Effects of Backpack Loads on Kids Posture

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Abstract

Kids carrying heavy loads as a part of everyday activity may be related to bend their trunks forward to maintain body posture and balance while walking. This study was to determine a correlation between the weight of a child's backpack, their body weight, and certain features of their body posture. The study group consisted of 6 children, in age of primary school. The anthropometry (age, length, weight) were taken for each volunteers. A school backpack was specially built for the present study. Walking gait was filmed in three cases: (zero kg, 3 kg and 6 kg) backpack.

Posture was analyzed by using (Kenova and MATLAB) computer programs.

The results show that the forward inclination of the trunk increases when the load and the walking distance are increased, this forward inclination segment may impose greater stress over the vertebral column (ligaments and intervertebral disks) and increase the risk of back problems.

Spine and back health may be adversely affected by load carriage and it may be important to use spinal curvature as a measure of posture for load carriage. This study shows that the backpack load cause a lumbar asymmetry by 10 to 20 degree according to the load which has a significant amount of back pain in kids.

Keywords: posture, spine, gait analysis, back pain, kids.

1. Introduction

Postural sway is a term used to describe oscillations of the center of mass within the base of support during normal erect standing posture due to variations in muscle tension. Kids display postural sway, which decreases as their nervous and muscular systems mature [1]. Changes in posture from load carriage have called attention of many researchers and ergonomists due to the functional problems of the vertebral column which are influenced by several factors such as the weight of the load, transport strategy, bag type and subjects' physical characteristics [2].

Spinal curvature (posture) is influenced by heredity, pathological conditions, an individual’s mental state, and the forces subjected on the spine. Biomechanically, the curves of the spine enable it to absorb more shock without injury than if the spine were straight. A lordotic lumbar posture, alternatively, increases loading of the posterior annulus and facet joints, while full lumbar flexion changes the line of action of the lumbar extensor muscles, such that they cannot effectively counteract anterior shear. Anterior shear load on the lumbar spine has been associated with increased risk of back injury [3].

Backpacks are widely used by adolescents to carry their personal and school materials and represent one of the most usual physical efforts related to weight handling performed by young subjects. This concern has been confirmed by recent clinical studies that have shown increased occurrence of back pain due to excessive / repeated load applied to immature spinal structures while carrying/handling weights [4].

Unfortunately, most studies have focused on the lower limb dynamics and only a reduced number of studies about how the spine behaves during symmetric backpack load carriage have been conducted. Probably, technical problems related to the visualization of the spinal landmarks have limited a more detailed kinematic assessment of vertebral column during the task [5].

Finally, it's not known whether the postural adjustments performed by adults are also replicated by adolescents. This is particularly relevant because children and adolescents that experienced thoracic and lumbar pain have increased risk of back discomforts in adulthood [6].

Previous studies have examined the effects of carrying on the human body through epidemiological, experimental and modelling methods. One epidemiological study reported an increased risk of low back disorders among workers who repeatedly carried heavy loads. Experimental studies have examined the costs of carrying loads by examining changes in whole body oxygen O2 consumption, heart rate and electromyography (EMG) [7].

Vacheron et al in [8] performed a kinematic analysis of the spine in which they reported a reduced range of movement about the lumbar (S1-L3-T12) and thoracic (L3-T12-T7) segments of the spine. These adjustments were also accompanied by an increased range of motion of the cervical region (T7-C7). They tested only one load condition (22.5 kg), which did not allow a more comprehensive understanding of how the load magnitude (i.e. expressed as a fraction of the body weight) influences and determines spinal postural adjustments during the task [8].

Korovesis et al in [9] performed a quantitative postural analysis in students aged 12-18 years-old and showed that backpack carrying (asymmetrically placed) causes changes in upper trunk, shoulder and cervical lordosis. They recommended the use of symmetric backpacks [9].

Abe et al [10] found that O2 consumption dropped with the use of a backpack (BP) under certain conditions. Heart rate, however, was found to significantly increase with BP use [10].

The aim of the present study is to identify the movements of the vertebral column of kids during backpack carriage using two loads in comparison to the pattern obtained in an unloaded condition. The understanding of how kids respond to different loads may help to identify spinal loading mechanisms and provide evidence to design preventive measures. It is a particular concern for professionals involved in physical activity for kids as this information are relevant to intervene in early stages of postural adjustments.

2. Human Spine Biomechanics

The spine is a complex and functionally significant segment of the human body. Providing the mechanical connection between the lower and upper extremities, the spine enables motion in all three cardinal planes, the delicate spinal cord was protected by bony protector. The lumbar region of the spine is of particular interest to many clinicians and researchers, because low back pain is a major medical and socioeconomic problem in recent times [3].

