The effect of Frontpacks,Shoulder bags and Handheld bags on 3D back shape and posture in young university students: An ISIS2 study

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Abstract.

Background: Students at school and university settings have been shown to carry heavy loads in a variety of pack systems. Both type and mode of load carriage have been shown to cause significant postural adaptations that can lead to injuries in the shoulder, arms, hands and back. Whilst backpacks have been well researched, there is a paucity of literature on the effects of frontpacks, shoulder bags and hand-held bags on 3D posture and back shape.
Objective: The objective of this study was to evaluate the effect of carrying three different types of bag (shoulder, front and handheld), each containing a load of 15% body weight.
Materials: The Integrated Shape Imaging System 2 (ISIS 2) was used to evaluate 3 D back shape and posture.
Participants: The study involved twenty-five university students. A repeated measures design was used to record the effects of four conditions using no load (reference), a frontpack, a shoulder bag and a handheld bag. Measurements with ISIS 2 were taken 5 minutes post loading. All of the conditions were randomised in an attempt to offset any order effects.
Results showed an increase in extension and lumber lordosis angles for the front bag ($P<0.001$) and an increase in flexion and reduced lumber lordosis in the shoulder and hand held bags ($p<0.05$). Kyphosis curves were also significantly increased in the hand held bag ($p<0.006$). Right unilateral load carriage also demonstrated the greatest right volumetric asymmetry.
Discussion: Bilateral front carriage as supported by previous literature produces a symmetrical shift away from the load. Unilateral carriage however produces an asymmetrical deviation away from the load which results in significant postural deviations and adaptations.
Conclusion :Frontbags may be more suitable for load carriage within the young adult student population as they produce a symmetrical postural deviation in one plane in response to load. The shoulder and handheld bags produce postural deviations in all planes which may cause adverse stress and strain on spinal structures and ultimately lead to pain and progressive postural scoliosis.

Keywords. Backshape, posture, ISIS2, topographical scanning, load carriage

1. Introduction

Load carrying systems are commonly used within recreational and occupational settings, with bags in particular routinely used throughout most of the educational years at school, college and university to transport heavy books and stationary [1]. The link between load carriage and musculoskeletal pain in the neck, back and shoulders has been well documented [2,3] with prevalence of back pain documented to be as high as 30-51% in adolescent students and requiring 4-31% to seek medical intervention [3]. Prevalence in children has been shown to be near to that in adults with 1 in 3 individuals affected in the UK, with 20% seeking medical consultation and causing an estimated £1,632 million burden to the NHS in 1998 [3]. Back pain in adolescents is associated with long term back pain [4].The application of an external load, such as with a rucksack, causes significant postural deviations in response to the compensational shift in the bodies' centre of gravity (COG) within the base of support (BOS) [5,6]. The actual mode of load carriage has been shown to cause different postural shifts resulting in adverse stress and strains on the surrounding spinal structures resulting in back pain. Bettany-Saltikov et al [5] and Negrini et al [7] reported trunk flexion in response to load carried in a backpack, the extent of which varies between ergonomic and standard bags. Motmans et al [8] and O`Shea et al [6]reported lateral deviation in the frontal plane (i.e. a spinal curve concave/ convex within the frontal plane) in response to a bag carried on one shoulder whilst Zultowoski and Aruin [9] reported increased medial/lateral postural sway when carrying a hand held brief case. There is however a distinct lack of research into specific spinal curve angles in front bags and hand held loads despite wide use within the military, manual labour occupations, college students` as well as the population at large.

2. Objective

The objective of this study was to evaluate the effect of carrying three different types of bag (front, right shoulder, and right handheld), each containing a load of 15% body weight on 3D back shape and posture.

3. Participants:

The study involved twenty-five university students. A repeated measures design was used to record the effect of four different loading conditions; no load (reference), a frontpack, a right shoulder bag and a right handheld bag. Measurements with ISIS 2 were taken 5 minutes post loading. All the conditions were randomised in an attempt to offset any order effects. The mean characteristics of participants within the study are presented in table 1.

4. Materials

The ISIS 2 equipment measures the 3D shape of the spine by capturing (with the camera) the distorted patterns of parallel fringes that are projected onto the participants

back, allowing distances and height between the participant and reference screen to be calculated incorporating crossed-optical-axis geometry on the user interface. From the results a scan was produced showing visual interpretations of calculated parameters and explanations of parameters.

