DOI: 10.4274/jmsr.galenos.2022.2022-7-1
Journal of Multiple Sclerosis Research 2022;2(2):41-45

RESEARCH ARTICLE

Relationship Between Upper Extremity Functions and Gait in People with Multiple Sclerosis

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Abstract

Objective: Approximately 66% of people with multiple sclerosis (pwMS) have upper extremity dysfunction that is underestimated in the evaluation and treatment process. Gait interference is another important motor problem identified. In pwMS, changes seen in gait parameters include decreased stride length, decreased cadence, and decreased joint range of motion. Although the relationship between gait and arm swing has been investigated in the general population, the existing relationship has not been clearly demonstrated for pwMS. This study aimed to examine the relationship between upper extremity function and gait in pwMS.

Materials and Methods: The study included 29 pwMS followed at the outpatient Multiple Sclerosis Clinic of Dokuz Eylul University Hospital. The arm function in MS questionnaire (AMSQ), nine-hole peg test (N-HPT), and Jamar hand dynamometer were used for upper extremity assessment. Gait was assessed with weekly step count according to the SenseWear armband (SWA) and preference-based MS index (PMSI) walking subparameter. The Expanded Disability Status Scale (EDSS), age, sex, and disease duration were recorded. The partial correlation controlling for the EDSS, age, sex, and disease duration was used.

Results: The clinical and demographic profiles of the participants were as follows: mean age, 44.41±11.30; mean EDSS score, 3.34±1.68; mean disease duration, 12.44±9.63; mean N-HPT, 25.72±7.13; mean Jamar score, 20.94±9.12; mean PMSI, 0.65±0.24; mean step count, 29037.9±18638.62; mean AMSQ score, 68.86±32.40. A moderately negative correlation was found between SWA and AMSQ (r=-0.483, p=0.017). Moreover, a moderately positive correlation was found between AMSQ and PMSI walking sub parameter (r=0.430, p=0.036).

Conclusion: The results of this study revealed no significant relationship between upper extremity performance-based measurement and gait, whereas a significant relationship was noted between upper extremity function and gait in the self-reported assessment.

Keywords: Multiple sclerosis, upper extremity, gait

Introduction

Multiple sclerosis (MS) is a neurodegenerative disease of the central nervous system (CNS) characterized by chronic autoimmune processes, axonal loss, demyelination, and gliosis (1). MS symptoms are differentiated according to the involved area of the nervous system. The spectrum of symptoms ranges from motor to cognitive problems (2). The most common symptoms were as follows: weakness, spasticity, tremors, visual symptoms, sensory symptoms, executive dysfunction, and memory problems (2). Motor impairment is the most common reported symptom that affects the daily living activities and psychosocial status of people with MS (pwMS) (3).

Walking problem, which is the most common motor symptom of pwMS with a high rate of approximately 75%, is reflected as ambulatory dysfunction and occurs because of factors such as weakness and spasticity in the lower extremities (4,5). Motor and sensory problems (paresis, spasticity, cerebellar ataxia, etc.) resulting from CNS damage are the primary causes of gait disturbance (6). Depending on the labeling, walking speed and step length decrease, double support time increases, and as a result, people restrict walking (6). Although measurements such as the timed 25-foot walk (T25FW) objectively reflect ambulation in a climatic setting, they may not reflect walking activity beyond the clinical setting (7). Block et al. (8) showed

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Received: 27.07.2022 **Accepted:** 12.09.2022

that fewer steps beyond the clinic were associated with disability and lower ambulation. They also emphasized that performance-based disability scores and the number of steps reflect similar results (8).

