EFFECTS OF VARYING BACKPACK LOADS ON TRUNK INCLINATION DURING LEVEL WALKING IN CHILDREN

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Several studies have been completed to determine the effects of backpack load on the changes of posture and gait pattern. The study on the trunk posture usually consists of the trunk inclination angle and range of motion. The purpose of this paper is to study the effects of load carriage on the trunk inclination angle of children while walking with different loads. Two male subjects, aged 6 years old were asked to walk at their comfortable speeds while carrying their schoolbags with load 0%, 10%, and 20% of body weight. The children were required to walk on an 8 m track a few times before their movement was recorded. The result showed that carrying heavy load of 10% and 20% of body weight induced a significant increase in forward lean of the trunk.

KEY WORDS: backpack; trunk inclination angle; load carriage; school children.

INTRODUCTION:

Backpack use is a daily task for adults and children. Studies have shown that carrying heavy backpacks may lead to changes in trunk posture and muscle activity. By adding more weight to the back of the body, the center of gravity is shifted towards the rear of the base of support both for children (Brackley and Stevenson, 2004) and adults (Goh et al., 1998). In response to this change, subjects have to shift their trunk segments either backward or forward to counterbalance the load of the backpack. Several studies have been completed to determine the effects of backpack load on the changes of posture, while level walking and also while walking on a treadmill. Garciaguirre et al. (2007) studied the immediate postural responses and footfall modifications of 14 month-old infants who walked with different loads. In the experiment, they found that infants walked with a backwards trunk lean while carrying load at the back of their bodies. In this case they accommodated to load carriage in order to control the balance of the body while walking, which is in contrast with adults and older children who compensated for load carriage by leaning away from the direction of the load. Li and Hong (2001) investigated the impact on children's trunk position and breathing pattern when carrying different weight of schoolbags while walking on a treadmill for 20 min. Results showed that the 20% load condition induced a significant increase in trunk forward lean, decreased trunk movement range and increased respiratory frequency. Another study on trunk posture responses to backpack load during level walking in children was conducted by Hong and Cheung (2002). Eleven primary school boys aged between 9 to 10 years old participated in the experiment. The subjects were asked to carry backpack loads of 0%, 10%, 15%, and 20% of body weight while walking around a perimeter of a basketball court with a total distance of 1978 m. The results showed that there were a significant increase in trunk inclination angle for the 20% load compared to that of 0%, 10%, and 15% of body weight. The positive degree of the trunk inclination angle for each backpack weight means that the children walked with a forwards trunk lean in all load conditions. Goh et al. (1998) studied load carriage of adults age 19 $\pm$ 1.1 years during walking, with three different load conditions; 0% (as control), 15% and 30% of body weight. When compared between control condition (no load) with loading, it was found that subjects walked with a backwards trunk lean throughout the gait cycle, with mean trunk angle of -8.38°, while walking with load 15% of body weight, mean trunk angle was reduced to about -0.57° in extension. However, walking with load 30% of body weight resulted in a mean trunk angle of about $+4.26^{\circ}$, which implied that the subjects walked with a forward trunk flexion posture during this load condition. Another study on the effect of carrying backpack on trunk posture was reported by Al-Khabbaz YSSM et. al. (2008). In this study, 19 male aged 21 $\pm$ 3 years were asked to stand in four modes; unloaded standing, 10%, 15%, and 20%

of body weight load. Unloaded standing, served as a reference to the three different load modes. The results of the changes in trunk posture for all three conditions of backpack load showed that the trunk inclined backward –3.37º, –3.02º and –3.90º during 10%, 15% and 20% of body weight load respectively. Although only a few studies focused mainly on the trunk inclination, there is no research done on the trunk inclination for 6 year-old children carrying load while level walking. Li and Hong (2004) investigated age difference in trunk kinematics for children aged 6 and 12 years old who walked on a treadmill. Thus the purpose of this paper is to study the effects of load carriage on the trunk inclination angle of children age 6 year-old while level walking with different loads.

