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FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
master in de revalidatiewetenschappen en de kinesitherapie

Masterproef

Simultaneous performance of motor and cognitive tasks in persons with multiple sclerosis: dual task assessment

Promotor :
Prof. dr. Peter FEYS

Copromotor :
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Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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Content

In accordance with the guidelines of the International Committee of Medical Journal Editors
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1 Research context

This master thesis is situated in the domain of neurological rehabilitation research. People suffering from neurological diseases like stroke, multiple sclerosis (MS), Parkinson's disease (PD) etc. have a lot of motor and functional deficits such as gait and balance problems, muscle weakness, coordination problems etc. Beside these motor impairments, it has also been shown that these people suffer from cognitive impairments, which can have a huge impact on their daily activities (O'Sullivan, Schmitz, & Fulk, 2014).

While performing a cognitive and a motor task simultaneously, we can measure the dual task cost (DTC), a percentage change between the performance on a single task (ST) and dual task (DT) condition (Plummer & Eskes, 2015). So far, cognitive-motor interference (CMI) has been investigated during several dual task paradigms, however without examining its measurement error hampering the interpretation of results . To quantify the measurement error, we investigated the test-retest reliability of the dual task cost during diverse dual cognitive-motor task conditions. In cooperation with the University of Liège (ULg), we examined if values are consistent under the same conditions, on different days. The results on reliability will inform us which DTC outcome measure can be proposed as experimental outcome measure in interventional and observational studies.

Together with two students from the University of Liège (ULg), persons with MS and healthy controls have been assessed on cognitive-motor interference. Pauline Colaux (4th year of Physiotherapy) has tested all MS patients, while Quentin Luremonde (3rd year of Physiotherapy) and Dimitri Remacle (2nd Master of Physiotherapy at the University of Hasselt) have tested the healthy control (HC) group. Prof. Dr. Peter Feys and Dr. Ilse Baert from UHasselt REVAL were the (co-)promoters of this work. Dr. Xavier Giffroy, a physical therapist in the Centre Hospitalier Universitaire (CHU), was the external co-promoter. All tests were also supervised by Dr. Dive, head of the MS-department in the CHU. The same test procedure was followed in the Masku Neurological Rehabilitation Centre (Finland) under the supervision of Prof. Dr. P. Hämäläinen and Dr. A. Romberg. All analyses were performed on the data from the CHU in Liège and the Neurological Rehabilitation Centre in Masku.

2 Article

2.1 Abstract

Background: People with multiple sclerosis (MS) suffer from motor and cognitive impairments. In recent years, some studies investigated the impact of performing both cognitive and motor task simultaneously compared to singular. A decreased velocity by taking fewer and shorter steps was found. So far, cognitive-motor testing was mostly only executed once, with a current lack of knowledge on its reliability limiting its use as an experimental outcome measure.

Objectives: To investigate the between-day reliability of dual task costs (on cognition and mobility) during diverse cognitive-motor interference test conditions in persons with MS (pwMS) and age-gender matched healthy controls.

Methods: Twenty-two pwMS and 22 healthy controls (HC) were tested and retested three to five days later on single cognitive/motor tasks and cognitive-motor dual tasks. Cognitive tasks were: counting backwards by seven, titrated digit span backwards and auditory vigilance with alphabet. Motor tasks were: walking at a self-selected speed, walking while stepping over low obstacles, walking crisscross and walking while carrying a cup filled with water. Experimental outcome measure was the cognitive-motor interference (CMI), expressed in cognitive, motor and combined dual task cost (DTC). For normally distributed data, a t-test was calculated followed by ICC calculations with a two-way random effect with absolute agreement ($ICC_{2,1}$). For not normally distributed data, the Wilcoxon signed rank test was provided to assess systematic differences between both test sessions. After that, Spearman correlation coefficients were calculated to indicate reliability.

Results: DTC values ranged from 3.63% to 18.64% for walking speed and from -4.21% to 23.14% for cognition. Five ICCs could be calculated in total. For motor DTC, ICCs and Spearman correlations ranged from 0.13 to 0.82 in the MS group. In the HC group, these values ranged from 0.43 to 0.92. For cognitive DTC, Spearman correlations ranged from -0.01 to 0.43 in the MS group, while in the HC group values ranged from 0.04 to 0.54. Looking at the combined DTC, Spearman correlations ranged from 0.06 to 0.61 and from -0.33 to 0.80 in the HC group.

Conclusion: Reliability of the motor DTC was better than cognitive DTC. The most reliable test of all dual task conditions was the 'vigilance walk', who showed the highest correlation in both groups for combined (and motor) DTC, but not for cognitive DTC. There were no clear and systematic differences on reliability between the MS and HC group.

2.2 Introduction

Multiple sclerosis is a worldwide neurological disease that affects 2.3 million people in the world, with a ratio of 2:1 for women. The highest prevalence in Europe is found in Scotland and Northern Ireland with approximately 200 per 100.000 inhabitants (Howard, Trevick, & Younger, 2016).

The initial symptoms of MS are vision problems and numbness in various organs (Marandi, Nejad, Shanazari, & Zolaktaf, 2013). Further symptoms are fatigue, pyramidal syndrome, ataxia and balance and coordination problems. During the progression of the disease, these symptoms cause a reduced endurance, walking distance, impaired gait pattern or inability to support body weight, resulting in a need for mobility aids or the use of a wheelchair (O'Sullivan et al., 2014).

However, besides different levels of mobility impairments, persons with MS (pwMS) also commonly experience cognitive impairments (CI). These mobility impairments are more frequently reported than the quite invisible cognitive ones, maybe due to the major impact that physical disability has on work, private and social life. Eighty-five % of pwMS reported walking as the most major impact (Larocca, 2011), while 65% reported cognitive impairments in the study of Winkelmann, Engel, Apel, & Zettl (2007). A combination of both walking and cognitive impairment may affect people's daily life and activities.

Cognitive-motor dual-task performance is highly relevant to everyday living e.g. walking and calling or walking and avoiding people on the street. "The changes incurred during simultaneous performance of motor and cognitive tasks are a result of cognitive-motor interference (CMI)" (Wajda & Sosnoff, 2015). One approach for experimentally examining cognitive-motor coupling involves using a dual-task (DT) paradigm and is calculated by the dual task cost (DTC) (Learmonth, Pilutti, & Motl, 2015). DTC is the percent change in performance between a dual task and a single-task (Ellmers, Cocks, Doumas, Williams, & Young, 2016).

Learmonth et al. (2015) found dual task (DT) of naming alternate letters of the alphabet while walking resulted in slower walking velocity (12.5% in MS group, 17.5% in HC group) characterized by MS patients taking fewer and shorter steps while spending more time with both feet on the ground compared to the single task (ST) walking trials. In the study of Sosnoff et al. (2014), a same decrease of 12.5% was found in gait velocity. It has also been showed that the DTC in cognitive and motor tasks in older women (72.4 years old) was worse under dual-task condition compared with young (25.12 years old) and middle-aged (47.42 years old) groups, so age is also a contributing factor (Brustio, Magistro, Rabaglietti, & Liubicich, 2015).

Cognitive-motor interference is important to measure in e.g. real-life walking. “A diminished capacity for dual-task performance may significantly impede functional mobility activities and community participation” (Plummer et al., 2013). But this DTC has to be reliable. This term is used to describe the ability of an instrument to measure a variable with consistency. A high reliability means results found are not due to errors variance or differences in ratings between coders, but due to true score variance or similarity in ratings (Portney & Watkins, 2009a).

There are some evidences about which cognitive and motor task can be used for the dual task paradigm. Monticone et al. (2014) evaluated the inter-rater reliability of a motor and cognitive task in pwMS. As single motor task, they had to walk at their normal speed during 30 meters and perform a manual task, being carrying a tray with glasses. Both task were also performed simultaneously (dual motor task). The intra-class correlation (ICC) was found very high in both MS and control group.

Some studies have focused on other neurological diseases. In the study of Strouwen et al. (2016), reliability of several CMI paradigms were investigated in Parkinson’s disease. The values of the DTC for the ‘digit span’ task combined with comfortable walking was up to 0.87, which was very high. Muhaidat, Kerr, Evans, & Skelton (2013) tested the inter-rater reliability in fallers and non-fallers, where eight dual tasks were assessed. Motor tasks were walking 10m straight right door, TUG, avoiding a moving obstacle and a manual task was carrying a cup of water. The cognitive tasks were naming animals and subtraction in threes. The reliability of performance gait speed in ST and DT ranged from poor to excellent (ICC 0.11 to 0.79). The intra-class correlation (ICC) of the TUG was also verified in a healthy population by Hofheinz & Schusterschitz (2010). Practicing the TUG meanwhile receiving a cognitive order (counting back in threes) gave an intra-rater reliability of 0.94.

The test-retest reliability has also been tested in people with chronic stroke (Yang, He, & Pang, 2016). People had to walk at their self-selected speed, their maximal speed, avoid crisscross some obstacles or walk backward at a self-selected speed. The three attentiondemanding tasks were (single or dual): carrying a cup of water in their non-paretic hand, counting back in threes and giving as many words as they can when a category was given by the therapist. A good to excellent reliability (0.70-0.93) was found for walking time under dual task. In the second session, the correct response rate (CRR) was significantly higher, while a decrease of spilled water was found under dual task. No significant changes in dual task effect were detected between the first and the second session (Yang et al., 2016).

The aim of current study is to investigate the test-retest reliability of diverse dual task test conditions in persons with MS and age-gender matched healthy controls. For motor DTC, cognitive DTC, combined DTC, intra-class correlations (ICC) and Spearman correlations were calculated to measure the reliability of the diverse tasks.

2.3 Methods

2.3.1 Participants

According to the significance level, power and effect size, a minimum of 20 persons per group were needed to be evaluated two times (test and retest) to examine the reliability of the interference between cognitive tasks and walking defined by the dual task cost (Portney & Watkins, 2009b). For this reason, 22 pwMs and 22 age-gender matched healthy subjects were assessed twice, approximately five days apart at the same time of the day, in the Finnish Neurological Rehabilitation Centre in Masku and the Centre Hospitalier Universitaire (CHU) de Liège, Belgium. The typical ration seen in MS population of 2:1 (women:men) was sought. The objective was to have an equal distribution of men and women in both groups. Unfortunately, one MS man in Liège and one HC woman in Masku dropped out, so there was no equal distribution of men and women between both groups anymore. The MS patients were recruited in their own neurological centre, while the healthy subjects were recruited by flyers or were acquaintances from the assessors.

The participants of the MS group had to be diagnosed with the disease of MS, according to the McDonald criteria, and had to be between 18 and 65 years old (Polman et al., 2011). All types of MS were allowed. Other inclusion criteria were: 1) an Expanded Disability Status Scale (EDSS) between two and five as determined by neurologists, which includes ability to walk without aid or rest some 200m, 2) no relapse within the last 30 days, 3) no changes in disease modifying treatment and no corticoid-therapy within the last 50 days.

4) An appropriate cognitive capacity (MMSE ≥ 26, see appendix document 2) and 5) the presence of dual task interference (dual task screening list ≥1, see appendix document 3) (Strouwen et al., 2014). Exclusion criteria where the following: 1) other medical conditions interfering with mobility (e.g. acute/subacute fractures, pregnancy >20w, …), 2) other neurological diagnoses (stroke, Parkinson, …), 3) MS-like syndromes such as neuromyelitis optica, 4) not able to understand and execute simple instructions, 5) problems (even after adjustment with hearing aids or glasses) with hearing or vision interfering with the assessment and 6) ongoing dual task training or other interfering physical therapy or cognitive training / neuropsychological rehabilitation.

