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### Physical exercise and dementia

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# CHAPTER

# 3

*The Groningen Meander Walking  
Test: a dynamic walking test for  
older adults with dementia.<sup>1</sup>*

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<sup>1</sup>See also: *Physical Therapy* 2014;94:262-72. doi: 10.2522/ptj.20130077

## ABSTRACT

### Background and aim

Current dynamic walking tests, used in studies with older adults with dementia, rely strongly on healthy cognitive and physical function. Therefore, the Groningen Meander Walking Test (GMWT) was developed, specifically for persons with dementia. The aim of the GMWT is to measure dynamic walking ability by walking over a meandering curved line, with an emphasis on walking speed and stepping accuracy, while changing direction. The objective of this study was to investigate the feasibility, test-retest reliability, and Minimal Detectable Change (MDC) of the GMWT.

### Methods

Forty-two subjects with dementia participated in a repeated measures design. Adherence rate, adverse events, repetition of instructions during test performance, test duration, and number of oversteps were assessed.

### Results

Adherence rate was excellent, with no adverse events. No repetitive instructions were given during test performance and test duration was short (mean: 17.16s) with few oversteps (mean: 1.94 oversteps). Test-retest reliability for participants without a walking device was excellent for the GMWT time score (ICC = .942), with a MDC of 2.96s. Test-retest reliability for participants with a four-wheeled walker was moderate (ICC = .837) with a MDC of 10.35s. For the overstep score a marginal ICC = .630 was found with a MDC of 4.38 oversteps.

### Limitations

No fall data were available and there was a volunteer bias.

### Conclusions

The GMWT is a feasible test. With the GMWT time score, a reliable and sensitive field test to measure walking abilities in older adults with dementia is available. The GMWT overstep score can be used to give information about the execution according to protocol, and should be emphasized during the instructions. Future studies need to investigate the validity of the GMWT.

## INTRODUCTION

Compared with healthy older adults, their peers with dementia are about 2 - 3 times more likely to fall.<sup>1,3</sup> In older adults with dementia the ongoing degeneration of brain tissue eventually leads to a loss of cognitive (e.g., executive functions, memory, attention) and physical functions (e.g., gait, balance, muscle strength).<sup>4-6</sup> This leads to a decrease in their level of physical activity.<sup>7</sup> Consequently, cognition and physical function may decline further and increased risk of falling may emerge.<sup>6,8,9</sup>

The likelihood of falling in cognitively impaired older adults is related to a decline in executive function and a decline in dynamic balance (e.g., balance during walking).<sup>9</sup> Specific physical properties that relate to a loss of balance during walking are; a lower walking speed and a wider step support.<sup>10</sup> Recent studies suggest that older adults with dementia may counteract the cognitive and physical decline by taking part in exercise interventions.<sup>9,11</sup>

Interventions should aim to enhance executive functions, improve walking speed, and reduce gait width because most falls occur in walking activities that require these dynamic balance abilities.<sup>12</sup> Several neuropsychological tests are already available to measure intervention effects on executive function.<sup>13</sup> However, to measure intervention effects on walking abilities, both walking speed and gait width should be tested while changing direction.

A recent review revealed that studies in people with dementia only used walking and balance tests that were originally designed for cognitively non-impaired older adults.<sup>13</sup> The most frequently used balance test was the Functional Reach Test.<sup>13,14</sup> However, because no walking is involved in this test, the clinical relevance for dynamic walking is minor. A dynamic walking test is the Figure of Eight (FoE). In this test, participants are asked to walk as quickly and accurately as possible over a figure of eight without stepping outside the lines.<sup>15</sup> For clinical practice it is crucial that such a test is feasible, meaning that a patient is capable to successfully accomplish the presented test according to protocol. Furthermore, a test should be reliable, valid, and sensitive to measure change for the population of older adults with dementia in the home environment.

Currently available dynamic tests, such as the Functional Reach Test and FoE, are reliable in older adults with dementia. However, they seem to depend too strongly on healthy cognitive functioning, and require considerable executive functioning and memory resources to execute them according to protocol.<sup>16-18</sup> Furthermore, the Minimal Detectable Change (MDC), which is a measure for the amount of change that is needed to exceed measurement error or participant variability, was too large

to detect clinical relevant changes.<sup>18</sup> This hampers the feasibility and clinimetric properties of these tests. To counter this, a test for people with dementia should provide an obvious, unambiguous test assignment (to meet impaired executive functioning), and short test instructions with a maximum of a three step command (to meet impaired memory and attention), because cueing during a test negatively affects test results.<sup>17,19</sup> At the physical level, the test duration should also be short to avoid fatigue and enable the participant to perform the test according to protocol, which may decrease the MDC.<sup>19</sup> Therefore, a more feasible, reliable, sensitive, and valid test to assess walking abilities is needed for persons with dementia.

