REFINEMENT OF NEW ITEMS IN THE ASSESSMENT OF CAPACITY FOR MYOELECTRIC CONTROL FOR MULTI-ARTICULATING HANDS

Kristi L. Turner, DHS, OTR/L [1,] Wendy Hill, BScOT ,[2] Eric J. Earley, PhD[3,4], Maria Munoz-Novoa,[5] Liselotte Hermansson, PhD[6,7], Helen Lindner, PhD[8]

[1] *Center for Bionic Medicine, Shirley Ryan AbilityLab, Chicago, IL, USA*
[2]*Institute of Biomedical Engineering, University of New Brunswick, Fredericton, Canada*
[3]*Bone-Anchored Limb Research Group, University of Colorado, Aurora, CO, USA*
[4]*Department of Orthopedics, University of Colorado School of Medicine, Aurora, CO, USA*
[5]*Center for Bionics and Pain Research, Mölndal, Sweden*
[6]*Dept of Prosthetics and Orthotics, Faculty of Medicine and Health, Örebro University, Örebro, Sweden.*
[7]*University Health Care Research Center, Faculty of Medicine and Health, Örebro University, Örebro, Sweden*
[8]*School of Health Sciences, Örebro University, Örebro, Sweden*

ABSTRACT

This paper discusses the enhancement of the Assessment of Capacity for Myoelectric Control (ACMC) with the introduction of three new assessment items specifically designed for multi-articulating prosthetic hands. With the advent of these advanced prosthetics, assessing a user's capability to effectively operate them in functional tasks becomes crucial. The new ACMC items bridge the existing evaluation gap by focusing on the nuanced control skills required by users with upper limb loss or difference (ULL/D). This innovation, achieved through a collaborative effort among clinical and prosthetic researchers, utilizes video analysis and consensus to ensure these items accurately measure the adeptness in controlling multi-articulating hands during bimanual activities.

INTRODUCTION

Recent advancement in multi-articulating hands offer increased function to individuals with upper limb loss or difference (ULL/D) that have been previously using a single degree of freedom (DOF) prosthetic hand. While individuals with ULL/D generally prefer the enhanced functions and appearance of multi-articulating hands [1], several studies have reported challenges in learning to operate them and use in daily activities. Skills such as grip-switching, prepositioning various prosthetic components for grasping, and selecting the most secure grips require proper training and regular practice [2].

One way to monitor progress in learning multi-articulating hands is to use an assessment tool that captures different aspects of controlling a multi-articulating hand. The Assessment of Capacity for Myoelectric Control (ACMC) is an observation-based assessment that evaluates a person's ability to control a myoelectric prosthetic hand in bimanual activities [3]. Originally developed for conventional standard myoelectric hands with a single DOF, the ACMC items are not designed to capture the nuanced control of multi-articulating hands.

Here, we provide a brief report on the process of testing the degree to which the three new items capture several skills specifically related to the control of multi-articulating hands. Using video analysis and a consensus method, a group of clinical and prosthetic researchers used and refined the three new items to assess upper limb prosthesis users with various types of multi-articulating hands.

METHODS

Four raters (occupational therapists and researchers) with extensive clinical experience and knowledge of the ACMC participated in meetings to discuss areas not currently covered in the current ACMC. From these meetings, definitions were created with the intent to capture use and control strategies of multi-articulating hands [4]. After presenting these definitions at an ACMC training course, two certified raters (a physical therapist and an engineer), who were newly utilizing the ACMC in their research lab, provided feedback on the new items based on their experiences using the ACMC with their research participants [5], and were subsequently included in further discussions and refinement of item definitions, as described below (Figure 1).

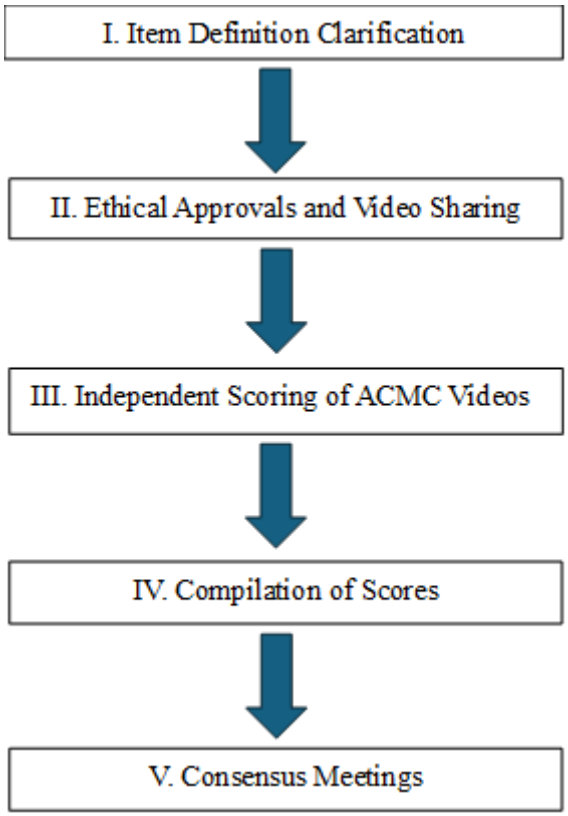

Figure 1: A flow chart to illustrate the process for definition refinement.

