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ORIGINAL REPORT

LINKING CEREBRAL PALSY UPPER LIMB MEASURES TO THE INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY AND HEALTH

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Background: **Intervention studies describe outcomes as measuring specific domains of the International Classification of Functioning, Disability and Health (ICF). However, the same measure may be described by different authors as assessing different domains, resulting in considerable confusion and inconsistent reporting of outcomes.**
Objective: **To systematically link the scored items from the Melbourne Assessment of Unilateral Upper Limb Function, Quality of Upper Extremity Skills Test and Assisting Hand Assessment to domain(s) of the ICF.**
Methods: **The meaningful concept for each scored item was defined. Using ICF linking rules, the concepts were assigned ICF codes to determine the outcome's overall domain of measurement.**
Results: **The Melbourne Assessment predominantly evaluates concepts in the body function domain. Coding of the Quality of Upper Extremity Skills Test indicated that dissociated movement, weight-bearing and protective extension predominantly measure concepts in the body function domain. Grasp was the only domain where concepts were coded in both the body function and activity domains. The Assisting Hand Assessment was the only measure where the majority of items assessed concepts in the activity domain.**
Conclusion: **Measures of upper limb function can be categorized according to ICF domains. These findings should resolve confusion surrounding the classification of these measures and provide a reference for reporting the impact of intervention.**

Key words: cerebral palsy; assessment; upper extremity.

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INTRODUCTION

International Classification of Functioning, Disability and Health

The International Classification of Functioning, Disability and Health (ICF) was developed in 2001 by the World Health Organization (WHO) as a framework for measuring health and disability, based on a global consensus of multiple stakeholders (1). The WHO did not intend for the ICF to act as a static framework, rather it was to respond to researcher, clinician and consumer feedback with ongoing development and future revision. As such, recognition of the need for an ICF version that could be universally adopted for children and youth led to the publication of a specific version known as the ICF-Children and Youth (ICF-CY) (2). This adaptation was designed to record the unique characteristics of the developing child and their surrounding environment (2).

Over the past decade, the ICF conceptual framework and language has emerged as the international standard across health-related disciplines for understanding and communicating an individual's health condition and functioning. Jette (3) acknowledges understanding of this framework as fundamental to advancing the science of disablement. The ICF views human functioning as a concept along a continuum that encompasses the domains of body functions and structures, activities and participation. Using this framework, the ability of an individual to function is seen as a dynamic interaction between elements of these domains and influenced by contextual factors including environmental and personal factors (1). The multi-dimensional framework and language of the ICF bear similarities with other disablement models such as Nagi's (4) Disablement Model, which considers the health condition in association with personal and environmental factors as influences in functioning and disability. It is also consistent with the dynamic and interactive view of person and environment that underpin the core philosophies of occupational therapy practice (5) including the Model of Human Occupation (MOHO) (6) and the Canadian Model of Occupational Performance (CMOP) (7).

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Across health-related disciplines, the ICF framework has acted to translate many discipline-specific concepts allowing the explicit identification and reporting of domains of practice and treatment effect in a commonly understood language (8). The development of linking rules by Cieza et al. (9) has also provided a standardized procedure to enable intervention and outcome measures to be linked to the ICF. Importantly, this provides "a connecting framework between interventions and outcome measures, facilitating the selection of the most appropriate outcome measure for the aim of the intervention" (10).

Cerebral palsy and the influence of the ICF

Cerebral palsy is a health condition that describes "a group of disorders of the development of movement and posture causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain" (11). The integration of the term *activity limitation* in the most recent description of cerebral palsy by Rosenbaum et al. (11) serves as evidence for the recognition and endorsement of the ICF as the framework for articulating and reporting outcomes related to children with cerebral palsy. Rosenbaum & Stewart (12) note the influence of the ICF upon cerebral palsy assessment and treatment as it has helped to expand thinking beyond fixing impairments to promoting functional activity and full participation of children in life activities. As a result, recent research has placed more emphasis on what children actually do rather than what they can do in a controlled environment or how normal their movements appear. This shift has significantly influenced the treatment of hand function in children with hemiplegic cerebral palsy and has lead to greater promotion, exploration and targeting of outcomes related to the activity and participation domain of the ICF.

ICF: Activity and Participation domain

The ICF defines activity as "the execution of a task or action by an individual" and participation as "involvement in a life situation" (1). The WHO reports that this domain can be used to denote activities or participation or both. The domain is further delineated by two qualifiers known as capacity and performance. Capacity describes an individual's ability to execute actions or tasks in an optimal environment and performance describes what an individual does in his or her current environment or the real world (2). The ICF has led to a greater understanding that maximal capacity demonstrated during optimal conditions is not automatically an indicator of performance in everyday life (13). The gap between capacity and performance often reflects the impact of the ideal and current environment, providing a useful guide as to what can be altered or adapted in the individual's environment to improve performance.

In 2003, Jette et al. (14) initially distinguished activity and participation as two separate concepts, however the authors later questioned the wisdom of adopting this view (3, 15). Unfortunately, the lack of operationally defined distinction between activity and participation currently remains the ICF's greatest limitation (3, 16). It is felt that the ability to separate this domain as two distinct concepts remains essential if the ICF is to achieve longstanding acceptance as an international classification framework (3, 17). In addition, precise internal coherence within the ICF is necessary for the understanding of constructs within existing and newly developed assessment tools (3).

Despite the current lack of clarity in operational differentiation, occupational therapists, along with other health professionals, often view activity and participation as distinct concepts for both measurement and the articulation of health-related outcomes for children with cerebral palsy. This is particularly evident in recent cerebral palsy literature, where clinical measures have been categorized as distinct activity (18, 19) or participation measurement tools (20, 21). In addition, further differentiation within the activity domain of the ICF has also seen the capacity and performance qualifiers being used to categorize activity domain measures (18, 22, 23).

