**Authors:**

Ralph J. Marino, MD
Giorgio Scivoletto, MD
Mary Patrick, RN
Federica Tamburella, PT
Mary Schmidt Read, DPT
Anthony S. Burns, MD
Walter Hauck, PhD
John Ditunno, Jr., MD

**Affiliations:**

From the Regional Spinal Cord Injury Center of the Delaware Valley (RJM, MP, MSR, ASB, JD), Thomas Jefferson University/Magee Rehabilitation, Philadelphia, Pennsylvania; Spinal Cord Unit (GS, FT), IRCCS Fondazione S. Lucia, Rome, Italy; Lyndhurst Centre (ASB), Toronto Rehabilitation Institute, Toronto, Canada; and Sycamore Consulting LLC (WH), New Hope, Pennsylvania.

**Correspondence:**

All correspondence and requests for reprints should be addressed to Ralph J. Marino, MD, Thomas Jefferson University, 132 S. 10th Street, Suite 375 Main Building, Philadelphia, PA 19107.

**Disclosures:**

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article. Portions of this work were presented at the 2008 annual meeting of the American Spinal Injury Association, San Diego, CA. This work was supported in part by grant H 133 N000023 from the National Institute on Disability and Rehabilitation Research, Office of Special Education and Rehabilitative Services, Department of Education.

0894-9115/10/8901-0007/0
*American Journal of Physical Medicine & Rehabilitation*


DOI: 10.1097/PHM.0b013e3181c560eb



ORIGINAL RESEARCH ARTICLE

# Walking Index for Spinal Cord Injury Version 2 (WISCI-II) with Repeatability of the 10-m Walk Time

## Inter- and Intrarater Reliabilities

## ABSTRACT

Marino RJ, Scivoletto G, Patrick M, Tamburella F, Read MS, Burns AS, Hauck W, Ditunno J: Walking Index for Spinal Cord Injury version 2 (WISCI-II) with repeatability of the 10-m walk time. Am J Phys Med Rehabil 2010;89:7–15.

**Objective:** To demonstrate the inter-/intrarater reliability of the Walking Index for Spinal Cord Injury version 2 scale and the repeatability of the time to walk 10 m in chronic subjects.

**Design:** In this reliability study, 26 subjects from the United States and Italy with spinal cord injury/disorder were tested by two blinded raters on two separate days to determine self-selected and maximum Walking Index for Spinal Cord Injury levels and the time to complete a 10-m walk. Subjects were progressed from self-selected to maximum Walking Index for Spinal Cord Injury incrementally until they failed the higher level. Intraclass correlations were calculated for Walking Index for Spinal Cord Injury levels and repeatability coefficients for the 10-m time.

**Results:** Twenty-two of 26 subjects showed increases of one to eight levels from self-selected to maximum Walking Index for Spinal Cord Injury, whereas 10-m walking time remained relatively unchanged ($n = 15$) or increased markedly ($n = 7$). Inter- and intrarater reliabilities were 1.00 for the self-selected Walking Index for Spinal Cord Injury level. Intrarater reliability for the maximum level was 1.0; interrater reliability was 0.98. Repeatability coefficients for time to walk 10 m were smaller (better) at self-selected than at maximum Walking Index for Spinal Cord Injury and on the same day than on different days. On same-day assessments, repeatability coefficients were 18%–20% of 10-m walk time, excluding subjects with discrepant Walking Index for Spinal Cord Injury levels ($n = 2$). For different-day assessments, repeatability coefficients were 27%–35% of 10-m walk time.

**Conclusions:** The determination of both self-selected and maximum Walking Index for Spinal Cord Injury levels is highly reliable, whereas 10-m walking time is more variable. Walking "profiles" of speed at self-selected and maximum Walking Index for Spinal Cord Injury may better characterize walking ability than a single Walking Index for Spinal Cord Injury level.

**Key Words:** Spinal Cord Injuries, Outcome Assessment, Ambulation, Reliability

Valid and reliable outcome measures are essential in spinal cord injury (SCI) clinical trials and needed to determine accurately the effectiveness of treatment interventions.[1–3] Outcome measures related to walking function include measures of walking capacity, such as short-distance timed walk, long-distance walk (e.g., 6-min walk), the walking index for SCI version 2 (WISCI-II) and balance (e.g., Berg Balance Scale), and disability measures, such as the locomotor Functional Independence Measure and the mobility items in the Spinal Cord Independence Measure.[4,5] A number of these measures were reviewed[6] with the conclusion that they "seem to encompass adequate descriptors for outcomes of walking trials for incomplete SCI." The timed walk tests and the WISCI were cited as the two most reliable measures of walking capacity for use in SCI clinical trials in the published guidelines[3] developed by the International Campaign for Cure of Spinal Cord Paralysis.

