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A normative sample of temporal and spatial gait parameters in children using the GAITRite® electronic walkway

Stacey C. Dusing [a], Deborah E. Thorpe [b,*]

[a] *Department of Physical Therapy, Virginia Commonwealth University, Medical College of Virginia, Richmond, VA, United States*

[b] *Center for Human Movement Science, Division of Physical Therapy, University of North Carolina at Chapel Hill, Campus Box #7135, Medical School Wing E, Chapel Hill, NC 27599-7135, United States*

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Abstract

Purpose: The purpose of this study was to develop a normative sample of temporal and spatial gait parameters for children (ages 1–10 years) using the GAITRite® electronic walkway. Reliability of the GAITRite® for assessing gait in children is similar to its reliability in adults. Normative temporal and spatial gait parameters have not been published using the GAITRite® limiting clinicians and researchers ability to compare children to a large normative sample.

Methods: A total of 438 children (1–10 years) completed two walks of at least three steps each at a self-selected speed. The mean velocity, cadence, step length, stride length, heel to heel base of support, double support, and toe in/out angle for each age group was calculated.

Results: Mean self selected velocity ranged from 82.05 ± 25.28 to 133.63 ± 15.44 cm/s with the largest variability in subjects under 7 years of age. Cadence decreased with increasing age. Step length and stride length increased with age. Heel to heel base of support remained relatively constant between age groups with a mean of 8.77 ± 2.74 cm. Toe in/out angle was extremely variable for all age groups.

Conclusions: Developmental patterns of temporal and spatial gait parameters assessed using the GAITRite® are similar to those reported in previous studies. However, the mean values for each age group differ slightly from previous gait study results. The normative data presented in this study will be useful to clinicians and researchers using the GAITRite® electronic walkway to evaluate clinical populations. Data derived from other gait assessment tools and methods may not be a valid comparison to the values calculated using the GAITRite®.

Keywords: Gait; GAITRite®; Pediatric; Ambulation; Normative

1. Introduction and purpose

To assess variations in gait parameters in a clinical population, a reliable and norm-referenced data collection system is required. Normative data exists on the changes in gait parameters secondary to maturation. However, many of the tools used in previous studies are not feasible in a clinical setting [1–3] or lack documented reliability [4]. Clinical observation is limited in its ability to document some aspects of gait [2]. Specialized systems used to assess gait kinematics and kinetics can be costly and require a great deal of practice to use reliably. Footprint studies, which include the manual measurement of spatial and temporal gait parameters are time consuming and less reliable [4]. Several electronic walkway systems have been developed to improve the clinical feasibility of assessing spatial and temporal gait parameters [5–7].

The GAITRite®[1] system is an electronic walkway that automates the collection of spatial and temporal parameters of gait [6]. The standard GAITRite® electronic walkway contains six sensor pads encapsulated in a roll-up carpet, to produce an active area 61 cm wide and 366 cm long. In this arrangement the active area is a grid with dimensions of 48 sensors by 288 sensors, placed on 1.27 cm centers. The 3.66 or 4.88 m walkway is portable, can be laid over any flat surface, requires minimum setup and collection time, and

* Corresponding author.
E-mail address: dthorpe@med.unc.edu (D.E. Thorpe).

[1] IR Systems, MAP/CIR Inc., 1625 East Darby Road, Havertown, PA 19083, 610-449-4879, United States.

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does not require the placement of any devices on the patient. As the patient ambulates across the walkway, the system captures the relative arrangement, the geometry and the applied pressure, of each footfall as a function of time. The application software controls the functionality of the walkway, processes the raw data into footfall patterns, and computes the temporal and spatial parameters. The software stores each walk by patient and supports a variety of reports and analyses. The system can be utilized to test patients with or without shoes and assistive devices.

