INTRODUCTION

External ankle load is usually used to increase the moment of inertia of the legs and facilitate the pendulum swing of the legs during locomotion [1]. It is recognized that external ankle load can stimulate the activities of ankle plantar flexors and enhance load sensory feedback during push off [2]. A quick unloading has been found to trigger the stance-to-swing transition and initiate leg swing [3]. No study has been conducted to investigate how external ankle load affects the ground reaction force (GRF) and impulse variables in children with and without disabilities. This study aimed to investigate the effect of both treadmill speed and external ankle load on kinetic walking patterns in preadolescents with and without Down syndrome (DS).

METHODS

Participants: There were ten preadolescents with DS (8 M/2 F, mean age: 9.1 years, average height and weight: 1.25 m and 31.7 kg, respectively) and 10 children with typical development (TD) (8M/2F, mean age: 9.3 years, average height and weight: 1.34 m and 30.1 kg, respectively).

Experimental design: There were two treadmill speed conditions: 75% (SS) and 100% (FS) of the participant’s preferred overground walking speed. Average SS and FS conditions were 0.76 m/s and 1.04 m/s, respectively, in the DS group, and 1.03 m/s and 1.37 m/s in the TD group. There were two external ankle load conditions: with (AL) and without (NL) bilateral external ankle load which was equal to 2% of the participant’s body weight on each side. Average AL condition was 6.0 N in the DS group and 5.9 N in the TD group.

Data collection: A total of four conditions (2 treadmill speed by 2 ankle load) were tested. Two 60-second trials were collected for each condition. The order of condition presentation was mostly randomized across the two groups. Because some participants in the DS group initially had difficulty executing treadmill walking under the FS condition, the SS condition was presented first to allow acclimation in these participants [4]. A Zebris FDM-T instrumented treadmill was used to collect vertical GRF data.

Data analysis: Customized Matlab programs were used to determine the first peak force (FZ1), the minimal force (FMIN), and the second peak force (FZ2) for each gait cycle, in a unit of body weight (BW). To assess the rate of loading after heel strike and the rate of unloading before toe off, loading rate and unloading rate were calculated in these two regions, respectively, in a unit of BW/sec (Fig. 1).

Impulse variables J1 to J4 were calculated in Fig. 1. Total FZ impulse was the sum of J1 to J4. All the impulse variables had a unit of BW*sec.

Statistical analysis: A series of three-way (2 group x 2 speed x 2 ankle load) ANCOVA with repeated measures on the last two and with a covariate of speed were conducted on each dependent variable. Post hoc pair-wise comparisons with Bonferroni adjustments were conducted when appropriate. Statistical significance was set at p<0.05.
RESULTS AND DISCUSSION

There was a group by speed interaction on $F_{Z2}$ (Fig. 2). The DS group decreased $F_{Z2}$ from the SS to the FS condition while the TD group increased $F_{Z2}$ accordingly. There was also a group by ankle load interaction on $F_{Z2}$ (Fig. 2). The DS group increased $F_{Z2}$ from the NL to the AL condition to a lesser extent than the TD group.

![Fig. 2](image)

There was a group by speed interaction on the unloading rate (Fig. 3). The DS group increased the unloading rate from the SS to the FS condition to a lesser extent than the TD group.

![Fig. 3](image)

There was a group by ankle load interaction on J3 (Fig. 4) and total $F_{Z}$ impulse (Fig. 5). The DS group increased both J3 and total $F_{Z}$ impulse from the NL to the AL condition to a lesser extent than the TD group.

![Fig. 4](image)

F$_{Z2}$ was lower than body weight in the DS group but higher than body weight in the TD group (Fig. 2). The DS group may use hip flexors and extensors rather than ankle plantar flexors to accommodate the inadequate F$_{Z2}$ during push off. When adapting to external ankle load, both groups increased the magnitude of F$_{Z2}$, suggesting that inclusion of external ankle load may be a promising approach to strengthening leg muscles and eliciting a more powerful push off in children with DS.

External ankle load may facilitate the DS group to increase vertical propulsive impulse and propel them upward during push off. However, the lower magnitude of impulses in the DS group suggests that even with external ankle load, the DS group still produced a less efficient push off.

CONCLUSIONS

External ankle load helps the DS group increase F$_{Z2}$ and vertical propulsive impulse and may facilitate push off and the initiation of leg swing during treadmill walking.

REFERENCES


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