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[ORIGINAL ARTICLE]

Effect of static and dynamic loading of backpack on cervical and shoulder posture in school going children of age group 10-15 years old – Pre-test and Post-test Experimental study

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ABSTRACT :

Background: Musculoskeletal problems associated with use of backpack have become an increasing concern with school children due to its direct and indirect effect on health. School bag loads are reported to cause many problems in children such as body pain, cardio-respiratory changes, postural changes, and balance impairment.

Method: A pre-test and post-test experimental study carried out to study the effect of static and dynamic loading of backpack on cervical and shoulder posture in school going children of age group 10-15 years old.

Result: The result shows that there is significant effect of static and dynamic loading of backpack on cervical and shoulder posture in school going children of age group 10–15 years old.

Conclusion: The study concludes that backpack weighing 10% of body weight shows significant changes in cervical and shoulder posture. These changes are more after dynamic activities when compared with static loading and unloaded condition.

Key words: Cervical posture, Shoulder posture, Backpacks, Static loading, Dynamic loading, School going children.

Introduction:

Nowadays education has become part and parcel of our lives and its quality is only that matters. That is the reason schools and colleges have formulated syllabus in such a manner, that students can gain more knowledge in less time. So the child has to carry more books to school.[1] The backpacks are one of the several form of manual load carriage that provides versatility and are also known as personal load carriage system for daily transferring of personal belonging, books and stationary to and from workplaces or schools.[2,3] There are various types and styles of carrying the backpack.[4] Worldwide more than 90% of school children carry backpacks for transporting their belonging to and from school.[5] The backpack is an appropriate way to load the spine closely and symmetrically, while maintaing the stability.[3]

Backpack used by children have increased recently because of several factors, such as increased homework and assignments, larger textbooks and other objects that is being carried to school and most of the Indian school do not provide lockers to the students, that is the reason student cannot keep any books at school and has to carry all books with them in school bag. All these factors leading to both an increase in backpack weight and time spent carrying them.[6]

There are 191 million children going to school in India.[7] More than 2.5 million elementary school children carry bags on their shoulder 5 days in a week for the entire school year.[8] In India, 54-91% of school children carry bags that are above the recommended bag weight carriage level.[9] Schoolbags are heavy in 79.1% children, leading to fatigue in 65.7%.[10] The same backpack that was designed to become ease and comfortable for the home school route may cause serious postural deviations.[11] A study done that showed that level of

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physical stress was severe in12- 13 years children that was 56.66% where as children of 10.11 years age faced maximal physical stress 42.5%.[12] Musculoskeletal problems associated with use of backpack have become an increasing concern with school children due to its direct and indirect effect on health.[9] School bag loads are reported to cause many problems in children such as body pain, cardio-respiratory changes, postural changes, and balance impairment.[13]

Postural assessment is a procedure, which includes many intrinsic and extrinsic factors that can influence an individual´s posture, such as the environment, his/her social, cultural and emotional status, physical activity, obesity, physiological developmental disorders, sexual maturation, gender and heredity.[14] The efficient erect human posture reflects least amount physical activity that is required to maintain body position in space and which minimizes antigravity stresses on body tissues. It generally occurred in unloaded state when the body is closely aligned with a vertical reference (reflecting gravity).[15] Posture can be defined as the position of all body segments observed at a specific moment. Adequate posture occurs when the body is kept in balance with least energy expenditure.[12] Ideal posture alignment, according to Kendall, “a minimal amount of stress and strain and is conductive to maximal efficiency of the body”. Ideal posture is described using a theoretical plumbline (a vertical posture line) that passes through the auditory meatus, just anterior to acromion, just anterior to greater trochanter, slightly anterior to knee joint and just anterior to ankle joint in sagittal view. Children reach full spinal growth by 24 years of age and experience several growth periods, especially during their school age year, from 5-18 years. Postural responses to daily demands may differ according to gender and individual’s skeletal maturity.[16] The ability to hold and align body segments depends on the ability to fix and restore the center of mass in an optimal position. School bag loads will blunt this ability and sometimes may leads to fall and injuries in school children.[13]