In order to provide such a test that fits the population of older adults with dementia, the Groningen Meander Walking Test (GMWT) was developed. The aim of the GMWT was to measure walking abilities by walking over a meandering curved line, with an emphasis on walking speed and stepping accuracy, while changing direction. The GMWT has some similarities with the FoE (i.e., meandering lines, timed performance, requires accuracy while walking). However, the GMWT is distinctly different from the FoE because it was designed specifically for older adults with dementia to maximize feasibility (i.e., a more intuitive task, short, no cross-over of the track, little instructions needed). For older adults with dementia it is suggested that the GMWT may lead to more reliable outcome measures compared to the FoE. Therefore, we assume that the GMWT is more suitable for testing walking abilities in this specific population. This test may help to determine treatment effects after an intervention that is aimed to improve walking abilities. After validation, this test may be a useful tool to estimate dynamic balance control and individual fall risk. The aims in this study were to investigate feasibility, test-retest reliability, and MDC, as a first step towards the clinimetric evaluation of the GMWT.

## METHODS

### Participants

Fifty subjects were recruited from four specialized nursing homes in and around Groningen in the Netherlands, meeting the following inclusion criteria: (1) 70 years or older, (2) Dutch native speakers, (3) diagnosis of dementia according to medical file, (4) Mini Mental State Examination (MMSE) score in the range of 9 to 24,<sup>20</sup> (5) able to walk independently with or without a walking device but without personal assistance. Exclusion criteria were: (1) use of a wheelchair for mobility, (2) language problems such as aphasia, (3) direct cause of physical problems (e.g., having a sprained ankle), (4) vision problems that could hamper mobility or test performance, (5) history of psychiatric illness (e.g., schizophrenia), and (6) history of alcoholism. Due to unwillingness to cooperate ( $n = 4$ ), physical injury before admission of the test ( $n = 2$ ), and illness ( $n = 2$ ), 42 subjects eventually participated in this study. Characteristics of the participants are presented in Table 3.1. The Medical Ethical Committee of the University Medical Center Groningen, the Netherlands, approved this study. If participants were eligible for participation, informed consent was obtained from their legal representatives.

**Table 3.1.** Characteristics of the participants (N=42).

| Characteristics   | Value                    |
|---|--------------------------|
| Women, no. (%)  | 33 (78.6%)               |
| Age, y, mean $\pm$ SD (range)                                   | 86.7 $\pm$ 5.2 (75 – 99) |
| <i>Diagnosis dementia Type, no. of participants<sup>a</sup></i> |                          |
| Alzheimer's Disease   | 24                       |
| Vascular Dementia   | 8                        |
| Alzheimer's Disease / Vascular Dementia                         | 9                        |
| Lewy Body Disease   | 1                        |
| <i>Cognitive state</i>  |                          |
| MMSE score, mean $\pm$ SD (range)                               | 17.1 $\pm$ 4.3 (9 – 24)  |
| Mild dementia (MMSE 21 – 24), no. of participants               | 12                       |
| Moderate dementia (MMSE 10 – 20), no. of participants           | 28                       |
| Severe dementia (MMSE < 10), no. of participants                | 2                        |
| No. prescribed drugs / day, mean $\pm$ SD (range) <sup>b</sup>  | 6.97 $\pm$ 3.71 (1 – 15) |
| <i>Physical state</i>   |                          |
| No use of walking aid indoors, no. of participants              | 23                       |
| Use of four-wheeled walker indoors, no. of participants         | 19                       |

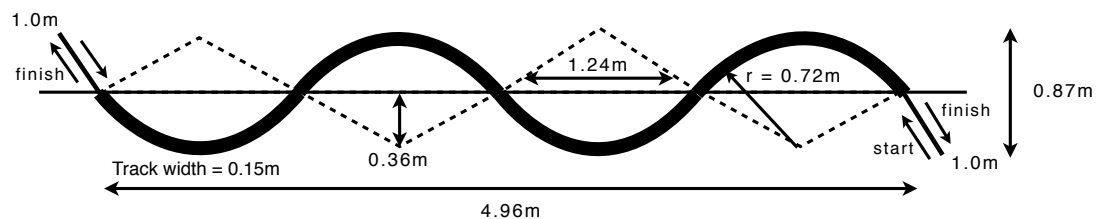
Note: <sup>a</sup>, based on available preliminary diagnoses according to medical files; <sup>b</sup>, medication data was available for 40 participants.

### Groningen Meander Walking Test

The dimensions of the GMWT are shown in Figure 3.1. The 6.00m track of the GMWT, which has four bends, was drawn on a smooth dark blue mat. The width of the meandering track was 0.15m. To exclude the effects of start-up speed and slow-down speed, participants started the test one meter before the start of the track and stopped one meter after the end of the track. The test as a total was performed in two parts; first forth and then back.

Participants were instructed to walk as fast and accurately as possible. The instructions were as follows: "Please walk over the path as fast and accurate as possible. Try not to step outside the white lines. We will measure the time and count the number of times you step outside the lines". No practice trial was included and a walking device was allowed.

