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POSTURAL STRATEGIES FOR RUNNING GAIT TERMINATION: COMPARISON BETWEEN CHILDREN AND ADULTS

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INTRODUCTION

Children who do not acquire age-appropriate motor skills are more likely to avoid physical activity and adopt a sedentary lifestyle [1]. The ability to manipulate body momentum in response to environmental stimuli during running is important for successful participation in childhood games and sports. Differences in postural strategies for balance [2] and locomotion [3] across age groups suggest that the development of strategies used to control body momentum continues into late childhood and adolescence. However, current studies are limited to the assessment of walking tasks with slower velocity demands. The goal of this study was to compare postural strategies between children and adults using a running gait termination paradigm that induces a more dynamic challenge to postural control. Successful termination of forward momentum requires modulation of both position and velocity of the body's center of mass (COM) [4]. It is expected that adults will accomplish the task by employing a stereotypic extension strategy [5,6]. Compared to adults, children will modulate COM position and velocity differently, and will not employ features of an extension strategy.

METHODS

Subjects

Three adults (male) and three children (male) participated (Table 1).

Table 1: Subjects characteristics.

	n	Age (yrs)	Height (m)	Mass (kg)
Adults	3	24 ± 3.0	1.83 ± 0.11	81.84 ± 11.08
Children	3	8 ± 0.0	1.30 ± 0.14	35.99 ± 16.38

Instrumentation

Full-body 3D kinematics were collected at 250Hz using a 11-camera motion capture system (Qualisys, Inc. Sweden).

Procedures

Subjects were instructed to perform two running tasks as fast as possible: 1) a maximum effort run along a 21m unobstructed pathway (RUN) and 2) a maximum effort run and stop at a pre-determined location, 13 meters away from initial position (STOP).

Data Analysis

To account for performance differences between groups, peak velocity (Vmax) was calculated during the RUN trial and it was used to normalize the approach velocity during STOP trials. All variables were analyzed during the deceleration phase of STOP, defined as the time between 2 events: 1) the initial decrease in COM anterior velocity, defined as the time at which velocity decreased 1 standard deviation of the average of the previous 30 frames, and 2) the time at which the anterior displacement of the heel marker of terminating foot strike is zero. The variables used to quantify running gait characteristics were: number of steps, step length (normalized to leg length, LL), distance (normalized to LL) and time required to decelerate. The variables used to quantify postural strategies were: approach velocity, expressed as a percent of Vmax, and COM horizontal position in relation to the center of gravity of the stance foot (COGf) normalize to the vertical postion of the COM (COM-COGf). The kinematic variables used to describe postural differences included: sagittal plane hip, knee, and ankle angles as well as sagittal plane trunk angle (relative to global reference frame). COM-COGf and joint angles were calculated at the initial contact (IC) of each step during deceleration and averaged. Data from 3 successful trials were averaged (±SE) and effect size (ES) was used to indicate strength of the measurement of group differences.

RESULTS AND DISCUSSION

Children used relatively longer steps than adults over a longer distance and time during deceleration (Table 2).

Table 2: Running gait characteristics during deceleration. Values are Mean ± SE.

Variable	Adults	Children	ES
Distance/LL	2.68 ± 0.13	3.78 ± 0.22	2.04
Time (s)	0.77 ± 0.03	1.10 ± 0.11	1.37
Number of Steps	5.56 ± 0.18	5.33 ± 0.29	0.31
Step Length/LL	0.59 ± 0.03	0.88 ± 0.03	2.85

Compared to adults, children approached the STOP task at a relatively faster velocity and exhibited a less posterior COM position (Table 3).

Table 3: Approach velocity (App Vel) and COM position during deceleration. Values are Mean ± SE.

Variable	Adults	Children	ES
App Vel (%Vmax)	79.21 ± 1.81	88.63 ± 2.70	2.19
COM-COGf (%CMOz)	50.09 ± 1.42	44.70 ± 1.06	1.43

The difference in approach velocity suggests that adults plan the execution of the task differently, facilitating task completion over a shorter distance and period of time. This is consistent with literature [3] which indicates that children require additional time compared to adults to execute necessary adjustments to accomplish locomotor tasks.

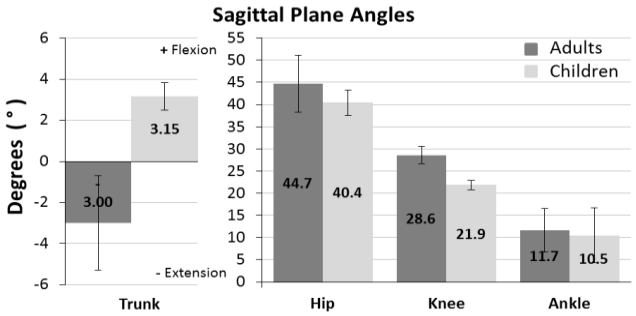

Figure 1: Trunk (relative to lab) and lower extremity sagittal plane angles. + = flexion and ankle plantarflexion.

Children appear to adopt a slightly more extended lower extremity posture with greater knee and hip extension (hip ES 0.29, knee ES 1.44, ankle ES 0.08) compared to adults (Figure 1). On average children exhibited trunk flexion during deceleration as opposed to trunk extension observed in adults (ES 1.22). The kinematic results indicate that children utilize a more extended lower extremity and more flexed trunk posture to modulate forward momentum during a run and stop task compared to adults.

Children are known to alternate between combined hip and knee extension or hip and knee flexion strategies to terminate walking gait [7]. Even though this flexed posture is thought to hinder the ability to control forward momentum in adults [5], children using this posture are able to successfully terminate gait [7]. Given the differences in anthropometrics between children and adults, requirements for modulation of forward momentum in children may be smaller, allowing for a less posterior position of the COM.

CONCLUSIONS

Our results suggest that a mature strategy used for the successful completion of running gait termination involves the modulation of both COM position and velocity with an extension strategy prominent at the trunk. Children modulate these variables differently than adults approaching the task at a faster relative velocity and a less posterior position using a postural strategy that includes trunk flexion and greater limb extension. Further research is needed to determine the underlying factors that contribute to successful strategies to terminate running gait in both children and adults.

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