Spinal Cord (2014) 52, 333–336

www.nature.com/sc

ORIGINAL ARTICLE

Concurrent validity of the 10-meter walk test as compared with the 6-minute walk test in patients with spinal cord injury at various levels of ability

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Study design: Cross-sectional design.
Objectives: To evaluate the concurrent validity of the 10-meter walk test (10MWT) as compared with the 6-minute walk test (6MinWT) in patients with spinal cord injury (SCI) at various levels of walking ability, as determined using the criteria from the functional independence measure locomotor (FIM-L) scores.
Setting: A major tertiary referral hospital in Thailand.
Methods: Ninety-four independent ambulatory subjects with SCI (FIM-L scores 5–7) were assessed for their functional abilities using the 10MWT and 6MinWT.
Results: The data of the 10MWT and the 6MinWT had excellent correlation in subjects with FIM-L 7 ($r=0.83$, $P<0.001$), good correlation in subjects with FIM-L 6 ($r=0.74$, $P<0.001$), but poor correlation in subjects with FIM-L 5 ($r=0.31$, $P>0.05$).
Conclusion: The 6MinWT is a thorough assessment to reflect functional endurance, but it requires a long time and a large area to administer. The findings confirm the utility of the 10MWT as an alternative monitoring tool to the 6MinWT, but only for the patients with rather good walking ability.
Spinal Cord (2014) **52,** 333–336; doi:10.1038/sc.2013.171; published online 21 January 2014

Keywords: tetraplegia; paraplegia; walking; rehabilitation; functional tests

INTRODUCTION

The current trend toward the decreased length of stay in a hospital for patients with spinal cord injury (SCI)[1] suggests the importance of a monitoring method using a standard, sensitive and practical measure in order to clearly quantify functional alteration of the patients after discharge. Previously, the 6-minute walk test (6MinWT) and the 10-meter walk test (10MWT) have been advocated as valid, reliable and sensitive measures to quantify the ambulatory ability of patients.[2–7] The 6MinWT measures the longest distance walked in 6 min, whereas the 10MWT commonly investigates the time required to walk over a 4- to 10-m walkway.[3,4,8] Results of the 6MinWT indicate the global and integrated responses of the pulmonary, cardiovascular and muscular systems; thus, they reflect the functional status for daily activities. However, the process of assessment is area- and time-consuming (at least 6 min). Moreover, standardization of the 6MinWT is more difficult than the 10MWT, because it depends strongly on the facilities.[3] Some studies measured the 6MinWT by asking the subjects to walk up and down a walkway of a specific length, which allows the application of the test in a setting with limited area.[9,10] However, the number of turns, particularly total turns, considerably influences the walking speed and distance covered in 6 min, especially in patients with neurological disorders. Therefore, in these individuals, the 6MinWT should be measured using a rectangular walkway.[3–5] Furthermore, the instruction and encouragement provided during the test have substantial impacts on the distance covered after 6 min; thus, the instruction should be rigorously standardized.[3] In contrast, the 10MWT is a quick and easily administered tool that can be performed along a 10- to 14-m walkway.[8] It is clinically interpretable and potentially modifiable, and hence the result is considered as a surrogate for the overall quality of gait and motor function.[11,12]

van Hedel *et al.*[5] reported that the 10MWT, when measured at a comfortable/preferred walking speed, had excellent correlation and best predictive ability for data of the 6MinWT. However, the findings were derived from 18 subjects who had good walking ability [median walking index for SCI II (WISCI II) score = 17.5]. Thus, the results may not clearly indicate the use of the 10MWT as an alternative tool to reflect data of the 6MinWT in patients with different levels of walking ability. van Hedel *et al.*[6] found that the preferred walking speed of the 10MWT had good to excellent correlation with the 6MinWT in subjects with SCI who had either good or poor walking ability. However, the researchers categorized the levels of ability of the subjects using criteria from the WISCI II, which incorporates 0–20 gradations according to the physical assistance and the device required for walking over 10 meters.[13] Ditunno and Dittuno,[13] the developers of the WISCI II, indicate that the ranking scores of the tool are based