While lower extremity motor problems appear more critical because they affect daily activities such as walking performance, balance, climbing stairs, and sitting, >60% of pwMS are highly affected by the motor control of upper extremity function, i.e., ability to build and relax muscle strength quickly (9-11). In addition, disease progression results in the accumulation of disability over time, and individuals need unilateral or bilateral support within 15-20 years (12). As a result, pwMS must rapidly build up upper extremity muscle strength during daily living activities by using walking aids and prevent falls or object manipulation (10). In addition, an arm swing during human movement increases stability during walking, reduces energy expenditure during walking, and facilitates leg movements (13,14). Eke-Okoro et al. (15) reported that people who walk with restricted arm movements have lower step frequency, slower walking speed, and shorter stride length than those who walk without restraint.

Since pwMS can walk with a shorter stride length, lower walking speed, and more prolonged double support phase than healthy controls, increasing the arm swing will contribute to the gait pattern. In light of this information, it is necessary to examine the relationship between upper extremity and lower extremity more closely in pwMS (16). For this reason, we aimed to reveal the relationship between the upper and lower extremities in pwMS with the number of steps reflecting daily living.

Materials and Methods

Participants and Procedures

The study was approved by the Dokuz Eylul University Ethics Committee (approval number: 2021/23-20, date: 18.08.2021). The study was conducted in the MS Center of Dokuz Eylul University Hospital. All participants included in the study signed an informed consent form before the assessments.

The eligibility criteria were as follows: provided consent to participate in the study, aged >18 years, and diagnosed with definite MS according to 2017 McDonald criteria (17). The exclusion criteria were having a disabling neurological disease other than MS, a relapse up to 30 days before the study, and an orthopedic or cognitive problem that may affect the evaluations.

Outcome Measures

Information such as the date of diagnosis, disease duration, and MS type was obtained from the iMed 7.02 software used to create the database.

Expanded Status Disability Scale

Expanded Status Disability Scale (EDSS) is the most widely used scale for assessing disability in MS, consisting of neurological examination of eight functional systems, designated as pyramidal, cerebellar, brainstem, sensory, bladder and intestinal, visual, cerebral, and others (18). The neurologist calculates in 0.5-point increments from 0 (no physical disability) to 10 (death due to MS) (18).

Upper Extremity Assessments

The nine-hole peg test (N-HPT) is an upper extremity skill test consisting of nine sticks and nine holes in which these sticks are placed. Participants place the sticks one by one and collect them in the same way (19). Two trials are taken for both hands, first the dominant and then the non-dominant hand. The test completion time was recorded, and the average was calculated separately (19).

Upper extremity grip strength was evaluated with Jamar hand dynamometer (20). In the sitting position, with the knees and elbows flexed to 90° and the wrist in a neutral position, the pwMS was asked to squeeze the device as hard as possible. Three attempts were made for each hand (20). The average of the enemas was recorded in kilograms (kg). The average of the trials was taken. The highest of the three attempts was recorded as Jamar Max (20).

The arm function in MS questionnaire (AMSQ) evaluates the limitation during activities of daily living related to arm function in pwMS in the last 2 weeks (21). Each activity is scored at six levels and consists of 31 activities. The total score is obtained by summing up all the scores. An increase in limitation in function characterizes an increase in the score (21).

Gait Assessments

The preferential MS index (PMSI) is a patient-based assessment scale consisting of five items: fatigue, walking, concentration, mood, roles, and responsibilities (22). Items are intended to assess health-related quality of life. In this study, we included the analysis of walking subparameters of PMSI. Scoring was provided by a special algorithm, and a higher score was associated with worse walking (22).

The SenseWear armband is a 3-axis accelerometer (23). It provides information about the person's physical activity level by making metabolic equivalent and energy expenditure with special algorithms (24). It also provides information such as the sleep duration and number of steps. It has been recommended for use in pwMS. In the study, 1-week step count of individuals was taken (25).

Statistical Analysis

The normality distributions of the variable were checked using the Shapiro-Wilk test, plot investigation, and histogram. Partial correlation coefficients were performed to determine the relationship between upper extremity and gait measurements while controlling for the EDSS, disease duration, age, and sex. The correlation coefficients between 0.1 and 0.29, 0.3 and 0.49, and 0.5 and1.0 were considered weak, moderate, and strong correlations, respectively (26). All data analyses were performed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). The significance level was set at $p<0.05$.

