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ORIGINAL ARTICLE

Development and Psychometric Validation of Capacity Assessment of Prosthetic Performance for the Upper Limb (CAPPFUL)

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Abstract

Objectives: (1) To develop a performance-based measure for adult upper limb (UL) prosthetic functioning through broad (ie, overall performance) and functional domain-specific (eg, control skills) assessment of commonplace activities; (2) to conduct initial psychometric evaluation of the Capacity Assessment of Prosthetic Performance for the Upper Limb (CAPPFUL).

Design: Internal consistency of CAPPFUL and interrater reliability for task, functional domain, and full-scale (sub)scores among 3 independent raters were estimated. Known-group validity was examined comparing scores by amputation level. Convergent validity was assessed between CAPPFUL and 2 hand dexterity or function tests; discriminant validity was assessed against self-reported disability.

Setting: Six prosthetic rehabilitation centers across the United States.

Participants: Subjects (N=60) with UL amputation using a prosthesis.

Interventions: Not applicable.

Main Outcome Measures: Not applicable.

Results: Interrater reliability was excellent for scoring on the task, domain, and full-scale scores (intraclass correlation coefficients=.88-.99). Internal consistency was good (α=.79-.82). Generally, subjects with higher UL amputation levels scored lower (worse) than subjects with lower UL amputation levels. CAPPFUL demonstrated strong correlations with measures of hand dexterity or functioning (r_s=−.58 to .72) and moderate correlation with self-reported disability (r=−.35).

Conclusions: CAPPFUL was designed as a versatile, low-burden measure of prosthesis performance for any UL functional prosthetic device type and any UL amputation level. CAPPFUL assesses overall performance and 5 functional performance domains during completion of 11 tasks that require movement in all planes while manipulating everyday objects requiring multiple grasp patterns. Psychometric evaluation indicates good interrater reliability, internal consistency, known-group validity, and convergent and discriminant validity.

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Many factors influence patient satisfaction and functional success with the use of an upper limb (UL) prosthetic device.[1-5] Integrating technology with an amputated human limb requires careful consideration of prosthetic interventions, associated training, and psychosocial factors related to such a significant loss. Numerous assessment tools have been used in an attempt to measure different aspects of UL prosthetic performance.[6,7] However, few are specific to UL prosthesis use, assess prosthetic performance during commonplace tasks, or have been adequately validated for users of UL prosthetic devices.[8] As a result, there is no industry standard measure to inform prosthetic prescriptive and rehabilitation decisions for persons with UL amputations.[9] Instead, clinicians often use a variety of outcome measures to

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assess general areas of functionality or, alternatively, assess only 1 area of prosthetic performance in an attempt to gain evidence-based information regarding the use of a prosthesis.[6,7,10] However, the use of multiple, generalized outcome measures in the UL prosthetic rehabilitation environment results in increased testing time and burden on the patient, nonspecific results, and the potential for decreased efficiency and effectiveness in UL prosthetic rehabilitation.[7,10,11]

The shortage of clinically relevant, performance-based UL prosthetic rehabilitation information—obtained through reliable and valid measures—affects the rehabilitation provider's ability to make UL prosthetic prescriptive decisions, to make rehabilitation care decisions, to inform and motivate patients on rehabilitation progress, and to project functional outcomes. Evidence-based medical standards, the advent of technologically advanced UL prosthetic components, and health care reimbursement justification requirements demand a clear confirmation of the functional benefit of UL prosthetic devices. Consequently, there is an urgent need for population-specific, performance-based measures to demonstrate the medical and functional benefit of prescriptive prosthetic options and rehabilitation treatment decisions for those with UL amputation.

