JRRD Guest Editorial

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More than the final score: Development, application, and future research of Comprehensive High-Level Activity Mobility Predictor

Since September 11, 2001, the United States has become involved in two major conflicts [1]. As of December 3, 2012, the Congressional Research Service reported that the number of battle-injury amputations from Operation New Dawn, Operation Iraqi Freedom (OIF), and Operation Enduring Freedom (OEF) was 1,715 [2]. Explosions or blasts have produced the highest percentage (54%) of limb injuries seen among wounded servicemembers (SMs) since World War II [3]. Owens et al. reported almost symmetrical distribution between wounds to the upper (51%) and lower limbs (49%) with SMs wounded in action in OIF/OEF from October 2001 through January 2005 [3]. Prior to 2005, approximately 75 percent of major limb amputations occurred to the lower limbs, with 15 percent of SMs sustaining multiple limb loss [4]. By 2009, the numbers had increased such that 82 percent of major limb amputations were to the lower limbs, with 24 percent sustaining multiple limb loss and the majority occurring in bilateral lower limbs. Since 2010, the number of SMs sustaining more than one limb loss has continued to increase, with also greater concomitant injuries [5].

Historically, SMs who sustained a major limb amputation were medically retired from Active Duty (AD) military service [6]. Today, however, expectations have changed and provisions have been established to allow SMs with major limb loss, who so desire, to remain on AD. A report published in 2009 found that 11 percent of SMs with major lower-limb loss who have completed the medical boarding process either qualified for Continuation on AD or Continuation on Active Reserve or were determined to be Fit for Duty [7]; by 2010, the number rose to 16 percent [8].

With military SMs achieving such high levels of activity after major limb loss, it became clear to the rehabilitation community that the outcome measures for this unique patient population needed to be adjusted. In 2006, Pasquina and Fitzpatrick reported the need to develop novel outcome measures for use in assessing patient progress and determining optimal treatment strategies for SMs with lower-limb loss receiving care at Walter Reed Army Medical Center, Bethesda, Maryland [9]. They reported that these patients were quickly exceeding functional outcome expectations and quickly reaching a ceiling effect on existing outcome measurement tools such as the Amputee Mobility Predictor (AMP) or Timed Up and Go Test. They therefore concluded that a need existed to develop a more robust outcome measure geared toward assessing high levels of mobility for this specific population in order to better quantify functional capability, change in function over time, and readiness to return to AD and/or competitive sports.

Developing a novel high-level mobility outcome measurement tool would require extensive academic rigor, especially to develop one that was both reliable and valid. The single-topic section of this issue of the *Journal of Rehabilitation Research and Development* (*JRRD*) describes the development of the Comprehensive High-Level Activity Mobility Predictor (CHAMP), which we propose the rehabilitation community consider using when providing state-of-the-art care for today's people with amputation who want to return to high-level activity. The CHAMP was developed to be a performance-based assessment instrument to measure high-level mobility of people with lower-limb amputation. In developing the CHAMP, we analyzed existing military, amputation, and nonamputation literature and determined that balance, postural stability, coordination, power, speed, and agility were the most important factors that influenced high-level mobility. We then examined published outcome measures that had been purported for use with individuals with lower-limb amputation and found that the Single Limb Stance, Edgren Side Step Test, T-Test, and Illinois Agility Test best captured these factors. Therefore, we used these measurement tools as the basis for constructing the CHAMP.

Once achieving appropriate "face" and "content" validity in developing the CHAMP, we set forth to determine its psychometric properties. The CHAMP was administered to a population of SMs with traumatic lower-limb loss as well as a group of AD SMs without amputation. A representative sample of participants with amputation included those with unilateral and bilateral lower-limb loss. A convenience sample of age-matched AD SMs without any physical impairments or injuries was used as a comparison group to establish normative data for high-level mobility and establish threshold levels of performance on the CHAMP. The interrater and test-retest reliability were established for the CHAMP and found to be excellent, which therefore indicates that a variety of clinicians could administer the CHAMP with confidence. The test-retest reliability results support the CHAMP as a stable, repeatable measure of high-level mobility. As a result, clinicians should feel confident that the CHAMP is a stable and repeatable measure of high-level mobility.