Also 22 age-gender matched healthy controls were screened and tested, following the same procedure as the MS group.

The leading ethical committee of the Centre Hospitalier Universitaire de Liège and local ethical committee in Finland have approved this study and all participants received written information and signed an informed consent form.

2.3.2 Procedure

This study is part of a larger project investigating cognitive-motor interference in persons with MS on dual task assessment and training. For the reliability, testing was spread over three days. On the first testing day (T0) descriptive outcomes (demographical, cognitive, mobility, quality of life measures and a dual task screening list) were assessed. On the second testing day (T1), experimental cognitive-motor interference measures (single cognitive, single motor and dual cognitive-motor tasks) were assessed and repeated at the third testing day (T2). There was a time window of approximately six to ten working days foreseen to complete the whole test battery at the different measurement points. All measures were assessed according to a standardized instruction booklet, including details on test procedures, verbal instructions and level of encouragement.

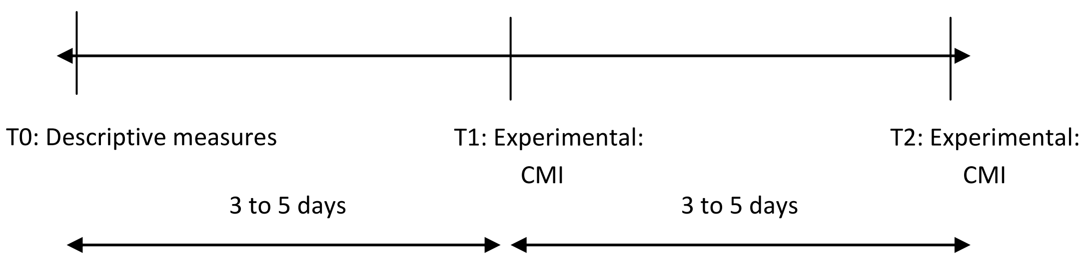


Figure 1: scheme (procedure) of the testing

2.3.3 Outcome measures

2.3.3.1 Descriptive measures

On the first testing day (T0), following patient characteristics were recorded for MS patients: age, gender, disease duration since diagnosis, type of MS (relapsing remitting, primary progressive, secondary progressive), disability level by the use of the Expanded Disability Status Scale (EDSS), the history of falling in the past six months, their living arrangement and years of education. The same characteristics were recorded for the healthy subject, except the MS related topics. Several cognitive and mobility measures were also assessed.

2.3.3.1.1 Cognitive outcome measures

The Brief Repeatable Battery of Neuropsychological Tests (BRB-NT) was used to assess to the patient's cognitive function (Boringa et al., 2001). The BRB-NT incorporated several tests. The first one was the Selective Reminding Test (SRT), a test of verbal memory acquisition. After the therapist enumerated a list of 12 words, the patient had to tell him as much words as he remembered and that six times in a row. The words that he missed were recalled by the therapist. Long Term Storage was defined as any word that is spontaneously recalled, i.e. without reminding, and was identified by two consecutive recalls of the word. The second test was the 10/36 Spatial Recall Test (SPART), a visual memory acquisition test. For 10 seconds, a checkerboard with a design on it was placed in front of the patient. After these 10 seconds, the checkerboard was removed and the patient had to make the same design on his empty checkerboard. The number of correct and confab answers were counted. The third and fourth test were the Symbol Digit Modalities Test (SDMT) and the Paced Auditory Serial Addition Test (PASAT), both an attention, concentration, and speed of information processing test. For the SDMT, the patient had to write the correct number under a given symbol. Each number from one to nine had a different symbol. After 90 seconds, the patient was told to stop. The PASAT was the most difficult one. The patient heard a list of single digit numbers (represented at the rate of one every three seconds first, then at a rate of one every two seconds). The patient had to add the first two digits up and tell the answer to the therapist. When he/she heard the next number, he/she had to add it to the one he heard right before that. The fifth and sixth test were the SRT-delay and the SPART delay. These were the same tests as mentioned above (SRT and SPART), but after a delayed time. The last one was the Word List Generation (COWAT) for verbal fluency on semantic stimulus. For this test, the category “fruits and vegetables” was given to the patient and he/she had to enumerate every word that came in his/her mind that has to deal with that category during 90 seconds. The tests of the BRB-NT was administered in the following order: SRT , SPART, SDMT, PASAT 3”, PASAT 2”, SRT-Delayed (SRT-D), SPART-Delayed (SPART-D), COWAT.

2.3.3.1.2 Mobility outcome measures

Diverse mobility performance scales, self-reported questionnaires and habitual walking were also assessed. Performance scales quantified the mobility ability, while questionnaires gave us a better view insight in the subjects’ perception and behavioral consequences of disability problems on the impact on activities of daily life.

Walking speed was measured by the Timed 25 Foot-walk (T25FW). The patient was instructed to walk 25 feet (7.62m) first two times at a normal speed, then two times as quickly as possible, but still safely. Mean score of the T25FW with normal speed and mean of the quick T25FW was taken. For the Timed up and go (TUG), the time taken (in seconds) to stand up from a standard arm chair, walk three meters, turn, walk back to the chair, and sit down was recorded twice. The patient had to walk as quickly as possible, but still safe. Also here, the mean score was taken. During the Dynamic Gait Index (DGI) the patient was asked e.g. to walk a normal speed, turning their head left-right and up-down or changing their speed, and the two-minutes walking test (2MWT), were the patient had to walk as quickly as possible for two minutes, captured the walking endurance. Questionnaires (patient-reported outcome measures) included the Multiple Sclerosis walking scale-12 (MSWS-12) to assess subjective walking ability and Falls Efficacy Scale - International (FES-I) evaluating the concern about the possibility to fall. These measures were administered in the following order: T25FW, TUG, MSWS-12, DGI, FES-I, 2MWT.

2.3.3.1.3 Quality of life – participation

After the completion of the cognitive and motor measures, the assessor asked the subjects to fulfill two questionnaires: the Multiple Sclerosis Impact Scale-29 items (MSIS-29) measuring the impact of MS and the Modified Fatigue Impact Scale (MFIS) measuring the severity of fatigue. These two questionnaires were completed by the pwMS group only.

2.3.3.2 Experimental outcomes

2.3.3.2.1 CMI (cognitive-motor interference)

On the second and third testing day, single cognitive, single motor, and integrated cognitive-motor assessments were recorded. The order in which the blocks of single cognitive/motor or cognitive-motor dual tasks were performed were computerized randomized, but remained the same in each test session for the participant. Single cognitive/motor and cognitive-motor dual tasks were performed during one minute. The assessor had to be sure the participants understood the task prior to the start of the assessment itself. Participants had a break of about a minute between the trials while the assessor was setting up the next trial. The whole test had a during of approximately one hour.

2.3.3.2.1.1 Cognitive tasks & parameters

Three different cognitive functions (working memory, information processing speed and sustained attention) at a high complexity level were used as cognitive distracters.

- **Titrated digit span backwards**

The digit span was used as a part of executive function. Participants had to listen to a titrated string of digits (e.g., three-two-five) at the presented rate of one per second and repeated them in the reverse order. The sequence of digits was delivered by an auditory program through a developed tablet application and the participants response was recorded on the tablet and via a wireless headset microphone (Logitech H110 USB Wireless Headset with Noise Cancelling Microphone) allowing the assessor to calculate afterwards the number of answers correctly recalled. The sequence length was assessed for each patient before the first trial in order to determine the subject’s digit span (titrated): four trials were given at each sequence length starting from three digit length. If three out of four trials at a given length were correct, the participant had passed that sequence length and the length was increased by one digit. Each participant’s digit span was determined as the last sequence length at which three out of four (75%) trials were correct. The same length was hold for all the trials that incorporated the ‘digit span’.

- **Auditory vigilance with alphabets**

Vigilance refers to a "state of readiness to detect and respond to certain small changes occurring at random time intervals" (Mackworth, 1957). Participants listened 60 seconds to recorded alphabets at the presented rate of one letter per two and one half seconds. Two letters out of the alphabet were targeted letters. He/she said aloud 'yes' every time he/she heard that targeted letters and he/she was not allowed to talk when another letter than the targeted ones was heard (24 letters all together of which 10 target letters). Number of correct responses was measured as the participant said 'yes' to a targeted letter or was silent when another one was heard. The same equipment was used as for the titrated digit span.

- **Counting backwards by 7, starting from '102, 144, 165, 174, 198'**

Starting from a given number, the patient had to count backwards by seven after hearing one of the above numbers. Performance of this task was measured by the number of correct serial subtractions.

2.3.3.2.1.2 Motor tasks & parameters

The chosen motor tasks in this study included common walking activities carried out in daily life:

- Walking at self-selected speed
- Walking at self-selected speed while stepping over low obstacles (10 cm height) every three meters in a straight line
- Walking at self-selected speed crisscross from cone to cone every two meters, fixed 80cm width
- Walking at self-selected speed while carrying a regular cup filled with water.

These walking activities were standardized performed based on course set up specifications. The same quite (no by-passing persons) corridor of 30m was used as testing location for each measurement point.

For the motor and dual tasks, the APDM system "Mobility Lab" was used for quantifying participant's movement involving mobility. People had to wear 3 APDM sensors (one on each foot and one on the lumbar region). In this study, walking speed (m/s) and turn duration (°/s) were used for calculating motor DTC.

The hand function was evaluated by asking two questions based on the Motor Activity Log (MAL) (see appendix document 5): “Tell me how you would rate the amount you used your best arm to perform activities of daily living?” and “Tell me how you would rate how well you used your best arm to perform activities of daily living?” (Taub et al., 1993).

2.3.3.2.1.3 Dual cognitive-motor task performance

Participants were instructed to perform simultaneously the motor and cognitive task at their best level, without giving more priority to one task then on the other one. The combination of three cognitive and four motor tasks will lead to the performance of 12 dual cognitive-motor tasks. The assessments of each cognitive and motor task were performed using the same procedures described for the single cognitive or motor task conditions. For calculating the motor DTC, the walking speed (m/s) was selected, expect for the ‘crisscross’ tasks, were the turn duration (°/s) was used.

- Motor DTC (%) = $\left(\frac{\text{ST motor score} - \text{DT motor score}}{\text{ST motor score}}\right)$*100

For the cognitive DTC, the number of correct answers was used for both single and cognitive tasks.

- Cognitive DTC (%) = $\left(\frac{\text{ST cognitive score} - \text{DT cognitive score}}{\text{ST cognitive score}}\right)$*100

For the combined DTC, both motor and cognitive DTCs were added up and divided by two.

- Combined DTC (%) = $\left(\frac{\text{DTC motor} + \text{DTC cognitive}}{2}\right)$*100

2.3.3.2.2 Dual task questionnaire

At the end of the second testing day, people also had to fill in a dual task questionnaire (appendices document 4; Evans, Greenfield, Wilson, & Bateman, 2009). This questionnaire contained 14 questions and verified if the patients had some problems with practicing dual tasks (e.g. walking and phoning). Both groups had to fill it in.

2.3.3.3 Statistics

Data were analyzed with IBM SPSS Statistics 24.