The first outcome measure was the time to perform the test. The forth and back walk were timed separately: the stopwatch stopped once the participants finished the forth and restarted once they started their walk back. The final score was the mean time in seconds of the forth and back walk. A faster time score indicated better performance. The second outcome measure, simultaneously measured with the time score, was the number of oversteps outside the track. If the participant stepped completely outside the indicated track, this was noted as overstep. The oversteps of the forth and back walk were counted separately. The final score was the mean number of oversteps of the forth and back walk. A fewer number of oversteps indicated a better performance.



**Figure 3.1.** Dimensions of the Groningen Meander Walking Test (GMWT).  $r$ =radius to draw the curved GMWT path.

### Protocol

The primary researcher administered the MMSE to control for the inclusion criteria. Furthermore, background data was collected from the medical files of the participants with respect to age, gender, diagnosis of dementia, and medication use. A repeated measures design (T0 - T1) for the GMWT time and overstep score was used to study the feasibility, test retest reliability, and MDC of the GMWT. The adherence rate of the GMWT for T0 and T1 was assessed as an indicator of feasibility. In addition, reasons for non-participation, not completing the test, adverse events, repetition of the instructions during test performance, test duration, and number of oversteps were noted. These results allowed the practitioner to estimate the chance of successfully administering the test, collect consistent measurements under consistent conditions, and quantify the amount of change that is needed to exceed measurement error or participant variability.

Repeated measures were administered by the same well trained, experienced test instructors with one week in between, at the same time, and at the same location, at an illuminated closed off corridor in the specialized nursing homes. All test instructors were trained by the primary researcher, who gave written and oral instructions of how to perform and assess the tests according to protocol. Instructions for the GMWT began with verbal step-by-step instructions, with concurrent visual cues and gestures. Interacting with the participants was done in a way that was easy to understand, with the use of clear speech, friendly facial expressions, and eye contact during speech.<sup>21</sup> Then, the instructions were repeated while demonstrating the task. Finally, the test instructor asked the participant if the instructions were understood.

### Data management

PASW Statistics 18 for Windows was used for data management and analyzes. Level of significance was  $p < .05$  for all statistical analyzes. All analyzes were performed for the total group and for the participants without a walking device, and those with a four-wheeled walker (4WW), separately.

To identify possible structural differences (e.g., learning effect) between T0 and T1, the differences between the scores of the GMWT time and overstep for the repeated measures (T1 - T0) were tested. This was done with a paired sample t-test for normally distributed data and Wilcoxon Signed Rank tests for non-normally distributed data. The relationship between the time score and overstep score was analyzed with a Spearman correlation.

Assessment of the test retest reliability for the GMWT time and GMWT overstep score was performed with a Model 3 (two way mixed) Intra Class Correlation (ICC) analysis. The ICC was calculated with a 95% Confidence Interval (CI), single measure, absolute agreement model. For group studies (e.g., epidemiological studies) a test-

retest reliability ICC < .70 is marginal. For clinical individual measurements an ICC > .90 represents the required consistency of a test.<sup>22</sup>

To plot the similarity between T0 and T1 of the GMWT time and overstep score, for the total group, the group that did not use a walking device, and the group that used a 4WW, Bland-Altman plots with limits of agreement were created.<sup>23, 24</sup> The width of the limits of agreement give an adequate view of the absolute measurement variability, which is caused by patient variability and / or measurement error. A larger width of the limits of agreement indicates a larger variability, and thus a lower test retest reliability. To calculate the limits of agreement for skewed data, the following formula was used:  $-2X * [ ((10^a)-1) / ((10^a)+1) ]$  and  $+2X * [ ((10^a)-1) / ((10^a)+1) ]$ ; with  $a=1.96 * \sqrt{2\sigma_{ER}^2}$  and  $\sigma_{ER}^2$  reflecting the residual-error variance.<sup>24</sup> The MDC at a 95% CI was calculated with formula:  $MDC_{95} = SEM * 1.96 * \sqrt{2}$ , representing the amount of change that is needed to exceed anticipated measurement error or patient variability.<sup>25</sup>

The standard error of measurement (SEM) scores, with a 95% CI, were calculated following Stratford and Goldsmith (1997).<sup>26</sup> The MDC is closely related to the SEM, but is more conservative (~2.7 SEMs). Therefore, interpretation of the results will focus on the MDC.

## Results

Table 3.2 presents the GMWT time and overstep scores for all participants (n = 42), and for participants without (n = 23), and those with a 4WW (n = 19), separately. In addition, the test results for differences between T0 and T1, as well as the reliability coefficients, are presented.

