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Narrative Review

Evaluation of Performance-Based Outcome Measures for the Upper Limb: A Systematic Review

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Abstract

Objective performance-based outcome measures (OMs) have the potential to provide unbiased and reproducible assessments of limb function. However, very few of these performance-based OMs have been validated for upper limb (UL) prosthesis users. OMs validated in other clinical populations (eg, neurologic or musculoskeletal conditions) could be used to fill gaps in existing performance-based OMs for UL amputees. Additionally, a joint review might reveal consistent gaps across multiple clinical populations. Therefore, the objective of this review was to systematically characterize prominent measures used in both sets of clinical populations with regard to (1) location of task performance around the body, (2) possible grips employed, (3) bilateral versus unilateral task participation, and (4) details of scoring mechanisms. A systematic literature search was conducted in EMBASE, Medline, and Cumulative Index to Nursing and Allied Health electronic databases for variations of the following terms: *stroke, musculoskeletal dysfunction, amputation, prosthesis, upper limb, outcome, assessments*. Articles were included if they described performance-based OMs developed for disabilities of the UL. Results show most tasks were performed with 1 hand in the space directly in front of the participant. The tip, tripod, and cylindrical grips were most commonly used for the specific tasks. Few measures assessed sensation and movement quality. Overall, several limitations in OMs were identified. The solution to these limitations may be to modify and validate existing measures originally developed for other clinical populations as first steps to more aptly measure prosthesis use while more complete assessments for UL prosthesis users are being developed.

Level of Evidence: Level III.

Introduction

A variety of prosthetic technologies are currently available to upper limb (UL) amputees. Some prostheses are operated through body movements [1], whereas others use electromyography signals to manipulate an electromechanical terminal device [2]. Next-generation prostheses strive for closer mimicry of intact limbs in range of motion, dexterity, and sensory feedback [3]. The DARPA Hand Proprioception and Touch Interfaces (HAPTIX) program seeks to improve prosthetic control systems by implementing direct neural control through implanted peripheral nerve interface technology, restoring sensory feedback and allowing intuitive control of complex hand movements [4].

Although the potential for benefit to the user is high, such advancements in technology are accompanied by increased risks associated with implanted medical devices

[5,6]. The measurement of efficacy and benefit of these devices through outcome measures becomes vital to ensure optimal device selection; track rehabilitative progress; and inform device regulation and review, as higher-risk devices require more stringent evaluation criteria to ensure a balance of risks and benefits.

To assess prosthesis user outcomes, clinicians and therapists use subjective self-report measures and objective performance-based measures. Self-report outcome measures typically report information about abstract concepts, such as quality of life, pain, and patient's perception of experiences (eg, Trinity Amputation and Prosthesis Experience Scale [7]). Although these self-report measures provide important information about abstract constructs, self-reporting on functional performance may be biased according to individual experience and variation in the recall of past events [8].

Objective performance-based outcome measures have the potential to provide unbiased and reproducible assessments of function during the performance of activities relevant to daily living. Such measures are also useful for clinical [9], regulatory, and reimbursement decisions. However, very few of them have been validated for UL prosthesis users [3,7,10,11]. Recognizing the dearth of performance-based outcome measures in this population, some clinicians and researchers use measures that have been studied and validated in other populations with UL impairments and disabilities, such as those resulting from neurologic or musculoskeletal conditions [12-14]. Outcome measures validated in these other clinical populations could potentially be used to fill gaps in existing performance-based outcome measures for UL amputees. In addition, we reasoned that a joint review might reveal consistent gaps across multiple clinical populations and highlight the need to design and develop more complete measures. Therefore, we sought to systematically characterize prominent measures currently used in both sets of clinical populations with regard to (1) location of task performance around the body, (2) possible grips employed, (3) bilateral versus unilateral task participation, and (4) details of the scoring mechanisms, including subjectivity, assessment of sensation, and assessment of quality of motion (QoM). To our knowledge, this is the first review to focus on evaluating and comparing these specific characteristics of performance-based outcome measures for UL function.

Methods

A systematic literature search was conducted using the EMBASE, Medline, and Cumulative Index to Nursing and Allied Health electronic databases from 1970 to June 2015 to identify relevant clinical studies that used UL performance-based outcome measures as functional endpoints. The following search terms were used in each database: (stroke OR musculoskeletal dysfunction OR amputation OR prosthesis OR prosthetic limb OR artificial limb OR prostheses) AND (upper limb OR upper limbs OR arms OR arm OR upper extremity OR upper extremities) AND (treatment outcome OR evaluation OR outcome measures OR outcome OR outcomes OR assessment OR assessments).

The inclusion criteria for publications to be used in this review were the following:

1. Studies described 1 or more outcome measures that
 - a) were developed for amputees or individuals with neurologic/musculoskeletal impairments or disabilities of the UL,
 - b) were intended to measure the functional restoration/improvements through a series of activities or tasks (ie, outcome measure falls under the "Activities" classification within the World Health Organization [WHO] International Classification of

- Functioning, Disability and Health [ICF] framework), and
 - c) were intended for use in the adult population;
2. Studies included a sample of at least 10 people with an UL deficiency;
3. Publications were written in English.

Publications were excluded from this review if the main topic of the studies was centered on cardiac, molecular, or ambulatory research in stroke, or the use of drugs to decrease spasticity in stroke patients; the article was not written in English; or if the article inadequately described an outcome measure that otherwise would require purchase to thoroughly review scoring and tasks.

Extracted Outcome Measure Qualities

For each identified outcome measure, specific characteristics were extracted: areas around the body in which tasks are performed; the types of grips that a user could possibly employ; bilateral versus unilateral task participation; and the subjectivity and details of the scoring mechanisms, with a particular focus on the assessment of sensation and QoM. In this review, QoM was defined as any consideration of how a movement was performed, as distinct from the acquisition of a target or goal. Any outcome measure that assessed perceived normality of the motion, smoothness and swiftness while completing a task, correctness, or faultlessness of movements was determined to assess QoM. Each selected outcome measure was also labeled using the WHO ICF framework [7]. A summary of the results for each outcome measure is included in Table 1, and further discussed in the scoring details of the Results section.

Results

Literature

The search resulted in 3844 articles due to the inclusion of stroke in the search terms. Thousands of articles were related to cardiac research, ambulatory studies in stroke, or pharmaceutical interventions, and were immediately discarded. The remaining 2194 article titles and abstracts were then examined to compile a list of 68 outcome measures used in the studies to assess rehabilitative interventions or functionality. Self-report measures and questionnaires were removed from the list of 68, leaving 22 measures. Articles that fit the inclusion criteria for this review and used any of the qualified 22 measures were identified and obtained. A total of 71 full-text articles were read, from which 48 were selected for their descriptions and validations of the outcome measures. Further article searches were performed based on the outcome measure of interest and the above guidelines, resulting in a final list of 17 outcome measures. An additional literature search was

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