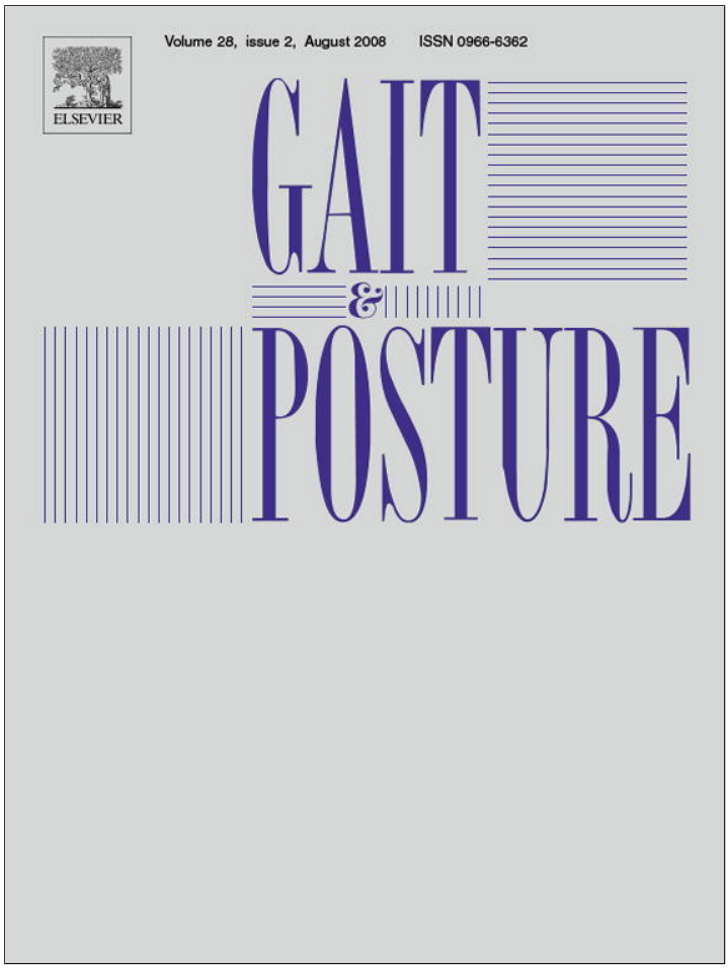

Available online at www.sciencedirect.com
ScienceDirect
Gait & Posture 28 (2008) 343–346
www.elsevier.com/locate/gaitpost

Technical note

The reliability of physical performance measures in peripheral neuropathy

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Received 2 March 2007; received in revised form 31 December 2007; accepted 20 January 2008

Abstract

The purpose of this study was to evaluate the test–retest reliability of select physical performance measures among people with peripheral neuropathy (PN).

Methods: 20 PN patients (12 women, 8 men, mean age = 68.4 ± 12.5 years) were assessed on two separate occasions. Plantar pressure sensitivity was determined with a monofilament of known strength. Functional capacity and mobility were measured by the 6-min walk (6MW) and timed up-and-go (TUG) tests, respectively. Standing balance was evaluated by computing the average velocity (VEL) and area enclosing 95% of the body COP (A95) while participants stood quietly with eyes closed for multiple trials of varying length. Isokinetic knee extensor and flexor peak torque (KEPT, KFPT) were measured with an dynamometer during five maximal voluntary contractions.

Results: Plantar sensitivity and all measures of physical function demonstrated significant reliability. High reliability was observed for the 6MW (ICC = 0.94) and the two-trial average TUG (ICC = 0.99). Similarly, KEPT and KFPT were highly reliable whether using the top trial, or averaging the three best trials (ICCs > 0.96). Averaging multiple standing balance trials generally increased ICC values, with 30 s trials appearing to possess the highest reliability.

Discussion: Despite the heterogeneity of the PN population, select measures of physical performance are highly reliable and therefore recommended for use when examining physical function in these patients.

Published by Elsevier B.V.

