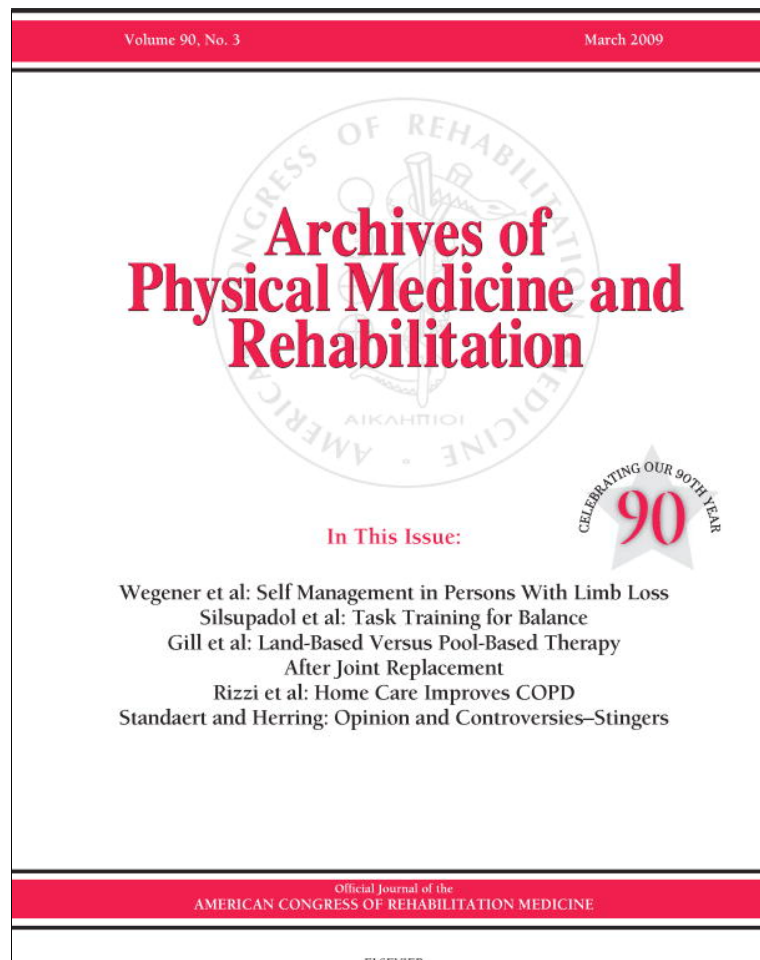


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ORIGINAL ARTICLE

Use of the Continuous Scale Physical Functional Performance Test in Stroke Survivors

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ABSTRACT. Manns PJ, Tomczak CR, Jelani A, Cress ME, Haennel R. Use of the continuous scale physical functional performance test in stroke survivors. *Arch Phys Med Rehabil* 2009;90:488-93.

Objective: To (1) determine the feasibility of the continuous scale physical functional performance 10-item test (CS-PFP10) for the measurement of physical function in stroke survivors, (2) characterize physical functional performance of stroke survivors and their matched controls, and (3) explore the associations among physical functional performance, ambulatory activity, and peak oxygen uptake (VO_2 peak).

Design: Case control.

Setting: University research setting.

Participants: Ten participants with stroke and 10 healthy controls matched for age, sex, and physical activity.

Interventions: Not applicable.

Main Outcome Measures: The CS-PFP10 test was used to measure functional ability. The test requires performance of 10 serial tasks that range from low to high difficulty. The step activity monitor was used to measure absolute ambulatory activity and was reported as the average number of steps a day over a 4-day period. VO_2 peak was determined using a metabolic cart and a recumbent cycle ergometer.

Results: Stroke survivors scored lower than healthy controls on all individual tasks, domains, and the total score on the CS-PFP10. Higher VO_2 peak was associated with higher total scores on the CS-PFP10 in both stroke survivors and controls. In stroke survivors, lower levels of impairment (as indicated by the Chedoke-McMaster stroke assessment) were associated with higher total CS-PFP10 scores.

Conclusions: The CS-PFP10 is a measure of physical performance that is feasible to use with ambulatory participants with stroke. Future investigations with people with stroke should explore the ability of the CS-PFP10 to provide meaningful information about change in CS-PFP10 subscales with interventions that target items on the subscales, such as balance or upper extremity strength.

