Dual-Task Cost of Discrimination Tasks During Gait in People With Multiple Sclerosis

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Purpose: The aim of the study was to assess dual-task cost to spatio-temporal gait parameters in people with multiple sclerosis and a matched control group.

Method: The multiple sclerosis group was composed of 17 participants with a diagnosis of multiple sclerosis and an Expanded Disability Status Scale score of less than 6. A total of 17 healthy participants were allocated to the control group by stratification. Controls were matched on the basis of age, sex, sociocultural habits, and body structure. Dual-task cost was determined by within-group repeated-measures analysis of variance. Participants were instructed to ambulate under normal conditions and perform a discrimination and decision-making task concurrently. Then, between-group analysis of variance was used to assess differences in mean dual-task cost between groups and determine dual-task cost differential. Testing was performed using three-dimensional photogrammetry and an electronic walkway.

Results: Based on dual-task cost differential, gait cycle time increase (−5.8%) and gait speed decrease (6.3%) because of multiple sclerosis–induced impairment.

Conclusions: During single- and dual-task conditions, gait speed was lower in multiple sclerosis participants, because of a shorter step length and increased swing time. Increased gait time might be the result of compensatory mechanisms adopted to maintain stability while walking specially during the double-support phases.

Key Words: Motor Control, Biomechanics, Multiple Sclerosis, Gait, Dual Tasking

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Multiple sclerosis (MS) is a chronic progressive disease of the central nervous system that causes unpredictable motor, sensory, and cognitive alterations and affects normal gait (NG) pattern in 41% of patients.[1] Multiple sclerosis–induced gait alterations include increased double-support time, reduced step speed and length, elevated step width, and greater step width variability.[2–6] Changes in gait pattern are an indicator of MS-related physical deterioration and are used in scales, such as the Expanded Disability Status Scale.[3,7,8] However, technical difficulties in detecting subtle gait alterations at the onset of MS and variability in the manifestations of the disease hinder early diagnosis.

One of the techniques used to assess gait alterations in early disease is dual tasking. Changes in gait pattern are assessed with the subject performing two tasks concurrently, where the two tasks compete for resources and processes.[2,9] Alterations in gait pattern are called "dual-task cost" (DTC). Dual-task cost has been consistently related to neurological, functional and sensory impairment in MS patients, which cause muscle weakness, spasticity, and unbalance.[2]

The occurrence of changes in spatio-temporal gait parameters in dual tasking is widely known. However, whether these changes are characteristic of people with MS or also occur in healthy participants without cognitive and motor impairment is unknown. Identifying subtle changes in gait pattern is not only difficult for technical reasons but also hindered by another two factors, namely, (*a*) the type of concurrent task that should be used for the different groups to meet different objectives and (*b*) the lack of data on the DTC of concurrent tasks in healthy-matched groups.

Regarding dual tasking, Al-Yahya et al. (2011)[10] established a general classification of cognitive tasks based on their mental demands and the mental processes they involved. The most widely used cognitive tasks in dual tasking were verbal fluency, working memory, and mental tracking tasks. In contrast, contradictory results have been obtained in studies on dual tasking with executive discrimination and decision-making tasks. These tasks require to focus selective attention on a specific stimulus and responding accordingly, which frequently occurs when walking in complex and changing environments. As to DTC to gait pattern in healthy participants, significant changes have been consistently reported in spatio-temporal gait parameters[9–11] even in highly automated movements as those executed by elite athletes.[5,12]

In the light of the facts exposed previously, this research study had two objectives: (*a*) to determine the effect of performing a discrimination and decision-making task (dual task) on gait performance in two groups: participants with MS and participants without any pathology, and (*b*) to calculate their DTC and identify the effect of MS from the cost differential between the two groups.

Two hypotheses were postulated: (*a*) dual tasking will increase all gait time parameters, reduce step length and center of mass velocity, and increase gait time variability and step length in the two groups, and (*b*) the average DTC to gait time and space parameters will be higher for the MS group as compared with the group without pathologies.

