Original Article

# Effect of backpack loading on cervical and sagittal shoulder posture in standing and after dynamic activity in school going children

**Nirav P. Vaghela[1], Sanket K. Parekh[1], Dixa Padsala[1], Dhruti Patel[1]**

[1]*Department of Physiotherapy, K M Patel Institute of Physiotherapy, Karamsad, Anand, Gujarat, India*

## Abstract

**Background:** Adolescent age group as school going children who experience a period of accelerated growth and development of skeletal and soft tissue. Any daily physical stresses external forces such as load carrying may also influence alignment of the human body. It is assumed that daily intermittent abnormal postural adaptations could result in pain and disability. **Objectives:** To know the effect of backpack loading on cervical and sagittal shoulder posture (SSP) in standing and after dynamic activity in school going children. **Materials and Methods:** The research project was conducted after getting clearance from Human Research Ethics Committee of the H M Patel Institution for Education and research center. Study was conducted on 160 school going children, and measurement were taken to know the loading over the cervical region along with their bagpacks were weighed. **Results:** Total 160 students were enrolled in the present study. Study found that average value of the subject's body weight was 34.83 kg, and subjects backpack weight was 6.42 kg that was equivalent to 18% of the subject's body weight. The mean value of cranio-vertebral angle (CVA) without school bag was 40.62. The mean values of cranio-horizontal angle (CHA) while standing with 18% of body weight and after dynamic activities with 18% of body weight were 24.51 ± 10.3 and 28.93 ± 4.34, respectively. The mean value of SSP without school bag was 39.39 ± 4.31, whereas the mean values of SSP while standing with 18% of body weight and after dynamic activities with 18% of body weight were 54.38 ± 21.19 and 77.62 ± 17.50, respectively. **Conclusions:** Study revealed that there is a significant reduction in the CVA (or increased forward head position), increase in CHA, and SSP were found while carrying a backpack weight 18% of body weight over both shoulders.

**Keywords:** Adolescents, bagpacks, gait, load carriage, neck and back pain trunk forward lean, posture, students

## Introduction

School children are adolescent who experience a period of accelerated growth and development of skeletal and soft tissue. Their spinal structures are thus different from those of adults. Children have relatively larger heads and also have higher center of mass at about T12, compared to L5-S1 in adults. As growth of the spinal structures extends over a longer period of time than the other skeletal tissues incongruities in rate of tissue development can pose a threat to postural integrity.[1] Ideal alignment of head, neck, and shoulder - the ear lobe is in line with the shoulder tip (acromian process) and high point of iliac crest. This line is the lateral line of the reference dividing the body into front and back halves equally.[2] Changes in alignment of neck can produce strain of cervical joints and soft tissues as well as imbalanced muscle performance. Children are at a higher risk of overuse injuries for two reasons. First, a child's skeleton has great amounts of cartilage, especially in areas where growth occurs, as it is a predecessor to bone ossification. These cartilaginous regions include the articular cartilage, the epiphyses, and the apophyses. Each form of cartilage is susceptible to different types of injury. Articular cartilage is vulnerable to sheer stress, whereas the epiphysis and apophyses

**Address for correspondence:** Dr. Sanket Kiritbhai Parekh, K M Patel Institute of Physiotherapy, Shree Krishna Hospital, Gokal Nagar, Karamsad, Anand, Gujarat - 388 325, India.
E-mail: sanketkp@charutarhealth.org