The validity of the GAITRite® system has been supported by studies in adults comparing clinical gait assessment techniques including footprint studies [5,8] using shoe switches [9] and more technologically advanced techniques such as kinematic assessments [10]. Interclass correlation coefficient (ICC) reported for spatial parameters, including step length and stride length ranged from 0.97 to 0.99 with lower ICCs (0.61–0.67) for step time and stride [5]. Comparison of two-dimensional video analysis with the GAITRite® revealed high correlation (0.94–1.0) for step length, step period, stride velocity, stance duration, and swing duration [10]. However, with increasing speeds greater differences were noted for spatial gait parameters including step length and stride velocity. These differences may be related to differences in the method used to identify the initiation of a foot fall [10]. Inter-trial reliability for walking speed, cadence, and step length at preferred and fast speeds in adults ranged from good to excellent (ICCs 0.76–0.97) and was slightly lower at slower speeds [9,11].

Less work has been completed looking at the reliability and validity using the GAITRite® with children [12,13]. Inter-trial reliability using the GAITRite® for selected gait parameters on 57 children aged 1.3–10.9 years was determined in a recent study by Thorpe et al. [13] In that study, Intraclass correlation coefficients ICC (1,1) values and 95% (CI) were calculated as were the Bland-Altman limits of agreement and the coefficient of variation. ICC values ranged from 0.05 to 0.93. Results revealed that the amount of clinically relevant error (CV) was acceptable for all gait variables across age groups with the exception of the toe in/out variables (CV = 46.7–92.9%) and the heel to heel base of support variable (CV = 18.6–31.5%). Concurrent validity of the GAITRite® for select gait parameters in 4–10-year-old children was reported to range from 0.86 to 0.99 with high (0.94–1.00) inter-rater reliability for multiple tester processing of the data [12].

Currently, normative spatial and temporal gait parameters for children using the GAITRite® system have not been published. This data is imperative when comparing clinical populations to typically developing peers. While normative gait parameters have been established using methods other than the GAITRite®, previous research [9,10] suggests the definitions of spatial and temporal gait parameters may have an impact on agreement between systems, compromising the validity of data collected on the GAITRite® system. The purpose of this study was to develop a normative sample of spatial and temporal gait parameters for children using the GAITRite® system.

2. Methods

2.1. Subjects

A total of 438 children aged 1.19–10.98 years were recruited from local elementary schools, preschools, daycares and the community (Table 1). The children were age stratified with the range in each age group spanning 12 months (i.e. children aged 12–23 months were considered to be 1-year old). This study was approved by the Committee for the Protection of Human Subjects at the University of North Carolina at Chapel Hill and parents and/or children provided consent/assent. All children were able to walk at least 100 ft independently, had no evidence of a muscle, bone, joint, brain or nerve dysfunction, and no incidence of an injury to either lower extremity in the previous month (Table 1).

2.2. Data collection and reduction

The GAITRite® mat was positioned on the floor and connected to a laptop computer, with a 2 m acceleration/deceleration walkway at either end. Subjects were asked to walk at their typical speed to the designated end of the walkway, a total of 7.66 m of which 3.66 m were on the GAITRite® mat. "Stop" signs were positioned on the floor 2 m past each end of the walkway providing visual feedback

Table 1
Subject demographics by age group ($N = 438$)

Age groups (years)	N	Age (years) (X, S.D.)	Female (%)	Caucasian (%)	Height (cm) (X, S.D.)	Weight (kg) (X, S.D.)
1	22	1.58 ± 0.26	36.4	77.3	79.62 ± 4.51	11.35 ± 1.90
2	24	2.43 ± 0.28	29.2	83.3	88.62 ± 4.85	13.11 ± 1.92
3	21	3.41 ± 0.27	52.4	90.5	97.80 ± 5.21	14.77 ± 1.58
4	30	4.54 ± 0.26	43.3	100	105.52 ± 4.41	17.33 ± 3.19
5	60	5.50 ± 0.24	46.7	65.0	112.73 ± 5.39	20.72 ± 4.61
6	58	6.32 ± 0..29	39.7	70.7	117.94 ± 7.56	22.43 ± 5.20
7	60	7.45 ± 0.27	45.0	75.0	123.33 ± 6.18	26.35 ± 7.39
8	56	8.50 ± 0.25	46.4	69.6	132.28 ± 6.80	33.36 ± 9.83
9	54	9.48 ± 0.33	51.9	68.5	137.69 ± 7.80	37.58 ± 10.41
10	53	10.43 ± 0.32	47.2	75.5	141.90 ± 7.52	40.78 ± 10.37