MOVEMENT KINEMATICS OF TREADMILL WALKING UNDER LOAD CARRIAGE IN 6-YEAR-OLD CHILDREN – A PRELIMINARY REPORT

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This paper reports the preliminary results of a study on the biomechanical and physiological responses of 6-year-old children to walking under load carriage. Eleven male children participated in the study, and each walked on a treadmill for 20 minutes with a load that was equivalent to 10%, 15%, and 20% of their body weight, and without a load. Their walking movements were videotaped and analysed in 2 dimensions. The results showed that walking with a load that was equivalent to 20% of body weight increased trunk forward lean, swing duration, and knee maximum flexion, while it decreased double support duration. No significant difference was observed in the head orientation with increased load.

KEY WORDS: children, load carriage, gait, posture

INTRODUCTION: The influence of over-weight schoolbags on the health of children has drawn much attention from the community. Studies have revealed heavy load induced kinematics and cardiovascular strain in 10-year-old children. During treadmill walking, the carriage of backpacks with loads equivalent to 20% of body weight was found to induce significant increases in trunk forward lean and the duration of double support, and decreases in trunk angular motion and swing duration, as well as prolonged blood pressure recovery, when compared to no load carriage. In Hong Kong, primary school children range from 6 to 12 years of age. Children at these ages experience significant growth and motor development, but there is no information about the impact of heavy backpack loads on the movement kinematics and cardiovascular and metabolic systems of six-year-old children. Hence, we conducted a project focusing on the biomechanical and physiological responses of children at this age during load carriage. The present paper reports the preliminary results of this project, and measures the changes in gait and posture control induced by different weights carried in backpacks as our subjects participated in treadmill walking.

METHODS: A group of 15 male students aged 6 years was randomly selected from a primary school. Each subject participated in eight trials: four involved walking on an athletics track, and four on a treadmill. In each situation, the subjects were without schoolbags (and therefore carried a load of 0% of body weight), and then carried a schoolbag that was equivalent to 10%, 15% and 20% of the mean body weight of the sample group. Schoolbags with double padded shoulder straps were carried on the mid-back of the subjects. On the athletics track, subjects were asked to walk for 100 m at a speed that was consistent with the speed at which they normally walked to school. Only the time elapsed for the middle 80-m was recorded and used to calculate the average speed for that distance. This speed, or pace, was recorded for each child at each carrying load, and the mean walking speed at each workload was then used as the treadmill speed at that load. On the treadmill, the subjects walked for 20 minutes at each trial. For each subject, different trials were randomly assigned to different testing days in the respective situations.
Before walking on the treadmill, each subject was measured for body weight and height. A 3-CCD video camera of 50 Hz frequency, set at 250/s-shutter speed, was located at a distance of 5m from the subject so that the lens axis of the camera was perpendicular to the motion plane. The videotapes were then digitised and analysed with the advanced motion measurement system to provide detailed linear and angular kinematics of the walking movement, such as stride frequency, stride length, single leg supporting time, double leg supporting time, and trunk inclination angle. Three complete strides at each 5-minute interval during walking were selected for digitisation. Eighteen anatomical points on the body were digitised on each frame. These 18 points were the middle point of the ears, the middle point of the shoulders, the right and left

shoulders, and the elbows, wrists, hips, knees, ankles, heels and toes. One-way Analysis of Variance (ANOVA) with repeated measures was used to test for significant differences. Post hoc analysis was conducted with Scheffe's Significant Difference Test to evaluate the significant mean differences. The 0.05 probability level was used for all tests as the criterion value in determining the presence or absence of statistically significant results.

RESULTS AND DISCUSSION: To overcome the lack of information in the literature, this study used the kinematic approach to examine some aspects of the walk patterns and body posture of the youngest group of primary school children during treadmill walking under the carriage of different loads. Walking with a load that was equivalent to 20% of body weight induced more pronounced trunk forward lean than walking under a 0% load condition. This forward lean was the result of subjects shifting their trunk segment forward to counterbalance the load of the backpack. No significant difference was found among the other load conditions in this parameter. These results agreed with findings for 10-year-old children under the same experimental conditions (Hong & Brueggemann, 2000).

Movement of the head showed a different pattern than that of the trunk. No significant difference in head orientation angle was found under any load condition. This result indicated that although heavy loads forced the subjects to alter their body positions to counteract the deviation from the normal kinematic pattern when the body posture and balance were disturbed, the head remained stable. Another possible explanation for the head orientation angle was the treadmill walk. This walking situation might constrain the head position.

In the present study, the normalised swing duration was significantly shorter under a load that was equivalent to 20% of body weight than under 0% or 10% load conditions, while the normalised double support time increased with the load. These observations also agreed with the findings for the study of 10-year-old children (Hong & Brueggemann, 2000).

The altered walk pattern was also demonstrated in knee and ankle flexion. The mean knee and ankle angles during the stance after heel strike were significantly smaller under the 20% load than under 0% or 10% loads. The heavy load most likely caused increased knee flexion, which reduced the initial impact forces during heel strike. This change can also be explained as an adjustment of the lower extremity to sustain the walk task under load. Six-year-old children experience rapid growth and development. Their musculo-skeletal systems, especially the musculature distributed on the trunk, are considerably weaker than that distributed on the lower extremity. The subjects probably reduced muscular strain and increased balance by shifting the loads to their lower extremities.

Holewijn (1990) has suggested that the load of a pack on the shoulders provides pressure, strain on musculature, and skin irritations that are limiting factors to tolerable pack weight. Orthopaedists are of the opinion that continual exposure to weighted loads can promote damage, owing to the imposed postural problem (Sander, 1979). The determination of a maximum pack weight that does not alter an individual's posture might provide the basis of a recommended pack weight for children. Six-year-old children need backpack limitations that are sensitive to their age, weight, growth patterns, and fitness levels.

This paper delivers the preliminary results of our more comprehensive study on children and load carriage. The data were obtained from a small group, which contained 11 subjects at 6 years of age. Our final report will include data collected from a larger sampling group, and more valuable information is expected.

CONCLUSION: Loads that were equivalent to 20% of body weight forced the subjects to alter body position and counteract the deviation from the normal kinematic pattern when their body posture and balance were disturbed. Notable alterations were increased swing duration and maximum knee flexion. The subjects' heads maintained relatively stable anterio-posterior orientation under the different loads. Prolonged load carriage during the daily walk to and from school will affect the growth and development of children in this age group.

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