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are more susceptible to repetitive micro trauma.[3] The peak rate of growth occurs during puberty, and the growth of the appendicular skeletal system ceases around 16 years of age for females and 18 years for males.[4] However, secondary ossification of vertebrae is not complete until the mid-twenties. Therefore, the spine may be susceptible to injury for a greater length of time, and therefore, proper backpack use should be emphasized during these years. When the backpack load is positioned posterior to the body, the center of gravity shifts posteriorly. This shift is accomplished by either leaning forward at the ankle or hip or inclining the head, and the rigidity of postural muscles controlling these adjustments increases to support the load.[5] Moreover, external forces such as load carrying may also influence the growth, development, and maintenance of alignment of the human body.[6] Within developed nations, backpack use among school children has become the most popular means of transporting belongings to and from school. Backpack use is an appropriate way for carrying loads on the spine, closely and symmetrically, while maintaining stability.[7] The daily physical stresses associated with carrying backpacks cause significant forward lean of the head and trunk. It is assumed that daily intermittent abnormal postural adaptations could result in pain and disability. According to Dr. Scott Bautch, A Chiropractitioner, Wis. "Many of these kids are carrying a quarter of their body weight over their shoulders for a large portion of the day. That's equivalent to a 180-pound man carrying around a 45-pound load." Forward head posture involves flexion of the lower cervical spine in combination with extension of the upper cervical spine. It is often accompanied by protracted scapulae and increased thoracic kyphosis.[8] Because of the repeated stress, there can be permanent disability or the chronic pain at the early age only. Hence, as a part of clinical practice, physician or any health professional has to consider preventing the early chronic disability or pain that can hamper the Quality of Life of the students or school going children. As many role of the clinical physician, it is also part of them to prevent the chronic disability or altered posture of the children and posture correction of the shoulder and neck that is more prone to get affected. Methods to assess cervical and sagittal shoulder posture (SSP) are plumb line method, photography method, and x-ray method.[8-11] Here, in this study, we are using photography method to assess the cervical and SSP, which is reliable and most convenient method. To evaluate posture of the cervical and shoulder region, three angles of measurement were used as measures of cervical and shoulder posture in the study. The angles in the lateral view are as follows:

- Cranio-horizontal angle
- Cranio-vertebral angle
- Sagittal shoulder posture.

## Definitions

- Cranio-horizontal angle (CHA): The angle formed at the intersection of horizontal line through the tragus of the ear and the line joining the tragus of the ear and external canthus of the eye. It is believed to provide an estimation of head on neck angle or position of upper cervical spine. (Raine and Twomey 1994)
- Cranio-vertebral angle (CVA): It is the angle formed at the intersection of a horizontal line through the spinous process of C7 and line of the tragus of the ear. This believed to provide an estimation of neck on upper trunk positioning. A small angle indicates forward head posture. (Wickens and Kiputh 1937, Raine and Twomey 1994).

Sagittal shoulder posture (SSP): The angle formed by intersection of a horizontal line through C7 and line between the midpoint of the greater tuberosity of the humerus and posterior aspect of acromian process. This provides measurement of forward shoulder position. (Raine and Twomey 1994).

## Objectives

- To find out the average weight of the school bag carried by school going children
- To assess the cervical posture without school bag in school going children
- To assess the cervical posture with school bag in school going children in standing and after dynamic activity
- To assess the SSP without school bag in school going children
- To assess the SSP with school bag in school going children in standing and after dynamic activity
- To compare the cervical and SSP without and with school bag in standing and after dynamic activity.

# Materials and Methods

## Study design

Cross-sectional survey.

## Study population

Study included the school going children from various schools from western region of the India.

## Sample size

Total 160 participants who are school going children aged between 10 and15 years.

## Inclusion criteria

- School going children with bagpack over both the shoulders
- Age: 10 to 15 year (both gender).

## Exclusion criteria

- Any recent systemic illness
- Any musculoskeletal, cardiorespiratory, or neurological problem
- Any congenital deformities

## Methodology of study

1st phase of the study included survey that how much bag weight school children carry every day. In this, we selected various schools of western region of the India. Inform consent of the principal of the school and also of the parents of the selected