Keywords: Balance; Biomechanics; Locomotion; Neuropathy; Reliability

1. Introduction

Peripheral neuropathy (PN) affects 20 million Americans [1], thus outnumbering well-known diseases including diabetes (17–18 million), coronary heart disease (13.2 million), and asthma (15 million) [2]. Although over 100 causes have been identified, PN most frequently develops secondary to diabetes mellitus. In fact, nearly one-third of all diabetes patients suffer from this comorbid condition [1].

PN refers to damage or disorder of the peripheral nervous system [3], and chronic sensorimotor neuropathy accounts for over 85% of documented cases [4]. Initial symmetrical sensory nerve damage to the distal extremities usually progresses proximally. In advanced cases, motor involvement and small muscle wasting has been documented [3]. PN is associated with reduced functional independence [4] and life-altering complications including foot ulceration [5] and falls [6]. There is a resulting need to examine the physical consequences of PN, along with interventions aimed at alleviating symptoms, reducing risk of associated complications, and maintaining function [1].

A necessary step in conducting this research is identifying reliable assessments of both peripheral sensitivity and physical performance. The purpose of this study was therefore to examine this issue concerning sensitivity, strength, balance, and mobility assessments in all-cause PN. Physical tests were chosen based on common employment in physical evaluations of aging and pathological populations [7–9]. Following determination of reliability, comparison between populations will allow elucidation of the identifying characteristics of the PN population.

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0966-6362/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.gaitpost.2008.01.004

2. Methods

2.1. Participants

Participants with all-cause, physician-diagnosed PN were recruited (12 women, 8 men, age = 68.4 ± 12.5 years, height = 169.7 ± 9.6 cm, body mass = 83.5 ± 24.2 kg). Inclusion criteria were the ability to ambulate with or without assistance and understand instructions. All participants obtained physician approval and provided written consent as approved by the Itramural Review Board at the LSouisisan State University and in comply with the principles laid down in the Declaration of Helsinki (IRB #: 2434).

2.2. Procedures

Age, height, body mass, cause and duration of PN from diagnosis were recorded. Participants were evaluated in tests of sensitivity, strength, balance, and mobility. The tests were repeated 7 days later by the same researcher at the same time of day. Adequate rest was given throughout all testing.

2.3. Plantar pressure sensitivity

Participants were seated with eyes-closed and right leg supported while sensitivity was assessed with a 5.07 gauge Semmes–Weinstein monofilament (North Coast Medical Inc.). Testing sites (heel, mid-sole, bases of first/fifth metatarsals, hallux [10]) were tested three times in random order. A score of "1" was given when a "yes" response accompanied the detected pressure, whereas no response was given a score of "0." The one-trial method consisted of adding the scores of the first trial for all five sites. The three-trial method consisted of reassigning a "1" to those sites that received a combined score of ≥2 over three trials and a "0" to those sites with a combined score of <2. The assigned scores were then added to produce an overall sensitivity score ranging from 0 to 5.

2.4. Knee flexor/extensor strength

Knee extensor (KEPT) and flexor peak torque (KFPT) were measured at 60°/s with a Biodex dynamometer (Biodex Medical, Shirley, NY). Warm-up consisted of five reciprocal knee extension/flexion movements. Participants were instructed to increase force with each trial so as to generate maximal force during the fifth trial. Following rest, five maximal trials were completed with 10 s rest between trials. Verbal encouragement was provided to facilitate maximal values. For the five extension/flexion movements, peak torque (N m) from the best trial was recorded. Additionally, peak torque from the three best trials was recorded and averaged.