The construct convergent validity of the CHAMP was established using two outcome measures that demonstrated a similar construct (6-minute Walk Test [6MWT] and AMP). The results signify that CHAMP scores correlate with the distance walked in 6 min, demonstrating that a relationship exists between the two measures and mobility. In addition, we propose that using the CHAMP in combination with the AMP best measures lower-limb amputation mobility levels across a continuum, where the AMP predicts and assesses the foundational components of mobility and the CHAMP assesses higher-level mobility capabilities.

The subsequent articles in this single-topic section provide details of the CHAMP studies with respect to the methodology and results. In addition, we discuss the relevance of the CHAMP and other outcome measures as a viable clinical tool to enhance rehabilitation. We believe that outcome measures such as the CHAMP have the potential to provide more than just an individual's score at a single point of time but can also help clinicians gather more refined information about a patient's performance to help develop more specific and targeted treatment interventions.

DIRECTIONS FOR FUTURE RESEARCH

The use of outcome measures is rapidly becoming a requirement in all fields of rehabilitation. Moreover, "comparative effectiveness research" will likely guide the future of healthcare in the United States [10]. While incorporating outcome measures into clinical practice can be challenging, their utility can be multifaceted, allowing clinicians to (1) classify patient populations based on a predetermined scale, (2) predict the functional capabilities of a patient or population based on a predetermined criteria, (3) determine the functional capabilities of a patient at a specific time during rehabilitation, (4) detect change in function over time, (5) determine the contribution of a particular set of variables, (6) identify functional limitations in performance to guide treatment, and (7) enhance prescription of more specific exercises

or rehabilitation treatments. Each of these benefits is described in more detail next.

Classify Patient Populations Based on Predetermined Scale

Access to valid and reproducible tools to more accurately classify patients allows clinicians to better understand patient populations, refine treatment strategies, and help predict outcomes. Frequently used methods of classifying lower-limb amputations include cause of amputation (acquired vs traumatic), injury severity (Injury Severity Score or New Injury Severity Score [NISS]), and level of limb loss [11–12]. These characteristics, however, lack the specificity needed to best define particular patient populations and also lack the sophistication to elucidate more relevant clinical determinants of an individual's functional independence. Current functional scales such as the Medicare Functional Classification Level (MFCL) use functional ability by primarily describing household and community ambulation, but descriptors for civilians with amputation are not necessarily translatable for military SMs with amputation. More relevant descriptors for a military population might be "combat ready," "worldwide deployable," "restricted duty," etc., suggesting that more refined tools still need to be developed for this unique patient population. Furthermore, future classification methods should also incorporate the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) to more accurately describe all aspects of human disability and function. The ICF model has the potential to classify the influence of prosthetic devices on activity and participation; however, its use would require numerous modifiers and further refinement because current published works are limited for amputation populations [13–15].

Predict Functional Capabilities of Patient or Population Based on Predetermined Criterion

Once a classification of the patient population with a predetermined scale has been defined, the discrimination between each defined class can be established based on a range of scores with a specific outcome measure or a set of measures. The CHAMP may have the potential to assist clinicians and other stakeholders in predicting the functional capabilities of people with limb loss who exceed the MFCL descriptors and have the potential for higher-level activities or employment.

Currently, even without a formal classification scale, the CHAMP can be used by clinicians, patients, and medical reviewers to assess readiness to return to high-level activity or work for people with lower-limb loss. It may even have a role for individuals with other lower-limb musculoskeletal injuries. For example, people in the civilian population such as firefighters and law enforcement agents are at risk for musculoskeletal injuries due to their job requirements. Both occupations are required to perform a physical abilities test catered to determine their physical readiness to perform on-the-job activities [16–17]. Future research should examine the relationship between CHAMP performance and the physical abilities test for both firefighters and law enforcement agents to determine whether the CHAMP could be used as a clinical tool to determine readiness to return to work for these professionals.

