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Deciphering Distance-Induced Deceleration of Gait and Ataxia in People with Multiple Sclerosis

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ABSTRACT

Introduction: We previously suggested that the deceleration index (DI) was a measure of locomotor fatigability of people with multiple sclerosis (pMS). We recently designed a device based on range laser scanners (RLS) capable to track feet paths of walking subjects. Our purpose was to investigate alteration in RLS-derived gait descriptors over a distance of 500m in pMS with low or high DI compared to healthy volunteers (HV) Methods: Fourty pMS (considered as with a low or high motor fatigability according to a cut-off DI value of 0.8) and 28 HV performed a 500m walk (500MW) as fast as possible. The absolute and relative differences of the values of 26 gait descriptors – crudely dichotomized in « efficiency» and « quality » of gait – between the first and the last 100m of the 500MW were compared in the 3 populations using unpaired t-tests. Results: (i) apart from an older age in pMS, the two populations were comparable. (ii) Over a distance of 500m there was a significantly more important change of efficiency of gait descriptors in pMS compared to HV and in pMS with a high compared to pMS with a low DI, while there was no difference between pMS with a high DI and HV. (iii) A significant change of quality of gait descriptors was observed over 500m in pMS compared to HV, with no difference when stratified according to their DI. Conclusions: This work, based on RLS-derived gait descriptors, further validates the DI as marker of locomotor fatigability in pMS and demonstrates an additional component in gait alteration during a sustained effort in pMS, which seems to be independent from motor fatigue.

Introduction and Purpose

• By analysing walking speed (WS) of people with multiple sclerosis (pMS), we previously suggested that gait deceleration during a sustained walking effort was a manifestation of motor fatigue. We hypothesised that the ratio between the WS of the Timed 25-Foot Walk and the last 100m of the Timed 500-Meter Walk – the Deceleration Index (DI) – was a measure of this locomotor fatigue[1]

• We recently designed and validated on healthy voluteers (HV) a **device based on *range laser scanners* technology**[2] **(Fig 1)** capable to **track feet paths (Fig 2)** during various walking tasks, through which several gait descriptors (currently 26) can be measured

• This study's ***purpose*** was to investigate alteration in RLS-derived gait descriptors over a distance of 500m in pMS with low or high DI compared to healthy volunteers (HV)

Methods

• This study was approved by the local ethics comittee
• **Fourty pMS and 28 HV** were recruited
• The design was cross-sectionnal

Walking Tasks

• The subjects were asked to walk along **two trajectories**: (i) a line of 9,62m (i.e. 25 feet + 2m) and (ii) a 8-shaped figure of 20m (**Fig 1**)
• The evaluation was part of a multimodal evaluation including **four walking tasks and three walking modes.** The current study was performed with the data collected from the **Timed 25-Foot walk (T25FW)** and the **Timed 500-Meter walk (T500MW)** which were performed « **as fast as possible** »

RLS-derived gait descriptors

• Twenty-six gait descriptors can be extracted and quantified from the recorded foot paths
• A crude dichomization was applied by separating **efficiency of gait descriptors** (EG), i.e. 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 path, mean interfeet distance, mean lateral interfeet distance, double/single limb support time, variability of left/right foot trajectory and step length asymmetry
• The **Deceleration Index (DI)** was calculated as the ratio between the WS of the T25FW over the WS of the last 100m of the T500MW
• **Absolute difference** over 500m of a gait descriptor A was defined as the value of A over the last 100m ($A_{400\text{-}500}$) minus the value of A over the first 100m ($A_{0\text{-}100}$) of the T500MW, while its **relative difference** was defined as $(A_{400\text{-}500}\text{-}A_{0\text{-}100})/A_{0\text{-}100}$

Statistical analysis

• HV (n=28) were compared to pMS (n=40), who were classified and compared according to their DI as ≥ 0.8 (n=27) or < 0.8 (n=13)
• Unpaired comparison of the gait descriptors were applied between groups and **paired comparison of the first 100m vs the last 100m of the T500MW** were applied within groups
• Unpaired and paired 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

Fig 1 ***The two trajectories surrounded by 4 range laser scanners***

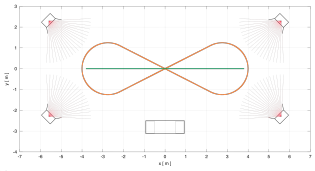


Fig 2 ***Example of feet path recorded along a lap of 20m along the 8-shaped trajectory***