METHOD

Design of the Study

Two groups matched for age, sex, and sociocultural habits were established: (*a*) participants with a confirmed diagnosis

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of MS (*MS group*) and (*b*) participants without any pathology, with full cognitive and motor function (*control group*). Firstly, a within-group repeated-measures analysis of variance was used to compare gait patterns between groups in two different experimental conditions: (*a*) *NG*, where the participant was instructed to walk at self-selected pace; (*b*) *walking while performing an executive task*, where the participant had to start walking when two traffic lights placed in front of them turned green simultaneously and stop as fast as possible when the two traffic lights turned red simultaneously. Secondly, DTC was calculated for each group and a between-group analysis of variance was used to compare differences in DTC and determine DTC differential.

Gait patterns in the two experimental conditions were analyzed on the basis of the gait-phase parameters that determine stride time (ST). Stride time was defined as the time interval between the first and second contact of the right foot with the ground.[5]

Mean velocity and displacement during the different phases of the gait cycle were calculated from the spatial coordinates of the center of gravity (CG) with respect to time. CG coordinates were used to assess dynamic stability from the maximum vertical and lateral displacement of the CG during left and right step (displacement CGx and displacement CGz, respectively). Finally, gait cadence (steps/minute) and variability in gait pattern were calculated based on changes in ST and left and right step length, expressed as percentages (CV% Stride t., CV% $\mathrm{L}_{\mathrm{LEFT\ STEP}}$, CV% $\mathrm{L}_{\mathrm{RIGHT\ STEP}}$, respectively).

Dual-task cost to each parameter was calculated in each group ($\mathrm{DTC\%}_{(\mathrm{MS})}$ and $\mathrm{DTC\%}_{(\mathrm{CONTROL})}$) from percentage difference between NG and dual-task gait or DTG values.[9] Dual-task cost to each variable was calculated in each group ($\mathrm{DTC\%}_{(\mathrm{MS})}$ and $\mathrm{DTC\%}_{(\mathrm{CONTROL})}$) based on percentage difference between NG values and dual-task gait or DTG.[9] Dual-task cost differential for each participant of the MS group ($\mathrm{D\_DTC\%}_{(\mathrm{MS})i}$) was calculated as the difference between the corresponding DTC ($\mathrm{DTC\%}_{(\mathrm{MS})i}$) and the mean DTC for the control group ($\mathrm{M}_{\mathrm{DTC}}\%_{(\mathrm{CONTROL})}$) following these expressions (Equation 1).

$$\mathrm{DTC\%} = \frac{\mathrm{NG}-\mathrm{DTG}}{\mathrm{NG}} \cdot 100;$$

$$\mathrm{D}_{\mathrm{DTC}}\%_{(\mathrm{MS})i} = \left(\mathrm{DTC\%}_{(\mathrm{MS})i}\right) - \left(\mathrm{M}_{\mathrm{DTC}}\%_{(\mathrm{CONTROL})}\right)$$

Participants

The MS group was composed of 17 patients diagnosed with MS (eight men and nine women). Inclusion criteria were as follows: (*a*) a confirmed diagnosis of MS with an Expanded Disability Status Scale score of 0–6; (*b*) ability to walk without aid or assistance; (*c*) no history of surgery or fracture in the lower limbs in the last year; and (*d*) absence of MS flare-ups in the last 6 mos. All participants underwent an analysis of body composition, using the InBody-230 system.

Based on personal data and previous medical examinations, 17 healthy subjects with full motor and cognitive function were allocated to the control group (eight men and nine women). Table 1 shows characteristics of participants. In accordance with the guidelines of the ethics committee of the university, written informed consent was obtained from all participants.

Materials and Measurement Systems

Participants walked along a 4.6-meter long electronic walkway (GAITRite system; Clifton, NJ) that had been previously marked with a spatial reference system (RS), which consisted of 12 equidistant points placed in the center of the walkway (3.16 m long × 1.58 m wide × 1.68 m high) associated with the ground. The horizontal axis (Y) corresponded to gait direction, the transverse axis (X) was perpendicular to the horizontal axis, and the vertical axis (Z) was perpendicular to the other two axes (Fig. 1).

