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A COMPARATIVE STUDY ON GAIT INITIATION: CENTER OF PRESSURE BEHAVIOR IN INFANTS, CHILDREN AND ADULTS

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SUMMARY
Gait initiation is the transition from standing posture to cyclic walking. It is an important activity of daily life, requires a higher demand on the neuromuscular system and is a special challenge to be mastered by young children. Thus, the aim of this study is to describe comparatively the COP behavior during gait initiation in infants that have just begun to walk independently, children and adults. Twenty-nine subjects of both genders participated in this study and were subdivided into three groups: GI (15-16 months-old: 10 infants), GC (3 years-old: 9 children) and GA (20-25 years-old: 10 adults). The anterior-posterior (AP) and medial-lateral (ML) displacements and velocities of the center of pressure (COP) were measured with a force platform. The COP displacement was divided in three periods [1,2,3] as shown in Figure 1. Significantly smaller COP displacements in both directions (AP and ML) were found for infants when compared to the more experienced children and the adults, especially during the Period 1. Therefore, COP behavior during gait initiation is influenced by independent walking experience. Children seem to ensure balance control in the transition from standing to walking through minimizing AP and ML COP shifts during the anticipatory period.

INTRODUCTION
Gait initiation is the transition from standing posture to cyclic walking. This process requires anticipatory postural adjustments necessary to propel the body forward [1] which are controlled by a known motor program [2]. The initiation of gait is a special challenge to be mastered by young children, amputees and also by elderly subjects with neurological disorders.

Gait initiation is an important activity of daily life and may require a higher demand on the neuromuscular system than steady walking. This is the functional task used to analyze anticipatory postural adjustments prior to start a new walking cycle. This process imposes a challenge to the postural control system (balance), as the subject moves from the quasi-static balance to the steady-state gait, a continuous process of recovering stability [1].

Studies with the adult population have aimed to understand the limitations of postural and neurological disorders as well as aging in the gait initiation process [3,4], but little is known concerning how the acquisition of independent walking affects the transition from standing to walking [1,5].

Therefore, it is the aim of this study to describe comparatively the COP behavior during gait initiation in infants that have just begun to walk independently, children and adults. It is expected that this study may reveal the infant's ability to deal with gravity and dynamic balance during the transition from the quasi-static stance position to the first step.

METHODS
Twenty-nine subjects of both genders participated in this study. They exhibited age-related differences in the walking control. The subjects were subdivided into three groups: GI (15-16 months-old: 10 infants), GC (3 years-old: 9 children) and GA (20-25 years-old: 10 adults).

The anterior-posterior (AP) and medial-lateral (ML) displacements and velocities of the center of pressure (COP) were measured during the gait initiation with a force platform (Bertec Corporation – USA). The kinetic data of the force platform were sampled at 100 Hz. Data processing was performed with Matlab (The MathWorks Inc., USA). The nonparametric Kruskal Wallis test was used to detect differences between groups, the significance level was set at $p < 0.05$ and Statistica 8.0 (Statsoft) software was used.

The subjects performed five trials. They were told to stand on the force platform and to wait for a vocal command to start walking.

The COP displacement was divided in three periods [1,2,3] as shown in Figure 1:
Period 1 – Anticipatory: from the beginning of the movement until the most lateral position of the COP in the direction of the swing foot (COPAP_1 and COPML_1);
Period 2 – First step: from the end of the period 1 to the most medial COP positon in the direction of the support foot (COPAP_2 and COPML_2)

Period 3 – Second step: from the end of period 2 to the end of the movement, when the COP moves forward (COPAP_3 and COPML_3).