## Feasibility

Forty-two participants performed both measurements of the GMWT according to protocol (adherence rate was 100%), and no adverse events occurred during test administration. Further, only repetitive instructions were given to the participants before the second walk over the GMWT. Test duration of the GMWT was short (mean: 17.16s) and the amount of oversteps ranged between 0 - 11.50 oversteps. Twelve participants (28.6%) made no overstep (n = 8 without a walking device, n = 4 with a 4WW) and 30 participants (71.4%) made one overstep or more. Furthermore, the range of oversteps was smaller in participants without a 4WW (range: 0 - 7.50 oversteps), compared to participants that used a walker (range: 0 - 11.50 oversteps). A significant correlation between the GMWT time and overstep score was found (r = 0.36, p < .01), indicating that participants who had more trouble to stay within the GMWT path performed the test slower. Preliminary hip accelerometer data in older adults with dementia (N = 20) suggested that there may be a relation between the performance of the GMWT and mediolateral regularity during walking (r = 0.495,

CI = 0.066 - 0.770), and the stride regularity during walking (r = 0.527, CI = -0.787 - -0.109).

## GMWT time score

The total group of participants showed no significant differences in mean GMWT time score between T0 and T1. An excellent test retest reliability (ICC = .942), with a MDC of 5.35s, was found. Looking at the two groups separately, participants that walked without a walking device (mean GMWT time = 13.26s, SD = 6.40) showed a higher test-retest reliability (ICC = .972), and a smaller MDC (2.96s) compared with those who used a 4WW (mean GMWT time = 21.88s, SD = 7.44; ICC = .748; MDC = 10.35, respectively).

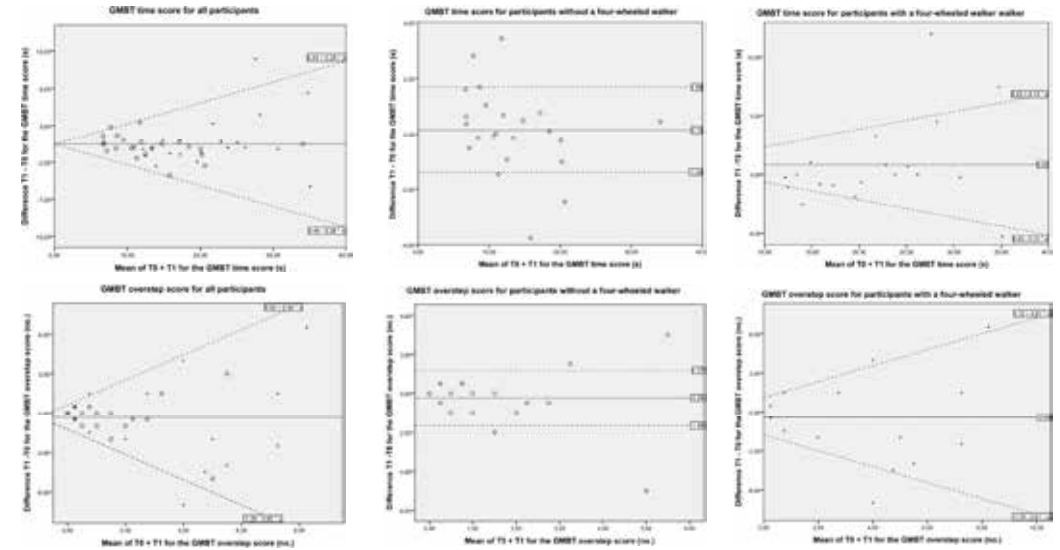
## GMWT overstep score

The total group of participants showed no significant differences in mean GMWT overstep score between T0 and T1. However, the total group showed a marginal test retest reliability (ICC = .630) with a MDC of 4.38 oversteps. Looking at the two groups separately, participants that performed the test without and with a 4WW both showed marginal test-retest reliability (ICC = .672 and ICC = .578, respectively). However, the MDC for participants without a walking device was smaller compared to participants that used a 4WW (MDC = 2.71 oversteps versus MDC = 5.78 oversteps, respectively).

**Table 3.2.** GMWT time (s) and overstep (no.) mean scores (standard deviation), range for repeated measures T0 and T1, difference between T1 and T0 with their statistical value, Intraclass Correlation with 95% CI, Standard Error Measurement (SEM) with 95% CI and the Minimal Detectable Change at a 95 % CI. These values are presented for all participants, the group of participants without, and those with a four-wheeled walker.

