

Detection and Quantification of Efficiency and Quality of Gait Impairment in Multiple Sclerosis through Foot Path Analysis

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ABSTRACT

Introduction: Walking speed is generally considered as the best outcome measure in trials for people with multiple sclerosis (pMS). We recently designed a device based on range laser scanner capable to track feet paths of walking subjects. Our purpose was to explore gait descriptors of pMS and compare them with those of healthy volunteers (HV). **Methods:** Forty-four pMS (considered as moderately or highly disabled according to a cut-off EDSS value of 3.0) and 28 HV performed 4 walking tasks along 2 trajectories in 3 walking modes. Twenty-six gait descriptors crudely dichotomized in « efficiency » and « quality » of gait were compared in the 2 populations using unpaired t-tests. **Results:** (i) apart from an older age in pMS, the two populations were comparable, (ii) efficiency of gait descriptors including walking speed distinguished HV from pMS, and pMS with moderate from pMS with high disability, (iii) quality of gait descriptors were also significantly altered in pMS, including in walking tasks where their walking speed was comparable to that of HV. **Conclusions:** RLS technology can distinguish pMS from HV according to (i) more efficiency of gait descriptors than the sole walking speed and (ii) quality of gait descriptors, including in subjects with a « normal » walking speed.

Introduction and Purpose

- The vast majority of researchers and clinicians consider **walking speed**^{1,2} (WS) measured with a stopwatch as the best outcome measure to **quantify gait** of persons with multiple sclerosis (pMS)
- We recently designed and validated on healthy volunteers (HV) a **device based on range laser scanners technology (Fig 1)**³ capable to **track feet paths (Fig 2)** during various walking tasks, through which several gait descriptors (currently 26) can be measured
- This exploratory study's **purpose** was to compare gait descriptors from pMS versus those of HV

Methods

- This study was approved by the local ethics committee
- Forty-four pMS and 28 HV** were recruited
- The design was cross-sectional

Walking Tasks

- The subjects were asked to walk along **two trajectories**: (i) a line of 9.62m (25 feet + 2m) and (ii) a 8-shaped figure of 20m (**Fig 1**)
- Four walking tasks** were performed: the Timed 25-Foot Walk Test (T25FW), the Timed 20-Meter Walk Test (T20MW, 1 lap of trajectory ii), the Timed 100-Meter Walk Test (T100MW, 5 laps of trajectory ii) and the Timed 500-Meter Walk Test (T500MW, 25 laps of trajectory ii). Patients with an EDSS > 4.0 were asked to walk as far as possible on the T500MW
- Three walking modes** were studied: preferred pace, as fast as possible and tandem gait (« heel-to-toe »)
- The **walking paradigm** used is resumed in **Table 1** and took approximately 20 minutes per subject

RLS-derived gait descriptors

- Twenty-six gait descriptors can be extracted and quantified from the recorded foot paths
- A crude dichotomization was applied by separating **efficiency of gait descriptors (EG)**, i.e. conceptually directly implicated in walking speed from **quality of gait descriptors (QG)**, i.e. without any direct relation to walking speed but perhaps related to other gait feature such as balance and proprioception
- EG** included mean walking speed, mean/maximum left/right foot speed, gait cycle time while **QG** included mean, maximal and RMS deviation from the trajectory, mean interfeet distance, mean lateral interfeet distance, double/single limb support time, variability of left/right foot trajectory and step length asymmetry

Statistical analysis

- HV (n=28) were compared to pMS (n=44), who were classified and compared according to their EDSS as ≤ 3.0 (n=22) or > 3.0 (n=22)
- Unpaired t-test comparison were applied with a two-tailed analysis and 0.05 as a level of significance and were performed using the function "t_test" bundled with Octave (<http://www.gnu.org/software/octave/>) version 3.2.4