3. Structure of the spine

Vertebral Column: The spine consists of a curved stack of thirty three vertebrae divided structurally into five regions (Figure 1). Proceeding from superior to inferior, there are: seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, five fused sacral vertebrae, four small, fused coccygeal vertebrae. There may be one extra vertebra or one less, particularly in the lumbar region [3].

Because of structural differences and the ribs, varying amounts of movement are permitted between adjacent vertebrae in the cervical, thoracic, and lumbar portions of the spine. Within these regions, a motion segment is called to two adjacent vertebrae and the soft tissues between them, which is considered the functional unit of the spine (Figure 2).

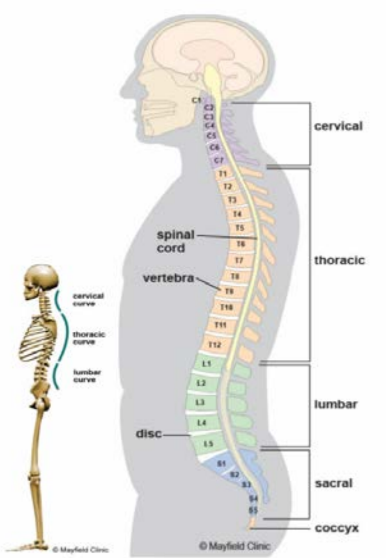


Figure 1: Left: The spine has three natural curves that form an S-shape. Right: The five regions of the spinal column [8].

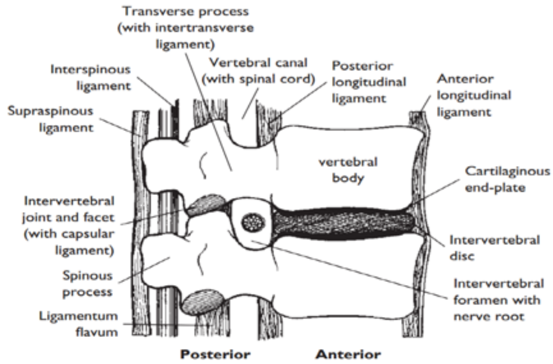


Figure 2: The motion segment, composed of two adjacent vertebrae and the associated soft tissues, is the functional unit of the spine [3].

Each motion segment contains three joints. The vertebral bodies separated by the intervertebral disks form a symphysis type of amphiarthrosis. The right and left facet joints between the inferior and superior articular processes are diarthroses of the gliding type that are lined with articular cartilage [3].

There is a progressive increase in vertebral size from the cervical region down through the lumbar region. The lumbar vertebrae, in particular, are larger and thicker than the vertebrae in the superior regions of the spine. This serves a functional purpose. The size and angulation of the vertebral processes vary throughout the spinal column (Figure 3). This changes the orientation of the facet joints, which limit range of motion in the different spinal regions. In addition to channeling the movement of the motion segment, the facet joints assist in load bearing [3].

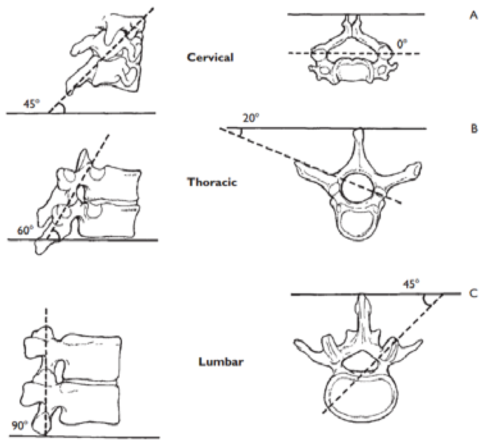


Figure 3 Approximate orientations of the facet joints [3].

The articulations between adjacent vertebral bodies are symphysis joints with intervening fibro cartilaginous disks that act as cushions. Healthy intervertebral disks in an adult account for approximately one-fourth of the height of the spine. The cervical, thoracic, and lumbar curves of the spine are produced by the differences in the posterior and anterior thicknesses of the disks when the trunk is erect [3]. The articulations of each vertebra with a neighboring vertebra permit movements in three planes so that the structure of the spine permits movements including flexion–extension, lateral flexion, and rotation. The inner part of the disk-the nucleus pulposus-is created from a gelatinous material, and it is surrounded by a tough outer covering, the annulus fibrosus, composed of fibrocartilage (Figure 4). During human activities the disk is loaded with a combination of compression, bending, and torsion. Flexion, extension, and lateral flexion of the spine produce tensile and compressive stresses in the disk, while rotations produce shear stresses [12]. These fibers, which are crucial for the biomechanical functioning of the disk, display changes in organization and orientation with loading of the disk, as well as with disk degeneration [13].

