress at different points are plotted against different points is shown in fig. 4. It shows that the maximum stress yielding points are 1, 2 and 3 greatly contributing the body pain.

IV. Material and Methods Used in SRT

To reduce the stress from the points back pack which are responsible for the injuries and adverse health effect on children's body, Stress Reduction Technique (SRT) is used. Stress depends on two factors one is weight of objects in backpack which may not be alter because it varies as per requirement, second factor is area of contact of backpack and body which is inversely proportional to the stress. So the impact of stress can be reduced by increasing the area of contact by using SRT.

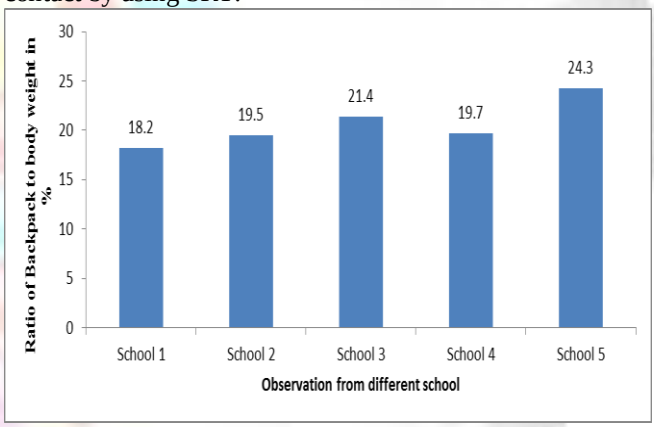

Fig. 1: Study of Backpack to body weight ratio of children from different school

Fig. 2: Backpack weighting 7.84kg

Fig. 3: Maximum stress measured at different points due to backpack

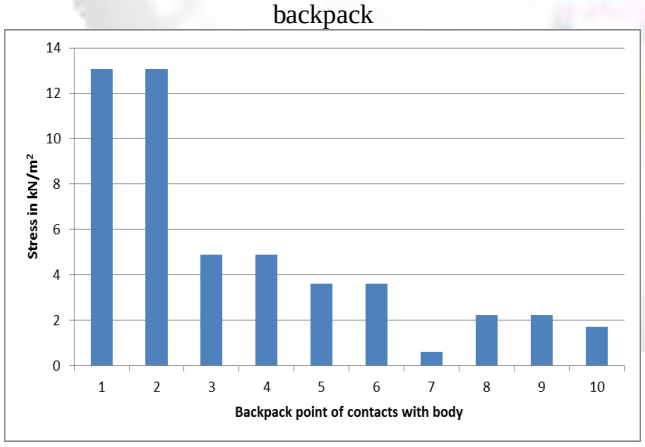

Fig. 4: Magnitude of stress due to backpack at different contact points with body (for a backpack of 7.8 kg).

Fig.5 shows the model of back pack which is constructed on the basis of SRT method. In this model shoulder straps are modified using circular structure at point 1 and 2, made by light weighed foam materials to reduce the maximum stress of body, point 3 and point 4 are provided with strips of sponge materials used to reduce the backlog stress and relief in pain due to bulk weight of backpack. Two adjustable belts are installed at point 5 and 6 as to distribute the load which is adjacent to the back of body posture while walking. Semi cylindrical trapped structures of porous foam material are attached at point 8 and 9. A dish like structure made of thick layers of clothing is used at point 7, which is adjustable according to the load in backpack and give comfort to the back of body. A sponge butt is attached at point 10 used to increase the area between body and lower portion of backpack and reduce the direct contact of the point where maximum load of bag is concentrated due to gravitational pull. When the magnitude of stress at 10 different point of backpack model is measured experimentally using SRT results as shown in fig. 6.

It is observed that the stress at every point is reduced after using SRT model when the magnitude of stress of back pack using SRT model with normal backpack carry (7.84 Kg) of weight, it is clearly observed that the impact of stress will be reduced as shown in fig.7. This risk to health of children will be reduced.

Fig. 5: Low Stress Model of backpack using SRT.

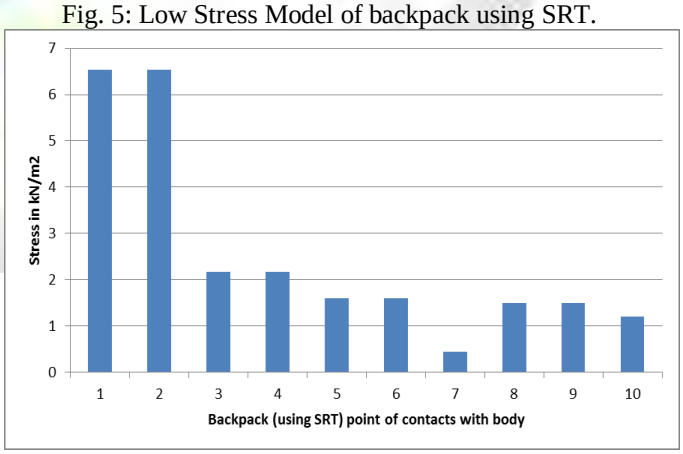

Fig. 6 Magnitude of stress due to backpack (using SRT method) at different contact points with body for a backpack of 7.84 kg

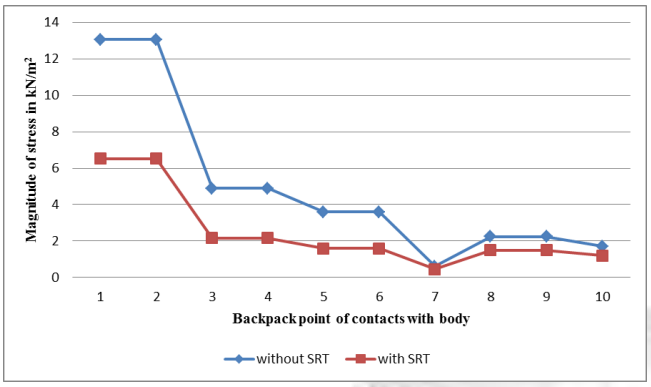

Fig. 7: Comparison of magnitude of stress at difficult body contact point using SRT method and normal backpack.

V. Conclusion

This paper shows the survey of around 600 students including both girls and boys which gives the average of ratio of backpack weight and student weight is 20.62% and which is decreased by SRT method. It is an efficient method as it is of low cost and with increase in only 115-150 gm of backpack weights it reduces the impact of stress of backpack on children.

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