Normality of the data was assessed with the Shapiro-Wilk test, QQ plots and histograms. For the descriptive part, mean and standard deviations (SD) were provided for continue data, while for ordinal data, median and interquartile ranges (IQR) and for categorical data frequency and percentage were provided. For the primary outcome, mean and standard deviations were also calculated for the DTCs. DTCs above the three standard deviations were seen as outliers and excluded from further analyses. If data were normally distributed for cognitive, motor or combined DTC, t-test was calculated followed by ICC calculations with a two-way random effect with absolute agreement ($ICC_{2,1}$). The cut-offs from Shrout and Fleiss' were used to name the importance of correlation: <0.40 was poor, 0.40-0.75 was fair to good and >0.75 was excellent (Portney & Watkins, 2009c; Shrout & Fleiss, 1979). Standard error measures (SEM) and Minimal Clinical Differences were also calculated (SEM = SD pooled * $\sqrt{1 - \mathrm{ICC}}$; MDC = SEM * 1.96 *√2) (Strouwen et al., 2016; Weir, 2005). To visualize the mean differences between two tests, a Bland and Altman plot was drawn. This is a method to quantify agreement between two quantitative measurements by constructing the mean difference and the limits of agreement by plotting the differences against the average of the two tests. "It's recommended that 95% of all the data points should lie within ± two standard deviations of the mean difference." (Giavarina, 2015). If data were not normally distributed, the Wilcoxon signed rank test was provided to assess systematic differences between both test sessions. After that, Spearman correlation coefficients were calculated to indicate reliability. An almost perfect reliability was found with a cut-off of >0.80, while a cut-off between 0.80 and 0.61 a moderate reliability indicated (Landis & Koch, 1977).

2.4 Results

2.4.1.1 Descriptive

Table 1 represents the demographic measures of the participants. Due to some dropouts, 44 participants were included in this study: 22 in the MS group and 22 in the healthy control (HC) group. The majority of pwMS were female (73%) with a mean age of 47.72 years. Nineteen people (86.4%) suffered from the relapsing remitting MS, while two suffered from primary progressive MS and only one from secondary progressive MS. The median of the EDSS score was 3.0 (2.5-3.5) and mean disease duration was 12.64 (SD 11.81). MS People studied approximately 16.68 (SD 2.30) years starting from the nursery class. Most MS participants still lived together with their partner and children (77.3%). Eight (36.4%) out of the 22 were retired due to MS, eight were still partly (18.2%) or fully (18.2%) employed, while only three out of the 22 were unemployed. Both groups were comparable looking at age, gender, years of education and living arrangement. However, MS patients were significantly less fully employed. In table 2, measures of mobility, cognitive function, quality of life and a questionnaire for cognitive-motor interference were described. MS persons were mild to moderate disabled on motor level (Gijbels et al., 2012; O'Sullivan et al., 2014), moderate disabled on cognitive functions (Goldman et al., 2013; Boringa et al., 2001) and mild disabled on quality of life (da Silva et al., 2016). Persons with MS scored sign worse on 2MWT, DGI, FES-I, SDMT, PASAT 2 seconds and DTC questionnaire than HC ($p<0.05$).

Table 1: Demographic measures

	MS Patients (n=22)	Healthy Controls (n=22)
Age in years (mean, SD)	47.72 (±9.27)	48.09 (±9.3)
Sex (n, %)		
■ Men	6 (27.3%)	7 (31.8%)
■ Women	16 (72.7%)	15 (68.2%)
Phenotype (n, %)		
■ RR	19 (86.4%)	-
■ SP	1 (4.5%)	-
■ PP	2 (9.1%)	-
EDSS score (median, IQR)	3.0 (2.5-3.5)	-
Disease duration in years (mean, SD)	12.64 (±11.81)	-
Number of falls in the last 6 months (mean, SD)	2.00 (±4.42)	-
Years of Education (mean, SD)	16.68 (±2.30)	17.05 (±2.54)
Living arrangement (n, %)		
■ Alone	3 (13.6%)	2 (9.1%)
■ With family (children…)	10 (45.5%)	13 (59.1%)
■ With partner	7 (31.8%)	7 (31.8%)
■ Other	2 (9.1%)	-
*Work state (n, %) **		
■ Fully employed	4 (18.2%)	16 (72.7%)
■ Partly employed	4 (18.2%)	2 (9.1%)
■ Regular retired (because of age)	2 (9.1%)	2 (9.1%)
■ Retired because of my health	8 (36.4%)	-
■ Unemployed	3 (13.6%)	-
■ Other	1 (4.5%)	2 (9.1%)

Abbreviations: RR (Relapsing Remitting), SP (Secondary Progressive), PP (Primary Progressive), EDSS (Expanded Disability Status Scale), SD (Standard Deviation), IQR (Interquartile Range),
* Significant differences between the two groups ($p<0.05$)

Table 2: Measures of cognitive function, motor function, quality of life (QOL) and questionnaire for cognitive-motor interference (CMI)

	MS Patients (n=22)	Healthy Controls (n=22)
Motor state		
T25FW usual (s) *(mean, SD)*	6.02 (±1.74)	6.32 (±1.01)
T25FW fast (s) *(mean, SD)*	4.80 (±1.06)	4.39 (±0.70)
TUG (s) *(mean, SD)**	6.94 (±1.32)	6.11 (±1.29)
2MWT (m) *(mean, SD)**	182.18 (±33.78)	218.14 (±25.92)
MSWS-12 (0-100) (median, IQR)	33.34 (18.27-57.29)	-
DGI (0-24) (median, IQR)*	24.00 (21.75-24)	24.00 (24.00-24.00)
FES-I (16-64) (median, IQR)*	24.00 (20.75-32.50)	16.00 (16.00-17.00)
Cognitive state (BRB-NT) (mean, SD)		
SRT-Long term (0-70)	50.23 (±11.33)	53.77 (±11.37)
SRT-Consistent (0 -70)	40.23 (±14.02)	45.55 (±15.32)
SRT delay (0-12)	10.05 (±2.17)	10.14 (±2.05)
10/36 SPART total (0-30)	21.41 (±5.16)	20.68 (±4.49)
10/36 SPART delay (0-10)	7.14 (±2.19)	7.91 (±2.09)
SDMT (0-110) *	40.32 (±17.09)	54.26 (±9.85)
PASAT 3 (0-60)	43.76 (±9.81)	48.23 (±14.50)
PASAT 2 (0-60) *	32.62 (±9.63)	41.91 (±12.57)
WLG (n)	30.22 (±8.8)	30.55 (±9.67)
QOL (median, IQR)		
MSIS-29 (0-100)		
MSIS-29 Physical	19.38 (13.44-35.00)	-
MSIS-29 Psychological	22.22 (13.20-34.03)	-
MFIS (0-84)		
MFIS Physical (0-36)	16.00 (10.75-23.25)	-
MFIS Cognitive (0-40)	16.00 (10.75-23.25)	-
MFIS Psychosocial (0-8)	3.00 (1.00-4.00)	-
CMI		
Dual Task questionnaire* [1] (0-40)	15.00 (9.50-21.00)	4.50 (1.50-6.00)

Abbreviations: T25FW (Timed 25-Foot Walk), TUG (Timed Up and Go), 2MWT (2 Minute Walking Test), MSWS-12 (12 Item MS Walking Scale), DGI (Dynamic Gait Index), FES-I (Fall Efficacy Scale - International), BRB-NT (The Brief Repeatable Battery of Neuropsychological Tests), SRT (Selective Reminding Test), SPART (Spatial Recall Test) SDMT (Symbol Digit Modalities), PASAT (Paced Auditory Serial Addition Test), WLG (World List Generation), QOL (Quality of Life), MSIS-29 (Multiple Sclerosis Impact Scale-29), MFIS (Modified Fatigue Impact Scale), CMI (Cognitive Motor Interference), SD (Standard Deviation), IQR (Interquartile Range)

* Significant differences between the two groups ($p<0.05$)

[1]Evans, Greenfield, Wilson, & Bateman (2009)

2.4.1.2 Reliability

In general, the distributions of the DTCs were mostly not normally distributed, expect for some conditions for motor and combined DTC. DTC values ranged from 3.63% to 17.73% for walking speed (table 3a) and from -1.74% to 23.14% for cognition (table 4a) in the MS group. In the HC group DTC values varied from 9.00% to 18.64% (table 3b) for walking speed and from -4.21% to 16.04% (table 4b) for cognition. The motor DTC was mostly much higher than the cognitive DTC in the MS group and always much higher in the HC group. All cognitive tasks combined with the 'walk' conditions and all motor conditions combined with the 'vigilance' condition, showed a higher correlation for the motor parameter compared to the cognitive parameter in both groups.

2.4.1.2.1 Motor DTC

Motor DTC did significantly differ from values on the second test day only for the conditions 'digit span obstacles', 'digit span cup' and 'subtraction obstacles' in the MS group ($P<0.05$) (table 3a) and for 'digit span cup' ($P<0.05$) in the HC group (table 3b). Only two ICC's (table 3a) and Bland and Altman plots (figure 2 and 3) could be calculated in the MS group and one in the HC group (figure 4). Points were perfectly distributed for 'vigilance cup' (figure 3), but more or less equally distributed around zero for 'subtraction cup' (figure 2) so still showing at least one bias in the results. In the MS group, ICCs and Spearman correlations ranged from 0.13 to 0.82, with significantly moderate to high values for all conditions, expect for the 'digit span crisscross' and 'subtraction crisscross'. In the HC group, ICCs and Spearman correlations ranged from 0.43 to 0.92. For the 'digit span walk' and 'subtraction cup' correlations were found higher in the MS group compared to the HC group. All other tasks had a lower or equal correlation in the MS group. The highest correlation was found for the 'vigilance walk' in the HC group, which was the second highest in the MS group. The lowest correlations were found for the 'digit span crisscross' in the MS group and for the 'vigilance crisscross' in the HC group. For the motor tasks, the 'walking conditions' showed highest correlations and 'crisscross conditions' showed the lowest correlations in the MS group, while in the HC group 'walking conditions' and 'obstacles conditions' the highest correlations showed and 'cup conditions' the lowest. No priority could be made between cognitive tasks in the MS group, while in the HC group the highest correlations were found for 'digit span conditions'.

Tabel 3a: Test-retest score of MS people for motor Dual-task cost (%) and statistical analyses on difference (Wilcoxon Signed Rank test or T-test) and correlation (Spearman or ICC)

Task	Test day 1 $\bar{X}$ (SD)	Test day 2 $\bar{X}$ (SD)	Wilcoxon Signed Rank test (p-value)	Spearman correlation	T-test value	ICC (CI 95%)	SEM	MDC
Digit span Walk	16.37 (11.97)	15.69 (9.52)	0.74	**0.82****	na	na	na	na
Digit span Obstacles	14.06 (11.54)	8.51 (8.45)	0.03	**0.46***	na	na	na	na
Digit span Crisscross	11.64 (9.92)	14.27 (10.11)	0.76	0.13	na	na	na	na
Digit span Cup	17.06 (12.25)	13.25 (8.24)	0.05	**0.70****	na	na	na	na
Subtraction Walk	17.73 (9.99)	17.35 (7.95)	0.41	**0.72****	na	na	na	na
Subtraction Obstacles	15.62 (9.42)	12.61 (8.38)	0.02	**0.63****	na	na	na	na
Subtraction Crisscross	14.24 (10.18)	15.37 (9.71)	0.81	0.32	na	na	na	na
Subtraction Cup	16.48 (13.74)	14.53 (8.20)	0.17	**0.71[1]****	0.18	0.78 (0.46-0.91)	1.86	5.15
Vigilance Walk	8.82 (8.82)	9.99 (6.78)	0.14	**0.80****	na	na	na	na
Vigilance Obstacles	5.17 (8.57)	3.63 (6.37)	0.14	**0.67****	na	na	na	na
Vigilance Crisscross	6.17 (9.93)	8.77 (11.23)	0.64	**0.43***	na	na	na	na
Vigilance Cup	9.43 (9.20)	8.67 (6.21)	0.52	**0.62[1]****	1.13	0.58 (-0.06 – 0.83)	2.10	5.82

*Significance level of 0.05
**Significance level of 0.01

SD (Standard Deviation), ICC (Intra-class correlation), CI (Confidence Interval), SEM (Standard Error Measurement), MDC (Minimal Detectable Change), na (not applicable)

In case of non-normally distributed data, Wilcoxon is presented instead of the t-value to indicate differences between both tests and Spearman correlations are presented instead of ICC values.

