To Determine the Efficacy of Addition of Horizontal Waist Strap to the Traditional Double Shoulder Strap School Backpack Loading on Cervical and Shoulder Posture in Indian School Going Children

Mathur H1, Desai A2 and Khan SA3

1Department of Physiotherapy, Jaipur National University, India
2Indian Spinal Injuries Centre, Institute of Rehabilitation Sciences, India
3Department of Physiotherapy, Jamia Hamdard University, India

Corresponding author: Mathur H, Department of Physiotherapy, Jaipur National University, India, Tel: +91-9649784338; E-mail: himansh88@yahoo.co.in

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Abstract

Study Design: Experimental same subject design.

Objective: To determine the efficacy of addition of horizontal waist strap to the traditional double shoulder strap school bag on cervical and shoulder posture in Indian school going children.

Methods: A total of 60 school children aged 10-16 years were randomly selected from CBSE affiliated schools in Delhi, which participated in this study. Each child’s body weight, height, and school bag weight were measured. Posture was measured in the form of three angles: (1) CVA, (2) CHA, (3) SSP, from the sagittal plane and recorded photographically under two different types of backpacks: (1) Double Shoulder Strap Backpack and, (2) Additional Waist Strap Backpack, each backpack had three conditions: (1) unloaded 0% body weight, (2) Static with 10% body weight, (3) post dynamic with 10% body weight.

Data analysis: Comparison of postural angles was done between the two types of backpacks and between the three types of loading conditions. The significance of changes in data for the loading conditions was estimated using repeated measure analysis of variance on each angle with which planned contrast were made of the unloaded condition with each of two other loaded condition. The significance of changes in data for the two types of backpacks was estimated using paired t-test on each angle with which planned contrast were made of similar loading conditions between the backpacks. Statistical test were considered significant if p=0.05.

Results: The changes in the postural angles with backpack loading were found to be less significant in backpack with additional waist strap as compared to double shoulder strap backpack. A significant change in postural angle was found in 2 loading conditions, static loading (10% BW) and dynamic loading (10% BW) when comparing with unloaded condition. Results revealed that using a backpack with additional waist strap to a traditional double shoulder strap backpack can bring significantly less changes in cervical and shoulder posture.

Conclusion: The results of the study suggests that addition of horizontal waist strap to the traditional double shoulder strap backpack loading with 10% body weight reduces the changes in cervical and shoulder postures as compared with the traditional double shoulder strap backpack loading with 10% body weight.

Keywords: Load carriage; Type of backpacks; Waist strap; Posture; School children

Introduction

Education today has become part and parcel of our lives. What matters in present scenario is quality education, that is the reason schools and colleges have formatted syllabus in such a manner, that students can gain more knowledge in less time. Also there is a limitation in the timings of school, so maximum syllabus has to be covered within those timings. Thus the child has to carry more books to school daily which in turn leads to more load carrying problems. Most of the Indian schools do not provide lockers to the students, because of which student cannot keep any books at school and has to carry all the books along with him in school bag. Because of the curriculum the load carried by the child cannot be reduced, also we cannot decrease the load carrying time. Thus, the only solution to reduce the risk of load carrying problems could be a proper design of the backpack, which can cause minimal changes in the normal posture of the student.

Backpack use is an appropriate way for carrying loads on the spine, closely and symmetrically, while maintaining stability [1]. The daily physical stresses associated with carrying backpacks cause significant forward lean of the head and trunk [2]. However musculoskeletal problems associated with backpack use have become of increasing concern [3-8]. Recent studies confirmed high prevalence rate (10% to 40% depending upon back pain definition and age) of back pain among adolescent in many countries like New Zealand [7], United
Kingdom [9], India [6], Italy [3], America [6], Finland [5], and Switzerland. There are also few reports of other problems associated with backpack i.e. functional scoliosis, rucksack palsy [10,11] and reduced lung function [12-14].

When the backpack load is positioned posterior to the body, the center of gravity shifts posteriorly, over the base of the support; the area covered by the feet [15]. This shift is accomplished by either leaning forward at the ankle or hip, inclining the head and the rigidity of postural muscles controlling these adjustments increase to support the load.

These alterations can lead to back pain and injury by stressing ligaments or muscles in the back or by changing the forces applied to the intervertebral discs. As the individuals fatigue and these changes become more pronounced, there is potential for the risk of injury to the load carrier. The study done by other researchers proves that carrying backpack can lead to forward head position [16-18]. 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 [2].

