From "Wheelchair Circuit" to "Wheelchair Assessment Instrument for people with Multiple Sclerosis": reliability and validity analysis of a test to assess driving skills in manual wheelchair users with multiple sclerosis

Masterproef voorgelegd tot het behalen van de graad van Master in de Gezondheidsvoorlichting en –bevordering

Door Monia Vereecken

Promotor: Prof. Dr. Guy Vanderstraeten
Begeleiders: Dr. Stephan Ilsbroukx
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Abstract

Objectives. To assess the reliability and validity of the "Wheelchair Assessment Instrument for people with Multiple Sclerosis" (WAIMS), a test to measure driving skills in manual wheelchair users with multiple sclerosis.

Design. Three test trials per subject were conducted by 2 raters to examine reliability (inter- and intrarater) and validity (concurrent and construct).

Setting: the rehabilitation center of the National Multiple Sclerosis Centre, Melsbroek, Belgium.

Participants: Convenience sample of 50 manual wheelchair users with multiple sclerosis, getting an in- or outpatient rehabilitation program in het National Multiple Sclerosis Centre.

Intervention: Not applicable.

Main outcome measures: The WAIMS consists of 8 items and results in 3 final test scores: ability sum score, performance time sum score and covered distance. These 3 scores are used to calculate inter- and intrarater reliability, concurrent validity and construct validity. Concerning validity, the test scores on the WAIMS are compared to (1) the Belgian medical prescription of a wheelchair on the item d445 (hand and arm use), based on the International Classification of Functioning, Disability and Health (ICF), (2) the Expanded Disability Status Scale (EDSS) and (3) the mobility (wheelchair) item of the FIM.

Results. Intrarater was found higher than interrater reliability. Except for the interrater reliability of the ability sum score, all intraclass correlation coefficients (ICC’s) met our
standard of 0.80. Concurrent validity was rather low, but construct validity showed that the WAIMS is a valid instrument to assess driving skills in manual wheelchair users with multiple sclerosis.

Conclusions. The WAIMS is a promising tool to assess driving skills in manual wheelchair users with multiple sclerosis, but it needs some refinements and future studies to confirm this statement.

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Abstract

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Finally we made it! This master’s thesis is (almost) done! It has been a long journey in which I got lost a few times, but thanks to many people around me I was able to get back on track or find a new and even better destination. Two important travel guides through this journey are Prof. Dr. Guy Vanderstraeten, my promoter, and Dr. Stephan IJsbrukx, my instructor. I would like to thank them for their support, their feedback and their help during the past 2 years, and also for the confidence they had in me. The combination of these factors gave me a lot of self confidence, which allowed me to work in an independent way. I could not have wished for a better guidance than they have provided me.

Another very important person in this journey is Pascal Vanderbeeten. He was the one who notified me that the world of mobility was worth exploring, and right he was. He supported me through this journey by sharing his expertise with me, but also by making the test trials, the data analysis, etc. possible in practice. Thank you Pascal, for our nice cooperation, in the past, the present and the future.

Marijke, I would like to thank you for believing in me from the beginning. Thanks to your support, it was possible to combine working with studying during that first, time-consuming year. Also a big thank you to my colleagues. Not only for their help in the data collection, but also for understanding my irregular working schedule.

When I decided to aim for a masters degree back in 2008, I knew this decision would have a big impact on my life. What I wasn’t aware of at that time, is that my decision would not only affect my life, but also on the lives of the people around me. The one who suffered the most was Andries, my partner. Willy-nilly, he shared in all the sacrifices I made. One of those sacrifices is not going on a
holiday in the past 3 years, so I guess he doesn’t like the journey metaphor much. Besides that, he has been a great support. When I couldn’t see the wood for trees anymore, he has always been there to help me through.

Also very important to me, is the support and the help of my parents. Mama, thank you for being such a critical reader and for supporting me through thick and thin. I’ve known you my whole life, and still you surprise me with your knowledge and enthusiasm each day. Thank you for that! My father is the handyman who has designed and created a perfect fitting doorstep, a solid platform and clever slopes. Thank you, papa, for spending so many evenings drawing, sawing, spiking, sandpapering and painting.

As recommended in the checklist Archives of Physical Medicine and Rehabilitation provides, the article is edited by a native American, Elleni. She did a very precise job and read the article very carefully, although medicine is not her main interest. Elleni, thank you for the efforts you have done!

Last but not least I would like to mention all participants. You people are great! You have participated with so much energy and so much dedication, thank you!

Finally, I would like to say I learned a lot from this project. This is the first research I conducted. Besides I have learned to organize, plan and the applied techniques, I have also learned that I really like doing research. I truly hope I have a career in research ahead of me.
1 Introduction

Concerning this master’s thesis, I opted to submit it as an article, in consultation with my promoter Prof. Dr. Guy Vanderstraeten and my instructor Dr. Stephan Ilsbroukx. In a first stage, I preferred to submit the article to a Dutch or Flemish journal, as it would be less time consuming to write the whole thesis in Dutch. Afterwards I would take some time to rewrite the article in English to resubmit it to an English, American, Canadian or Australian journal. After we won the best poster award on the 16th annually RIMS conference (Rehabilitation In Multiple Sclerosis) in Turku, Finland, I reconsidered that choice and we decided to aim for an English, American, Canadian or Australian journal right away. This way, we would reach a larger public. After some considerations, we decided to submit the article to the American journal ‘Archives of Physical Medicine and Rehabilitation’. On their website, this journal presents itself as follows:

Archives of Physical Medicine and Rehabilitation publishes original articles that report on important trends and developments in physical medicine and rehabilitation and in the more interdisciplinary field of rehabilitation. Archives of Physical Medicine and Rehabilitation brings readers authoritative information on the therapeutic utilization of physical and pharmaceutical agents in providing comprehensive care for persons with disabilities and chronically ill individuals. Archives began publication in 1920, publishes monthly, and is the official journal of the American Congress of Rehabilitation Medicine. Its papers are cited more often than any other rehabilitation journal.\(^1\)

Archives of Physical Medicine and Rehabilitation publishes 12 issues per year and has obtained an impact factor of 2.254 in 2010.\(^2\) The impact factor is a measure, based on the average number of citations to articles published in the concerning journal.
In practice, we notice that people with multiple sclerosis using a wheelchair experience more and more mobility difficulties throughout the years. These observations have always been a subjective impression from the patient with multiple sclerosis himself, his family, a paramedic and/or significant others. Pascal Vanderbeeten, head of the department occupational therapy of the National Multiple Sclerosis Centre Melsbroek and expert in mobility, made us aware of the fact that an objective tool to assess the driving skills of wheelchair users is missing in practice. A literature study confirmed this, and soon it became clear that there are a lot of potential research topics in the domain of wheelchair mobility in people with multiple sclerosis. After delimiting the research topic and making some decisions, the aim of this study is described as follows:

The aim of this study is to develop a reliable and valid instrument to assess the driving skills in manual wheelchair users with multiple sclerosis.

