Performance Stability and Interrater Reliability of Culturally Adapted 10-Meter Walking Test for Danes with Neurological Disorders

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Background: The 10-meter Walking Test (10MWT) is often used to assess people with, e.g., stroke, but often using different procedures. The aims of this study were to translate the 10MWT into Danish, to determine the number of trials needed to achieve performance stability, and to examine the interrater reliability and agreement of the 10MWT in people with neurological disorders. *Methods:* Translation followed international recommendations, and evaluated in a consecutive sample of 50 people with a neurological disorder. All participants performed 5 timed 10MWT trials (usual speed) with 20-seconds rest intervals between trials, supervised by a physical therapist. A second session was conducted with another physical therapist, separated with a mean (SD) of 2.7 (0.9) hours. The order of raters was randomized and they were blinded to each other's ratings. Repeated measures ANOVA determined performance stability, while ICC1.1, standard error of measurement (SEM), and minimal detectable change (MDC95) determined reproducibility. *Results:* Participant's improved their 10MWT scores significantly between the first and second trial only. The faster of the 2 trials took a mean of 11.95 (5.40) seconds, and significantly ($P < 0.001$) faster than the slowest; mean of 12.80 (6.13) seconds. The intraclass correlation coefficient (ICC; 95% confidence interval), SEM, and MDC, based on the fastest of 2 trials, were 0.97 (0.95-0.98), 0.06 m/s, and 0.17 m/s, respectively, and with no systematic between rater's bias. *Conclusions:* We suggest that the faster of 2 timed trials be recorded for the 10MWT in people with neurological disorders, as we found excellent interrater reliability and low measurement error using this score.

Key Words: Outcome assessment (health care)—walking—rehabilitation—reproducibility of results—gait speed

Introduction

Gait disorders are common in people with neurological disorders, including reduced walking speed and endurance, not being able to walk independently indoors or in the community.[1-4] Evaluation and training of gait and walking performance are important aspects of evidence-based neurorehabilitation,[5-8] including the use of valid and reliable tests of gait performances.

Improved walking speed is one measure of change, it is quick and easy test to administer, and widely used, also in people with neurological disorders. One systematic review of 108 studies by Graham et al[9] which investigated walking speed in different patient groups, revealed that 10 m was the most common distance used with neurological populations. However, nearly half of the studies included in that review did not describe the testing protocol used to assess walking speed. Accordingly, Graham et al recommended that clinicians and researchers use the following test procedures: "(1) Adopt the 10-m straight line walk. (2) Use a static start with timing commencing at the start. (3) Usual or comfortable pace be used as the

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standard, and fast paced be used as appropriate for specific research questions. (4) Walking protocol be reported in detail including pace instructions, verbal or other encouragement, and specific timing procedures."[9]

The 10-meter Walking Test (10MWT) protocol published by Watson in 2002[10] satisfies these recommendations. The 10MWT is used worldwide with different diagnostic groups and older people, but has not been translated into Danish according to international recommendations.[11] Nor has a Danish version of the 10MWT been examined for performance stability or reliability (i.e., is one trial sufficient or should three trials be used?). Moreover, should the fastest time or the average time of performances be reported?[10,12]

Watson[10] found that healthy participants (age 18-21 years) are likely to have a maximum variation in walking speed over 3 trials of just over 1 second. Much larger variations in speed were recorded across three trials in people with traumatic brain injury, and it was not possible to make a definitive statement regarding which of the 3 timed trials should be reported. The 10MWT procedure described by Watson[10] states that "one test session should consist where possible of three trials," which corresponds with recommendations for the Timed Up & Go test in patients with hip fractures and older individuals, where the fastest of 3 timed trials is reported.[13,14] However, testing is time consuming and should be limited to the number of trials that are absolutely necessary to provide valid results.

The objectives of this study were therefore to (1) translate into Danish and cross culturally adapt the "Watson" 10MWT, (2) determine the number of trials needed to achieve performance stability, (3) examine the interrater reliability and agreement, and (4) examine concurrent validity of the 10MWT in people with neurological disorders.