According to Latalski.M et al 2013 “Posture” is a motor habit shaped on a specified morphological and functional background. Based on this point of view posture is an indicator of the mechanical efficacy of the kinetic sense, as well as muscular balanced and neural muscular coordination. As throughout the entire life, human body posture changes continuously, but the biggest challenge will be seen during the period of dynamic development. To restore a new balance according to these changes, human body performs several compensatory actions may be the reason for postural deviations. Ningthoujam R., 2014, considers“ posture” as a product of human behavior, emphasizing the factors affecting a wrong posture are features of daily behavior. According to him "posture" reflects the well-being of the individual, reflects its activity and somehow relevant personality.[17]

Studies among Indian school going children have reported the prevalence of musculoskeletal pain to range between 55% and 86%.[13] Recent studies confirmed high prevalence rate of back pain among adolescent in many countries like New Zealand, United Kingdom, India, Italy, America, Finland and Switzerland.[18] A cross sectional study was conducted on primary school children between age group of 6 to 12 years revealed that 66% male and 65.7% female had musculoskeletal pain mainly back and neck.[19] There are also few reports of other problems associated with backpack i.e. functional scoliosis, rucksack palsy and reduced lung functions.[1]

Musculoskeletal symptoms in school children are multifactorial in origin, the carriage of heavy school bag is one of them. Packing the load posteriorly in a limited space can overload the bag.[20] The combined effect of heavy load, position of the load on the body, size and shape of the load, and load distribution, time spent carrying, physical characteristics and physical conditions of the individual are associated with musculoskeletal symptoms which puts an additional stress on rapidly growing adolescent spinal structure.[3,5]

The epidemiological and clinical literature have identified a strong association between spinal posture and the use of backpack.[21] Pascoe et al reported the association of school bag load and educational failure, lack of motivation, lack of learning, and absenteeism studies have shown that more than 50% of the students carry heavy bag loads and 55% of the student carried loads which weigh more than recommended limit (10-15% of the body weight) to school which can damage the vertebral column and cause musculoskeletal pain.[13] It is assumed that daily discontinuous postural adaptations could result in pain and disability school going children.[8] Carrying a heavy backpack can be a source of chronic strain; and can cause shoulder, neck and back pain in children.[12]

There is widespread belief that repeated carrying of heavy loads, such as school backpacks, place additional stress on rapidly growing adolescent spinal structures and make them prone to postural changes.[22] Many studies indicated that load carriage changed the kinematics and plantar pressure of walking. These biomechanical changes caused by load carriage might contribute to high levels of back pain, muscle discomfort, joint problems, metatarsal stress, fractures, metatarsalgia and foot blisters.[23] Carrying a backpack in an incorrect manner can cause various biomechanical, physiological and neuromuscular disorders that may result physical performance.[4]

The Chairman of Assocham's health committee B K Rao said, as per the Children's School Bag Act 2006, a backpack should not weigh more than 10 per cent of a child's weight. Rao also added that "if students are started getting back pains at such a young age, then there may be a possibility that they will have it for life long".[24]Likewise The American Occupational Therapy Association, the American Academy of Orthopaedic Surgeons and The International Chiropractic Paediatric Association suggest that backpack load should not be more than 10% of body weight.[5]

A recent survey conducted by Associated Chambers of Commerce and Industry of India (ASSOCHAM) under its Healthcare Committee has found that 68 % of school children under the age of 13 years across India may suffer from mild back pain, which can develop into chronic pain and later into hunchback. Jaime Quinn (DPT), Professional Physical Therapy partner and regional clinical director, NYC, she explained that "Wearing a heavy backpack for prolonged periods may cause excessive strain in one's neck, back and shoulders". "Over time, muscles may fatigue, and the wearer may fall into poor posture, which may lead to muscle imbalances, if long-term, may cause increased risk of injury". She recommended strengthening the back and core (abdominal) muscles in order to improve posture and ease the burden of carrying a heavy backpack for long periods of time.[13]

Hong et al suggested that altered biomechanics required by children to carry increased loads on a daily basis might be harmful and influence their normal musculoskeletal developmental growth.[23] Application of external forces to the body (such as backpack) is commonly associated with postural deviation from close alignment with gravitational axis.[5] When load is positioned posterior to the body in the form of backpack it changes posture because of change of centre of gravity. The body tries to keep the centre of gravity between the feet, so with a backpack trunk is in more forward position or inclining the head, placing abnormal forces on the spine.[25]