Afterwards, an overview of the existing instruments to assess the driving skills of manual wheelchair users was made. One test, the Wheelchair Circuit\textsuperscript{3,4}, was closest to our expectations concerning a wheelchair driving skills test for our target population. Therefore we decided to review and modify this test, and call the new test the ‘Wheelchair Assessment Instrument for people with Multiple Sclerosis’ (WAIMS).

The information above is summarized in the title:

From ‘Wheelchair Circuit’ to ‘Wheelchair Assessment Instrument for people with Multiple Sclerosis’: reliability and validity analysis of a test to assess driving skills in manual wheelchair users with multiple sclerosis.

In literature, Multiple sclerosis is described as a neurodegenerative disease of the central nervous system, which is characterized by a broad spectrum of signs and symptoms: visual deficits, gait problems, sensory deficits, cognitive problems, fatigue, weakness, tremor, spasticity, etc.\textsuperscript{5-14} Not only
do the symptoms vary between individuals, but they may also vary from day to day or even from hour to hour in a single individual.\textsuperscript{5,6,9} In most people with multiple sclerosis, mobility is affected by these symptoms\textsuperscript{5-7}: as many as 90\% report mobility impairment.\textsuperscript{8,14} People with multiple sclerosis use mobility aids such as canes, walkers, wheelchairs, etc.\textsuperscript{5,15}, among which manual wheelchairs are the most common.\textsuperscript{15}

Fifteen years after their diagnosis, people with multiple sclerosis have 25\% chance of using a wheelchair.\textsuperscript{8} Recently diagnosed patients tend to overestimate the risk of wheelchair dependency in the short-term (2 years) and in the mid-term (10 years): the mean perception of wheelchair dependency is 22.5\% in the short-term and 38.7\% in the mid-term, whereas the actual risk is 5-10\% and 20-25\%, respectively. Conversely, the lifetime risk is generally underestimated in the same population: 54.0\% expect to end up in a wheelchair although the actual risk is 70-80\%.\textsuperscript{16}

In most cases, people with multiple sclerosis’ wheelchair use changes over time. In the beginning, the wheelchair might be used part-time or as a primary exclusive mobility option for those who are experiencing fatigue, muscle weakness, spasticity, balance difficulties and/or frequent falls.\textsuperscript{5} Depending on the specific mobility needs of that moment, people with multiple sclerosis appear to ‘mix and match’ different mobility devices.\textsuperscript{15}

Until now, some tests have been described to assess the skills of people using a manual wheelchair, but these tests are non specific for people with multiple sclerosis. The Wheelchair Skills Test (WST)\textsuperscript{17-19}, the Obstacle Course Assessment of Wheelchair User Performance (OCAWUP)\textsuperscript{20}, the Wheelchair Users Functional Assessment (WUFA)\textsuperscript{21}, the Wheelchair Physical Functional Performance test (WCPFP)\textsuperscript{22} and the Tufts Assessment of Motor Performance (TAMP)\textsuperscript{23} can be used for wheelchair users with various diagnoses; the Wheelchair Circuit\textsuperscript{3,4}, the Five Additional Mobility and Locomotor items (5-AML)\textsuperscript{24} of the Functional Independence Measure (FIM)\textsuperscript{25}, Valutazione Funzionale Mielolesi (VFM)\textsuperscript{26} and the Manual Wheelchair Slalom Test (MWST)\textsuperscript{27} in people with spinal cord injuries. All these tests
include objective observations of skills. Other tests are questionnaire-based such as the Wheelchair Skills Test Questionnaire (WST-Q)\textsuperscript{28} or the Self-Efficacy in Wheeled Mobility Scale (SEWM)\textsuperscript{29}.

Of the listed tests to assess the skills of people using a manual wheelchair, it is the Wheelchair Circuit which is reviewed and modified in this research, as mentioned above. The applied changes involved eliminating the treadmill and a revision of the scoring instructions, considering our target population.

The WAIMS consists of 8 items and results in 3 final test scores: ability sum score, performance time sum score and covered distance. After the test was administered in 50 people with multiple sclerosis, 3 times each (except for 3 dropouts), the 3 final scores are used to calculate inter- and intrarater reliability, concurrent validity and construct validity. Concerning validity, the test scores on the WAIMS are compared to (1) the Belgian medical prescription of a wheelchair on the item d445 (hand and arm use), based on the International Classification of Functioning, Disability and Health (ICF), (2) the Expanded Disability Status Scale (EDSS) and (3) the mobility (wheelchair) item of the FIM.

In this paper, the literature review includes a description of multiple sclerosis and an overview of the different existing wheelchair tests. Subsequently, the methods are described, and the results are reported and analyzed. Finally, a conclusion is written to give a broad overview of this research.
2 Description of multiple sclerosis

2.1 In general

The prevalence of multiple sclerosis is globally estimated at about 2 - 2.5 million\textsuperscript{8,11}, and is the main cause of disability in young and middle-aged people in the Western world\textsuperscript{13}. Multiple sclerosis is an immune-mediated disease, which is characterized by the demyelination of axons\textsuperscript{12}. This causes a wide spectrum of symptoms, e.g. visual deficits, gait problems, sensory deficits, cognitive problems, fatigue, weakness, tremor, spasticity, etc.\textsuperscript{5-14} (cf. infra).

The course of multiple sclerosis is variable.\textsuperscript{6,30} The most common course is relapsing-remitting multiple sclerosis, in which symptoms occur over a period of several days, stabilize and may improve again afterwards. Generally, this course turns into a secondary progressive course: a steady progression of worsening neurologic symptoms.\textsuperscript{6} A minority experiences this steady progression of worsening neurologic symptoms from the onset of the disease, called the primary progressive course. Other courses include benign and malignant multiple sclerosis, but these are rather scarce.