Gait analysis was completed by three-dimensional (3D) photogrammetry based on data provided by two high-speed cameras (JVC GC-PX100$_{\mathrm{BE}}$) set at 200 Hz placed along one of the sides of the walkway at a distance of 20 meters from the geometric center of the RS and at 30 meters from each other. Cameras were synchronized using an electronic signal that activated a led located within the active field of the two cameras. The concurrent validity of the GAITRite system and 3D photogrammetry for ST and length for the two experimental conditions were high ($\mathrm{ICC}_{\mathrm{STRIDE\ TIME}} = 0.996$ and 0.873 for normal walking and dual tasking, respectively; $\mathrm{ICC}_{\mathrm{STRIDE\ LENGTH}} = 0.965$ and 0.967 for normal walking and dual tasking, respectively).

To force the use of selective attention, two traffic lights were installed on a tripod at the end of the walkway. Their geometric center was at 1.70 meters from the ground. Each traffic light was composed of three 25-led color lights 0.10 meters in diameter. The two traffic lights were connected to a computer with a programmed external card that controlled the activation of the six lights (Fig. 1).

Procedures

Participants were instructed to walk under two experimental conditions. In the *NG condition,* each participant was instructed to walk normally at self-selected pace. In the *dual-tasking condition*, participants had to start walking at self-selected pace when the two traffic lights turned green simultaneously and stop when they turned red. While walking, lights randomly turned on and off. To familiarize them with the procedure, each subject performed three trials where data were not collected. Experimental conditions were presented in random order.

Data for each group and condition were collected from five valid trials. In the *dual-tasking condition*, red lights never turned on simultaneously in the five valid trials. Three further trials were performed where red lights turned on simultaneously to maintain attention of the participants, although data from these trials were not recorded. The eight trials were performed in random order. Three-dimensional photogrammetry was based on data from the trial in which ST was the median of the five STs obtained in each experimental condition.

Data Analysis

Cadence and gait variability were calculated using GAITRite 4.7 software. Data from 13 steps were gathered to estimate gait cadence (steps/minute) and variability in ST and right and left step length in the two experimental conditions. Coefficients of variation (relative standard deviations) were expressed as percentages of distance (CV%) of the gait cycle. The CV% values were calculated using software Excel (Microsoft Corporation, 2010) sheet that contained data from each trial.

TABLE 1. Characteristics of participants

	MS Group	Control Group
Characteristics	Mean ± SE (Range)	Mean ± SE (Range)
Age, yr	40.6 ± 8.5 (26–54)	45.3 ± 6.5 (27–52)
Height, m	1.70 ± 0.09 (1.84–1.55)	1.71 ± 0.09 (1.88–1.55)
Weight, kg	71.2 ± 15.8 (106–50)	72.4 ± 13.7 (91–51)
Skeletal muscle mass, kg	28.3 ± 6.5 (37.6–17.5)	30.1 ± 7.8 (41.8–18.8)
Skeletal muscle mass, %	39.3 ± 5.08 (48.2–34.1)	40.6 ± 4.9 (48.1–34.9)
Body fat mass, kg	19.4 ± 6.6 (31.9–9.2)	19.6 ± 6.7 (29.9–10.2)
Body fat mass, %	27.5 ± 7.8 (35.7–13.9)	26.9 ± 7.7 (36.2–15.4)
Body mass index, kg/m^2	23.9 ± 3.1 (29.8–20.4)	25.2 ± 3.7 (31.3–19.0)
EDSS	3.6 ± 1.7 (6–1)	—

EDSS, Expanded Disability Status Scale.