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Received 21 June 2013; revised 17 December 2013; accepted 23 December 2013; published online 21 January 2014

on the severity of the impairment, not on functional independence in the environment, and thus the ranking criteria focus on capacity, and not disability or burden of care. Consequently, the tool may be suitable to quantify impairment improvement rather than levels of functional independence in environments of patients with SCI.[4,13] Hence, the existing reports may not clearly indicate the use of the 10MWT as an alternative tool to the 6MinWT in ambulatory patients with SCI at various levels of ability. On the contrary, the functional independence measure locomotor (FIM-L) measures levels of ability of the patients in different environments according to a minimum distance walk, assistive device and external assistance required, and safety issues while walking. Thus, the researchers believed that using the criteria from the FIM-L score might truly reflect the level of ability or the burden of care for the patients,[4,14] and the findings may clearly indicate the use of the 10MWT as an alternative monitoring tool to the 6MinWT in patients with different levels of ability. Therefore, the present study evaluated the concurrent validity of the 10MWT as compared with the 6MinWT in patients with SCI at various levels of walking ability, as determined using the criteria from the FIM-L scores.

MATERIALS AND METHODS

Subjects

This study was conducted cross-sectionally in 95 subjects with SCI, aged at least 18 years, who were able to walk independently with or without a walking device over at least 15 meters (FIM-L 5–7). Subjects with FIM-L 5 (household ambulation, $n=31$) were those who could walk only a short distance (a minimum of 15 meters) independently with or without a walking device, took more than a reasonable time to complete the activity or had safety considerations. Subjects with FIM-L 6 (modified independence, $n=31$) were those who could walk a minimum of 50 meters with the use of an orthosis and/or walking device, took more than a reasonable amount of time to complete the activity or had safety considerations. Subjects with FIM-L 7 (complete independence, $n=33$) were those who were able to walk a minimum of 50 meters safely without any assistive devices.[4] Subjects were excluded if they presented signs and symptoms that might affect walking ability such as pain in the muscles or joints of the lower extremities, deformity of the spine and lower extremities or if they had medical complications that limited mobility. All of them provided a written informed consent form approved by the Khon Kaen University Ethics Committee for Human Research before participation in the study.

Protocol of the study

Subjects were interviewed and assessed for their baseline demographics, SCI characteristics (including causes, levels and severity of SCI and post-onset time) and baseline walking ability (FIM-L scores). Next, they were assessed for their functional ability using the 10MWT followed by the 6MinWT in order to reduce the effects of fatigue that might occur owing to the high demands of the 6MinWT affecting the outcome of the 10MWT. Details of the tests are as follows.

10-meter walk test. Subjects walked with or without a customary walking device at a preferred walking speed along a 10-m walkway without any break to the end point. The time required to cover the middle 4 m of the walkway was recorded in order to obtain a rhythmic phase of walking speed.[2,7,15] Then the time required over 3 trials was converted to the walking speed.

6-minute walk test. Subjects were instructed to walk as far as possible in 6 min around a rectangular walkway measuring 6 m by 4 m and marked at 1-m intervals with a traffic cone at each corner in order to ensure the size of the walkway used for every subject. During the test, an assessor (SN.) walked alongside the subjects to ensure their safety, and to inform them of the time left every minute and offer verbal encouragement. Subjects were allowed to rest as needed without stopping timing and continued walking as soon as they could. Then, the distance covered after 6 min was recorded.[16–18]

Statistical analyses

Descriptive statistics were applied to explain baseline demographics, SCI characteristics and findings of the study. The Kruskal–Wallis test was used to analyze the different findings among the groups. The Pearson correlation coefficient was used to analyze the correlation between the data of the 10MWT and 6MinWT in each group. Then, the simple linear regression analysis was applied to formulate a predictive equation for the 6MinWT using the data from the 10MWT. The level of significant difference was set at $P<0.05$.