Inconsistency in reported ICF classification of upper limb measurement tools

There are a few commonly used outcome measures for children with cerebral palsy, such as the Quality of Upper Extremity Skills Test (QUEST) (24) and the Melbourne Assessment of Unilateral Upper Limb Function (Melbourne Assessment) (25), that have been used to evaluate change following upper limb intervention over the past two decades. Recently, the Assisting Hand Assessment (AHA) (26) has also emerged as a popular outcome measure. The lack of clear definition of, and distinction between, body function, activity and participation, and varying interpretation of the conceptual nature of these ICF domains has lead to inconsistent categorization of these commonly used outcome measures. This has led to inconsistent reporting of the type of outcome that can be expected following intervention. Inconsistencies are particularly evident for these 3 measures where items appear to assess change across more than one domain of the ICF. In addition, many items are administered within the context of functional activities; however the specific scoring criteria for these items measure components of the movement or body functions within the activity, rather than the outcome of the activity itself. Therefore, what might appear to be a change in activity level performance may actually reflect change in the body function domain. For example, the *reach to brush from forehead to back of neck* item in the Melbourne Assessment is scored from observation of the child performing the action of brushing the palm of their hand from their forehead to the back of their neck. Scoring this item involves rating two movement components observed as the child performs the action. These components are active range of movement (B7011, B7601) and fluency (B7651), both of which are items in the body function domain of the ICF.

This confusion has had detrimental effects on the interpretation of research outcomes. Without further clarification this confusion has the potential to hamper communication between researchers and clinicians and the advancement of knowledge on outcomes related to upper limb intervention in children with cerebral palsy. This is particularly relevant for emerging research that aims to explore relationships and interactions between domains of the ICF (23).

Current classifications of the Melbourne Assessment, QUEST and AHA according to ICF domains, as reported in cerebral palsy intervention trials and review papers are summarized in Table I. This summary highlights the current inconsistency in ICF classification and interpretation for these measures. The Melbourne Assessment has exclusively been classified as an activity domain measure, except by Wasiak et al. (27), and Hoare & Imms (28) who initially provided the classification of body function/body structure and, later, a combination of both body function/body structure and activity (29). A similar issue exists for the QUEST, where 5 out of 9 papers report the tool as a measure of activity. Hoare & Imms (28) and Olesch et al. (30), however, assign a classification of body function/body structure. Hoare et al. (29) later provided a classification of both body function/structure and activity, which was consistent with Klingels et al. (31). The only assessment to demonstrate consensus across all papers was the AHA, where all authors classified it as an activity level measure.

Table I. *Upper limb cerebral palsy studies providing classification of measures according to International Classification of Functioning, Disability and Health (ICF) domains*

Study name	Study type	Reported ICF domain
Melbourne		
Wasiak et al., 2004 (27)	BoNT-A review	BF
Boyd, 2004 (32)	BoNT-A RCT	ACT
Hoare & Imms, 2004 (28)	BoNT-A review	BF
Speth et al., 2005 (33)	BoNT-A RCT	ACT
Reeuwijk et al., 2006 (34)	BoNT-A review	ACT
Wallen et al., 2008 (35)	CIMT pilot study	ACT
Klingels et al., 2008 (31)	Reliability study	ACT
Sakzewski et al., 2009 (36)	UL systematic review	ACT
Baird & Vargus-Adams, 2009 (37)	Outcome review	ACT
Gilmore et al., 2009 (18)	Outcome review	ACT
Braendvik et al., 2009 (23)	Outcome relationship study	ACT
Boyd et al., 2010 (38)	RCT methodology	ACT
Hoare et al., 2010 (29)	BoNT-A review	BF & ACT
QUEST		
Hoare & Imms, 2004 (28)	BoNT-A review	BF
Reeuwijk et al., 2006 (34)	BoNT-A review	ACT
Hoare et al., 2007 (39)	CIMT review	ACT
Klingels et al., 2008 (31)	Reliability study	BF & ACT
Olesch et al., 2009 (30)	BoNT-A RCT	BF
Sakzewski et al., 2009 (40)	UL systematic review	ACT
Baird & Vargus-Adams, 2009 (37)	Outcome review	ACT
Gilmore et al., 2009 (18)	Outcome review	ACT
Hoare et al., 2010 (29)	BoNT-A review	BF & ACT
AHA		
Gordon, 2007 (41)	Commentary	ACT
Hoare et al., 2007 (39)	CIMT review	ACT
Wallen et al., 2008 (35)	CIMT pilot study	ACT
Braendvik et al., 2009 (23)	Outcome relationship study	ACT
Boyd et al., 2010 (38)	RCT methodology	ACT
Hoare et al., 2010 (29)	BoNT-A review	ACT

Melbourne: Melbourne Assessment of Unilateral Upper Limb Function; QUEST: Quality of Upper Extremity Skills Test; AHA: Assisting Hand Assessment; ACT: ICF Activity domain; BF: ICF Body Function domain; BoNT-A: botulinum toxin-A; RCT: randomized controlled trial; CIMT: constraint-induced movement therapy; UL: upper limb.

Aim

The aim of this paper is to systematically define and objectively link the meaningful concepts of scored items contained in 3 commonly administered standardized upper limb outcome measures used in cerebral palsy research, i.e. the Melbourne Assessment, QUEST and AHA, to specific codes within the ICF-CY. This process aims to: (*i*) resolve current confusion with identifying the conceptual understanding and domain classification of these important outcomes; (*ii*) serve as an important reference for clinicians and researchers for identifying and reporting the impact of upper limb intervention for children with hemiplegic cerebral palsy; and (*iii*) assist in the selection of appropriate outcome tools for future intervention trials. The paper does not aim comprehensively to describe or review the psychometric properties of each measure as these are been reported elsewhere in the literature (25, 42–44).

