Physical Fitness, Walking Performance, and Gait in Multiple Sclerosis

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Introduction

Walking impairment and deconditioning are prevalent and life-altering physical features of both early and advanced stages of multiple sclerosis (MS). There has been recent speculation that physiological deconditioning (i.e., reductions in aerobic capacity, balance, and muscular strength) contributes to walking and gait impairments in this population.

Purpose

The current study examined the associations among aerobic capacity, balance, and lower limb strength asymmetries, walking performance, and spatiotemporal parameters of gait in persons with MS and controls.

Participants

The sample included 31 cases of MS and 31 controls matched by age, sex, height, and weight (Table 1).

Measures

Aerobic capacity: Aerobic capacity was expressed as VO_{2peak}(ml/kg/min) based on an incremental exercise test on a cycle ergometer (Lode BV, Groninen, The Netherlands) using an open-circuit spirometry system (TrueOne, Parvo Medics, Sandy, UT, USA) for analyzing expired gases.

Muscular Strength: Bilateral isometric knee extensor and flexor peak torque were measured using a Humac Norm Isokinetic dynamometer (CSMI Solutions, Stoughton, MA, USA).

Balance: Balance was quantified with a force platform (Kistler model 928/B11) and balance was expressed as the total area (cm^2) of a 95% confidence ellipse of the center of pressure (COP).

Walking Performance: Measures of walking performance included the T25FW and 6MW tests.

Table 1: Fitness, Walking Performance, and Gait Characteristics of 31 persons with MS and 31 healthy controls matched by age, sex, height, and weight

Variable	MS (n=31)	Controls (n=31)
VO_{2peak} (ml/kg/min)	23.5 (6.4)	29.3 (8.8)
95% COP Ellipse (cm^2)	5.2 (3.8)	2.2 (1.5)
KE asymmetry	16.7 (13.6)	10.9 (10.2)
KF asymmetry	17.7 (16.8)	14.1 (10.4)
6MW distance (ft)	1760 (427.5)	2210 (287.7)
T25FW (s)	4.8(2.1)	3.7 (0.6)
Velocity (cm/s)	127.5 (27.7)	143.9 (18.0)
Cadence (steps/min)	110.8 (13.2)	114.2 (7.2)
Step Length (cm)	68.4 (9.6)	75.7 (8.8)
Base of Support (cm)	11.0 (4.0)	9.5 (2.4)
Double Support (% cycle)	27.9 (4.9)	25.9 (2.9)

Note: Data are reported as mean (*SD*); VO_2peak = Peak Aerobic Capacity; COP=Center of Pressure; KE=Knee Extensor; KF=Knee Flexor; 6MW=Six Minute Walk; T25FW=Timed 25-Foot Walk

Measures (continued)

Gait Parameters: Velocity, cadence, step length, base of support, double support were measured using a GaitRite™ electronic walkway (CIR Inc., Havertown, MA).

Procedure

The study protocol involved two testing sessions with a seven-day period separating the sessions. During the first testing session, the participants completed the T25FW, gait kinematics assessment, balance testing, and 6MW, followed by the assessment of muscle strength asymmetry. One week later, participants returned to our laboratory and completed a demographics form, followed by an incremental exercise test on a cycle ergometer to measure peak oxygen consumption.

Data Analysis

Data were analyzed in PASW Statistics version 18.0 (SPSS Inc., Chicago, IL) using independent-samples *t*-tests; bivariate Pearson product-moment correlations (*r*); hierarchical linear regression with direct entry to examine if fitness accounted for group differences in walking performance and gait parameters; and multiple linear regression analyses with stepwise entry to examine the independent contributions of fitness for explaining variance in walking performance and gait parameters in only the MS sample.

Results

There were significant differences in fitness, walking, and gait variables between persons with MS and matched controls (Table 1). Aerobic capacity, balance, and knee extensor asymmetry were associated with walking performance and gait in the overall sample (*r*'s = .2 - .7) and in persons with MS (*r*'s = .2 - .6) (Table 2). Aerobic capacity and knee extensor asymmetry explained group differences in T25FW performance (ΔR^2 = .28), 6MW distance (ΔR^2 = .29), and step length (ΔR^2 = .30), whereas aerobic capacity alone explained group differences in gait velocity (ΔR^2 = .27) and time spent in double support (ΔR^2 = .34) (Table 3). Among persons with MS, aerobic capacity and knee extensor asymmetry, but not balance, explained significant variance in walking performance and gait parameters (R^2's = .32 - .58) (Table 4).