The WISCI-II is a capacity measure according to the International Classification of Functioning, Disability and Health of World Health Organization. Capacity is a subdomain (qualifier) of activities, and documents a person's ability to execute a task or action in a standardized environment.[7] This differs from performance measures of mobility such as the related items in the Functional Independence Measure and the Spinal Cord Independence Measure, in which walking is assessed as it is usually performed in the person's current environment. The WISCI was designed to identify improvements in walking ability resulting from neurologic improvement after SCI. It ranks walking capacity from most impaired to least impaired.[6] It has been clearly stated very recently by international and national study groups that the WISCI and the 10-m walk time each measure a separate component of walking capacity and are the most valid and useful tests of walking function for SCI clinical trials.[8]

A meeting hosted by the National Institute on Disability and Rehabilitation Research in 2006 on outcome measures in SCI endorsed the validity of the 10-m timed walk and the WISCI-II for use in clinical trials and suggested further reliability studies of the WISCI-II scale. As a result, the following study was undertaken to demonstrate the reliability of the WISCI-II measure in a group of subjects with SCI. Our hypotheses were first, that the determination of self-selected (SS) and maximum WISCI levels is highly reliable; second, that the time of the 10-m walk is a reliable measure; and third, to confirm[9] that often persons with chronic SCI can ambulate at a higher WISCI level (maximum) than the level typically used for ambulation (SS).

## METHODS

### Participants

Study subjects were recruited from (1) the Regional Spinal Cord Injury Center of the Delaware Valley, a partnership of Thomas Jefferson University Hospital and Magee Rehabilitation Hospital, Philadelphia, PA, and (2) the Spinal Unit, IRCCS Santa Lucia, Rome, Italy. Candidates were primarily identified from a group of subjects who had previously participated in studies of ambulation and who expressed an interest in study participation. To be included, subjects had to have a history of either a traumatic SCI or a spinal cord disorder at least 6 mos before testing. In addition, subjects had to provide a history of independent lower-limb weight bearing (standing or ambulating) a minimum of once a week to minimize the risk of pathologic fractures. Subjects were excluded if their SS WISCI level was 20 because it would not be possible to walk at a higher level (ceiling effect), or $<6$ because parallel bars are not routinely available to chronic patients, and differences in the use of parallel bars between Europe and the United States have been noted previously.[10] Subjects were also excluded if they had any history of heart disease, uncontrolled asthma, or other medical condition that could limit their ability to ambulate safely. Informed consent was obtained from each subject before the initiation of testing. The study was approved by the institutional review boards at each center.

### Assessments

Neurologic assessment was performed by SCI physicians or trained physical therapists according to the International Standards for Neurologic Classification of SCI.[11] The upper- and lower-limb key muscles were graded by manual muscle testing on a five-point scale for each limb, and the American Spinal Injury Association Impairment Scale was determined for each subject.

WISCI testing was performed by physical therapists trained in the use of the WISCI and instructed in the purpose of testing for inter- and intrarater reliabilities. Two therapists, blinded to the other's evaluation, tested subjects on two different days for the SS and maximum WISCI levels according to a specified protocol. Briefly, each therapist interviewed the subject to determine the SS WISCI level, defined as the level the subject was ambulating in the community, or in the household if the subject was not a community ambulator. To determine maximum WISCI, the therapist advanced the subject sequentially through WISCI levels until the subject failed a level or was deemed unsafe for the next level. To avoid fatigue, if the therapist thought the subject could ambulate three or more levels above SS WISCI, then the subject

could skip to the higher level. However, if the subject failed to complete that level, then the subject would be tested at the first skipped level and advanced until failure.

The time to walk 10 m during each assessment was determined using a stop watch, and the data were recorded to one-tenth of a second. The stop watch was started precisely at the initiation and completion of the 10-m walk without allowances for acceleration and deceleration used in the standard testing of walking speed.[6,12,13] Testing was performed at the same time of day for each session (first day and second day), and subjects were allowed to rest between assessments to recover. The second day of assessment ranged from 2 days to several weeks after the first assessment, and the order of therapists performing assessments on a subject was the reverse of the first visit.

### Statistical Analysis

Inter- and intrarater reliabilities were determined for the SS WISCI and maximum WISCI levels using intraclass correlation coefficients with a one-way, random-effects model (intraclass correlation coefficient, 1.1).[14] For the 10-m walk time, Bland-Altman plots were used to assess the agreement and trends between tests conducted by the same rater (days 1–2) and by different raters (same day). In a Bland-Altman plot, the average of the two walking times is plotted on the x-axis, and the difference between the two times is plotted on the y-axis. If differences are as a result of chance, then points should be equally distributed above and below the x-axis. If there is an unequal distribution of points, e.g., more points above or below the x-axis, this suggests that some other nonrandom factor is influencing test results.

