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Clinical Observations

Gait Characteristics in Adolescents With Multiple Sclerosis

Alon Kalron PhD [a,*], **Lior Frid MA** [b], **Shay Menascu MD** [b,c]

[a] *Sackler Faculty of Medicine, Department of Physical Therapy, Tel-Aviv University, Tel-Aviv, Israel*
[b] *Multiple Sclerosis Center, Sheba Medical Center, Tel Hashomer, Israel*
[c] *Sackler Faculty of Medicine, Tel-Aviv University, Tel-Aviv, Israel*

ABSTRACT

BACKGROUND: Multiple sclerosis is a progressive autoimmune disease of the central nervous system. A presentation of multiple sclerosis before age18 years has traditionally been thought to be rare. However, during the past decade, more cases have been reported. **PATIENT DESCRIPTION:** We examined gait characteristics in 24 adolescents with multiple sclerosis (12 girls, 12 boys). Mean disease duration was 20.4 (S.D. = 24.9) months and mean age was 15.5 (S.D. = 1.1) years. The mean expanded disability status scale score was 1.7 (S.D. = 0.7) indicating minimal disability. Outcomes were compared with gait and the gait variability index value of healthy age-matched adolescents. **RESULTS:** Adolescents with multiple sclerosis walked slower with a wider base of support compared with age-matched healthy control subjects. Moreover, the gait variability index was lower in the multiple sclerosis group compared with the values in the healthy adolescents: 85.4 (S.D. = 8.1) versus 96.5 (S.D. = 7.4). **CONCLUSIONS:** We present gait parameters of adolescents with multiple sclerosis. From a clinical standpoint, our data could improve management of walking dysfunction in this relatively young population.

Keywords: multiple sclerosis, gait, adolescents, juvenile

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Introduction

Multiple sclerosis (MS), a progressive autoimmune disease of the central nervous system, causes the destruction of myelin, oligodendrocytes, and axons. It is the most common cause of neurological disability among young adults, usually appearing between 20 and 40 years of age, peaking at 25 years.[1]

A presentation of MS before age 18 years has traditionally been thought to be rare. However, during the past decade, more cases have been reported, possibly as a result of advances in diagnostic techniques and increased awareness among pediatricians.[2] In a retrospective study which included 1129 people with MS, juvenile-onset MS was identified in 6.5% cases (n = 74) and 0.89% (n = 10) with childhood-onset MS.[3] In most individuals with childhood and juvenile-onset MS, persistent physical disability develops after a longer disease interval relative to adults with MS, occurring when patients are only in their third or fourth decade of life.[4]

No study examining gait in teenagers with MS was found in the PubMed database. Data on gait performance in adolescents with MS would be beneficial. First, addressing walking problems early in the disease process might be more effective compared with treatment in the later stages of the disease. Second, quantitative gait scores might aid in neurological follow-up examinations as improved indicators of walking deterioration.

Worth noting, adolescents with MS early in the disease course have minimal motor disability making it difficult to detect gait alterations on clinical walking tests. However, instrumented gait devices possess specific advantages in detecting slight gait changes invisible to the naked eye. Furthermore, gait alterations revealed by these tools direct the medical professional to specific abnormal walking components. Accordingly, explicit recommendations in terms of physical therapy intervention programs can be offered to the adolescent and the patient's parents.

Hence, the objective of this study was to examine gait characteristics in adolescents with MS. We hypothesized

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* Communications should be addressed to: Dr. Kalron; Sackler Faculty of Medicine; Department of Physical Therapy; Tel-Aviv University; Tel-Aviv, Israel.
E-mail address: alkalron@gmail.com

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that adolescents with MS would perform poorly both on gait tests compared with age-matched healthy comparative data.

Cohort Description

We evaluated retrospective data collected from the Multiple Sclerosis Center, Sheba Medical Center, Tel Hashomer, Israel's computerized database, a population-based registry documenting demographic and clinical data of all MS patients followed at the Center from January 2012 through March 2016.

A computerized questionnaire was used to select patients according to the following inclusion criteria: (1) a neurologist-confirmed diagnosis of MS according to the revised McDonald criteria[5]; (2) age range of 14 to 17 years, inclusive; (3) patient had undergone an instrumented gait test on an electronic walkway; and (4) patients was relapse-free for at least 30 days before testing.

Exclusion criteria included (1) orthopedic disorders that could negatively affect mobility; (2) blurred vision; (3) cardiovascular disorders; (4) respiratory disorders; and (5) taking steroids or fampridine.

The integrity of the data registry was evaluated by a computerized logic-algorithm-questioning process identifying data entry errors. The study was approved by the Sheba Institutional Review Board.