The World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) defines domains for impact evaluation of medical intervention: *function* (eg, mechanical capabilities of prosthetic devices); *activity* (ie, ability to effectively perform intended actions); and *participation* (eg, satisfaction with and perception of their abilities with prosthetic devices).[12] Several comprehensive literature reviews have examined strengths and weaknesses, WHO ICF domains, and the level of evidence for existing outcome measures used in UL prosthetic rehabilitation.[6,13] These reviews indicate a notable lack of validated measures to assess the WHO ICF *activity domain* for adult UL prosthetic users. More specifically, these reviews indicate that only 5 adult measures of *hand* function have the potential to meet psychometric criteria to assess the use of an UL prosthesis. However, while these measures have promise, none of the measures had been psychometrically validated among nonmilitary adult UL prosthetic users to assess the use of all types of prosthetic devices and components. Since these reviews, Resnik et al[14] developed a new outcome measure for adults with UL amputation to measure *activity*—the Activities Measure for Upper Limb Amputees (AM-ULA). The AM-ULA evaluates UL prosthesis users' performance during 18 common daily activities and has demonstrated good psychometric properties. However, although several aspects of functioning are considered within the scoring of each task, patients are ultimately given a singular score to indicate performance. Although these singular ratings may aid in the general assessment of performance, a more nuanced level of measurement (ie, for various domains of functioning) may be useful in highlighting areas that need improvement through prosthetic modification or training and in highlighting strengths and weaknesses of various prostheses and prosthetic components.

The Capacity Assessment of Prosthetic Performance for the Upper Limb (CAPPFUL) was developed as a novel outcome measure of prosthetic function for adults with UL amputation. The goal of CAPPFUL is to provide a comprehensive, performance-based measure for UL prosthetic use with any UL functional prosthesis at any amputation level through assessment of commonplace activities that take place in various planes of movement. Importantly, the CAPPFUL is designed to measure 5 unique functional domains that affect UL prosthetic performance and to provide a general score for task-specific and overall performance. This article details the development of CAPPFUL and an initial psychometric evaluation of the measure.

List of abbreviations:

AM-ULA	**Activities Measure for Upper Limb Amputees**
BBT	**Box and Block Test**
CAPPFUL	**Capacity Assessment of Prosthetic Performance for the Upper Limb**
DASH	**Disability of the Arm, Shoulder, and Hand**
ICC	**intraclass correlation coefficient**
ICF	**International Classification of Functioning, Disability and Health**
JTHF	**Jebsen-Taylor Hand Function Test**
UL	**upper limb**
WHO	**World Health Organization**

Methods

Task Conceptualization, Domain Conceptualization, and Scoring

The CAPPFUL content was developed by an expert panel of occupational and physical therapists, prosthetists, and a rehabilitation psychologist to measure factors that affect functional use of a prosthesis in comparison to the abilities of a sound UL. To begin the process, the researchers completed a review of the literature to identify tasks appropriate for evaluation of UL prosthetic factors of component, fit, and training impact on users' performance of functional tasks. This review, combined with a series of interviews with UL prosthetic rehabilitation therapy specialists (eg, regarding grasp patterns critical to the performance of functional tasks), resulted in an initial list of approximately 300 performance-based tasks. Next, an expert panel of rehabilitation specialists used an Estimate-Talk-Estimate (ie, mini-Delphi[15,16]) method to refine the initial list down to 25 tasks, each of which was systematically vetted to produce the final list of tasks for the CAPPFUL. This iterative process culminated in 11 timed, unilateral, and bilateral functional tasks—each varying the required functional *envelopes* (ie, area in which a prosthesis is operated), the position of the body (eg, sitting, standing), the grasp patterns typically used for the tasks (eg, lateral grip to turn a knob), or the weight and/or size of the task-specific object(s).

For each of the CAPPFUL tasks, administrators evaluate and score 5 domains of functioning: control skills, component utilization, maladaptive compensatory movement, adaptive compensatory movement, and task completion. As can be seen in fig 1, there are 4 interactive spheres—object, prosthesis, subject (prosthesis user), and space—that guided the conceptual model of these CAPPFUL domains, which were derived from the review of UL neuromotor control literature[17,18] and clinical observation of the human (ie, user), contextual (eg, environment), and technological features that affect performance on functional tasks (eg, grasp, movement). With the exception of task completion, which evaluates performance of tasks in a functionally reasonable amount of time, each of the domains assesses the intersection of at least 2