Mean and SD for differences in times between and within raters were calculated, as was the repeatability coefficient (RC). Bland and Altman[15] described the repeatability of an instrument based on the within-subject SD. The standard deviation is the square root of the residual mean square in a one-way analysis of variance. The repeatability is $\sqrt{2} \times 1.96 \times$ within-subject SD. The difference in two scores in a stable subject is expected to be less than this value for 95% of pairs of observations. Beckerman et al.[16] called this statistic the smallest real difference, which they defined as "the smallest measurement change that can be interpreted as a real difference." For the RC to be appropriate to apply to a measure, there should be an equal variance of differences across the range of scores (i.e., equal spread of differences above and below the entire x-axis of a Bland-Altman plot). If the spread is unequal, e.g., increasing spread as walking time increases, then a transformation should be used to equalize the spread.[15] Otherwise the RC will be too small at one end of the scale and too large at the other.

## RESULTS

There were 26 subjects recruited in the United States ($n = 9$) and Italy ($n = 17$); 16 were men and 10 were women, with an average age of 46.4 ± 19.3 yrs. The time from injury/onset ranged from 8 to 336 mos with a mean of 58 mos and most subjects (22 of 26) 1 year or more postinjury. The majority of the subjects had traumatic SCI ($n = 18$), and those with spinal cord lesions ($n = 8$) were as a result of ischemia (3), myelopathy (3), and tumor (2). The neurologic levels were cervical in 7, thoracic in 11, and lumbar in 8. Most subjects were classified as American Spinal Injury Association Impairment Scale grade D (23 of 26); 2 were ASIA Impairment Scale A (L3 levels) and 1 ASIA Impairment Scale C. Twenty-two of 26 subjects improved from one to eight levels above the SS WISCI level when asked to walk at a maximum level. The changes for individual subjects are listed in Table 1.

### Reliability of WISCI Level Determination

Intraclass correlation coefficients for intrarater reliability were 1.00 for SS and maximum WISCI levels for both therapists. Interrater reliability was also 1.00 for SS WISCI and 0.98 for maximum WISCI. Raters differed in maximum WISCI on one subject on both days and a second subject on day 1 only. The first subject (number 17, Table 1) had a SS WISCI level of 13 (walker, no braces, no assistance) as determined by Therapists A and B. Therapist A advanced this subject to maximum WISCI level 16 (two crutches, no braces, no assistance) on both days, whereas Therapist B did not advance the subject beyond level 13 on either day. The second subject (number 10, Table 1) had a SS WISCI level of 12 (two crutches, braces, no assistance) as determined by Therapists A and B. Therapist A advanced this subject to maximum WISCI level 20 (no devices, braces, or assistance) on day 1, but Therapist B stopped at level 19 (one cane, no braces, no assistance) on day 1. Both therapists agreed on level 20 on day 2.

### Repeatability of Time for 10-m Walk at SS or Maximum WISCI Level

Bland-Altman plots for differences in time show that the time for the 10-m walk at SS WISCI varied more from 1 day to the next than between raters on the same day. The difference in time for the two walks on the same day (interrater) was within 25% of the average time in all cases (Fig. 1*a*), whereas the difference in time from days 1 to 2 (intrarater) exceeded 25% of average time on several occasions (Fig. 1*b*). There was, however,

**TABLE 1** Individual injury levels, WISCI levels and average 10-m walk times

| Subject Number | WISCI Level | | Time (sec) | | Injury Level | AIS Grade |
|---|---|---|---|---|---|---|
| | Self-Selected | Maximum | Self-Selected | Maximum | | |
| 1 | 9 | 9 | 42.1 | 42.1 | L1 | D |
| 2 | 9 | 10 | 42.6 | 53.5 | L3 | A |
| 3 | 11 | 16 | 19.8 | 18.8 | L1 | D |
| 4 | 11 | 14 | 57.8 | 49.5 | L1 | D |
| 5 | 12 | 19 | 11.2 | 20.8 | L3 | C |
| 6 | 12 | 16 | 14.3 | 13.5 | T12 | D |
| 7 | 12 | 18 | 15.3 | 20.5 | L1 | D |
| 8 | 12 | 15 | 16.8 | 21.0 | L1 | D |
| 9 | 12 | 16 | 20.3 | 21.8 | T9 | D |
| 10 | 12 | 19/20 | 22.2 | 94.2[a] | C6 | D |
| 11 | 12 | 16 | 41.0 | 47.8 | T8 | D |
| 12 | 12 | 12 | 63.3 | 63.3 | T12 | D |
| 13 | 13 | 16 | 13.8 | 19.5 | T5 | D |
| 14 | 13 | 16 | 30.3 | 47.7 | L3 | A |
| 15 | 13 | 16 | 56.0 | 74.0 | T6 | D |
| 16 | 13 | 14 | 71.0 | 70.0 | T2 | D |
| 17 | 13 | 13/16 | 73.5 | 104.2[b] | C6 | D |
| 18 | 13 | 13 | 79.8 | 79.8 | T12 | D |
| 19 | 13 | 13 | 135.0 | 135.0 | T1 | D |
| 20 | 16 | 20 | 12.8 | 31.7 | C6 | D |
| 21 | 16 | 20 | 19.3 | 24.0 | C3 | D |
| 22 | 16 | 17 | 66.0 | 80.8 | T11 | D |
| 23 | 19 | 20 | 11.8 | 12.0 | C5 | D |
| 24 | 19 | 20 | 14.6 | 25.9 | T5 | D |
| 25 | 19 | 20 | 16.0 | 15.5 | C8 | D |
| 26 | 19 | 20 | 44.8 | 96.1 | C5 | D |