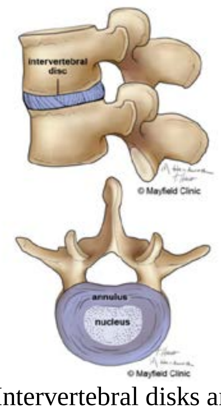


Figure 4 Intervertebral disks are made of a gel-filled center called the nucleus and a tough fibrous outer ring called the annulus [11].

Once pressure on the disks is relieved, the disks quickly reabsorb water, and disk volumes and heights are increased.

Disk height and volume are typically greatest when someone wake up in the morning. Early in the morning, there appears to be a heightened risk of disk injury because increased disk volume also translates to increased spinal stiffness. Measurements of spinal shrinkage following activities performed for one hour immediately after rising in the morning yielded average values of 7.4 mm for standing, 5.0 mm for sitting, 7.9 mm for walking, 3.7 mm for cycling, and 0.4 mm for lying down [14].

The intervertebral disks have a blood supply up to about the age of 8 years, but after that the disks must rely on a biomechanically based means for maintaining a healthy nutritional status. Intermittent changes in posture and body position vary internal disk pressure, causing a pumping action in the disk. The water influx and out flux transports nutrients in and flushes out metabolic waste products, basically fulfilling the same function that the circulatory system provides for vascularized structures within the body. Maintaining even an extremely comfortable fixed body position over a long period curtails this pumping action and can negatively affect disk health [15].

The water-absorbing capacity of the disks are reduced by aging irreversibly and injury, with a concomitant decrease in shock-absorbing capability. Studies on magnetic resonance imaging (MRI) show degenerative changes to be the most prevalent at L5-S1, the disk subjected to the most biomechanical stress by virtue of its position. However, the fluid content of all disks begins to diminish around the second decade of life. A typical geriatric disk has a fluid content that is reduced by approximately 35%. As this normal degenerative change occurs, abnormal movements occur between adjacent vertebral bodies, and more of the compressive, tensile, and shear loads on the spine must be assumed by other structures-particularly the facets and joint capsules. Results include reduced height of the spinal column, often accompanied by degenerative changes in the spinal structures that are forced to assume the loads of the disks. Postural alterations may also occur. The normal lordotic curve of the lumbar region may be reduced as an individual attempts to relieve compression on the facet joints by maintaining a posture of spinal flexion [3].

Spinal Curves: The spine contains four normal curves. The thoracic and sacral curves, which are concave anteriorly, are present at birth and are referred to as primary curves. The lumbar and cervical curves, which are concave posteriorly, develop from supporting the body in an upright position after young children begin to sit up and stand. Since these curves are not present at birth, they are known as the secondary spinal curves. Although the cervical and thoracic curves change little during the growth years, the curvature of the lumbar spine increases approximately 10% between the ages of 7 and 17. Spinal curvature (posture) is influenced by heredity, pathological conditions, an individual's mental state, and the forces to which the spine is habitually subjected. Mechanically, the curves enable the spine to absorb more shock without injury than if the spine were straight [16].

The amount and directions of the forces acting on bones are constantly influence the response of bone in model or shape. Similarly, the spine habitually loaded with asymmetrical forces can distort the four spinal curves [3].

Abnormal spinal curvatures: Exaggeration of the lumbar curve, or lordosis, is often associated with weakened abdominal muscles and anterior pelvic tilt (Figure 5). Congenital spinal deformity, weakness of the abdominal muscles, poor postural habits, and overtraining in sports requiring repeated lumbar hyperextension, such as gymnastics, javelin throwing, and swimming the butterfly stroke all are include causes of lordosis. Some have hypothesized that excessive lordosis is a prohibition factor for low back pain development because lordosis put more compressive stress on the posterior elements of the spine. Restricted range of motion in hip extension is associated with exaggerated lumbar lordosis [17]. Fatness causes reduced range of motion of the entire spine and pelvis, and fat individuals conduct show increased anterior pelvic tilt and an associated increased lumbar lordosis. Similarly, during running increased anterior pelvic tilt and increased lordosis are greater than during walking [3].