Key Words: Activities of daily living; Rehabilitation; Stroke; Walking; Outcome assessment.

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EPIDEMIOLOGIC STUDIES SHOW that 40% of stroke survivors experience long-term disability, as measured by the Rankin Scale.¹ More specifically, most stroke survivors report difficulty in completing activities of daily living tasks such as light housework, meal preparation, and shopping.^{2,3} Stroke survivors have low cardiovascular fitness⁴ and ambulatory activity levels,⁵ both of which may contribute to challenges in activities of daily living.

Cardiovascular fitness may be measured by peak or submaximal exercise tests. In stroke survivors, peak aerobic power (VO_2 peak) is associated with cardiovascular endurance as measured by the six-minute walk test,^{6,7} and activity limitations such as balance.⁶ Ambulatory activity has been measured with stroke survivors using a Step Activity Monitor^{5,8,9} and a pedometer.¹⁰ Greater ambulatory activity (steps a day) is associated with higher VO_2 peak,^{5,10} better balance,⁸ and greater motor subscale scores on the FIM.⁹ However, the associations among VO_2 peak, ambulatory activity, and a comprehensive performance measure of activities of daily living in stroke survivors are not known.

To explore those associations, an appropriate measure of activities of daily living is required. The CS-PFP10¹¹ measures the ability to perform 10 everyday activities. The CS-PFP10 was originally developed and validated for use with older community-dwelling adults¹² and has since been used with individuals with heart disease¹³ and people with Parkinson disease.¹⁴ The CS-PFP10 has not been used previously with people with stroke. However, it has been used fully and safely with a group of nonagenarians,¹⁵ individuals who may have similar physical capacity as stroke survivors. The CS-PFP10 has the advantage of the measurement of serial tasks, provision of subscale and total scores on a continuous score, and the absence of ceiling and floor effects.^{12,14,15}

The purposes of this study were therefore to (1) determine the feasibility of the CS-PFP10 for the measurement of physical function in stroke survivors, (2) characterize physical functional performance of stroke survivors and their matched controls using the CS-PFP10, and (3) explore the associations among physical functional performance, ambulatory activity, and VO_2 peak.

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List of Abbreviations

CI	confidence interval
CMSA	Chedoke McMaster stroke assessment
CS-PFP10	continuous scale physical functional performance 10-item test
VO_2 peak	peak oxygen uptake
SAM	step activity monitor

METHODS

Study Participants

Ten participants with hemiparetic stroke and 10 healthy controls matched for age, sex, and physical activity were enrolled. Subjects in the stroke group were medically stable and were recruited from community-based stroke rehabilitation programs and an exercise center for people with disabilities. Subjects in the control group were recruited through advertisement at the University of Alberta. Exclusion criteria for this investigation were documented heart failure, unstable angina, stroke less than 6 months prior, a positive (peak exercise) stress test during day 1 of testing, comorbidities precluding cycle ergometry exercise testing, inability to walk greater than 10m with or without a walking aid, or the inability to provide written and informed consent. Self-reported physical activity status was matched between groups within 1 day/week and was determined using a questionnaire¹⁶ in the participants with stroke, and by self-report for the control participants. This investigation was approved by the Research Ethics Board at the University of Alberta, and all participants provided written and informed consent.

Procedures

Participants were tested on 2 separate days, at least 2 days apart. Testing on day 1 consisted of questionnaires (health history, physical activity), and measurement of participant characteristics (height, weight, gait speed, use of walking aids, impairment). For the stroke survivors, impairment was measured by a physical therapist using the CMSA.¹⁷ The CMSA stages of recovery are scored separately for the arm, hand, leg, and foot on a scale of 1 (no recovery) to 7 (normal movement).¹⁷ A graded exercise test (for measurement of VO_2peak) and set up and accuracy checks for the step activity monitors were also completed on day 1. On the second day of testing,

participants completed the physical functional performance (CS-PFP10) test battery.