Note that for two subjects, the raters found different maximum WISCI levels, and the 10-m walk time was much longer at the higher level.

[a]Subject 10: maximum time at level 19 = 44.1 secs and at level 20 = 111.0 secs.

[b]Subject 17: maximum time at level 13 = 72.7 secs and at level 16 = 135.8 secs.

AIS, Association Impairment Scale.

more variability in times for the maximum WISCI than the SS WISCI for both days and raters (Figs. 1*c, d*).

For the 10-m walking time at SS WISCI, there was also greater variability in times with slower walking speed (longer average time), but this was not so apparent for the time to walk 10 m at maximum WISCI (Fig. 1). Therefore, the RC for the 10-m walking time at SS WISCI was calculated using percentage differences, which did not increase with average time, and the RCs (Table 2) confirmed the relationships observed in the Bland-Altman plots. For 10-m walking time at SS WISCI levels, interrater (same day) RCs were smaller than intrarater (different day) RCs, 17%–18% *vs.* 27%–35% of 10-m walking time. For 10-m walking time at maximum WISCI level, interrater RCs were greatly affected by the two subjects where WISCI level differed. For days 1 and 2, the RCs were 41.6 and 28.9 secs, respectively, for all subjects but only 19.9 and 14.8 secs after removal of the two subjects where raters did not agree on maximum WISCI.

## Comparison of Self-Selected and Maximum Times

Of the 22 subjects with a higher maximum than SS WISCI level, the majority (15 of 22) demonstrated a decline, no increase, or a moderate increase in 10-m walking time of <50% when advanced from the SS to the maximum WISCI (Fig. 2). The remaining subjects (7 of 22) showed a large to dramatic increase in time, with an increase of >100% in three subjects. Both subjects with discrepant maximum WISCI levels had a large increase in walking time at the higher level. The one subject (Fig. 2, open arrow) completed the 10-m walk at WISCI level 13 in 72.7 secs but at level 16 required 135.8 secs. The other subject (Fig. 2, closed arrow) completed the 10-m walk at WISCI level 19 in 44.1 secs but required 111.0 secs at level 20.

## DISCUSSION

The hypothesis that the WISCI scale is a reliable measure is demonstrated by the 100% agreement between therapists when testing the SS WISCI level and near perfect agreement when testing the