2.2 Distribution of the disease

2.2.1 By age

The mean age of onset of the disease is about 30 years. Almost 70\% of the patients experiences his first symptoms between ages 20 and 40. Rarely, the onset of the disease is experienced by persons younger than 10 or older than 60.\textsuperscript{31}
2.2.2 By gender

There is a clear difference in the occurrence of multiple sclerosis in males and females, being that females are almost twice more frequently affected than men. 31

2.2.3 By place

The incidence and prevalence of multiple sclerosis is very uneven throughout the world.9,11-13 (See figure 1.) To clarify this fact, different assumptions are found in literature, but there seems to be no consensus. Both geographical and genetic factors are seen as a possible explanation. From a geographical point of view, the further from the equator, the greater the incidence and prevalence of multiple sclerosis, in both northern and southern hemispheres.9,12,13 This uneven distribution is explained by the lack of vitamin D at the extremes of latitude. In certain periods, the sun shines less in these regions, what may cause insufficient synthesis of vitamin D.32 Another explanation found in literature is the hygiene hypothesis. This hypothesis states that children in the modern industrialized world are overprotected against infectious challenges. The presence or absence of certain infections in certain life stages may influence the risk of multiple sclerosis. These challenges are required for the development of a healthy immunoregulatory network. The most frequent described infection concerning the risk of multiple sclerosis, is the Epstein-Barr virus. It seems that contact or infection with the Epstein-Barr virus in early childhood protects against multiple sclerosis, but late contact with the same agent may cause the disease.11,33 The hygiene hypothesis not only explains the rise in incidence of multiple sclerosis, but also the rise in incidence of other diseases associated with immune dysregulation, such as asthma, allergy, autoimmunity and some forms of cancer.33
2.2.4 Genetics

Some races, such as Caucasians from Scandinavia and Scotland, are extremely susceptible to multiple sclerosis. Conversely, in other races, such as Mongolians, American Indians, Eskimos, Japanese and Chinese people, multiple sclerosis is very rare. It is also less frequent in African blacks, Aboriginals, Norwegian Lapps and Gypsies. These observations do suspect genetic susceptibility, and twin and family studies confirm these suspicions. Studies revealed that about 20% of multiple sclerosis patients have at least one affected relative, and the risk for developing multiple sclerosis in first-degree relatives is increased with 3.4 – 5.13%. 11

2.3 Symptoms

2.3.1 Mobility limitations

Limitation in mobility is an umbrella symptom, caused by different other symptoms which may include fatigue, spasticity, muscle weakness, visual deficits, etc.
The World Health Organization defines mobility as follows:

Moving by changing body position or location or by transferring from one place to another, by carrying, moving or manipulating objects, by walking, running or climbing, and by using various forms of transportation.\(^{34}\)

People with multiple sclerosis consider limited mobility as one of the most important factors that has a negative influence on their quality of life, and is reported in up to 90% of people with multiple sclerosis.\(^8,14\) The progressive worsening of mobility, results in the need of some kind of mobility aid, such as foot or knee orthosis, one or two canes, a walking frame, a wheelchair, etc. Fifteen years after diagnosis, people with multiple sclerosis have an approximate chance of 40% for needing some form of walking assistance and an approximate chance of 25% for use of a wheelchair.\(^8\)

### 2.3.2 Other

Other symptoms due to multiple sclerosis include:\(^{35}\)

- pain, which has been reported as being up to 86% in people with multiple sclerosis;
- spasticity, which has been reported in up to 84% in people with multiple sclerosis;
- fatigue, which has been reported in up to 95% in people with multiple sclerosis;
- bladder and bowel dysfunctions;
- cognitive and emotional problems, which has been reported in up to 38%;
- visual deficits;
- dizziness;
- sexual problems;
- tremors;
- swallowing and speech problems;
- seizures;
- muscle weakness;
2.4 **Treatment of multiple sclerosis**

Multiple sclerosis is treated in different ways. On the one hand, the progressiveness of the disease is suppressed with disease-modifying drugs. These drugs reduce relapse rate and slow down the disease progression, but pre-existing neurological damage cannot be repaired. On the other hand, symptoms are treated to minimize the effect of these symptoms on the functioning and the quality of life of the patient. Symptomatic treatment can be conducted using drugs, such as anti-spastic drugs (e.g. baclofen) and pain reducing drugs (e.g. paracetamol). Beside drug therapy, multidisciplinary rehabilitation is an important component of symptomatic and supportive treatment for people with multiple sclerosis. An RCT concluded that multidisciplinary rehabilitation does not change the level of impairment, but may have a positive influence on the experience of people with multiple sclerosis by improving the activity level and participation.
3 Wheelchair skills tests for manual wheelchair users

Until now, some tests have been described to assess the skills of people using a manual wheelchair, but these tests are non specific for PwMS. The Wheelchair Skills Test (WST)\textsuperscript{17-19}, the Obstacle Course Assessment of Wheelchair User Performance (OCAWUP)\textsuperscript{20}, the Wheelchair Users Functional Assessment (WUFA)\textsuperscript{21}, the Wheelchair Physical Functional Performance test (WC-PFP)\textsuperscript{22} and the Tufts Assessment of Motor Performance (TAMP)\textsuperscript{23} can be used for wheelchair users with various diagnoses; the Wheelchair Circuit\textsuperscript{34}, the Five Additional Mobility and Locomotor items (5-AML)\textsuperscript{24} of the Functional Independence Measure (FIM)\textsuperscript{25}, Valutazione Funzionale Mielolesi (VFM)\textsuperscript{26} and the Manual Wheelchair Slalom Test (MWST)\textsuperscript{27} in people with spinal cord injuries.

Below, a short description is given of every test.