Gait measurement tool and protocol

Gait was studied using an electronic mat (GAITRite, CIR Systems, Inc Haverton, PA, USA) system. Measurements were performed at the Center of Advanced Technologies Rehabilitation Center, Sheba Medical Center, Tel Hashomer, Israel by a physical therapist specialized in neurological rehabilitation. The system consisted of a 4.6 m long electronic walkway containing 2304 compression-sensitive sensors arranged in a grid pattern. As the subject ambulates across the walkway, pressure is exerted by his feet, thus activating the sensors. Simultaneously, targeted software uses special algorithms to automatically group the activated sensors and form footprints. The system integrates all footprints and provides spatiotemporal parameters of gait.

A single valid walking trial was defined once the adolescent walked independently at his self-selected speed across the electronic mat, in one direction without stopping. Each participant performed six consecutive walking trials, during the first half of the day (from 9:00 AM to 12:00 PM), with a 1-minute interval between the tests.

Height and weight were documented for all subjects. Lower limb length was also measured, defined as the distance between the greater trochanter and the ground, passing through the lateral malleolus.

Gait data analysis

We extracted the following parameters from the GaitRite system's software: mean step length (cm), base of support (cm), cadence (steps/minute), velocity (cm/second), single support (% gait cycle), double support (% gait cycle), and stance phase (% gait cycle). Gait parameter scores were individually extracted for each pass. The values from all six trials performed by each participant were then averaged.

In line with the procedures described by Gouelle et al.[6] and recommended by Hof,[7] the step length, base of support, walking speed, and cadence were normalized by taking the lower limb length and gravity into account using the following formulas:

- Normalized step length $= \frac{\text{Step length}}{\text{lower limb length}}$
- Normalized base of support $= \frac{\text{Base of support}}{\text{lower limb length}}$
- Normalized cadence $= \frac{(\text{Cadence}/120)}{\sqrt{(g/\text{lower limb length})}}$
- Normalized velocity $= \frac{\text{Velocity}}{\sqrt{(g/\text{lower limb length})}}$

Step length, base of support, and lower limb leg length was recorded in meters, cadence in steps/minute, and velocity in meters/second.

Furthermore, the gait variability index was calculated using macro-instruction presented in the appendix of Gouelle et al.'s article.[8] The gait variability index quantifies the distance between the amount of variability in a reference group and the amount of variability in an individual. To enhance applicability, the value of the gait variability index is transformed into a score of 100 representing the mean score for the reference group. The standardized mean score and S.D. of the reference population are defined as 100 and 10, respectively. A gait variability index score of 100 indicates that the individual's level of variability is similar to the reference group. For a gait variability score <100, each 10-point difference corresponds to a separation of 1 S.D. from the score of the reference group.

Statistical analysis

Descriptive statistics determined the demographic and clinical characteristics of the study participants. Gait data were normally distributed according to the Kolmogorov-Smirnov test. Outliers were determined for each outcome using box plots.

To determine normality of gait in the MS group, we compared our results with values presented in the study by Gouelle et al.[6] Their study presented spatiotemporal parameters of gait and gait variability index values in healthy populations according to age. For our study, we extracted the values of the age group 14 to 17 years.

The standard score was calculated according to the following formula: (MS gait parameter – norm gait parameter)/S.D. norm gait parameter. All analyses were performed using SPSS software (version 23.0 for Windows, SPSS Inc, Chicago, IL, USA).

Results

The total sample included 24 adolescents with MS (12 girls, 12 boys). Mean disease duration was 20.4 (S.D. = 24.9) months and mean age 15.5 (S.D. = 1.1) years. The mean expanded disability status scale score was 1.7 (S.D. = 0.7) indicating minimal disability. The individuals' characteristics and neurological assessment scores are summarized in Table 1.

According to the normalized gait parameters, adolescents with MS walked slower with a wider base of support compared with age-matched healthy control subjects. In terms of velocity components, MS participants walked with longer steps and at a slower pace. Moreover, the gait variability index was lower in the MS group compared with the values in the healthy adolescents: 85.4 (S.D. = 8.1) versus 96.5 (S.D. = 7.4). All gait outcome scores are presented in Table 2.

TABLE 1.
Demographic, Anthropometric, and Clinical Characteristics of the Study Group

Variable	MS (n = 24)
Age (years)	15.5 (1.1)
Girls/boys	12/12
Disease duration (months)	20.4 (24.9)
Height (cm)	160.3 (8.5)
Leg length (cm)	73.1 (3.8)
Body mass (kg)	57.0 (14.3)
BMI (score)	22.2 (3.9)
EDSS	1.7 (0.7)
Pyramidal	1.0 (0.9)
Cerebellar	0.5 (0.7)
Sensory	0.1 (0.6)

Abbreviations:
BMI = Body mass index
EDSS = Expanded disability status scale
MS = Multiple sclerosis
All data are presented as the mean (S.D.).

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