The remaining parameters (distances, time, and velocity values) were calculated by 3D photogrammetry using an adapted modular system designed ad hoc for gait analysis (Cyborg V. 3.0). The gait cycle chosen for analysis was the one where initial contact of the right foot was closest to left end of the RS. To this purpose, a model of human body with 21 marks identifying 14 segments was used, and direct linear transformation method was used to determine the 3D components of the marks. The CG of each participant was determined using the inertial parameters described by Zatsiorsky and Seluyanov (1985)[13] and adapted by de Leva (1996).[14]

The spatial coordinates of the 21 markers that define the human model were calculated in the following three phases: (*a*) digitization of the plane coordinates of the 12 points that determine the RS and the positions for the 21 markers from the images of each camera. To avoid interfering with motion, manual digitization was performed at 50 Hz without using markers associated with participant's body, (*b*) flat coordinates were interpolated at 100 Hz using quintic splines functions with a smoothing level of 0.0001[15]; and (*c*) the direct linear transformation method[16] was used to obtain the spatial 3D coordinates for the 21 points with respect to the RS at sequential intervals of 0.01 sec.

Space-time gait parameters were measured based on the spatial coordinates of the 21 points with respect to time. The spatial coordinates of the CG with respect to time were obtained from the sequential positions of the segments and their corresponding inertial parameters. Finally, CG velocity components were calculated from the first derivative of their respective spatial coordinates with respect to time using a quintic spline function.

Statistical Analysis

Means and standard deviations were calculated for each group and experimental situation. Firstly, to determine differences between the two experimental conditions (NG *vs.* dual-task gait), multifactorial analysis of variance of repeated measures was used. Secondly, DTC was calculated for each group. Differences in mean DTC between groups (MS group *vs.* control group) were determined by Student's *t* test. Because of the number of statistical comparisons and to reduce the risk of type I error, the experiment-wide error rate was established a priori at $P \leq 0.05$, using a Bonferroni correction and resulted in a per comparison α level of $P \leq 0.003$ for the first research actuation and $P \leq 0.004$ for the between-group mean DTC differential analysis. Effect-size statistics were assessed using Cohen's *d*.[17] Taking into account the cutoff established by Cohen, the effect size can be small (<0.2), medium (<0.5), or large (<0.8). An analysis of variance of repeated measures was performed to confirm test reliability in each experimental condition, for all trials (five valid trials for each experimental condition). Stride time was used as dependent variable. No significant differences were observed among trials in each experimental condition. The intraclass correlation

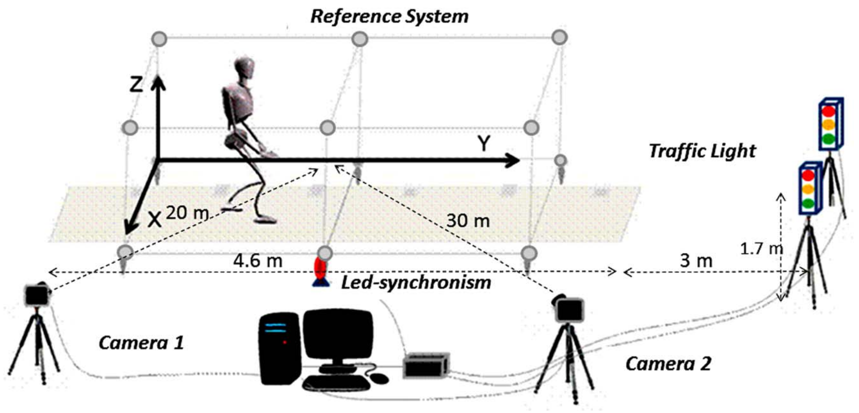

FIGURE 1. Illustration of the recording systems used for the two experimental conditions during gait analysis.

coefficient for the MS group was 0.912 ($P < 0.001$) for normal walking versus 0.897 ($P < 0.001$) for dual-task walking. The intraclass correlation coefficient for the control group was 0.992 ($P < 0.001$) for normal walking versus 0.987 ($P < 0.001$) for dual-task walking.