3.1 The Wheelchair Skills Test\textsuperscript{17}

The Wheelchair Skills Test (WST) consists of 33 skills, organized in 12 different groups:
Table 1: overview of the different skills in the WST

<table>
<thead>
<tr>
<th>Group</th>
<th>Skill No.</th>
<th>Skill</th>
<th>Group</th>
<th>Skill No.</th>
<th>Skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brakes</td>
<td>1</td>
<td>On</td>
<td>Reaching</td>
<td>17</td>
<td>Floor</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Off</td>
<td></td>
<td>18</td>
<td>Knapsack</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Brake extensions</td>
<td></td>
<td>19</td>
<td>High object</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Caster locks</td>
<td>Maneuvering</td>
<td>20</td>
<td>Slalom</td>
</tr>
<tr>
<td>Footrests</td>
<td>5</td>
<td>Flip up / down</td>
<td></td>
<td>21</td>
<td>3 point turns</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Swing away / back</td>
<td></td>
<td>22</td>
<td>Parallel parking</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Remove / replace</td>
<td>Doors</td>
<td>23</td>
<td>Open toward</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Elevate / lower</td>
<td></td>
<td>24</td>
<td>Open away</td>
</tr>
<tr>
<td>Armrests</td>
<td>9</td>
<td>Flip or swing</td>
<td></td>
<td>25</td>
<td>Threshold</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Remove / replace</td>
<td>Level</td>
<td>26</td>
<td>50 m</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Elevate / lower</td>
<td>surfaces</td>
<td>27</td>
<td>Soft</td>
</tr>
<tr>
<td>Transfer</td>
<td>12</td>
<td>Unweighting</td>
<td>Incline (5°)</td>
<td>29</td>
<td>Ascend</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>To / from</td>
<td></td>
<td>30</td>
<td>Descend</td>
</tr>
<tr>
<td>Folding</td>
<td>14</td>
<td>Cushion, and so forth</td>
<td></td>
<td>31</td>
<td>Ascend</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Fold / open</td>
<td>Curb (10 cm)</td>
<td>32</td>
<td>Descend</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Quick release</td>
<td>Wheelie</td>
<td>33</td>
<td>Pop / hold</td>
</tr>
</tbody>
</table>

On every skill, a score of 0, 1 or 2 was assigned: 0 was given when people failed on the skill, 1 when they were partially able to complete it and 2 when they successfully completed it.

3.2 The Obstacle Course Assessment of Wheelchair User Performance

The Obstacle Course Assessment of Wheelchair User Performance (OCAWUP) consists of 10 obstacles, organized in 4 environmental categories:
Table 2: overview of the different obstacles of the OCAWUP

<table>
<thead>
<tr>
<th>Environmental situation categories</th>
<th>Obstacles in the course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving and maneuvering while avoiding vertical obstacles</td>
<td>Moving down a narrow corridor, between cones and through a doorway</td>
</tr>
<tr>
<td>Getting over a doorstep or onto a sidewalk</td>
<td>Getting over a 2.5 cm doorstep</td>
</tr>
<tr>
<td></td>
<td>Getting over a 7.5 cm doorstep</td>
</tr>
<tr>
<td></td>
<td>Getting onto a 5.0 cm sidewalk</td>
</tr>
<tr>
<td></td>
<td>Getting onto a 15.0 cm sidewalk</td>
</tr>
<tr>
<td>Moving on different surfaces</td>
<td>Moving on a carpet (quite thick and soft)</td>
</tr>
<tr>
<td></td>
<td>Moving on gravel 6 – 19 mm</td>
</tr>
<tr>
<td>Going up and down an incline</td>
<td>Going up and down a 6 m incline of 1:16</td>
</tr>
<tr>
<td></td>
<td>Going up and down a 6 m incline of 1:12</td>
</tr>
<tr>
<td></td>
<td>Going up and down a 6 m incline of 1:8</td>
</tr>
</tbody>
</table>

Two variables are used to evaluate wheelchair user performance on each obstacle: performance time (in seconds) and degree of ease: 0 was given when the participant failed completely, 1 for a partial failure, 2 when he completed the item with success but with difficulties and 3 when the item was performed with total success.

The degrees of ease are summed to obtain the global score of ease, which varies from 0 to 30.

3.3 The Wheelchair Users Functional Assessment

The Wheelchair Users Functional Assessment (WUFA) consists of 13 items:

- Tight space
- Uneven terrain
- Door management
- Street crossing
- Ramp
- Curb
- Bed transfer
- Toilet transfer
- Floor transfer
- Bathing
- Upper and lower dressing
- Reaching function
- Picking up objects / sweeping

To score these items, the level of independence is used, similarly to the FIM. The scores range from 1 (total dependence) to 7 (completely independent). Slightly different from the FIM, a specific time requirement for task completion is included in the scores 6 and 7.

The scores on the different items are summed to obtain a total score, which varies from 13 to 91.

3.4 **The Wheelchair Physical Functional Performance test**

The Wheelchair Physical Functional Performance test (WC-PFP) is used to measure the performance on tasks which are important for living independently. Eleven different tasks are organized in 3 different groups:

- Basic level tasks
  - Lift and transfer pan of weight
  - Transfer and pour from jug into a cup
  - Put on and remove a jacket
  - Put a velcro-closed strap over shoe
  - Pick up 4 scarves from floor

- Intermediate level tasks
  - Transfer 5.9 kg of laundry from washer to dryer and from dryer to counter
- Place and remove a sponge from an adjustable shelf

- Difficult level tasks
  - Carry groceries 52.3 m
  - Pull open and pass through a door
  - Transfer to a standard chair
  - Six-minute wheel

To score these items, a physical functional performance score, which is based upon the amount of weight the patient can carry and how fast he completes the task, is given.

3.5 The Tufts Assessment of Motor Performance

The Tufts Assessment of Motor Performance (TAMP) consisted of 31 functional items, with 105 independent motor performance tasks. Of these 105 tasks, 9 were listed under the performance factor ‘wheelchair’, but were conducted in 4 different items:

- Transfer to mat
  - Prepares wheelchair for transfer

- Transfer to wheelchair
  - Prepares wheelchair for transfer
  - Reassembles wheelchair parts after transfer to wheelchair

- Propel wheelchair
  - Positions self to propel wheelchair
  - Moves wheelchair 10 ft with turn
  - Aligns wheelchair behind line

- Wheelchair ramp
  - Positions self to propel wheelchair
- Moves wheelchair 10 ft with turn
- Aligns wheelchair behind line

Other performance factors were grasp / release, manipulation, typing, fasteners, dynamic balance, mat mobility and locomotion.