Very few studies have been done to compare the effect of different types of school backpacks on the posture of school children. Also, no such study has been done on Indian students. As a matter of fact, the economical and curricular scenario of our country is very different from west. Thus, there is a need to do such study in our country. The purpose of the present study was to compare the effect of two different kinds of school backpacks on the cervical and shoulder postural angles in Indian school going children. In this study, we aim to find out the appropriate type of school backpack to minimize the problems of today's children as they are the future of the tomorrow's world.

Methodology

Sample

a) Sample Size: Number of subjects - 60
b) Source of subjects: Schools of Delhi

Sampling: 3. Subjects were recruited on the basis of voluntary participation through informed consent.

Inclusion criteria

- Age: 10 to 16 years
- Gender: Male.
- Standard of education: 5th, 6th & 7th standard.

Exclusion criteria

- Recent Fever
- Any Diagnosed Systemic illness
- Any Musculoskeletal problem which can lead to limitation in required function (shoulder, lower limbs, back)
- Any Neurological disorder
- Any malignancy
- Genetic syndromes
- Any recent or past complain of back pain or neck pain
- Congenital deformities/Acquired deformities-Like Scoliosis/Kyphosis, Limb Length Discrepancies
- Students already using waist strap school bag.

Study design

Same subject experimental design was used for the study.

Equipment/Tools

1. Traditional Double Shoulder Strap School Bag (DSBP) (Figure 1)
   (L=17.5 cm, W=13 cm)
2. Modified Bag with an Additional Waist Strap (AWSBP) (Figure 1)
   (L=17.5 cm, W=13 cm)
3. Weight bearing scale
4. Measuring tape (Wall Mounted)
5. Weight for school backpack-Books carried by student.
6. Sony digital camera (14 Mega Pixels, Model No. DSC-320) (Figure 2)
7. Tripod stands (Figure 1)
8. Digitizing Software-Image Tool UTHSCA version 3.0

Variables

Independent variable: a) Double Shoulder Strap Backpack (DSBP):- bi compartmental school bag has two adjustable shoulder straps; b) Additional Waist Strap Backpack (AWSBP):- bi compartmental school bag has two adjustable shoulder straps with an waist strap.

Dependent variable: (Figure 1) A. Cervical Posture: (i) Cranio Horizontal Angle (CHA); (ii) Craniovertebral Angle (CVA); B. Shoulder Posture: (i) Sagittal Shoulder Posture (SSP)

Posture analysis tool

Measures of cervical and shoulder posture angles were calculated from digital photographs using the digitizing software (Image Tool UTHSCA version 3.0 University of Texas Health Service Center, San Antonio, TX).

Procedure

Postural evaluation for both the types of backpacks was done to find out CVA, CHA and SSP, in both static and post dynamic condition, using UTHSCA software, version 3.0.

Data Analysis

Firstly, Using Double Shoulder Straps backpack, Study was carried out and Postural angles (CVA, CHA and SSP) were compared for three of the above conditions. Similarly, Using Additional Waist Strap Backpack, Study was carried out. The test used here was repeated measure analysis of variance (ANOVA).
Results

The mean age of subjects enrolled was 11.68 ± 1.35. The mean height and mean weight of the subjects enrolled were 139.75 ± 11.01 cm's and 31.61 ± 10.16 kg respectively. The mean BMI of the subjects was found to be 15.93 ± 3.54.

Baseline values were obtained by analyzing the Craniovertebral angle, Craniohorizontal angle, and sagittal shoulder posture in the unloaded condition (0% of their body weight), using UTHSCA software, for both the types of backpacks. The mean values of CVA, CHA and SSP in unloaded condition when using DSBP were found to be as 43.31 ± 5.59, 17.52 ± 3.55 and 41.34 ± 7.32 respectively. The mean values of CVA, CHA and SSP in unloaded condition when using AWSBP were also found to be as 43.31± 5.59, 17.52 ± 3.55 and 41.34 ± 7.32 respectively.

Comparison of CVA results between Double Shoulder Strap Backpack and Additional Waist Strap Backpack

Pair wise comparison of CVA was done between Double Shoulder Strap Backpack and Additional Waist Strap Backpack. The comparison was made between static (with 10% BW) and post dynamic (with 10% BW) of both the type of backpacks using paired t-test. The mean value of CVA in unloaded condition was same in both the type of backpacks.