METHODS

The meaningful concept for each scored item on the Melbourne Assessment, QUEST and AHA were defined with careful consideration of the test situation, rationale and purpose of each measure. Using the 8 revised ICF linking rules outlined by Cieza et al. (10) (Appendix SI, available from http://www.medicaljournals.se/jrm/content/?doi=10.2340/16501977-0886), the meaningful concepts were assigned ICF-CY codes to determine the outcome's overall ICF domain of measurement. Where possible, codes were assigned at the fourth level, indicated by 4 digits following the prefix. Items not specifically meeting fourth level ICF-CY descriptions were coded at the third level. Two raters (BH, MR) independently linked codes from the ICF-CY to the meaningful concept for individual items on each outcome measure. A third independent rater (CI) evaluated the assigned codes for agreement. Any disagreements were resolved by discussion between the 3 raters.

RESULTS

Tables II–IV provide a description of scored items, meaningful concept and consensus agreement for the ICF-CY codes assigned to each item for the Melbourne Assessment, QUEST and the AHA. Many of the activities within each measure included multiple scored items. For example, the release of crayon item in the Melbourne Assessment required scoring of range of movement, quality of movement and accuracy of release. Through discussion of this item consensus was reached and 3 distinct meaningful concepts were identified for each score. As a result, individual items for each measure could be assigned multiple ICF codes.

Assignment of ICF-CY codes to the meaningful concepts of score items on the Melbourne Assessment indicated that this assessment predominantly evaluates change at the body function domain of the ICF-CY (see Table II). Only 1/37 scored items relates to the activity domain alone, whilst 19/37 relate to body function and, 16/37 a combination of both body function and activity. One item, speed of upper limb movement on reach to mouth, was not definable. Consistent with the purpose of the Melbourne Assessment, to quantify the quality of upper limb motor function in children with unilateral upper limb impairment, the majority of the items score mobility of joints, control of simple or complex

Table II. *International Classification of Functioning, Disability and Health (ICF) classification codes for the Melbourne Assessment of Unilateral Upper Limb Function*[a]

Scored item	Meaningful concept	ICF code	Description	ICF domain
1) Reach forwards				
1.1 ROM	Active ROM at shoulder, elbow and wrist on reach	B7101	Mobility of several joints	BF
1.2 Target accuracy	Ability to reach with precision to a target	D4452	Reaching	ACT
		B7600	Control of simple voluntary movements	BF
1.3 Fluency	Smoothness of UL movement	B7651	Tremor	BF
2) Reach forwards to an elevated position				
2.1 ROM	Active ROM at shoulder, elbow and wrist on reach	B7101	Mobility of several joints	BF
2.2 Target accuracy	Ability to reach with precision to a target	D4452	Reaching	ACT
		B7600	Control of simple voluntary movements	BF
2.3 Fluency	Smoothness of UL movement	B7651	Tremor	BF
		B7602	Coordination of voluntary movements	BF
3) Reach sideways to an elevated position				
3.1 ROM	Active ROM at shoulder, elbow and wrist on reach	B7101	Mobility of several joints	BF
3.2 Target accuracy	Ability to reach with precision to a target	D4452	Reaching	ACT
		B7600	Control of simple voluntary movements	BF
3.3 Fluency	Smoothness of UL movement	B7651	Tremor	BF
4) Grasp of crayon	Thumb and finger movements used when holding a crayon	D4401 B7101	Grasping Mobility of several joints	ACT BF
5) Drawing grasp	Thumb, finger and forearm movements used to actively direct movement of crayon when drawing	D4401 B7601 B7101	Grasping Control of complex voluntary movements Mobility of several joints	ACT BF BF
6) Release of crayon				
6.1 ROM	Range of wrist, thumb and finger movements when releasing crayon	B7101 D4403	Mobility of several joints Releasing	BF ACT
6.2 QOM	Precision and co-ordination of finger and thumb movements when releasing crayon	B7602 D4403	Coordination of voluntary movement Releasing	BF
6.3 Release Accuracy	Ability to control release of crayon into a container	D4403 B7601	Releasing Control of complex voluntary movements	ACT BF
7) Grasp of pellet	Thumb and finger movements used when holding a pellet	D4401 B7101	Grasping Mobility of several joints	ACT BF
8) Release of pellet				
8.1 ROM	Range of wrist, thumb and finger movements when releasing pellet	B7101 D4403	Mobility of several joints Releasing	BF ACT
8.2 QOM	Precision and co-ordination of finger and thumb movements when releasing pellet	B7602 D4403	Coordination of voluntary movements Releasing	BF ACT
8.3 Release Accuracy	Ability to control release of pellet into container	D4403 B7601	Releasing Control of complex voluntary movements	ACT BF
9) Manipulation				
9.1 Finger dexterity	Co-ordination of finger and thumb movements when manipulating a block	D4402	Manipulating	ACT
9.2 Fluency	Smoothness of finger movement when manipulating a block	B7651	Tremor	BF
10) Pointing				
10.1–10.4	Ability to reach with precision to a target and isolate index finger movement to accurately point	B7600 D440	Control of simple voluntary movements Fine hand use	BF ACT
11) Reach to brush from forehead to back of neck				
11.1 ROM	Active ROM at shoulder, elbow, forearm and wrist on reach to forehead	B7101 B7601	Mobility of several joints Control of complex voluntary movements	BF BF
11.2 Fluency	Smoothness of UL movement on reach to head	B7651	Tremor	BF
12) Palm to bottom				
12.1 ROM	Active ROM at shoulder, elbow, forearm and wrist on reach to bottom	B7101 B7601	Mobility of several joints Control of complex voluntary movements	BF BF
12.2 Fluency	Smoothness of UL movement on reach to bottom	B7651	Tremor	BF
13) Pronation/ supination	Active range of forearm movement	B7100	Mobility of a single joint	BF
14) Hand to hand transfer	Ability to coordinate sequential actions of left and right hands when transferring an object between hands	B7602	Coordination of voluntary movements	BF

