*ORIGINAL ARTICLE*

# Changes in Craniovertebral Angle and Sagittal Shoulder Angle: Comparation between Modified Backpack and Conventional Backpack Users in 11- 12 Aged Boys

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**ABSTRACT**

**Objectives:** to develop a better design of ergonomic backpack and to evaluate the effect of wearing conventional and modified backpack on CVA and SSA changes.
**Methods**: 34 male students of grade 5 and 6 elementary school who met the inclusion criteria (boys, 11-12 years old, normoweight, normoposture, and able to follow instruction) were included in the experimental and cross sectional studies to evaluate duration, time of complaint, and changes in CVA and SSA between the conventional and modified backpack groups; and subject preference to backpack design. This study was statistically analysed through Mann-Whitneym Wilcoxon, and Mc Nemar tests.
**Results**: The modified backpack with two compartments, hip strap, compartment strap and wide shoulder strap gives more benefits. Majority of students preferred the modified design to conventional design. The modified design also gave students the ability to stand up longer. Narrowing CVA while wearing backpack was evident in conventional group (n=25) in comparison with modified group (n=15, p= 0.022). Moreover, narrowing SSA was also found more (n=18) in the conventional group than the modified group (n=4, p=0.000).
**Conclusions:** Modified backpack design with two compartments, hip straps, wide shoulder straps, and compartment straps provides less CVA and SSA changes in comparison to conventional beckpack group. Minimal changes of CVA and SSA contributes to the development of a more ergonomic model of modified backpack to maintain postural stability.

**Key Words**: *posture, craniovertebral angle, backpack, ergonomics.*

## INTRODUCTION

School-aged children experienced accelerating musculoskeletal development when growth spurth occurs. Any vertebral development problem would deteriorate postural integrity in the future. Carrying excess load, such as heavy backpack may result in disproportionate vertebral alignment.[4,5]

For about 7,277 patients per year visit the emergency room due to backpack carrying related trauma based on the data of Illinois State Board of Education. The number tends to increase as much as 330 % since 1996.[2] This happens when children exhibit intense compensation due to overweight backpack or excessive inclination to one side. A backpack study in Australia, Chansirinukorn et al found that postural changes, such as decreasing cervical lordosis appeared more in backpack user group who wore backpack weighed 15% of the body weight, compared to other group not

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wearing backpack. Decreasing cervical lordosis has strong relationship with high incident of neck muscle spasm and tension headache in adulthood.[3,9,14,15,16,17,19,20,22]

The aim of this study is to design the ergonomic backpack and to evaluate our hypothesis that modified backpack would cause minimal changes on cervical lordosis and shoulder position in comparison to conventional backpack.

## METHODS

Design of this study consists of a) designing modified backpack which is ergonomic for school-aged children based on biomechanic theory; b) cross-sectional study to evaluate duration, complaint and preference subject of the backpack; and c) experimental study pre- and post design to test the hypothesis of the study. Inclusion criteria of this study are boys, aged 11-12 years old, normal body weight, normal postur, and able to follow instruction. While the exclusion criteria consists of cardiorespiratory disease and any complaints of neck pain, upper or and lower back pain.

We adopt craniovertebral angle (CVA) and sagittal shoulder angle (SSA) for posture measurement. Craniovertebral Angle (CVA) is the angle formed at the intersection of a horizontal line through the spinous process of C7 and line of the tragus of the ear. This provides an estimation of neck on upper trunk positioning. Narrow angle indicates forward head posture. Sagittal Shoulder Angle (SSA) is formed through the intersection of C7 and the line between the mid point of greater tuberosity of humerus and the posteror aspect of acromion procress. This shows the measurement of forward shoulder position.[5,17,19,21,22,23,24,25]