RESULTS

Table 2 shows descriptive and inferential statistics for gait time parameters for the two groups in the two experimental conditions. The effect of dual task in the MS group indicates that gait cycle time increased slightly under dual-tasking condition. Mean gait cycle time increased slightly because of the longer double-support time, with no differences in single-support time. Dual tasking reduced slightly cadence, whereas it had no impact on gait cycle time variability (CV%). Dual tasking had no significant effects on mean time values for the control group. Slightly higher coefficient of variance in gait cyle time was observed for dual tasking.

Descriptive and inferential statistics for spatial gait parameters for the two groups in the two experimental conditions are shown in Table 3. Data are expressed as percentages of the mean height of the two hips in anatomical position (greater trochanter). The effect of dual tasking indicates that stride and step length decreased significantly in the two groups ($P < 0.003$). The variability of both steps increases with the dual task, which also occurs in the control group, although there were only significant differences between means for left step.

Table 3 also contains descriptive and inferential statistics for mean CG velocity while in gait cycle ($v_{\mathrm{m\ CG\ (STRIDE)}}$) and its respective phases. The effect of dual tasking indicates that the mean velocity of the CG decreased significantly in the two groups in the dual-task condition ($P < 0.003$). Conversely, no statistically significant differences were observed in CGz displacement and CGx displacement.

Table 4 provides descriptive and inferential statistics for between-group mean DTC differential for time, distances and velocities variables, negative values in temporal variables, and positive values in distances and velocities indicate lower performance in dual tasking. In general, the results confirm that dual tasking had a greater impact on gait cycle time in the MS group as compared with the control group ($P < 0.004$). Between-group DTC differential (D_DTC%) shows a mean increase of 5.8% in ST caused by MS and, more specifically, by increased double-support time. There were no statistically significant differences in the DTC% to ST and cadence. In addition, Table 4 shows slightly decrease of 6.3% in CG velocity during gait caused by MS.

DISCUSSION

Gait speed was lower in participants with MS because of a shorter step length and increased double-support time. Time variability was greater and cadence was lower in the MS group as compared with controls. The results obtained are consistent with the ones obtained in previous studies.[2–4,6] However, this study is focused on the dual-task paradigm and our objective was to compare DTC in people with MS (DTC$\%_{(\mathrm{MS})}$) versus subjects with full cognitive and motor function (DTC$\%_{(\mathrm{CONTROL})}$). Thus, dual tasking caused a reduction in step length and mean gait speed ($P < 0.003$) in the two groups.

The changes observed in the control group (DTC$_{(\mathrm{CONTROL})}$) indicate that dual tasking has a DTC in participants without any pathology. The executive and decision-making tasks used in this research involve cognitive and motor reprogramming processes, which are characterized by a strong inhibition of the programmed gait and adaptation to the new environment.[18] Dual-task cost is supported by the theory of the two visual streams,[19,20] according to which uncertainty caused by concurrent inhibitory tasks requires the dominance of the ventral system over the dorsal system. Thus, ventral system dominance results in a reduction of the speed of motion. When an individual shifts their direction or suddenly halts, they are using strategic or high-order facilitation, which allows inhibiting the first action and selecting the most appropriate action.[21] This inhibitory mechanism occurs at higher cortical levels, which causes response delay.[22,23]

Based on the two-stream theory, with the objective of identifying the effects of the disease, the differential between the DTC of MS subjects and the mean DTC of controls was calculated to determine the cost caused by MS-related neurological impairment (Equation 1). Dual-task cost differential shows that the mean CG velocity while walking decreased by 6.3% as a result of neural, sensory, and motor dysfunction secondary to MS (Table 4). Dual-task cost differential data for spatio-temporal variables indicate that the DTC to mean CG velocity is caused by increased double-support time induced by MS-related impairment.