RESULTS

The data of one subject with FIM-L 5 were excluded because of being an outlier. Table 1 presents baseline demographics, SCI characteristics and findings of the study ($n=94$). Most subjects were males, having an SCI at a chronic stage from a non-traumatic lesion. The data of the 10MWT and 6MinWT of the subjects were significantly different among the groups ($P<0.001$, Table 1). Figures 1a–c illustrate the correlation between the data of the 10MWT and the 6MinWT in subjects with FIM-L 5, 6 and 7, respectively. The data showed significantly good to excellent correlation in subjects with FIM-L 6 and 7 ($r=0.74$ and 0.83, $P<0.001$, Figures 1b and c), but poor and no significant correlation in those with FIM-L 5 ($r=0.306$, $P=0.113$, Figure 1a). Consequently, the researchers converted the data of both tests into walking speed and formulated predictive equations for the 6MinWT using the data of the 10MWT only for subjects with FIM-L 6 and 7.

The predictive equation for subjects with FIM-L 6 was as follows:

$$\text{6MinWT speed} = 0.51\times(\text{10MWT speed}) + 0.13;$$
$$\left[\text{adjusted } R^2 = 0.55(0.33-0.68)\right].$$

Table 1 Demographics, spinal cord injury characteristics and data of walking tests of subjects ($N=94$)

Variable	*FIM-L 5 (N = 30)*	*FIM-L 6 (N = 31)*	*FIM-L 7 (N = 33)*
Age[a] (years)	45.2 ± 13.2 (40.13–50.36)	51.9 ± 13.2 (47.1–56.8)	49.2 ± 10.0 (45.6–52.7)
Post-injury time[a] (mean ± s.d.) (months)	34.6 ± 26.56 (21.78–47.38)	44.3 ± 43.2 (28.4–60.1)	36.7 ± 30.6 (25.9–47.6)
Gender[b]: males (*n* (%))	18 (64)	24 (77)	23 (70)
AIS class[b]: *D* (*n* (%))	4 (14)	18 (58)	30 (91)
Level of injury[b]: incomplete tetraplegia (*n* (%))	10 (36)	5 (16)	13 (39)
Walking device: walker/crutches/cane (*n*)	26/2/0	18/5/8	—
10-meter walk test[a] (mean ± s.d.) ($m\,s^{-1}$)	0.15 ± 0.04 (0.13–0.16)	0.39 ± 0.18 (0.32–0.46)	0.83 ± 0.27 (0.74–0.93)
6-minute walk test[a] (mean ± s.d.) (m)	37.07 ± 9.91 (32.22–40.91)	118.51 ± 45.55 (101.81–135.22)	227.32 ± 83.43 (197.73–256.90)

Abbreviations: AIS, American spinal injury association (ASIA) impairment scales; FIM-L, functional independence measure locomotor.
[a]The data are presented using mean ± s.d. (95% confidence intervals).
[b]These variables were categorized according to the following criteria: gender: male/female, AIS class: C/D, level of injury: incomplete paraplegia/incomplete tetraplegia.

The predictive equation for subjects with FIM-L 7 was as follows:

$$6\text{MinWT speed} = 0.72\times(10\text{MWT speed}) + 0.03;$$
$$\left[\text{adjusted } R^2 = 0.68(0.54 - 0.89)\right].$$

DISCUSSION

The study explored the concurrent validity of the 10MWT as compared with the 6MinWT in independent ambulatory subjects with SCI who had different levels of walking ability, as determined using criteria from the FIM-L scores. The findings indicate that the 10MWT has good to excellent correlation with the 6MinWT in subjects with FIM-L 6 and 7 ($P<0.001$, Figures 1b and c), but no significant correlation, and poor correlation, in those with FIM-L 5 ($P>0.05$, Figure 1a). The predictive capability of the 10MWT for the data of the 6MinWT was 55 and 68% for subjects with FIM-L 6 and 7, respectively.