Epidemiological studies have shown a high prevalence of spinal posture deviations in children and adolescents, with forward head posture and protracted shoulder are the most common postural deviations.[26] Backpacks alter the unloaded posture and reposition it in to a more strained or stressed improper and potentially unbalanced posture with addition of excessive external force.[21]

Studies have revealed that "backpack load carriage increases ground reaction forces and increases the stiffness in the upper extremity and may cause transmission of higher amount of forces from the lower extremity to the head. [25] According to article by Sacco et al., bone deformities develop between 7-14 years of age and it is a good period for postural corrections.However, the exposure of children in this age group to increasing loads is common such as supporting school bags asymmetrically and inappropriately leading to postural adjustments and compensatory actions.[27] It is assumed that daily intermittent postural adaptations could result in pain and disability in school going children. The developmental growing stages of the younger aged children may be more vulnerable to these external loads causing misalignment of the spine.[21] Human posture is a result of association between gravity and the body's limbs and may undergo changes overtime. Alteration commonly begin during school age, as bodily growth and development occur in that period. Age, gender, school backpack weight, anthropometric parameters, position at the computer, time spent in sitting position, decreased flexibility and less active lifestyle are some of the factors that generates discomfort, musculoskeletal changes and influence posture.[28] The postural habits adopted in childhood and adolescence will be continued into adulthood bringing a permanent or temporarydisability.[29]

Although, the backpack is an appropriate way to load the spine closely and symmetrically whilst maintaining the stability.[3] The epidemiological and clinical literature have identified a strong association between spinal posture and the use of backpack.[22] Musculoskeletal symptoms in school children are multifactorial in origin, the carriage of heavy school bag is one of them.[21]

Shruti. R. Iyer states that Indian school children carry school bags weighing 18.5% of their body weight, studies done by Whittfield JK et al claims that the average weight of school bag is above 15% of their body weight in various countries.[19] Several studies have revealed that 30%-50% of school going children carry bags that are more than the recommended bag levels. In India, 54%-91% of school children carry bags that are above the recommended bag carriage levels. According to Children SchoolBags Act in India 2006, school children should not carry bags weighing more than 10% of their body weight.[9]

In recent years, school health has been the center of attraction in the scientific community, especially with regard to postural changes of the spine and backpain in children and teenagers.[22] Heavy school backpacks may deform natural curves in the back. If the curves are interrupted in the lower and middle back, this may result in muscle strain and irritation to the rib cage or spine joints. Much of this suffering is brought by bad habits that are initiated during our younger years may be because of carrying overweight backpacks to school.[8]

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.[22]

The material carried in backpacks, the weight of this material, school furniture, and body composition among other factors, verifying the high prevalence of postural problems in school due to lack of proper orientation on the nutritional quality of students as well as the quality of life and specific guidance on posture where these phases, changes, sudden and disorderly occur during the development and growth of the individual allowing for the development or enhancement of postural problems.[14]

Carrying a backpack also causes postural changes such as excessive forward head angle, and forward shoulder and changed scapular positions.[21] Relationship between the duration of carrying backpack and back pain, have showed the result that children who carry backpack for 20-30 minutes or more per day suffered three times more from back pain than those who carry backpack less than 10 minutes. This finding was also supported by other studies revealing that longer periods oftime spent carrying a backpack each day influences cervical, shoulder and lumbar posture and can contribute to musculoskeletal pain.[30]

Various studies have been done that indicate the change in cervical and shoulder posture while carrying a backpack and walking (dynamic loading) but there is lack of literature on standing loading (static loading) of backpack. The static loading or static posture refer to physical exertion in which the same posture is held throughout the exertion. This type of exertion put increased loads or forces on the muscle and tendons, which contribute to fatigue. The longer or more frequently static loading occurs, the greater the risk of injury due to overuse of muscles, joints and other tissues. It also suggested that load requirements for adult females should be lower than adult males to account for physiological and biomechanical differences.[31] Therefore, the purpose of this study to study the effect of static and dynamic loading of backpack on cervical and shoulder posture in school going children of aged group 10-15 years old. As the early adolescence is a key time for spinal growth, in the early and mid-adolescent spine increases in length and volume without substantially adding mass, which causes the adolescent spine to be less able to withstand stresses that are normal for adult spine. It is important to diagnose postural deviations in children because their skeletal system is till susceptible to change and poor posture is more easily corrected at this stage.[32]

Thus this study will not only provide us information about the safe load carriage in school students but also help to protect them while they are still developing and to prevent the injuries associated with prolonged load carrying. It is important to diagnose postural deviations in children, because their skeletal system is still susceptible to changes and poor posture is more easily corrected at this stage of development. Thus, postural assessment should become a common practice in schools, in order to detect early and treat postural deviations in students. Besides this, schools have the potential to develop children´s knowledge and skills and to help them learn how to live a healthy life.