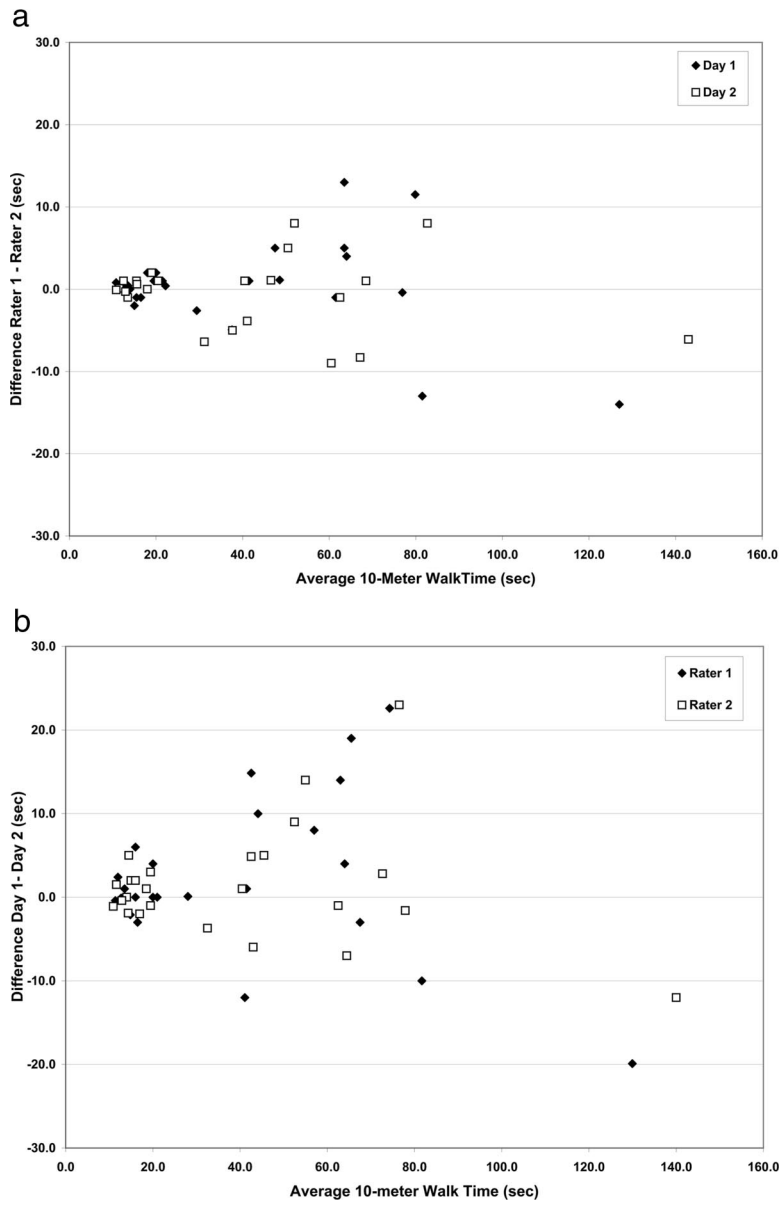


**FIGURE 1** *Bland-Altman plots of time to complete 10-m walk for SS and maximum WISCI levels.* (a) *Interrater (same day) time for SS WISCI;* (b) *intrarater (different day) time for SS WISCI;* (c) *interrater (same day) time for maximum WISCI, circled values represent two subjects where raters disagreed on WISCI level; and* (d) *intrarater (different day) time for maximum WISCI.*

maximum WISCI level. Of course, the SS level would be communicated to each therapist by the patient and in most cases was how the patient was walking on entering the study site; therefore, 100% agreement was expected. The progression from the SS to maximum WISCI level, however, also showed high agreement between and within raters, and these levels were assessed with no communication between therapists. In both cases where there was a disagreement in maximum WISCI level, the speed of gait greatly deteriorated at the highest level compared with the SS level. The time required to ambulate 10 m at maximum WISCI exceeded 100 secs, which converts to a speed of $<0.1$ m/sec.

There may be country-specific differences between United States and Italian raters, but because of the study design and small sample size, we were unable to determine whether such a factor was present. There have been differences noted in progression of WISCI level during rehabilitation for patients in Europe compared with the United States, with Centers in the United States using parallel bars less often and braces more often than European Centers.[10] A different training style (e.g., oriented toward independence rather than performance) may make patients more or less prone to accept lower SS WISCI levels or better able to sustain higher WISCI levels when requested. Ther-