|                            | T0           |               | T1           |               | T1-T0 |                                |                    | MDC <sub>95</sub>  |       |
|----------------------------|--------------|---------------|--------------|---------------|-------|--------------------------------|--------------------|--------------------|-------|
|                            | Mean (SD)    | Min. – Max.   | Mean (SD)    | Min. – Max.   | Diff. | Paired test                    | ICC (95% CI)       |                    |       |
|                            |              |               |              |               |       |                                | SEM (95% CI)       |                    |       |
| <b>GMWT Time (s)</b>       |              |               |              |               |       |                                |                    |                    |       |
| All (N = 42)               | 16.93 (7.90) | 5.86 – 37.73  | 17.39 (8.37) | 6.93 – 38.49  | 0.46  | t = -1.060 <sup>b</sup> , n.s. | .942 (.895 - .968) | 1.93 (1.64 – 2.54) | 5.35  |
| No Device (N = 23)         | 13.19 (6.69) | 5.86 – 33.83  | 13.33 (6.23) | 6.93 – 34.28  | 0.14  | Z = -0.669 <sup>b</sup> , n.s. | .972 (.937 - .988) | 1.07 (0.84 – 1.54) | 2.96  |
| 4-wheeled walker (N = 19)  | 21.46 (6.90) | 12.31 – 37.73 | 22.29 (8.11) | 11.87 – 38.49 | 0.83  | Z = -0.080 <sup>b</sup> , n.s. | .748 (.707 - .949) | 3.73 (2.02 – 3.97) | 10.35 |
| <b>GMWT Overstep (no.)</b> |              |               |              |               |       |                                |                    |                    |       |
| All (N = 42)               | 2.11 (2.63)  | 0.00 – 8.50   | 1.77 (2.60)  | 0.00 – 11.5   | -0.34 | Z = -1.098 <sup>b</sup> , n.s. | .630 (.409 - .782) | 1.58 (1.31 – 2.03) | 4.38  |
| No Device (N = 23)         | 1.37 (1.79)  | 0.00 – 7.50   | 1.13 (1.66)  | 0.00 – 7.00   | -0.24 | Z = -0.920 <sup>b</sup> , n.s. | .672 (.371 - .846) | 0.98 (0.77 – 1.41) | 2.71  |
| 4-wheeled walker (N = 19)  | 3.00 (3.21)  | 0.00 – 8.50   | 2.55 (3.29)  | 0.00 – 11.50  | -0.45 | Z = -0.882 <sup>b</sup> , n.s. | .578 (.179 - .813) | 2.09 (1.61 – 3.15) | 5.78  |

Note: <sup>a</sup>, Paired Sample T-test; <sup>b</sup>, Wilcoxon Signed Rank Test; GMWT, Groningen Meander Walking Test; Diff., Difference T1 – T0; Sign, Significance; ICC, Intraclass Correlation; CI, Confidence Interval; SEM, Standard Error Measurements; MDC<sub>95</sub>, minimal detectable change at 95% Confidence Interval; n.s., p > 0.05.



**Figure 3.2:** Bland-Altman plots with limit of agreement for the Groningen Meander Balance Test time score (upper) and GMWT overstep score (lower) for respectively the total group (left), participants without a walking device (middle), and participants with a walker (right).

Figure 3.2 displays the Bland Altman plots, with 95% limits of agreement, for the time score and overstep score for the total group, participants without, and those with a 4WW. The GMWT time and overstep data for the total group were positively skewed and heteroscedastic. This is reflected by limits of agreement becoming wider, meaning a higher variability between T0 and T1 with increasing values. In clinical practice this means that the test retest reliability for the GMWT time and overstep score becomes lower with slower test performance or more oversteps. Looking at the groups separately, for the group that did not use a 4WW, the data of the GMWT time and overstep score was homoscedastic with constant limits of agreement. This resulted in a constant variability, which is independent of the magnitude of the GMWT time or overstep score. In contrary to this, time and overstep data for the group that used a 4WW was heteroscedastic, with higher scores yielding higher variability. In practice, reliability of the GMWT time and overstep score for the group that used a 4WW declines with slower performance or more oversteps. Based on data in the current study, no relation was found at baseline between cognition (MMSE) and GMWT time ( $r = -0.160$ ,  $p = 0.312$ ), and between cognition and GMWT oversteps ( $r = -0.098$ ,  $p = 0.539$ ). A subgroup reliability analysis between moderate cognitive level participants ( $MMSE \geq 20$ ,  $N = 13$ ) and lower cognitive level participants ( $MMSE < 20$ ,  $N = 29$ )<sup>20</sup> showed a difference in test retest reliability for the GMWT time score (ICC = 0.963 versus ICC = 0.933, respectively) and the GMWT overstep score (ICC = 0.792 versus ICC = 0.569, respectively).

## DISCUSSION

In the absence of an appropriate field test to measure dynamic walking performance in older adults with dementia, the GMWT was developed. Main goals in this study were to investigate feasibility, test retest reliability, and MDC, as a first step towards the clinimetric evaluation.