The findings extended those of van Hedel *et al*.[6] who found that the data of the 10MWT had good to excellent correlation with the 6MinWT in subjects with SCI who had either poor or good walking ability ($\rho = -0.92$ to -0.96). The different findings may relate to the criteria used to classify levels of ability of the subjects. van Hedel *et al*.[6] categorized the ability of the subjects using criteria from the WISCI II, including (1) those who scored less than or equal to 10 ($n=15$) and those with a score between 11 and 20 ($n=47$), and (2) dependent walkers (WISCI II scores = 0–8, 10, 11, 14, 17, $n=19$) and independent walkers (WISCI II scores = 9, 12, 13, 15, 16, 18–20, $n=43$).[6] Nevertheless, the WISCI II scores consider the ability of walking at least 10 m, and thus the similar ranking scores might include subjects with a wide range of walking abilities (distance). Indeed, subjects with low walking ability in van Hedel *et al*.[6] could walk at a speed of approximately 0.05–0.67 m s^{-1} and could cover approximately 23–410 m in 6 min. Such variability of walking may allow excellent correlation between the two tests in the subjects.

In contrast, the present study adopted criteria from the FIM-L scores to categorize subjects into the groups with similar levels of walking ability, including the ability to walk a short distance (<50 m) with or without a walking device (FIM-L 5), walk a long distance (at least 50 m) with a walking device (FIM-L 6) and walk a long distance (at least 50 m) without a walking device (FIM-L 7).[4] By using such criteria, levels of walking ability of the subjects showed statistical and clinical significance among the groups ($P<0.001$, 10MWT > 0.13 m s^{-1} and 6MinWT > 45.8 m, Table 1).[19]

The different correlation in each group (FIM-L 5–7) may relate to the requirement of a walking device and to the level of ability of the subjects. Walking with a walking device puts a considerable demand on the upper extremities and energy expenditure, and this impact is greater on a long walking test (6MinWT) than a short distance test (10MWT).[7,20] As a result, the correlation and the predictive ability of the 10MWT for the 6MinWT in subjects with FIM-L 6 were lower than those with FIM-L 7 (Figures 1b and c).

FIM-L 5 implies that the subjects could walk for only a short distance or had minimal functional endurance because of having either a high degree of lesion severity or being just at the start of walking. Such characteristics may limit their ability to perform a more challenging task of a long walking test (6MinWT) than a short walking test (10MWT). Thus, the correlation between the tests was lowest in these subjects (Figure 1a). Furthermore, the obvious limited ability of walking (0.1–0.3 m s^{-1} on the 10MWT and 20 m-50 m on the 6MinWT, Table 1 and Figure 1a) reduced the variability of the data, which inevitability decreased the correlation between the two tests.

