Multi-Modal Measurement of Fatigue-Induced Gait Changes in a Person with Multiple Sclerosis during a 12-Minute Walk Test

Chen, D.,[1] Cohen, E.T.,[1] Muth, S.,[2] Ferraro, R.[1], Meyer, L.[1]
[1] Rutgers, The State University of New Jersey, - School of Health Professions, New Jersey, USA;
[2] Thomas Jefferson University, Pennsylvania, USA

Background

- Motor fatigability, a measurable change in performance with sustained activity, may result in changes in gait in people with multiple sclerosis (MS).
- The use of a single measuring mode may be inadequate to identify the gait deviations that may be most amenable to rehabilitation.
- A combined model that examines both temporal-spatial and kinematic measures during prolonged walking may enable clinicians to better assess these changes.

Objectives

- To examine changes in gait induced by motor fatigability by comparing temporal-spatial and kinematic parameters during the 1st and 12th minutes of a 12-minute walk test (12MWT).
- We hypothesized that temporal-spatial and kinematic measures would change between the first and last minutes of the 12MWT.

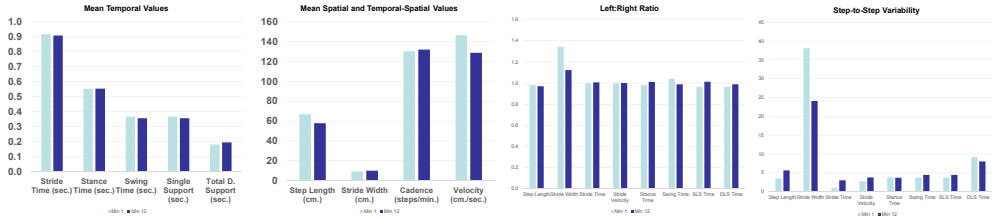
Participants

- The participant in this case example was a 65 year old woman with a 20-year history of RRMS
  - Disease Steps = 3
  - Patient-Determined Disease Steps = 4

Methods

- The participant completed the 12MWT along a modified pathway (a short oval track) with an instrumented walkway (CIR Systems, Sparta, NJ) laid over one straightaway.
- Temporal and spatial gait measures were recorded and analyzed with PKMAS Gait Analysis Software (Protokinetics, Inc., Havertown, PA).
- Kinematic data were collected for peak range of motion at the bilateral ankles, knees and hips with an 8-camera (Vicon Motion Systems Ltd. UK) 3D motion capture system, and interpreted with Motion Monitor software (Innovative Sports Training, Inc., Chicago, IL).
- Mean values were calculated for all recorded walking strides during the 1st and 12th minutes of the 12MWT.

Results: Differences in Temporal-Spatial Parameters of Gait



Parameter	Δ Min1 to Min 12	% Difference
Stride Time (sec.)	-0.01	-0.87
Stance Time (sec.)	0.00	0.18
Swing Time (sec.)	-0.01	-2.72
Single Support (sec.)	-0.01	-2.72
Total D. Support (sec.)	0.01	7.73
Step Length (cm.)	-9.02	-13.46
Stride Width (cm.)	0.69	7.31
Cadence (steps/min.)	1.56	1.20
Velocity (cm./sec.)	-17.60	-12.01

Parameter	Δ Min 1 to Min 12	% Difference
Step Length	-0.01	-1.02
Stride Width	-0.22	-16.44
Stride Time	0.01	0.90
Stride Velocity	0.00	0.30
Stance Time	0.03	3.16
Swing Time	-0.05	-4.91
SLS Time	0.05	5.20
DLS Time	0.03	2.70

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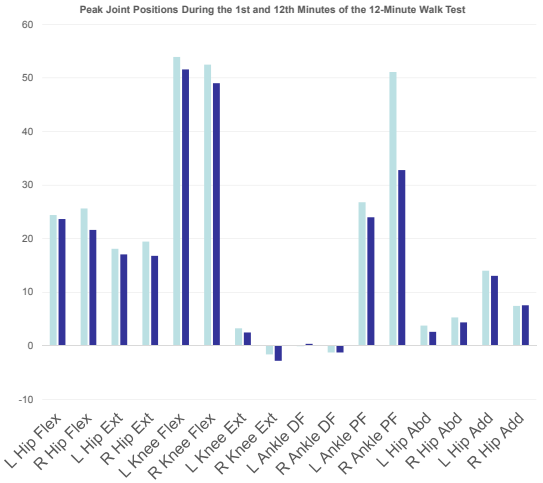
Results: Differences in Gait Kinematics



Joint/Movement	Δ Min1 to Min 12	% Difference
L Hip Flex	-0.8	-3.2
R Hip Flex	-4.0	-18.5
L Hip Ext	-1.1	-6.3
R Hip Ext	-2.6	-15.7
L Knee Flex	-2.3	-4.5
R Knee Flex	-3.5	-7.0
L Knee Ext	-0.8	-30.0
R Knee Ext	-1.2	42.9
L Ankle DF	0.5	121.3
R Ankle DF	0.0	0.8
L Ankle PF	-2.8	-11.7
R Ankle PF	-18.3	-55.8
L Hip Abd	-1.2	-44.6
R Hip Abd	-0.9	-20.7
L Hip Add	-1.0	-7.4
R Hip Add	0.1	1.8

Results

- From the first to the last minute of the 12MWT, this participant had notable changes:
  - ↓ mean walking velocity and step length
  - ↑ mean cadence, and step-to-step variability of step length, step time, stride velocity, single-limb support time and swing time.
  - ↓ peak right hip flexion and extension, bilateral ankle plantarflexion and hip abduction, and variability in left ankle dorsiflexion.

Conclusions

- This case describes the impact of motor fatigability induced by prolonged walking on temporal-spatial parameters of gait and LE kinematics in a person with MS.
- A notable deterioration in gait may be experienced by people with MS during prolonged walking.
- The use of a multimodal gait analysis can well-describe these changes. For example, one hypothesis that emerges from this data is that this person's diminished step length and velocity may be attributed to reduced peak right hip flexion/extension and bilateral ankle plantarflexion.
- Further research should be conducted using similar multimodal analysis to acquire a richer and more granular description of the impact of motor fatigability on walking during prolonged activity in people with MS.

Acknowledgements

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