[1] Values for Wilcoxon Signed Rank and Spearman correlation for ‘subtraction cup’ and ‘vigilance cup’ were added to compare differences between both test moments

Table 3b: Test-retest score of HC people for motor Dual-task cost (%) and statistical analyses on difference (Wilcoxon Signed Rank test or T-test) and correlation (Spearman or ICC)

Task	Test day 1 X̄ (SD)	Test day 2 X̄ (SD)	Wilcoxon Signed Rank test (p-value)	Spearman correlation	T-test value	ICC (CI 95%)	SEM	MDC
Digit span Walk	14.65 (9.97)	13.29 (7.62)	1.00	0.73	na	na	na	na
Digit span Obstacles	15.21 (7.64)	14.03 (9.45)	0.43	0.73	na	na	na	na
Digit span Crisscross	17.37 (11.27)	18.44 (12.95)	0.99	**0.65[1]****	-0.59	0.86 (0.67-0.94)	1.81	5.02
Digit span Cup	16.66 (8.43)	14.79 (9.08)	0.01	0.87	na	na	na	na
Subtraction Walk	18.64 (9.81)	17.49 (9.79)	0.51	0.77	na	na	na	na
Subtraction Obstacles	15.07 (7.77)	14.42 (9.70)	0.61	0.77	na	na	na	na
Subtraction Crisscross	16.95 (11.36)	18.01 (10.51)	0.76	**0.72****	na	na	na	na
Subtraction Cup	17.23 (8.67)	17.44 (8.43)	0.57	0.65	na	na	na	na
Vigilance Walk	11.00 (8.97)	10.13 (7.21)	0.82	0.92	na	na	na	na
Vigilance Obstacles	9.38 (7.46)	9.00 (8.95)	0.52	0.67	na	na	na	na
Vigilance Crisscross	11.93 (11.68)	10.48 (8.04)	0.12	0.43	na	na	na	na
Vigilance Cup	11.34 (6.51)	11.01 (8.05)	0.59	0.66	na	na	na	na

*Significance level of 0.05

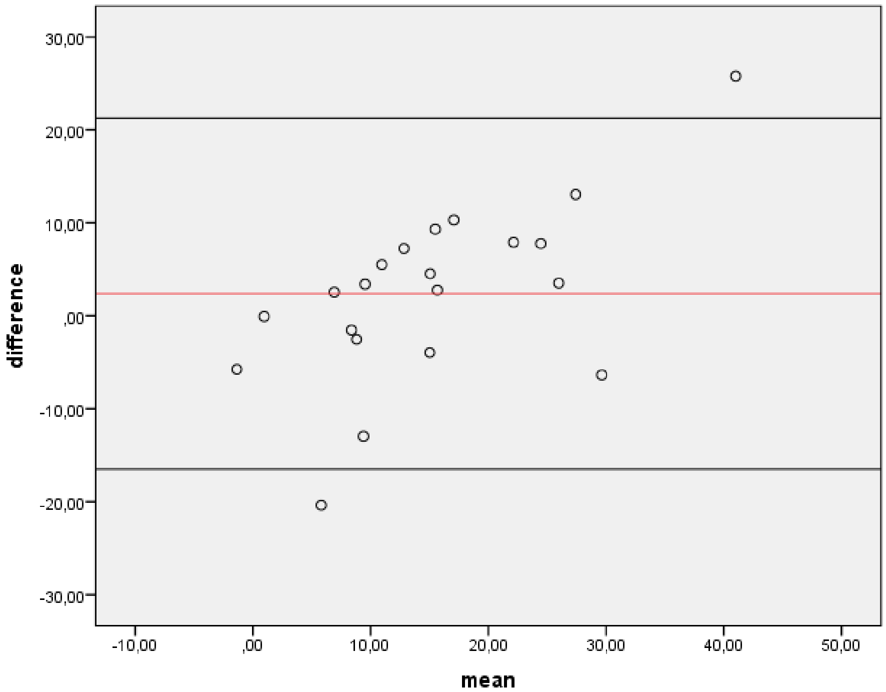
**Significance level of 0.01

SD (Standard Deviation), ICC (Intra-class correlation), CI (Confidence Interval), SEM (Standard Error Measurement), MDC (Minimal Detectable Change), na (not applicable)

In case of non-normally distributed data, Wilcoxon is presented instead of the t-value to indicate differences between both tests and Spearman correlations are presented instead of ICC values.

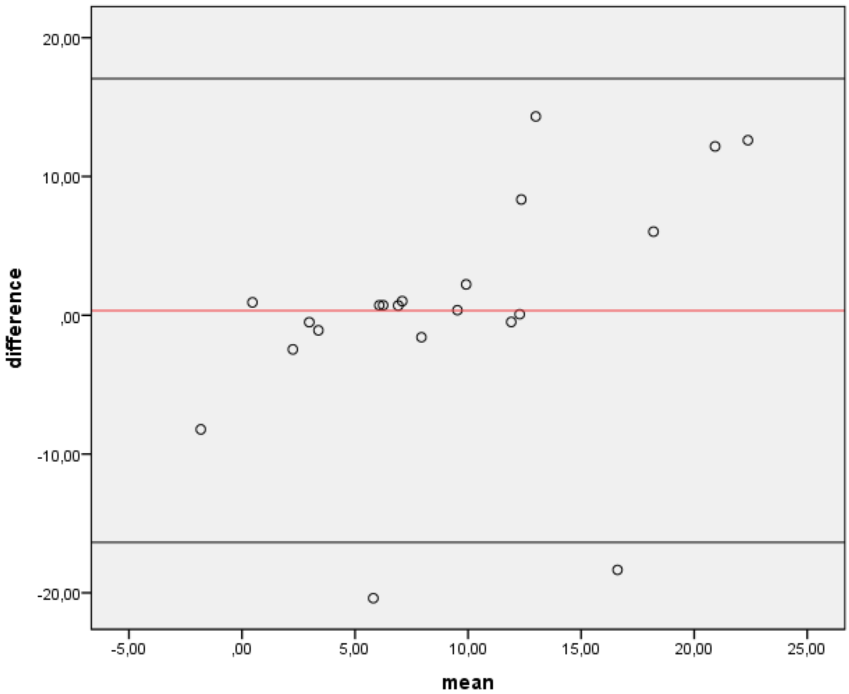
[1]Values for Wilcoxon Signed Rank and Spearman correlation for ‘digit span crisscross’ were added to compare differences between both test moments

Figure 2: Difference between test day 1 and test day 2 (percentage) for the 'subtraction cup' in the MS group (motor DTC)



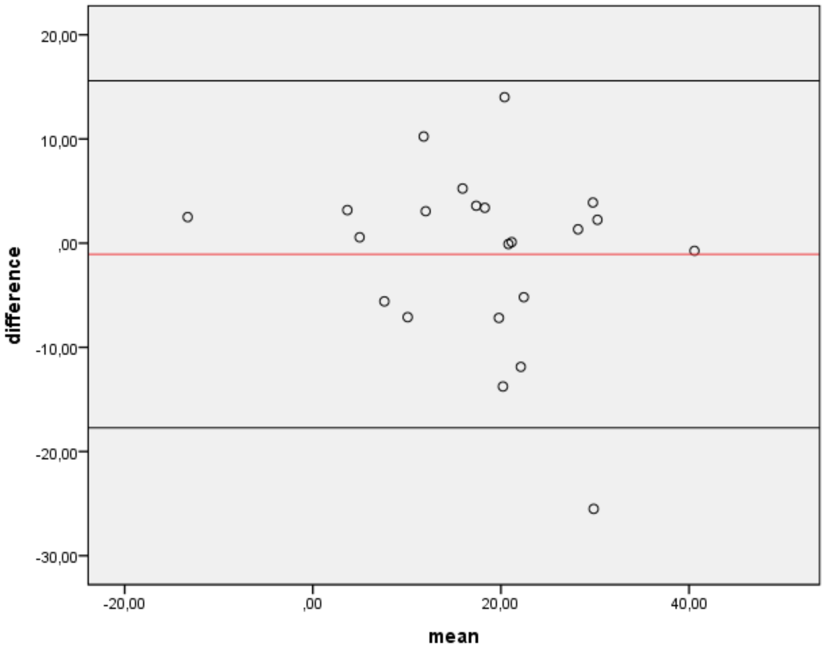
Graphic 1: Subtraction Cup MS (Motor)

Figure 3: Difference between test day 1 and test day 2 (percentage) for the 'vigilance cup' in the MS group (motor DTC)



Graphic 2: Vigilance Cup MS (Motor)

Figure 4: Difference between test day 1 and test day 2 (percentage) for the 'digit span crisscross' in the HC group (motor DTC)



Graphic 3: DigitSpan Crisscross HC (Motor)

2.4.1.2.2 Cognitive DTC

In the MS group, cognitive DTC on test day 1 did not significantly differ from values on the second measurement time point (table 4a). This was also the case for the HC group, with exception for the 'vigilance walk' and 'vigilance crisscross' ($P<0.05$) (table 4b). In the MS group, Spearman correlations ranged from -0.23 to 0.43, with one significant value for the 'vigilance crisscross' test condition ($P<0.05$). In the HC group correlations ranged from -0.40 to 0.54, with a significant value for the 'subtraction walk' ($P<0.05$) condition. No correlations were found for 'vigilance obstacles' and 'vigilance cup' in the HC group. The reason for this is that almost all participants, during the second testing day, had a maximum score on these 2 tasks. We can speak here of a ceiling effect. For the 'digit span' conditions correlations were mostly higher in the MS group compared to the HC group, while the opposite was found for the 'subtraction tasks'. The 'subtraction' task condition revealed slightly higher correlations than the 'digit span' and 'vigilance' tasks, but this was only the case in the HC group. For the motor tasks, the 'walking conditions' compared to all other motor conditions ('cup, 'obstacles' and 'vigilance') showed the highest correlations in the HC group, while in the MS group no clear priority could be made.

2.4.1.2.3 Combined DTC

Combined DTC did not significantly differ from values on the second measurement time point in the MS group (table 5a). In the HC group, this was only the case for the 'digit span obstacles' (P<0.05) (table 5b). No ICC's could be calculated in the MS, while in the HC only two could be calculated (figure 5 and 6). Points on the Bland and Altman plots were also here more or less equally distributed around zero, but still showing at least one bias in the results. The highest ICC was found in the HC group for the 'vigilance cup' (ICC=0.74), which is fair to good.