2.5. Standing balance

AccuSway (AMTI, Watertown, MS) was used to record center-of-pressure (COP) during eye-closed stance. Participants stood with arms at side, heels 5 cm apart, and feet abducted 10°. Three 5 s and three 30 s trials were completed in random order with 1-min

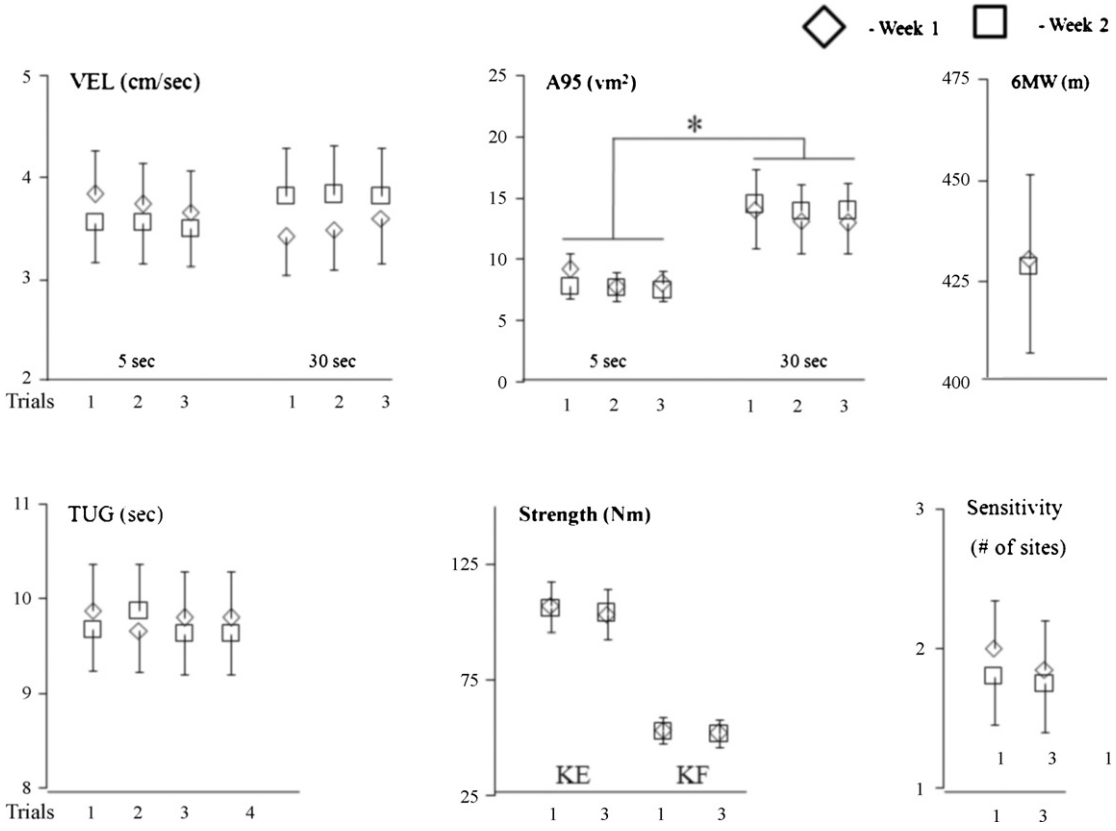

Fig. 1. Mean (±S.E.) scores for plantar pressure sensitivity and each physical performance assessment by testing session. Trial numbers given below the *x*-axes indicate the number of trials averaged to produce each respective mean. *Indicates significant difference at $p < 0.05$.

rest between trials. The average velocity (VEL) of the COP, and the area of an ellipse enclosing 95% of the COP (A95) was recorded.

2.6. 6-min walk (6MW)

Cones were placed 30 m apart along a lighted hallway. Participants were instructed to walk as far as possible in 6-min by walking back and forth around the cones [11]. Distance covered to the nearest meter was recorded.

2.7. Timed up-and-go (TUG)

The participant was seated with back against a chair and feet on the floor with a cone 3 m in front of the chair. Instructions were to stand up using arm rests if needed, walk around the cone, and sit with back against the back of the chair. The timer was started on the word "go," and stopped when the participant's back touched the back of the chair. The time to complete each of six trials was recorded [12].

2.8. Data analysis

Performance differences by session were tested using student's *t*-test. Several methods have been employed to examine test–retest reliability [13]. Intraclass correlation coefficients (ICC) (model 1.1) [14] were chosen to examine the consistency of participant performance across testing sessions as measured by a single rater. 95% confidence intervals of ICCs were also computed. ICC values below 0.60 where considered poor and above 0.80 as high reliability [14].