15) Reach to opposite shoulder				
15.1 ROM	Active ROM at shoulder, elbow and wrist on r each to opposite shoulder	B7101 B7601	Mobility of several joints Control of complex voluntary movements	BF BF
15.2 Target accuracy	Ability to reach to opposite shoulder with precision	D4452 B7600	Reaches Control of simple voluntary movements	ACT BF
15.3 Fluency	Smoothness of UL movement on reach to opposite shoulder	B7651	Tremor	BF
16) Hand to mouth and down				
16.1 ROM	Active ROM at shoulder, elbow and wrist on reach to mouth	B7101	Mobility of several joints	BF
16.2 Target accuracy	Ability to reach to mouth with precision	B7602	Coordination of voluntary movements	BF
16.3 Fluency	Smoothness of UL movement on reach to mouth	B7651	Tremor	BF
16.4 Speed	Speed of UL movement on reach to mouth	nd-ph	Not definable	

[a]The overall aim of the Melbourne Assessment is to score the quality of unilateral upper-limb motor function based on items involving reach, grasp, release, and manipulation (24). The test is administered using standardized items from a test kit to elicit specific movements and actions that simulate functional tasks. Standardized verbal instructions are provided by the test administrator and the performance is videotaped for scoring.
ROM: range of movement; QOM: quality of movement; UL: upper limb; BF: ICF Body Function/Structure domain; ACT: ICF Activity domain.

Table III. *International Classification of Functioning, Disability and Health (ICF) classification codes for the Quality of Upper Extremity Skills Test*[a]

Scored item	Meaningful concept	ICF code	Description	ICF domain
Dissociated Movement Domain				
1.1 Shoulder flexion	Active ROM at shoulder, elbow, wrist	B7101	Mobility of several joints	BF
1.2 Shoulder flexion	Active ROM at shoulder, elbow, wrist, fingers	B7101	Mobility of several joints	BF
1.3 Shoulder abduction	Active ROM at shoulder, elbow, wrist	B7101	Mobility of several joints	BF
1.4 Shoulder abduction	Active ROM at shoulder, elbow, wrist, fingers	B7101	Mobility of several joints	BF
1.5 Elbow flexion	Active ROM at elbow	B7100	Mobility of a single joint	BF
1.6. Elbow extension	Active ROM at elbow	B7100	Mobility of a single joint	BF
1.7 Elbow flexion	Active ROM at elbow	B7100	Mobility of a single joint	BF
1.8 Elbow extension	Active ROM at elbow	B7100	Mobility of a single joint	BF
1.9 Wrist extension	Active ROM wrist, elbow	B7100	Mobility of several joints	BF
1.10 Wrist extension	Active ROM wrist, elbow	B7101	Mobility of several joints	BF
1.11 Wrist extension	Active ROM wrist, elbow	B7101	Mobility of several joints	BF
1.12 Wrist extension	Active ROM wrist, elbow	B7101	Mobility of several joints	BF
1.13 Wrist flexion	Active ROM wrist, elbow	B7101	Mobility of several joints	BF
1.14 Independent finger wiggling	Ability to isolate independent finger movements with/without associated reactions	B7601	Control of complex voluntary movement	BF
1.15 Independent thumb movement	Ability to isolate independent thumb movement with/without associated reactions	B7600	Control of simple voluntary movements	BF
1.16 Grasp of cube using thumb	Ability to grasp a cube using the thumb with a neutral shoulder, extended elbow and neutral to extended wrist	D4401 B7101	Grasping Mobility of several joints	ACT BF
1.17 Grasp of cube using palm	Ability to grasp a cube using the palm with a neutral shoulder, extended elbow and neutral to extended wrist	D4401 B7101	Grasping Mobility of several joints	ACT BF
1.18 Release of cube from thumb and fingers	Able to release a cube from the thumb and fingers with a neutral shoulder, flexed elbow and neutral to extended wrist	D4403 B7101	Releasing Mobility of several joints	ACT BF
1.19 Release of cube from palm	Able to release a cube from the palm with a neutral shoulder, flexed elbow and neutral to extended wrist	D4403 B7101	Releasing Mobility of several joints	ACT BF
Grasps domain				
2.1 Sitting posture (Head)	Posture/control of the head when grasping in seated position	B755 D4155	Involuntary movement reaction functions Maintaining head position	BF ACT
2.2 Sitting posture (Trunk)	Posture/control of the trunk when grasping in seated position	B755 D4153	Involuntary movement reaction functions Maintaining a sitting position	BF ACT
2.3 Sitting posture (Shoulder)	Posture/control of the shoulder when grasping seated position	B755	Involuntary movement reaction functions	BF
2.4 Radial digital grasp (cube)	In sitting, able to use a radial digital grip, with the wrist in a neutral to extended position, to pick up a cube	D4400 B7101 B7601	Picking up Mobility of several joints Control of complex voluntary movements	ACT BF BF
2.5 Radial palmar grasp (cube)	In sitting, able to use a radial palmar grip, with the wrist in a neutral to extended position, to pick up a cube	D4400 B7101 B7601	Picking up Mobility of several joints Control of complex voluntary movements	ACT BF BF
2.6 Palmar grasp (cube)	In sitting, able to pick up a cube using a palmar grasp	D4400 B7100 B7600	Picking up Mobility of a single joint Control of simple voluntary movements	ACT BF BF