In the MS group, Spearman correlations ranged from 0.06 to 0.61, with significant values for 'digit span walk' (P<0.05), 'digit span crisscross' (P<0.05), 'vigilance walk' (P<0.01) and 'vigilance obstacles' (P<0.05). In the HC group, correlations ranged from -0.33 to 0.80, with significant values for 'subtraction crisscross' (P<0.05) and the 'vigilance walk' (P<0.01). Like found for motor DTC, the highest correlation, with a significant value, was found for the 'vigilance walk' and this in both groups. Correlations were found higher in the MS group for all tasks, expect for 'subtraction crisscross' and 'vigilance walk' who showed lower correlations compared to the HC group. Comparing the motor conditions, the 'walking' conditions showed the highest correlations, while the 'cup' conditions the lowest correlations showed in the MS group. In the HC group, the highest correlation was found for the 'crisscross' conditions, while the lowest for the 'cup' conditions". For comparing the reliability between the diverse cognitive tasks, 'digit span' conditions showed the highest correlations in the MS group, while all 'subtraction' conditions a lower correlation showed. In the HC group, no real consistency could be found for the conditions with the highest correlations, while the 'digit span conditions' the lowest correlations showed.

Table 4a: Test-retest score of MS people for cognitive Dual-task cost (%) and statistical analyses on difference and correlation

Task	Test day 1 X̄ (SD)	Test day 2 X̄ (SD)	Wilcoxon Signed Rank test (p-value)	Spearman correlation
Digit span Walk	19.92 (32.16)	9.65 (21.08)	0.14	0.33
Digit span Obstacles	23.14 (24.38)	16.92 (20.61)	0.54	0.26
Digit span Crisscross	20.42 (56.18)	16.03 (21.99)	0.36	0.20
Digit span Cup	19.19 (22.25)	-1.74 (40.15)	0.26	0.30
Subtraction Walk	5.42 (25.89)	12.10 (23.42)	0.61	0.16
Subtraction Obstacles	26.82 (29.19)	13.10 (18.38)	0.18	-0.23
Subtraction Crisscross	8.78 (33.55)	12.47 (22.86)	0.96	0.34
Subtraction Cup	3.42 (39.27)	9.64 (15.85)	0.60	-0.01
Vigilance Walk	2.66 (4.75)	0.70 (4.67)	0.11	0.27
Vigilance Obstacles	2.18 (3.91)	2.05 (6.10)	0.51	0.12
Vigilance Crisscross	1.38 (3.65)	0.91 (3.89)	0.55	**0.43***
Vigilance Cup	2.40 (4.74)	1.00 (1.83)	0.28	0.11

*Significance level of 0.05

Table 4b: Test-retest score of HC people for cognitive Dual-task cost (%) and statistical analyses on difference and correlation

Task	Test day 1 X̄ (SD)	Test day 2 X̄ (SD)	Wilcoxon Signed Rank test (p-value)	Spearman correlation
Digit span Walk	4.24 (33.94)	-4.21 (23.84)	0.51	-0.40
Digit span Obstacles	12.41 (27.00)	11.68 (32.61)	0.86	0.19
Digit span Crisscross	11.92 (34.37)	5.42 (26.86)	0.37	0.04
Digit span Cup	5.28 (29.13)	7.11 (24.07)	0.86	0.10
Subtraction Walk	7.50 (25.94)	11.40 (14.56)	0.62	**0.54***
Subtraction Obstacles	4.51 (29.76)	10.67 (20.31)	0.28	0.19
Subtraction Crisscross	9.12 (25.65)	16.04 (16.65)	0.18	0.43
Subtraction Cup	-5.06 (23.32)	2.92 (17.45)	0.09	0.14
Vigilance Walk	2.65 (3.97)	0.00 (0.00)	0.02	/
Vigilance Obstacles	2.84 (4.34)	1.33 (2.37)	0.15	-0.10
Vigilance Crisscross	2.08 (2.80)	0.40 (1.25)	0.01	/
Vigilance Cup	0.66 (1.56)	1.33 (1.99)	0.70	-0.22

*Significance level of 0.05

Table 5a: Test-retest score of MS people for combined Dual-task cost (%) and statistical analyses on difference and correlation

Task	Test day 1 $\bar{X}$ (SD)	Test day 2 $\bar{X}$ (SD)	Wilcoxon Signed Rank test (p-value)	Spearman correlation
Digit span Walk	13.54 (24.51)	12.51 (12.99)	0.30	**0.46***
Digit span Obstacles	9.95 (29.73)	7.40 (18.91)	0.46	0.41
Digit span Crisscross	15.94 (28.35)	15.15 (13.14)	0.46	**0.45***
Digit span Cup	7.74 (31.11)	5.75 (20.69)	0.85	0.21
Subtraction Walk	9.18 (18.04)	14.73 (12.49)	0.61	0.26
Subtraction Obstacles	17.75 (20.46)	12.91 (10.23)	0.23	0.06
Subtraction Crisscross	10.66 (16.57)	13.83 (11.97)	0.64	0.19
Subtraction Cup	4.04 (26.66)	12.15 (8.10)	0.39	-0.10
Vigilance Walk	5.94 (4.28)	5.34 (3.34)	0.36	**0.61****
Vigilance Obstacles	4.20 (5.04)	2.76 (3.78)	0.20	**0.45***
Vigilance Crisscross	4.12 (3.95)	3.66 (6.24)	0.41	0.33
Vigilance Cup	6.31 (5.27)	3.41 (4.45)	0.08	0.20

*Significance level of 0.05

**Significance level of 0.05

Table 5b: Test-retest score of HC people for combined Dual-task cost (%) and statistical analyses on difference (Wilcoxon Signed Rank test or T-test) and correlation (Spearman or ICC)

Task	Test day 1 $\bar{X}$ (SD)	Test day 2 $\bar{X}$ (SD)	Wilcoxon Signed Rank test (p-value)	Spearman correlation	T-test value	ICC	SEM	MDC
Digit span Walk	9.73 (16.58)	5.46 (13.71)	0.85	-0.33	na	na	na	na
Digit span Obstacles	12.61 (12.17)	-4.58 (24.73)	0.01	-0.23	na	na	na	na
Digit span Crisscross	15.22 (18.83)	11.93 (15.61)	0.50	0.22[1]	0.62	0.48 (-0.29 – 0.79)	4.45	12.33
Digit span Cup	12.17 (16.36)	11.12 (13.97)	0.36	0.32	na	na	na	na
Subtraction Walk	12.90 (14.46)	14.44 (9.93)	0.72	0.30	na	na	na	na
Subtraction Obstacles	10.97 (11.43)	14.49 (14.10)	0.48	0.34	na	na	na	na
Subtraction Crisscross	12.68 (14.16)	17.03 (10.31)	0.08	**0.53***	na	na	na	na
Subtraction Cup	6.29 (13.12)	11.68 (10.06)	0.07	0.03	na	na	na	na
Vigilance Walk	6.68 (4.99)	5.16 (3.49)	0.12	**0.80****	na	na	na	na
Vigilance Obstacles	5.62 (2.93)	5.16 (4.69)	0.58	0.24	na	na	na	na
Vigilance Crisscross	7.21 (5.92)	5.64 (4.27)	0.09	0.41	na	na	na	na
Vigilance Cup	7.27 (4.64)	6.17 (3.96)	0.29	0.65[1]**	0.99	0.74	0.84	2.33

*Significance level of 0.05

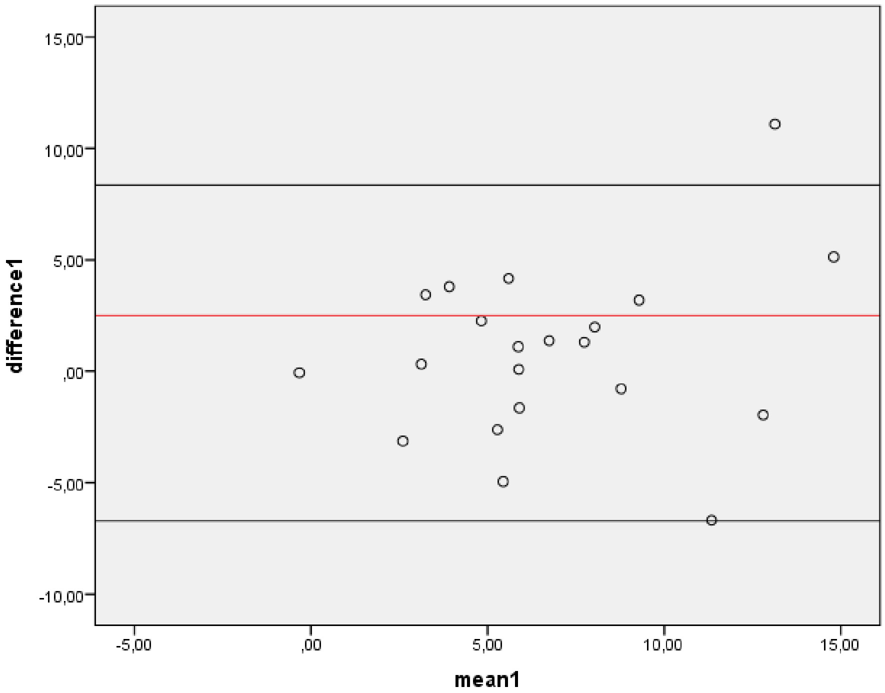
**Significance level of 0.01

SD (Standard Deviation), ICC (Intra-class correlation), CI (Confidence Interval), SEM (Standard Error Measurement), MDC (Minimal Detectable Change), na (not applicable)

In case of non-normally distributed data, Wilcoxon is presented instead of the t-value to indicate differences between both tests and Spearman correlations are presented instead of ICC values.

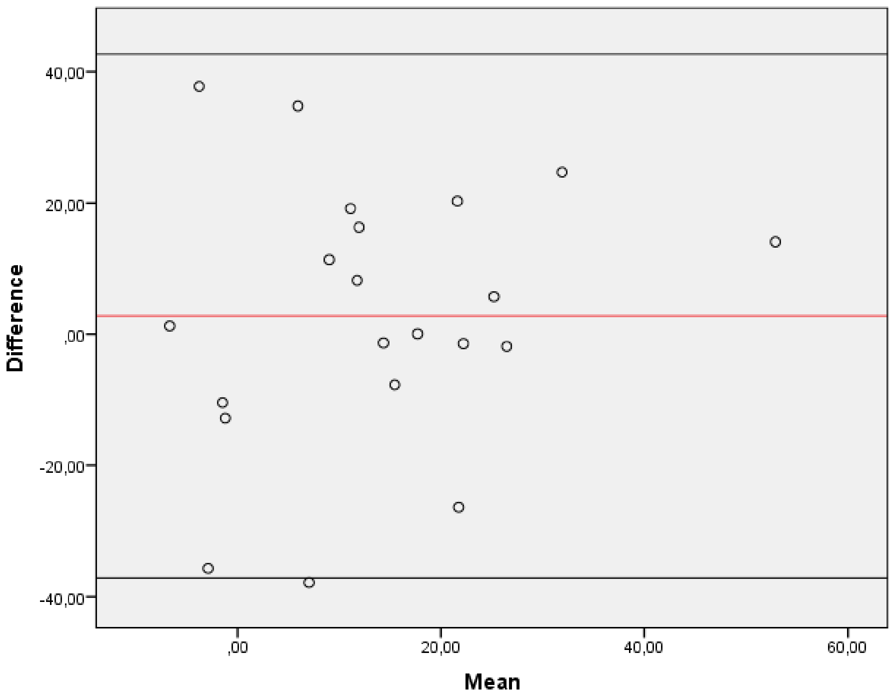
[1] Values for Wilcoxon Signed Rank and Spearman correlation for "digit span crisscross" and "vigilance cup" were added to compare differences between both test moments