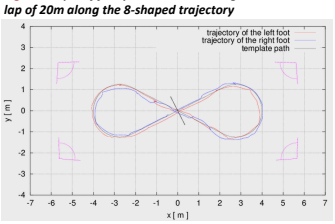


Table 1 ***Demographic characteristics of HV and pMS***

	Healthy Volunteers	people with MS		
		All	DI ≥ 0.8	DI < 0.8
Number	28	40	27	13
Age (years, mean ± SD)	31.2 ± 1.3	42.5 ± 11.7	41.9 ± 12.8	44.3 ± 10.3
Gender (female, %)	46.4	63.6	66.7	53.8
EDSS (mean ± SD)	n.a.	3.3 ± 1.3	2.9 ± 1.2	3.5 ± 1.1
MS type (CIS/RR/P, %)	n.a.	14.9/59.6/23.4	22.2/55.5/22.2	0/84.6/15.4
Disease duration (year, mean ± SD)	n.a.	11.7 ± 10.6	8.8 ± 8.2	16.8 ± 10.9
DI (mean ± SD)	0,83 ± 0.06	0.79 ± 0.13	0.86 ± 0.09	0.66 ± 0.07

Results

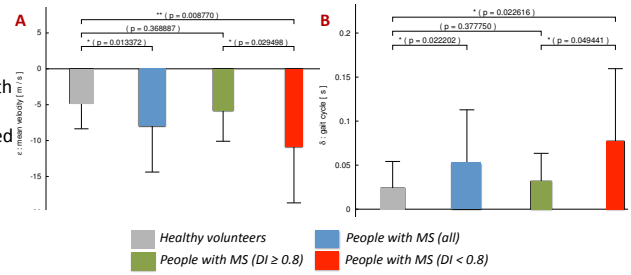
Demographic charateristics **(Table 1)**:

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

Walking speed deceleration and efficiency of gait descriptors **(Fig 3)**

A significant decrease in WS and other efficiency of gait descriptors was observed in each group when comparing their value over the first and the last 100m of the T500MW (paired compairon yielding a p-value < 0.001 for all groups, data not shown). The relative difference of the WS was significantly higher in pMS compared to HV, and in pMS with a low DI compared to pMS with a high DI (**Fig 3A**). There was no difference between pMS with a high DI compared to HV. This was also the case for other gait descriptors directly related to walking speed, such as individual foot mean or maximal velocity (data not shown). The gait cycle time displayed a similar pattern when considering its absolute (**Fig 3B**) or relative difference.

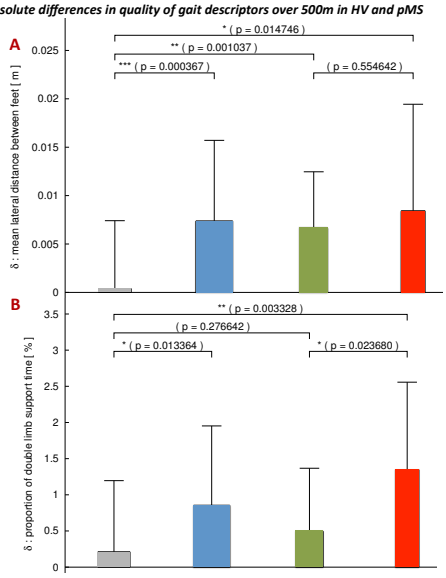
Figure 3 ***Relative and absolute differences in efficiency of gait descriptors over 500m in HV and pMS***



Quality of gait descriptors **(Fig 4)**

Over a distance of 500m, significant differences in the modification of certain gait descriptors apparently unrelated to walking speed were observed between the 3 studied populations. While the absolute difference in the mean lateral interfeet distance was very low in HV, it significantly increased in the pMS population, whether with a low or a high DI (**Fig 4A**). A similar pattern of differences was observed for the time of double limb support (**Fig 4B**), which was significantly increased in pMS than in HV, and in pMS with a high DI compared to those with a low DI. A pattern of significant decrease of feet moving time mirrored this observation (data not shown). There was no significant difference in the changes of gait descriptors related to the deviation from the trajectory (data not shown).

Figure 4 ***Absolute differences in quality of gait descriptors over 500m in HV and pMS***



Conclusion – Discussion – Perspectives

- This study investigates the details of gait alteration associated with walking speed deceleration over a long distance walking effort, which is considered as a manifestation of the increased motor fatigue of pMS
- We further confirmed the validity of the Deceleration Index as a valuable tool to discriminate pathological gait deceleration in pMS by demonstrating the alteration of efficiency of gait descriptors in pMS with a high DI compared to pMS with low DI, without clear differences between pMS with high DI and HV
- Beyond these « efficiency » measures, alterations over a long distance of qualitative gait descriptors were observed in pMS but not in HV. The possible relevance of these to balance, proprioception and perhaps cognition has to be confirmed in future studies, but confirms the notion that gait ataxia occurs in pMS with a low level of disability[3] independently from motor fatigue

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. Pierard and M. Van Droogenbroeck have nothing to disclose.