Results

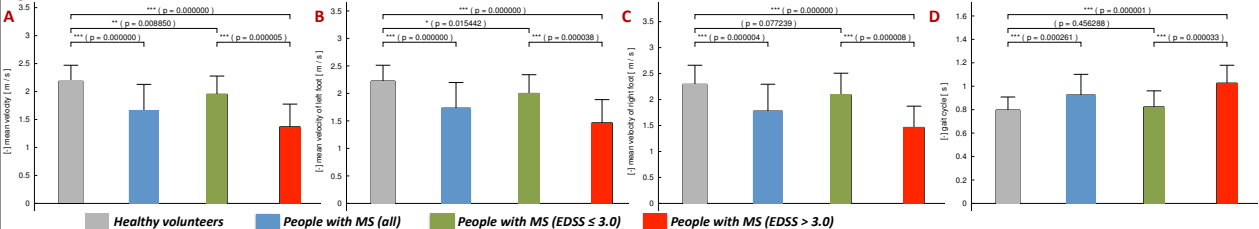
Demographic characteristics (Table 2):

- pMS were around 12.3yo older than HV (p<0.001)
- no other significant differences were observed between groups

Efficiency of gait descriptors (Fig 3)

Along the T25FW, administered according to the MSFC recommendations² (i.e. « as fast as possible »), significant differences were obviously found between groups when considering the mean walking speed (**Fig 3A**). Other gait descriptors conceptually directly related to walking speed displayed the same pattern of alteration, such as individual foot mean walking speed (**Fig 3B** and **3C**) or gait cycle time (**Fig 3D**)

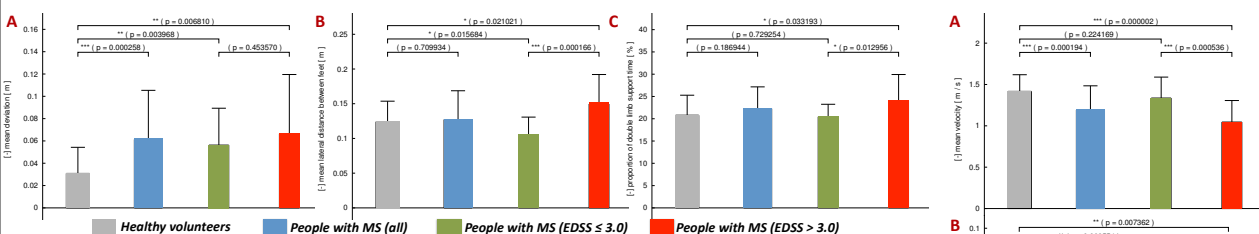
Figure 3



Quality of gait descriptors (Fig 4 and 5)

During the same walking test, we observed significant differences between the 3 studied populations in gait descriptors apparently unrelated to walking speed, such as the mean deviation from the trajectory (**Fig 4A**), the mean lateral interfeet distance (**Fig 4B**) or the time of double limb support (**Fig 4C**). Interestingly, when the subjects were asked to walk along the same distance of 25 feet at their preferred pace, these same differences were present in moderately disabled pMS (**Fig 5A**), while their walking speed remained unaltered in comparison to HV (**Fig 5B**).

Figure 4 Timed 25-Foot Walk Test in the « as fast as possible » mode of walk



Conclusion – Discussion – Perspectives

- This exploratory study investigated the potential of RLS technology, which is easily applicable in the context of routine clinical practice (± 20 minutes per subject), to quantify gait alterations of pMS.
- In addition to the mean walking speed, other gait descriptors can be measured and may enrich the sensitivity of clinical trials considering gait « efficiency » as an outcome measure
 - this assumption will be investigated with a larger number of subjects on a prospective basis
 - this is specially relevant regarding the progressive type of MS where relevant outcome measures are lacking
- Beyond these « efficiency » measures, differences in gait qualitative descriptors that might be relevant to balance, proprioception and perhaps cognition have been observed in pMS, paving new grounds for the investigations of gait abnormalities in the field of multiple sclerosis

References

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Disclosures

R. Phan-Ba serves on scientific advisory boards for Genzyme-Sanofi Aventis and has received funding for travel from Genzyme-Sanofi Aventis, Bayer Schering Pharma and Biogen Idec.
S. Belachew serves on scientific advisory boards for Bayer Schering Pharma, Biogen Idec, Genzyme-Sanofi Aventis, Novartis Pharma, and Merck-Serono; has received funding for travel and speaker honoraria from Bayer Schering Pharma, Biogen Idec, Genzyme-Sanofi Aventis, Novartis Pharma, Teva, and Merck-Serono and has received research and/or educational grant supports from Biogen Idec, Merck-Serono, Sanofi-Aventis, Teva, and Novartis Pharma.
S. Piérard and M. Van Droogenbroeck have nothing to disclose.