Materials and Method :

1. This was pre and post experimental study conducted in a school. Total duration of study was 12 months. Total 180 School going children with age group of 10-15 years were included using convenience sampling. :Inclusion Criteria was Age 10-15 years old , Both gender , Weight of backpack not more than 10% of their body weight and Individuals willing to participate. Exclusion crCrit was Congenital anomalies , Cardiorespiratory problems and Any neurological deficits, Injury to upper limb And Structural abnormalities

Method: Permission from the institutional head, ethical committee and school authority were taken. Consent from the parent was taken. Participants from 10-15 years of age group of both gender who fulfill the eligibility criteria were selected and demographic data was collected. Clothing was rearranged so that shoulders were exposed with the participant standing; adhesive markers were placed on anatomical points i.e. external canthus of right eye, right tragusof the ear, a mid-point between greater tuberosity of humerus and posterior aspect of acromion process of right shoulder and spinous process of C7vertebra. Participant was asked to stand comfortably with arms by their side in normal standing posture and was asked to place their weight evenly on their feet. Photographs was taken from right lateral view in the following order: Without backpack, After 5 minute standing with the backpack weighing 10%of their body weight on first day (static loading of backpack). After 5 minute walk with the backpack weighing 10% oftheir body weight on second day (dynamic loading of backpack). All the anatomical points were digitized with a specific sequence using MB ruler software and angles were calculated. Data was analyzed.

Results: Total number of participants included in the study were 180 of aged between 10-15 years. Participants who met the inclusion criteria were included in the study.Participants cervical and shoulder postural angles were evaluated using Mb ruler from the photographs taken in unloaded, static loaded and dynamic loaded condition.

Following are observation of the study:

1. Number of participants of age 10 years are 28, of age 11 years are 32, of age 12 years are 43,of age 13 years are 38,of age 14 years are 28,of age 15 years are 11. Therefore, total 180 participants were included in the study with mean age 12.21 years and SD of 1.46 years. (Table 1, Graph1)

Following are the results of this study:

Effect of static loading and dynamic loading of backpack on craniohorizontal angle

1. Mean craniohorizontal angle in unloaded condition was 28.88 with SD of 3.91, in static loading condition was 30.63 with SD of 4.10 and in dynamic loading condition was 31.79 with SD of 4.10 in the study population.
2. There was statistically significant change in craniohorizontal angle with p value 0.0001 in static loading and dynamic loading of backpack from unloaded condition.(Table 2, Graph 2)

Effect of static loading and dynamic loading of backpack on craniovertebral angle:

1. Mean craniovertebral angle in unloaded condition was 52.68 with SD of 2.12, in static loading of backpack was 50.48 with SD of 3.10 and in dynamic loading of backpack was 49.07 with SD of 2.35 in the study population.
2. There was statistically significant change in craniovertebral angle with p value 0.0001 in static loading and dynamic loading of backpack from unloaded condition.(Table 3, Graph 3)

Effect of static loading and dynamic loading of backpack on sagittal shoulder angle:

1. Mean sagittal shoulder angle in unloaded

condition was 110.10 with SD of 2.32, in static loading of backpack was 112.0 with SD of 2.30 and in dynamic loading of backpack was 113.18 with SD of 2.44 in the study population.