children have been taken. Twenty subjects of 10–15 years of age from each school selected were randomly. Each subject's body weight and school bag weight were measured on weighing machine and recorded. Average values of body weight and school bag weight were calculated. In 2nd phase of the study, 160 (89 boys and 71 girls) school going children of age 10–15 years were randomly selected. Each subject's body weight and school bag weight were measured. Each subject's school bag weight was adjusted with 18% of his/her body weight. Subject was instructed to stand straight with the right shoulder facing the wall without school bag [Figure 1]. Markers were placed over c7 spinous process, in front of left tragus, external canthus of the left eye, mid-point of greater tuberosity of left humerus, and posterior aspect of the left acromion process as reference points to measure the mentioned angles. Samsung 12 megapixel digital camera was placed on a tripod stand at 1 m distance from the subject on the left side. Height of the camera was adjusted accordingly. Further, photo of the subject was taken from the left lateral view. Then, the same subject was instructed to carry school bag, which was equivalent to 18% of his/her body weight, on both the shoulders and stand straight as mentioned above. Again photo of the subject was taken from the left lateral view. Then, the same subject was instructed to do stair climbing carrying the same school bag for 5 min. After completing the activity, the subject was instructed to stand straight as mentioned above. Photo of the same subject was taken from the left lateral view. Now, the photographs of all the 3 positions were imported in UTHSCSA image tool software in computer.[12] SSP, CHA, and CVA were measured using markers as reference point in each position to assess shoulder and cervical posture. Data were collected. Sagittal shoulder and cervical posture in standing position with school bag were compared without school bag in standing posture, and also comparison were done between standing with school bag and after dynamic activity with school bag in standing posture, and results were concluded from that.

## Results

### Phase 1

We found that average value of the subject's body weight was 34.83 kg with standard deviation (SD) of 9.89 kg. We found that average value of the subjects backpack weight was 6.42 kg with SD of 1.41 kg that was equivalent to 18% of the subject's body weight.

**Table 1: Average body weight of the school children and average school bag weight**

| Variables | Mean (SD) |
|---|---|
| Subject's body weight | 34.83 (9.89) |
| School bag weight | 6.42 (1.41) |

Table 1 shows the average body weight of the school children and average school bag weight; they are carrying on their shoulders every day.

Table 2 shows average values of postural angles that were measured with no school bag, with school bag over shoulders equivalent to 18% of the body weight in standing, and after dynamic activities in standing. The mean value of CVA without school bag was 40.62 ± 10.16, whereas the mean values of CVA while standing with 18% of body weight and after dynamic activities with 18% of body weight were 36.16 ± 10.5 and 33.86 ± 7.96, respectively. The mean value of CHA without school bag was 20.51 ± 8.17, whereas the mean values of CHA while standing with 18% of body weight and after dynamic activities with 18% of body weight were 24.51 ± 10.3 and 28.93 ± 4.34, respectively. The mean value of SSP without school bag was 39.39 ± 4.31, whereas the mean values of SSP while standing with 18% of body weight and after dynamic activities with 18% of body weight were 54.38 ± 21.19 and 77.62 ± 17.50, respectively.

As per a Table 3 significant difference was found in the CVA between standing without school bag and standing with school bag equivalent to 18% body weight, as Z calculated value, 3.87, is greater than Z tabulated value 1.97 at 5% level of significance. In addition, significant difference was found in CVA between standing and standing after dynamic activities with school bag equivalent to 18% body weight, as Z calculated value, 2.21, is greater than Z tabulated value 1.97 at 5% level of significance. Significant difference was found in the CHA between standing without school bag and standing with school bag equivalent to 18% body weight, as Z calculated value, 3.88, is greater than Z tabulated value 1.97 at 5% level of significance. Moreover, significant difference was found in CHA between standing and standing after dynamic activities with school bag equivalent to 18% body weight, as Z calculated value, 5.02, is greater than Z tabulated value 1.97 at 5% level of significance. Significant difference was found in the SSP between standing without school bag and standing with school bag equivalent to 18% body weight, as Z calculated value, 8.81, is greater than Z tabulated value 1.97 at 5% level of significance. Further, significant difference was found in SSP between standing and standing after dynamic activities with school bag equivalent to 18% body weight, as Z calculated value, 10.70, is greater than Z tabulated value 1.97 at 5% level of significance.

**Table 2: Shows average values of postural angles which were measured with no school bag, with school bag over shoulders equivalent to 18% of the body weight in standing and after dynamic activities in standing**

| Conditions | Cranio-vertebral angle (CVA) Mean (SD) | Cranio-horizontal angle (CHA) Mean (SD) | Sagittal shoulder posture (SSP) Mean (SD) |
|---|---|---|---|
| Without school bag | 40.62 (10.16) | 20.51 (8.17) | 39.39 (4.31) |
| With school bag (18% of body weight.) in standing | 36.16 (10.5) | 24.51 (10.30) | 54.38 (21.19) |
| After dynamic activity with school bag (18% of body weight.) in standing | 33.86 (7.96) | 28.93 (4.34) | 77.62 (17.50) |