Physical Functional Performance

Physical functional capacity in 5 domains (upper-body strength, lower-body strength, upper-body flexibility, balance and coordination, and endurance) was measured using the short version of the CS-PFP10.¹¹ The CS-PFP10 uses a 10-task test battery that includes everyday tasks such as donning and doffing a jacket, getting up and down off the floor, and carrying a pot. Table 1 shows a full list of tasks. Eight tasks are scored according to the time taken. For 2 of those timed tasks, carrying a pot and carrying groceries, weight (participant-selected) is additionally measured. Two tasks, overhead reaching and distance walked in 6 minutes, are scored by distance. Participants were allowed to use a walking aid during the CS-PFP10 testing.

The CS-PFP10 takes 30 to 40 minutes to complete and is a valid and reliable performance measure that is responsive to changes with an intervention in healthy older adults.¹¹ The long version of the CS-PFP (16 tasks)¹² has been validated for use with persons with cardiovascular disease¹³ and Parkinson disease^{14,18} but has not previously been used with persons with stroke. The CS-PFP10 provides a score on each of the 5 domains, as well as a total score. CS-PFP10 testing and scoring was carried out according to set specifications¹⁹ by trained personnel. Training for the tester was completed at the University of Georgia with the developer of the test. A scoring algorithm was used to calculate each domain score, with a maximum score of 100.

Ambulatory Activity

Ambulatory physical activity was measured for 4 days using the SAM.^{20,a} The SAM uses an accelerometer to determine number of strides a day, and can also measure pattern and

Table 1: CS-PFP10 Scores for Stroke Survivors and Controls

	Stroke Survivors	Controls	CS-PFP10 Task Ranges
	Mean \pm SD	Mean \pm SD	Minimum–Maximum ²⁸
Individual tasks			
Pan carry (s)	7.0 \pm 2.0	3.2 \pm 0.9	3.5–9
Pan carry (kg)	7.6 \pm 3.2	19.7 \pm 6.1	3.2–29.5
Jacket (s)	32.3 \pm 14.7	9.9 \pm 2.2	10–60
Reach (ratio to body height)	1.26 \pm 0.03	1.32 \pm 0.03	1.15–1.40
Floor sweep (s)	66.3 \pm 38.3	20.1 \pm 4.4	15–75
Laundry 1 (s)	43.9 \pm 12.9	19.1 \pm 5.1	18–60
Laundry 2 (s)	28.8 \pm 10.2	13.2 \pm 4.6	12–50
Scarves (s)	18.3 \pm 9.2	4.3 \pm 1.4	2.5–10
Grocery (s)	146.1 \pm 66.2	48.4 \pm 4.8	36.0–178.2
Grocery (kg)	5.8 \pm 2.8	22.9 \pm 7.7	2.3–29.5
Up and down off floor (s)	22.6 \pm 26.5	5.5 \pm 2.1	5–50
Stairs (s)	20.1 \pm 8.0	4.8 \pm 1.1	3.0–9.0
Walk (m)	263.3 \pm 111.9	625.8 \pm 75.8	162.2–859.8
Domain scores			
Upper-body strength	20.0 \pm 10.4	75.9 \pm 15.8	NA
Upper-body flexibility	34.6 \pm 13.1	79.3 \pm 8.2	NA
Lower-body strength	12.8 \pm 7.1	71.6 \pm 16.6	NA
Balance and coordination	14.9 \pm 8.2	75.4 \pm 14.2	NA
Endurance	15.6 \pm 8.7	76.4 \pm 13.6	NA
Total score	16.5 \pm 8.3	75.2 \pm 13.5	NA

NOTE: Data are expressed as means \pm SDs. Significant difference between all individual and domain scores, and the total score between stroke survivors and controls. Abbreviation: NA, not applicable.

intensity of activity. These monitors are accurate and reliable in the measurement of ambulatory ability in people with stroke.²¹ Evidence from the accelerometry literature states that 4 days of measurement provides a reliable measure of activity.^{22,23}

An accuracy check of each SAM took place before providing the device to each participant. Using the SAM software, the monitor was set to the participant's height, typical walking speed (ie, slow, normal, fast), and leg motion (ie, dynamic/fidgety, normal, gentle/geriatric). The participants walked for 30 seconds at a comfortable gait speed, and an observer used a manual step counter to count strides taken during that time. The manual count was compared with the count from SAM (red light flashing when step counted), and 95% accuracy was achieved on the first calibration trial with all participants.