Figure 5: Difference between test day 1 and test day 2 (percentage) for the 'vigilance cup' in the HC group (combined DTC)



Graphic 4: Vigilance Cup HC (Combined)

Figure 6: Difference between test day 1 and test day 2 (percentage) for the 'digit span crisscross' in the HC group (combined DTC)



Graphic 5: DigitSpan Crisscross HC (combined)

2.5 Discussion

This study aimed to investigate the between-reliability of the motor, cognitive and combined dual task costs during diverse cognitive-motor interference testing conditions in pwMS and age-gender matched healthy controls. It's not the first study who examined the cognitive-motor interference in persons with MS. In their review, Leone, Patti & Feys (2014) provided a state-of-the-art overview of research into dual-tasking during walking in persons with MS, based on 14 recent papers. In our study, DTC values ranged from 3.63% to 17.73% for motor performance and from -1.74% to 26.82% for cognition in the MS group. In the HC group, for motor performance, DTC values varied from 9.00% to 18.64% for motor performance and from -5.06% to 16.04% cognition. In general, ICC values for motor DTC were good to excellent (ICC=0.48-0.86) and Spearman correlations varied from 0.13 to 0.82 in the MS group and from 0.43 to 0.92 in the HC group. These values were in general much higher than correlations for the cognitive DTC, which varied from -0.23 to 0.43 in the MS group and from -0.40 to 0.54 in the HC group. Reliability of motor DTC was found higher compared to cognitive DTC. These results are in the line with the one of Muhaidat et al. (2013), who showed in elderly community dwellers that reliability of the absolute dual task effect in walking time (ICC = 0.53–0.67) was only moderate, but was better than that for the correct response rate (verbal fluency: ICC = 0.04–0.33).

The larger range of variability in cognitive DTC compared to motor DTC may have resulted in lower reliability. It seems that HC produced more reliable results compared to the MS patients. This can be explained by the fact MS patients had a higher score and variability on the DT questionnaire and were mildly impaired on cognitive level. This statement can be reinforced by Monticone et al. (2014), who found lower standard deviation for velocity and cadence in the HC group compared to the MS group.

DTC and its reliability depends on the test condition. DTC values and variability were the highest for motor DTC for the 'subtraction' conditions in both MS and HC group. Spearman correlations varied from 0.32 to 0.72 in the MS group and from 0.65 to 0.77 in the HC group. No study has investigated the 'subtraction' task in a multiple sclerosis population. Patel & Bhatt (2014) used the 'subtraction' task in people who had a stroke compared to a young healthy group. The results are in the line with the one of our study, with a wide range of variability for walking speed. For cognitive DTC, we clearly see a higher DTC value and variability, especially in the MS group, when practicing the ‘digit span’ task. Spearman correlations were poor (r=0.20-0.33) and non-significant. The reason ‘digit span conditions’ a higher variability showed for cognitive DTC can be due to differences in length of sequence. While for cognitive DTC values and variability for the ‘digit span’ were high, ‘digit span crisscross’ showed an excellent reliability (ICC=0.86) in the HC for the motor DTC. These results are also consistent with the one of Strouwen et al. (2016), who tested the reliability in Parkinson Disease patients. There, ICC value for DT ‘digit span’ task gait was 0.90 which is in line with our value of 0.86 (ICC). In this study, pwMS will give more wrong answers and less adapt their walking speed.

The reliability for motor DTC was the highest in the MS group for ‘digit span walk’ condition (r=0.82), while ‘digit span crisscross’ (r=0.13) the lowest showed. In the HC group, ‘vigilance walk’ (r=0.92) showed the highest correlation. This was also the case for combined DTC in both groups (r=0.61 in MS group, r=0.80 in HC group). ‘Vigilance crisscross’ (r=0.43) showed the lowest correlation in the HC group for motor DTC. ‘Walking’ conditions showed the highest correlations in both groups, and this for motor and combined DTC. A possible explanation is the EDSS score of patients (3.0) and the fact walking was an easy task. The ‘vigilance’ task was the most easy cognitive task, like patients said. Almost every patient scored a maximum on this test. For this reason, we would expect higher correlations for the ‘vigilance’ tasks, but this was not always confirmed by our results.

All ‘crisscross’ conditions showed the lowest correlation in the MS group (r=0.13-0.43). In both groups, standard deviations were also higher compared to other tasks. For these ‘crisscross’ conditions, the APDM system could not calculate the gait velocity, so turning velocity was used instead of it. This could explain the differences between correlations and the high variability.

For the cognitive DTC, highest correlation was found for ‘vigilance crisscross’ (r=0.43) and the lowest for ‘subtraction obstacles’ (r=-0.23) in the MS group. In the HC group, ‘subtraction walk’ (r=0.54) showed the highest correlation. This reinforces the statement “vigilance” and ‘walking’ conditions were the most easy tasks. Different test conditions in the same group can result in less or more reliability. No clear priority for a better reliability of one cognitive task, neither for one motor task, could be found in both groups.

Motor and cognitive DTCs were all positive in the MS group, which means a deterioration in walking speed or turn duration and a lower number of corrected answers given. Results are in the line with the one of Wajda & Sosnoff (2015), who found a percentage decline in gait speed with the simultaneous performance of cognitive task that ranged from 6% to 27%. Hamilton et al. (2009) also found a deterioration in corrected answers during walking, with significant differences for the titrated 'digit span'. In the HC group, same tendency was found, expect for combined DTC 'digit span obstacles' and cognitive DTC 'digit span walk'. No explanation could be given to that. In stroke patients DT conditions in both young and stroke groups showed a significant decline in performance on gait and cognitive parameters when using the 'subtraction task'. In the stroke group, the velocity was the slowest for serial 'subtraction' DT conditions. The motor cost of gait velocity was also the highest for the serial subtraction ($P<0.05$). A decrease in number of correct responses on the serial subtraction task was found ($P<0.05$) (Patel & Bhatt ,2014).

It's the first time reliability was broadly investigated in the motor, cognitive and combined domain. It's also the first study who incorporated so many dual tasks: 12 in total. In his study, Etemadi (2017) focused on the cognitive aspect of the CMI, but did not investigate the reliability. Results showed that dual task resulted in a reduced walking velocity and a decreased correct response rate. Results are in the line with the ones found in our study. Monticone et al. (2014) investigated the reliability of CMI in pwMS focusing on the motor parameter. They made use of only one motor and one cognitive task. People had to walk while saying as many words as possible starting with a targeted letter. Results showed a high intra-class correlation for DTC velocity (ICC=0.87 in MS group; ICC=0.97 in the HC group) and cadence (ICC=0.87 for both groups). When looking at Yang et al. (2016), who tested the reliability of dual-task mobility in people with stroke, the reliability in Correct Response Rate (CRR) was only poor to fair (ICC=0.31) for the 'subtraction' by three. When looking at our Spearman correlations for cognitive DTC, all coefficients were under 0.43 for the MS population and under 0.54 for the HC population, which was fair. In our study ICCs and Spearman correlations ranged from 0.32 to 0.78 in the MS group and from 0.65 to 0.77 in the HC group for motor DTC.

Implication for clinical practice and research. Based on current study results, Spearman correlations between test performances on different days were found higher for motor DTC compared to the cognitive DTC. Despite the fact some conditions resulted in a high DTC value and are therefrom better to trace dual task problems, they are not always reliable. This can be a stumbling-block in longitudinal studies and so these tests could not be used in practice-research. Cognitive DTC was more variable and had a lower reliability. Despite the important meaning of the cognitive DTC, this will be less useful in clinical intervention studies. However, the cognitive methods are still suited to be applied in order to investigate the motor DTC.

Methodological considerations

The current study has some weaknesses as well as strengths, starting with enumerate some limitations of this study, followed by the strengths and implementations for future research.

Study limitations. Many variables were not normally distributed. This could be due to the small sample size (n=22). Fifteen subjects per group per center were pursued, leading to 30 subjects in each group. However, due to illness of the researcher in Masku Center part of the data of Finland could not be timely collected and included in the analyses so far. Due to the small sample and the fact data were not normally distributed, no ICC could have been calculated for cognitive DTC and most of the motor DTC.

Although an instruction day and instruction booklets with detailed information on test procedures, verbal instructions and level of encouragement was provided, we cannot exclude some discrepancy between the test behavior of raters of the different centers and impact of the different language. In Liège, tests took place in a small corridor of approximately 2 meters. Therefore, people had to avoid obstacles, but also had to pay attention to not touch the wall. Sub-analyze will indicate if the relative small place between the cones and the corridor could have influenced results. Moreover, by the period the tests were done (December 2016 - February 2017) in Liège, important works took place in the corridor of the hospital. A lot of patients were distracted by the noise workers made and had problems with hearing what was told in the headset. Unfortunately, not all tests could be stopped and redone so some answers could not have been given correctly and reaction/response time could have been delayed.

Strengths: The greatest strength of this study was the investigation of reliability of diverse conditions in MS and HC group. It was the first time a so much tasks were used in one study. The fact two different centers from two different countries were incorporated in this study, enabled larger sample size. Another strength was the good communication between the students mutually on one hand and between students and promoters on the other hand. If something went wrong during the tests, the external co-promoter was always there to help. If there were some problems with the results (e.g. one answer was given correctly, but had to be marked as wrong), a mail was immediately send to the study coordinator. Participant were also very excited about the tests. Everyone of them get the best out of themselves to prove they could do as good as HC people.

Future research: MS patients had a mean EDSS score of 3.0 in this study. Results of this study cannot be generalized to more severe disabled MS patients. For further research, on one hand, pwMS with a higher EDSS score could be included. They will be more affected at the motor level. On the other hand, people with a higher cognitive impairment could also be included. Patients with more severe motor and/or cognitive impairments could reveal other results. A larger sample is required to be more representative and hopefully this will also results in more normal distribution of the data so more ICC could be calculated. In this study, DTC was used for measuring the reliability. Strouwen et al. (2016) used the DT instead of the DTC and concluded that DTC had a lower reliability, compared to the absolute value of DT for gait and cognitive performances. Using DT instead of DTC in future research could give higher ICCs.

Conclusions: In this study, reliability of the motor DTC was better than cognitive DTC, so more caution is required when using cognitive DTC in longitudinal or interventional studies. The most reliable test of all dual task conditions was the “vigilance walk”, who showed the highest correlation in both groups for combined (and motor) DTC, but not for cognitive DTC. There were no clear and systematic differences on reliability between the MS and HC group Future research will be needed to confirm this findings in a larger more disabled sample.

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3 Appendices

Document 1 : Informed Consent French (CHU Liège)

Document 2 : Mini Mental State Examination (French)

Document 3: Questionnaire à double tache

Document 4: Liste de doubles tâches afin de déterminer les difficultés à pratiquer des doubles tâches

Document 5 : Motor Activity Log

Document 1 : Informed Consent French (CHU Liège)

La pratique simultanée de tâches motrices et cognitives chez des personnes souffrant de sclérose en plaque: évaluation (MCS-IV-CMI&DTT)

Formulaire d'information et de consentement

Une étude dans le cadre de

Cher participant éventuel,

Vous êtes invité à participer volontairement a une étude clinique concernant l'interférence cognitive et motrice, qui apparait lorsqu'on pratique une action motrice et cognitive simultanément (e.g. parler en marchant), chez des personnes souffrant de la sclérose en plaque. Avant de participer à cette étude, il est important de lire ce formulaire avec attention. Dans celui-ci, vous trouverez toutes les informations nécessaires concernant le but de l'étude, les recherches, les risques potentiels, les avantages associés à l'étude et l'anonymisation des données. Apres avoir lu toutes ces informations, vous serrez libre de poser des questions supplémentaires et disposerez d'un temps de réflexion (avec possibilité de concertation avec la famille/les amis) pour prendre votre décision de participation. Si vous acceptez, nous vous demandons de signer le formulaire de consentement joint à ce document. Une copie du formulaire d'information et du formulaire de consentement signé vous sera rendu.