To rate each task, 1 measurement dimension is used:

- 7: independent with full motor proficiency
- 6: independent with modified proficiency (may need device or uses an altered motor strategy)
- 5: minimal assistance (close supervision or minimal stabilization)
- 4: minimal assistance with modified proficiency
- 3: moderate physical assistance (requires help with about half of the task)
- 2: maximal physical assistance (requires help with more than half of the task)
- 1: total dependence (unable to attempt task because of difficulty)

3.6 The Wheelchair Circuit\textsuperscript{3,4}

The Wheelchair Circuit is a test developed for people with a spinal cord injury. It consists of 9 different tasks:

- Figure-of-8 shape
- Crossing a doorstep (4 cm)
- Mounting a platform (10 cm)
- Sprint (15 m)
- Walking
- 3% slope (on a treadmill)
- 6% slope (on a treadmill)
- Wheelchair driving (on a treadmill)
- Transfer

To items were scored by measuring performance time, task feasibility (the ability to perform the tasks as required – yes or no) and heart peak rates.

### 3.7 The Five Additional Mobility and Locomotor items (5-AML) of the Functional Independence Measure (FIM)\(^{24}\)

The Five Additional Mobility and Locomotor items (5-AML) are described for people with a spinal cord injury. It is used in conjunction with the Functional Independence Measure (FIM)\(^{38}\) and included 2 mobility and 3 locomotor items:

- **Mobility**
  - Get from a supine position in the middle of gymnasium plinth to a sitting position on the edge of the plinth in preparation for transfer
  - Get from the floor back into the wheelchair

- **Locomotor**
  - Propel a manual wheelchair over flat ground
  - Propel a manual wheelchair up a ramp
  - Propel a manual wheelchair up a curb

Criteria for scoring are based on ability to complete the key components of each task within a reasonable amount of time.
The Valutazione Funzionale Mielolesi (VFM) was developed for patients with spinal cord injury. It includes 8 functional domains with each a different number of tasks. One functional domain is ‘wheelchair use’:

- Locks the brakes
- Releases the brakes
- Puts on the foot rest
- Takes off the foot rest
- Push-up
- Push-up lower limb
- Maneuvers wheelchair
  - Indoors
  - Outdoors
  - Irregular ground
  - Turn
  - Uphill
  - Downhill
  - Up curb
  - Down curb
  - Balancing

Other functional domains include bed mobility, eating, transfers, grooming and bathing, dressing and social avocational skill.

A score of 1 to 5 is assigned to each task:
- 5: patient is able to perform the assigned task without difficulties, modifications or slowing down; he / she does not require any help.

- 4: patient is still able to perform the assigned task independently even though one or more problems (hesitations, mild modification, longer than reasonable time needed to complete the task) may exist.

- 3: patient requires some supervision (verbal cueing or coaxing) or very limited help (very moderate physical help by the examiner); he / she makes 75% or more of the effort.

- 2: patient needs major physical help by one examiner or assistance from two or more people; he / she makes 25% or more of the effort

- 1: patient is unable to carry out the task and completely depends on other people.

3.9 The Manual Wheelchair Slalom Test

The Manual Wheelchair Slalom Test (MWST) is used in people with spinal cord injury. This test consists of a slalom trajectory with a linear length of 18 meters. Participants had to drive around 7 heavy, bright colored cones with flags mounted on a 1.5 m pole, aligned in a straight line and set 3 m, 2 m, and 1 m apart from one another. A starting line was drawn 3 m in front of the first cone, a finishing line 3 m behind the last cone.

To score this test, only performance time is measured.

3.10 Conclusion

The aim of this study is to assess the wheelchair driving skills of people with multiple sclerosis. Regarding that aim, the items of the Wheelchair are the most interesting in this study. These items will be reviewed and adapted where necessary.
4 Methods

4.1 Subject recruitment

A convenience sample of 50 participants was composed, which were recruited in the rehabilitation department of the National multiple sclerosis Center Melsbroek in Belgium. For inclusion in this research, subjects had to be diagnosed with multiple sclerosis (according to the McDonald Criteria\textsuperscript{39}) and use a manual wheelchair, which they propel themselves, to get around in the rehabilitation center. People were excluded when they experienced an exacerbation in the past 3 months or they suffered from acute pains, which impeded their driving skills, such as shoulder pain, back pain, etc. Every participant read the patient information form and signed the informed consent.

4.2 The Wheelchair Assessment Instrument for people with Multiple Sclerosis

In the previous chapter, some other tests which assess wheelchair skills are described. Our aim is to focus on the driving skills of people with multiple sclerosis using a manual wheelchair. Therefore we decided to modify the Wheelchair Circuit\textsuperscript{3,4}, as this test was closest to our expectations concerning a wheelchair driving skills test for our target population. The applied changes involved eliminating the treadmill and a revision of the scoring instructions, considering our target population.

The result is the Wheelchair Assessment Instrument for people with Multiple Sclerosis (WAIMS). This test consists of 6 to 8 items, which measure wheelchair driving skills such as wheelchair turning, dealing with level differences, mounting and descending slopes and endurance. The first 7 items are scored in 2 ways: an ability score (0, 1 or 2) is given and the performance time is measured. For every item a maximum performance time was predetermined, ranging from 60 to 120 seconds depending
on the item. The platform item was only presented to those participants who got an ability score of 1 or 2 on the doorstep item and the 10% slope only to those who obtained an ability score of 2 on the 5% slope. Participants who didn’t start a certain item because it was not presented to them or because they chose not to perform the task, were scored 0 on that item and the maximum performance time was assigned. The last item, which is based on the 6-Minute Walk Test⁴⁰, scores the distance the individual has covered. This item has also been described in the WC-PFP test²², but our implementation was slightly different (e.g. one lap in the WAIMS has a distance of 30 meters, while one lap in the WC-PFP test is at least 91.44 meters).

The WAIMS has 3 final scores: the ability sum score and performance time sum score are both calculated from the first 6 items and the covered distance is copied from the last item.

For safety, the researcher or occupational therapist stays behind the wheelchair, ready to capture the wheelchair handles, especially in those items where the front wheels have to be lifted.

To conduct this test, the next materials are required:

- A stopwatch
- 2 orange traffic cones
- A doorstep with a height of 4 cm, a depth of 20 cm and a width of approximately 100 cm
- A platform with a height of 10 cm, a depth of 150 cm and a width of 120 cm
- A slope with a length of 100 cm and a height of 10 cm
- A slope with a length of 200 cm and a height of 10 cm. (In our configuration, the slope of 100 cm is prolonged with another 100 cm.)
- A barrier tape in contrasting colors
- A measuring tape

The doorstep, the platform and the slopes have been created for this study.

