Physical Medicine and Rehabilitation - International

Open Access

Austin Publishing Group

Research Article

Clinical Efficacy of Shoes and Custom-modeled Insoles in Treating Down Syndrome Children with Flatfoot

Keiji Hashimoto*, Sayaka Aoki, Kohei Miyamura, Anri Kamide and Manami Honda
Division of Rehabilitation Medicine and Developmental Evaluation Center, National Center for Child Health and Development, Tokyo, Japan

***Corresponding author:** Keiji Hashimoto, Division of Rehabilitation Medicine and Developmental Evaluation Center, National Center for Child Health and Development Okura Setagaya-ku Tokyo, Japan

Received: September 14, 2015; **Accepted:** October 07, 2015; **Published:** October 10, 2015

Abstract

Objective: In this study, we performed a prospective study to determine whether wearing shoes and custom-modeled insoles can influence the walking pattern of Down syndrome (DS) children with flatfoot.

Methods: Participants consisted of 41 DS children with flatfeet that were prescribed orthotic insoles. A 2.4 m sheet-type gait analyzer was used to analyze gait patterns. We measured the following variables: walking velocity (cm/min), cadence (steps/min), step length (cm), and single-limb stance (SLS) phase ratio (%) in three conditions. In the first condition, the participants walked barefoot, in the second, they wore shoes without insoles, and in the third condition, and they wore shoes with custom-modeled insoles.

Results: When compared with the barefoot condition, significant increases in walking speed, step length, and SLS phase ratiowere observed in the group wearing shoes with custom-modeled insoles (repeated measure ANOVA; p=0.010, 0.000, 0.000).

Conclusion: Our results indicate the clinical efficacy of shoes and custom-modeled insoles in increasing walking velocity, step length and SLS phase ratio of DS children, which are determinants of gait maturity.

Keywords: Down syndrome; Flatfoot; Gait analysis; Custom-modeled insoles

Introduction

Down syndrome (DS) results from a common chromosome abnormality in live births (1 in 800–1000) [1] and shows a variety of dysmorphic features, congenital malformations, and other health problems and medical conditions. Frequently, children with DS suffer from musculoskeletal problems, including hypotonia, ligament laxity, atlantoaxial instability, hip and patella dislocation, foot deformities, and the delayed achievement of motor milestones [2-4]. Specifically, flatfoot is a prevalent musculoskeletal problem observed among DS children, with an estimated prevalence range of 19.9% to 83% [2,5]. At the National Center for Child Health and Development, Tokyo, we routinely monitor the gait pattern in DS children and in other children with gait impairment using the sheet-type limb gait analyzer. Sutherland et al., investigated determinants of gait maturity in typical children, and described 5 aspects of gait changes over time: increases in walking velocity, step length, duration of single-limb stance (SLS), and the ratio of pelvic span to ankle speed, and a decrease in cadence [6]. Young D Schildren show delayed acquisition of the ability to control their legs smoothly, possibly due to hypotonus [7], thus, unique patterns of development for each gait parameter are expected. Several therapies have been developed to address these developmental issues, including the use of customized orthoses [8]. However, the clinical efficacy of customized insoles as therapy for gait abnormalities in DS children has not been examined. Here, we performed a prospective analysis of the gait of young DS children who are prescribed insoles for flat feet, to identify the clinical efficacy of shoes and custom-modeled insoles as therapy for gait abnormalities in DS children.

Methods

Participants

Forty-one DS pediatric patients (20 boys; age range, 1–13 years; mean age, 4.2 ± 2.5 years) diagnosed with flatfeet and prescribed with orthotic insoles at our institution, the National Center for Child Health and Development, between July 2010 and October 2013 were included in the study. All the participants had achieved independent walking before proceeding to our gait evaluation. Experienced physiatrists made the diagnosis of flatfeet. The criteria for insoles prescription were as follows; (i) existence of flatfeet, (ii) their walking pattern are stabilized by wearing insoles, (iii) their family want to use custom-modeled insoles to improve walking pattern of the patients. Prior to participation in the study, the subjects' parents provided informed consent. This study was approved by the research ethics committee of the National Center for Child Health and Development.

Equipment, procedures, and measures

Gait pattern was analyzed using a 2.4 m sheet-type gait analyzer, Walk Way MW-1000™ (Anima, Tokyo, Japan). The equipment allows the users to analyze the gait pattern of an individual walking on the long thin sensor sheet through real-time monitoring of the individual's foot contact and foot pressure distribution. Data includes diverse variables relevant to gait pattern. For this study, the following variables were calculated from collected data: (i) walking velocity

Citation: Hashimoto K, Aoki S, Miyamura K, Kamide A and Honda M. Clinical Efficacy of Shoes and Custom-modeled Insoles in Treating Down Syndrome Children with Flatfoot. Phys Med Rehabil Int. 2015; 2(8): 1061.