Introduction générale

Cette étude multicentrique a lieu dans le cadre du RIMS Européen (Rehabilitation In Multiple Sclerosis Network for best practice and research, www.eurims.org), plus spécifiquement dans le domaine du 'Special Interest Group on Mobility'. Le SIG (pôle d'intérêt commun) Mobility est un groupe de cliniciens, principalement des kinésithérapeutes et docteurs en kinésithérapie et des chercheurs spécialisé dans l'étude de la mobilité en SEP. Ce groupe de personnes se réuni chaque année pour échanger des informations, améliorer la communication entre les kinésithérapeutes, les cliniques spécialisées et le chercheurs. Il permet également le développement d'une revalidation basée sur les évidences scientifiques. Les études multicentriques menées sur un nombre important de participants ont permis au 'SIG mobility » d'aboutir à des résultats de première importance pour la pratique de la kinésithérapie en SEP.

Introduction

Les doubles tâches (exécuter 2 tâches simultanément), comme par exemple marcher tout en tenant une discussion téléphonique ou parcourir la liste des courses en marchant, sont des tâches quotidiennes. L'interférence cognitive et motrice survient lorsque la performance d'une tâche motrice ou cognitive est diminuée par la réalisation simultanée d'une seconde tâche (cognitive ou motrice). Le 'dual task cost' ou 'coût de la double tâche' correspond à la différence de performance lorsque la tâche est réalisée seule ou en combinaison avec une seconde tâche.
Cette interférence cognitive et motrice, plus élevée chez les personnes âgées et chez les personnes souffrant d'une maladie neurologique, est susceptible de limiter les activités de la vie quotidienne. Chez les personnes souffrant de SEP, il est fréquent d'observer une altération des capacités de marche et des fonctions cognitives, et ce dès le stade précoce de la maladie. En outre, il est possible que la double tâche révèle des anomalies pourtant infracliniques lors de tâches motrices ou cognitives isolées. Cette étude se focalise sur la mesure de l'interférence cognitivo-motrice et l'efficacité d'une intervention axée sur l'entraînement d'activités menées en double tâche visant à améliorer les capacités fonctionnelles tout autant que la qualité de vie des personnes atteintes de SEP.

Buts de l'étude

Pour l'instant, la marche et les fonctions cognitives sont mesurées à l'aide de tests individuels comme l'évaluation de la vitesse de marche ou des fonctions mnésiques. Cependant, ces tests standards ne renseignent pas sur les performances d'une tâche lorsqu'elle est effectuée concomitamment à une seconde tâche, situation fréquemment rencontrée dans la vie de tous les jours.
Cette étude a plusieurs objectifs : (1) quantifier du coût de la double tâche ('dual task cost', i.e. la difficulté à réaliser différentes tâche simultanément) basée sur des distracteurs cognitifs recrutant différentes fonctions supérieurs (traitement de l'information, mémoire, attention,…) menés simultanément à une activité motrice orientée vers la marche ; (2) tester la reproductibilité test-retest de la mesure d'interférence cognitivo- motrice (est-ce que le test, réalisé dans les mêmes conditions expérimentales, chez le même sujet, mais à plusieurs jours d'intervalle, produit les mêmes résultats ?) ; (Taub et al.) mesurer le lien entre le 'coût de la double tâche', d'une part, et les déficits moteurs, cognitifs, la fatigue et la qualité de vie d'autre part.

Description de l'étude

Tous les tests auront lieu au Centre Hospitalier Universitaire d'Esneux. L'évaluation se fera en 2 jours par un thérapeute entrainé selon des instructions de mesure et directives standardisées. Le premier jour, quelques données démographiques (âge, sexe, statut professionnel, niveau d'étude) et cliniques en rapport avec la maladie (handicap, type de SEP, date du diagnostic, médicaments, l'utilisation d'une orthèse plantaire, l'historique des chutes) seront encodées. Ensuite, il y aura 2 moments de mesure qui dureront 1 heure chacun: un pour mesurer la mobilité et l'autre pour mesurer la cognition. Un neuropsychologue ou une personne entraînée évaluera vos capacités cognitives en vous demandant de retenir des choses, de vous concentrer, d'énumérer des mots, de calculer,… Un kinésithérapeute mesurera votre niveau de mobilité (capacité à la marche, à se lever d'une chaise, à contourner un obstacle, à monter et descendre les escaliers, à changer de rythme,…) à l'aide différentes échelles de mesure et d'auto-questionnaires (limitation à la marche en lien avec la SEP, peur de la chute,…). Pour mesurer l'impact de la SEP sur votre qualité de vie et sur la fatigue ressentie, il vous sera demandé de remplir 2 questionnaires.

L'investigateur prendra compte de vos possibilités et, si besoin, interrompra le test afin d' effectuer une pause. Le second jour de test, la capacité à pratiquer simultanément une tâche motrice et cognitive sera évaluée. Pour cela, il sera demandé aux participants de pratiquer des tâches quotidiennes (marcher, marcher sur des obstacles, en zigzag ou pendant que vous avez une tasse en main) et des tâches cognitives (retenir et répéter une série de chiffres (e.g. 3-2-5-7) dans le bon ordre ou dans le sens inverse, écouter les lettres de l'alphabet et dire 'oui' quand vous entendez une lettre spécifique, calculer en arrière par 7 ou 3). Ces tâches motrices et cognitives seront pratiquées simultanément et séparément (p.e. marcher en zigzag pendant que vous calculez à l'envers) et dureront 1 heure. Après 3 à 5 jours de récupération, vous repasseriez ces tests.

Risques et inconforts

Le protocole décrit ci-dessus correspond aux bonnes pratiques médicales. Votre participation à cette étude ne revêt aucun risque pour la santé. Des kinésithérapeutes/investigateurs entraînés et spécialisés évalueront votre mobilité et cognition. La sécurité est la priorité absolue. L'appareil de mesure de l'activité quotidienne sera placé de telle sorte que l'inconfort soit minimum.

Assurance

En vertu de la loi du 7 mai 2004 relative aux expérimentations sur la personne humaine, le promoteur assume, même sans faute, la responsabilité du dommage causé au participant ou à ses ayants-droit, dommage lié de manière directe ou indirecte à l'expérimentation. Il a contracté une assurance à cet égard.

Avantages

Les données sont encodées grâce à des questionnaires, des échelles cliniques et des appareils de mesures objectifs. Dès lors, vous aurez une image claire quant à vos capacités et restrictions concernant votre mobilité, votre cognition et votre aptitude à réaliser une tâche cognitive et motrice simultanément. Votre participation apportera une contribution à la recherche dont la communauté scientifique saura apprécier la valeur.

Protection de la vie privé

L'équipe de recherche se porte garante pour que vos données personnelles, tout comme les résultats de mesure, soient traités de manière confidentielle et codés, conformément à « l'article 7 » en vertu de « la loi du 8 décembre 1992 relative au traitement des données personnelles ». En accord avec les recommandations s de bonnes pratiques médicales, la consultation de votre dossier médical par l'investigateur local aura lieu uniquement dans le cadre de cette étude. Vos informations seront transférées, traitées et analysées électroniquement et d'une manière codée par les investigateurs principaux (Université d'Hasselt). Les résultats de cette étude seront uniquement mentionnés lors de conférences et publiés dans des articles scientifiques, en veillant à ne pas mentionner votre identité. Celle-ci reste secrète, étant donné le codage de vos données personnelles.

Avec votre accord uniquement, vos résultats pourront être par des collaborateurs mandatés de l'Université d'Hasselt et du comité d'éthique médicale.

Participation volontaire

Vous participez volontairement a cette étude et avez donc le droit de décliner cette proposition. Vous avez aussi la possibilité d'interrompre l'étude à tout moment. Si vous quittez l'étude, avec votre permission, les données collectionnées jusqu'à ce moment là seront conservées afin de garantir la validité de l'étude. Aucune acquisition ultérieure ne sera réalisée. Votre engagement de participation n'aura aucune influence sur vos traitements ultérieurs.

Coûts lies à votre participation

La participation à cette étude n'implique aucun frais pour le sujet, à l'exception des frais de transport. Aucune compensation financière n'est prévue.

Comité d'étique

L'étude telle que décrite ci-dessus a été examinée et approuvée par un Comité d'Ethique Indépendant, notamment le « Comité d'Ethique médicale de l'UZ/KU Leuven », âpres consultation du comité étique médicale locale de Hasselt et Liège. Cette approbation ne doit pas avoir d'influence sur votre décision de participation. .

Chercheur principal et personne de contacte

La direction et la coordination de cette étude multicentrique seront seront assurées par l'université d'Hasselt, REVAL Rehabilitation Research Center, dans la section BIOMED Biomedical Research Institute sous la supervision du Prof. Dr. P. Feys (président du RIMS) et Dr. I. Baert.

Le clinicien/investigateur dans votre centre clinique local est …………………………... N'hésitez pas le/la contacter pour des informations supplémentaires en rapport avec cette étude. (e-mail:…………………….., tél:..............................). (Voyez la liste des centres participants, personnes de contactes)

Formulaire de consentement du patient

La pratique simultanée de tâches motrices et cognitives chez des personnes souffrant de sclérose en plaque: évaluation et entraînement de la double tâche.

Je (prénom et nom de famille) ………………………………………………déclare avoir lu et compris le formulaire d'information ci-dessus et accepte de participer à l'étude décrite ci-dessus. Je déclare:

- Avoir été suffisamment informé sur le but et le protocole de l'étude
- Avoir eu suffisamment de temps pour y réfléchir et avoir eu l'occasion de poser toutes les questions qui me sont venues à l'esprit
- Avoir compris que ma participation à cette étude est posée sur base volontaire
- Être conscient de pouvoir interrompre ma participation à cette étude sans que cela n'ait de répercussion sur ma prise en charge ultérieure
- Accepter la consultation de mes données personnelles par un mandataire.
- Accepter que les données puissent être utilisées dans une publication par les investigateurs.

Date et Signature du sujet, précédée de la mention «pour accord» Date: …………………………………………..

Signature du titulaire de droit du participant,

Précédé des mots « pour accord » ,

Je, soussigné, (prénom et nom de famille de l' investigateur) ……………………………………déclare avoir expliqué au participant (prénom et nom de famille) …………………………………………. du mieux que possible les buts, la procédure, les avantages, tout comme les risques et désagréments de l'étude. Le participant s'engage à participer à cette recherche. Je remets au participant les informations relatives à l'étude, ainsi qu'une copie signée du formulaire de consentement.

Date: ……………………………………………

Signature de l'investigateur:

En cas d'incapacité de consentement du participant: Formulaire de consentement du titulaire de droit

La pratique simultanée de tâches motrices et cognitives chez des personnes souffrants de la sclérose en plaque: mesurage de double tâche et entrainement.