Participants with stroke wore the SAM on the ankle of the unaffected leg,²⁴ control participants on the right ankle. They were instructed to wear the SAM from the time of rising in the morning until the time they went to bed at night, excluding time spent bathing or participating in water activities. Oral and written instructions were provided to the participants regarding proper SAM placement and wearing schedule.

After retrieval, SAM information was downloaded via a universal serial bus port and visually inspected with the participant for anomalies (for example, seeking confirmation of periods of activity or inactivity, such as, "What were you doing at about 6 PM?"). The SAM file identified each of 1440 minutes in the day, as well as the number of strides taken in each of those minutes. An algorithm was written using MatLab^b to allow calculation of absolute daily activity (summation of number of strides, in all non-0 or non-1 cells). We chose not to include cells with 1 step as we felt that cell did not represent activity. SAM data are presented as strides and were multiplied by 2 to represent steps. Results are presented as steps a day, averaged over 4 days.

Peak Oxygen Uptake

All participants completed a peak exercise test (VO_2peak) on a custom modified recumbent (112° angle at the waist) cycle ergometer.^c For the stroke group, exercise began with cycling at 15W for 1 minute, with 10-W increments every minute thereafter. The stroke participants wore their ankle-foot orthosis at their discretion, and the foot or orthosis was secured to the ergometer pedal during the exercise test. For the control group, exercise began with cycling at 25W for 1 minute with 15-W increments every minute thereafter. Participants were instructed to maintain a cycling cadence of 50 to 60 revolutions a minute. Exercise testing was terminated when the subject reached volitional fatigue, when a cycling cadence of 50 revolutions a minute could not be maintained, or when signs of exertional intolerance were observed.²⁵

Pulmonary gas exchange and ventilation parameters were recorded continuously during peak exercise testing using a commercially available metabolic system.^d Prior to testing, the paramagnetic O_2 and infrared CO_2 gas analyzers were calibrated with known gas concentrations and the pneumotachograph flow meter calibrated with a 3.0-L syringe across a range of expected breathing frequencies. Participants breathed through a 2-way rebreathing low-resistance flow valve^e that was fastened to the participant's head and connected with tubing to a heated pneumotachograph flow meter^e and baffled mixing chamber. VO_2peak was defined as the highest 30-second average. A 12-lead electrocardiogram was monitored throughout the test and brachial cuff blood pressure monitored every 2 minutes. A physician supervised all tests.

Data Analysis

Descriptive statistics with means, SDs, and percentages were used to describe participant characteristics. Independent *t* tests were used to determine the differences between the stroke and control subjects on the primary variables. Pearson correlation coefficients were used to assess the relationship among the primary variables of physical functional performance, absolute ambulatory activity, and VO_2peak . Additionally, a Spearman correlation analysis was used to examine the association between impairment and physical functional performance.

RESULTS

Ten stroke survivors and 10 controls completed all testing. Detailed demographic and VO_2 exercise test findings in this cohort have been reported.²⁶ Briefly, the control participants matched for sex (4 men, 6 women) and age (54 ± 10 vs 54 ± 11 y) were not different from the stroke survivors on any of the demographic variables, including height (168 ± 7 vs 170 ± 8 cm) and weight (74 ± 11 vs 82 ± 17 kg). Six stroke survivors were medicated for high blood pressure. Other comorbidities in stroke survivors included chronic obstructive pulmonary disease (1 participant) and type II diabetes (1 participant). Three participants took β -blockers, which were withheld for all exercise testing. None of the control participants were taking cardiovascular or pulmonary-related medications. Physical activity frequency did not differ between the 2 groups. Characteristics of stroke survivors on gait and impairment outcomes are reported in table 2.