### Feasibility

In the process of test development, there was an emphasis on the feasibility of the GMWT. At the cognitive level, an obvious, unambiguous test assignment with a simple and short three step instruction was provided.<sup>17</sup> At the physical level, fatigue was avoided by providing a short test duration.<sup>19</sup> Current results support an excellent feasibility, since all participants were able to perform the test fluently, without hesitation, and without any adverse events. Also, test instructors did not use repetitive instructions during the execution of the test. Only repetitive instructions between the two walks over the GMWT were given. Not repeating test instructions while a participant is performing the test prevents cognitive interference, which strengthens the test retest reliability.<sup>27</sup> However, measurements with cognitively impaired older adults are known to be less reliable compared with measurements with cognitively non-impaired older adults.<sup>25</sup> Based on data in the current study no relationship was found at baseline between cognition (MMSE) and GMWT time, and cognition and GMWT oversteps. However, a subgroup reliability analysis between moderate cognitive level participants (MMSE  $\geq$  20, N = 13) and lower cognitive level participants (MMSE < 20, N = 29)<sup>20</sup> showed a difference in test retest reliability for the GMWT time score and the GMWT overstep score. Therefore, for the GMWT a lower cognitive level may lead to less reliable outcome scores. Future research with larger subgroups is needed to further evaluate these findings.

The active duration of the GMWT was shorter (range 5.86s - 37.73s), compared with the FoE (range 18.28s - 117.41s).<sup>18</sup> This may have contributed to the feasibility at the cognitive level (e.g., memory, attention), and the physical level (e.g., fatigue).<sup>4-6</sup> Furthermore, the number of oversteps can provide information about the clinical value of the GMWT time score, whereas participants who made a large amount of oversteps were not able to follow the marked path. As a consequence, reliability of the time score declines. Our data showed that 31 participants (73.8%) performed the GMWT with less than four oversteps. However, eleven participants (26.2%) made more than four oversteps, of whom eight were using a 4WW. For older adults with dementia who did not use a 4WW, the mean number of oversteps per meter for the GMWT (0.23 oversteps / meter) was lower compared to the amount of oversteps of the FoE in a study with mild dementia patients (0.66 oversteps / m).<sup>17</sup> Thus, the use of a 4WW may negatively affect the accuracy during test performance. This may be

reflected by a lower feasibility to perform the GMWT according to protocol.

Participants made less oversteps during the GMWT compared with the FoE. Therefore, the question rises whether the limits of test performance on dynamic balance were reached. Data showed that walking speed on the GMWT was approximately 0.35 m/s, which is twice as slow as a comfortable walking speed in a straight line in people with dementia.<sup>18</sup> Furthermore, the number of oversteps was positively correlated with the GMWT time score ( $r = 0.36$ ,  $p < .01$ ), which indicates that participants who had more trouble staying within the GMWT path were slower on the test. Evidently, the limits of test performance may have been reached, in view of the fact that walking speed decreased in an attempt to execute the test as accurately as possible.

### Test retest reliability

Reliability studies of dynamic walking tests, such as the Parallel Walk test<sup>28</sup> and FoE<sup>18</sup>, combined data of participants with and without a walking device. However, current results showed that combining data of participants with and without a walking device might lead to an underestimation of the reliability for people that did not use a walking device, and an overestimation of the reliability for people that used a walking device. From a clinical perspective, an ICC  $> .90$  represents the required reliability of a test for individual clinical measurements.<sup>22</sup> Therefore, only the test retest reliability for older adults with dementia, who walked without a walking device, was sufficient (ICC = .972) to obtain reliable data, which can be used in clinical practice.

When the GMWT is performed with a walking device, a clinician or researcher needs to be aware that this may negatively affect the test retest reliability of the GMWT time score. Furthermore, it is shown that the use of a 4WW in geriatric patients negatively affects the assessment of changes over time in gait and mobility performance.<sup>29</sup> To get around the constraints that a walking device may cause, such as an increased cognitive attention and planning demand while steering,<sup>30</sup> higher cardiorespiratory demands,<sup>31</sup> and possibly reduced sight during feet placement, future research should investigate if it is feasible, reliable, and safe to perform the GMWT without a walking device, for persons using a walking device in daily life.

For the GMWT overstep score, both people with and without a 4WW showed marginal test retest reliability. The current results were comparable with results of a study that was performed with the Modified FoE, which included older community-dwelling women (ICC = .73).<sup>32</sup> The low test retest reliability of the overstep scores may have been caused by a relatively large stepwise increment of the test score. Because a majority of the participants (73.8%) made less than four oversteps, a small change in the number of oversteps caused a relatively large variability. As a consequence, this negatively affected the reliability and caused a large MDC, which could complicate



the detection of clinically relevant changes. However, the overstep score plays an important role to get a meaningful time score, because of the significant correlation that was found between the two. This significant relation showed that participants who had more trouble to stay between the GMWT lines walked slower on the test, thereby adding purpose for the time score. In clinical research, where tests with a time and overstep score were used, such as the FoE, often only the time scores<sup>33, 34</sup> or only the overstep scores<sup>35, 36</sup> were presented. However, for clinical practice it is crucial that both scores are measured and presented, as this tells us how the tests were performed. Future research into the validity of the GMWT should further investigate the role of oversteps in relation to the time score of the GMWT.