Description of the different items:
4.2.1 Figure-of-8-shape (left)

A starting line and 2 cones were placed 1.5m away from each other. Subjects started with the front wheels behind the starting line and drove the wheelchair in a figure-of-8-shape around the cones, passing the first cone at the left side of the cone. Time was recorded from the moment the subjects began to drive until the front wheels passed the starting line in the opposite direction.

Maximum performance time: 60 seconds.

Ability score:
- 2: clear trajectory
- 1: collision with 1 cone
- 0: collision with 2 cones or expiration of the maximum performance time.

4.2.2 Figure-of-8-shape (right)

The same as the previous item, but the subjects pass the first cone at the right side.

4.2.3 Doorstep

A wooden doorstep, 4cm high and 20cm deep, is placed in a doorway with a width of 100cm. Two lines were drawn on the floor, 1m in front and 1m behind the doorstep. Subjects started behind the first line and had to cross the second line as fast as possible, while crossing the doorstep. Time was recorded from the moment subjects began to drive until the front wheels passed the second line, while sitting in the wheelchair.

Maximum performance time: 120 seconds.

Ability score:
- 2: clear trajectory
- 1: front wheels crossed the doorstep but stuck with back wheels, or alternative way to cross the doorstep (push the wheelchair up with one or both feet, get out the wheelchair and push him over the doorstep, etc.)
- 0: not able to cross the doorstep, not even partially or fall.

4.2.4 Platform

This item is only presented to the subjects who obtained an ability score of 1 or 2 on the previous item.

A wooden platform of 10cm high, 120cm wide and 120cm long was placed against a wall. A starting line was drawn on the floor 2 meters before the platform and a finishing line on the platform, 60cm away from the wall. Subjects started with the front wheels behind the starting line and drove up onto the platform. Time was recorded from the moment the subjects began to drive until the front wheels passed the finishing line, while sitting in the wheelchair.

Maximum performance time: 120 seconds.

Ability score:

- 2: clear trajectory
- 1: front wheels on the platform, or alternative way to mount the platform (push the wheelchair up with one or both feet, get out the wheelchair and push him up the platform, etc.)
- 0: not able to mount the platform, not even partially or fall.

4.2.5 5% slope

In front of the platform, a wooden slope with a length of 200cm was placed. A starting line was drawn on the floor 1 meter before the slope started and a finishing line on the slope: when descending the slope, 25 cm before the end of the slope. Subjects started with the front wheels behind the starting line and drove up onto the platform via the slope. When all 4 wheels were on the platform, subjects had to turn 180° and drive down the slope. They had to stop with the front wheels between the finishing line and the floor. Time was recorded from the moment the subjects began to drive until they fully stopped.
Maximum performance time: 120 seconds.

Ability score:

- 2: clear trajectory
- 1: reached the platform with 4 wheels but something went wrong afterwards (not able to turn on the platform, not able to stop with front wheels on the slope, etc.)
- 0: not able to reach the platform with 4 wheels.

4.2.6 10% slope
This item is only presented to the subjects who obtained an ability score of 2 on the previous item.
The same as the previous item, but the wooden slope has a length of 100cm.

4.2.7 Sprint
A starting line and finishing line are drawn 15m away from each other. The width of the wheelchair is measured and a lane is drawn with barrier tape, 30cm larger than the wheelchair. Subjects started with the front wheels behind the starting line and had to drive as fast and as straight as possible over the finishing line. Time was recorded from the moment the subjects began to drive until the front wheels passed the finishing line.

Maximum performance time: 60 seconds.

Ability score:

- 2: clear trajectory
- 1: crosses the barrier tape once and less than a quarter of the trajectory
- 0: crosses the barrier tape twice or more, or once but a quarter or more of the trajectory, or not able to cross the finishing line.
4.2.8   **Endurance**

Two cones were placed 14 meters away from each other, so the distance of one length (including one turn around a cone) is 15 meters. Subjects have 6 minutes to cover as much distance as possible. They drive around the cones while the researcher or occupational therapist counts the lengths. If the patients finished somewhere between the cones, a measuring tape was used to define the exact distance of the unfinished length. At the end of the item the covered distance is calculated.

4.3    **Testing procedure**

This research involved 3 performance trials of the WAIMS. The first and the third trial (resp. t1 and t3) were accomplished by the researcher, the second trial (t2) by the rendering occupational therapist. Before each trial, participants were asked to express their level of fatigue on a Visual Analogue Scale (VAS)\(^1\). The tests took place in the rehabilitation center of the National Multiple Sclerosis Center Melsbroek. Only one test a day was performed and the testing interval was maximum 3 weeks. One trial takes between 20 and 30 minutes. Participants used their own wheelchair to complete the test trials.

During all test trials, the ability scores are objectively assessed by the researcher or the occupational therapists and the performance times were measured with a stop-watch.

This protocol has been approved by the Ethics Committee of the National Multiple Sclerosis Center Melsbroek.

4.4    **Statistical analysis**

We used SPSS 16.0\(^a\) for the data analysis.

4.4.1    **Reliability**
To calculate intra- and interrater reliability, we compared the 3 final scores of resp. t1 with t3 and t1 with t2 (see figure 1). The intraclass correlation coefficient (ICC) was used to measure reliability. For both intra- and interrater reliability, a two way random effects model was applied. A priori, an ICC of .80 or higher was defined as an indication of good reliability.

![Figure 1: Assessment of intra- and interrater reliability](image)

### 4.4.2 Validity

The results of the first trial were used to calculate concurrent and construct validity.

#### Concurrent validity

A Spearman correlation was calculated between the 3 final scores on the WAIMS and the scores on

- the Belgian medical prescription of a wheelchair on the item d445 (hand and arm use), based on the International Classification of Functioning, Disability and Health (ICF)\(^ {42}\)
- the Expanded Disability Status Scale (EDSS)\(^ {43}\)
- the mobility (wheelchair) item of the FIM\(^ {25}\).

All scores are collected from the patient records.

#### Construct validity

Four hypotheses which contain expected group differences were formulated:
- Participants with an ICF-score ≥ 2 on the item d44S (hand and arm use) obtain a lower ability sum score, need more performance time and cover less distance on the WAIMS than participants with an ICF-score < 2.