2. There was statistically significant change in sagittal shoulder angle with p value 0.0001 in static loading and dynamic loading of backpack from unloaded condition.(Table 4, Graph 4)

Comparison of change in angle from unloaded to static and to dynamic in craniohorizontal angle, craniovertebral angle and sagittal shoulder angle:

1. Craniohorizontal angle was increased by 1.75 from unloaded to static loading of backpack and by 2.91 from unloaded to dynamic loading of backpack.There was statistical significant difference in change in craniohorizontal angle from unloaded to static and to dynamic with p value 0.0001.
2. Cranivertebral angle was decreased by 2.18 from unloaded to static of backpack and by 3.60 from unloaded to dynamic loading of backpack. There was statistical significant difference in change in craniovertebral angle from unloaded to static and to dynamic with p value 0.0001.
3. Sagittal shoulder angle was increased by 1.90 from unloaded to static loading of backpack and by 3.08 from unloaded to dynamic loading of backpack.There was statistical significant difference in change in sagittal shoulder angle from unloaded to static and to dynamic with p value 0.0001. (Table 5, Graph 5)

Table 1. : Distribution of sample population according to age in years:

Age in years	Number of subjects	Percentage
10	28	15.56
11	32	17.78
12	43	23.89
13	38	21.11
14	28	15.56
15	11	6.11
total	180	100
Mean Age± SD(range)	12.21 ±1.46 (10-15)	

Graph 1 : Distribution of sample population according to age in years:
Total 180 participants were included with mean age 12.21 in years

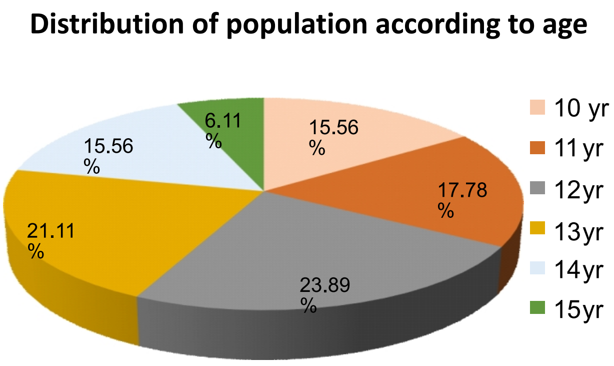
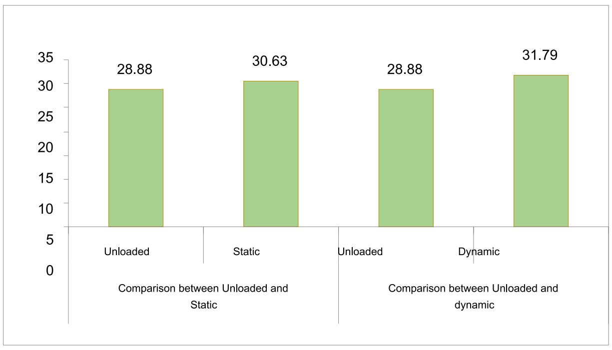


Table 2 : Effect on Craniohorizontal Angle between Unloaded to Static loading and to dynamic loading of backpack

	Comparison between unloaded and static loading		Comparison between Unloaded anddynamic Loading	
	Unloaded	Static Loading	Unloaded	Dynamic Loading
mean	28.88	30.63	28.88	31.79
SD	3.91	4.10	3.91	4.10
t value	60.6180		74.7616	
p value	<0.0001		<0.0001	

Graph 2 : Effect on Craiohorizontal angle from unloaded to static loading and to dynamic loading of backpack

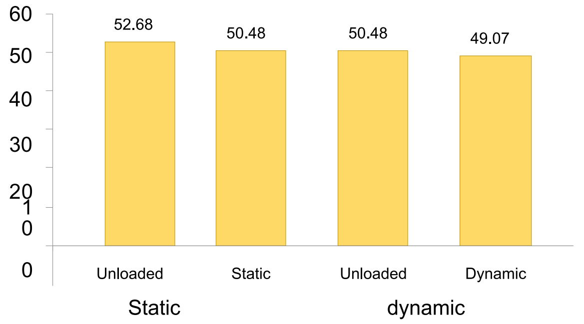


For 180 participants; mean score for unloaded condition was 28.88, in static loading of backpack was 30.63 and dynamic loading of backpack was 31.7.

Table 3. Effect on Craniovertebral Angle between Unloaded to Static loading of backpack and to dynamic loading of backpack.

	Comparison between unloaded and static loading		Comparison between Unloaded anddynamic loading	
	Unloaded	Static Loading	Unloaded	Dynamic Loading
mean	52.68	50.48	50.48	49.07
SD	2.12	3.10	2.12	2.35
t value	12.7010		36.6913	
p value	<0.0001		<0.0001	

Graph 3 : Effect on Craniovertebral Angle from Unloaded to Static loading of backpack and to dynamic loading of backpack.