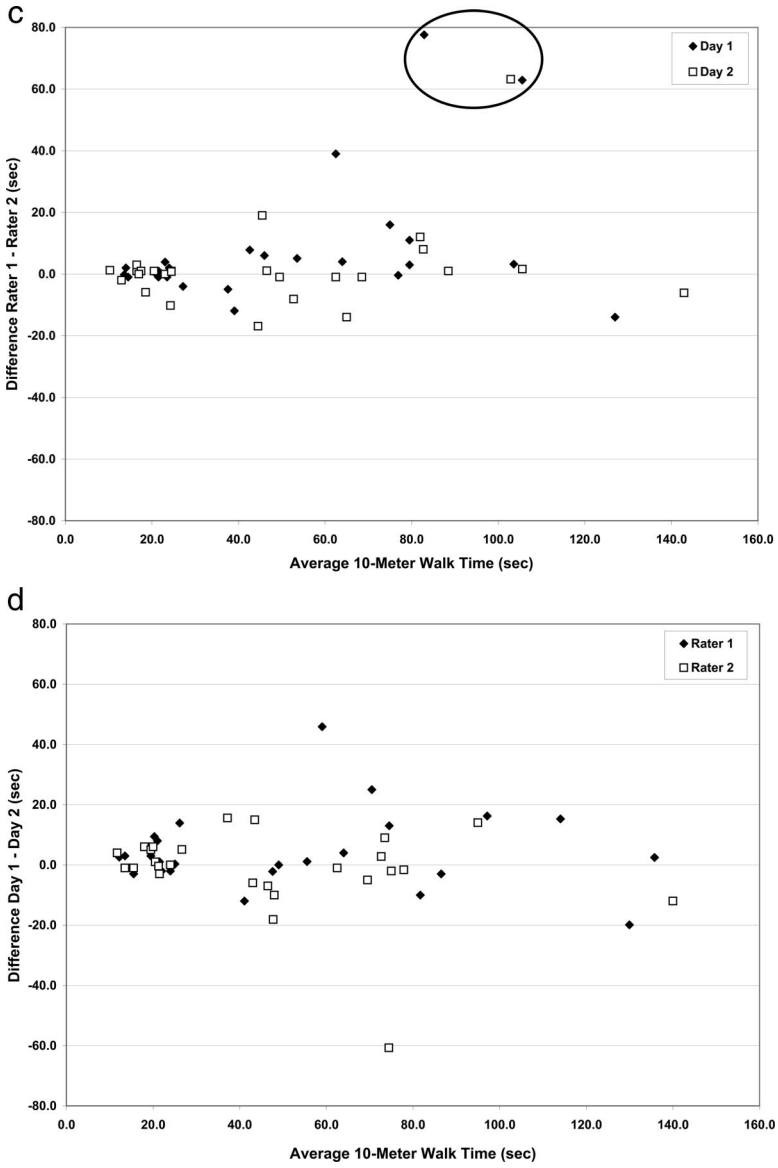


**FIGURE 1** *Continued.*

apist–patient interactions may have been important in the testing of the two subjects who achieved different maximum WISCI levels with different therapists. Both subject and tester must be comfortable advancing to the next higher WISCI level, which may mean tolerating a more unstable gait pattern with higher risk of injury.

The repeatability of the time required to walk 10 m was better (smaller time or percent difference) at SS WISCI than at maximum WISCI level. Day-to-day variability in walking time was greater than same-day variability for both the SS and maximum WISCI levels. Large day-to-day variability in walking speed, particularly for poorer walkers, was also noted by van Hedel et al.[17] in a study comparing the WISCI, Timed Up and Go, and 10-m walk test. This study also suggested that there may be a learning effect to the timed walking tests because subjects did better on the second test session than the first for the Timed Up and Go and the 6-min walk tests. These findings have implications for clinical trials assessing ambulation because variability would be reduced more by evaluating ambulation on two separate days than by averaging same-day assessments. Although it would add some complexity to the trial, multiple baseline and final assessments would make it easier to detect a true change in ambulation ability.

The original rationale for evaluating maximum WISCI was to identify patients who could walk functionally with fewer devices or with less assistance than the way they entered the study center or both to detect real changes in function. This was believed to be an important issue, based on observations from a previous study,[9] which demonstrated that subjects could ambulate at mul-

**TABLE 2** Repeatability coefficients (RC) for 10-m walk time at SS WISCI and maximum WISCI

| | RC for SS WISCI Time | | RC for Maximum WISCI Time | |
|---|---|---|---|---|
| 10-m Walk Time | Seconds | Percent | Seconds ($n$ = 26) | Seconds ($n$ = 24)[a] |
| Interrater (same day) | | | | |
| Day 1 | 11.2 | 18.2 | 41.6 | 19.9 |
| Day 2 | 8.5 | 17.7 | 28.9 | 14.8 |
| Intrarater (different day) | | | | |
| Rater 1 | 18.5 | 35.0 | 25.2 | — |
| Rater 2 | 13.6 | 27.7 | 28.8 | — |

[a]Repeatability coefficient without two subjects where raters disagreed on WISCI level.

tiple WISCI levels. We were able to increase WISCI levels over SS levels in 85% of subjects, in half the cases by three or more WISCI levels. There was not a consistent relationship between walking speed and WISCI level within subjects. In only three subjects did the time required for the 10-m walk increase markedly (more than twice SS). It is interesting to speculate why patients tend to prefer a lower SS level, particularly those who could walk almost as quickly at a higher level. Is it because their training as outpatients has not been maximized, or is it possibly as a result of the preference of patients to ambulate in a particular manner? Patient preference for type of aid, such as a walker without a brace instead of a brace and cane, would impact SS WISCI level. As has been noted by others,[17] WISCI levels are not ordered by degree of independence but by degree of underlying impairment. This results in some levels with physical assistance ranked above levels requiring more braces/devices but no physical help. Acceptance of physical assistance may be influenced by cultural factors, age, environment, or availability of help. The only two of our subjects who required physical assistance at SS WISCI were older than 70 yrs and from Italy.