The mean values of CVA in static loading (with 10% body weight) in double shoulder straps backpack and in additional waist strap backpack were 39.91 ± 6.24 and 41.08 ± 6.04 respectively. The mean values of CVA in post dynamic loading (with 10% body weight) in double shoulder straps backpack and in additional waist strap backpack were 37.47 ± 6.30 and 39.14 ± 5.84 respectively (Graphs 1 and 2).

The pair wise comparison of CVA was done between double shoulder strap backpack and additional waist strap backpack in both static and post dynamic loading using paired t-test. Significant difference was found with p value 0.01 using paired t-test.

Comparison of CHA results between Double Shoulder Strap Backpack and Additional Waist Strap Backpack

Pair wise comparison of CHA was done between Double Shoulder Strap Backpack and Additional Waist Strap Backpack. The comparison was made between static (with 10% BW) and post dynamic (with 10% BW) of both the type of backpacks using paired t-test. The mean value of CHA in unloaded condition was same in both the type of backpacks.

The mean values of CHA in static loading (with 10% body weight) in double shoulder straps backpack and in additional waist strap backpack were 21.33 ± 4.28 and 19.96 ± 3.94 respectively. The mean values of CHA in post dynamic loading (with 10% body weight) in double shoulder straps backpack and in additional waist strap backpack were 24.32 ± 4.93 and 22.50 ± 4.97 respectively (Graphs 3 and 4).

The pair wise comparison of CHA was done between double shoulder strap backpack and additional waist strap backpack in both static and post dynamic loading using paired t-test. Significant difference was found with p value 0.01 using paired t-test.
Comparison of SSP results between Double Shoulder Strap Backpack and Additional Waist Strap Backpack

Pair wise comparison of SSP was done between Double Shoulder Strap Backpack and Additional Waist Strap Backpack. The comparison was made between static (with 10% BW) and post dynamic (with 10% BW) of both the type of backpacks using paired t-test. The mean value of SSP in unloaded condition was same in both the type of backpacks.

The mean values of SSP in static loading (with 10% body weight) in double shoulder straps backpack and in additional waist strap backpack were 48.22 ± 10.12 and 46.02 ± 9.35 respectively.

The mean values of SSP in post dynamic loading (with 10% body weight) in double shoulder straps backpack and in additional waist strap backpack were 51.72 ± 10.66 and 49.36 ± 9.93 respectively (Graphs 5 and 6).

Graph 1: Comparison of CVA in static condition between DSBP and AWSBP.

Graph 2: Comparison of CVA in post dynamic condition between DSBP and AWSBP.

Graph 3: Comparison of CHA in post dynamic condition between DSBP and AWSBP.

The pair wise comparison of SSP was done between double shoulder strap backpack and additional waist strap backpack in both static and post dynamic loading using paired t-test. Significant difference was found with p value 0.01 using paired t-test.
Discussion

The results of the study demonstrated that addition of horizontal waist strap to the traditional double shoulder strap backpack significantly reduces the changes in the cervical and shoulder posture.

Craniovertebral angle

In this study we found that Craniovertebral angle reduces in static loading (with 10% BW) as compared to unloaded condition, and reduces further more in post dynamic loading condition (with 10% BW) as compared to static and unloaded condition. This was true for both the types of backpacks. This reduction in CVA was more in the double shoulder strap backpack loading, as compared to the backpack with additional waist strap.

Graph 4: Comparison of CHA in static condition between DSBP and AWSBP.

Graph 5: Comparison of SSP in static condition between DSBP and AWSBP.

Craniovertebral angle provides an estimation of head on upper back. A small angle indicates more forward head posture [19]. A child assumes forward head posture while carrying heavy backpacks [20]. Most of the causes of forward head posture can be considered to be repetitive micro traumatic events. The carriage of backpacks by school children is one of the repetitive micro traumatic events that can lead to postural anomaly of forward head posture [19,21]. The kinematic coupling pattern of lower cervical flexion and upper cervical extension (posterior cranial rotation) is believed to be present in forward head posture. However, some authors have failed to find an association of upper cervical extension with lower cervical flexion in asymptomatic individuals [22]. Mannheimer et al. [23] suggested that forward head posture can exist with and without posterior cranial rotation. The posterior cranial rotation of the head on the upper cervical spine that is associated with the position may be sufficient to compress the arteries and nerves exiting the skull suboccipitally [24]. The changes in alignment of neck in forward head posture can produce strain of cervical joints and soft tissues as well as imbalanced muscles performance [22,25]. This can cause pain in cervical, thoracic and shoulder regions [25].