### Minimal Detectable Change

Current results show that the MDC of the GMWT time score was 5.35s. This indicates that in clinical practice a difference of approximately 31% is needed to measure a difference that exceeds the 95% variability bounds.<sup>26</sup> Despite this large values required to detect change, which poses a problem when monitoring differences over time, it is an improvement compared to the existing balance tests that were already used in older adults with dementia, such as the FoE (~40% change is needed to exceed MDC) and the FICSIT-4 (~59% change is needed to exceed MDC).<sup>18</sup> Therefore, the GMWT time score appears to be better than dynamic walking tests that are currently available.

Current data showed that the GMWT time score had a large difference in MDC values for participants without a walking device and those with a 4WW. For participants without a walking device, a smaller change is enough to require a reliable result (MDC = 2.96s), in contrast with the larger change that is needed in participants with a 4WW (MDC = 10.35s). For clinical practice, this implies that the GMWT time score for participants without a 4WW should change with ~22% to be sure that this change was not caused by variability alone, whereas for participants with a 4WW, the GMWT time score needs to change with ~42%. Thus, the GMWT time is most sensitive to change in people with dementia that do not use a 4WW. The GMWT time may be used in persons with a 4WW, but this will pose a larger uncertainty in monitoring differences over time. Then again, the GMWT time is currently the best available test in this field compared with other tests.

### Limitations

In this study no fall history data was collected. Therefore, no definitive claims can be made about the GMWT as an indicator to assess fall risk. However, preliminary hip accelerometer data in older adults with dementia (N = 20) suggested that there may be relations between the performance of the GMWT and medio-lateral regularity during walking, and the stride regularity during walking. These relationships are in line with an accelerometer study with older adults that showed relationships

between accelerometer data and risk of falls.<sup>37</sup> Therefore, we suggest that the GMWT scores could be indicative to balance ability and fall risk. However, future research to validate these findings is necessary and should include fall diaries.

While the generalizability of our study appears adequate given the heterogeneity of the participants, the enrollment of participants over four different specialized nursing homes in the North of The Netherlands might have resulted in a limited geographical variability. Furthermore, recruitment of participants was based on the inclusion criteria and the willingness of residents to participate. This led to a volunteer bias. However, in clinical practice the participant needs to be willing to participate. Therefore, the study population that participated in this study is most likely to be equal to the goal population in clinical practice.

## CONCLUSION

The GMWT is a feasible test to use in clinical practice and research. With the GMWT time score, a reliable and more sensitive field test for dynamic walking abilities in older adults with dementia is available. The GMWT overstep score can be used to give information about the execution of the test according to protocol, and should be emphasized during the instructions. Future studies need to investigate the validity of the GMWT in older adults with dementia.