Methods

Translation Procedure

The 10MWT was translated into Danish according to international recommendations,[15] after approval for translation was given by the author, Martin J. Watson, as shown in Figure 1. Three translators (A, B, and C) independently translated the English version into Danish. The translators included 2 physiotherapists whose primary language was Danish, and one whose mother tongue was English. The translators first prepared a consensus version (First Danish version). This version was checked for linguistic errors by 2 graduates of the Master of Art in the Danish language, then pilot tested by 14 physical therapists from 3 different hospitals (Testing the first Danish version). The physical therapists were asked 3 questions: Is the version easy to understand and administer? Are there any phrases you and your colleagues understand differently? Do you have any other comments? Their responses were incorporated into a revised Danish version. Back translation was completed by a physiotherapist (D) whose mother tongue was English. The back-translated version, a report describing the translation procedure, and reasons for changing a few phrases were sent to Martin Watson for approval to ensure the original constructs were retained (E).

Participants

Patients admitted with a neurological disorder between June and November 2013 were eligible for inclusion and invited to participate. The 2 inclusion criteria were[1] able to walk a minimum of 10 m independently with or without a walking aid and[2] able to understand instructions. The study was conducted according to the Declaration of Helsinki II.[16] The 10MWT and other measures were collected as part of normal discharge routines. All participants gave informed consent before participation. The study was registered with the data protection agency no. "j.nr.: 2012-58-0004."

Procedures

Detailed information (verbal and written) was provided to 4 physical therapists who supervised all testing. The investigator explained and demonstrated procedures to therapists with 1 patient. Each physical therapist completed pilot testing of 5 patients each, before the final data collection commenced. According to the COSMIN guideline, a sample size of 50 is considered as good.[17] We therefore planned to include a minimum of 50 people with complete data for the present study.

Number of Trials Needed for Performance Stability

Each participant was asked to perform a minimum of 5 10MWT trials (if possible) in each session, separated by a pause of approximately 20 seconds, and continued, if possible, until no further improvement was recorded. That is, the same result or a slower result had to be recorded twice before completing the session, with a maximum of 8 trials. Participants used their present walking aid during testing, if required. Reasons for not being able to perform at least 5 trials were recorded by the physical therapist supervising the session, if necessary. The physical therapists were instructed not to announce results during the test session; participants were first informed about their test result after the second session.

Reliability

All participants conducted two 10MWT sessions, separated with a mean (SD) of 2.7 (0.9) hours, and supervised by two independent skilled physical therapists. A computer-generated randomization list secured that each physical therapist group (group 1, rater A and B and group 2, rater C and D) randomly supervised half of sessions as the