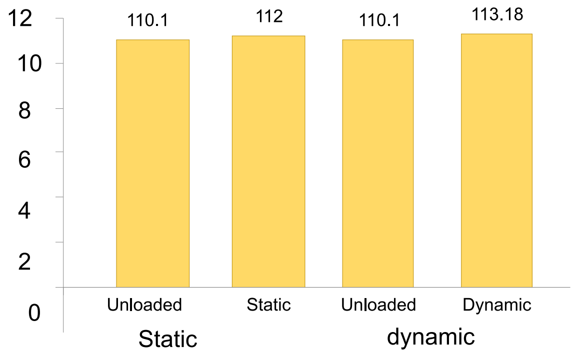


For 180 participants; mean score of Craniovertebral angle for unloaded condition was 52.68, for static loading of backpack was 50.48 and for dynamic loading of backpack was 49.07.

Table 4 : Effect on Sagittal Shoulder Angle from Unloaded to Static loading of backpack and to dynamic loading of backpack.

	Comparison between unloaded and static loading		Comparison between unloaded and dynamic loading	
	Unloaded	Static Loading	Unloaded	Dynamic Loading
mean	110.10	112.0	110.10	113.18
SD	2.32	2.30	2.32	2.44
t value	84.0198		86.8752	
p value	<0.0001		<0.0001	

Graph 4 : Effect on Sagittal shoulder angle from Unloaded to Static loading and to dynamic loading of backpack

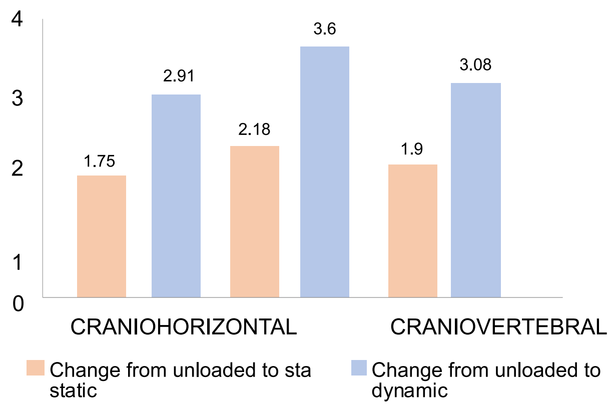


For 180 participants mean score of Sagittal Shoulder Angle for unloaded condition was 110.1, for static loading of backpack was 112 and for dynamic loading of backpack was 113.18.

Table 5 : Comparison of change in 3 angles from unloaded to static loading and to dynamic loading of backpack.

Angles	Change from Unloaded to staticloading		Change from unloaded to dynamic loading		t value	p value
	Mean	SD	Mean	SD		
cranio horizontal	−1.75	0.38	−2.91	0.52	37.7328	<0.0001
cranio vertebral	2.18	2.31	3.60	1.31	7.1114	<0.0001
sagital shoulder	−1.90	0.30	−3.08	0.47	38.4237	<0.0001

Graph 5 : Comparison of change in 3 angles from unloaded to static loading and to dynamic loading of backpack.



For 180 participants; mean change for craniohorizontal angle from unloaded to static loading was 1.75 and from unloaded to dynamic loading was 2.19, forcraniovertebral angle from unloaded to static loading was 2.18 and from unloaded to dynamic loading was 3.6, for sagittal shoulder angle from unloaded to static loading was 1.9 and from unloaded to dynamic loading was3.08.

Discussion:

A pre-test and post-test experimental study was carried out on asymptomatic school children of age group 10-15 years old to find the effect of static and dynamic loading of backpack on cervical and shoulder posture. In the present study the cervical and shoulder posture i.e craniohorizontal angle, craniovertebral angle and sagittal shoulder angle was measured using the photographic method by Mb ruler software in unloaded, static loaded (standing with backpack for 5 minutes) and dynamic loaded (walking with backpack for 5 minutes) backpack conditions.