This is in line with previous studies[3,24,25] that suggest that postural control associated with MS causes an increase in double-support time as a strategy to maintain balance and postural control while walking. Hence, differences between the two groups in dynamic stability were minor, and the effect of

TABLE 2. Descriptive and inferential statistics for ST parameters for the two groups in the two experimental conditions

	MS Group				Control Group			
Variables	**NG**	**Dual Gait**	***F***	**Effect Size, d**	**NG**	**Dual Gait**	***F***	**Effect Size, d**
Gait cycle time, GCT, sec	1.079 ± 0.107	1.137 ± 0.149	10.60	0.5	0.951 ± 0.088	0.945 ± 0.083	0.87	0.1
Left-foot double-support time, sec	0.170 ± 0.047	0.202 ± 0.086	6.84	0.5	0.113 ± 0.022	0.116 ± 0.026	0.79	0.1
Left-foot single-support time, sec	0.375 ± 0.030	0.373 ± 0.035	0.08	0.1	0.360 ± 0.028	0.355 ± 0.023	1.25	0.2
Right-foot double-support time, sec	0.168 ± 0.040	0.193 ± 0.071	5.04	0.5	0.119 ± 0.027	0.121 ± 0.027	0.88	0.1
Right-foot single-support time, sec	0.367 ± 0.022	0.370 ± 0.024	0.32	0.1	0.359 ± 0.033	0.353 ± 0.028	3.68	0.2
Coefficient of variance gait cycle time, CV%	3.73 ± 1.56	4.35 ± 1.89	2.51	0.4	1.84 ± 0.77	2.71 ± 1.00	12.48	1.0
Cadence, steps/min	105.3 ± 24.5	101.3 ± 24.1	10.59	0.2	128.6 ± 10.5	126.8 ± 10.4	0.42	0.2

TABLE 3. Descriptive and inferential statistics for distances and CG velocity for the two groups in the two experimental conditions

	MS Group				Control Group			
Variables	**NG**	**Dual Gait**	***F***	**Effect Size, d**	**NG**	**Dual Gait**	***F***	**Effect Size, d**
Stride length, %	156.5 ± 33.0	147.2 ± 33.4	21.8[a]	0.3	188.7 ± 10.7	180.3 ± 11.2	61.1[a]	0.8
Left step length, %	77.4 ± 16.9	72.4 ± 16.4	19.9[a]	0.3	93.6 ± 5.3	89.4 ± 5.3	30.2[a]	0.8
Right step length, %	79.0 ± 16.6	74.8 ± 17.4	16.5[a]	0.2	95.1 ± 5.9	90.9 ± 6.8	25.3[a]	0.7
Step width, %	15.0 ± 11.3	15.0 ± 11.4	0.0	0.0	9.0 ± 4.3	9.2 ± 3.1	0.04	0.1
Coefficient of variance left step length, CV%	3.57 ± 1.27	5.33 ± 2.00	8.59	1.1	2.43 ± 1.11	3.44 ± 0.93	8.21	1.0
Coefficient of variance right step length, CV%	3.63 ± 1.36	5.17 ± 1.47	10.01	1.1	3.05 ± 1.41	3.99 ± 1.59	3.31	0.6
Velocity CG of the gait cycle, m/sec	1.43 ± 0.38	1.30 ± 0.37	22.2[a]	0.3	1.95 ± 0.20	1.88 ± 0.22	14.8[a]	0.3
Velocity CG left-foot double support, m/sec	1.51 ± 0.40	1.35 ± 0.40	21.8[a]	0.4	2.07 ± 0.22	2.01 ± 0.28	2.54	0.2
Velocity CG left-foot single support, m/sec	1.38 ± 0.37	1.27 ± 0.37	13.9	0.3	1.84 ± 0.18	1.77 ± 0.20	11.1	0.4
Velocity CG right-foot double support, m/sec	1.49 ± 0.40	1.35 ± 0.40	15.3	0.4	2.08 ± 0.24	1.99 ± 0.22	19.6	0.4
Velocity CG right-foot single support, m/sec	1.34 ± 0.36	1.23 ± 0.33	21.6[a]	0.3	1.80 ± 0.18	1.74 ± 0.19	16.2	0.3
Displacement CGz, m	0.05 ± 0.01	0.04 ± 0.01	2.27	1.0	0.05 ± 0.01	0.04 ± 0.01	3.81	1.0
Displacement CGx, m	0.05 ± 0.03	0.06 ± 0.04	3.17	0.3	0.04 ± 0.01	0.03 ± 0.01	0.08	1.0