The CS-PFP10 scores were significantly lower for stroke survivors on all individual tasks, the domain scores, and the total score (see table 1). Participants with 1 nonfunctional upper extremity ($N=6$, defined as stage of recovery score on CMSA for arm of 3 or less) scored significantly lower on the CS-PFP10 than those participants who used both upper extremities for functional activities (11.1 ± 5.3 vs 24.7 ± 3.5 ; $P=.002$). Three of the 4 individuals with 2 functional upper extremities were also men. Three of the stroke participants were not able to get up and down off the floor and thus scored 0 on that item. Otherwise, all participants were able to complete all tasks. The stroke survivors had a significantly lower VO_2peak (16 ± 4 vs

Table 2: Characteristics of the Stroke Survivors

	Stroke (n=10)
Brain lesion side, left:right	6:4
Time since stroke (y)	7.5 ± 8.3
CMSA	
Leg score	4.7 ± 1.7
Median (range)	5 (2-7)
Arm score	3.6 ± 2.2
Median (range)	3 (1-6)
Functional upper extremity, n (%)	4 (40)
Gait speed (m/min)	43 ± 16
Range (m/min)	21-72
Ankle-foot orthosis, n (%)	6 (60)
Walking aid	
None, n (%)	1 (10)
Single point cane, n (%)	6 (60)
Quad cane, n (%)	3 (30)

NOTE: Data are expressed as means \pm SDs unless otherwise specified. Possible scores on the CMSA range from 1 to 7 with a score of 1 indicating no movement, scores of 3 or less indicating movement primarily in synergy, and a score of 7 representing normal movement.

Table 3: Pearson Correlational Analysis Among CS-PFP10 and Fitness and Activity Measures

	CS-PFP10 Total	Vo ₂ peak	Steps a Day
Stroke			
Vo ₂ peak	0.755 (.012)*		
Steps a day	0.497 (.144)	0.253 (.481)	
Impairment	0.667 (.040)*	0.300 (.433)	0.500 (.170)
Control			
Vo ₂ peak	0.747 (.013)*		
Steps a day	0.168 (.642)	0.341 (.335)	

NOTE: R values (P values).

*Significant correlations.

28±6mL/kg/min) than the controls (P<.001). Absolute ambulatory activity in steps a day was lower in stroke survivors (7379±3107 steps) than in the controls (14730±4522 steps; P<.001).

In the stroke survivors, of the fitness and activity measures, only Vo₂peak demonstrated a significant association with the total score on the CS-PFP10 (table 3; fig 1). The association between CS-PFP10 total score and absolute ambulatory activity was not significant (r=0.497; P=.144). Impairment, as measured by the CMSA (aggregate arm, hand, leg, foot score), was negatively associated with the CS-PFP10 total score, but was not associated with Vo₂peak or ambulatory activity. In the control participants, a higher Vo₂peak was associated with higher CS-PFP10 scores.

DISCUSSION

This study is the first, to our knowledge, to use the CS-PFP10 to measure physical functional performance in stroke survivors. Unlike other measures of functional ability, the measure requires the completion of tasks in a serial fashion, as

participants may do in their everyday activities.¹¹ This measure provides a score on a continuous scale and captures effort of activity by recording weight carried and time required to complete a task. We showed that the CS-PFP10 can be used successfully to assess function with individuals with stroke. We did not find a floor effect with the test even though 6 of the 10 participants were unable to use 1 upper extremity in functional tasks. Following the standard protocol, participants are allowed to complete the tasks using whatever strategy was successful for them (ie, use of a cane, carrying groceries in bag looped over shoulder while using cane, 1-handed sweeping with dust pan anchored against foot). As such, the CS-PFP10 measures performance rather than capacity to complete activities as described by the *International Classification of Functioning and Health*.²⁷ The scores for our participants were lower than our controls, people with Parkinson disease,^{14,18} or people with coronary heart disease,^{13,28} but comparable to those of nonagenarians.¹⁵

All of our stroke participants scored below a previously established independence threshold of 57 (CI, 47.8–58.6) on the CS-PFP total score, where there is an increased probability of dependence below the threshold.²⁹ Further, all but 1 had Vo₂peak scores below the cutoff for physical independence (20.1mL/kg/min; CI, 17.3–22.9) as suggested by Cress and Meyer.²⁹ Our sample of stroke survivors were for the most part (technically) independent with the tasks on the CS-PFP10; however, those tasks took longer to complete. Increased time to complete functional activities may reduce the amount of discretionary energy expenditure available for tasks related to participation in life activities and quality of life. Half of the stroke survivors lived alone, all lived in the community, and all had varying amounts of support from family and friends, primarily support for transportation and heavier household tasks. One participant received assistance from home care for morning dressing and bathing activities. Clearly, the stroke