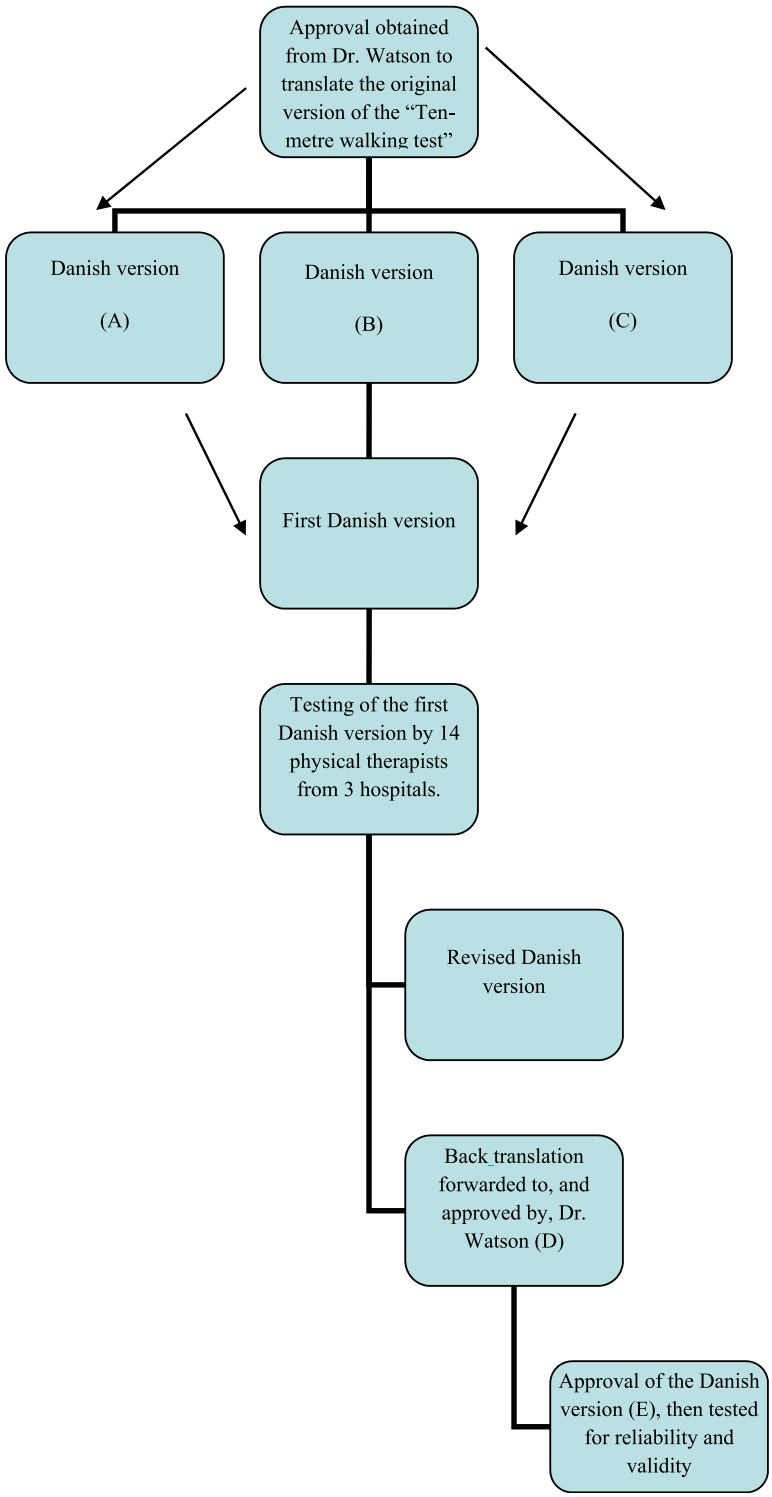

Figure 1. *Flowchart of translation and cross-cultural validation of the "Watson" 10MWT procedure.*

first rater group. All physical therapists were blinded to each other's ratings until the end of the study.

Other Variables

Age, gender, the length of stay in the rehabilitation unit, diagnosis, and the patient's discharge walking aid were recorded. The functional level at discharge was recorded using the Berg Balance Scale (0-56 points) with a score of 56 indicating a high level, and the Barthel Index (0-100 points), with a score of 100 indicating a high level. The scores of these 2 measurements were used to evaluate the relationship with the 10MWT. All variables including the 10MWT trials were recorded