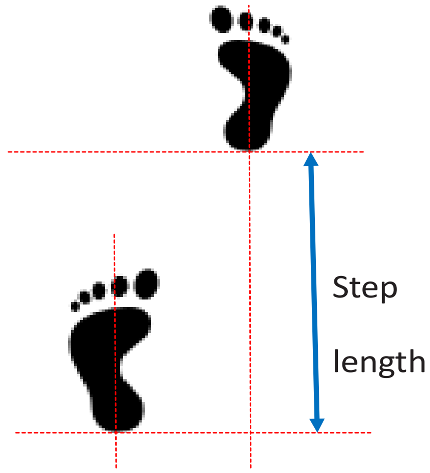

Figure 1: Step length.

(cm/min); (ii) cadence (steps/min); (iii) step length (cm; Figure 1); and (iv) SLS phase ratio (%, ratio of the time during which only one foot was in contact with the ground to that of the whole stride. Data for the first three variables was produced directly by the gait analyzer. For the last variable, the SLS phase ratio was calculated using three variables measured by the gait analyzer: duration of stance phase (length of time for which a foot is in contact with the ground); duration of double-limb stance (DLS) phase (length of time for which both feet are in contact with the ground); and duration of swing phase (length of time for which a foot is not in contact with the ground), using the following formula:

$$Duration\ of\ SLS\ phase\ ratio = \frac{the\ duration\ of\ (stance\ phase - DLS\ phase)}{the\ duration\ of\ (stance\ phase + swing\ phase)}$$

The duration of SLS phase was calculated for each foot separately, and then the results were averaged. Participants were asked to walk barefoot straight over the sensor sheet at their self-selected pace, from one end of the sheet to the other. The number of trials depended on each participant (range, 1–13 trials; median, 3 trials) because the study was conducted in the middle of clinical service and the physiatrist often needed to observe the gait again from several different perspectives for diagnostic/treatment purposes. For all the measured variables, the average of the trials was used for analysis. To evaluate clinical efficacy of shoes and custom-modeled insoles in treating DS children with flatfoot, we measured the following variables: walking velocity (cm/min), cadence (steps/min), step length (cm), and SLS phase ratio (%) in three conditions: the first condition was barefoot, the second condition wore shoes without insoles, and the third condition wore shoes with custom-modeled insoles.

Statistical analysis

The data were analyzed using IBM® Statistics 22.0 (IBM Japan, Tokyo, Japan). To determine whether using shoes and custom-modeled insoles can influence the walking pattern of DS children with flatfoot in each of the four gait parameters (walking velocity, cadence, step length, and SLS ratio), repeated measure ANOVA was conducted.

Results

When compared with the barefoot condition, a significant increase in walking speed, step length, and SLS phase ratio was observed in the condition using shoes with custom-modeled insoles (repeated measure ANOVA; p=0.010, 0.000, 0.000). In addition, a significant increase in the SLS phase ratio was observed in the condition wearing shoes without custom-modeled insoles compared with the barefoot condition (repeated measure ANOVA; p=0.003). However, there was no significant difference between the barefoot condition and the condition wearing shoes with custom-modeled insoles in cadence (repeated measure ANOVA; p=0.304; Table 1).

Discussion

Previously, we demonstrated that children with DShave unique gait development patterns. Although walking velocity, cadence, and step length were found to develop with age, as in typical children, the SLS phase ratio did not change with age in DS children [9]. As children grow, their increase in height has a large influence on several gate parameters. Previous studies indicated that a significant portion of variation in walking velocity and step length might be explained by individual variation in height [10,11]. Since temporal parameters are also considered to be affected by leg length and body mass [12], the change in height may also explain, at least in part, the decrease in cadence for both DS children and typical children. In contrast, the duration of the SLS phase is related to age only in typical children, and this observation may be explained by characteristics of DS children that are not observed in typical children.

In this study, a significant increase in walking speed, step length, and SLS phase ratio was observed in the condition wearing shoes with custom-modeled insoles over that observed in the barefoot condition. These results suggest the clinical efficacy of shoes and custom-modeled insoles in increasing the walking velocity, step length, and SLS phase ratio of DS children, which are determinants of gait maturity.

Wegener C et al [8] reviewed the effect of children's shoes on gait, and concluded that shoes affect the gait of children. With shoes, children walk faster by taking longer steps with greater ankle and knee motion and increased tibia is anterior activity. Shoes reduced

Table 1: Mean values ± SD of four gait parameters in the three groups.