There are several important issues to consider when measuring the time/velocity/speed of walking

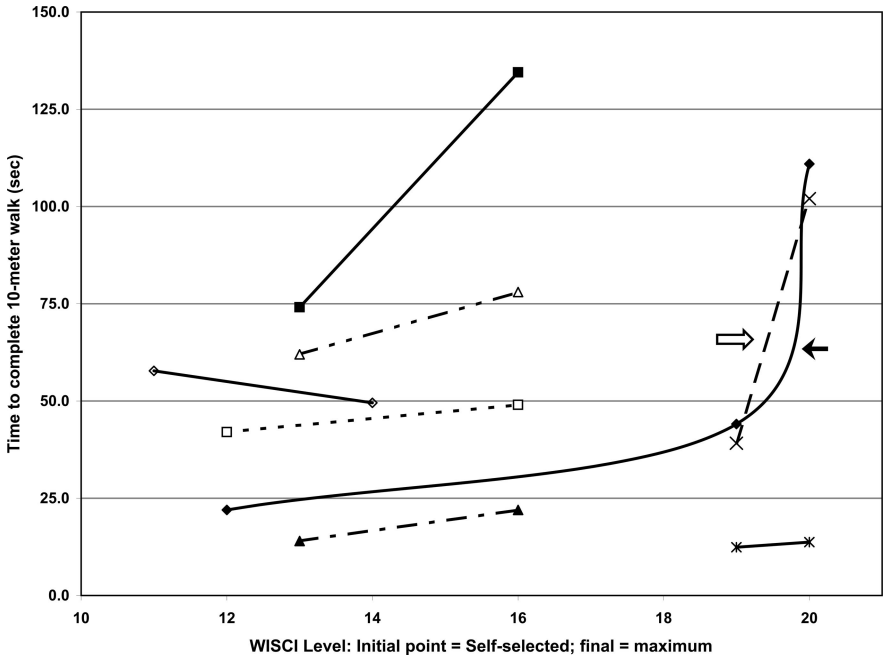


**FIGURE 2** *Sample of individual subject SS and maximum WISCI levels and corresponding 10-m walk times. At higher WISCI levels, time to walk 10 m could decrease or increase a small amount, or increase by a large amount, depending on the subject. Open and closed arrows represent subjects where raters disagreed on maximum WISCI level. See text for details.*

in trials of subjects with chronic SCI. The choice of walking speed and distance has not been consistent across studies of ambulation in SCI. In the Spinal Cord Injury Locomotor Trial study, subjects were assessed at maximal speed over short distances (50 ft or about 15 m), whereas the European Network assesses subjects at SS speeds over short distances (10 m; 14 m including acceleration/deceleration). There has been no comparison of efficiency of SS speed with maximal speed for short distances in acute SCI studies, although van Hedel et al.[18] found that persons with recent SCI chose to walk at a speed closer to their maximum speed than did nondisabled persons. Distances longer than 10 m may be needed to show differences in speed or energy cost. Most measures of energy cost based on oxygen consumption require longer durations than the time to walk 10 m to reach steady state.[19] In a previous study,[9] we observed that chronic subjects had a slower speed and higher energy cost per meter at maximum WISCI than at SS WISCI when ambulating 100 m. Several recent reports from the Spinal Cord Injury Locomotor Trial[13] and the European Network[20] indicate that the 10-m walk is sufficient to assess ambulation, and there is no benefit in measuring the 6-min walk. Both of these studies had subjects who walked using their typical devices and braces (SS WISCI). The results of Kim et al.[9] suggest that a longer distance walk may reveal differences in walking function if subjects are tested at maximum WISCI rather than SS WISCI.

Either use of fewer devices/less assistance (e.g., walker to cane) or improved gait speed could be considered an improvement in walking ability. What we observed in this study was that nearly half of the participants could walk at a higher than usual WISCI level without a major deterioration in gait efficiency (increased time). It would be important to know this in a clinical trial of an intervention designed to improve ambulation, so that this change is not mistaken for improvement. Conversely, if a subject in such a trial could not initially ambulate efficiently with fewer devices/assistance and could at the end of the trial, we would want to identify this improvement as resulting from the intervention. It seems essential to identify the walking "profile" of subjects, based on clear detailed criteria and procedures, at the start of a clinical trial where ambulation is an outcome of interest. For example, subjects could have SS WISCI and 10-m walking time recorded and then be advanced up the WISCI scale to the maximum WISCI level that could be achieved without a significant increase in 10-m walking time. The WISCI levels and 10-m walking times at SS and maximum levels would constitute the baseline walking profile.

Although the number of subjects in our study was small, the distribution of level of injury and American Spinal Injury Association Impairment Scale grade were similar to other studies of chronic ambulatory patients with SCI.[17] Because this study was limited to chronic subjects, a future reliability study of the WISCI scale should be performed on acute subjects. Strict criteria need to be used in the determination of the maximum WISCI at baseline and final endpoint. In acute studies, the SS and maximum WISCI levels are generally determined by the therapist[21] because patients are unlikely to be the judge of safe walking as they recover from the weakness of paralyzed muscles and other impairments. Patient–therapist interactions may play a larger role in maximum WISCI level determination in the early period after injury, when safety concerns predominate over pushing the limits of capacity. In the acute subject, the maximum WISCI level must be achieved safely with foot flat, stable ankle, and minimum lurch. In chronic subjects, therapists and patients may be more comfortable with a poorer quality gait during testing to achieve a higher WISCI level.[9]

## CONCLUSIONS

The WISCI scale is a highly reliable measure of walking capacity, but the assessment of SS and maximum WISCI levels should be supplemented with walking speed. Attention to strict criteria and procedures for advancing subjects to maximum WISCI will enhance the reliability of WISCI level determination, and repeating assessments on separate days at baseline and at the end of the study may mitigate the day-to-day variability in walking speed. Further research is needed to determine whether evaluating maximum walking speed in addition to preferred speed will add to the walking profile of a given subject.

