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CONCURRENT VALIDITY OF THE CONTINUOUS SCALE-PHYSICAL FUNCTIONAL PERFORMANCE-10 (CS-PFP-10) TEST IN TRANSFEMORAL AMPUTEES

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Abstract

The Continuous Scale-Physical Functional Performance-10 (CS-PFP-10) test consists of 10 standardized daily living tasks that evaluate overall physical functional performance and performance in five individual functional domains: upper body strength (UBS), upper body flexibility (UBF), lower body strength (LBS), balance and coordination (BAL), and endurance (END). This study sought to determine the concurrent validity of the CS-PFP-10 test and its functional domains that involve the lower extremities (LBS, BAL, or END) in comparison to measures that have established validity for use in persons with transfemoral amputation (TFA). Ten TFA patients functioning at K3 or higher (Medicare Functional Classification Level) completed the study. Participants were assessed performing the CS-PFP-10, Amputee Mobility Predictor (AMP), 75 m self-selected walking speed (75 m SSWS) test, timed down stair walking (DN stair time), and the limits of stability (LOS) balance test. Concurrent validity was assessed using correlation analysis. The AMP, 75 m SSWS, LOS, and the DN stair time tests were strongly correlated ($r = \pm 0.76$ to 0.86) with their paired CS-PFP-10 domain score (LBS, BAL, or END) and CS-PFP-10 total score. These findings indicate that the lower limb and balance domains of the CS-PFP-10 are valid measures to assess the physical functional performance of TFA patients.

Keywords

Activities of daily living; Lower extremity amputees; Outcome measures; Physical therapy; Psychometric testing

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INTRODUCTION

There are approximately two million persons presently living with limb loss in the U.S. Of these, approximately 350,000 have transfemoral amputation (TFA) (1). For clinicians, it is often challenging to select appropriate outcome measures to evaluate physical functional performance for persons with lower extremity amputation (LEA). An important consideration for using any outcome measure is to have evidence that the measure has strong psychometric properties for its target population. Psychometric properties include the level of measurement of the outcome data, the validity and reliability of the test, and the test's sensitivity to detect change among different interventions.

The Amputee Mobility Predictor (AMP) is a 21-item test of functional mobility used to predict an LEA patient's ability to ambulate. The AMP was shown to have moderate to strong concurrent validity with the six-minute walk test (6MWT) ($r = 0.69$ to 0.82) and the Amputee Activity Survey ($r = 0.67$ to 0.77) (2). It was also found to have strong test-retest and inter-rater reliability (intraclass correlation coefficients (ICC) = 0.86 to 0.98) (2). Recently, Resnik and Borgia (3) reported a minimal detectable change of 3.4 points for the AMP. This population-specific test is designed to require minimal equipment and approximately 10 to 15 min to administer. While these are all positive attributes, there are limitations to the AMP. For instance, at the item level, the AMP is scored with ordinal ranking. Arguably, this necessitates non-parametric analysis. Additionally, some assessment items on the AMP may be inordinately difficult or easy for different amputees. For example, maintaining single-limb balance for persons with higher level amputation (i.e., hip disarticulation, transfemoral) may be quite difficult, while maintaining seated balance for amputees who function as community ambulators may be quite easy. The AMP is ultimately a test of mobility that includes walking. However, walking distance is actually quite limited within the AMP test (24 to 48 feet). Furthermore, the AMP does not assess activities of daily living (ADL) function, and there is no way to compare amputee values from the AMP test with other diagnostic groups or with non-amputees.