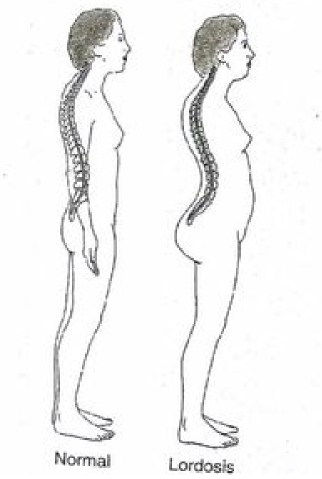


Figure 5 Lordosis [3].

Kyphosis is another abnormality in spinal curvature which is (exaggerated thoracic curvature) (Figure 6). The happening of kyphosis has been considered to be as high as 8% in the general inhabitance, with equal distribution across male and female. Kyphosis can result from a congenital abnormality, a pathology such as Scherman's disease or osteoporosis, in which one or more wedge shaped vertebrae develop because of the behavior of abnormal epiphyseal plate.

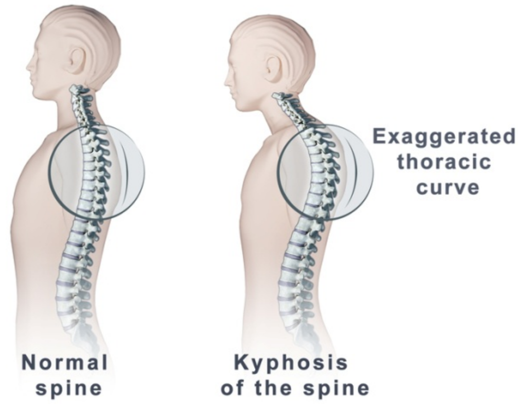


Figure 6 Kyphosis [17].

Scherman's disease typically develops in persons between 10 to 16 years old, which is the period of most quick growth of the thoracic spine. Both hereditary and biomechanical factors are considered to play a role. The situation has been called swimmers back because it is considerably seen in adolescents who have trained heavily with the butterfly stroke.

Scherman's disease is not limited to swimmers, however, research shows a strong relation between incidence of this pathology and progressive training time in any sport. Treatment for moderate cases may consist of exercises to strengthen the posterior thoracic muscles, although bracing or surgical corrections are used in more hard cases. Both the thoracic vertebrae and the intervertebral disks in the part develop a characteristic wedge shape.

Lateral deviation or deviations in spinal curvature are indicated to as scoliosis (Figure 7). The lateral deformity is coupled with rotational deformity of the involved vertebrae, with the condition ranging from mild to hard. Scoliosis may seem as either a C- or an S-curve encompassing the lumbar spine, the thoracic spine, or both.

A distinction is made between structural and nonstructural scoliosis. Structural scoliosis includes inflexible curvature that carry on even with lateral bending of the spine. Nonstructural scoliotic curves are flexible and are refined with lateral bending.

Variety of causes result scoliosis. Congenital abnormalities and selected cancers can contribute to the development of structural scoliosis. Nonstructural scoliosis may occur secondary to a leg length discrepancy or local inflammation.

Small lateral deviations in spinal curvature are relatively common and may result from an action such as carrying books or a heavy handbag on one side of the body every day. Approximately 70-90% of all scoliosis, however, is called idiopathic, which means unknown causes. Idiopathic scoliosis is most commonly diagnosed in kids between ten to thirteen years old, but can be found at any age. It is present in 2-4% of kids between ten to sixteen years old and is more prevalent in females. Low bone mineral density is normally associated with idiopathic scoliosis and may play a causative role in its development. Symptoms associated with scoliosis vary with the riskiness of the condition.

Figure 7 Scoliosis [17].

Moderate cases may be non-symptomatic and may self-correct with time. A growing body of evidence supports the performance of suitable stretching and strengthening exercises for fix the symptoms and appearance of mild to moderate scoliosis. Severe scoliosis, however, which is characterized by excessive lateral deviation and localized rotation of the spine, can be painful and deforming, and is treated with refreshing and/or surgery. As is the case with kyphosis, both the vertebrae and the intervertebral disks in the affected region(s) suppose a wedge shape [3].

Effects of load on spinal curves: The weight of load carried as part of everyday activity may be related to the shape of curvatures of the spine, in particular when the activity requires taking a specific, forced posture. A person carrying a heavy load will tend to lean forward to balance their center of gravity, which results in a reduction of lumber lordosis and increased thoracic kyphosis. Such a posture may become habitual and be maintained even after taking the load off [18].