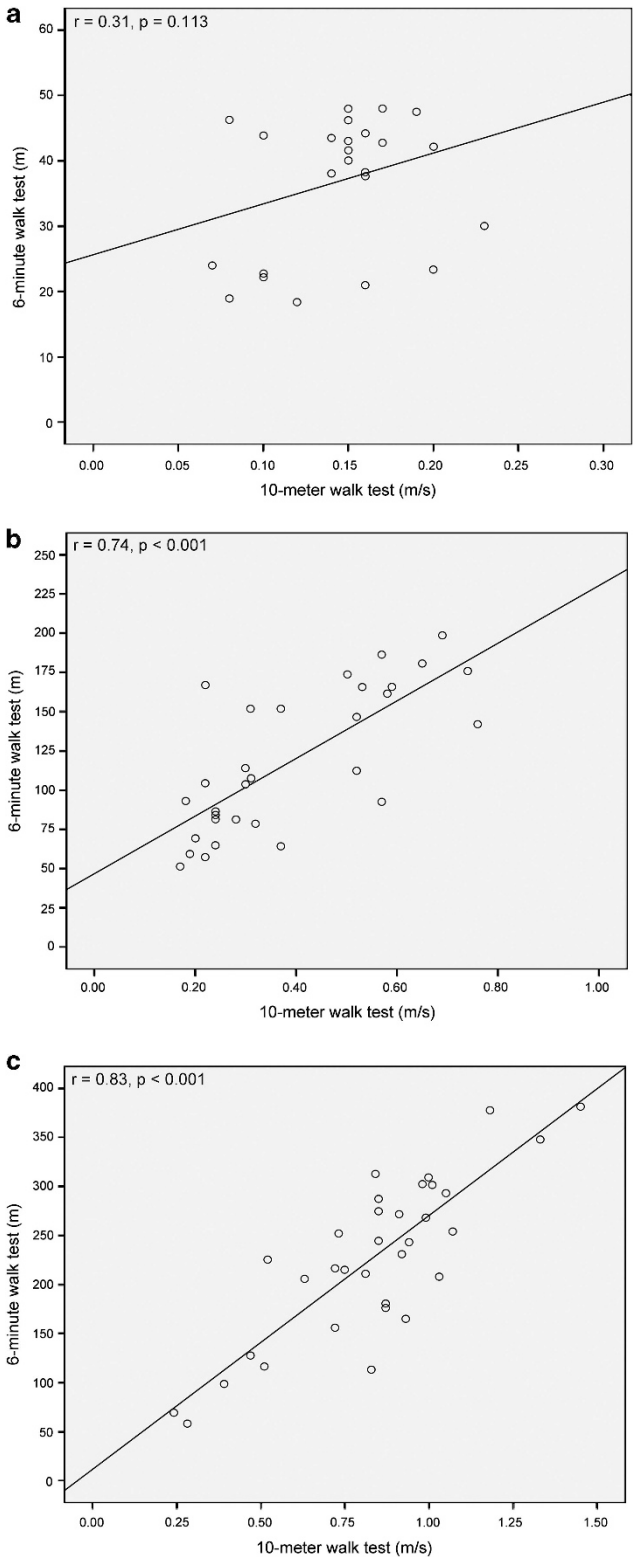

Figure 1 Correlation between the data of the 6-minute walk test and the 10-meter walk test. (**a**) For subjects with FIM-L 5. (**b**) For subjects with FIM-L 6. (**c**) For subjects with FIM-L 7. FIM-L = functional independence measure locomotor.

Findings of the present study confirm the concurrent validity of the 10MWT as compared with the 6MinWT, but only for patients with rather good walking ability. Therefore, with the limitation of time and

area for the test, the 10MWT can be used as an alternative tool to the 6MinWT to monitor functional alteration in these individuals.

However, there are some noteworthy limitations of the study. First, the rather low predictive ability (55 and 68% for subjects with FIM-L 6 and 7, respectively) may suggest the high possibility of data mismatch between the two tests, and the 6MinWT may be needed if the distance covered in 6 min is required. In addition, the low predictive ability may suggest effects of other factors influencing the data transformation, which is beyond the scope of this study. Second, the 10MWT was measured over a 10-m walkway and the time was recorded over 4 m in the middle of the walkway because of area limitation. Graham *et al.*[8] reviewed 108 studies that measured walking speed in clinical research and found that the speed was mostly recorded during 4-, 6- and 10-m distances. Finch *et al.*[15] indicate that acceleration and deceleration periods of walking take up to 3 m in order to obtain a rhythmic phase. Therefore, this study allowed 3 m before and after the timing period and recorded the time over the 4 m in the middle of the 10-m walkway. Data of our colleagues suggest that this method is valid and reliable to use in ambulatory subjects with SCI.[2,7] Finally, the researchers realize that the 6MinWT should be administered along a large rectangular walkway in order to reduce the number of turns, which has a high impact on walking speed and total distance covered after 6 min. However, the protocol was conducted in a rehabilitation ward and in subjects' houses to increase the number of subject participation. After surveying for subject availability, the 6MinWT was executed using a 6-m by 4-m rectangular walkway in order to offer a similar testing area among the subjects. Nevertheless, using this size might affect the association between the tests and data comparison with other studies.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

This study was supported by funding from the Improvement of Physical Performance and Quality of Life (IPQ) research group, and Khon Kaen University. The researchers sincerely thank Mr Ian Thomas for his contribution in preparing the manuscript.

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