2.7 Fine pincer grasp (cereal)	In sitting, able to use a fine pincer grip, with the wrist in a neutral to extended position, to pick up a piece of cereal	D4400 B7101 B7601	Picking up Mobility of a several joints Control of complex voluntary movements	ACT BF BF
2.8 Pincer grasp (cereal)	In sitting, able to use a pincer grip, with the wrist in a neutral to extended position, to pick up a piece of cereal	D4400 B7101 B7601	Picking up Mobility of several joints Control of complex voluntary movements	ACT BF BF
2.9 Inferior pincer grasp (cereal)	In sitting, able to use an inferior pincer grip to pick up a piece of cereal	D4400 B7101 B7601	Picking up Mobility of several joints Control of complex voluntary movements	ACT BF BF
2.10 Scissor (cereal)	In sitting, able to use a scissor grip to pick up a piece of cereal	D4400 B7101 B7601	Picking up Mobility of several joints Control of complex voluntary movements	ACT BF BF
2.11 Inferior scissor (cereal)	In sitting, able to use an inferior scissor grip to pick up a piece of cereal	D4400 B7101 B7601	Picking up Mobility of several joints Control of complex voluntary movements	ACT BF BF
2.12 Dynamic tripod grasp (pencil)	Able to independently pick up a pencil/crayon and adopt a dynamic tripod grip. Observe where pencil is grasped and the position of the thumb, index and middle finger	D4400 B7601	Picking up Control of complex voluntary movements	ACT BF
2.13 Static tripod grasp (pencil)	Able to independently pick up a pencil/crayon and adopt a static tripod grip. Observe where pencil is grasped and the position of the thumb, index and middle finger	D4400 B7601	Picking up Control of complex voluntary movements	ACT BF
2.14 Digital pronate grasp (pencil)	Able to independently pick up a pencil/crayon. Observe the position of the forearm, wrist, thumb and fingers	D4400 B7601	Picking up Control of complex voluntary movements	ACT BF
2.15 Palmar supinate grasp (pencil)	Able to independently pick up a pencil/crayon. Observe the position of the forearm, wrist, thumb and fingers	D4400 B7601	Picking up Control of complex voluntary movements	ACT BF
Weight-bearing domain				
3.1 – 3.6 Weight bearing	Ability to bear weight on arms in prone/4-point kneeling. Observe the position of elbow, fingers, thumb	B7101 B7603	Mobility of several joints Supportive functions of arm or leg	BF BF
3.7 – 3.8 Weight bearing with reach	Ability to bear weight on a fully extended right and left arm while reaching with the other arm.	B7101 B7603 D4452	Mobility of several joints Supportive functions of arm or leg Reaching	BF BF ACT
3.9 – 3.14 Hands forward	While sitting, ability to bear weight on arms with hands forward. Observe the position of shoulders, elbows, fingers, thumbs.	B7101 B7603	Mobility of several joints Supportive functions of arm or leg	BF BF
3.15 – 3.20 Hands by side	While sitting, ability to bear weight on arms with hands by side. Observe the position of shoulders, elbows, fingers, thumbs.	B7101 B7603	Mobility of several joints Supportive functions of arm or leg	BF BF
3.21 – 3.26 Hands behind	While sitting, ability to bear weight on arms with hands behind. Observe the position of shoulders, elbows, fingers, thumbs.	B7101 B7603	Mobility of several joints Supportive functions of arm or leg	BF BF
Protective extension domain				
4.1 – 4.6 Forward	Demonstrates forward UE equilibrium reactions. Observe the position of elbow, fingers	B7101 B755	Mobility of several joints Involuntary movement reaction functions	BF BF
4.7 – 4.12 Side	Demonstrates sideways UE equilibrium reactions. Observe the position of elbow, fingers	B7101 B755	Mobility of several joints Involuntary movement reaction functions	BF BF
4.13 – 4.18 Backward	Demonstrates backwards UE equilibrium reactions. Observe the position of elbow, fingers	B7101 B755	Mobility of several joints Involuntary movement reaction functions	BF BF

[a]The overall aim of the QUEST is to "evaluate quality of upper extremity function in four domains: dissociated movement, grasp, protective extension, & weight bearing" (23). The test is administered using non-standardized items to facilitate specific movements. Positions must be held for 2 s and verbal/physical prompts can be provided to encourage the required movement.
BF: ICF Body Function/Structure domain; ACT: ICF Activity domain; ROM: range of movement; UE: upper extremity.

movement and tremor. The items in the Melbourne Assessment that measure activity level performance within the ICF-CY include concepts of hand skill development such as grasp, release, manipulation, pointing and reaching (see Table II).

The QUEST includes 34 items that evaluate both upper extremities separately in 4 domains including: dissociated movement, grasp, protective extension, and weight-bearing. Each meaningful concept for scored items from the 4 domains were coded separately. Dissociated movement items predominantly measure concepts in the body function domain with 15/19 scored items coded as the body function alone and the remaining 4/19 a combination of body function and activity. A similar outcome was obtained for weight-bearing, with 24/26 scored items coded as body function alone and 2/26 a combination of body function and activity. All meaningful concepts for protective extension were in the body function domain (18/18). Grasp was the only domain of the QUEST where concepts for scored items were coded as both the body function and activity (14/15). The remaining item was in the body function domain (1/15; Table III).

Table IV. *International Classification of Functioning, Disability and Health (ICF) classification codes for the Assisting Hand Assessment*[a]

