Temporal-Spatial Gait Parameters and Their Variability in Children Ages One to Five Years

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Introduction

The purpose of this study is to characterize temporal-spatial parameters of gait of healthy children without disabilities ranging in age from one to five years. We hypothesized that the variability of temporal-spatial gait parameters, and the parameters themselves would be related to maturation, represented here by age in months.

Clinical Significance

Not only can temporal-spatial variables assist clinicians in early detection of gait pathology or immaturity, but the variability or consistency of these gait variables also can be used for this purpose. The high variability of gait patterns in this age group must be considered before classifying a child's gait as abnormal.

Methodology

Data were collected from 90 children in four age groups and included: eight females and six males (12 to 23 mos.), seven females and sixteen males (24 to 35 mos.), seventeen females and twelve males (36 to 47 mos.), and seventeen females and seven males (48 to 59 mos.). Children were recruited from local day care facilities and schools. Each subject met the following inclusion criteria: (1) walking by 15 months of age, (2) between 12 months and five years of age at time of testing and (3) free of any known or observable gait deviations, or gait impairing or altering diagnosis. The study, its consent form and procedure were approved by the IRB. GAITRite®, an electronic walkway of 460 cm x 90 cm x 0.6 cm (L x W x H) containing six sensor arrays, in a 4.6 meter mat was positioned in an area conducive to data collection in each facility. A validity test comparing ten steps from one 3-year-old subject and fifteen steps from another 1-year-old subject were compared to hand measured variables using a 100 x 100 centimeter squared machine etched Plexiglas® sheet and a Fowler vernier caliper to one millimeter to optimize accuracy by blind examiners. ICC(2,1) were .75, step length, .96 for stride length and .45 for base of support.

Demographic information, bilateral leg length, height, weight, and ASIS breadth were collected. Participants wore sneakers during data collection. At the start of each trial, subjects stood behind a designated starting line and were instructed to begin walking when signaled. Eight strides per subject were collected. Anthropometric measurements on the first 20 subjects tested were from two blind examiners were compared using (ICC 2, 1) and all proved have high reliability (.88-.99)

Results

Right and left step length and right and left stride length had high positive correlations ($r > 0.8$) with age in months. Right and left stride velocities had mod-good positive correlation with age ($r = 0.58$ and 56 respectively) (Table 1). Right and left step length and percent single support, and right stride velocity coefficients of variation (COV) also fell within the moderate to good correlation range but, were inversely related to age (.5-.58) (Table 2). Results of paired t-tests run on right and left values for step length, stride length, percent single support, and percent double support showed no significant asymmetry.

Table 1.
Means correlated with age in mo., n=90
↑= increase; ↓= decrease

Good to Excellent (0.75 - 1.00)		
Step Length (R)	↑	0.82
Step Length (L)	↑	0.80
Stride Length (R)	↑	0.82
Stride Length (L)	↑	0.82
Moderate to Good (0.50 - 0.75)		
Stride Velocity (R)	↑	0.58
Stride Velocity (L)	↑	0.56
Fair (0.25 - 0.50)		
Norm Step Length (R)	↑	0.32
Norm Step Length (L)	↑	0.30
Norm Stride Length (R)	↑	0.31
Norm Stride Length (L)	↑	0.30
Support Base (R)	↓	-0.42
Support Base (L)	↓	-0.42
Differential (SSrt-SSlt)	↓	-0.28

Table 2.
Variability correlated with age in months
↑= increase; ↓= decrease

Moderate to Good (0.50 - 0.75)		
COV Step Length (R)	↓	-0.56
COV Step Length (L)	↓	-0.58
COV % SS (R)	↓	-0.53
COV % SS (L)	↓	-0.54
COV Stride Velocity (R)	↓	-0.50
Fair (0.25 - 0.50)		
COV Stride Velocity (L)	↓	-0.46
COV Stride Length (R)	↓	-0.47
COV Stride Length (L)	↓	-0.44
COV % DS (R)	↓	-0.44
COV % DS (L)	↓	-0.49
COV Support Base (L)	↑	0.27

Discussion

The relationship between step length, stride length and age may reflect changes in stature, since the correlation was greatly diminished when data were normalized to leg length. However, a fair correlation (r = 0.30 – 0.32) was still present between these normalized variables and age indicating that factors other than stature seem to affect this relationship. Stride velocity demonstrated a steady increase with age. As reported by Sutherland, et al.[1], the rate at which walking velocity increased leveled off at about three and one half years of age. We found this same leveling off between 40 and 45 months of age. The lack of significant asymmetry for any age group, confirmed the findings of Sutherland et al.[1] and Preis et al.[2] and refuted findings of Wheelwright et al.[3]. Percent single support differential showed a fair negative correlation (0.28) to increasing age, which may warrant further study. Coefficients of variation decreased as age increased for each parameter examined, with the exception of right and left support base (least reliable). When variability was correlated with age, five of the eight parameters examined showed a notable negative relationship. Sutherland et al.[1] also reported a decrease in variability with age. Decreasing variability may be a good representation of a young child's increasing skill level.

References

1. Sutherland DH, et al. *J Bone Joint Surg [Am]*. 1980;62:336-53.
2. Preis S, et al. *Dev Med Child Neurol*. 1997;39:228-33.
3. Wheelwright EF, et al. *Dev Med Child Neurol*. 1993;35:114-25.