

The Groningen Meander Walking Test: A Dynamic Walking Test for Older Adults With Dementia

Willem J.R. Bossers, Lucas H.V. van der Woude, Froukje Boersma, Erik J.A. Scherder, Marieke J.G. van Heuvelen

W.J.R. Bossers, MSc, Center for Human Movement Sciences, University of Groningen and University Medical Center Groningen, PO Box 196, 9700 AD, Groningen, the Netherlands. Address all correspondence to Mr Bossers at: w.j.r.bossers@umcg.nl.

L.H.V. van der Woude, PhD, Center for Human Movement Sciences, University of Groningen and University Medical Center Groningen.

F. Boersma, PhD, Center for Human Movement Sciences, University of Groningen and University Medical Center Groningen.

E.J.A. Scherder, PhD, Center for Human Movement Sciences, University of Groningen and University Medical Center Groningen, and Faculty of Neuropsychology, VU University, Amsterdam, the Netherlands.

M.J.G. van Heuvelen, PhD, Center for Human Movement Sciences, University of Groningen and University Medical Center Groningen.

[Bossers WJR, van der Woude LHV, Boersma F, et al. The Groningen Meander Walking Test: a dynamic walking test for older adults with dementia. *Phys Ther.* 2014;94: 262–272.]

© 2014 American Physical Therapy Association

Published Ahead of Print:

October 3, 2013

Accepted: September 24, 2013

Submitted: March 7, 2013

Background. 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 people 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.

Objective. The purpose of this study was to investigate the feasibility, test-retest reliability, and minimal detectable change (MDC) of the GMWT.

Design. A repeated-measures design was used.

Methods. Forty-two people with dementia participated in the study. Adherence rate, adverse events, repetition of instructions during test performance, test duration, and number of oversteps were assessed.

Results. The adherence rate was excellent, with no adverse events. No repetitive instructions were given during test performance, and test duration was short (mean=17.16 seconds) with few oversteps (mean=1.94 oversteps). Test-retest reliability for participants without a walking device was excellent for the GMWT time score (intraclass correlation coefficient [ICC]=.942), with an MDC of 2.96 seconds. Test-retest reliability for participants with a 4-wheeled walker (4WW) was moderate (ICC=.837), with an MDC of 10.35 seconds. For the overstep score, a marginal ICC of .630 was found, with an MDC of 4.38 oversteps.

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

Conclusions. The GMWT is a feasible test for people with dementia. 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.



Post a Rapid Response to
this article at:
ptjournal.apta.org

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

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

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.¹² Several neuropsychological tests are already available to measure intervention effects on executive function.¹³ However, to measure intervention effects on walking abilities, both walking speed and gait width should be tested while changing direction.

A recent review¹³ revealed that studies in people with dementia only used walking and balance tests that were originally designed for older adults without cognitive impairment. The most frequently used balance test was the Functional Reach Test (FRT).^{13,14} However, because no walking is involved in this test,

the clinical relevance for dynamic walking is minor. An example of 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.¹⁵ For clinical practice, it is crucial that such a test is feasible, meaning that a patient is capable of successfully accomplishing 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.

The FoE was found to be reliable in older adults with dementia. However, the FoE appears to depend too strongly on healthy cognitive functioning and requires considerable executive functioning and memory resources to execute the test according to protocol.¹⁶⁻¹⁸ Furthermore, the minimal detectable change (MDC), which is a measure of the amount of change that is needed to exceed measurement error or participant variability, was too large to

detect clinical relevant changes.¹⁸ This finding hampers the feasibility and clinimetric properties of the FoE. To counter these limitations of the FoE, 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 3-step command (to meet impaired memory and attention) because cueing during a test negatively affects test results.^{17,19} At the physical level, the test duration also should be short to avoid fatigue and enable the participant to perform the test according to protocol, which may decrease the MDC.¹⁹ Therefore, a more feasible, reliable, sensitive, and valid test to assess walking abilities is needed for people 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

The Bottom Line

What do we already know about this topic?