Table 2: Correlations Among Fitness, Walking, and Gait Variables for the overall (n=62) and MS (n=31) samples

	VO_{2peak}		95% COP Ellipse		KE Asymmetry		KF Asymmetry	
Variable	Overall Sample	MS	Overall Sample	MS	Overall Sample	MS	Overall Sample	MS
T25FW	-.48*	-.46*	.42*	.35*	.41*	.48*	.49*	.50*
6MW	.74*	.62*	-.44*	-.32*	-.39*	-.51*	-.53*	-.56*
Velocity	.53*	.46*	-.32*	-.24	-.32*	-.45*	-.39*	-.39*
Cadence	.22*	.33*	-.23*	-.17	-.20	-.26	-.37*	-.44*
Step Length	.60*	.49*	-.30*	-.26	-.35*	-.54*	-.31*	-.31*
Base of Support	-.24*	-.33*	.30*	.31*	.12	.16	.25*	.30*
Double Support	-.54*	-.56*	.32*	.30*	.27*	.43*	.48*	.55*

Note: Pearson product-moment correlation coefficient (*r*); * denotes statistical significance at *p*<.05; VO_2peak = Peak Aerobic Capacity; COP=Center of Pressure; KE=Knee Extensor; KF=Knee Flexor; T25FW=Timed 25-Foot Walk; 6MW=Six Minute Walk;

Conclusions

Such results support (1) the hypothesis that physiological deconditioning might impair walking and gait kinematics in persons with MS and (2) the implementation of multimodal exercise training interventions as a modifiable approach for improving mobility outcomes in this population.

Table 3: Summary of hierarchical regression analysis for predicting walking and gait variables in persons with MS (n=31) and controls (n=31)

Table 3a: T25FW Performance

Variable	B	SE B	β
Step 1			
Group	-1.082	0.391	-0.336*
Step 2			
Group	-0.153	0.393	-0.047
VO_2peak	-0.064	0.023	-0.325*
Balance	0.111	0.060	0.224
KE Asymmetry	0.037	0.014	0.284*

Note: R^2=.336 for Step 1; ΔR^2=.283 for Step 2 (*p*<.05, two-tailed test). *p<.05 with one-tailed test.

Table 3b: 6MW Distance

Variable	B	SE B	β
Step 1			
Group	450.097	92.542	0.532*
Step 2			
Group	200.721	75.734	0.237*
VO_2peak	30.293	4.358	0.583*
Balance	−10.512	11.575	-0.081
KE Asymmetry	−6.971	2.761	-0.201*

Note: R^2=.532 for Step 1; ΔR^2=.286 for Step 2 (*p*<.05, two-tailed test). *p<.05 with one-tailed test

Table 3c: Velocity

Variable	B	SE B	β
Step 1			
Group	16.338	6.079	0.333*
Step 2			
Group	5.420	6.128	0.110
VO_2peak	1.417	0.378	0.437*
Balance	−0.570	0.936	-0.076
KE Asymmetry	−0.435	0.224	-0.217*

Note: R^2=.333 for Step 1; ΔR^2=.270 for Step 2 (*p*<.05, two-tailed test). *p<.05 with one-tailed test.

Table 3d: Double Support Time

Variable	B	SE B	β
Step 1			
Group	-1.994	1.051	-0.242*
Step 2			
Group	0.069	1.050	0.008
VO_2peak	-0.255	0.065	-0.468*
Balance	0.172	0.160	0.137
KE Asymmetry	0.056	0.038	0.166

Note: R^2=.242 for Step 1; ΔR^2=.339 for Step 2 (*p*<.05, two-tailed test). *p<.05 with one-tailed test.

Table 4: Summary of multiple linear regression analysis with stepwise entry for predicting walking and gait variables in persons with MS (n=31)

Table 4a: T25FW performance

Variable	B	SE B	β
KF Asymmetry	0.057	0.018	0.458*
KE Asymmetry	0.068	0.022	0.444*

Note: R^2=.440 for model (*p<.05, one-tailed test).

Table 4b: 6MW Distance

Variable	B	SE B	β
VO_2peak	19.362	10.800	0.290*
KE Asymmetry	-12.541	4.082	-0.400*
KF Asymmetry	-9.067	3.968	-0.356*

Note: R^2=.584 for model (*p<.05, one-tailed test).

Table 4c: Velocity

Variable	B	SE B	β
VO_2peak	1.563	0.701	0.362*
KE Asymmetry	-0.703	0.330	-0.346*

Note: R^2=.322 for model (*p<.05, one-tailed test).

Table 4d: Step Length

Variable	B	SE B	β
KE Asymmetry	-0.304	0.106	-0.433*
VO_2peak	0.544	0.227	0.364*

Note: R^2=.410 for model (*p<.05, one-tailed test).

Table 4e: Double Support

Variable	B	SE B	β
VO_2peak	-0.434	0.118	-0.564*

Note: R^2=.318 for model (*p<.05, one-tailed test).

Note: No variables entered into the equation for base of support.
VO_2peak = Peak Aerobic Capacity; COP=Center of Pressure; KE=Knee Extensor; KF=Knee Flexor 6MW=Six Minute Walk; T25FW=Timed 25-Foot Walk

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