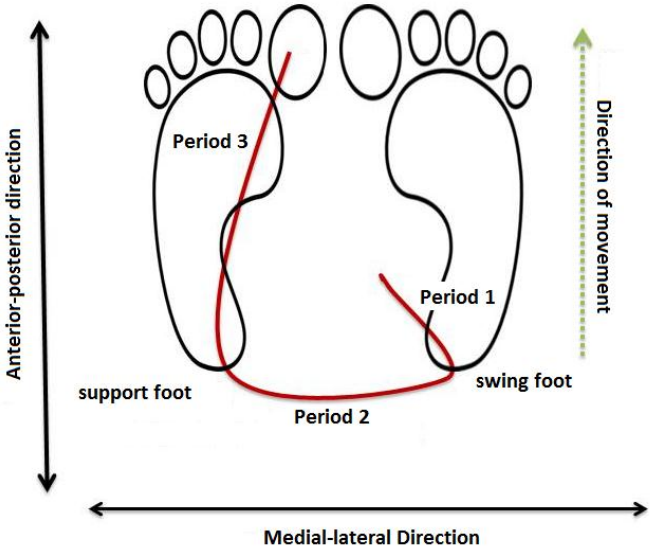

Figure 1: COP displacement during gait initiation. Period 1 – Anticipatory; Period 2 – First step; Period 3 – Second step.

RESULTS AND DISCUSSION

Table 1 presents COP displacements in the anterior-posterior (AP) and medial-lateral (ML) directions during the three periods of gait initiation.

Period 1 - Anticipatory

Significantly smaller COP displacements in both directions (COPAP_1 and COPML_1) were found for GI when compared to the more experienced children (GC) and the adults (GA). It is implied that anticipatory postural adjustments to walking in the GI group is not yet completed, and independent walking may act as functional training to develop this ability.

There were progressive increases in COPAP_1 and COPML_1 among the studied groups. It is possible that lateral and posterior displacements of the COP develop with age and enhance the ability to safely shift the center of mass (COM) forward. Infants may be more engaged in preserving balance of standing posture, instead of producing forward momentum [2,1].

Period 2 - First Step

A gradual increase with age was also found for COPAP_2 and COPML_2 displacements. A higher shift in COPML_2 for adults appears to be linked to a wider base of support compared to children. However the VELML_2 was not statistically different among groups and it is suggested that adults control the COP movements in mediolateral direction better than children [1].

Period 3 - Second Step

COPAP_3 displacement for GA was significantly higher than GI and GC. This result is consistent with the fact that adults have longer lower limbs and can transfer their COP forward for a longer path.

CONCLUSIONS

COP behavior during gait initiation is influenced by independent walking experience. Children seem to ensure balance control in the transition from standing to walking through minimizing COPAP and COPML shifts during the anticipatory period.

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Table 1: COP anterior-posterior and medial-lateral displacements during the anticipation periods of gait initiation.

COP Variables	Group GI (infants)	Group GC (children)	Group GA (adults)	P_ value
Period 1 – Anticipatory				
COPAP_1(cm)	2.98 (±1.99)	4.77 (±2.31)	5.11 (±4.23)	0.04*
COPML_1(cm)	4.23 (±2.66)	6.34 (±2.38)	9.64 (±5.71)	0.03*
VELAP_1(cm/s)	8.16 (±1.92)	6.23 (±1.47)	5.44 (±1.92)	0.04*
VELML_1(cm/s)	5.58(±3.55)	7.53 (±1.68)	8.03 (±2.59)	0.04*
Period 2				
COPAP_2(cm)	5.69(±2.09)	6.54 (±2.39)	8.35 (±3.25)	0.04*
COPML_2(cm)	6.82 (±3.73)	8.02 (±1.69	9.39(±4.73)	0.03*
VELAP_2(cm/s)	7.95 (±3.67)	5.28 (±2.81)	8.16 (±3.63)	0.03*
VELML_2(cm/s)	6.55 (±3.19)	6.63 (±2.37)	5.92 (±2.04)	0.07
Period 3				
COPAP_3(cm)	6.36 (±1.43)	6.44 (±2.25)	9.08 (±2.13)	0.04*
COPML_3(cm)	7.61 (±2.36)	7.57 (±1.62)	8.61(±2.98)	0.06
VELAP_3(cm/s)	7.60 (±2.78)	8.17 (±2.41)	9.92 (±5.84)	0.06
VELML_3(cm/s)	7.09 (±3.34)	7.27 (±2.22)	8.23 (±3.79)	0.07

Data are expressed as mean ± standard deviation. AP: anterior-posterior, ML: medial-lateral. * significant post Dunn's test ($p < 0.05$).