Gait & Posture 39 (2014) 659–661

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short Communication

The effects of clothes on independent walking in toddlers

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ARTICLE INFO

Article history:
Received 8 October 2012
Received in revised form 24 May 2013
Accepted 26 August 2013

Keywords:
Toddlers
Walk
Locomotion
Diaper
Trousers

ABSTRACT

The spatiotemporal features of walking in toddlers are known to be related to the level of maturation of the central nervous system. However, previous studies did not assess whether there could be an effect of clothes on the acquisition of walking. In this study, it was hypothesized that clothes modify the toddlers' walking. To test this hypothesis, 22 healthy toddlers divided into 3 groups of walking experience were assessed in four clothing conditions (Diaper + Trousers; Diaper + Pants of tracksuit; Diaper; Underwear). Results revealed significant effects of clothing on velocity and step length of toddlers from 6 to 18 months of walking experience. These results suggested that biomechanical constraints induced by the textile features alter the walking of toddlers. Therefore, in studies of toddler's gait, the clothing worn should be carefully mentioned and controlled.

1. Introduction

The studies analyzing the spatiotemporal features of walking showed that walking velocity, step length and cadence as well as step width increased with the walking experience (WE) of toddlers [1,2]. These walking parameters have therefore been used to assess the level of maturation of the central nervous system [3]. In such studies, toddlers wore either a diaper and/or specific clothes [4,5] but this variable had not been discussed. The scarce studies of toddlers walking and clothing only assessed the impact of a Lycra®'s garment [6] and footwear [5]. The aim of the present study was to assess for the first time the effect of clothing on walking features of toddlers.

2. Materials and methods

2.1. Subjects

22 toddlers (19 ± 5 months) participated in this experiment. Independent walking was acquired for all toddlers at 13 ± 2 months and was considered to start when toddlers were able to perform two independent steps without falling [8–10]. Toddlers were divided in 3 groups with regard to their WE: 0–3 months (G1), 3–6 months (G2) and 6–18 months (G3) of WE. Written informed consent was obtained from all parents before the experiment in accordance to the Declaration of Helsinki.

2.2. Experimental set-up

Toddlers were encouraged to walk over a 5.18 m long electronic pathway (Gaitrite®) at a self-paced speed. Four randomized conditions were performed: Diaper + Trousers, Diaper + Pants of tracksuit, Diaper and Underwear. Five walking trials were measured per condition for a total of 20 trials per toddler. Anthropometric data of each toddler group are presented in Table 1.

2.3. Data analysis

For each walking trial, velocity, step length, cadence and step width [1,2] were recorded. Step-time parameters were normalized according to Hof [11].

2.4. Statistical analysis

To investigate the effect of the clothing conditions on walking, a 3 group (G1 vs. G2 vs. G3) $\times$ 4 clothing (Diaper + Trousers vs. Diaper + Pants of tracksuit vs. Diaper vs. Underwear) analysis of variance (ANOVA) with repeated measures on the last factor was applied to the four dependent variables. Tukey post hoc tests were used whenever necessary. The level of significance was set to $p < 0.05$.

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http://dx.doi.org/10.1016/j.gaitpost.2013.08.031

Table 1
Features of the three groups of toddlers.

	G1 0–3 month of WE	G2 3–6 month of WE	G3 6–18 month of WE
Number of subjects	8	7	7
Age (month)	15.3 ± 2.3	17.6 ± 10.1	25.8 ± 3.3
Height (cm)	74.7 ± 3.6	80.3 ± 0.9	87.5 ± 3.2
Weight (kg)	9 ± 1	10.9 ± 1	11.9 ± 0.8
Leg length (cm)	32.5 ± 2	35.1 ± 1.6	37.2 ± 2.3
Walking Experience (month)	1.5 ± 1	4.6 ± 1.3	12.6 ± 4.1
Age of independent walk onset (month)	13.8 ± 2.6	13 ± 2.4	13.2 ± 1.7

G, group; WE, walking experience.

3. Results

3.1. Walking velocity

As illustrated in Fig. 1A, analysis of walking velocity showed significant main effects of group ($p = 0.011$) and clothing ($p < 0.001$). The interaction of group × clothing was also significant ($p = 0.018$). The decomposition of the interaction into its simple main effects showed significant differences between Trousers and Diaper ($p = 0.001$), and Trousers and Underwear ($p < 0.001$) after 6 months of WE, only.

3.2. Step length

As illustrated in Fig. 1B, analysis of step length showed significant main effects of group ($p = 0.039$) and clothing ($p < 0.001$). The interaction of group × clothing was also significant ($p = 0.038$). The decomposition of the interaction into its simple main effects showed a step length decrease between Trousers and Diaper ($p = 0.012$), Trousers and Underwear ($p < 0.001$), and Pants of tracksuit and Underwear ($p < 0.001$) after 6 months of WE, only.

3.3. Cadence

As illustrated in Fig. 1C, analysis of cadence showed a tendency toward a group effect ($p = 0.055$) and a main effect of clothing ($p < 0.001$). The interaction of group × clothing was not significant ($p = 0.220$).