A dynamic walking test suitable for older adults with dementia has not been available previously. Therefore, the Groningen Meander Walking Test (GMWT) was developed.

What new information does this study offer?

This study showed that GMWT is a feasible, reliable, and sensitive dynamic walking test for older adults with dementia.

If you're a patient or a caregiver, what might these findings mean for you?

Your physical therapist may use the GMWT to measure treatment effects after an intervention, such as an exercise program, to improve walking abilities. Furthermore, the GMWT may provide information about fall risk. More research is necessary to confirm these applications.

A Dynamic Walking Test for Older Adults With Dementia

Table 1.

Characteristics of the Participants (N=42)

Characteristic	Value
Women, n (%)	33 (78.6)
Age (y), $\bar{X}\pm SD$ (range)	86.7 \pm 5.2 (75–99)
Diagnosis of dementia type, no. of participants ^a	
Alzheimer disease	24
Vascular dementia	8
Alzheimer disease/vascular dementia	9
Lewy body disease	1
Cognitive state	
MMSE ^b score, $\bar{X}\pm SD$ (range)	17.1 \pm 4.3 (9–24)
Mild dementia (MMSE score 21–24), no. of participants	12
Moderate dementia (MMSE score 10–20), no. of participants	28
Severe dementia (MMSE score <10), no. of participants	2
No. of prescribed drugs per day, $\bar{X}\pm SD$ (range) ^c	6.97 \pm 3.71 (1–15)
Physical state	
No use of walking aid indoors, no. of participants	23
Use of 4-wheeled walker indoors, no. of participants	19

^a Based on available preliminary diagnoses according to medical files.

^b MMSE=Mini-Mental Status Examination.

^c Medication data were available for 40 participants.

speed and stepping accuracy, while changing direction. The GMWT has some similarities with the FoE (eg, 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 (eg, a more intuitive task, short, no crossover of the track, few instructions needed). For older adults with dementia, we hypothesized that the GMWT may lead to more reliable outcome measures compared with 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 at improving walking abilities. After validation, this test may be a useful tool to estimate dynamic balance control and individual fall risk. The aim of this study was to investigate feasibility, test-retest

reliability, and MDC as a first step toward the clinimetric evaluation of the GMWT.

Method Participants

Fifty participants were recruited from 4 specialized nursing homes in and around Groningen in the Netherlands, meeting the following inclusion criteria: (1) 70 years of age or older, (2) Dutch native speakers, (3) diagnosis of dementia by a psychiatrist or a medical doctor, (4) Mini-Mental Status Examination (MMSE) score in the range of 9 to 24,²⁰ and (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 (eg, having a sprained ankle), (4) vision problems that could hamper mobility or test performance, (5) history of psychiatric illness (eg, schizophre-

nia), 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 individuals eventually participated in this study. Characteristics of the participants are presented in Table 1. If participants were eligible for participation, informed consent was obtained from their legal representatives.

GMWT

The dimensions of the GMWT are shown in Figure 1. The 6.00-m track of the GMWT, which has 4 bends, was drawn on a smooth, dark blue mat. The width of the meandering track was 0.15 m. To exclude the effects of start-up speed and slow-down speed, participants started the test 1 m before the start of the track and stopped 1 m after the end of the track. The total test was performed in 2 parts: first forth and then back.

Participants were instructed to walk as fast and accurately as possible. The instructions were: "Please walk over the path as fast and accurately 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 walks were timed separately: the stopwatch was stopped once the participants finished the forth walk and was restarted once they started their walk back. The final score was the mean time (in seconds) of the forth and back walks. 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

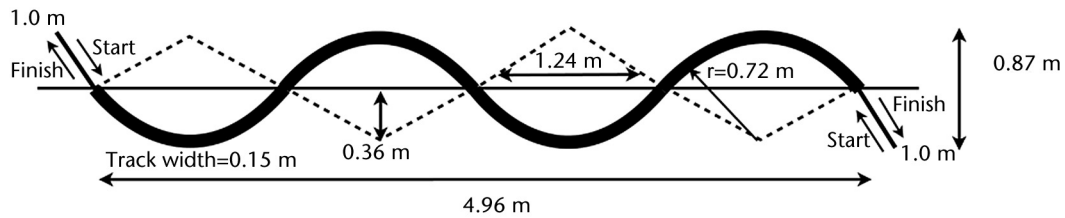


Figure 1.