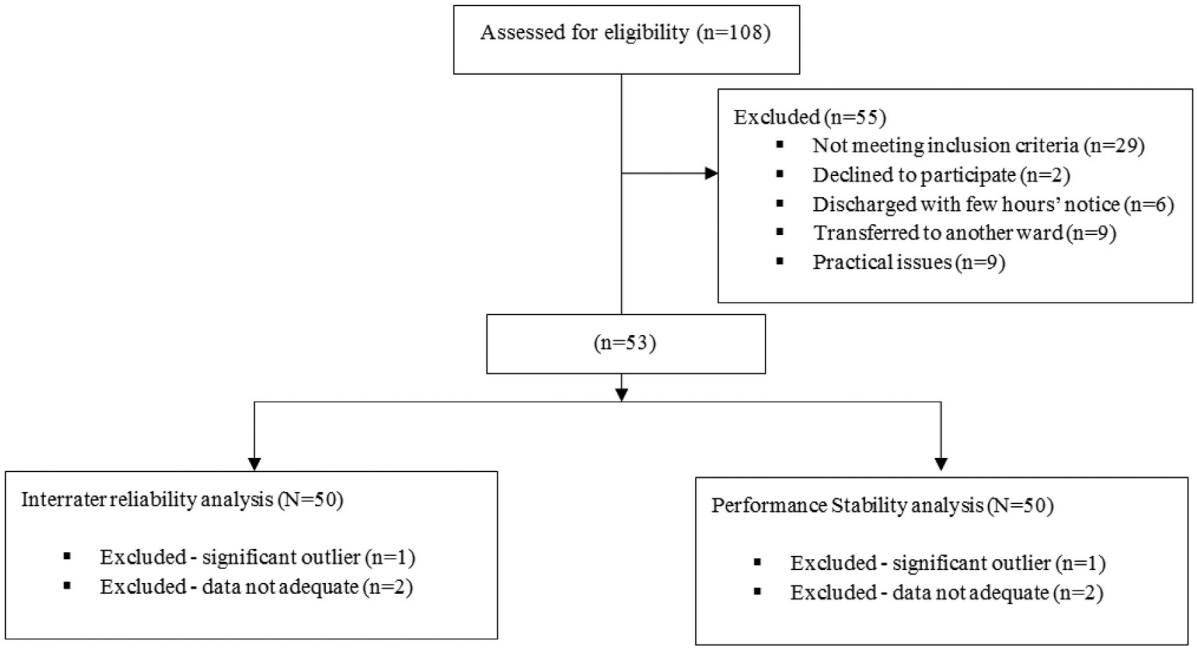

Figure 2. *Flowchart of enrolment of participants.*

within the last 3 days before discharge from the rehabilitation unit.

Statistical Analysis

Descriptive statistics were calculated to present baseline characteristics of the participants. The 10MWT and age data were normally distributed when evaluated using the Kolmogorov-Smirnov test, while other continuous variables were not. Repeated measures analysis (ANOVA) with Bonferroni adjustment,[13] was used to examine significant differences between scores of the up to 5 timed 10MWT trials. Relative reliability was calculated using the $ICC_{1.1}$ (absolute agreement) with the corresponding 95% confidence interval (95% CI). Each participant was not measured by all raters, and reliability was calculated using a single measurement (the faster of 2 timed trials). An intraclass correlation coefficient (ICC) above 0.75 indicated "excellent" reliability, between 0.40 and 0.75 indicated "fair to good" reliability, and below 0.40 indicated "poor" reliability.[18] Raters were randomly selected and considered representative of a larger population of similar raters. A paired *t* test was used to look for systematic between-rater group bias for the timed trials and number of steps taken, and illustrated using Bland-Altman plots. To assess absolute reliability, the standard error of measurement (SEM) was calculated as $SD \times \sqrt{(1 - ICC)}$, where SD is the SD of all 10 MWT times and steps taken from all subjects.[19] To quantify the amount of change in seconds that must be observed to be considered to exceed measurement error and reflect a real change at the individual level, the minimal detectable change (MDC) was calculated with 95% confidence level as $SEM \times 1.96 \times \sqrt{2}$. Also, we calculated the SEM% = (SEM/mean) × 100 and the MDC% = (MDC/mean) × 100, where mean was the mean of all 10MWT walking test times and steps recorded by both raters. We used Spearmans rank order rho to examine the concurrent validity between the 10MWT, the Berg Balance scale and Barthel-100 index scores. All data analyses were conducted using SPSS, version 22.0 (IBM Corp. USA, Armonk, NY) while the GraphPad Prism 6.03 (GraphPad Software Inc., La Jolla, CA) was used for graphics. A *P*value less than 0.05 was considered significant.

Results

From June to November 2013, a total of 108 people with a neurological disorder were admitted to a 21-bed neurorehabilitation unit at (blinded for review). A total of 53 participants met the inclusion criteria and were consecutively recruited to the study (Fig 2). Three participants were excluded from analyses (2 due to incomplete data, and 1 considered an extreme outlier who used more than 40 seconds for completing the 10MWT). Baseline characteristics and outcome of the 50 participants (21 women and 29 men, with an age range from 18-91 years) included in analysis, are shown in Table 1.