3.4. Step width

As illustrated in Fig. 1D, analysis of step width showed no significant main effect of group ($p = 0.121$) but a main effect of clothing ($p = 0.011$). The interaction of group × clothing was not significant ($p = 0.720$).

4. Discussion

The results showed that walking velocity and step length increased whereas the step width decreased along with the increase of walking experience. These results are in accordance with the literature showing that development of walking improves quickly between the third and the sixth month of walking experience with an important growth around 6 months [12,13].

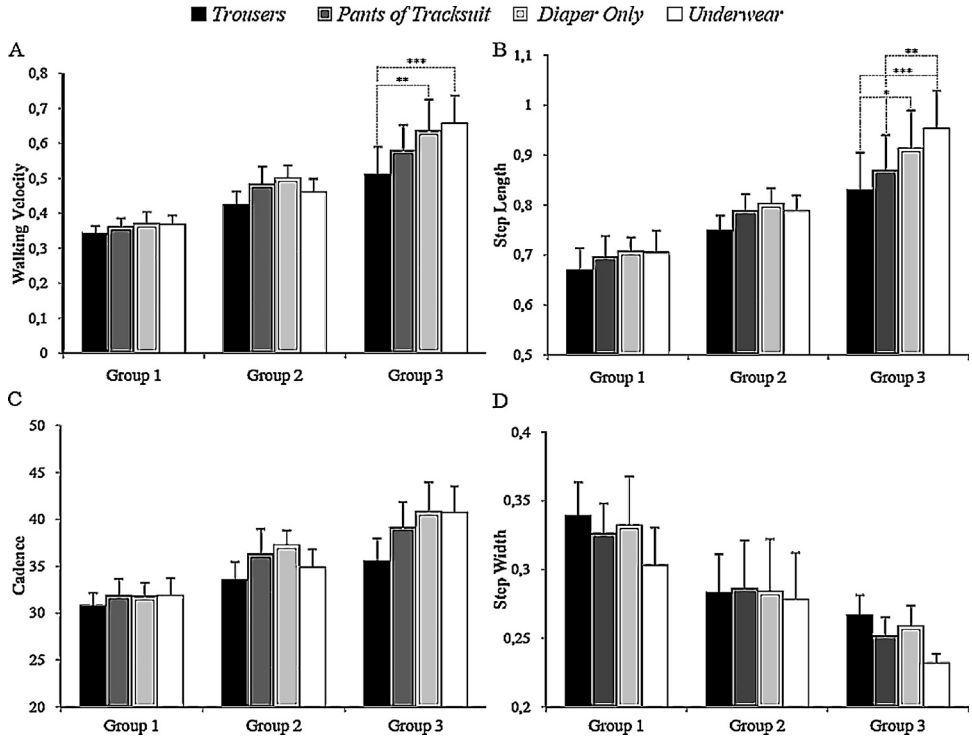

Fig. 1. Charts A, B, C and D show the mean and the standard error of the mean of normalized walking velocity, step length, cadence and step width, respectively; For the 3 groups of toddlers based on walking experience (Group 1: 0–3 months of WE; Group 2: 3–6 months of WE; Group 3: 6–18 months of WE). $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

These authors suggested that walking of toddlers changed from a tendency to fall forwards to a better controlled gait. Finally, during the first year of life, the infant passes gradually from a digitigrade walking to a plantigrade walking [14]. The present results corroborated this literature by showing that the period from 3 to 6 months of walking experience is an important period in the development of children's walking.

Especially, the results showed that Trousers induced a decrease of walking velocity and step length as compared to the Diaper and Underwear conditions. Whereas the Trousers condition, Pants of tracksuit only reduced the step length and only as compared to the underwear condition. Therefore, the impact on walking was differently affected by Trousers which are characterized by stiff plain weaves (not stretchable textile) and the Pants of tracksuit fleece (more stretchable). This result suggested that the type of pants (armor, material, cut) influenced the walking in toddlers. The step length decrease observed in Trousers suggested greater biomechanical constraints that could be related to a decrease of hip and/or knee range of motion. These differences were only observed after 6 months of walking experience which suggested that the more mature the walking was, the more the toddlers' walking was sensitive to the clothing condition. These results were consistent with previous studies that evidenced an increase of flexion and lateral rotation of the hip and knee flexion during the first year of independent walking [3,15]. Indeed, trousers may prevent knee and/or hip joints from moving freely through their full range. These possible joint-related alterations may explain the decrease in step length observed in the present study.

The main effect of clothing observed for the step width variable was likely due to a decrease in the underwear condition as compared to the other clothing conditions (Fig. 1D). This result could be explained by a decreased constraint on hip joints in the absence of diaper related to the thickness of the diaper. However, the diaper had no impact on the walking velocity and step length.

5. Conclusion

Clothing influences the walking features of toddlers especially (1) when they have more than 6 months of walking experience, and (2) for velocity and step length. The decrease observed in these two parameters suggested that stiffness and cut of clothes impact walking in toddlers. Specifically, as compared to a control condition (underwear), walking was more degraded in toddlers wearing trousers with stiff plain than pants of tracksuit.

Acknowledgements

We owe many thanks to the children, their parents and the Ludogym club who participated in this research

Conflicts of interest statement

The authors have nothing to disclose.

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