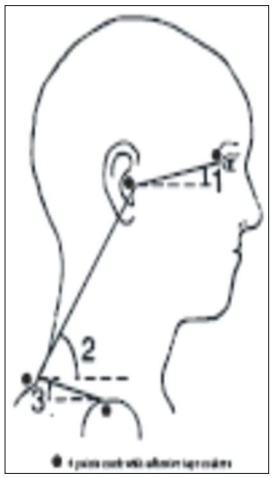


**Figure 1:** Shows the measurement of the angles

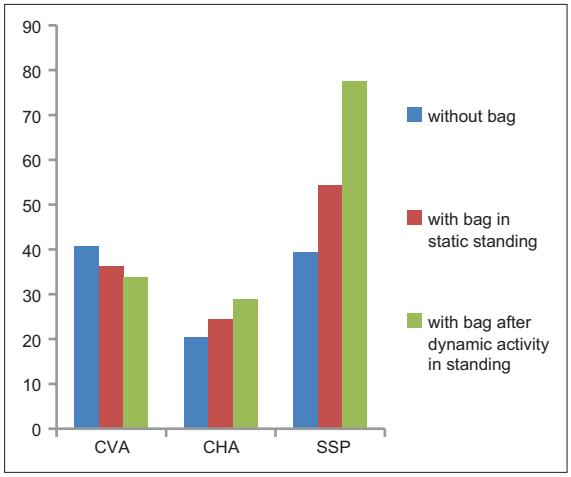


**Figure 2:** Shows Comparison between Without school bag and with school bag in standing

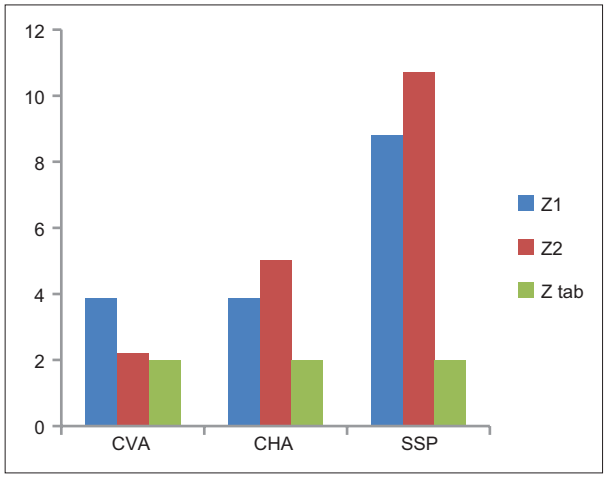


**Figure 3:** Shows Comparison between standing and after dynamic activity with school bag

- Z1: Comparison between without school bag and with school bag in standing
- Z2: Comparison between standing and after dynamic activity with school bag.

## Phase 2

- Baseline values were obtained by measuring CVA, CHA, and SSP without school bag
- The mean values of CVA significantly reduced in two conditions, in standing and after dynamic activity in standing with school bag in comparison without school bag
- The mean values of CHA increased in two conditions, in standing and after dynamic activity in standing with school bag in comparison without school bag [Figure 2]
- The mean values of SSP increased in two conditions, in standing and after dynamic activity in standing with school bag in comparison without school bag [Figure 3].

# Discussion

The result of this study revealed that most of the children in the age group of 10–15 years carried school bag weighing average 6.42 kg ± 1.41 kg, which was found to be 18% of their body weight. The weight of the school bag expressed in percentage of body weight was found to be consistent with study done by Shruti. R Iyer. Shruti. R Iyer in her study found that Indian children carry school bags weighing 18.5% of their body weight.[13-15]

## Effect of backpack on Cranio-vertebral angle

In this study, we found that there was significant decrease in CVA in standing with school bag equivalent to 18% of the body weight as compared to standing without school bag. In addition, we found that there was significant decrease in CVA in standing after dynamic activity as compared to standing with school bag equivalent to 18% of the body weight. A small angle indicates more forward head position. When load is positioned posterior to the body in the form of backpack it changes posture because of change in the center of gravity.[16,17] The body tries to keep the center of gravity between feet, so with a backpack, this is accomplished by either leaning forward at the ankle or hip or inclining the head. Similar studies were done by Cheung CH, Shum ST, Tang SF, Yau PC, Chiu TT (The Hong Kong Polytechnic University, Hong Kong) revealed that CVA gradually decreased with increment of backpack loadings and the amount of decreases became significant from 10% body weight onwards.[18]