Scored item	Meaningful concept	ICF code	Description	ICF domain
1) Approaches objects	Whether the AH is used to stabilize objects	D445	Hand and arm use	ACT
2) Initiates use	How quickly the child initiates use of the AH	D445	Hand and arm use	ACT
3) Chooses AH when closer to objects	How the AH is used when an object in placed beside the child on the affected side	D445	Hand and arm use	ACT
4) Stabilizes by weight or support	The effectiveness of stabilization of objects	D445	Hand and arm use	ACT
5) Reaches	How a child reaches with AH for objects placed on the table	D4452	Reaching	ACT
	Range of motion at shoulder and elbow	B7101	Mobility of several joints	BF
6) Moves upper arm	Range and frequency of active movement at the shoulder	B7100	Mobility of a single joint	BF
7) Moves Forearm	Range and frequency of active movement at the shoulder	B7100	Mobility of a single joint	BF
8) Grasps	Whether objects are grasped with the AH and where objects are grasped from.	D4400	Picking up	ACT
		D4401	Grasping	ACT
9) Holds	How objects are held in the AH Types of objects held in AH	D4401	Grasping	ACT
10) Stabilises by grip	How effectively objects are stabilized in the AH using grip	D440	Fine hand use	ACT
		D4401	Grasping	ACT
11) Readjusts grip	Ability and frequency in re-grasping objects using the AH	D440	Fine hand use	ACT
		D4401	Grasping	ACT
12) Varies type of grasp	Types of grasps used	D440	Fine hand use	ACT
	Frequency of grasp types used	D4401	Grasping	ACT
13) Releases	Where objects are released to with the AH Speed of release of objects	D4403	Releasing	ACT
14) Puts down	Where objects are released to with the AH Precision of release	D4305	Putting down objects	ACT
15) Moves fingers	Range and frequency of active finger/thumb movement	B7107	Mobility of several joints	BF
16) Calibrates	Regulation of grip force	D440	Fine hand use	ACT
		B7300	Power of isolated muscles and muscle groups	BF
17) Manipulates	How objects are moved in the AH	D4402	Manipulating	ACT
18) Coordinates	Coordination of the left and right hand/arm	B7602	Coordination of voluntary movements	BF
19) Orients objects	How objects are oriented and positioned during task performance	B7602	Coordination of voluntary movements	BF
		D4453	Turning or twisting the hands or arms	ACT
		D4401	Grasping	ACT
20) Proceeds	Pace of task performance	B1470	Psychomotor control	BF
21) Changes strategy	Pace and how task performance is adapted as a result of actions	B1472	Organisation of psychomotor functions	BF
		D1750	Solving simple problems	ACT
		D3101	Comprehending simple spoken messages	ACT
		D3150	Comprehending with – receiving – body gestures	ACT
22) Flow in bimanual task performance	The independent performance of tasks and how sequences of actions are affected by limited functions/structures.	B760	Control of voluntary movement functions	BF
		D445	Hand and arm use	ACT

[a]The overall aim of the AHA is to "describe and measure how effectively people with a unilateral dysfunction actually use the affected hand/arm with the well-functioning hand to perform tasks requiring bimanual performance" (25). The test is administered in a play-based context using standardized bimanual toys from a test kit to elicit the child's spontaneous use of the affected hand.

BF: ICF body function/structure domain; ACT: ICF activity domain; AH: Assisting Hand.

The AHA was the only measure where a majority of scored items were found to evaluate concepts in the activity domain or a combination of activity and body function (17/22). Only 5/22 scored items exclusively measured concepts in body function. Many aspects of hand function, including reach, grasp, release, putting down, picking up, and coordination are evaluated in the context of bimanual activities. The AHA is distinct from the Melbourne Assessment and QUEST as some concepts include the use of cognitive strategies required for hand function including solving simple problems, comprehending simple spoken messages and body gestures (Table IV).

DISCUSSION

Using the ICF, a universally acknowledged framework for measuring health and disability, this paper has defined the meaningful concept for each scored item on the Melbourne Assessment, the QUEST and the AHA. The Melbourne Assessment and the QUEST were found to predominantly include concepts within the body function domain, whilst the AHA predominantly includes concepts in the activity domain. All assessments however, possess items that include concepts within both the body function and activity domains.

Despite recent findings demonstrating a high correlation between the Melbourne Assessment and the QUEST (indicating concurrent validity) (31), the Melbourne Assessment's emphasis on evaluation of quality of movement provides distinctly different information when compared with the QUEST. The Melbourne Assessment includes multiple test items that measure control of simple or complex movement and tremor, making it ideally suited for measurement of children with movement-based disorders such as dystonic or athetoid cerebral palsy. Recently, further investigation of the construct validity of the tool established that the 37 score items on the Melbourne Assessment do not comprise a uni-dimensional scale (45). A series of Rasch analyses established evidence to support the Melbourne Assessment as consisting of 4 separate uni-dimensional sub-scales. The sub-scales identified separately measure elements of movement quality including: range movement, accuracy (of reach and release), fluency of upper limb movement and dexterity (of grasp). These sub-scales, developed for the updated modified Melbourne Assessment (45) will continue to provide measurement at the body function or a combination of both body function and activity domains of the ICF-CY.

The QUEST was designed in 1993 to capture patterns of movement that are part of normal development and considered to be the basis for upper limb performance (43). At a time where a popular emphasis was on the use of neuro-developmental therapy techniques for children with cerebral palsy, the QUEST provided an evaluation tool that was able to measure a child's ability to move out of pathological patterns against gravity and their protective reflex responses (43). Following analysis of longitudinal data obtained using the QUEST, it has been suggested that the impairments that underlie many of the items in the QUEST are unlikely to improve through movement or task-related practice (46). Improved clarity from assignment of ICF-CY codes to the meaningful concepts of the QUEST now provides additional support and evidence for this suggestion. Movement-based interventions predominantly target change in the activity domain. Except for the grasp domain, the QUEST overwhelmingly evaluates concepts in the body-function domain, making it more appropriate for evaluation of interventions that target improvements in body functions. The changes on the QUEST seen in previous clinical intervention trials of movement-based therapies may predominantly be related to change in the grasp domain. This warrants analysis and reporting of the separate domains of the QUEST. Future research evaluating upper limb practice-based or movement-based interventions (i.e. constraint-induced movement therapy, bimanual occupational therapy) in children with cerebral palsy should question the use of total QUEST scores in these trials. Improvements in the body structure and function are unlikely to be associated with similar levels of improvement in activities and participation (47). Expectations and hopes for additional influence across domains are common features of many recent intervention trials targeting change in the body function domain; however, we cannot expect change to be seen in any other domain other than the one on which treatment is focused (48).