3. Results

Causes of PN included diabetes ($n = 3$), chemotherapy ($n = 2$), and trauma ($n = 2$). The remaining participants had unknown-cause PN. Duration of PN was 4.6 ± 3.0 (mean $\pm$ S.E.) years. Testing results are presented in Fig. 1. No significant testing session differences were observed. However, A95 obtained from 30 s trials was greater than that of the 5 s trials ($p = 0.02$).

ICCs and 95% confidence intervals are presented in Table 1 ($p < 0.001$ for all ICCs). The ICC value of the three-trial sensitivity method (0.96, 95% CI: 0.94–0.98) was greater than that of the one-trial method (0.90). In a similar manner, averaging the three best trials produced greater ICC values than using only the top trial for both KEPT/KFPT. For balance, averaging three 30 s trials produced the highest ICC values for both VEL and A95. The 6MW possessed high reliability, and ICC values produced by averaging two or more TUG trials were greater than using one-trial (0.93).

Table 1
Test–retest reliability of selected tests

	Duration (s)	Number of trials	ICC	95% CI (lower–upper)
Sensitivity	–	1	0.90	0.78–0.96
	–	3*	0.96	0.94–0.98
KEPT	–	Top trial*	0.97	0.96–0.99
	–	Three-trial average*	0.98	0.98–0.99
KFPT	–	Top trial*	0.97	0.95–0.98
	–	Three-trial average*	0.99	0.98–0.99
VEL	5	1	0.67	0.33–0.86
	5	2	0.83	0.62–0.93
	5	3	0.84	0.63–0.93
	30	1	0.89	0.74–0.96
	30	2	0.94	0.84–0.98
	30	3*	0.98	0.96–0.99
A95	5	1	0.65	0.28–0.85
	5	2	0.76	0.48–0.90
	5	3	0.80	0.56–0.92
	30	1	0.86	0.68–0.94
	30	2	0.86	0.68–0.94
	30	3*	0.91	0.77–0.96
6MW	–	1*	0.94	0.90–0.98
TUG	–	1	0.93	0.86–0.96
	–	2*	0.99	0.98–0.99
	–	4	0.99	0.99–0.99
	–	6	0.97	0.94–0.99

* Indicates the recommended protocol for plantar sensitivity assessment and variables associated with each physical performance assessment in the all-cause PN population. Recommendations were based on the protocol that produced the highest ICC values. If two protocols possessed similar reliability, the protocol calling for the least number of trials was chosen.

4. Discussion

Measures of sensitivity and physical performance were highly reliable for ambulatory, community dwelling PN patients. Additionally, protocols optimizing test–retest reliability were identified (Table 1). Reliability of included physical assessments generally matched that of other populations. The higher ICC values for the 6MW and TUG tests (ICC > 0.90) were unexpected. Rockwood et al. [8] reported moderate reliability of TUG scores in community dwelling older adults (ICC = 0.56). As opposed to the current study, however, tests were administered by different raters at different times of day. While the present study thus supports the reliability of these variables, generalization of results may be limited to relatively high-functioning individuals.

A95 was greater during 30 s trials (Fig. 1) due to increased chances of the COP trajectory covering greater area during longer trials. Although longer trials increased reliability, benefits gained from conducting even longer trials would likely not outweigh costs of time and potential fatigue-induced variability. Although learning effects of 6MW across repeat trials has been reported [15], the test–retest sample means and standard errors were virtually identical (Fig. 1).

In conclusion, the tests of plantar pressure sensitivity, knee strength, standing posture, and functional mobility are highly reliable outcome measures for all-cause PN patients. With reliability established, research can focus on delineat-

ing the physical effects of PN, with the ultimate goal of using these measures as evaluation and diagnostic tools.

Acknowledgements

This project was assisted by a graduate fellowship from Life Course and Aging Center to BM; and LA-STEM undergraduate fellowship to AD.

Conflict of interest

None.

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