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## REFERENCES

1. Nyberg L, Gustafson Y, Janson A, Sandman PO, Eriksson S. Incidence of falls in three different types of geriatric care. A Swedish prospective study. *Scand J Soc Med*. 1997;25:8-13.
2. de Carle AJ, Kohn R. Risk factors for falling in a psychogeriatric unit. *Int J Geriatr Psychiatry*. 2001;16:762-767.
3. Kerse N, Peri K, Robinson E, et al. Does a functional activity programme improve function, quality of life, and falls for residents in long term care? Cluster randomised controlled trial. *BMJ*. 2008;337:a1445.
4. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. Clinical diagnosis of alzheimer's disease: Report of the NINCDS-ADRDA work group under the auspices of department of health and human services task force on alzheimer's disease. *Neurology*. 1984;34:939-944.
5. van Iersel MB, Hoefsloot W, Munneke M, Bloem BR, Olde Rikkert MG. Systematic review of quantitative clinical gait analysis in patients with dementia. *Z Gerontol Geriatr*. 2004;37:27-32.
6. Allali G, Assal F, Kressig RW, Dubost V, Herrmann FR, Beauchet O. Impact of impaired executive function on gait stability. *Dement Geriatr Cogn Disord*. 2008;26:364-369.
7. Ballard C, Fossey J, Chithramohan R, et al. Quality of care in private sector and NHS facilities for people with dementia: Cross sectional survey. *BMJ*. 2001;323:426-427.
8. Fabre JM, Ellis R, Kosma M, Wood RH. Falls risk factors and a compendium of falls risk screening instruments. *J Geriatr Phys Ther*. 2010;33:184-197.
9. Liu-Ambrose T, Nagamatsu LS, Hsu CL, Bolandzadeh N. Emerging concept: 'central benefit model' of exercise in falls prevention. *Br J Sports Med*. 2012;47:115-117.
10. Taylor ME, Delbaere K, Mikolaizak AS, Lord SR, Close JC. Gait parameter risk factors for falls under simple and dual task conditions in cognitively impaired older people. *Gait Posture*. 2012;37:126-130.
11. Blankevoort CG, van Heuvelen MJ, Boersma F, Luning H, de Jong J, Scherder EJ. Review of effects of physical activity on strength, balance, mobility and ADL performance in elderly subjects with dementia. *Dement Geriatr Cogn Disord*. 2010;30:392-402.
12. Eriksson S, Strandberg S, Gustafson Y, Lundin-Olsson L. Circumstances surrounding falls in patients with dementia in a psychogeriatric ward. *Arch Gerontol Geriatr*. 2009;49:80-87.
13. Bossers WJR, Van der Woude LHV, Boersma F, Scherder EJA, van Heuvelen MJG. Recommended measures for the assessment of cognitive and physical performance in older patients with dementia: A systematic review. *Dement Geriatr Cogn Disord Extra*. 2012;2:589-609.
14. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: A new clinical measure of balance. *J Gerontol*. 1990;45:M192-7.
15. Frandin K, Sonn U, Svantesson U, Grimby G. Functional balance tests in 76-year-olds in relation to performance, activities of daily living and platform tests. *Scand J Rehabil Med*. 1995;27:231-241.
16. Alexander NB, Mollo JM, Giordani B, et al. Maintenance of balance, gait patterns, and obstacle clearance in alzheimer's disease. *Neurology*. 1995;45:908-914.
17. Pettersson AF, Engardt M, Wahlund LO. Activity level and balance in subjects with mild alzheimer's disease. *Dement Geriatr Cogn Disord*. 2002;13:213-216.
18. Blankevoort CG, van Heuvelen MJ, Scherder EJ. Reliability of six physical performance tests in older people with dementia. *Phys Ther*. 2012;93:69-78.
19. Nordin E, Rosendahl E, Lundin-Olsson L. Timed "up & go" test: Reliability in older people dependent in activities of daily living--focus on cognitive state. *Phys Ther*. 2006;86:646-655.
20. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12:189-198.
21. Miller CA. Communication difficulties in hospitalized older adults with dementia. *Am J Nurs*. 2008;108:58-66.
22. Scientific Advisory Committee of the Medical Outcomes Trust. Assessing health status and quality-of-life instruments: attributes and review criteria. *Qual Life Res*. 2002;11:193-205.
23. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet*. 1986;1:307-310.
24. Euser AM, Dekker FW, le Cessie S. A practical approach to bland-altman plots and variation coefficients for log transformed variables. *J Clin Epidemiol*. 2008;61:978-982.
25. Ries JD, Echternach JL, Nof L, Gagnon Blodgett M. Test-retest reliability and minimal detectable change scores for the timed "up & go" test, the six-minute walk test, and gait speed in people with alzheimer disease. *Phys Ther*. 2009;89:569-579.
26. Stratford PW, Goldsmith CH. Use of the standard error as a reliability index of interest: An applied example using elbow flexor strength data. *Phys Ther*. 1997;77:745-750.
27. Sheridan PL, Solomont J, Kowall N, Hausdorff JM. Influence of executive function on locomotor function: Divided attention increases gait variability in alzheimer's disease. *J Am Geriatr Soc*. 2003;51:1633-1637.
28. Lark SD, McCarthy PW, Rowe DA. Reliability of the parallel walk test for the elderly. *Arch Phys Med Rehabil*. 2011;92:812-817.
29. Schwenk M, Schmidt M, Pfisterer M, Oster P, Hauer K. Rollator use adversely impacts on assessment of gait and mobility during geriatric rehabilitation. *J Rehabil Med*. 2011;43:424-429.
30. Miyasike-Dasilva V, Tung JY, Zabukovec JR, McIlroy WE. Use of mobility aids reduces attentional demand in challenging walking conditions. *Gait Posture*. 2012;37:287-289.
31. Foley MP, Prax B, Crowell R, Boone T. Effects of assistive devices on cardiorespiratory demands in older adults. *Phys Ther*. 1996;76:1313-1319.
32. Jarnlo G, Nordell E. Reliability of the modified figure of eight - a balance performance test for elderly women. *Physiother Theory Pract*. 2003;19:35-43.
33. Shkuratova N, Morris ME, Huxham F. Effects of age on balance control during walking. *Arch Phys Med Rehabil*. 2004;85:582-588.
34. Franzen E, Paquette C, Gurfinkel VS, Cordo PJ, Nutt JG, Horak FB. Reduced performance in balance, walking and turning tasks is associated with increased neck tone in Parkinson's disease. *Exp Neurol*. 2009;219:430-438.
35. Noren AM, Bogren U, Bolin J, Stenstrom C. Balance assessment in patients with peripheral arthritis: Applicability and reliability of some clinical assessments. *Physiother Res Int*. 2001;6:193-204.
36. Hansson EE, Mansson NO, Hakansson A. Balance performance and self-perceived handicap among dizzy patients in primary health care. *Scand J Prim Health Care*. 2005;23:215-220.
37. Bautmans I, Jansen B, Van Keymolen B, et al. Reliability and clinical correlates of 3D-accelerometry based gait analysis outcomes according to age and fall-risk. *Gait Posture*. 2011;33:366-372.



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