The Continuous Scale-Physical Functional Performance-10 (CS-PFP-10) test measures physical function across a wide range of functional abilities (4). The CS-PFP-10 consists of 10 standardized ADL tasks that evaluate overall physical functional performance and performance in five individual physiologic functional domains: upper body strength (UBS), upper body flexibility (UBF), lower body strength (LBS), balance and coordination (BAL), and endurance (END). A key difference in measuring physical performance in this way is that the test's activities are familiar to participants in terms of their usual activities as opposed to isolated tests that may have seemingly little relevance to participants. Raw data (time, distance, mass) from each task are converted, via an algorithm within licensed scoring software, into a continuously scaled score (0 to 100) for a singular overall performance score

and five individual domain scores. The continuous scaling (ratio level data) allows the use of more precise parametric statistical analyses and provides sensitivity to discriminate small differences with a small number of participants. In a study with healthy elderly, the CS-PFP-10 demonstrated strong psychometric properties (ratio level data/parametric statistical analyses, convergent validity, test-retest reliability, and sensitivity to change) (4). Thus, the CS-PFP-10 meets requirements to recommend its use in clinical and research applications. Furthermore, the CS-PFP-10 has been utilized in multiple diagnostic groups, including frail elderly (4, 5); wheelchair users (6); persons with stroke (7), cardiac disorders (8, 9), and Parkinson's disease (10); and others (11–15). Therefore, performance comparisons against different populations are possible.

Recently, the CS-PFP-10 was utilized to determine significant change differences in functional performance with TFA patients using two different microprocessor knee systems (Genium™ and C-Leg™) (16). This study reported that Genium use significantly improved UBF, BAL, and END domain scores (change difference 7% to 8.4%; effect size 0.28 to 0.45) compared to C-Leg use (16). However, in order to generally recommend use of the CS-PFP-10 as the preferred outcome measure for testing functional performance in TFA patients, additional testing of psychometric properties in this specific population is warranted. This study sought to determine the concurrent validity of the CS-PFP-10 and its domains that involved the lower extremities (LBS, BAL, or END) in comparison to measures of comparable ADL tasks or physiologic measures that have established validity for use in persons with TFA.

METHODS

Subjects

Adult individuals with unilateral TFA were considered for enrollment if they met the following inclusion criteria: had used a microprocessor prosthetic knee (MPK) system for 1 year; had no skin impairments on lower extremities for the previous 90 d; performed ADL tasks independently; and were able to ambulate independently within the home and community at K3 or higher (Medicare Functional Classification Level) (17). TFA subjects used their preferred prostheses with an MPK system and an energy storing and return prosthetic foot. Each participant had their prosthesis evaluated for proper fit, alignment, and function by the study's licensed prosthetist. The study protocol was approved by the University of South Florida's Institutional Review Board, and each study participant provided written informed consent.

Study Design

This was a cross-sectional study to determine concurrent validity (the extent of statistical correlation) of the CS-PFP-10 and its specific physiologic domains that involved the lower extremities (LBS, BAL, or END) in comparison to measures of comparable ADL tasks or physiologic measures that have established validity for use in persons with TFA. Participants were assessed performing the CS-PFP-10, AMP, 75 m self-selected walking speed test (75 m SSWS), down stair walking time (DN stair time), and the limits of stability (LOS) balance test.

CS-PFP-10—The CS-PFP-10 was administered using standardized procedures (i.e., certified test site and test administrators, script dialogue; all reported elsewhere) (4,18). The CS-PFP-10 consists of 10 ADL tasks performed at maximal effort within the person's judgement of safety and comfort. Tasks are performed serially from low to high difficulty. The CS-PFP-10 tasks use time, distance, and weight to evaluate overall physical functional performance and performance in five physiologic functional domains: UBS, UBF, LBS, BAL, and END. Raw data (time, distance, mass) are converted, via an algorithm within licensed scoring software, into a continuously scaled score (0 to 100) for a singular overall total performance score and five individual domain scores. The CS-PFP-10 requires approximately 30 to 40 min to complete. Table 1 provides a description of CS-PFP-10 tasks.