Results

Consistent with the sex discrimination in MS, the majority of the 29 study participants were women. At the same time, most of our study group had the relapsing-remitting MS phenotype. Although the age range was wide, the EDSS score also reflected that there may be upper extremity problems even at different disability levels. The mean and minimum-maximum values of outcome measures varied widely (Table 1).

It would be more correct to express this sentence as follows: no significant correlation was found between participants' grip strength and N-HPT scores ($p>0.05$). The same insignificant relationship was found between N-HPT and Jamar Max scores. No significant relationship was found between the number of steps and the N-HPT score and Jamar score ($p>0.05$). The PMSI walking subscore was not significantly associated with objective upper extremity measurements, but a significant moderate positive correlation was found between the patient-reported scale and the AMSQ (0.430; $p<0.05$). Similarly, although no difference was found between the number of steps and objective upper extremity measurements, a significant moderately negative correlation was found between the number of steps and the AMSQ (-0,483; $p<0.05$). Detailed information is presented in Table 2.

Discussion

This study revealed the relationship between the upper and lower extremities in pwMS, with the number of steps reflecting daily living. Our results showed a significant relationship between the patient-based upper extremity assessment and the number of steps and walking sub parameter of the PMSI. However, no significant difference was found between the upper extremity objective measurements and gait assessments.

Normal walking has patterns of coordination between the lower and upper body according to the walking speed (27). Although not a primary condition for walking, an arm swing is an important point in balancing the contralateral pelvis and lower extremity movement (28). In daily living, people manipulate objects around them while walking, which limits their typical arm swing. Restricted arm swing causes persons to change their lower and upper body movements (27).

Ortega et al. (29) suggest that the increased metabolic expenditure maintains stability when they limit arm swings during walking. Moreover, Meyns et al. (13) emphasized the importance of participation of the upper extremities in gait coordination for proper gait patterns. Delabastita et al. showed that children achieved stability by increasing stride width because of restricted arm movement in children with cerebral palsy (30). As a result, the gait pattern of this disease group was affected by upper extremity movement (30). A similar situation is seen in patients with Parkinson's disease whose gait is characterized by decreased symmetry, stride length, and walking speed. In addition to altered gait, upper extremity function is affected due to asymmetric arm swing. This situation affects the coordination between the upper and lower extremities (31). Our study showed a relationship between patient-determined

Table 1. Demographic and clinical data of the participants

	Minimum-Maximum	Mean (SD)
Age (year)	23-67	44.41±11.30
EDSS	1.0-6.5	3.34±1.68
Disease duration (months)	0.50-34.75	12.44±9.63
N-HPT (seconds)	17.98-47.10	25.72±7.13
Jamar (kilograms)	2.42-45.37	20.94±9.12
SenseWear number of steps (week)	2855-70871	29037.9±18638.62
PMSI gait score	0-1	0.65±0.24
AMSQ	31-144	68.86±32.40
Regular exercise, n (%)		
Yes	12 (40%)	
No	17 (56.7%)	
Sex, n (%)		
Female	24 (80%)	
Male	5 (16.7%)	
Employment, n (%)		
Unemployed	8 [26.7 11 (36.7%)]	
Employed	11 (36.7%)	
Retired	9 [30 11 (36.7%)]	
Student	1 [3.3 11 (36.7%)]	
Education, n (%)		
Primary school	1 (3.3%)	
Secondary school	2 (6.7%)	
High school	14 (46.7%)	
Graduate	12 (40%)	
Disease course, n (%)		
Relapsing-remitting MS	24 (80%)	
Secondary-progressive MS	3 (10%)	
Primary-progressive MS	2 (6.7%)	

SD: Standard deviation, N-HPT: Nine-hole peg test, PMSI: Preference-based MS index, AMSQ: Arm function in MS, EDSS: Questionnaire, Expanded disability status scale, MS: Multiple sclerosis