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

noted as overstep. The oversteps of the forth and back walks were counted separately. The final score was the mean number of oversteps of the forth and back walks. A fewer number of oversteps indicated a better performance.

Protocol

The primary researcher (W.B.) administered the MMSE to control for the inclusion criteria, for severe cognitive impairments in relation to language impairments. Furthermore, background data were collected from the medical files of the participants with respect to age, sex, diagnosis of dementia, and medication use.

A pretest (T0)-posttest (T1) repeated-measures design for the GMWT time and overstep scores was used to investigate 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 nonparticipation, not completing the test, adverse events, repetition of the instructions during test performance, test duration, and number of oversteps were noted. These results will allow 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 1 week between tests, 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 the test protocol (Appendix). 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.²¹ 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 (SPSS Inc, Chicago, Illinois) was used for data management and analyses. The level of significance was $P < .05$ for all statistical analyses. All analyses were performed for the total group and separately for the participants without a walking device and those with a 4-wheeled walker (4WW).

To identify possible structural differences (eg, learning effect) between T0 and T1, the differences between the GMWT time and overstep scores for the repeated measures (T1-T0)

were tested. This was done with a paired-samples t test for normally distributed data and the Wilcoxon signed rank test 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 overstep scores was performed with a model 3 (2-way mixed) intraclass correlation coefficient (ICC) analysis. The ICC was calculated with a 95% confidence interval (95% CI), single-measure, absolute agreement model. For group studies (eg, epidemiological studies), an ICC of less than .70 for test-retest reliability is marginal. For clinical individual measurements, an ICC greater than .90 represents the required consistency of a test.²²

To plot the similarity between T0 and T1 of the GMWT time and overstep scores for the total group, the group that did not use a walking device, and the group that used a 4WW, Bland-Altman plots²³ with limits of agreement were created.²⁴ The width of the limits of agreement give an adequate view of the absolute measurement variability, which is caused by patient variability or measurement error. A larger width of the limits of agreement indicates larger variability and thus lower test-retest reliability. To calculate the limits of agreement for skewed data, the following formula was used²⁴:

Table 2. Groningen Meander Walking Test (GMWT) Time and Overstep Mean Scores (Standard Deviation) and Range for Repeated Measures T0 and T1, Difference Between T1 and T0 With Their Statistical Value, Intraclass Correlation Coefficient, Standard Error of Measurement, and Minimal Detectable Change at 95% Confidence Interval^a

Measure	T0		T1		T1 - T0			ICC (95% CI)	SEM (95% CI)	MDC ₉₅
	\bar{X} (SD)	Range	\bar{X} (SD)	Range	Diff	Paired Test	P			
GMWT time (s)										
All (n=42)	16.93 (7.90)	5.86-37.73	17.39 (8.37)	6.93-38.49	0.46	t = -1.060 ^b	.295	.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 ^c	.503	.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 ^c	.936	.748 (.707-.949)	3.73 (2.02-3.97)	10.35
GMWT overstep (n)										
All (n=42)	2.11 (2.63)	0.00-8.50	1.77 (2.60)	0.00-11.5	-0.34	z = -1.098 ^c	.272	.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 ^c	.358	.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 ^c	.378	.578 (.179-.813)	2.09 (1.61-3.15)	5.78

^a These values are presented for all participants, the group of participants without a walking device, and the group of participants with a 4-wheeled walker. T0=pretest measurement, T1=posttest measurement, Diff=difference T1 - T0, ICC=intraclass correlation coefficient, 95% CI=95% confidence interval, SEM=standard error measurement, MDC₉₅=minimal detectable change at 95% CI.
^b Paired-samples t test.
^c Wilcoxon signed rank test.