Amputee Mobility Predictor (AMP)—The AMP is a 21-item test of functional mobility used to predict an LEA patient's ability to ambulate and was shown to have moderate to strong concurrent validity with the 6MWT and the Amputee Activity Survey (2). Specific details of each item and test administration of the AMP have been described previously (2). The following is a synopsis of the mobility functions assessed by the AMP (2). Items 1 and 2 test the ability to maintain sitting balance. Items 3 through 7 test the ability to maintain balance while performing tasks of transferring from chair to chair and standing unchallenged. Items 8 through 13 test more challenging standing balance activities. Items 14 through 20 evaluate quality of gait and the ability to negotiate specific obstacles. Item 21 accounts for the use of particular assistive devices. Most AMP items offer three scoring choices: 0 indicates inability to perform the task, 1 indicates minimal level of achievement or that some assistance was required in completing the task, and 2 indicates complete independence or mastery of the task. The AMP test requires approximately 10 to 15 min to administer. The AMP test was administered by the study's licensed physical therapist. The AMP score was used to test for correlations with the CS-PFP-10 total score and the END score.

75 m Self-Selected Walking Speed (75 m SSWS) Test—Walking tests, including the 75 m SSWS test, are accepted measures of ambulatory function for TFA patients using both mechanical and microprocessor knee systems (19). In this study, timed performance data were collected using a manual stopwatch for a distance-based walking test of 75 m on even terrain. The test included a turnaround at 37.5 m. Participants were instructed to walk at their preferred self-selected walking speed (SSWS). The average of three trials was the participant's representative time. The 75 m SSWS test was used to test for correlations with the CS-PFP-10 total score and the END score.

Down Stair Walking (DN Stair Time)—Stair descent is recognized as an important measure of functional independence for LEA patients (19–21). Participants walked down stairs from a bilaterally railed, four-step stair platform. Subjects were asked to walk down the stairs in the manner and speed that represents their usual technique if they were in their homes or out in public. Subjects were asked to begin at the platform, facing down the stairs. They were asked to walk down following the command, “ready, set, go.” A handheld stopwatch was used to record the time between the “go” command and the instant when both

feet were in contact with the floor. The average of three trials was the subject's representative time. DN stair time was used to test for correlation with the LBS score.

Limits of Stability (LOS)—For individuals to safely engage in functional activities while standing, they need to effectively maintain balance by positioning their center of mass (COM) within the limits of their base of support. The LOS balance test represents the maximal inclination from the vertical position that an individual can achieve without taking a step or falling (i.e., without changing their base of support) (22,23). The LOS test using computer posturography has validated that LEA patients have decreased LOS compared to non-amputee controls (22).

The Biodex Balance SD system™ (Biodex Medical Systems, Shirley, NY, USA) was used to measure LOS. The Biodex Balance SD system™ incorporates a hemispherical suspended force platform that can tilt any direction up to 20° from horizontal (23). The platform includes gridlines for test-retest positioning reliability and a screen to provide COM data in real time to the patient visually. LOS were assessed in eight directions: forward, backward, right, left, forward-right, forward-left, backward-right, and backward-left. Poor directional control is scored by large variance (unitless). Subjects had to maintain the COM in the middle of a concentric circle that appeared on a screen positioned in front of them at a comfortable height. The LOS assessment consisted of three trials of 20 s duration each with 25 s rest periods between trials. The Biodex SD tests LOS by displaying an onscreen target placed in front of the subject. The target appears randomly in eight different directions only once, indicated when the respective target blinks in an alternating color (yellow to red) onscreen. Subjects are instructed to move their COM toward the target without changing foot position. The system permits three difficulty levels for this task (100%, 50%, and 25%) depending on the degree of ankle motion required to reach the target. Pilot testing with two TFA patients (not study subjects) was used to select the appropriate level at which the targets could be reached safely without loss of balance. For safety reasons following pilot data assessment, we selected the 25% difficulty level, which required platform tilt of 2° anteriorly, 1° posteriorly, 2° towards right, and 2° towards left. Sway required to reach each target from the center by the perfect shortest vertical or horizontal path is recorded by the instrument and scored. A score of 100 is the maximal achievable score in any direction. In each LOS test, the system computes the eight directional LOS scores and an overall LOS score as a percentage of the maximal score, which is 100. A lower score indicates greater sway. The system also calculates the time it takes for the subject to reach all eight directional targets, thus completing the assessment. The overall LOS score was used to test for correlation with the BAL score.