In the current study, children of age group 10-15 years old of both gender were selected. This age is key time for spinal growth as spine increases in length and volume without adding mass, which causes spine to less able to withstand stresses than normal adult spine.[32]

In the current study, mean weight of children backpack was 3.22 kg which was equivalent to 10% of body weight. According school bag act 2006, the recommended level of children backpack was 10% of body weight.[24]

Effect of backpack on Craniohorizontal angle:

In the current study we found significant increase in craniohorizontal angle, from unloaded posture (mean= 28.88 ± 3.91) when compared with standing posture or static loading of backpack weighing equivalent to 10% of body weight (mean= 30.63± 4.10) with p value <0.0001. In addition, there is significant increase in craniohorizontal angle, from unloaded posture (mean =28.88 ± 3.91)when compared with after walking or dynamic loading of backpack weighing equivalent to 10% of body weight (mean 31.79 ± 4.10) with p value <0.0001. The mean change in craniohorizontal angle is increased by 1.75 from unloaded to static loading of backpack and by 2.91 from unloaded to dynamic loading of backpack. There is significant difference in craniohorizontal angle between static loading and dynamic loading of backpack in school going children with p value <0.0001.

The craniohorizontal angle provide an estimation of head on neck angle or positon of upper cervical spine. Higher angle indicates more forward head posture. This change in craniohorizontal angle can be due to hyperextension of the upper- cervical vertebra, which occurs in compensation of lower cervical flexion to maintain the centre of gravity between the feet or within the base of support.[43]

Effect of backpack on craniovertebral angle:

In the current study we found significant decreased in craniovertebral angle, from unloaded posture (mean= 52.68 ± 2.12) when compared with standing posture or static loading of backpack weighing equivalent to 10 % of their body weight (mean=50.48 ± 3.10) with p value <0.0001. In addition, there is significant decreased in craniovertebral angle, from unloaded posture (mean = 52.68 ± 2.12) when compared with after walking or dynamic loading of backpack weighing equivalent to10%oftheir body weight (mean= 49.07 ± 2.35) with p value <0.0001. The mean change in craniovertebral angle was decreased by 2.18 from unloaded to static loading of backpack and by 3.60 from unloaded to dynamic loading of backpack. There is significant difference in craniovertebral angle between static loading and dynamic loading of backpack in school going children with p value<0.0001.

The craniovertebral angle provides an estimation of position of neck on upper trunk. A small angle indicates more forward head posture. The change in craniovertebral angle can be due to repetitive micro trauma to cervical and shoulder muscle due to heavy backpack carriage. When backpack or load is positioned posterior to body, it changes posture because of change in centre of gravity. So the body tries to keep the centre of gravity between feet or within base of support, with backpack it is either accomplished by leaning forward at hip or ankle or by inclining the head.[1,43]

According to Korovessis forward head posture was a common method of counterbalancing the posterior load of backpack carriage especially for adolescents who depends on muscular contraction to sustain the postures because of immature bony development.

Effect of backpack on sagittal shoulder angle:

In the current study we found significant increased in sagittal shoulder angle, from unloaded posture (mean= 110.10 ± 2.32) when compared with standing posture or static loading of backpack weighing equivalent to 10 % of body weight (mean=112.0 ± 2.30) with p value <0.0001. In addition, there is significant increase in sagittal shoulder angle, from unloaded posture (mean = 110.10 ± 2.32) when compared with after walking or dynamic loading of backpack weighing equivalent to 10% of body weight (mean 113.18 ± 2.44) with p value <0.0001. The mean change in sagittal shoulder angle is increased by 1.90 from unloaded to static loading of backpack and by 3.08 from unloaded to dynamic loading of backpack. There is significant difference in sagittal shoulder angle between static loading and dynamic loading of backpack in school going children with p value<0.0001.

The sagittal shoulder angle provides the position of forward shoulder position or rounded shoulder. A large angle indicates the shoulder is further forward in relation to C7 or a more rounded shoulder. When the backpack is loaded in rested or static loading condition and followed by dynamic activities, the system (backpack + person) centre of gravity must fall within base of support for a person to accomplished balance, and hence increased sagittal shoulder angle is required to shift the system centre of gravity forward and balance the backward moment created by the posterior load.[1,43]

A study done by Jagdish Hundekari who had assessed the extent of backpack load on postural changesin school going children. He had divided studentsaccording to weight of backpack into three groups; group I backpack weighing <10% of body weight, group II backpack weighing 10-20% of body weight and group three 20-30% of body weight and cervical and shoulder postural angles were assessed. He concluded that the weight of backpack is associated with change in cervical and shoulder posture i.e. craniohorizontal angle, craniovertebral angle and shoulder sagittal posture and recommended weight of backpack should be less than 10% of body weight.Itsupportthecurrentstudy,thatbackpackweighing10%ofbodyweight can also lead to cervical and shoulder postural changes so backpack should weigh less than 10% of bodyweight.