(1)

$$-2X \frac{(10^a - 1)}{(10^a + 1)} \text{ and } +2X \frac{(10^a - 1)}{(10^a + 1)},$$

with $a = 1.96 \times \sqrt{2\sigma_{ER}^2}$ and σ_{ER}^2 reflecting the residual-error variance.

The MDC at a 95% CI (MDC₉₅), representing the amount of change that is needed to exceed anticipated measurement error or patient variability, was calculated with the following formula²⁵:

$$(2) \quad MDC_{95} = SEM \times 1.96 \times \sqrt{2}$$

For this calculation, the standard error of measurement (SEM) scores, with a 95% CI, were calculated following Stratford and Goldsmith.²⁶ 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 2 presents the GMWT time and overstep scores for all participants (N=42) and separately for participants without a walking device (n=23) and those with a 4WW (n=19). 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. Furthermore, only repetitive instructions were given to the participants before the second walk of the GMWT. Test duration of the GMWT was short (mean=17.16 seconds), and the number of oversteps ranged between 0 and 11.5. Twelve participants (28.6%) made no overstep (n=8 without a walking device, n=4 with a 4WW), and 30 participants (71.4%) made 1 or more oversteps. Furthermore, the range of oversteps

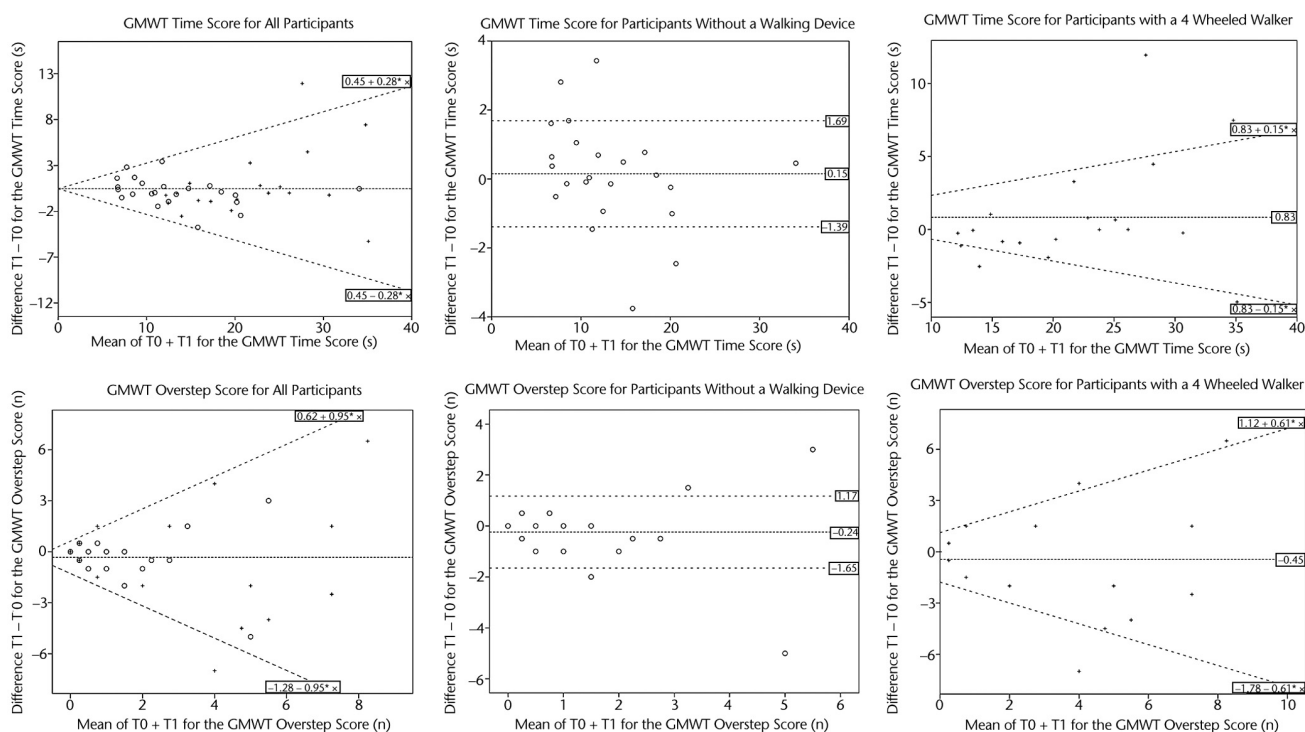


Figure 2.

Bland-Altman plots with limits of agreement for the Groningen Meander Walking Test (GMWT) time score (upper 3 graphs) and GMWT overstep score (lower 3 graphs) for the total group (left), participants without a walking device (middle), and participants with a 4-wheeled walker (right), respectively. T0=premeasurement test outcome, T1=postmeasurement test outcome.

was smaller in participants without a walking device (range=0–7.5 oversteps) compared with participants who used a walker (range=0–11.5 oversteps). A significant correlation between the GMWT time and overstep scores was found ($r=.36$, $P<.01$), indicating that participants who had more difficulty staying 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 relationship between the performance of the GMWT and mediolateral regularity during walking ($r=.495$, 95% CI=.066 to .770) and the stride regularity during walking ($r=.527$, 95% CI=–.787 to –.109).

GMWT Time Score

The total group of participants showed no significant differences in mean GMWT time score between T0

and T1. Excellent test-retest reliability (ICC=.942) with an MDC of 5.35 seconds was found. Looking at the 2 subgroups separately, participants who walked without a walking device (mean GMWT time=13.26 seconds, SD=6.40) showed higher test-retest reliability (ICC=.972) and a smaller MDC (2.96 seconds) compared with those who used a 4WW (mean GMWT time=21.88 seconds, SD=7.44; ICC=.748; MDC=10.35).