Statistical Analysis

The extent of statistical correlation was examined to determine concurrent validity. Data were entered into a database and examined for normality. For normally distributed data, Pearson product moment correlation coefficients (r) were calculated for each test pair (i.e., respective PFP total or domain score compared to a test with established validity for use with TFA). If data were abnormally distributed, Spearman rank correlation coefficients (r_s) were calculated. Strength of correlation values were categorized as 0 to ± 0.29 very weak,

± 0.30 to 0.49 weak, ± 0.50 to 0.69 moderate, and ± 0.70 to 1.00 strong (24). Statistical significance for test pairs was also assessed with a critical α of $p < 0.05$. Statistical analyses were performed using IBM SPSS (v21, Armonk, NY, USA).

RESULTS

Ten persons (eight males, two females) aged 24 to 75 years with unilateral TFA were recruited. See Table 2 for TFA participants' physical characteristics.

Correlations for Concurrent Validity

All four selected comparison tests, representing mobility, walking speed, balance, and stair walking capacity (i.e., the AMP test, 75 m SSWS test, LOS test, and the DN stair time test), strongly correlated (i.e., $r = \pm 0.76$ to 0.86) with their matched CS-PFP-10 domain score or total score. For example, the CS-PFP-10 domain score for LBS strongly correlated ($r = -0.79$) with stair descent time (DN stair time) as a concurrent measure of strength. Furthermore, all of the paired tests' correlations were statistically significant at $p = 0.01$ (Table 3).

DISCUSSION

To recommend the general use of an outcome measure, evidence is necessary that the measure has strong psychometric properties for the target population. Psychometric properties include the level of measurement of the outcome data, validity and reliability, and the test's sensitivity to detect change following intervention. Since the CS-PFP-10 provides ratio level outcome data, it allows for more precise parametric statistical analyses. Previous work by Highsmith et al. (16) has shown that the CS-PFP-10 was able to determine significant change differences in functional performance with TFA patients using two different interventions (i.e., microprocessor knee systems).

The primary findings of this study were that the CS-PFP-10 and its specific physiologic functional domains that involve the lower extremities (LBS, BAL, or END) demonstrated high concurrent validity (i.e., statistically significant, strong correlations) with measures of comparable ADL tasks or physiologic measures that have established validity for use with TFA patients.

Our findings of the correlation between the END domain (i.e., 6MWT) and AMP ($r = 0.76$) agree well with the correlation between the AMP and 6MWT reported by Gailey et al. ($r = 0.69$ to 0.82) (2). Additionally, the CS-PFP-10 total score correlates strongly with the AMP ($r = 0.80$). We suggest that it may be more advantageous to use the CS-PFP-10 rather than the AMP with TFA patients as a measure of general physical functional performance, as the CS-PFP-10 involves usual ADL tasks, including more functional walking tasks (i.e., carrying groceries 70 m, 6MWT, and manipulating clothing and cookware). Furthermore, use of the CS-PFP-10 allows for performance comparisons to other populations.

CONCLUSION

These findings, combined with the results reported by Highsmith et al. (16), indicate that the CS-PFP-10 has strong psychometric properties. These include the ability to detect change in

a small sample clinical trial and concurrent validity in high functioning persons with TFA. To further increase confidence with use of the CS-PFP-10 in TFA cases, additional psychometric properties should be determined, such as test-retest reliability.