- Participants using a standard manual wheelchair obtain a lower ability sum score, need more performance time and cover less distance on the WAIMS than participants using a lightweight manual wheelchair.

- Participants with an EDSS-score ≥ 7 obtain a lower ability sum score, need more performance time and cover less distance on the WAIMS than participants with an EDSS-score < 7.

- Participants with a FIM-score ≥ 6 on the item mobility (wheelchair) obtain a lower ability sum score, need more performance time and cover less distance on the WAIMS than participants with a FIM-score (mobility wheelchair) < 6.

A Kolmogorov-Smirnov test was used to determine whether a Mann-Whitney U for 2 independent samples or an Independent-Samples T Test should be used. This Kolmogorov-Smirnov test is conducted to analyze whether the variables are normally distributed or not. If the result on this test is significant, the variables are not normally distributed; if the result is not significant, the variables are normally distributed.
5 Results

5.1 Sample and participants characteristics

The sample consists of 50 participants, both in- and outpatient rehabilitants of the National Multiple Sclerosis Center Melsbroek. Subjects were between 26 and 73 years old, with a mean age of 50 ± 12, and 60% (n=30) were male. The mean EDSS is 6.5 ranging from 4.5 to 8.5. Relapsing remitting multiple sclerosis is observed in 22% (n=11) of the participants, secondary progressive multiple sclerosis in 46% (n=23) and primary progressive multiple sclerosis in 32% (n=16). Three participants dropped out during this study: one after the first test trial due to acute shoulder pain and two others after the second test trial: one due to minor surgery and the other due to organizational issues.

Participants use either a lightweight (36%; n=18), a standard (60%; n=30) or a modular (4%; n=2) manual wheelchair. The largest group uses only the hand-rims with both arms for propulsion. Another group also uses both arms, but guides their movements with one or both feet. One person with hemiplegic symptoms uses a standard manual wheelchair, propelling his chair with only one arm and correcting the direction with one foot. Another person with the same symptoms uses a standard lever-propelled wheelchair. This study does not elaborate on the effect of the different ways of propulsion.
5.2 Task feasibility

Table 3: Synopsis of final scores on the WAIMS (t1)

<table>
<thead>
<tr>
<th></th>
<th>Ability sum score</th>
<th>Performance time sum score</th>
<th>Covered distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± standard deviation</td>
<td>10 ± 2</td>
<td>263,44 ± 129,86</td>
<td>279 ± 121</td>
</tr>
<tr>
<td>Minimum</td>
<td>2</td>
<td>71,29</td>
<td>60</td>
</tr>
<tr>
<td>Maximum</td>
<td>14</td>
<td>609,10</td>
<td>558</td>
</tr>
</tbody>
</table>

The results of trial 1 were used to describe task feasibility (n=50). Table 3 presents a synopsis of the ability sum scores achieved, the performance time sum scores and the covered distances. Figure 2 gives an overview of the achieved ability scores and figure 3 of the mean performance time scores per item. As participants do not get an ability score and the duration is fixed on the endurance item, it is not shown in figure 2 and 3. One person got the maximum ability sum score (i.c. 14). The lowest ability sum score (i.c. 2) was obtained by someone who already started the application for a new, powered wheelchair. Concerning figure 3, it is important to mention that this figure includes the performance times of participants who didn’t start nor complete the concerning item. Those people were given the maximum performance times.

![Figure 2: Overview of the achieved ability scores per item (t1)](image-url)

Figure 2: Overview of the achieved ability scores per item (t1)
Due to 3 dropouts (one after the first trial, 2 after the second trial), the data of 47 and 49 participants were used to calculate intra- and interrater reliability, respectively. On t2, 14 different occupational therapists conducted the wheelchair circuit. The intra- and interrater ICC’s of the ability sum score, the performance time sum score and the covered distance are described in table 4. The interrater reliability of the ability sum score had an ICC of 0.75, and was below the desired value of 0.80.

### Table 4: Intra- and interrater reliability of the WAIMS

<table>
<thead>
<tr>
<th></th>
<th>Ability sum score</th>
<th>Performance time sum score</th>
<th>Covered distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrarater reliability (t1 - t3)</td>
<td>0.82</td>
<td>0.95</td>
<td>0.96</td>
</tr>
<tr>
<td>Interrater reliability (t1 - t2)</td>
<td>0.75</td>
<td>0.94</td>
<td>0.95</td>
</tr>
</tbody>
</table>

**Figure 3: Overview of the performance time per item (t1)**
5.4 **Validity**

5.4.1 **Concurrent validity**

To compare the 3 final scores of the WAIMS (ability sum score, performance time sum score and covered distance) with the scores on the EDSS and the FIM mobility (wheelchair), the data of 50 participants were used. Most people scored 5 or 6 on the FIM item (resp. 56% and 42%) and one person (2%) scored 4. As the scores on the d445 (hand and arm use) item of the ICF are assigned on the medical prescription for a wheelchair and patients might get this prescription elsewhere, we have this score for only 37 participants. For these 37 participants, 6% scored 0; 43% scored 1; 24% scored 2 and 27% scored 3. See Table 5 for the results of this validity analysis.

<table>
<thead>
<tr>
<th></th>
<th>Ability sum score</th>
<th>Performance time sum score</th>
<th>Covered distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDSS</td>
<td>-0.38*</td>
<td>0.35*</td>
<td>-0.36*</td>
</tr>
<tr>
<td>FIM Mobility (Wheelchair)</td>
<td>0.11</td>
<td>-0.31*</td>
<td>0.33*</td>
</tr>
<tr>
<td>ICF d445 (Hand and arm use)</td>
<td>-0.49*</td>
<td>0.35*</td>
<td>-0.48*</td>
</tr>
</tbody>
</table>

* P < 0.05

5.4.2 **Construct validity**

A Kolmogorov-Smirnov test showed that the ability sum score and performance time sum score were not normally distributed, so a Mann-Whitney U test was used to analyze these data in the different hypotheses. The covered distance, however, was normally distributed, so an Independent-Samples T Test was conducted. Table 6 gives an overview of the hypotheses and table 7 of the data.
Table 6: Construct validity of the WAIMS - hypotheses