Low Back Pain: After forty years old, infrequent are the persons who have no lower back pain or lumbar region pain caused by improper posture during their life. Many persons may come to have lumbar region pain, due to improper lifting of weight, for example, lifting a kids from the ground. Spinal erector muscles are the principal muscles used to bend the back or to lift objects from the ground. They connect the ileum and the lower part of the sacrum to all of the lumbar vertebrae and to four thoracic vertebrae. Research has presented that during a back flexion, the forces exerted by the spinal erector muscles on the spinal column can be represented by a single muscle force. The spinal column can be treated a rigid body, and the force is applied at a point at two third of its length from the sacrum, and forming an angle of 12° with the column. The axis of rotation is located at the fifth lumbar vertebra. The contact compressive force of largest concentration is applied exactly there during the bending of the back. If this force exceed a certain limit, the intervertebral disk flattens and its diameter increases, pressing on the nerve and, as a consequence, causing lumbar pain [19].

The incidence of low back pain in kids is nearly 30%. This range increases with age and by approaching sixteen years old that found in adults, with back pain more common in male than in female. In contrast to the situation for adults, however, low back pain in kids is associated with increased physical activity and stronger back flexor muscles. The main reasons of low back pain in kids are believed to be musculotendinous strains and ligamentous sprains [3].

A study investigated that the effect of backpacks on spinal curves, shoulder level, trunk alignment and back pain in adolescent, the result showed that girls sustained from Dorsal Pain more often and of much more severity than boys. They also sustained from a decrease in the angle known as Cranio-Cervical angel and a shoulder and upper trunk shift. Asymmetrically backpack carrying was associated with high concentration of back pain. It is highly recommended to carry symmetric backpack [20].

Shoulder and Neck Injury: Backpack straps can apply pressure to the blood vessels and nerves in human shoulder and neck. The pressure can cause pain and tingling in his arms, hands, legs and neck. Well-padded straps can prevent too much pressure.

There is a positive relationship between change in the posture during carrying the backpack and changes of trunk position and motion range due to the load being carried which might influence the response of respiration. Kids carrying heavy loads have to bend their trunks forward to maintain body posture and balance while walking. Considerable increase in forward lean and limit trunk range of motion appears to affect the movement of the thorax and appears to reduce the volume of the abdomen as the muscles are contracted in order to gain stability, preventing abdominal breathing. Thus, the only way that the subject could increase oxygen uptake to support the increased metabolic cost might be to use costal breathing and breathing faster [20].

Positioning the Center of Gravity: The more stable body is gotten when the body's center of gravity is closer to its base of support. If direction is to be changed, the center of gravity must be moved toward the new direction and shorter strides must be possessed. In most all cases, these changes in direction are initiated by a head movement; eg, forward in increasing velocity and backward in decreasing velocity. On level ground, walking can be treated biomechanically as forward translation of the body's center of gravity. This requires an external force, provided essentially by the hip and knee extensors and the ankle plantar flexors, whose efficiency is governed by the friction produced between the foot and the ground during push-off [21].

1. Practical (Experimental) Work

Six healthy schoolboys (three males and three females) different in their weights, heights and ages **agreed to volunteer in the present study after their parents sign an informed consent form.** A backpack was specially built for the present study. Two comfortable backpacks consisted of a pair shoulder handles were used, the first backpack with (3 kg) weight, this weight came from few books of prepare lessons for one day without any food and water, the second backpack with (6 kg) weight, this weight came from all books, food and bottle of water. All volunteers were asked their age in months and measured their weight by using scale in kilogram and height by using scoliometer.

The procedure of work was done in daylight in space of distance greater than 7 m. The camera should be mounted on a stationary, rigid tripod pointing towards the center of the plane of motion and there should be no movement of the camera, the background should be as uncluttered as possible, plain and non-reflective.

The following instructions were given to the **volunteer before recording the video**: walk in a comfortable manner, do not bend their neck, and look straight.

The gait was filmed by a (Canon) digital camera positioned lateral to the subjects with the lens axis perpendicular to the movement plane. Each subject was instructed to walking distance 7 m in three cases: without carrying any load, with carrying a light backpack (3 kg), and with carrying a heavy backpack (6 kg). The digital camera was steady to record before position the subject. Each subject was given full explanation, verbal instruction concerning the purpose and procedure of the study.

The gait cycle of walking include: heel contact of one foot, toe-off of the same foot and heel contact of the same foot. These **recording videos were moved to** computer program (Kinovea) [22]. The procedure was done in Kinovea to samples images from the video at regular interval and creates pictures that include three images for gait cycle in each subject, and when subject was submitted to three cases, that mean there were (nine) images for each subject. When exercise (six) volunteer, results in 54 images as a whole.