Aside from scored items, the administration procedures for the 3 assessments demonstrate important differences. It appears that these differences have contributed to the confusion in the literature surrounding the ICF classification of each measure, particularly the Melbourne Assessment and QUEST. These assessments have often been referred to as measures of a child's capacity (18, 31), suggesting activity domain measurement. In the context of functional activities, administration of the QUEST and in particular, the Melbourne Assessment often requires children to perform test items at their best capacity. The administration process itself however, is not the scored construct. The specific scoring criteria for many of the items measure components of the movement or body functions within these functional activities not the outcome of the activity itself. As demonstrated by the identification of meaningful concepts and application of the ICF coding procedure, it is inappropriate to continue to refer to the Melbourne Assessment or QUEST as measures of activity domain capacity. Only the grasp domain of the QUEST could be used for this purpose as the meaningful concepts for grasp relate to the activity domain or a combination of body function and activity domains.

The central aim of all upper limb motor-based interventions in children with hemiplegic cerebral palsy is to improve the actual use (performance) of their affected upper limb in a range of daily tasks, particularly those requiring bimanual performance (49). As stated by Gordon (41), and now supported by results of this ICF code assignment, at this time the only commonly used upper limb specific activity-level measure of performance for children with hemiplegic cerebral palsy is the AHA, which "sets the criterion standard in quantifying upper limb activity limitation" (41). The AHA has been constructed with the underlying principle that skilled hand use is influenced by a number of complex components including motor, perceptual, cognitive and environmental aspects. These components often represent the areas targeted by therapists using practice or movement-based interventions such as constraint-induced movement therapy or bimanual occupational therapy. Unlike other assessments, the AHA does not set out to capture these specific aspects individually or instruct a child to perform at their best. It attempts to synthesize all these components by observing the actual behaviour or functional use of the assisting hand when performing bimanual tasks (44). Changes on the AHA are therefore more likely to reflect what a child may do in their usual environment or assess the transfer of intervention effects into daily life.

In conclusion, the outcome of this identification and linking process has provided improved clarity and contributed evidence to support the validity of the measured concepts for the Melbourne Assessment, QUEST and AHA. The results can be used to guide clinicians and researchers in the interpretation of upper limb clinical intervention trials for children with cerebral palsy and in the selection of appropriate outcome measures for future intervention trials.