METHOD:

Data Collection: Two healthy boys aged 6.50 ± 0.25 years, with body mass 22.25 ± 0.80 kg and height 118.70 ± 5.50 cm were selected. The parents had given their written consents and the boys were free from any injuries prior to the experiment. The children used their own two-strap backpack and walked at their comfortable speeds few times before their movement were recorded. They were required to walk on an 8 m track with three different load conditions; 0%, 10%, and 20% of their body weight.

Data Analysis: In each condition, the movements were recorded by 6 infrared cameras of 200 Hz that were set at 1/250 shutter speed. 18 reflected markers were placed on the bony landmarks of the subject's body; the left and right shoulders, elbows, wrists, iliums, knees, ankles, heels and toes, the sacral vertebrae and at the back of the body of the right scapula to facilitate the identification of the left and right side during movement reconstruction. Another 4 markers were placed at the left and right of the shank and thigh segments. The 3-dimensional kinematic data were digitized on a motion analysis system (EVART 4.2). For each complete gait cycle, the mean trunk inclination angles which are defined as the angles of the line going through the shoulders and hips in relation to the horizontal line through the hips were then calculated.

RESULTS:

Graph of the mean average of trunk inclination angle for each load conditions is shown in Figure 1.

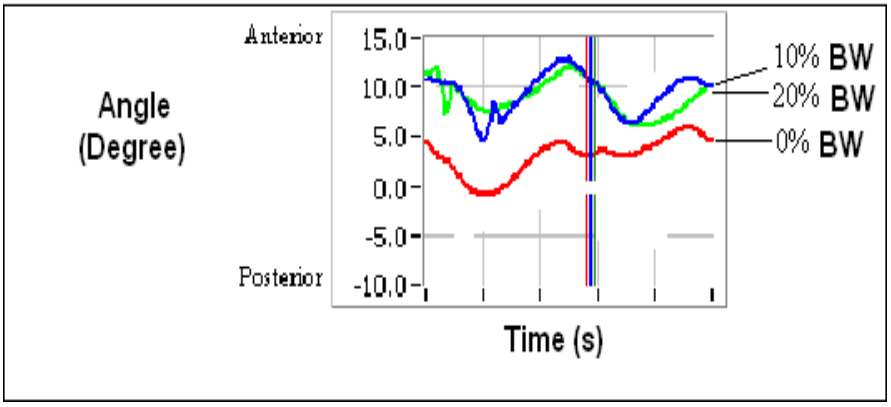

Figure 1 Graph of the mean average of trunk inclination angle with different load conditions during level walking

Figure 1 shows the changes in trunk inclination angle for different load conditions. In this study positive degree indicates forward inclination for all three different backpack load conditions. The trunk forward lean increases more than 5° with loads of 20% and 10% of the body weight compared to that of 0% load condition. No significant difference in trunk forward lean angle is observed between 10% and 20% of load conditions.

DISCUSSION:

The results of the present study are consistent with those of Hong and Cheung (2002). When the loads increase from no load condition to 10% and 20% of body weight load condition, significant trunk forward lean is observed. However, results from Goh et al. (1998) showed that the mean trunk angle of adult increased significantly from trunk extension posture (backward lean of trunk) at walking with no load to trunk flexion posture (forward lean of trunk) at walking with 30% of body weight load.

From Table 1, by comparing the results of children and adults, it seems that children have to lean forward while carrying backpack load regardless of what percentage of body weight, whereas adults only lean forward when the load increases to 30% of body weight. Children age 6 to 11 years old tend to lean forward when carrying heavy loads (10%, 15% and 20% of body weight) on their back. However for adults age 18 year-old (Goh et al.,1998) and 21 year-old (Al-Khabbaz YSSM et al.,2008), they tend to lean backward when carrying loads of 10%, 15% and 20% of body weight on their back. But with load 30% of body weight they tend to walk with a forward trunk flexion (Goh et al.,1998) which shows that this load condition is heavy for adults. In our opinion if by carrying load of 30% of body weight would induce a forward flexion in adults, then by carrying loads of 10%, 15% and 20% of body weight will induce a greater postural effects on young children and teenagers since at these load conditions they tend to walk with a forward flexion. This probably explain the findings of Patrick (2006) who discussed that spinal ligaments and muscles are not fully developed until after the 16th year of life. As we know, children experience rapid growth and have immature bony ossification. Compared to adults, their bones are particularly soft and as a result they can easily bend. For younger children, the increase in even less load (10% of body weight) will force them to lean forward in order to bring the center of gravity back over the base of support.