I. Initial meetings reviewed the item definitions and discussed any further clarifications. Raters engaged in detailed discussions to ensure a common understanding of the assessment items. The raters were in agreement that the refined name of each item was in accordance with their understanding:

Ability to switch grips

Positioning the hand appropriately for grasping

Choosing a secure grip for function

II. Ethical approvals were received by the respective raters to allow for sharing of ACMC videos. Subsequent meetings allowed for analysis of ACMC assessment videos from the raters' respective labs that captured a variety of control strategies, limb loss/ difference levels, components, and multi-articulating hands.

III. During each meeting, to prevent bias, ACMC videos were shared for each rater (n=5) to independently score the three new items without discussion with the other raters.

IV. After all videos were scored, each rater sent their ratings to the study facilitator who did not participate in the scoring meetings. Alongside the scores, raters provided justifications for each rating, offering insights into their decision-making process. The facilitator compiled the scores and justifications, allowing for a comparative review of the assessments.

V. At two consecutive meetings the study facilitator shared the results with the group of raters and chaired the discussion.

RESULTS

During the consensus meetings, the discussions focused on the individual scores in relation to the words of each item and rating scale definition. For example, the definition of "*Ability to switch grips*" before the consensus meeting read as "*about the mechanics of switching or accessing the grips available in the prosthetic hand. Is the person able to consistently and accurately switch between/access available grips*?" In the videos, often we saw inadvertent, **unintended**, or **delayed** switching of grips due to various reasons, such as unfamiliarity with the hand, the user's lack of ability to control, or the user not taking the opportunity to switch grips. As a result, raters initially rated this item 1 or 2 (Table 1) but after discussion all raters agreed to a score of 2.

Table 1. Initial individual scoring of one video of the item *Ability to switch grips*

	Rater 1	**Rater 2**	**Rater 3**	**Rater 4**	**Rater 5**
Score	2	2	2	1	1
Notes taken by rater from video	Slight delays when switching	Switched well but there were some delays	Slight delays when switching grips in particular at tabletop activities; significant delay when going to counter	Pick up suitcase with fine pinch. attempt to switch grip. grip shoes with fingers (good). Switching grip before packing toiletries bag. Change to lateral for shoe bag	Capable of switching, it is questionable whether it switches to the one he intended. Some delays in some task.

DISCUSSION

Using video analysis and a consensus method, we refined the new ACMC item definitions to evaluate the control of multi-articulating hands. The refined definitions include more comprehensive language, incorporation of examples, and additional details for scoring (e.g. number of reminders, specific descriptors) which improved the interpretability of the items. As an example, in the item "*Ability to switch grips"*, with the refined definition, the raters were able to reach consensus and agree on a common rating of this item.

This consensus process with raters of different backgrounds and experience with ACMC has strengthened the definitions and clarified the intent of capturing multi-articulating hand function. The next step is to validate the newly refined ACMC items together with the existing items with a sample of multi-articulating hand users.

REFERENCES

1. Widehammar C, Hiyoshi A, Lidström Holmqvist K, Lindner H, Hermansson L. Effect of multi-grip myoelectric prosthetic hands on daily activities, pain-related disability and prosthesis use compared with single-grip myoelectric prostheses: A single-case study. J Rehabil Med 2021.
2. Franzke AW, Kristoffersen MB, Bongers RM, Murgia A, Pobatschnig B, Unglaube F, et al. Users' and therapists' perceptions of myoelectric multi-function upper limb prostheses with conventional and pattern recognition control. PLoS One 2019;14(8):e0220899.
3. Lindner HYN, Linacre JM, Hermansson LM. Assessment of Capacity for Myoelectric Control: Evaluation of the construct and the rating scale. Journal of Rehabilitation Medicine 2009.
4. Hermansson, L, Turner, K, Lindner, H, Hill, W. Development of the Assessment of Capacity for Myoelectric Control Version 4 for use in Patients with Multi-Grip Prosthetic Hands. The 18th World Congress of the International Society for Prosthetics and Orthotics (ISPO), 1-4 November 2021.
5. Zbinden J, Sassu P, Mastinu E, Earley EJ, Munoz-Novoa M, Brånemark R, et al. Improved control of a prosthetic limb by surgically creating electro-neuromuscular constructs with implanted electrodes. Science Translational Medicine 2023;15(704):eabq3665.