Table 1: The mean characteristics for the 20 participants

Characteristics	Means and Standard Deviations
Age	23.85 ± 4.120232 (Years)
Height	172.95 ± 11.73041 (CM)
Weight	70.55 ± 17.76299 (KG)
BMI	24.645 ± 5.499902
Female	8
Male	12
Left Handed	5
Right Handed	15

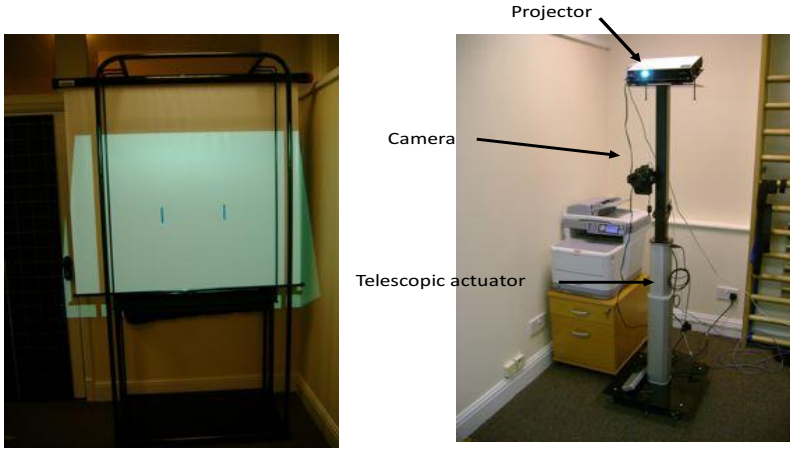
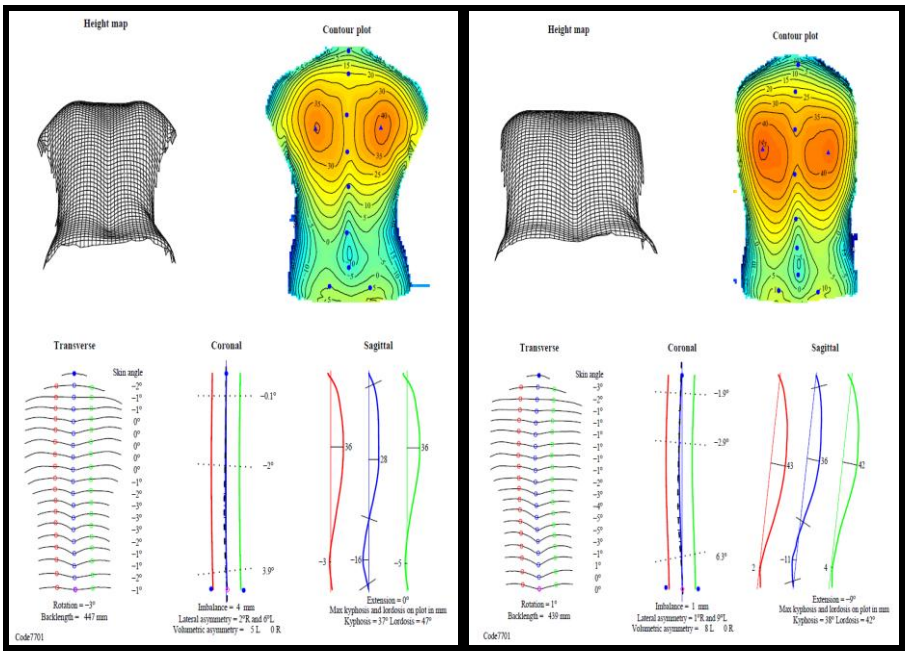


Figure 1: The ISIS2 SYSTEM

5. Results

A One Way ANOVA (Repeated measures) and a post-hoc Bonferroni test was performed. Although changes were seen in most parameters the results showed no overall statistically significant differences in back length, rotation, imbalance, Min skin angle and Left and right Lateral Asymmetry angles ($p>0.05$). Results also showed an increase in extension and lumber lordosis angles for the front bag ($P<0.001$) and an increase in flexion and reduced lumber lordosis in the shoulder and hand held bags ($p<0.05$). Kyphosis curves were also significantly increased in the hand held bag ($p<0.006$). Right unilateral load carriage also demonstrated the greatest right volumetric asymmetry.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Contour plot
Transverse
Coronal
Sagittal
Skin angle
Rotation = −3°
Backlength = 447 mm
Imbalance = 4 mm
Lateral asymmetry = 2°R and 6°L
Volumetric asymmetry = 5 L 0 R
Extension = 0°
Max kyphosis and lordosis on plot in mm
Kyphosis = 37° Lordosis = 47°
Code7701
Height map
Contour plot
Transverse
Coronal
Sagittal
Skin angle
Rotation = 1°
Backlength = 439 mm
Imbalance = 1 mm
Lateral asymmetry = 1°R and 9°L
Volumetric asymmetry = 8 L 0 R
Extension = −9°
Max kyphosis and lordosis on plot in mm
Kyphosis = 38° Lordosis = 42°
Code7701