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References

1. Zeigler-Graham K, Mackenzie EJ, Ephraim PL, Trivison TG, Brookmeyer R. Estimating the prevalence of limb loss in the United States: 2005 to 2050. *Arch Phys Med Rehabil.* 2008; 89(3): 422–9. [PubMed: 18295618]
2. Gailey RS, Roach KE, Applegate EB, Cho B, Cunniffe B, Licht S, Maguire M, Nash MS. The amputee mobility predictor: an instrument to assess determinants of the lower-limb amputee's ability to ambulate. *Arch Phys Med Rehabil.* 2002; 83(5):613–27. [PubMed: 11994800]
3. Resnik L, Borgia M. Reliability of outcome measures for people with lower-limb amputations: distinguishing true change from statistical error. *Phys Ther.* 2011; 91(4):555–65. [PubMed: 21310896]
4. Cress ME, Petrella JK, Moore TL, Schenkman ML. Continuous-scale physical functional performance test: validity, reliability, and sensitivity of data for the short version. *Phys Ther.* 2005; 85(4):323–35. [PubMed: 15794703]
5. Cress ME, Meyer M. Maximal voluntary and functional performance levels needed for independence in adults aged 65 to 97 years. *Phys Ther.* 2003; 83(1):37–48. [PubMed: 12495411]
6. Cress ME, Kinne S, Patrick DL, Maher E. Physical functional performance in persons using a manual wheelchair. *J Orthop Sports Phys Ther.* 2002; 32(3):104–13. [PubMed: 12168737]
7. 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(3):488–93. [PubMed: 19254616]
8. Brochu M, Savage P, Lee M, Dee J, Cress ME, Poehlman ET, Tischler M, Ades PA. Effects of resistance training on physical function in older disabled women with coronary heart disease. *J Appl Physiol* (1985). 2002; 92(2):672–8. [PubMed: 11796680]
9. Ades PA, Savage P, Cress ME, Brochu M, Lee NM, Poehlman ET. Resistance training on physical performance in disabled older female cardiac patients. *Med Sci Sports Exerc.* 2003; 35(8):1265–70. [PubMed: 12900677]
10. Hearty TM, Schenkman ML, Kohrt WM, Cress ME. Continuous scale physical functional performance test: appropriateness for middle-aged adults with and without Parkinson's disease. *J Neurol Phys Ther.* 2007; 31(2):64–70. [PubMed: 17558359]
11. Cress ME, Conley KE, Balding SL, Hansen-Smith F, Konczak J. Functional training: muscle structure, function, and performance in older women. *J Orthop Sports Phys Ther.* 1996; 24(1):4–10. [PubMed: 8807535]
12. Cress ME, Buchner DM, Questad KA, Esselman PC, deLateur BJ, Schwartz RS. Exercise: effects on physical functional performance in independent older adults. *J Gerontol A Biol Sci Med Sci.* 1999; 54(5):M242–8. [PubMed: 10362007]
13. Slade JM, Miszko TA, Laity JH, Agrawal SK, Cress ME. Anaerobic power and physical function in strength-trained and non-strength-trained older adults. *J Gerontol A Biol Sci Med Sci.* 2002; 57(3):M168–72. [PubMed: 11867653]

14. Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci*. 2003; 58(2):171–5. [PubMed: 12586856]
15. Panton LB, Kingsley JD, Toole T, Cress ME, Abboud G, Sirithienthad P, Mathis R, McMillan V. A comparison of physical functional performance and strength in women with fibromyalgia, age- and weight-matched controls, and older women who are healthy. *Phys Ther*. 2006; 86(11):1479–88. [PubMed: 17079747]
16. Highsmith MJ, Kahle JT, Miro RM, Cress ME, Lura DJ, Quillen WS, Carey SL, Dubey RV, Mengelkoch LJ. Functional performance differences between the Genium and C-Leg prosthetic knees and non-amputees. *J Rehabil Res Dev*. 2016 Forthcoming.
17. [CMS] Centers for Medicare and Medicaid Services. Healthcare Common Procedure Coding System. Springfield (VA): U.S. Department of Commerce, National Technical Information Service; 2007.
18. Cress ME, Buchner DM, Questad KA, Esselman PC, deLateur BJ, Schwartz RS. Continuous-scale physical functional performance in healthy older adults: a validation study. *Arch Phys Med Rehabil*. 1996; 77(12):1243–50. [PubMed: 8976306]
19. Kahle JT, Highsmith MJ, Hubbard SL. Comparison of nonmicroprocessor knee mechanism versus C-Leg on Prosthesis Evaluation Questionnaire, stumbles, falls, walking tests, stair descent, and knee preference. *J Rehabil Res Dev*. 2008; 45(1):1–14. [PubMed: 18566922]
20. Jones SF, Twigg PC, Scally AJ, Buckley JG. The mechanics of landing when stepping down in unilateral lower-limb amputees. *Clin Biomech (Bristol, Avon)*. 2006; 21(2):184–93.
21. Schmalz T, Blumentritt S, Marx B. Biomechanical analysis of stair ambulation in lower limb amputees. *Gait Posture*. 2007; 25(2):267–78. [PubMed: 16725325]
22. Kolarova B, Janura M, Svoboda Z, Elfmark M. Limits of stability in persons with transtibial amputation with respect to prosthetic alignment alterations. *Arch Phys Med Rehabil*. 2013; 94(11):2234–40. [PubMed: 23774381]
23. Ganesan M, Pal PK, Gupta A, Sathyaprabha TN. Dynamic posturography in evaluation of balance in patients of Parkinson's disease with normal pull test: concept of a diagonal pull test. *Parkinsonism & related disorders*. 2010; 16(9):595–9. [PubMed: 20832347]
24. Moore, DS.; Fligner, MA. The basic practice of statistics. 6. New York (NY): W. H. Freeman; 2012.

Table 1

Description of CS-PFP-10 Tasks

Task Difficulty	Task	Functional Domains				
		UBS	LBS	UBF	BAL	END
Low Difficulty	1. Pot carry 1 m	Mass			Time	
	2. Don/Doff jacket			Time	Time	
	3. Vertical reach			Distance		
Moderate Difficulty	4. Pick up scarves from floor		Time		Time	
	5. Floor sweep		Time		Time	
	6. Laundry: a) transfer clothes washer to dryer, b) dryer to basket	Time	Time		Time	
High Difficulty	7. Transfer from standing to long-sit on floor and back to standing		Time		Time	
	8. Stair ascent/descent		Time		Time	
	9. Carry groceries 70 m	Mass	Mass		Time	
	10. 6-minute walk test					Distance

Balance and coordination (BAL), endurance (END), lower body strength (LBS), upper body flexibility (UBF), and upper body strength (UBS).

Table 2

Physical Characteristics of Transfemoral Amputee (TFA) Participants

Gender	
Male	n = 8
Female	n = 2
Etiology of Amputation	
Cancer	n = 3
Peripheral Vascular Disease	n = 1
Trauma	n = 6
Age (y)	41.3 ± 15.5
Time since Amputation (y)	9.6 ± 10.8
Residual Limb Ratio (Residual limb length ÷ Intact limb length * 100%)	76% ± 19 %
Height (cm)	176.5 ± 5.2
Weight (kg)	78.8 ± 16.5

Table 3

Correlations for Concurrent Validity

CS-PFP-10 Total Score or Specific Domain Score	Comparative Test	Pearson Correlation Coefficient (<i>r</i>)
Total Score	AMP	0.80
Total Score	75m SSWS	−0.86
BAL Domain	LOS	0.76
END Domain	AMP	0.76
END Domain	75m SSWS	−0.81
LBS Domain	DN stair time	−0.79

Balance and coordination (BAL), endurance (END), lower body strength (LBS). Amputee Predictor (AMP), 75m self-selected walking speed (75m SSWS), down stair walking limits of stability (LOS). All paired tests' correlations were statistically significant at $p = 0.01$.