Application of Markers: By using Kinovea, markers were placed on the back of subject as refers to the spine, this markers were placed according to the stander shape of healthy spine that taken from reference [23]. The markers were applied for all **54 images** (Figure 8) **and these images moved to** computer program (MATLAB).

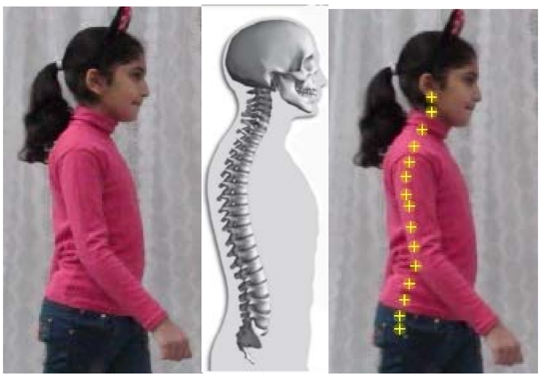


Figure 8 Application of markers.

2. Results and discussion

The anthropometric data of the six subject volunteers were taken. The gait of the volunteers carrying a backpack was filmed in three cases; 0, 3, 6 kg. The film and spine posture were analyzed by using (Kinovea & Matlab) computer programs. In table (1), the anthropometric data of the six subject volunteers is shown:

Table (1): Subject's anthropometry.

Name	Sex	Age (year)	Length (cm)	Weight (kg)	3kg %(BW)	6kg %(BW)
Zainab	F	8	120	21	14.3	28.57
Iessa	M	9	131	26	11.54	23.07
Hames	F	8	133	28	10.71	21.43
Zahraa	F	9.2	142	29	10.34	20.69
Sadiq	M	10.3	135	36	8.33	16.66
Abdulla	M	10.9	153	55	5.45	10.9

In table (2), the average, minimum and maximum of the anthropometric data in table (1) are shown

Table (2): The anthropometric average, minimum and maximum.

	Age (year)	Length (cm)	Weight (kg)	3kg %(BW)	6kg %(BW)
Mean	9.23	135.667	32.5	9.231	18.46
Min	8	120	21	14.3	28.57
Max	10.9	153	55	5.45	10.9

In figure (9), a sample of images that produce the gait of first subject in three cases: (a) carrying no load, (b) carrying 3kg load, (c) carrying 6kg load.

(a)

(b)

(c)

Figure 9 The subject 1: carrying 0, 3, 6kg load

The posture of subject one (Zainab) is show in figure (10), it can be shown from the figure that the great effect of the load (3 and 6 kg) on the posture than no load. Lumbar asymmetry was: 9.7 degrees with 3 kg, and 14.5 degrees with 5 kg.

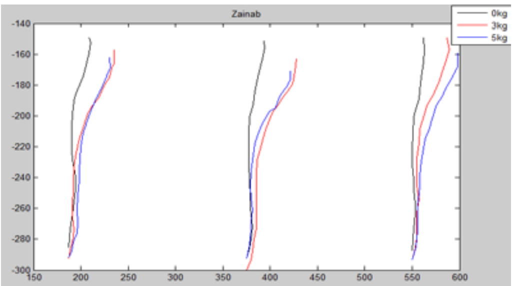


Figure 10 The result of spine posture of subject one (Zainab) dimensions in millimeters

In figure (11), a sample of images that produce the gait of second subject in three cases: (a) carrying no load, (b) carrying 3kg load, (c) carrying 6kg load.

(a)

(b)

(c)

Figure 11 The subject 2: carrying 0, 3, 6kg load

The posture of subject two (Iessa) is show in figure (12), it can be shown from the figure that the effect of the load (3 and 6 kg) on the posture,6 kg gives a great curvature of the spine than 3 kg, and 3 kg gives a significant curvature than no load. Lumbar asymmetry was: 11.2 degrees with 3 kg, and 16.3 degrees with 5 kg.