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 marginal test-retest reliability (ICC=.630), with an MDC of 4.38 oversteps. Looking at the 2 subgroups separately, participants who performed the test without a walking device and those who performed the test 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 with the MDC of participants who used a 4WW (MDC=2.71 oversteps versus MDC=5.78 oversteps, respectively).

Figure 2 displays the Bland-Altman plots, with 95% limits of agreement, for the time score and overstep score for the total group, participants without a walking device, and those with a 4WW. The GMWT time and overstep data for the total group were positively skewed and heteroscedastic. This finding was reflected by limits of agreement becoming wider, meaning a higher variability between T0 and T1 with increasing values. In clinical practice, this finding means that the test-retest reliability for the GMWT time and overstep scores becomes lower with slower test per-

formance or more oversteps. Looking at the groups separately, for the group that did not use a 4WW, the GMWT time and overstep scores were homoscedastic, with constant limits of agreement. This homoscedasticity resulted in constant variability, which is independent of the magnitude of the GMWT time or overstep scores. In contrast, time and overstep data for the group that used a 4WW were heteroscedastic, with higher scores yielding higher variability. In practice, for individuals using a 4WW, reliability of the GMWT time and overstep scores declines with slower performance or more oversteps.

Based on data in the current study, no relationship was found at baseline between cognition (MMSE) and GMWT time ($r = -.160$, $P = .312$) or between cognition and GMWT oversteps ($r = -.098$, $P = .539$). A subgroup reliability analysis between participants with a moderate cognitive level (MMSE ≥ 20 , $n = 13$) and those with a lower cognitive level (MMSE < 20 , $n = 29$)²⁰ showed a difference in test-retest reliability for the GMWT time score (ICC = .963 versus ICC = .933, respectively) and the GMWT overstep score (ICC = .792 versus ICC = .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. The main goal in this study was to investigate feasibility, test-retest reliability, and MDC as a first step toward 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