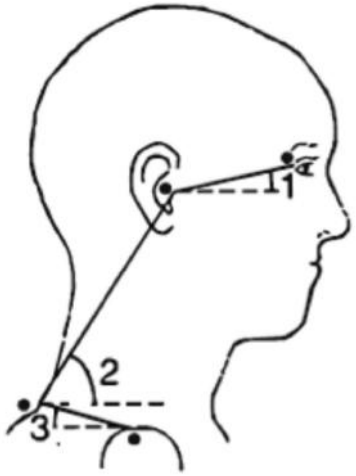


**Figure 1. The craniohrizontal angle (1) and carniovertebral angle (2), and sagittal shoulder posture (3).**

*Conventional backpack:*
Backpack dimension 23 cm x 35 cm x 10 cm, made of polyester, consist of 1 compartment, 2 shoulder strap 4,5 cm width.

*Modified backpack:*
Backpack dimension 28 cm x 35 cm x 13 cm, made of polyester, consist of 2 compartments with compartment strap, curve-shaped, thick paded shoulder strap 6 cm width, hip strap 4 cm width, backpack equipped with soft padding.

*Statistical analysis*

Mann-Whitney test is used to compare the complaint arised between the conventional backpack group and the modified backpack group. Wilcoxon test is employed to measure the backpack usage duration between the two groups. Lastly, Mc Nemar test is a comparison test of CVA and SSA between both groups.

*Procedure of the study*

Participants were those who agreed to parcipate and approved their informed consents independently. The CVA and SSA measurements were performed through the subject photographs. The photograph was taken from students wearing backpack between thoracal 1 (T1) and thoracal (T2) level.

Two photo sessions were carried out: At the first session, student was intructed to stand up without loading, followed by wearing a conventional backpack with load 15% of body weight for 10 minutes without changing the posture, then took a rest for one hour before continuing to wear a modified backpack for ten minutes; at the second session, which was on the following day, student was instructed to stand up without loading, followed by wearing a modified backpack with load 15% of body weight for ten minutes while standstill, then took rest for an hour, and end up by wearing a conventional backpack for ten minutes. The pictures were taken every 1 minute to observe any serial postural changes due to postural adaptation. The pictures were analyzed using digitalizing image program (Image Tool UTHCSA version 3.0 University of Texas Health Center, USA) for measurement of CVA and SSA.

## RESULTS

**Table 1 . Characteristics of the subject**

| | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|
| Age (years old) | 11 | 12 | 11.32 | 0.4 |
| Body weight (kg) | 24 | 59 | 34 | 7.3 |
| Body height (cm) | 127 | 156 | 140 | 7 |
| Shoulder width (cm) | 30 | 40 | 33.7 | 2,3 |
| Trunk height (cm) | 30 | 41 | 35.2 | 2,9 |

***Duration in carrying backpack***

Table 2 shows the mean duration of subjects wearing a backpack in static standing position. In this position, subjects were not allowed to change or correct the position of the backpack. In group with modified backpack, they could stand up as long as 0.5 minutes longer than the conventional backpack group, with $p = 0.804$ (Wilcoxon test).

**Table 2. Duration in Carrying Backpack up to Maximal Complaint**

| Variable | Mean | SD | Med |
|---|---|---|---|
| Duration carrying conventional backpack | 9.2 | 1.5 | 10.0 |
| Duration carrying modified backpack | 9.7 | 0.8 | 10.0 |

*p = 0.804 (Wilcoxon)*

**Tabel 3. Subject Preference to Backpack**

| Preference | N | % |
|---|---|---|
| Modified | 29 | 85.3 |
| Conventional | 4 | 11.8 |
| Indifference | 1 | 2.9 |
| Total | 34 | 100.0 |

**Table 4. Reason of Subject Preference to Modified Backpack**

| Reason | Conventional | Modified |
|---|---|---|
| Comfortable | 3 | 8 |
| Light | 0 | 12 |
| Wide shoulder strap | 0 | 9 |
| No hip strap | 1 | 0 |
| Total | 4 | 29 |