Determine Functional Capabilities of Patient at Specific Time During Rehabilitation

The CHAMP was designed to be performed once a patient has already achieved a minimal functional level with a prosthesis (e.g., achieving 37 points on the AMP or walking 250 m during the 6MWT). The CHAMP can be performed with a prosthesis by walking, jogging, running, or sprinting. Therefore, the CHAMP score would be expected to be lower during the early phase of rehabilitation and then increase as the patient's speed, power, and agility improve. Changes in CHAMP score could be recorded over time and offer a better way to document functional improvement or decline, further validating rehabilitation strategies used for an individual patient or patient population.

Detect Change in Function Over Time

One important benefit of an outcome measure for rehabilitation is the ability to assess the change in function such that the clinician can determine whether a patient has improved, stabilized, or declined in

functional capabilities. Detecting change in function can be determined by establishing the responsiveness of the outcome measure. Future research should focus on determining the minimally clinically important difference for the CHAMP. The anchor-based method is an approach that uses changes due to an intervention such as learning to stand, walk, jog, return to sports, and/or return to work to anchor the meaning of clinical importance that is interpretable and correlates with the outcome measure of choice [18–19].

Determine Contribution of Particular Set of Variables

During our assessment of the CHAMP, we determined that several variables seemed to correlate with CHAMP score variance. They were (1) ability to descend stairs, (2) waist circumference, (3) prosthetic foot type, (4) time since injury, and (5) NISS score [20]. While these results warrant further investigation with a larger sample size, we believe that the concept of identifying specific variables that influence performance can greatly assist clinical practice, particularly for those variables that may be modifiable. For example, the eccentric muscle control to descend a stair is import for agility activities; therefore, therapists can focus treatment sessions on specific physical attributes related to these skills. In addition, patients should be educated on the importance of body weight, in particular waist size, which may have a direct correlation with functional performance.

Tools such as the CHAMP may even be used to better refine prosthetic prescriptions. For instance, when we examined the contribution of prosthetic components to the improvement in high-level mobility performance, we found that only those participants with transtibial amputation (TTA) benefited from specific prosthetic foot designs. Specifically, those SMs with TTA were able to take advantage of the dynamic response properties of the carbon-fiber J-shaped prosthetic foot, which significantly predicted a portion of high-level mobility performance. The other groups with lower-limb amputation (individuals with transfemoral amputation and bilateral lower-limb loss) were not able to take advantage of either microprocessor and nonmicroprocessor prosthetic knee units or other dynamic response prosthetic foot designs. These results indicate that further investigation is needed to determine the effect that newer prosthetic technologies, including powered prosthetics, may have on high-level functional performance.

Identify Functional Limitations in Performance to Guide Treatment

In order to provide SMs with traumatic lower-limb loss with the most effective rehabilitation intervention to aid their return to high-level activity, an understanding of the movement strategies they use is necessary. An understanding of efficient movement strategies when performing high-level mobility will allow the therapist to develop an intervention that closely resembles optimal performance of those activities and the optimal use of the prosthetic components. For example, observational differences in performance of the CHAMP were seen between participants with TTA who demonstrated a raw score comparable with their nondisabled peers. The SMs with TTA with CHAMP scores equal to their nondisabled peers, in general, moved with a lower center of gravity; tended to maintain their center of mass over their prosthetic forefoot and contralateral forefoot, thus demonstrating greater trunk flexion and knee flexion; took advantage of the dynamic prosthetic foot dorsiflexion by pushing off the forefoot when propelling themselves laterally; and had symmetrical strides throughout each maneuver. The SMs who had lower CHAMP scores tended to move with a higher center of gravity with their trunk in a neutral position, thus demonstrating less knee flexion and prosthetic ankle dorsiflexion, and pushed off laterally with the heel of their prosthetic ankle/foot assembly instead of the toe, with asymmetrical strides between limbs throughout the test maneuvers. The efficient strategies performed by those individuals with TTA can be taught in order to maximize their physiological and prosthetic function. Future work should focus on gaining an understanding of these efficient movement strategies to help improve high-level mobility performance of SMs with traumatic lower-limb loss.