Translation

Translation into Danish and cross-cultural adaptation was done according to International recommendations. However, a few adaptations were made in accordance with Martin J. Watson, to address some "Frequently Asked Questions" from testers; (1) a sentence describing the use of walking aids was incorporated in the Danish version of the 10MWT, (2) physical therapists often encourage patients while performing a test, leading to a walking speed that is faster than "usual speed." The

Table 1. *Demographic characteristics and outcome of participants*

Variable	Sample characteristics (N = 50)
Age (y)	68.2 (15.6)
Women	21 (42)
Men	29 (58)
Diagnosis	
Stroke	36 (72)
Intracranial lesion	5 (10)
Peripheral nervous system disorders	9 (18)
Discharge destination	
Own home	36 (72)
Inpatient rehabilitation in the municipality	13 (26)
Another hospital	1 (2)
Length of stay at the neurorehabilitation unit (days)	23 (14-35)
Barthel Index at discharge (0-100 points)	98 (90-100)
Berg Balance Scale at discharge (0-56 points), n=49	51 (41-55)
Use of a walking aid during testing:	22 (44)
Rollator	19 (38)
One or two elbow crutches	3 (6)

Data are mean (SD), n (%) or median (25%-75% quartiles).

following sentence was therefore added: "It is not allowed to verbally encourage or provide physical support," clarifying that physical support is not allowed and that therapists may only accompany the person for safety reasons, (3) Martin Watson wrote that: "The stopwatch should be started at the moment that the subject first moves a foot to take a step." Testers, therefore, have to stand beside the patient at the start line, and we included that advice in our Danish adaptation. (4) Likewise, to be accurate "timing stop," the tester must be close to the patient at the finish line. In the published version, the procedure is therefore altered to read as follows: "Tester stands at the start line, and accompanies the person. The tester walks slightly behind the person."

Approval for these changes was given by Martin J Watson (July 2013), stating that the constructs remained in the back-translated version (Appendix A), and acknowledged to be published, January 2018.

Number of Trials

All 50 participants completed the 5 planned trials, 39 patients completed a sixth and a seventh trial, while 33 patients completed the maximum of eighth timed trials. The repeated measures analysis of variance comparing the time taken to complete 10MWT only reduced significantly between the first and second trial (P = 0.035), based on average times across 5 trials (Fig 3A). A corresponding result was seen for analysis of the first 3 trials only (P = 0.01, Fig 3B). The fastest of the first 2 timed trials, mean (SD, range) of 11.95 (5.40, 5.3-28.1) seconds, produced a significantly ($P < 0.001$) faster mean 10MWT time compared with the slowest of the two trials, 12.80 (6.13, 5.6-31.6), and with up to 6.72 seconds difference between trials. Accordingly, the faster of the first 2 timed trials were used in all reliability analysis. The predefined rest or pause of approximately 20 seconds between trials was sufficient for most participants.

Reliability

The fastest 10MWT times for each participant from each of the 2 sessions reached a mean of 11.95 (5.4) and 11.92 (6.1) seconds, respectively, and with no systematic between-rater bias observed (mean diff = 0.037 s, P= 0.86). The corresponding figures when converted into meters per second for each patient reach a mean of 0.98 (0.37) m/s and 1.00 (0.38) m/s, and with a mean difference of 0.015 m/s as illustrated in the Bland-Altman plot (Fig 4A). The $ICC_{1.1}$ was 0.97 (95% CI, 0.95-0.98), and the SEM and MDC_{95} were 0.99 seconds (0.06 m/s) and 2.7 seconds (0.17 m/s), respectively. The corresponding SEM% and MDC% were 6% and 17 %, respectively. For comparison we also calculated the ICC based on the commonly used "mean of three trials," which reached the exact same ICC values as those based on our faster of 2 timed trials analysis. The corresponding figures for the steps taken to complete the faster of two 10MWT trials are presented in Table 2 and Figure 4B. Eliminating the single outlier, as seen in the Bland-Altman plot (Fig 4A) reduced the measurement error at group level; SEM = 0.05 m/s (SEM% = 5%) and for a single person; MDC = 0.14 m/s (MDC% = 14%).