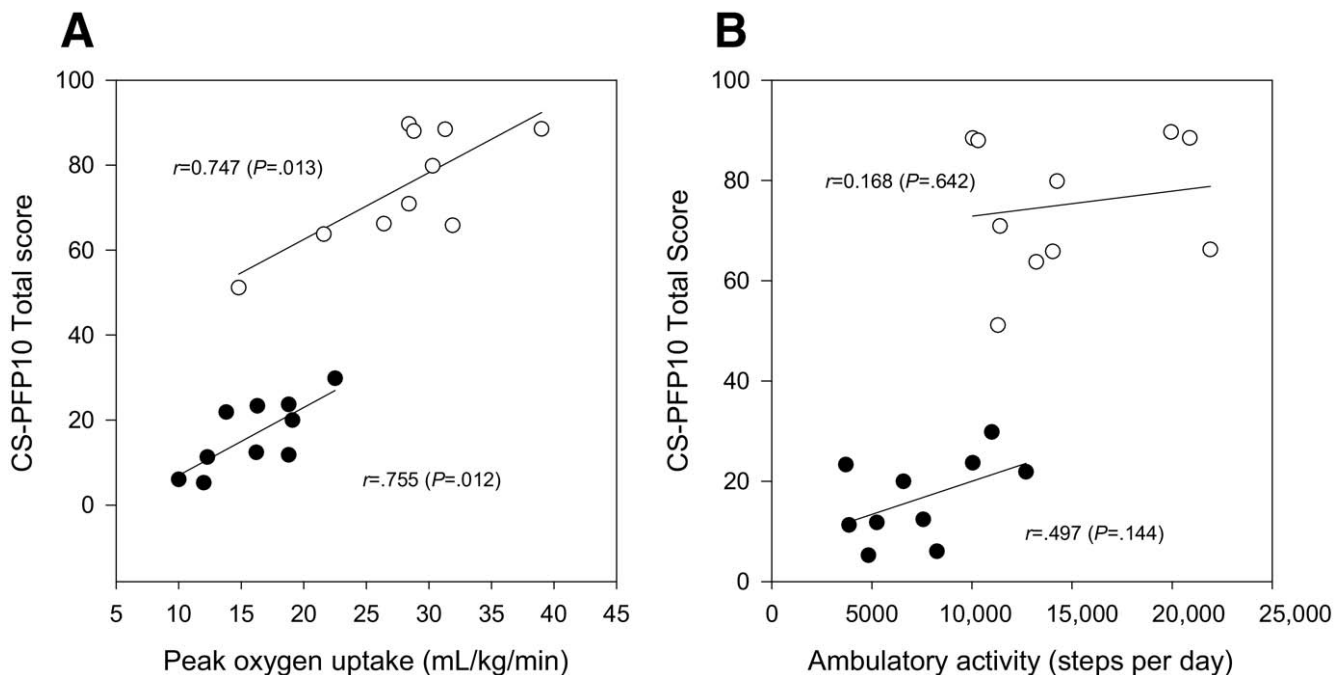


Fig 1. Scatterplots of physical functional performance (CS-PFP10) total scores, Vo₂peak (A), and absolute ambulatory activity (B). Closed circles, stroke survivors; open circles, control participants.

survivors in this study modified their activities or had social support to allow them to complete everyday tasks, as indicated by a score of less than 57 on the CS-PFP10.²⁹

The domain and total scores on the CS-PFP10 are calculated using lower and upper time and weight limits for each task, previously established with older adults¹² (see table 1). Thus, when the stroke participants took longer than the upper limit, or carried less than the lower limit, they scored 1 on that item (out of a maximal score of 100). In particular, stroke participants took longer than the upper time limit for the scarves task (picking up 4 scarves off the floor, 9 of 10 participants over the upper limit of 10 seconds) and the stairs task (ascending and descending 4 stairs, 7 of 10 participants over the upper limit of 9 seconds). However, for most items, stroke survivors scored within the limits established for older adults.¹²