[a] $P < 0.003$.

dual tasking on this variable was negligible (CGx displacement and CGz displacement) (Table 3). This suggests that dynamic stability remained constant during the gait cycle in the two groups and experimental situations. However, to maintain balance, which is compromised by neurological, functional, and sensory dysfunction secondary to MS, double-support time increases to execute compensatory strategies at hip and ankle level.[24] Comber et al. (2017)[6] reported that MS patients display a "cautious gait" as an attempt to reduce postural instability and increase overall control over motion.

No statistically significant differences were observed in mean cost differential (D_DTC%) for stride and step length between the two groups. This means that MS deficit did not affect DTC to stride and step length, which contradicts the literature on DTC in MS patients.[6] The same occurs with ST, step length and cadence variability. This suggests that DTC% is not only induced by neurological impairment associated with MS. The interaction between MS and DTC needs to be further explored using larger samples sizes that would allow more flexible analytic approaches with subgroup analyses.

CONCLUSIONS

Gait speed is slightly lower in people with MS as a result of shorter step length and increased double-support time. Time variability was greater and cadence was lower in the MS group as compared with controls. Step length and gait speed decreased in the two groups as a result of dual task involving a discrimination task. Therefore, the DTC obtained for the MS group ($DTC\%_{(MS)}$) may not be only associated with MS-induced neurological, functional, and sensory impairment.

Based on the DTC differential for the MS group and the mean obtained for the control group (D_DTC%), gait speed decreased by a mean of 6.3% as a result of cognitive, sensory, and motor impairment caused by MS. The most critical gait phase affected is the double-support phase. Increased double-support

TABLE 4. Between-group mean DTC differential for time, distances, and velocities variables

Variables	**MS Group (DTC%)**	**Differences (D_DTC%)**	**Control Group (DTC%)**	***P***	**Effect Size, d**
Gait cycle time, GCT, sec	−5.2 ± 5.7	−5.8	0.6 ± 2.8	0.001[a]	1.4
Left-foot double-support time, sec	−16.4 ± 19.4	−14.5	−2.0 ± 10.8	0.017	1.0
Right-foot double-support time, sec	−14.5 ± 18.4	−12.2	−2.3 ± 9.4	0.029	0.9
Coefficient of variance gait cycle time, CV%	−23.3 ± 41.2	41.1	−64.4 ± 80.0	0.088	0.7
Cadence, steps/min	4.3 ± 5.2	2.3	1.98 ± 6.0	0.268	0.4
Stride length, %	6.2 ± 4.9	1.8	4.5 ± 2.2	0.211	0.5
Left step length, %	6.5 ± 5.7	2.0	4.4 ± 3.1	0.242	0.5
Right step length, %	5.9 ± 5.4	1.5	4.5 ± 3.5	0.387	0.3
Velocity CG of the gait cycle, m/sec	9.9 ± 8.9	6.3	3.6 ± 3.3	0.016	1.0
Velocity CG left-foot double support, m/sec	11.2 ± 10.2	8.49	2.7 ± 6.3	0.011	1.0
Velocity CG left-foot single support, m/sec	9.2 ± 9.4	5.1	4.0 ± 4.6	0.071	0.7
Velocity CG right-foot double support, m/sec	10.6 ± 11.6	6.5	4.1 ± 3.5	0.048	0.9
Velocity CG right-foot single support, m/sec	8.9 ± 5.7	5.5	3.4 ± 3.4	0.003[a]	1.2

[a] $P < 0.004$.

time with respect to controls (D_DTC%) could be the result of compensatory strategies adopted at hip and ankle level to maintain stability during gait.

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