REFERENCES

1. World Health Organization (WHO). International Classification of Functioning, Disability and Health: ICF. Geneva: World Health Organization; 2001.
2. World Health Organization (WHO). International Classification of Functioning, Disability and Health: Children and Youth Version: ICF-CY. Switzerland: WHO Press; 2006.
3. Jette AM. Toward a common language of disablement. J Gerontol Series A: Biol Sci Med Sci 2009; 64: 1165–1168.
4. Nagi S. A study in the evaluation of disability and rehabilitation potential: concepts, methods, and procedures. Am J Public Health 1964; 54: 1568–1579.
5. Stamm TA, Cieza A, Machold K, Smolen JS. Exploration of the link between conceptual occupational therapy models and the International Classification of Functioning, Disability and Health. Austral Occup Ther J 2006; 53: 9–17.
6. Kielhofner G. A model of human occupation: theory and application. 2nd edn. Chicago: Williams and Wilkins; 1995.
7. Law M, Stanton S, Polatajko H, Baptiste S, Thompson-Franson T, Kramer C, et al. Enabling occupation: an occupational therapy perspective. Ottawa: CAOT Publications; 1997.
8. Imms C. The International Classification of Functioning, Disability and Health: they're talking our language. Austral Occup Ther J 2006; 53: 65–66.
9. Cieza A, Brockow T, Ewert T, Amman E, Kollerits B, Chatterji S, et al. Linking health-status measurements to the international classification of functioning, disability and health. J Rehabil Med 2002; 34: 205–210.
10. Cieza A, Geyh S, Chatterji S, Kostanjsek N, Ustun B, Stucki G. ICF linking rules: an update based on lessons learned. J Rehab Med 2005; 37: 212–218.
11. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol 2007; 109: 8–14.
12. Rosenbaum P, Stewart D. The World Health Organization International Classification of Functioning, Disability, and Health: a model to guide clinical thinking, practice and research in the field of cerebral palsy. Semin Pediatr Neurol 2004; 11: 5–10.
13. Krumlinde-Sundholm L, Holmefur M, Eliasson AC. Assisting hand assessment manual: English research version 4.4. Stockholm: Karolinska Institute; 2007.
14. Jette AM, Haley SM, Kooyoomjian JT. Are the ICF activity and participation dimensons distinct? J Rehabil Med 2003; 35: 145–149.
15. Jette AM, Tao W, Haley SM. Blending activity and participation sub-domains of the ICF. Disabil Rehabil 2007; 29: 1742–1750.
16. Guralnik JM, Ferrucci L. The challenge of understanding the disablement process in older persons: commentary responding to Jette AM. Toward a common language of disablement. J Gerontol Series A: Biol Sci Med Sci 2009; 64: 1169–1176.
17. Freedman VA. Adopting the ICF language for studying late-life disability: a field of dreams? J Gerontol Series A: Biol Sci Med Sci 2009; 64: 1172–1176.
18. Gilmore R, Sakzewski L, Boyd R. Upper limb activity measures for 5- to 16-year-old children with congenital hemiplegia: a systematic review. Dev Med Child Neurol 2009; 52: 14–21.
19. Harvey A, Robin J, Morris M, Graham HK, Baker R. A systematic review of measures of activity limitation for children with cerebral palsy. Dev Med Child Neurol 2008; 50: 190–198.
20. Sakzewski L, Boyd RN, Zivianni J. Clinimetric properties of participation measures for 5 to 13 year old children with cerebral palsy: a systematic review. Dev Med Child Neurol 2007; 49: 232–240.
21. Imms C, Reilly S, Carlin J, Dodd K. Diversity of participation in children with cerebral palsy. Dev Med Child Neurol 2008; 50: 363–369.
22. Greaves S, Imms C, Dodd K, Krumlinde-Sundholm L. Assessing bimanual performance in young children with hemiplegic cerebral palsy: a systematic review. Dev Med Child Neurol 2010; 52: 413–421.
23. Braendvik SM, Elvrum A-K, G, Vereijken B, Roeleveld K. Relationship between neuromuscular body functions and upper extremity activity in children with cerebral palsy. Dev Med Child Neurol 2009; 52: e29–e34.
24. DeMatteo C, Law M, Russell D, Pollock N, Rosenbaum P, Walter S. Quality of Upper Extremity Skills Test. Hamilton: Neurodevelopmental Clinical Research Unit, Chedoke-McMaster Hospitals; 1991.
25. Randall M, Carlin JB, Chondros P, Reddihough DS. Reliability of the Melbourne assessment of unilateral upper limb function. Dev Med Child Neurol 2001; 43: 761–767.
26. Krumlinde-Sundholm L, Holmefur M, Kottorp A, Eliasson AC. The Assisting Hand Assessment: current evidence of validity, reliability, and responsiveness to change. Dev Med Child Neurol 2007; 49: 259–264.
27. Wasiak J, Hoare BJ, Wallen M. Botulinum toxin A as an adjunct to treatment in the management of the upper limb in children with spastic cerebral palsy. Cochrane Database Systematic Rev 2004; Issue 4.
28. Hoare BJ, Imms C. Upper-limb injections of botulinum toxin-A in children with cerebral palsy: a critical review of the literature and clinical implications for occupational therapists. Am J Occupat Ther 2004; 58: 389–397.
29. Hoare BJ, Wallen MA, Imms C, Villanueva E, Rawicki HB, Carey L. Botulinum toxin A as an adjunct to treatment in the management of the upper limb in children with spastic cerebral palsy: an update. Cochrane Database of Systematic Rev 2010; Issue 1.
30. Olesch CA, Greaves SM, Imms C, Reid S, Graham HK. Repeat botulinum toxin-A injections in the upper limb of children with hemiplegia: a randomized controlled trial. Dev Med Child Neurol 2009; 52: 79–86.
31. Klingels K, De Cock P, Desloovere K, Huenaerts C, Molenaers G, Van Nuland I, et al. Comparison of the Melbourne Assessment of Unilateral Upper Limb Function and the Quality of Upper Extremity Skills Test in hemiplegic CP. Dev Med Child Neurol 2008; 50: 904–909.
32. Boyd RN. The central and peripheral effects of botulinum toxin A in children with cerebral palsy. DPhil thesis. Victoria: Schools of Human BioSciences and Physiotherapy. Faculty of Health Sciences. La Trobe University; 2004.
33. Speth LAWM, Leffers P, Janssen-Potten YJM, Vles JSH. Botulinum toxin A and upper limb functional skills in hemiparetic cerebral palsy: a randomised trial in children receiving intensive therapy. Dev Med Child Neurol 2005; 47: 468–473.
34. Reeuwijk A, van Schie PEM, Becher JG, Kwakkel G. Effects of botulinum toxin type A on upper limb function in children with cerebral palsy: a systematic review. Clin Rehabil 2006; 20: 375–387.
35. Wallen M, Ziviani J, Herbert RD, Evans R, Novak I. Modified constraint-induced therapy for children with hemiplegic cerebral palsy: A feasibility study. Dev Neurorehabil 2008; 11: 124–133.
36. Sakzewski L, Boyd R, Gilmore R, Corn K, Ziviani J. One hand or two? Randomised trial of constraint-induced movement therapy versus bimanual training for children with congenital hemiplegia. Dev Med Child Neurol 2009; 51 Suppl 2: S57.
37. Baird MW, Vargus-Adams J. Outcome measures used in studies of botulinum toxin in childhood cerebral palsy: a systematic review. J Child Neurol 2009; 25: 721–727.
38. Boyd RN, Sakzewski L, Ziviani J, Abbott DF, Badawy R, Gilmore R, et al. INCITE: a randomised trial comparing constraint induced movement therapy and bimanual training in children with congenital hemiplegia BMC Neurol 2010; 10: 4.
39. Hoare BJ, Wasiak J, Imms C, Carey L. Constraint-induced movement therapy in the treatment of the upper limb in children with hemiplegic cerebral palsy. Cochrane Database of Systematic Rev 2007; Issue 2.
40. Sakzewski L, Ziviani J, Boyd RN. Systematic review and meta-analysis of therapeutic management of upper-limb dysfunction in children with congenital hemiplegia. Pediatrics 2009; 123:

e1111–e1122.
41. Gordon AM. Measuring 'activity limitation' in individuals with unilateral upper extremity impairments. Dev Med Child Neurol 2007; 49: 245.
42. Johnson LM, Randall MJ, Reddihough DS, Oke LE, Byrt TA, Bach TM. Development of a clinical assessment of quality of movement for unilateral upper-limb function. Dev Med Child Neurol 1994; 36: 965–973.
43. DeMatteo C, Law M, Russell DJ, Pollock N, Rosenbaum P, Walter S. The reliability and validity of the Quality of Upper Extremity Skills Test. Phys Occupat Ther Pediatrics 1993; 13: 1–18.
44. Krumlinde-Sundholm L, Eliasson AC. Development of the Assisting Hand Assessment: a rasch-built measure intended for children with unilateral upper limb impairments. Scand J Occupat Ther 2003; 10: 16–26.
45. Randall M. Modification and investigation of the construct validity of The Melbourne Assessment of Unilateral Upper Limb Function. Bundoora: La Trobe; 2009.
46. Hanna SE, Law MC, Rosenbaum PL, King GA, Walter SD, Pollock N, et al. Development of hand function among children with cerebral palsy: growth curve analysis for ages 16 to 70 months. Dev Med Child Neurol 2003; 45: 448–455.
47. Majnemer A. Assessment for cerebral palsy: new directions. Future Neurol 2006; 1: 755–763.
48. Krumlinde-Sundholm L. Aspects of hand function in children with unilateral impairments caused by brachial plexus palsy or hemiplegic cerebral palsy. PhD thesis. Stockholm: Karolinska Institute; 2002.
49. Eliasson AC. Bimanual training for children with unilateral CP – is this something new? Dev Med Child Neurol 2007; 49: 806.