**Table 5. Distribution of Complaint Between Conventional and Modified Backpack Groups**

| Complaint | N | (%) |
|---|---|---|
| Conventional backpack | | |
| Positive | 27 | 79.4 |
| Negative | 7 | 20.6 |
| Modified backpack | | |
| Positive | 17 | 50.0 |
| Negative | 17 | 50.0 |

*p=0.013 (Mc Nemar test)*

**Table 6. Time When Subjects Start to Complain**

| Variable | Mean (minute-) | SD | Median |
|---|---|---|---|
| Conventional backpack (n=27) | 4.9 | 1.7 | 5.0 |
| Modified backpack (n=20) | 5.6 | 3.0 | 6.5 |

*p = 0.030 (Mann-Whitney)*

***Changes in CVA after carrying Modified Backpack compared to Conventional Backpack***

We found that 73.5% of conventional backpack users experienced narrowing CVA, 14.7% showed relatively stable CVA, and 11.8 % had widening CVA. Meanwhile, the modified backpack group showed 47.1% of users experienced narrowing CVA, 29.4% with relatively stable CVA, and 23.5 % experienced widening CVA (Table 7).

**Table 7. CVA Changes in Two Groups (n=34)**

| CVA Changes | N | % |
|---|---|---|
| Conventional backpack group | | |
| Narrow | 25 | 73.5 |
| Stable | 5 | 14.7 |
| Wide | 4 | 11.8 |
| Modified backpack group | | |
| Narrow | 15 | 44.1 |
| Stable | 13 | 38.2 |
| Wide | 6 | 17.6 |

***Changes in SSA after carrying Modified Backpack Compared to Conventional Backpack***

For about 47.1% of conventional backpack users experienced narrowing SSA, 29.4% had relatively stable SSA, and 23.5 % experienced widening SSA. On the other hand, the modified backpack group showed only 11.8% of narrowing SSA, 38.2 % were relatively stable, and 50% with widening SSA (Table 8).

**Table 8. Overall Postural Changes**

| Changes in SSA | N | % |
|---|---|---|
| Conventional backpack group | | |
| Narrow | 16 | 47.1 |
| Stable | 10 | 29.4 |
| Wide | 8 | 23.5 |
| Modified backpack group | | |
| Narrow | 4 | 11.8 |
| Stable | 13 | 38.2 |
| Wide | 17 | 50 |

## DISCUSSION

Participants who were male aged 11-12 years old are included because it is the period of growth spurt and any muscle imbalance will impair their future postural integrity. Moreover, boys have homogeinity property while girls at this age are susceptible to postural variation due to menarche and thelarche.[3,4]

This study found that most of complaint came from the conventional backpack group, such as back pain, fatigue and neck pain (Table 5). It is due to soft tissue tension and muscular imbalance. Subjects of modified backpack group began to complain later than the conventional as modified backpack have wider shoulder strap that causes less pressure on shoulder. In addition, most subjects preferred the modified backpack to conventional backpack because it provides less pressure to shoulder with its two compartments; and compartment, wide shoulder and hip straps; hence, gives wider load distribution and provides lighter backpack (Table 3, 4). Thus, subjects felt minimal pain and fatigue.[35,36,37]

Furthermore, modified backpack group demonstrated more stable CVA in comparison to conventional backpack group (Table 8). This is probably because of the even load distribution of the modified backpack design which results in postural stability. On the oher hand, conventional backpack model provides focus pressure at the posterior which leads the body to compensate the load through head forward leaning.[3,15,32,37,39,40]

Lastly, modified backpack group also showed more stable SSA which is probably due to comfortable design of wider shoulder strap that gives less pressure.[3,15,16]

## CONCLUSIONS

In conclusion, the modified backpack design impinges the CVA and SSA less than the conventional backpack.

However, further studies are needed to improve the postural knowledge, identify the postural impairment and obtain solution to maintain good posture in children.

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