	Barefoot	Shoes without insoles	Shoes with insoles	Comparison between barefoot and shoes without insoles	Comparison between shoes without insoles and shoes with insoles	Comparison between barefoot and shoes with insoles
Walking velocity (cm/sec)	67.0±22.1	70.4±22.3	74.7±22.2	p = 0.217	P = 0.092	P = 0.010*
Cadence (steps/min)	147.2±28.4	139.9±25.6	143.0±21.5	P = 0.062	P = 0.390	P = 0.304
Step length (cm)	27.5±8.5	30.2±10.5	31.9±10.3	P = 0.068	P = 0.153	P = 0.000**
Single-limb stance phase ratio (%)	0.52±0.05	0.60±0.14	0.60±0.12	P = 0.003**	P = 0.792	P = 0.000**

**Repeated measure ANOVA; p<0.01, *Repeated measure ANOVA; p<0.05

foot motion and increase the support phases of gait cycle. About orabi A et al [13] reported that regular shoes with functional foot orthoses caused a significant decrease of displacement of center of pressure (CoP) in flatfoot children. These results indicated a significant improvement in the symmetry of steps and walking speed with functional foot orthoses over medical shoes in children with flat feet. In the present study, no significant increase in walking speed and step length was observed by using shoes. Our findings suggest that walking speed, step length, and the SLS phase ratio are increased in DS children by wearing shoes and custom-modeled insoles.

There are several limitations in this study, which led us to propose possible directions of future studies. First, the sheet-type gait analyzer is not a three dimensional motion analysis system, so that we can't analyze motion elaborately. Second, we did not consider about the height and length of the foot, or the dominant hand in this study. Third, there are no disaggregated results according to sex/age/severity of flatfoot. Finally, participants used various types of shoes such as high-cut or middle-cut. To resolve these limitations, it is also necessary to conduct further studies with a larger sample size.

References

1. Presson AP, Partyka G, Jensen KM, Devine OJ, Rasmussen SA, McCabe LL, et al. Current estimate of Down Syndrome population prevalence in the United States. *J Pediatr*. 2013; 163: 1163-1168.
2. Diamond L. Orthopedic disorders in Down syndrome. In: Lott IT, McCoy EE, editors. Down syndrome: Advances in medical care. New York: Wiley-Liss. 1992: 111-126.
3. Tawada S. Motor Development of Down syndrome (in Japanese). *Journal of clinical rehabilitation.* 2011; 20: 529-534.
4. Merrick J, Ezra E, Josef B, Hendel D, Steinberg DM, Wientroub S. Musculoskeletal problems in Down Syndrome European Paediatric Orthopaedic Society Survey: the Israeli sample. *J. Pediatr. Orthop. B*. 2000; 9: 185-192.
5. Yamamoto T, Saito M, Nagao S, Taira K, Ishigami H. Treatment for Flexible Flatfoot in Down's Syndrome (in Japanese). *Journal of Japanese Paediatric Orthopaedic Association*. 2006; 15: 252-255.
6. Sutherland DH, Olshen R, Cooper L, Woo SL. The development of mature gait. J Bone Joint Surg Am. 1980; 62: 336-353.
7. Kanbayashi H, Ikeda Y. The development of walking movement in Down Syndrome children. *Bull Spec Educ*. 1988; 13: 9-16.
8. Weber A, Martin K. Efficacy of orthoses for children with hypotonia: a systematic review. *Pediatr Phys Ther*. 2014; 26: 38-47.
9. Naito M, Aoki S, Kamide A, Miyamura K, Honda M. Gait analysis in Down syndrome pediatric patients using a sheet-type gait analyzer: Pilot study. *Pediatr Int*. 2015; .
10. Beck RJ, Andriacchi TP, Kuo KN, Fermier RW, Galante JO. Changes in the gait patterns of growing children. *J Bone Joint Surg Am*. 1981; 63: 1452-1457.
11. Hausdorff JM, Zemany L, Peng C, Goldberger AL. Maturation of gait dynamics: stride-to-stride variability and its temporal organization in children. *J Appl Physiol* (1985). 1999; 86: 1040-1047.
12. Hof AL. Scaling gait data to body size. *Gait and Posture*. 1996; 4: 222-223.
13. Aboutorabi A, Saeedi H, Kamali M, Farahmand B, Eshraghi A, Dolagh RS. Immediate effect of orthopedic shoe and functional foot orthosis on center of pressure displacement and gait parameters in juvenile flexible flat foot. *Prosthet Orthot Int*. 2014; 38: 218-223.

Phys Med Rehabil Int - Volume 2 Issue 8 - 2015
ISSN : 2471-0377 | www.austinpublishinggroup.com

Citation: Hashimoto K, Aoki S, Miyamura K, Kamide A and Honda M. Clinical Efficacy of Shoes and Custom-modeled Insoles in Treating Down Syndrome Children with Flatfoot. Phys Med Rehabil Int. 2015; 2(8): 1061.