Chapter

Outcome Measures in OBPP

Shivani Gupta, Nivetha Srinivasan, Jasmine Mahajan, Amy Song, Alice Chu and Aleksandra McGrath

Abstract

Traditional outcome measurement scales, such as the Medical Research Council (MRC) score, the Active Movement Scale (AMS), and Mallet score, are used by surgeons to assess outcomes in patients with obstetric brachial plexus palsy (OBPP). The measurement scales used to evaluate patients fall under the International Classification of Functioning (ICF) domains of Body Function, Body Structure, Activity, Participation, and Environment and are used to assess function and disability of patients. Currently used outcome measures scales for OBPP are also contrasted with those used for another perinatal condition affecting the upper limb, cerebral palsy (CP).

Keywords: brachial plexus injury, brachial plexus palsy, evaluation measurement, international classification, outcome assessment

1. Introduction

Patients with OBPP are treated with a multidisciplinary approach. As soon as the diagnosis is suspected, patients are referred to neurology, as well as physical and occupational therapy. Rehabilitation focuses on contracture prevention, including passive range of motion exercises at relevant joints, supportive splints for elbows and hand, and muscle strengthening exercises to promote normal function [1, 2]. Primary or secondary surgical intervention is indicated in cases of severe nerve injury and absent or suboptimal functional recovery. Interventions include nerve microsurgery, joint and bony procedures, tendon lengthening and transfers [3]. Post-operative management after nerve surgery can also include electrical muscle stimulation to facilitate muscle function [4]. Botulinum toxin injections can be used to treat muscle imbalance and contractures. A systematic review identified 4 groups of indicators for botulinum injection: contracture of shoulder adduction, limited active elbow flexion and extension, and pronation contracture of the lower arm [5]. However, specific indications for nerve repair or secondary surgery are largely institution-specific due to a lack of randomized trials and multicenter prospective studies.

Outcomes are often difficult to compare due to the variability of anatomical lesions, variety in surgical technique, and difference in outcome reporting [6]. While the majority of OBPP outcome measurements focus on the functional limitation of the upper extremity, affected children often have associated psychosocial problems, most commonly in the area of activity and participation, such as sports [7]. In comparison to healthy children, children with OBPP have been found to be at high risk for anxiety, depression, and aggression. Mothers with children with OBPP