## Effect of backpack on Cranio-horizontal angle

We found a significant increase in CHA in standing with school bag equivalent to 18% of the body weight as compared to without bag in standing. In addition, we found a significant increase in CHA in standing after dynamic activity as compared to standing with school bag equivalent to 18% of the body weight. Change in CHA can be attributed to the hyperextension of the upper cervical vertebra, which occurs in compensation of lower cervical flexion to maintain the center of gravity between the feet.(Cyanthia C. Norkin) This is supported by the study done by M RAMPRASAD, JEBA ALIAS, AND AK RAGHUVEER (June 23, 2009) which says that head on neck angle (CHA) increases with the use of heavy backpack.

**Table 3: Z tab value at 5% level of significance: 1.97**

| | CVA | CHA | SSP |
|---|---|---|---|
| Comparison between without school bag and with school bag in standing Z calculated value | 3.87 | 3.88 | 8.81 |
| Comparison between standing and after dynamic activity with school bag Z calculated value | 2.21 | 5.02 | 10.70 |

Z tabulated value at 5% level of significance: 1.97

## Effect of backpack on sagittal shoulder posture

We found a significant increase in SSP in standing with school bag equivalent to 18% of the body weight as compared to without bag in standing. In addition, we found a significant increase in SSP in standing after dynamic activity as compared to standing with school bag equivalent to 18% of the body weight. Wunpen *et al.* from university of South Australia suggested that a larger sagittal shoulder angle may represent a more rounded shoulder. If the forward head posture is increased, the marker at C7 is displaced anteriorly. The closer the points at the shoulder and C7 are, the bigger the sagittal shoulder angle is. Therefore, the more anterior head position observed in most subjects in this study when carrying a backpack may contribute to an enlarged sagittal shoulder angle. These changes in alignment of the neck can produce strain of cervical joints and soft tissue as well as imbalanced muscle performances. This can cause pain in cervical, upper thoracic, and shoulder region (Micheli LJ, Fehlandt AF. Clin sports Med 1992; 11: 713-726.). Thus, it can be said that carrying school bags weighing 18% body weight would alter the head and shoulder position and may result in poor posture, muscle strain, and pain in the back, neck, and shoulders. (North American Spine Society, April 02, 2009).

As a preventive medicine, it is necessary to reduce down the prevalence of the wrong posture or permanent disability that is occurring in adolescents by advising the proper technique of carrying the school bag along with the advising the appropriate weight of the school bag which can help to rid down the stress over the cervical as well as on the shoulder joint. It is also important note for the clinical physician to rule out the common causes for the chronic pain, and clinically, these advices may help to reduce down the pain and disability in early childhood. Most chronic pain is due to the wrong adaptation, so physician or any health professional has to suggest proper technique of lifting or carrying the bagbacks, which can reduce down the prevalence of the musculoskeletal disorders. This project can help the medical professional to cure or to prevent the chronic pain or disability at early age rather than getting accumulative or getting permanent of the musculoskeletal disorders at older age.

## Conclusion

Present study revealed that there is a significant reduction in the CVA (or increased forward head position), increase in CHA, and SSP were found while carrying a backpack weight 18% of body weight over both shoulders. Study had a few limitations also like postural response to load has studied only in standing condition and following post dynamic activities in standing and not during dynamic conditions, such walking. The standing condition does not perfectly resemble a realistic environment for students during normal daytime school bag carriage. Another limitation was postural responses to load are best studied by observing changes in trunk forward lean, CVA, and spinal curvature. However, this study only examines cervical and shoulder posture. In addition, most importantly physical activity of the subject has not been considered. Hence, accordingly, we also recommend few further projection such as postural changes of the trunk because of backpack loading can be assessed, and the correlation of the effects of backpack loading on cervical and shoulder posture between boys and girls can be studied.

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## Conflicts of interest

There are no conflicts of interest.

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