Table 1 Biomechanics studies on the effect of backpack loads on trunk inclination during level walking

Study	Age (Years)	Sex	N	Distance Or Time	Load Carriage Backward/Forward Lean
Garciaguirre et al. (2007)	14 months	M&F	27	-(W)	15% BW TBL
This study	6.50 ± 0.25	M	2	8m(W)	0, TFL 10, TFL 20 % BW TFL
Hong & Cheung (2002)	9.43 ± 0.51	M	11	1978m(W)	0, TFL 10, TFL 15, TFL 20 % BW TFL
Shasmin et al.(2007)	10.28 ± 0.72	M	7	5m(W)	0, TFL 10, TFL 15, TFL 20 % BW TFL
Goh et al. (1998) TBL TBL TFL	19.90 ± 1.10	M	10	-(W)	0, 15, 30 %
Al-Khabbaz YSSM et al. (2008)	21± 3	M	1	- (S)	10, TBL 15, TBL 20 % BW TBL

BW = body weight; TFL = trunk forward lean; TBL = trunk backward lean; M = male; F = female
W = walking; S = standing

CONCLUSION:

The results of this study showed that carrying heavy load of 10% and 20% of body weight, during level walking induced a significant increase in forward lean of the trunk for children age 6 years old. No significant difference in trunk forward lean angle is observed between 10% and 20% of load conditions.

REFERENCES:

Al-Khabbaz YSSM, Shimada, T. & Hasegawa, M. (2008). The effect of backpack heaviness on trunk-lower extremity muscle activities and trunk posture. *Gait and Posture,* doi:10.1016/j.gaitpost.2008.01.002.

Brackley, H.M. & Stevenson, J.M. (2004). Are children's backpack weight limits enough? A critical review of the relevant literature. *Spine*, 29(19), 2184 – 2190.

Garciaguirre, J.S., Adolph, K.E., & Shrout, P.E. (2007). Baby carriage: Infants walking with loads. *Child Development*, 78(2), 664 – 680.

Hong, Y. & Cheung, C. K. (2002). Gait and posture responses to backpack load during level walking in children. *Gait and Posture*, 17, 28 – 33.

Goh, J.H.,Thambyah, A., & Bose, K. (1998). Effects of varying backpack loads on peak forces in the lumbosacral spine during walking. *Clinical Biomechanics*, 13(S1), S26 – S31.

Li, J.X. & Hong, Y. (2001). Changes of trunk position and breathing pattern in children walking under conditions of load carriage. *Scientific Proceedings of the XIX International Symposium on Biomechanics in Sports,* San Francisco, 177–179.

Li, J.X. & Hong, Y. (2004). Age difference in trunk kinematics during walking with different backpack weights in 6 to 12 year old children. *Scientific Proceedings of the 22nd International Symposium on Biomechanics in Sports,* Ottawa, Canada, 153–156.

Patrick, C., (2006). Spinal conditions, in: Campbell, S.K., Linden, D.W.V. & Palisano, R.J.(Eds),. *Physical Therapy For Children*, (pp 337 – 338), 3rd edn.,Saundets, Philadelphia,PA.

Shasmin, H. N., Abu Osman, N.A., Razali, R., Usman, J., & Wan Abas, W.A.B. (2007). Preliminary study of acceptable load carriage for primary school children. *IFMBE Proceedings*, 15, 171 – 174.

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