Concurrent Validity

Almost half of participants (23/50, 46%) scored the maximum 100 of points on the Barthel Index (34 participants scored ≥95 points). Only 10 (20%) participants achieved the maximum of 56 points on the Berg Balance Scale (25 participants scored ≥50). The correlation between the 10MWT was; r = 0.665, $P < 0.001$ for the Barthel and r = 0.833, $P < 0.001$ for the Berg Balance Scale.

Discussion

The 10MWT as described by Dr Watson in 2002 was successfully translated into Danish, with the back-translated version approved by Dr Watson. Two timed 10-MWT trials instead of 3 trials as suggested by Dr Watson appear to be enough to establish performance stability (e.g., no further improvement) in patients with neurological disorders at time of discharge from a neurorehabilitation unit. Further, We found excellent interrater reliability and low measurement noise when using the faster of the

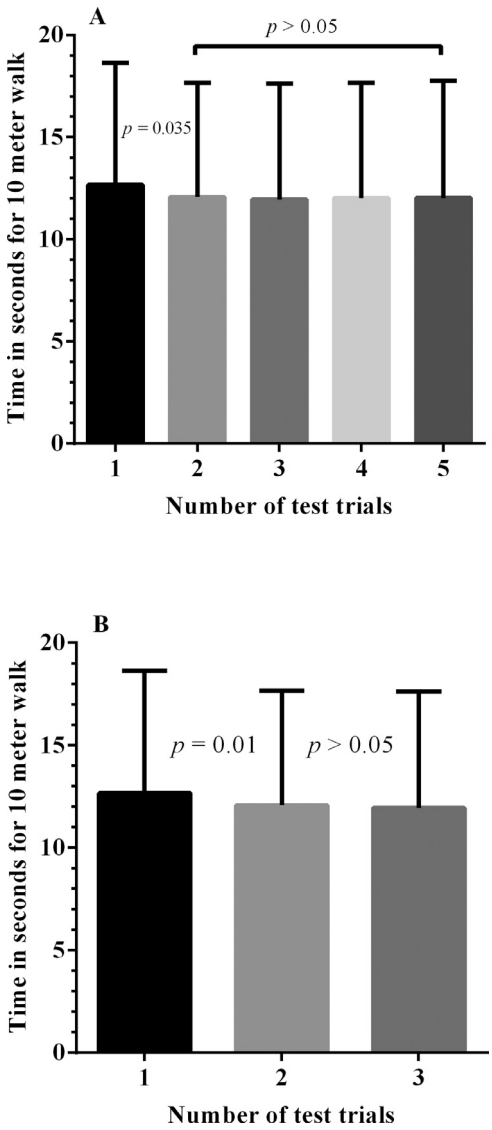

Figure 3. *Performances of the 5 (A) and 3 (B) repeated 10MWT trials (N = 50).*

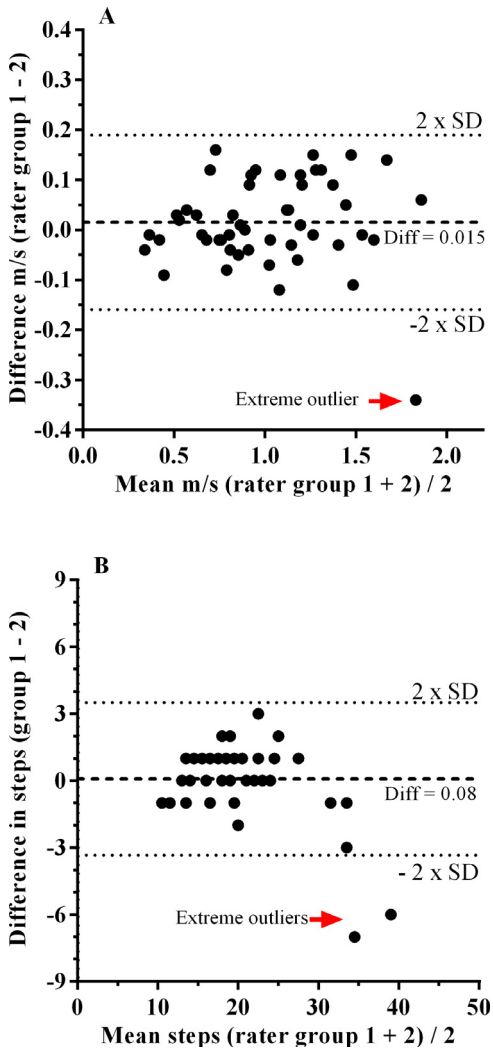

Figure 4. *Bland and Altman plot of walking speed (A) and steps taken (B) during the 10MWT (N = 50).*

first 2 timed 10MWT trials in analysis, and with no systematic between-rater group differences.

Translation and Protocol

As noted earlier, many studies do not describe the testing procedure used to assess walking speed,[9] and with a possibility of differences in performances reported.[20] We propose that the standardized procedure described by Dr Watson,[10] as used in the present study be adopted, but with a few adaptations based on the clinical evaluation by physical therapists before start of the present study. In the procedure by Watson it is not stated whether the faster or the mean of 3 timed 10MWT trials should be recorded as a result, which might add to variations in reporting. Thus, the mean of a certain number of trials are frequently used,[21–25] whereas the fastest trial is used by others (e.g., Graser et al.).[26] However, the faster of 2 timed 10MWT trials reflecting the best performance in our study seem highly applicable in clinical practice, avoiding time spent on calculating the mean.