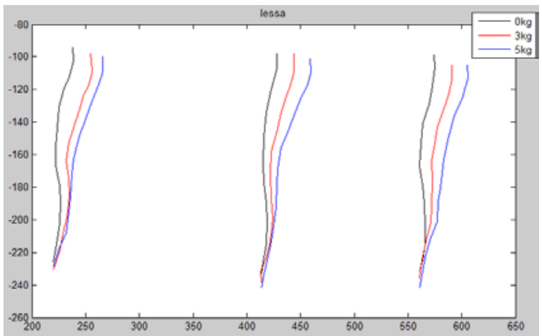


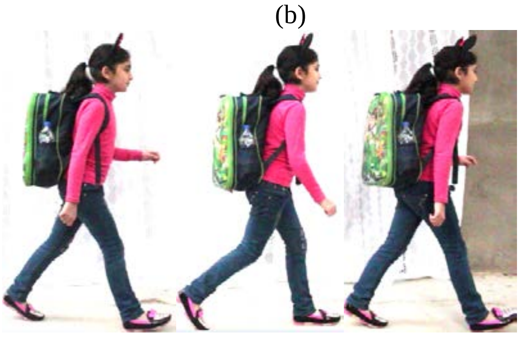
Figure 12 The result of spine posture of subject two

(Iessa), dimensions in millimeters

In figure (13), a sample of images that produce the gait of 3^{rd} subject in three cases: (a) carrying no load, (b) carrying 3kg load, (c) carrying 6kg load.

(a)

(b)



(c)

Figure 13 The subject 3: carrying 0, 3, 6kg load

The posture of subject three (Hames) is show in figure (14), it can be shown from the figure that the effect of the load (3 and 6 kg) on the posture that almost similar to subject two. Lumbar asymmetry was: 7.9 degrees with 3 kg, and 11.3 degrees with 5 kg.

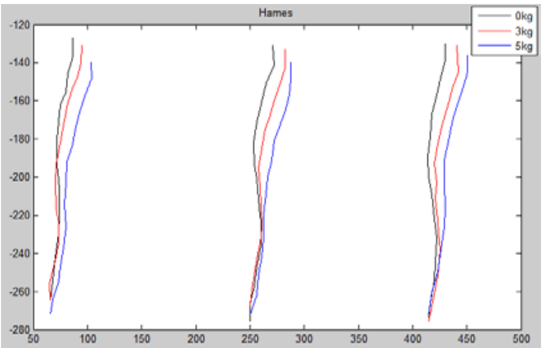


Figure 14 The result of spine posture of subject three (Hames), dimensions in millimeters

In figure (15), a sample of images that produce the gait of 4^{th} subject in three cases: (a) carrying no load, (b) carrying 3kg load, (c) carrying 6kg load.

(a)

(b)

(c)

Figure 15 The subject 4: carrying 0, 3, 6kg load

The posture of subject four (Zahraa) is show in figure (16), it can be shown from the figure that the effect of the load (3 and 6 kg) on the posture, the last gait produce a significant curvature than 1^{st} and 2^{nd} gait. Lumbar asymmetry was: 12.1 degrees with 3 kg, and 15.7 degrees with 5 kg.

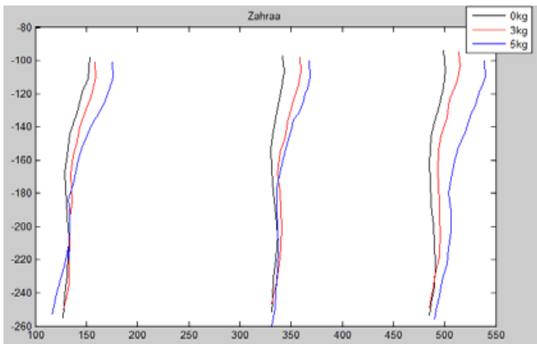


Figure 16 The result of spine posture of subject four (Zahraa), dimensions in millimeters

In figure (17), a sample of images that produce the gait of 5^{th} subject in three cases: (a) carrying no load, (b) carrying 3kg load, (c) carrying 6kg load.


(a)


(b)


(c)

Figure 17 The subject 5: carrying 0, 3, 6kg load

The posture of subject five (Sadiq) is show in figure (18), it can be shown from the figure that the effect of the load (3 and 6 kg) on the posture, a various change in curvature occur with various load and gait. Lumbar asymmetry was: 16.3 degrees with 3 kg, and 20.1 degrees with 5 kg.

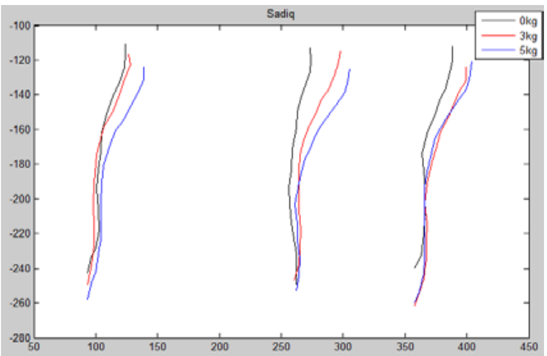


Figure 18 The result of spine posture of subject five (Sadiq), dimensions in millimeters

In figure (19), a sample of images that produce the gait of 6^{th} subject in three cases: (a) carrying no load, (b) carrying 3kg load, (c) carrying 6kg load.