In addition the forward head posture forces the mid-cervical spine into hyperextension, with subsequent narrowing of the intervertebral foramina and increased weight bearing of the facet joints, especially at C4-C5 and C5-C6 segments [26,27]. Also, intervertebral discs are put at risk due to increase in shearing force as a result of increasing the cervical lordosis [27]. The other structures that may lead to pain in cervical region are anterior longitudinal ligament, posterior longitudinal ligament, muscles, cervical plexus and neuromuscular bundles [28]. Additional consequences of forward head posture are shortening of SCM, upper trapezius and levator scapulae which elevate the scapula. The subsequent increase in thoracic kyphosis abducts the scapula, allowing the lengthening of the rhomboids and lower trapezius in association with shortening of serratus anterior. Also the shortening of the latissimus dorsi, teres major and subscapularis and pectoralis major and minor pull the humerus into relatively internally rotated posture. This posture alters the normal scapulohumeral rhythm and may precipitate an impingement syndrome of the soft tissues, subdeltoid bursa, and supraspinatus tendon in the subacromial space.

Graph 6: Comparison of SSP in post dynamic condition between DSBP and AWSBP.
during elevation of the arm. The result may be repetitive subacromial impingement of the humeral head.

Therefore it is important to limit postural changes with backpack loading. Good carrying habits, better backpack designs and limiting the weight of backpack have been recommended to reduce the immediate and chronic postural changes.

The results of the study are consistent with studies done by Mayank Mohan [2], Ramprasad [1], Sally Raine [22], Grimmer [18], Heather and Wunpen [29,30]. However, in this study we have compared this reduction in CVA angle between two types of backpack and have found that using a backpack having an additional waist strap causes significantly less reduction in CVA angle, thus leading to less forward head posture and consequently less musculoskeletal problems.

**Craniohorizontal angle**

In this study we found that sagittal Craniohorizontal angle increases in static loading (with 10% of body weight) as compared to unloaded condition and increases more in post dynamic condition (with 10% of body weight) as compared to both static and unloaded condition. We found that the increase in the angle was more in double shoulder strap backpack loading as compared to the backpack loading with additional waist strap.

Craniohorizontal angle (CHA) indicates the position of upper cervical segment. A higher angle indicates a forward head posture. The mechanism and reason for forward head posture is similar to that of CVA angle. The results of the study are consistent with studies done by Mayank Mohan [2], Ramprasad [1], Sally Raine [22], Grimmer [18], Heather [30] and Wunpen [29]. However, in this study we have compared this increase in CHA angle between two types of backpack and have found that using a backpack having an additional waist strap causes significantly less increase in CHA angle, thus leading to less forward head posture and consequently less musculoskeletal problems.

**Sagittal shoulder posture**

In this study we found that sagittal shoulder posture increases in static loading (with 10% of body weight) as compared to unloaded condition and increases even further in post dynamic condition (with 10% of body weight) as compared to static and unloaded condition. Also the increase in the angle was more in double shoulder strap backpack loading as compared to the backpack loading with additional waist strap.

When the child is loaded with 10% of body weight and following dynamic activities with 10% body weight, the system (pack+person) center of gravity (C of G) must fall within the base of support for a person to accomplish balance, and therefore increased SSP is required to shift the system COG forward and balance the backward moment created by the posterior load. The maximum SSP for an individual may be required even in a rested state (static loading) to satisfy these requirements [30].

Rounded shoulder posture is associated with imbalanced muscle performance and has been linked to impingement syndrome, neck pain [31], and headache [31] and craniofacial disorders [23]. Wunpen et al. [29] concluded that more anterior head position observed in most subjects when carrying a backpack contributes to an enlarged sagittal shoulder angle. The results of our study are consistent with studies done by Mayank Mohan [2], Ramprasad [1], Sally Raine [22], Grimmer [18], Heather [30] and Wunpen [29]. However, in our study we have compared this increase in SSP in static and post dynamic condition between two types of backpacks. We have found that using a backpack having an additional waist strap is more beneficial for the child, as it causes less reduction in increase in the SSP angle.

The changes in the postural angles were more markedly seen in backpack with double shoulder strap than in the backpack with additional waist strap. Because, by securing the backpack with an additional waist strap at the level of Iliac Crest we place the center of back pack at mid back level, which positions the backpack at lower level than the double shoulder strap backpack and also more closer to the body which reduces the posterior torque produced by the backpack, also the weight of the backpack is transferred to lower limb through iliac crest, which leads to fewer load on cervical and shoulder region, and hence less forward bending of head and trunk is required to maintain the COG within base of support.