3-step instruction was provided.¹⁷ At the physical level, fatigue was avoided by providing a short test duration.¹⁹ Current results support an excellent feasibility, as 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 2 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.²⁷ However, measurements in older adults who are cognitively impaired are known to be less reliable compared with measurements in older adults who are not cognitively impaired.²⁵

Based on data in the current study, no relationship was found at baseline between cognition (MMSE) and GMWT time or between cognition and GMWT oversteps. However, a subgroup reliability analysis between participants with a moderate cognitive level (MMSE ≥ 20 , $n = 13$) and those with a lower cognitive level (MMSE < 20 , $n = 29$)²⁰ showed a difference in test-retest reliability for the GMWT time and overstep scores. 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 = 5.86–37.73 seconds) compared with that of the FoE (range = 18.28–117.41 seconds).¹⁸ This shorter active duration may have contributed to the feasibility at the cognitive level (eg, memory, attention) and the physical level (eg, fatigue).^{4–6} Furthermore, the number of oversteps can provide information about the clinical value of the GMWT time score, whereas partici-

pants who made a larger number of oversteps were not able to follow the marked path. As a consequence, reliability of the time score declined. Our data showed that 31 participants (73.8%) performed the GMWT with fewer than 4 oversteps. However, 11 participants (26.2%) made more than 4 oversteps, of whom 8 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 per meter) was lower compared with the number of oversteps for the FoE in a study of patients with mild dementia (0.66 oversteps per meter).¹⁷ Thus, the use of a 4WW may negatively affect the accuracy of test performance. This lower accuracy of test performance may be reflected by a lower feasibility to perform the GMWT according to protocol.

Participants made fewer oversteps during the GMWT compared with the FoE. Therefore, the question arises whether the limits of test performance on dynamic balance were reached. The 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.¹⁸ Furthermore, the number of oversteps was positively correlated with the GMWT time score ($r = .36$, $P < .01$), 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 FoE,¹⁸ combined results of participants with and without a walking device. However, current results showed that

combining participants with and without a walking device might lead to an underestimation of the reliability for people who did not use a walking device and an overestimation of the reliability for people who used a walking device. From a clinical perspective, an ICC of $>.90$ represents the required reliability of a test for individual clinical measurements.²² 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 that can be used in clinical practice.

When the GMWT is performed with a walking device, a clinician or researcher needs to be aware that it may negatively affect the test-retest reliability of the GMWT time score. Furthermore, it has been shown that the use of a 4WW in geriatric patients negatively affects the assessment of changes over time in gait and mobility performance.²⁸ To get around the constraints that a walking device may cause, such as an increased cognitive attention and planning demand while steering,²⁹ higher cardiorespiratory demands,³⁰ and possibly reduced sight during feet placement, future research should investigate whether it is feasible, reliable, and safe to perform the GMWT without a walking device for people using a walking device in daily life.

For the GMWT overstep score, both people with and without a walking device showed marginal test-retest reliability. The current results are comparable to the results of a study performed with a modified FoE in elderly community-dwelling women (ICC=.73).³¹ 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 fewer than 4 oversteps, a small change in the

number of oversteps caused a relatively large variability. As a consequence, this change 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 in obtaining a meaningful time score because of the significant correlation that was found between the 2 scores. This significant relationship showed that participants who had more difficulty staying between the GMWT lines walked more slowly during the test, thereby adding purpose for the time score. In clinical research, where tests with time and overstep scores, such as the FoE, were used, often only the time scores^{32,33} or only the overstep scores^{34,35} were reported. However, for clinical practice, it is crucial that both scores be measured and reported, as these scores tell 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.

MDC

Current results show that the MDC of the GMWT time score was 5.35 seconds. This finding indicates that in clinical practice a difference of approximately 31% is needed to measure a difference that exceeds the 95% variability bounds.²⁶ Despite this large value required to detect change, which poses a problem when monitoring differences over time, it is an improvement compared with 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 Frailty and Injuries: Cooperative Studies of Intervention Techniques-4 (FICSIT-4) (~59% change is needed to exceed MDC).¹⁸ Therefore, the GMWT time score appears to be better than dynamic

walking tests that are currently available.