With a larger sample, it may be possible to develop normative data to allow benchmarking of individual physical functional performance scores against established ranges for stroke survivors, perhaps according to functional walking category³⁰ or impairment severity. Because the CS-PFP10 provides subscale scores for upper extremity strength and flexibility and lower extremity strength and balance, it may also be possible to address specific aspects related to those items with an intervention and measure changes in the subscale scores. In our cross-sectional study, participants with 1 nonfunctional upper extremity scored lower on the upper extremity strength subscale (14.9 ± 9.8 vs 27.8 ± 5.5) than those with 2 functional upper extremities, providing preliminary evidence for the ability of the upper extremity strength subscale to provide appropriate information. Further study is required to determine the utility of CS-PFP10 subscale information as an indication of improvement with a targeted intervention.

Association Between Physical Functional Performance and VO_2peak

Greater physical functional performance was associated with higher VO_2peak in stroke survivors. Our observation is not surprising because the associations between CS-PFP10 total scores and VO_2peak have been reported previously.²⁹ In addition, higher VO_2peak levels result in higher discretionary aerobic reserve and are associated with higher CS-PFP10 scores in older adults.³¹ Moreover, the six-minute walk test is a component of CS-PFP10, and positive correlations between the six-minute walk test and VO_2peak have been reported previously in stroke survivors.^{6,7}

Association Between Physical Functional Performance and Ambulatory Activity

In stroke survivors, the association between physical functional performance and ambulatory activity was not significant (see table 3). Our observations enhance the literature by exploring these relationships for the first time in stroke survivors, but the small sample size precludes more than exploration of these relationships. A recent study with older adults reported a significant association between physical activity level, as measured by doubly labeled water, and physical functional performance ($r=0.68$; $P<.001$), as measured by the CS-PFP10.¹⁵ Another study with older adults measured ambulatory activity with a pedometer and reported that participants with low functional ability (CS-PFP10 score <57) walked less than the higher functioning group (5048 vs 9503 steps/d) and reported more modifications in the way that they completed tasks.³² Finally, greater improvement in physical functioning as measured by the Short Physical Performance Battery was reported at 12 months in older adults who had better physical activity adher-

ence and higher activity levels, compared with those with lower levels of physical activity ($<150\text{min/wk}$ vs $>150\text{min/wk}$).^{33,34} The effect of an intervention that focuses on increasing walking activity may have similar effects on functioning in individuals with stroke, but that hypothesis requires further study.

Study Limitations

Our small sample size limits the conclusions that can be made. Moreover, we did not measure strength, which may have provided more insight into the impairments that were contributing to changes in functional ability.³⁵ Our research questions and outcome measures are novel, and the information provided may help generate further research in this area. Future research may help to guide programming for individuals with stroke in terms of appropriate emphasis, fitness versus physical activity. It may be more reasonable and achievable to strive for changes in activity than VO_2peak in persons with mobility impairments, and future studies may test the effect of activity interventions on functional abilities in people with stroke. Future research could also target specific domains to determine whether a walking program, balance program, or upper extremity program affects specific subscales on the CS-PFP10.

CONCLUSIONS

We report CS-PFP10 scores for stroke survivors for the first time. The CS-PFP10 is a measure of physical performance that is feasible to use with ambulatory individuals with stroke. The test did not require any modifications and did not demonstrate any floor or ceiling effects. Higher CS-PFP10 scores were associated with higher VO_2peak , but not ambulatory activity. Nevertheless, improvements in cardiovascular fitness and general activity are increasingly recognized as important for stroke survivors, and the provision of fitness interventions for people with disabilities is a recent point of emphasis for rehabilitation professionals.³⁶ The information provided herein may assist rehabilitation professionals to determine accurately the effects of their interventions on physical functional performance in stroke survivors.

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Suppliers

- a. OrthoCare Innovations, 700 12th St NW, Suite 700, Washington DC 20005.
- b. MatLab, 3 Apple Hill Dr, Natick, MA 01760-2098.
- c. Lode BV, Zernikepark 16, Groningen, 9747 AN, Nederland.
- d. Parvomedics, 8152 S 1715 East, Sandy, UT 84093.
- e. Model 2700; Hans Rudolph Inc, 8325 Cole Pkwy, Shawnee, KS 66227-3128.