(a)


(b)


(c)

Figure 19 The subject 6: carrying 0, 3, 6kg load

The posture of subject six (Abdulla) is show in figure (20), it can be show from the figure the effect of the load (3 and 6 kg) on the posture, small change occur in 1^{st} gait than 2^{nd} and 3^{rd} gait. Lumbar asymmetry was:7.3 degrees with 3 kg, and 13.9 degrees with 5 kg.

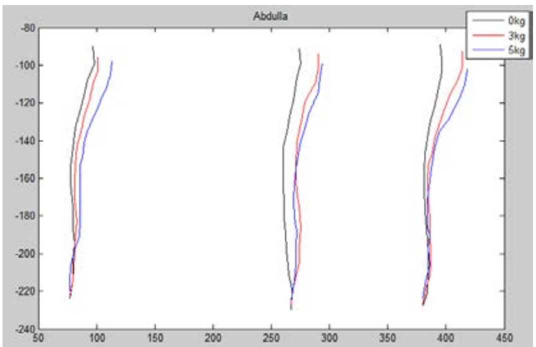


Figure 20 The result of spine posture of subject six (Abdulla), dimensions in millimeters

3. Discussion

The range of movement of the vertebral column in the sagittal plane increased when the backpack was carried, irrespective of the load magnitude and gait cycle phase. Probably, this is a compensatory strategy to counteract the effect of the load, which tends to displace the participant's center of mass away from mid-line. That forward inclination of spine to give balance to the body. The slow walking speed used in the present study may have not induced large changes in the kinematics of the vertebral column as in greater speeds. Thus, it is suggested that weight of the backpack is not the only factor that determines the movements of the vertebral column. This study shows an agreement with medical studies [24, 25]

4. Conclusions

1. The results show that the heavy load carried on the back would force the kids to alter their body posture to oppose the variation from the normal kinematics pattern when body posture and balance were disordered by carrying the essential extra load.
2. The results indicate that there is a relationship between the backpack load and the spine shape which are consistent with common sense.
3. The results also show that the forward inclination of the trunk increases when the load and the walking distance are increased.
4. The forward inclination of the trunk segment may impose greater stress over the vertebral column (ligaments and intervertebral disks) and increase the risk of back problems.

Spine and back health may be adversely affected by load carriage sooner than was previously thought, and it may be important to use spinal curvature as a measure of posture for load carriage.

5. Recommendation to the Ministry of Education

The ministry of education should adopt instructions to the schools to not force the students to bring all their books to their schools.

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التحليل الميكانيكي الاحيائي لتأثير الثقل على وضعية جسم الأطفال

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الخلاصة

الاطفال اللذين يحملون أحمال ثقيلة كجزء من نشاطاتهم اليومية من الممكن ان تؤدي الى إنحناء ابدانهم الى الأمام للمحافظة على هيئة الجسم والتوازن اثناء المشي. هذه الدراسة كانت لتحديد العلاقة المتبادلة بين وزن حقيبة الظهر للأطفال، مع وزن أجسامهم وتعيين الملامح لوضعية أجسامهم. تمت الدراسة بالاستعانة بستة أطفال متطوعين طبيعيين في مرحلة الدراسة الابتدائية، تم حساب الانثروبومترية (العمر والطول والوزن) للمتطوعين. تم اختيار حقيبة الظهر المدرسية لهذه الدراسة. تم تصوير خطوات المشي من المستوي الجانبي لثلاث حالات هي (صفر كغم و3 كغم و6 كغم) لحقيبة الظهر. تم تحليل وضعية الجسم باستخدام برنامجي الحاسوب (كينوفا وماتلاب). أظهرت النتائج زيادة في الأنحناء للأمام لجذع الجسم عند ازدياد الثقل ومسافة المشي، وهذا الأنحناء يفرض إجهاد عالي على العمود الفقري (الأربطة والأقراص الفقرية) والتي بدورها تزيد من خطر الإصابة بمشاكل الظهر. بينت الدراسة أن حمل الثقل يؤثر سلباً على العمود الفقري وصحة الظهر، ومن المهم استخدام انحناءات العمود الفقري لقياس وضعية