Sustakoski et al[20] recently showed that a participant's gait speed can be changed by altering the testing protocol. For example, the same individual walked 0.25 m/s faster on average when the instruction was to use a "fast" versus "usual" speed. This finding reinforces the need for consistency and reporting of testing protocols when comparing measures of gait speed.

Number of Trials

Watson found that normal subjects (age 18-21 years) are likely to demonstrate maximum variation across 3 trials. Similar finding were reported in a study examining the Timed Up & Go test involving patients with hip fractures,[13] and older individuals[14] where scores improved significantly up to, and including the third trial. On the contrary, a study of patients with a major lower limb amputation showed no learning curve in 5 one-leg-stand-test trials.[27] The latter study,

Table 2. *Interrater reliability and agreement of walking speed and steps taken in 10MWT*

	Mean (SD)	$ICC_{1.1}$ (95% CI)	SEM	MDC	SEM %	MDC %
Walking speed						
1. Session	0.98 (0.37) m/s	0.97 (0.95-0.98)	0.06 m/s	0.17 m/s	6	17
2. Session	1.00 (0.38) m/s					
Steps taken						
1. Session	19.7 (5.9) steps	0.96 (0.93-0.98)	1.3 steps	3.6 steps	7	18
2. Session	19.6 (7.1) steps					

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; MDC, minimal detectable change; SEM, standard error of measurement.

Values are based on the faster of 2 timed trials in each session.

therefore, suggests that the best (longest standing time) of 5 timed attempts be recorded. Thus, performance stability of outcome measures seems to differ depending on the test and the patient group examined. In comparison, we found that 2 timed 10MWT trials were enough to achieve performance stability. Furthermore, ICC values based on the faster of the 2 trials were the same as those calculated based on the average of 3 timed trials, which are commonly used.[23] This finding has implications for the amount of time required to conduct 10MWT testing, both in research and clinical practice.