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants with an ICF-score ≥ 2 on the item d445 (hand and arm use) have a lower ability sum score, need more time and cover less distance than participants with an ICF-score &lt; 2.</td>
<td>Confirmed</td>
</tr>
<tr>
<td>Participants with a standard manual wheelchair have a lower ability sum score, a higher performance time and cover less distance than participants with a lightweight manual wheelchair.</td>
<td>Confirmed</td>
</tr>
<tr>
<td>Participants with an EDSS-score ≥ 7 have a lower ability sum score, a higher performance time sum score and cover less distance than participants with an EDSS-score &lt; 7.</td>
<td>Confirmed</td>
</tr>
<tr>
<td>Participants with a FIM-score ≥ 6 on the item mobility (wheelchair) have a lower ability sum score, a higher performance time and cover less distance than participants with a FIM-score (mobility wheelchair) &lt; 6.</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

Table 7: Construct validity of the WAIMS - data

<table>
<thead>
<tr>
<th></th>
<th>Ability sum score</th>
<th>Performance time sum score</th>
<th>Covered distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group A</td>
<td>Group B</td>
<td>Group A</td>
</tr>
<tr>
<td>ICF d445</td>
<td>24*</td>
<td>14*</td>
<td>14.89*</td>
</tr>
<tr>
<td>Wheelchair</td>
<td>31*</td>
<td>19*</td>
<td>15.22*</td>
</tr>
<tr>
<td>EDSS</td>
<td>29*</td>
<td>19*</td>
<td>22.06*</td>
</tr>
<tr>
<td>FIM Mobility</td>
<td>27</td>
<td>24</td>
<td>20.19*</td>
</tr>
</tbody>
</table>

* P < 0.05

Group A: ICF d445 < 2; lightweight manual wheelchair; EDSS < 7; FIM Mobility (Wheelchair) < 6
Group B: ICF d445 ≥ 2; standard manual wheelchair; EDSS ≥ 7; FIM Mobility (Wheelchair) ≥ 6
6 Discussion

This study examined the reliability and validity of the WAIMS, a test designed to assess the skills of manual wheelchair users with multiple sclerosis. Only the 3 final scores (the ability sum score, the performance time sum score and the covered distance) are considered in the statistical analysis. For the reliability analysis, 3 test trials took place. For the task feasibility and validity analysis, only the scores on the first trial, conducted by the researcher, were considered.

Results showed that, except for the doorstep and the platform item, 78% or more of the participants got the maximum ability scores on each item of the WAIMS. This may be due to inclusion bias. First, the people who were included are familiar with driving their wheelchair. Second, when people were asked to participate in this study, those who had experienced wheelchair driving problems in the past often choose not to participate because they did not want to go beyond their comfort zone, which is understandable. The better wheelchair drivers were generally more challenged by the test trials and therefore more willing to participate. A future study with the inclusion of a more varied sample should answer the question whether the items are too easy or not.

Concerning reliability, the intrarater reliability is higher than the interrater reliability. The ICC of the ability sum score between the researcher and the occupational therapist was not found reliable enough. A possible cause might be the test and scoring instructions: it is not clear whether they are not detailed enough, or conversely too elaborate. This contradiction comes from an observation during the test trials. On the one hand, and this might seem the most obvious cause, the test instructions are not detailed enough. This might be true for the starting procedure, for example. (Should subjects take a dynamic start or static start? And does the person who conducts the test start timing when the subject crosses the starting line or when he says start?) On the other hand, the scoring instructions are explained in more detail, but it tends to be confusing for the occupational
therapists. They were confused when they conducted a test, because the scoring instructions are different for every item. Most of them kept the instruction bundle in their hands while conducting the test. During the test, they had to look in the instructions how they should score the item. Sometimes there is not enough time, and they might pick the wrong score. To resolve this contradiction, the occupational therapists will be surveyed in order to collect a decent amount of feedback. Based on this feedback, the decision will be made whether the instructions should be more detailed, or on the contrary more concise.

Another explanation could be the fact that people weren’t necessarily tested at the same time of the day, what may influence their level of fatigue. In case of the intrarater reliability, two different therapists were involved, whose schedules didn’t always match. This resulted in variable test moments during the day. Concerning intrarater reliability, test moments of t1 and t3 were the same if possible, but from time to time, organizational issues may have made this difficult.

The results of the concurrent validity analysis showed that the lowest correlations were found with the FIM, including a non-significant result of the ability sum score. A plausible cause is that the FIM is a functional assessment tool (‘what do you do?’) and the WAIMS a skills assessment tool (‘what are you able to do?’). This in combination with the low variation of the scores on the FIM and its low interrater reliability on the mobility item, makes the FIM a less suitable tool to compare with in this study. The highest correlations were found with the ICF item, ranging from 0.35 to -0.49, which is still rather low.

The conclusion that the FIM is a less suitable tool to compare with is supported by the construct validity analysis. The hypothesis based on the FIM is the only rejected one. The result of the Mann-Whitney U Test of the ability sum score was not significant and the Independent-Samples T Test of the covered distance gave the opposite results of the hypothesis. The results of the other 3 hypotheses were significant and as expected.
7 Conclusions

This first study on the WAIMS concludes that the WAIMS might be a valuable assessment instrument in the rehabilitation of people with multiple sclerosis, but it needs some refinements and future studies to confirm this statement. Refinements should include more precise test and scoring instructions to improve the interrater reliability of the ability sum score. The interrater reliability of the performance time sum score and the covered distance was found to be good, as well as the intrarater reliability of these 3 final scores on the WAIMS. Concurrent validity was rather low, but construct validity showed that the WAIMS is a valid instrument, keeping in mind that the FIM is not the right instrument to compare with in this study.

7.1 Limitations of the study

First, participants in this study are familiar with manual wheelchair driving. This may result in better scores on the different items than the general target population would achieve. Second, fatigue is not considered in this study, although this symptom may have a varying influence on the test results. A final limitation is the collection of the EDSS, FIM and ICF scores from patient records, which may result in some outdated data being included in this study.

7.2 Avenues for future research

Future studies should focus on the optimization of the different items, including the scoring instructions. Also the feasibility of the items in a more varied sample of people with multiple sclerosis should be assessed, to exclude or confirm whether the items are too easy or not.
We presented the preliminary results of this study on a poster at the 16th annually RIMS conference (Rehabilitation In Multiple Sclerosis) in Turku, Finland. We were given the best poster award for the presentation.
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