Enhance Prescription of Specific Exercises or Rehabilitation Treatments

As in the previous example, when SMs demonstrate less than optimal performance the clinician should be able to identify the fault in technique and prescribe specific exercises or training maneuvers. For example, one of the more common faults in performance is the inability to flex the anatomical knee and balance on the toe of the prosthesis. The therapist could prescribe a program of selected exercises to eccentrically strengthen the knee and hip extensors with a combination of standing balance progressing to more dynamic movement activities, such as maintaining standing balance while catching and throwing a ball. In time, the SM would progress to a series of jumping drills, then rapid change of direction drills, staying on the toe of the prosthesis and sensing the deflection of the prosthetic foot. Finally, the drills would advance to military- or athletic-related maneuvers, using the new skills with the prosthesis. Throughout the training process, the CHAMP should be readministered to monitor change over time and reassess treatment protocols and movement patterns, as well as provide motivation to the SM.

ADDITIONAL WORK

While the articles in this single-topic section of *JRRD* report the development and psychometric properties of the CHAMP, the applicability of this outcome tool for a broader patient population, particularly women and other individuals with lower-limb trauma, requires further investigation. Women have taken part in wartime activity on and off the battlefield in every conflict fought by the United States. Beginning in the Gulf War in 1991 and continuing in recent conflicts in Iraq and Afghanistan, women have compromised at least 10 percent of all AD personnel, serving in key combat support functions, driving trucks, flying planes and helicopters, running prisoner-of-war facilities, directing artillery, and serving in port and construction battalions [21]. January 23, 2013, was a historic day for women in the military. On that day, the Pentagon lifted the ban on women in combat [22]. With a greater involvement in battlefield activity, a risk exists for traumatic musculoskeletal injury and lower-limb loss. Recent reports suggest that 3 percent of female SMs with traumatic lower-limb loss from OIF/OEF is consistent with the national average of civilian females with traumatic amputations [8,23]. Stinner et al. were the first to report on female SMs returning to AD following combat-related traumatic lower-limb loss and demonstrated a similar return to AD rate as male SMs (18.2% vs 16.4%) [8]. Like their male counterparts, female SMs with traumatic lower-limb loss are required to perform high-level mobility activities in order to return to AD; thus, future research should help to establish normative CHAMP data for female SMs to determine threshold levels of performance.

Other populations of civilians who present with musculoskeletal injuries to the lower limbs who want and need to return to high-level activity could benefit from having established baseline or normative CHAMP data to aid in goal setting throughout the rehabilitation process. For example, student athletes, adult recreational athletes, or professional athletes who experience ankle or knee joint ligament injuries could benefit equally from using the CHAMP to assess rehabilitation progress. The CHAMP is a safe and unique performance-based outcome measure that quantifies high-level mobility capability during the performance of uniplanar, biplanar, and multiplanar movement. The CHAMP could be administered early on in the rehabilitation program once full weight-bearing is approved by the physician. In addition, the CHAMP could also be used to assess current high-level mobility capabilities in nondisabled athletic individuals before and after intervention, training, or athletic season. Collecting baseline CHAMP data provides both the clinician and individual with the preinjury high-level mobility performance or a benchmark to meet in order to return to high-level activity following injury.

CONCLUSIONS

The clinical use of outcome measures is more than just recording a score and documenting a one-time performance. Specific outcome measures can assist clinicians with classifying patient populations, predicting functional capabilities, detecting patient performance over time, determining specific variables that may limit function, and aiding in better exercise and prosthetic prescriptions. While determining whether a specific outcome measure is capable of some or all of these attributes may be a challenging task, further research can elucidate the CHAMP's role as a viable clinical tool. Moreover, as increasing pressure is applied to rehabilitation professionals to conduct comparative effectiveness research and demonstrate efficacy of interventions, outcome tools such as the CHAMP will likely be vital to the future of the profession.

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