Moi, titulaire de droit (prénom et nom de famille)…………………………………………. du participant (prénom et nom de famille) ……………………………………………… déclare avoir lu et compris le formulaire d'information ci-dessus et accepte de participer à l'étude décrite ci-dessus. Je déclare:

- Avoir été suffisamment informé sur le but et le protocole de l'étude
- Avoir eu suffisamment de temps pour y réfléchir et avoir eu l'occasion de poser toutes les questions qui me sont venues à l'esprit
- Avoir compris que ma participation à cette étude est posée sur base volontaire
- Être conscient de pouvoir interrompre ma participation à cette étude sans que cela n'ait de répercussion sur ma prise en charge ultérieure
- Accepter la consultation de mes données personnelles par un mandataire.
- Accepter que les données puissent être utilisées dans une publication par les investigateurs.

Date et Signature du sujet, précédée de la mention «pour accord» Date: …………………………………………..

Signature du titulaire de droit du participant,

Précédé des mots « pour accord » ,

Je, soussigné, (prénom et nom de famille du investigateur) ………………………………………déclare avoir expliqué au titulaire de droit (prénom et nom de famille) …………………………………………du participant (prénom et nom de famille)…………………………… du mieux que possible les buts, la procédure, les avantages tout comme les risques et désagrément de l'étude. Le participant s'engage à participer à cette recherche. Je remets au participant les informations relatives à l'étude, ainsi qu'une copie signée du formulaire de consentement.

Date: …………………………………………..

Signature de l'investigateur:

Document 2 : Mini Mental State Examination (French)

MINI MENTAL STATE EXAMINATION (M.M.S.E) Date :... Evalué(e) par : .... Niveau socio-culturel	Etiquette du patient

ORIENTATION

Je vais vous poser quelques questions pour apprécier comment fonctionne votre mémoire. Les unes sont très simples, les autres un peu moins. Vous devez répondre du mieux que vous pouvez.

Quelle est la date complète d'aujourd'hui ? ....

☞ *Si la réponse est incorrecte ou incomplète, posez les questions restées sans réponse, dans l'ordre suivant :*

	!0ou1!		!0ou1!
1. en quelle année sommes-nous ?	!____!	4. Quel jour du mois ?	!____!
2. en quelle saison ?	!____!	5. Quel jour de la semaine ?	!____!
3. en quel mois ?	!____!		

☞ *Je vais vous poser maintenant quelques questions sur l'endroit où nous nous trouvons.*

6. Quel est le nom de l'Hôpital où nous sommes ? !____!
7. Dans quelle ville se trouve-t-il ? !____!
8. Quel est le nom du département dans lequel est située cette ville ? !____!
9. Dans quelle province ou région est situé ce département ? !____!
10. A quel étage sommes-nous ici ? !____!

APPRENTISSAGE

☞ *Je vais vous dire 3 mots ; je voudrais que vous me les répétiez et que vous essayiez de les retenir car je vous les demanderai tout à l'heure.*

11. Cigare		[citron		[fauteuil	!____!
12. fleur	ou	[clé	ou	[tulipe	!____!
13. porte		[ballon		[canard	!____!

Répéter les 3 mots.

ATTENTION ET CALCUL

☞ *Voulez-vous compter à partir de 100 en retirant 7 à chaque fois ?*

14. 93 !____!
15. 86 !____!
16. 79 !____!
17. 72 !____!
18. 65 !____!

☞ *Pour tous les sujets, même pour ceux qui ont obtenu le maximum de points, demander :* « voulez-vous épeler le mot MONDE à l'envers » : E D N O M.

RAPPEL

☞ *Pouvez-vous me dire quels étaient les 3 mots que je vous ai demandé de répéter et de retenir tout à l'heure ?*

19. Cigare		[citron		[fauteuil	!____!
20. fleur	ou	[clé	ou	[tulipe	!____!
21. porte		[ballon		[canard	!____!

LANGAGE

22. quel est le nom de cet objet? Montrer un crayon. !____!
23. Quel est le nom de cet objet Montrer une montre !____!
24. Ecoutez bien et répétez après moi : « PAS DE MAIS, DE SI, NI DE ET » !____!

☞ *Poser une feuille de papier sur le bureau, la montrer au sujet en lui disant :* « écoutez bien et faites ce que je vais vous dire » (consignes à formuler en une seule fois) :

25. prenez cette feuille de papier avec la main droite. !____!
26. Pliez-la en deux. !____!
27. et jetez-la par terre ». !____!

☞ *Tendre au sujet une feuille de papier sur laquelle est écrit en gros caractères : « FERMEZ LES YEUX » et dire au sujet :*

28. «faites ce qui est écrit ». !____!

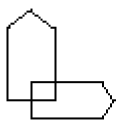
☞ *Tendre au sujet une feuille de papier et un stylo en disant :*

29. voulez-vous m'écrire une phrase, ce que vous voulez, mais une phrase entière. » !____!

PRAXIES CONSTRUCTIVES.

☞ *Tendre au sujet une feuille de papier et lui demander :*

30. « Voulez-vous recopier ce dessin ». !____!



SCORE TOTAL (0 à 30) !____!

Document 3: Questionnaire à double tache[1]

Nr. Du Participant **Date:**
QUESTIONNAIRE A DOUBLE TÂCHE- AUTO

Les questions suivantes ont rapport avec des problèmes que tout le monde a déjà été confronté avec, certains plus que d'autres. Nous voudrions bien savoir combien de fois, durant ces dernières semaines, ces problèmes sont survenus chez ………………………………………. Il y a 5 options, classé de « très souvent » à « jamais » ou « pas applicable ». Veuillez cochez la bonne case, s'il vous plaît.

	Est-ce que vous rencontrez l'une de ces difficultés suivantes..	Très souvent	Assez souvent	Occasion ellement	Très rare	Jamais	P/A
1	Garder votre attention sur plusieurs choses à la fois?						
2	Ressentir le besoin de devoir arrêter une activité afin de discuter ?						
3	Ne pas porter l'attention sur quelqu'un d'autre quand il parle, lorsque vous pratiquez vous-même votre activité ?						
4	Suivre ou participer à une conversation où plusieurs personnes ont la parole en même temps ?						
5	Une dégradation de la marche lorsque vous parlez avec quelqu'un où écouter quelqu'un en marchant ?						
6	Vous êtes tellement pris dans vos propres pensées, que vous ne remarquez pas ce qu'il se passe autour de vous ?						
7	Vous renversez une boisson en la transportant ?						
8	Vous renversez plus en parlant simultanément?						
9.	Vous foncez contre des personnes ou perdez quelque chose en pratiquant une autre tâche en même temps ?						
10.	Vous avez des difficultés à manger et regarder la télévision ou écouter la radio simultanément ?						
	Total pour chaque catégorie:	x4	x3	x2	x1	x0	-
	Sous-total:						

Somme des 4 sous-totaux =

Divisé par le nombre de questions répondues =

Moyenne par question répondue =

[1]Strouwen et al. (2014)

Document 4: Liste de doubles tâches afin de déterminer les difficultés à pratiquer des doubles tâches[2]

Le questionnaire suivant vérifie si vous avez des problèmes lors de la pratique d'une doubles tâche. Ci-dessous vous trouverez quelques situations à doubles tâches. Le but est de cocher 'oui' si vous avez des difficultés à :

> Marcher : est-ce que la marche se fait plus difficile en pratiquant une autre tâche simultanément comparé à la marche sans tâche supplémentaire ? Plus difficile veut dire e.g. marcher moins rapidement, faire des plus petits pas etc.

ET/OU

> La double tâche : est-ce que vous remarquez que la tâche que vous pratiquez simultanément se fait plus difficilement ? Plus difficile veut dire e.g. arrêter une discussion car vous avez du mal à trouver les mots, vous faites de fautes que vous ne feriez pas d'habitude, laisser tomber des choses etc.

Si une situation n'est pas d'application, vous devrez cocher la case « pas applicable ». S'il y a des situations que vous éviter dans le quotidien car vous savez qu'ils vous procureront des difficultés pendant la marche ou afin de pratiquer une tâche correctement, veuillez cocher la case « oui ».

DEBUT DU QUESTIONNAIRE

Est-ce que vous rencontrez des difficultés avec les combinaisons suivantes ?	Oui	Non	PA
Marcher et parler			
Marcher et téléphoner			
Marcher et porter un sac de course			
Marcher et porter une assiette remplie de nourriture			
Marcher et porter une tasse remplie			
Marcher et éviter des obstacles (par terre)			
Marcher et sortir quelque chose de la poche (abonnement de bus, mouchoir, argent, GSM)			
Marcher et adresser son attention sur autre chose (e.g. la circulation)			
Marcher et retenir quelque chose d'important (e.g. un numéro de téléphone, une adresse)			
Marcher et penser à d'autres choses			
Faire les magasins et chercher les marchandises			
Marcher et fermer votre tirette de manteau			
Marcher et chercher votre chemin (e.g. dans une gare, un aéroport)			

[2] Evans, Greenfield, Wilson, & Bateman (2009)

Il y a-t-il encore d'autres situations où vous rencontrez des difficultés à marcher of pratiquer une tâche supplémentaire ?

……………………………………..…………………………………………..…………………………………………..………
………………………………..…………………………………………..…………………………………………..………………
…………………………..…………………………………………..…………………………………………..………………………

Nom :……………………………..…………………………………………..…………………………………………..………

Âge :……………………………………..…………………………………………..…………………………………………..…….

MERCI DE VOTRE PARTICIPATION

Document 5 : Motor Activity Log

Cet outil met en évidence la sous-utilisation du membre supérieur hémiparétique. C'est une auto-évaluation, sous forme d'interview. Le patient est interrogé sur 30 AVQ et doit coter pour chacune d'entre elles la quantité et la qualité d'utilisation de son membre dans la réalisation de la tâche. Les questions concernent ce que le patient fait réellement, et pas ce qu'il pense être capable de faire : « Considérez vos activités durant la semaine passée (ou "depuis la dernière fois"), avez vous réalisé cette activité ? »

Le patient répond « Oui ». On évalue alors la quantité (Q1) et la qualité (Q2) d'utilisation du membre.

Q1 :

0- Je n'utilise jamais le bras atteint (pour cette activité).
1- J'essaie occasionnellement d'utiliser mon bras atteint (très rarement).
2- Parfois j'utilise mon bras atteint, mais je réalise la plus grande partie de l'activité avec mon bras le plus fort. (= rarement).
3- J'utilise mon bras atteint, à peu près à moitié aussi souvent qu'avant l'accident.
4- J'utilise mon bras atteint presque autant qu'avant l'accident (3/4).
5- J'utilise mon bras atteint autant qu'avant l'accident

Q2 :

0. Le bras atteint n'est pas utilisé du tout pour cette activité (jamais).
1. Le bras atteint bouge pendant cette activité, mais n'aide pas (très pauvre).
2. Le bras atteint est un peu utilisé durant cette activité, mais a besoin d'être aidé par le bras le plus fort (pauvre).
3. Le bras atteint est utilisé pour réaliser l'objectif, mais les mouvement sont lents ou sont fait avec effort.
4. Les mouvements réalisés par le bras lésé sont presque normaux mais pas aussi rapides ou précis que la normale (presque normal).
5. L'habileté du bras lésé pour cette activité est aussi bonne qu'avant l'accident (normal).

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Simultaneous performance of motor and cognitive tasks in persons with multiple sclerosis: dual task assessment

Richting: **master in de revalidatiewetenschappen en de kinesitherapie-revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen**
Jaar: **2017**

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