Short Communication

# Upper limb movement analysis during gait in multiple sclerosis patients

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## ARTICLE INFO

## ABSTRACT

*Purpose:* Gait disorders in multiple sclerosis (MS) are well studied; however, no previous study has described upper limb movements during gait. However, upper limb movements have an important role during locomotion and can be altered in MS patients due to direct MS lesions or mechanisms of compensation. The aim of this study was to describe the arm movements during gait in a population of MS patients with low disability compared with a healthy control group.
*Methods:* In this observational study we analyzed the arm movements during gait in 52 outpatients (mean age: 39.7 ± 9.6 years, female: 40%) with relapsing-remitting MS with low disability (mean EDSS: 2 ± 1) and 25 healthy age-matched controls using a 3-dimension gait analysis.
*Results:* MS patients walked slower, with increased mean elbow flexion and decreased amplitude of elbow flexion (ROM) compared to the control group, whereas shoulder and hand movements were similar to controls. These differences were not explained by age or disability.
*Conclusion:* Upper limb alterations in movement during gait in MS patients with low disability can be characterized by an increase in mean elbow flexion and a decrease in amplitude (ROM) for elbow flexion/extension. This upper limb movement pattern should be considered as a new component of gait disorders in MS and may reflect subtle motor deficits or the use of compensatory mechanisms.

## 1. Introduction

In multiple sclerosis (MS), motor deficits most commonly affect the lower extremities and gait abnormalities represent a major feature of the disease (Benedetti et al., 1999). Individuals with MS walk slower, take shorter, wider and slower steps, and spend greater percent of the gait cycle in double support (Allali et al., 2012; Givon, Zeilig, & Achiron, 2009; Kelleher et al., 2010; Sosnoff, Sandroff, & Motl, 2012). Although gait disorders in MS are well described, no studies have studied upper limb movements using 3D motion analysis despite the important role of arms movements in gait (Meyns, Bruijn, & Duysens, 2013).

Many studies have reported the role of arm movements during both healthy and pathological gait (Eke-Okoro, Gregoric, & Larsson, 1997; Ford, Wagenaar, & Newall, 2007; Meyns et al., 2013). Arm swing during human locomotion reduces

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the energetic cost of walking and facilitates leg movements (Meyns et al., 2013). This may be due to a greater angular momentum about the vertical that needs to be counteracted (Collins, Adamczyk, & Kuo, 2009) or because of the larger vertical movements of the center of mass that occur when the arms do not swing upward when the trunk moves downward (Umberger, 2008). In addition to this, many authors have claimed that arm swing during gait improves stability (Bruijn et al., 2010). In neurological conditions, such as Parkinson's disease (PD), altered arm swing movement and asymmetry during gait is often reported (Lewek et al., 2010), and rehabilitation of arm swing has been recognized to improve gait and normalize arm swing in patients with PD (Yoon et al., 2016). However, arm swing movement and asymmetry have been not studied in MS.

MS patients, even with low levels of disability (Morel et al., 2017), present with gait deviations. Therefore, arm movements in MS patients may be altered for two reasons, firstly, as a direct consequence of MS lesions, such as demyelinating lesions in the spinal cord, brain or cerebellum, and secondly as a compensatory mechanism resulting from lower-limbs gait deviations. Therefore, we hypothesize that MS patients would present abnormal upper limbs movements, even in the very mild form of the disease, in comparison to healthy adults. This study aims to compare upper limb movements during gait in MS patients with a control group and to study their association with age, disability and gait velocity.

## 2. Methods

### 2.1. Participants

Fifty-two outpatients with relapsing – remitting MS from the Department of Neurology at the Geneva University Hospitals and 25 healthy controls were included. The study protocol has been previously described in detail (Allali et al., 2014). Briefly, exclusion criteria were: acute medical illness in the past month, neurological and psychiatric diseases except MS, and any concomitant orthopaedic, rheumatologic or vestibular conditions that affect walking. All patients were stable without any MS exacerbation within 60 days prior to participation. The research protocol was approved by the Geneva University Hospitals Committee on Human research, and informed consent was obtained from all participants.

### 2.2. Upper limb movements

Shoulder angles in the frontal plane and elbow angles in the sagittal plane during walking were analyzed individually for the MS and control participants.

The shoulder angle corresponded to the abduction-adduction angle, which was defined as the motion of the humerus relative to the thorax in the frontal plane (Bonnefoy-Mazure et al., 2010). A positive angle corresponded to abduction (i.e., the humerus moving away from thorax). The elbow angle corresponded to the flexion/extension angle, a positive angle reflected a flexion movement, and a negative angle an extension movement. The normalized (by the patient's height) position of the hand was computed along the x-axis (anterior-posterior direction) and z-axis (top-bottom direction) to determine respectively a guard position of the hand and the elevated hand position. Finally, the arm angle was calculated as the angle between the upper arm segment and vertical axis (to measure the degree of the swinging motion in the arm) in the sagittal plane (Bonnefoy-Mazure et al., 2014; Meyns et al., 2011).

For the shoulder angle, the elbow angle, the hand movements and arm angles, two discrete parameters were computed during the gait cycle: the range of motion (ROM) value and the mean value. Arm swing was also described using an asymmetry index: the arm swing asymmetry was designed to represent asymmetry in arm swing magnitude between each arm and was calculated using a method previously validated by Zifchock et al. Zifchock et al. (2008).

### 2.3. Gait analysis

The gait analysis protocol was previously described in detail (Allali et al., 2012, 2014). Briefly, the participants' gait was recorded with a twelve-camera motion analysis system (VICON Mx3+; ViconPeak®, Oxford, UK) at self-selected gait speed along a 12-meter walkway. Data were collected for at least 3 gait cycles for each individual.

### 2.4. Statistics

The MS and control groups were compared with each other for all biomechanical parameters used to characterize the gait and the upper limb movements using an independent samples T test, the statistical significance was $p < 0.05$. The effects of age, EDSS (Expanded Disability Status Scale) and gait speed (independent variables) on upper limbs movements (dependent variable) were investigated with multivariable linear regression analysis. The comparisons were performed using SPSS (v.22, IBM Statistics, USA).

## 3. Results

### 3.1. Upper limb movements

As seen in Table 1, MS patients had a reduced elbow flexion ROM ($p = 0.006$) and an increase mean flexed elbow position ($p = 0.003$). In addition, the mean arm angle was significantly higher in the MS group ($p = 0.001$). However, neither the hand nor the shoulder kinematics showed any significant difference between the groups.