In this study we also found that regardless of backpack, wearing a backpack of 10% body weight load caused significant changes in the cervical and shoulder postures.

**Effect of horizontal waist strap**

Negrini et al. found that postural response to asymmetric backpack load deviates the trunk away from away from load such as to reposition the load over subject's centre of mass.

Chansirinukor found that backpacks weighing greater than 15% body weight prevented adolescent from maintaining and upright posture [32]. A 15% body weight backpack caused significant increase in the forward trunk lean of 10 year old children both while standing and walking for 1000 m [33]. Carrying a 17% body weight load in one-strap and two-strap backpack increased forward trunk lean and forward head positions in 11-13 year old children [34].

Horizontal waist strap acts as a corset around the waist. It is a studied fact that abdominal corset decreases the load on lumbar spine, improves the lumbar lordosis curve [35] and also has improving effects on joint proprioception thus helping in lumbar stability [36-38].

This waist strap acts on 3-point pressure system applying a force against the deforming force of backpack at shoulder and due to weight at the lower back [39]. The horizontal waist strap acting as a lumbar corset deloads the lumbar spine and the anterior abdominal muscles, therefore, improving the spine and shoulder posture.

**Relevance to clinical practice**

Physical therapy is concerned with health promotion, prevention, treatment or rehabilitation (as defined by world federation for physical therapy). Physiotherapist can play an important role in preventing musculoskeletal pain associated with carrying heavy school bags in children. The finding of this study will help us in planning more effective preventive strategies for school children. The students, parents, and teachers should be advised to restrict the school bag weight to less than 10% body weight of the child and to use a backpack with double shoulder straps and a waist strap. These straps should be well secured with the child's body but should not be too tight to cause any discomfort.

Imparting back care education program to school children is a professional avenue, which has been explored by physiotherapist and occupational therapist in different countries across the world. It has
been taken as a social responsibility by some professional organization like American Occupational Therapist Association, Professional Physiotherapist Association and Physiotherapist's of our country can also take an active part in increasing awareness about possible musculoskeletal problems associated with carrying school bags heavier than 10% body weight. As studies in past have shown that an effective back care program given to student by Physiotherapist with the collaboration of school teachers can potentially reduce the incidence of spinal pain in children.

**Limitation of the Study**

The small size makes it necessary to reduce the scope of study and limit it to single placement site i.e. low back.

1. In this study we have not considered the EMG study of muscles in static and dynamic loading. Study of EMG activity of muscles during these loading conditions, can give us a better understanding of the muscles involved and the kind of treatment required.

2. The postural responses to load are best studies by observing changes in trunk forward lean (TFL), and spinal curvature. However, this study only examines cervical and shoulder posture.

3. Postural response to load has been studied in static condition and post dynamic activities and not during dynamic conditions, like walking. The static condition may not perfectly resemble a realistic environment for students during normal day time school bag carriage.

4. Absence of female participants was the limitation of this study.

**Future Research**

A longitudinal study examining the relationship between load carrying behavior, posture and pain is required. The results of the study need to be confirmed in a larger population and a wider age group. Also cervical and shoulder posture should be studied in dynamic condition like walking. The cervical and shoulder postural response to lighter weight conditions should also be studied to increase our understanding. School bags with other designs for instance back packs with chest straps, compression straps should be studied to get a better understanding of most suitable back pack design.

**Conclusion**

The results of the study supports the experimental hypothesis that addition of horizontal waist strap to the traditional double shoulder strap backpack loading with 10% body weight significantly reduces the changes in cervical and shoulder postures as compared with the traditional double shoulder strap backpack loading. Significant change in cervical and shoulder posture is indicated by decrease in Craniovertebral angle, and increase in Craniohorizontal angle and sagittal shoulder posture. This was found more in double shoulder strap backpack loading as compared to backpack with an additional waist strap. Also, these changes were found more in static loading condition as compared to unloaded condition and even more in post dynamic condition as compared to both static and unloaded condition. This holds true for both the types of backpacks.

This implies that loading with 10% of body weight would be heavy for the child to maintain normal cervical and shoulder posture alignment. We have also found that 5 minutes of dynamic activities with 10% of body weight produce significant change in cervical and shoulder posture angles as compared to static and unloaded posture. This implies that duration of time spent in carrying school bag has an effect on shoulder and cervical posture.

Thus implying that school bag weighing less than 10% of body weight and using a backpack with double shoulder strap and a waist strap is recommended for school going children.

**References**