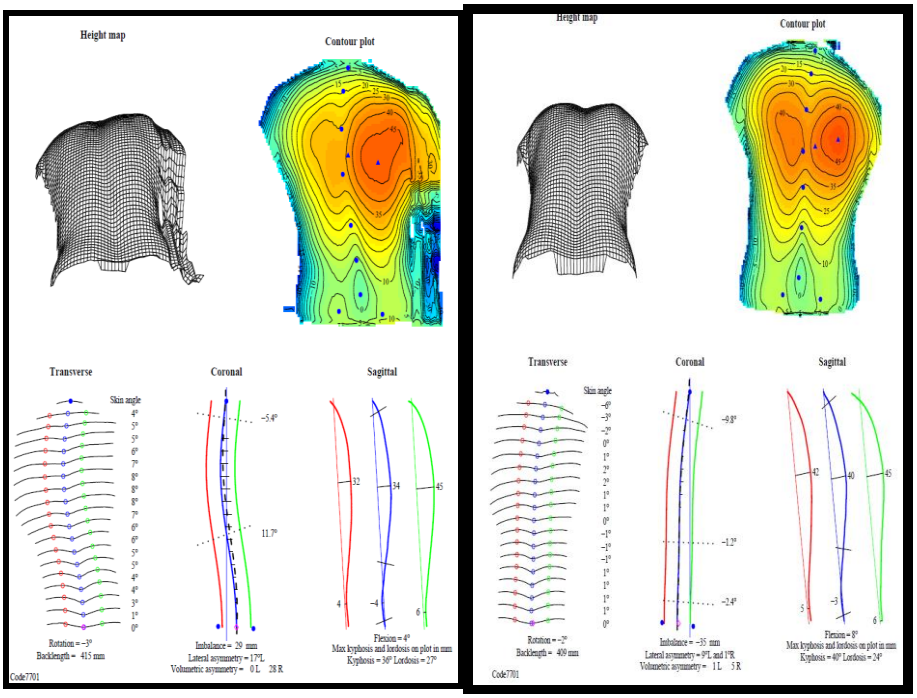
Height map
Contour plot
Transverse
Coronal
Sagittal
Skin angle
Rotation = −3°
Backlength = 415 mm
Imbalance = 29 mm
Lateral asymmetry = 17°L
Volumetric asymmetry = 0 L 28 R
Flexion = 4°
Max kyphosis and lordosis on plot in mm
Kyphosis = 36° Lordosis = 27°
Code7701
Height map
Contour plot
Transverse
Coronal
Sagittal
Skin angle
Rotation = −2°
Backlength = 409 mm
Imbalance = −35 mm
Lateral asymmetry = 9°L and 1°R
Volumetric asymmetry = 1 L 5 R
Flexion = 8°
Max kyphosis and lordosis on plot in mm
Kyphosis = 40° Lordosis = 24°
Code7701

Figure 2: Example of the ISIS2 scans of one subject with from top left, no load, top right, frontpack, bottom left, right shoulder bag and and bottom right, right hand held bag

6. Discussion and conclusions:

As expected all types load carriage types produced postural deviations, with asymmetrical loads causing significantly greater deviations than symmetrical loads. Bilateral front carriage as supported by previous literature produces a symmetrical shift away from the load resulting in spinal extension. Unilateral loading modes produced asymmetrical deviations away from the load which resulted in significant greater postural deviations and adaptations than symmetrical loading. Previous studies conducted at this centre compared symmetrical loading on the *back* to asymmetrical loading of both shoulders, to investigate the effects of carrying a rucksack (on each shoulder) on 3D spinal curvature in healthy young students [5]. Carrying the load on both shoulders resulted in no difference in the frontal plane angle but significantly decreased the thoracic kyphosis in the sagittal plane. However, carrying the load on the right shoulder significantly increased the thoracic lateral curvature in the frontal plane and decreased the thoracic kyphosis in the sagittal plane. A study by O`shea et al [6] further evaluated load carriage in asymmetrical postures; [either on one shoulder (same-side) or across the body (cross-body)] in healthy young adults. Results demonstrated significantly less impact on spinal posture from cross-body loading as compared to same-sided loading. In conclusion, the limitations of the current study included the lack of a sample size calculation before the study was conducted and the small numbers of participants which may have resulted in a type 2 error (this is where no significant differences are seen in some parameters when true differences do exist). In the current study symmetrical frontbags caused significantly less postural deviations than either shoulder or handheld asymmetrical modes of carriage. The shoulder and handheld bags produced postural deviations in all planes which may cause adverse stress and strain on spinal structures and ultimately lead to pain and progressive postural scoliosis. There was a definite trend towards greater postural deviations using a carrier bag than a shoulder bag.

7. References

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