Table 2. Relationship between upper extremity and gait measurements

	N-HPT-average	Jamar-average	Dominant-Jamar Max	Nondominant-Jamar Max	Number of steps per week	PMSI gait	AMSQ
N-HPT-average	1.000	-0.297	-0.294	-0.273	-0.213	0.168	0.353
Jamar-average	-0.297	1.000	0.834**	0.717**	0.126	-0.147	-0.243
Dominant-Jamar Max	-0.294	0.834**	1.000	0.624**	0.284	-0.382	-0.520*
Nondominant-Jamar Max	-0.273	0.717**	0.624**	1.000	-0.080	-0.089	-0.287
Number of steps per week	-0.213	0.126	0.284	-0.080	1.000	-0.658**	-0.483*
PMSI gait	0.168	-0.147	-0.382	-0.089	-0.658**	1.000	0.430*
AMSQ	0.353	-0.243	-0.520*	-0.287	-0.483*	0.430*	1.000

Adjusted for EDSS, disease duration, age, and sex. *Significant at $p<0.05$, **Significant at $p<0.001$. N-HPT: Nine-hole peg test, PMSI: Preference-based MS index, AMSQ: Arm function in MS questionnaire, EDSS: Expanded disability status scale, MS: Multiple sclerosis

upper extremity involvement in pwMS and the number of steps that are important for walking in daily living.

Despite deteriorations in the temporal and spatial parameters of walking in pwMS, the contribution of the upper extremity to this deterioration has not been clearly stated (32). Elsworth-Edelsten et al. (33) found that affected arm movements in MS would affect walking. However, it is unclear whether the impairment in arm movements is caused by the nature of MS or impaired walking. Benedict et al. (34) examined the relationship between upper extremity, lower extremity, and cognition based on MSFC (clinical assessment of disability progression) and determined a relationship between executive functions and motor activity. However, they did not state a conclusion about the relationship between upper and lower extremity motor performance. Likewise, we could not reveal a significant relationship between upper extremity objective measurements and the number of steps or the walking sub parameter of the PMSI. We think that this is due to the small number of people included in the study (35).

Although assessment measures such as N-HPT are widely used in clinical studies, detecting disease progression and mild change may be insufficient in examining the effects of deterioration (36). Patient-reported outcomes take the information directly from the patient and assess the effect of even mild symptoms on a person's quality of life (36). Thus, although no relationship was found between objective measurements and the upper and lower extremities, our study revealed that this relationship exists and is reflected in daily living.

Study Limitations

This study has some strengths and limitations. Owing to limited information regarding gait and upper extremity function, our study has brought a new perspective on this topic. First, our sample size was small. Second, although we included the N-HPT measurement result under the MSFC, we did not include the T25FW evaluation as an outcome measure. Finally, since the results of the SenseWear device are affected by the correct use of the patient, the study was conducted with the results related to its use by the patients. For future studies, we suggest conducting gait assessments using gait analysis or sensors for objective assessment.

Conclusion

The results of this study revealed no significant relationship between upper extremity performance-based measurement and gait, whereas a significant relationship was found between upper extremity function and gait in the self-reported assessment. Therefore, although handgrip strength and manual dexterity could not be related to gait, upper extremity functions that reflect daily living activities could affect the step count and perceived gait performance.

Ethics

Ethics Committee Approval: The study was approved by the Dokuz Eylul University Ethics Committee (approval number: 2021/23-20, date: 18.08.2021).

Informed Consent: All participants included in the study signed an informed consent form before the assessments.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: S.O., Concept: S.D., A.T.O., Design: S.D., S.O., I.Y., A.T.O., Data Collection or Processing: S.D., I.Y., Analysis or Interpretation: S.D., A.T.O., Literature Search: S.D., S.O., I.Y., A.T.O., Writing: S.D., S.O., I.Y., A.T.O.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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