### REFERENCES


1. Curt A, Schwab ME, Dietz V: Providing the clinical basis for new interventional therapies: Refined diagnosis and assessment of recovery after spinal cord injury. *Spinal Cord* 2004;42:1–6
2. Ditunno JF Jr, Burns AS, Marino RJ: Neurological and functional capacity outcome measures: Essential to spinal cord injury clinical trials. *J Rehabil Res Dev* 2005;42:35–41
3. Steeves JD, Lammertse D, Curt A, et al: Guidelines for the conduct of clinical trials for spinal cord injury (SCI) as developed by the ICCP panel: Clinical trial outcome measures. *Spinal Cord* 2007;45: 206–21
4. Dobkin BH, Apple D, Barbeau H, et al: Methods for a randomized trial of weight-supported treadmill training versus conventional training for walking during inpatient rehabilitation after incomplete traumatic spinal cord injury. *Neurorehabil Neural Repair* 2003;17:153–67

5. Catz A, Itzkovich M, Steinberg F, et al: The Catz-Itzkovich SCIM: A revised version of the spinal cord independence measure. *Disabil Rehabil* 2001;23: 263–8
6. Ditunno JF Jr, Barbeau H, Dobkin BH, et al: Validity of the walking scale for spinal cord injury and other domains of function in a multicenter clinical trial. *Neurorehabil Neural Repair* 2007;21:539–50
7. World Health Organization. *International Classification of Functioning, Disability and Health: ICF*. Geneva, World Health Organization, 2001
8. Alexander MS, Anderson KD, Biering-Sorensen F, et al: Outcome measures in spinal cord injury: Recent assessments and recommendations for future directions. *Spinal Cord* 2009;47:582–91
9. Kim MO, Burns AS, Ditunno JF Jr, et al: The assessment of walking capacity using the walking index for spinal cord injury: Self-selected versus maximal levels. *Arch Phys Med Rehabil* 2007;88:762–7
10. Ditunno JF, Scivoletto G, Patrick M, et al: Validation of the walking index for spinal cord injury in a US and European clinical population. *Spinal Cord* 2008; 46:181–8
11. American Spinal Injury Association. *International Standards for Neurological Classification of Spinal Cord Injury*. Chicago, IL, American Spinal Injury Association, 2002
12. Wirz M, Zemon DH, Rupp R, et al: Effectiveness of automated locomotor training in patients with chronic incomplete spinal cord injury: A multicenter trial. *Arch Phys Med Rehabil* 2005;86:672–80
13. Barbeau H, Elashoff R, Deforge D, et al: Comparison of speeds used for the 15.2-meter and 6-minute walks over the year after an incomplete spinal cord injury: The SCILT Trial. *Neurorehabil Neural Repair* 2007;21:302–6
14. Shrout PE, Fleiss JL: Intraclass correlations: Uses in assessing rater reliability. *Psychol Bull* 1979;86: 420–8
15. Bland JM, Altman DG: Measuring agreement in method comparison studies. *Stat Methods Med Res* 1999;8:135–60
16. Beckerman H, Roebroeck ME, Lankhorst GJ, et al: Smallest real difference, a link between reproducibility and responsiveness. *Qual Life Res* 2001;10: 571–8
17. van Hedel HJ, Wirz M, Dietz V: Assessing walking ability in subjects with spinal cord injury: Validity and reliability of 3 walking tests. *Arch Phys Med Rehabil* 2005;86:190–6
18. van Hedel HJ, Dietz V, Curt A: Assessment of walking speed and distance in subjects with an incomplete spinal cord injury. *Neurorehabil Neural Repair* 2007;21:295–301
19. Whipp BJ, Wasserman K: Oxygen uptake kinetics for various intensities of constant-load work. *J Appl Physiol* 1972;33:351–6
20. van Hedel HJ, Wirz M, Dietz V: Standardized assessment of walking capacity after spinal cord injury: The European network approach. *Neurol Res* 2008; 30:61–73
21. Ditunno JF Jr, Ditunno PL, Graziani V, et al: Walking index for spinal cord injury (WISCI): An international multicenter validity and reliability study. *Spinal Cord* 2000;38:234–43