A study done by Anand Kalaiselvan, to find the effect of backpack weighing 10% of body weight on cervical and shoulder posture under two experimental load condition (with backpack and after dynamic activities). He had measured the angles with backpack and after dynamic activities and found that there are more changes in cervical and shoulder posture after dynamic activities when compared with unloaded condition. It support the current study, that backpack weighing 10% of body weight during dynamic activities shows significant change in cervical and shoulder posture when compared with unloaded condition to maintain the centre of gravity within the base of support to maintain balance during dynamic activities.

A study done by Wupen Chansirinukor to determine the weight of backpack, its position on the spine or time carried affect the adolescents cervical and shoulder posture. He had tested change in cervical and shoulder posture from unloaded posture,carrying backpack over both shoulder, carrying over right shoulder, backpack weighing 15% of body weight and after 5 minute walk. A significant difference was found while comparing posture under different conditions. He also reported that weight of backpack and time carried has influenced on cervical and shoulder posture. It support the current study, that carrying a backpack for 5 minutes show significant change in cervical and shoulder posture.

A study done by Frances Kistner to study the effect of carrying backpack weighing up to 20% of body weight on posture and pain complaint on elementary school children. He had observed change in craniovertebral angle, forward trunklean and pelvic tilt angles carrying backpack before and after walking for 6 minutes while carrying backpack weighing 10%, 15% and 20% of body weight. He concluded that change in postural angles and pain increases as backpack the load. This leads to postural changes, increased risk for injury and pain due to increased backpack load and time spent carrying them. It support the current study that weight of backpack and time spent carrying them show significant changes inposture.

A study done by Nirav P. Vaghela to study the effect of backpack loading on cervical and sagittal shoulder posture in standing and after dynamic activities in school going children. He had observed that there is significant change in cervical and shoulder posture after static and dynamic loading of backpack from unloaded condition and these changes are more after dynamic loading of backpack. He concluded that there is significant reduction in craniovertebral angle (increased forward head posture),increased in craniohorizontal angle and sagittal shoulder angle while carrying a backpack weighing 18% of body weight over both shoulder. It support the current study that there is significant change in cervical and shoulder posture after static and dynamic loading of backpack weighing even 10% of bodyweight.

In this study we have seen the effect of static posture or static loading and dynamic loading of backpack from the unloaded or without backpack on cervical and shoulder posture. The cervical and shoulder postural angles i.e. craniohorizontal angle, craniovertebral angle and sagittal shoulder angle has shown significant change in both static and dynamic loading of backpack in school children.These changes are more after dynamic activities while carrying backpack weighing 10% of bodyweight.

The type and duration of loading can influence the tissue growth as well as affecting the type of tissue or joint being formed. Any increased in magnitude of load inhibits chondrocyte mitosis leading to halted or retarded growth in length of bone. Radin stated that repetitive impulse of loading aggravate the cartilage degeneration or lead to secondary changes in joint. Frost also explained the same by stretch creep rule which relates to creep i.e. elongation over time that occurs within tissues as tension or load isapplied.[42]

These changes in alignment of the neck and shoulder can produce strain on cervical joints and soft tissue as well as imbalanced muscle performances. This can cause pain in cervical, upper thoracic, and shoulder region.

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

Conclusion:

The result of the study supported the alternate hypothesis that there is significant effect of static and dynamic loading of backpack on cervical and shoulder posture in school going children of age group 10-15 years old. The significant change in cervical and shoulder posture is indicated by increased in cranio horizontal and sagittal shoulder angle, and decreased in cranio vertebral angle i.e. a forward head posture and rounded shoulder posture is observed. Also these changes are more in static loading condition as compared to unloaded condition and even more in dynamic loading condition as compared to both static and unloaded condition.

This implies that loading of backpack with 10% of body weight would be heavy for the child to maintain normal cervical and shoulder posture alignment. Also the duration of time spent carrying backpack has an effect on cervical and shoulder posture.

Thus implying that school bag weighing less than 10% of their body weight is recommended for school going children.

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