Reliability

According to Fleiss' classification,[18] interrater reliability in the present study was excellent, with an $ICC_{1.1}$ of 0.97, which is comparable with previous studies involving people with cerebral palsy,[25] spinal cord injury,[21] traumatic brain injury,[22] and stroke[28,29] with ICC estimates between 0.94 and 0.99. Further, our results of absolute reliability (SEM and MDC) are comparable to previous studies involving people with stroke (SEM = 0.07 m/s),[29] Parkinson Disease (SEM = 0.08 m/s),[23] and cerebral palsy (SEM = 0.07 m/s).[25] Also, the SEM of 0.06 m/s in the present study is below that considered a minimal clinically important difference of adults with pathology,[30] and further reduced when a single outlier was eliminated from our analysis. We consider reducing the number of steps during the 10MWT as a qualitative measure of gait improvement. However, to our knowledge, only a few studies have examined the interrater reliability of counting steps during the 10MWT. We found the ICC (0.96) to be excellent, and SEM = 1.3 steps and MDC = 3.6 steps. In comparison, Bowden and Behrman[31] demonstrated a SEM of 0.76 steps, with steps calculated by a step activity monitor compared with a handheld manual counter in a group of people with spinal cord injury. Lang et al.[23] demonstrated a SEM of 15.1 steps/minute for comfortable speed. We advocate counting steps during the 10MWT as an easy measure of monitoring kinematic/kinetics changes.

Limitations

Participants in the present study all had neurological disorders, and with a median (IQR) length of hospital stay of 23 days (14-35), at the time of testing. The people were recruited from one hospital and not from the community across several regions. They were able to understand instructions and had a reasonably high functional level as indicated by their Barthel Index and Berg Balance Scale scores. Results of the study, therefore, reflect a cohort of patients without severe cognitive or languages problems in the subacute stage following a neurological disorder, and therefore cannot be extrapolated to patients in a more acute stage or other patient groups. Strengths are that all testing followed the same standardized procedure, the sample size was large, and that raters were blinded to each other's results until end of study.

Conclusions

We suggest that the faster of 2 timed 10MWT trials be recorded for people with a neurological disorder in clinical practice and research, as excellent interrater reliability and low measurement noise was found. We suggest that therapists use the standardized 10MWT procedure originally described by Dr Watson, and include the adaptations used in the present study.

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Ethical Approval

According to national guidelines, ethical approval is not required for this type of study.

Conflict of Interest

None declared.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jstrokecerebrovasdis.2019.06.021.

Appendix A

The 10-Meter Walking Test Procedure[1]

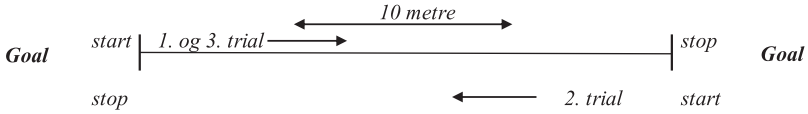
Aim

To measure the time (and if required the number of steps) taken for subjects to cover a distance of 10 m from a standing start, when walking at their usual speed, as a measure of change in aspects of their gait performance.

Requirements

A stopwatch which times to 1/100 second.

Distance of at least 12 m (and preferably more) of free floor space, with parallel tapes or other markers on floor, 10 m apart, to indicate a "start" and "stop" line.



Procedure

Subjects stand at the start line, with their toes up to the line. With any walking aid placed in front of them ready to use (If using a rollator, it must not be locked). If walking sticks are used, they are held in the hands.

Tester stands at the start line, and accompanies the person. The tester walks slightly behind the person. It is not allowed to verbally encourage or provide physical support.

A "target" (such as door, chair, or wall) is identified by the tester which is at least a meter beyond the finish line.

Instructions to subjects

"You see the (target) over there?

Please walk towards it, at your usual speed.

Please start walking when you are ready."

Timing start

Watch the subject's feet. The stopwatch should be started at the moment that the subject first moves a foot in order to take a step.

Timing stop

The stopwatch is stopped at the moment that the finish line is first touched or crossed by the leading foot, as the subject continues to walk toward the identified target.

Test session

One test session should consist where possible of three trials, with no more than 20 seconds between each trial. *Fastest time from the completed trials is recorded.* Record if the subject is unable to complete three trials. Alternatively, simply time the subject over one walk of 10 m.

Step count (optional)

Count the total number of steps taken to cover the 10-m distance within the time recorded. Record only completed steps − those where foot-floor contact has occurred before or on the finish line, within the time recorded (within-the-time within the line); i.e., stop counting when timing has stopped.

Record

Walking aid (if used). Time in seconds to 2 decimal places (fastest time). Time in meters per second (calculated as: 10/time to walk 10 m). Number of steps taken during the fastest time.

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