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

Limitations

We did not collect information about fall history in this study. 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 relationships between the performance of the GMWT and both mediolateral regularity during walking and stride regularity during walking. These relationships are in line with the results of an accelerometer study with older adults that showed relationships between accelerometer data and risk of falls.³⁶ Therefore, we suggest that the GMWT scores could be indicative of balance ability and fall risk. However, future research to

validate these findings is necessary and should include fall diaries.

Although the generalizability of our study appears adequate given the heterogeneity of the participants, the enrollment of participants over 4 different specialized nursing homes in the northern 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 approach led to a volunteer bias. However, in clinical practice, the patient 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.

All authors provided concept/idea/research design and writing. Mr Bossers provided data collection, study participants, and facilities/equipment. Mr Bossers, Dr van der Woude, and Dr van Heuvelen provided data analysis. Mr Bossers and Dr van der Woude provided project management. Dr van der Woude, Dr Scherder, Dr Boersma, and Dr van Heuvelen provided consultation (including review of manuscript before submission). The authors thank all participants, trained test instructors, and health care institutions ZINN and Zorggroep Groningen for their cooperation. They also thank Claire Bradley, MSc, for her language revisions.

The Medical Ethical Committee of the University Medical Center Groningen, the Netherlands, approved this study.

DOI: 10.2522/ptj.20130077

References

- 1 Nyberg L, Gustafson Y, Janson A, et al. 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, et al. 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, et al. 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, et al. 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*. 2013;47:115-117.
- 10 Taylor ME, Delbaere K, Mikolaizak AS, et al. Gait parameter risk factors for falls under simple and dual task conditions in cognitively impaired older people. *Gait Posture*. 2013;37:126-130.
- 11 Blankevoort CG, van Heuvelen MJ, Boersma F, et al. 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, et al. 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-M197.
- 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*. 2013;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; quiz 67.
- 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 Schwenk M, Schmidt M, Pfisterer M, et al. Rollator use adversely impacts on assessment of gait and mobility during geriatric rehabilitation. *J Rehabil Med*. 2011;43:424-429.

- 29 Miyasike-daSilva V, Tung JY, Zabukovec JR, McIlroy WE. Use of mobility aids reduces attentional demand in challenging walking conditions. *Gait Posture*. 2013; 37:287-289.
- 30 Foley MP, Prax B, Crowell R, Boone T. Effects of assistive devices on cardiorespiratory demands in older adults. *Phys Ther*. 1996;76:1313-1319.
- 31 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.
- 32 Shkuratova N, Morris ME, Huxham F. Effects of age on balance control during walking. *Arch Phys Med Rehabil*. 2004;85: 582-588.
- 33 Franzen E, Paquette C, Gurfinkel VS, et al. Reduced performance in balance, walking and turning tasks is associated with increased neck tone in Parkinson's disease. *Exp Neurol*. 2009;219:430-438.
- 34 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.
- 35 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.
- 36 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.

A Dynamic Walking Test for Older Adults With Dementia

Appendix.

Protocol of the Groningen Meander Walking Test (GMWT)

Equipment:

1. GMWT drawn on a smooth, dark blue mat
2. Stopwatch

Location:

A well-illuminated closed-off room or closed-off corridor.

Procedure:

For safety reasons, there should always be 2 instructors present during the administration of the test. During the test instruction, perform the test in front of the participant. Note if the participant uses a walking device during the test.

Instruction: "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. Do you understand what to do? Ready? Three-2-1-start." No practice trial is included.

Press "start" on the stopwatch when the participant crosses the start line. Press "stop" on the stopwatch when the participant crosses the finish line. After the first walk, let the participant turn around. Then, repeat the instruction above and do the test again in the opposite direction. Note the time of both walks and calculate the mean time. Also, note the number oversteps made of both walks and calculate the mean number of oversteps.