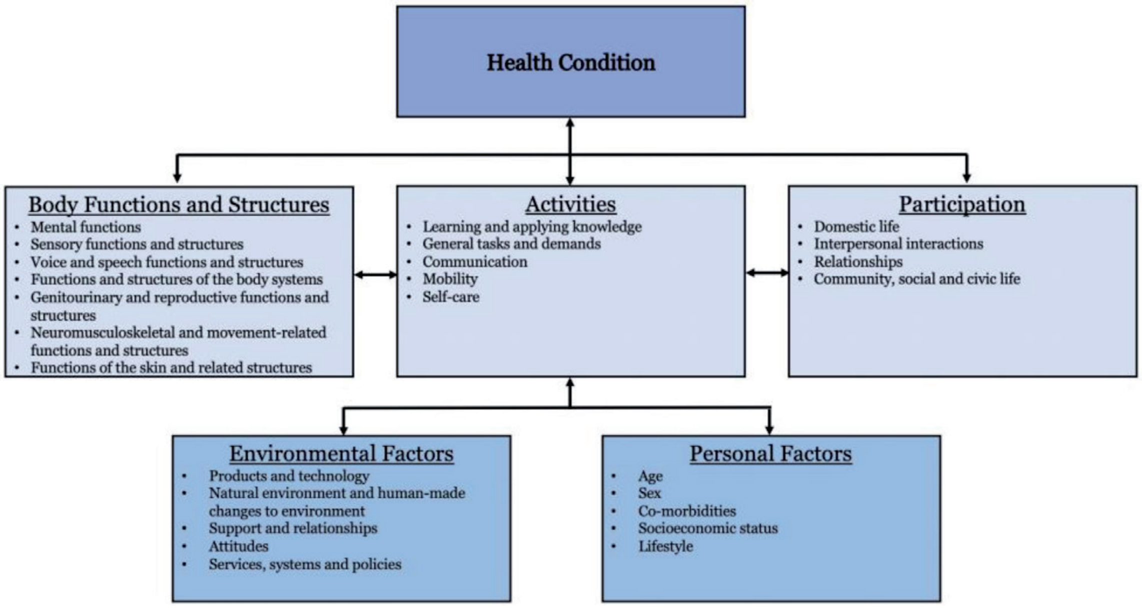

Figure 1.
Integrated ICF Model [9].

have been found to have increased maternal distress compared to mothers with healthy children [8].

The International Classification of Functioning, Disability and Health (ICF) is a validated and valuable tool developed by the World Health Organization for identifying and comparing areas of function and disability of persons in several domains. The ICF framework consists of five domains: body structure, body function, activity, participation, and environmental factors [9]. These domains are detailed in the integrated biopsychosocial model in **Figure 1**. The activity domain evaluates task execution in the context of disablement or physical ability. The participation domain addresses patient involvement in activities of daily living (ADL) or patient self-perception of engagement and psychometric well-being [10]. Children, adolescents, and young adults with OBPP are important stakeholders, and the application of holistic OBPP evaluation that measures various ICF domains can help improve understanding of their situation. In this chapter, we describe all currently used outcome measures for OBPP, map them against domains in International Classification of Functioning, Disability and Health, and contrast OBPP with another perinatal condition affecting the upper limb, cerebral palsy (CP).

2. Outcomes in OBPP

2.1 Traditional OBPP outcome measures

With the onset of World War I and II alongside the spread of poliomyelitis, surgeons and neurologists saw a rapid increase in peripheral nerve injuries in the hospitals. A majority of these cases affected the upper limb, including brachial plexus lesions. In response, the British Medical Research Council (MRC) created the MRC score to examine the limbs for peripheral nerve lesions as seen in **Table 1**. It tested limb segment positioning without and against gravity, and manual resistance was tested to grade muscle strength on a six point scale measuring no activity, flicker, movement with gravity eliminated, movement against gravity, and normal power. Grade 4 is subdivided into 3 categories: slight, moderate, and strong resistance. However, these subdivisions are subjective and thus, levels of resistance are highly

MRC score	
Grade	**Clinical Finding**
0	No contraction
1	Flicker, trace of contraction
2	Active movement with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

Table 1.
MRC score [11].

dependent on the evaluator [11]. The MRC scale has become the most recognized scale for evaluating strength in patients with peripheral nerve injuries, and it is commonly used for assessing elbow flexion in infants with OBPP [12–16]. Individual surgeons often develop and use their own modifications for documenting results, especially for how grade 4 can be defined for different movements or muscles.

Over time, the Gilbert Muscle Grading System emerged in 1987 to address MRC's limitations with manual resistance as seen in **Table 2**. It evaluates shoulder function on a 0–5 point scale, representing: flaccid, no active external rotation (ER) at abduction to 45°, no active ER at abduction to <90°, weak active ER at abduction to 90°, weak active ER at abduction to <120°, and complete active ER at abduction to >120° [17]. The Gilbert shoulder abduction sub score can be converted into the Mallet shoulder abduction sub score by utilizing the corresponding range of motion [18]. In both cases, the MRC scale is not suitable for infants due to the cognitive requirement for the exam [19].

The Miami scale was developed to address the limitation in choosing a grade within the Gilbert system. It totals the score for shoulder abduction and external rotation to calculate a grade of 0–5, where 0 represents no function and 5 is excellent. This score has been found to have a weak correlation with Gilbert and Mallet, but it has not been validated for OBPP [20].

A decade earlier, the Mallet score was created in 1972 to evaluate OBPP injuries on a scale of 1–5 by testing functionality of the affected limb as seen in **Table 3** [21]. Commonly used to assess shoulder abduction before and after surgery, the Mallet score translates grade of shoulder external rotation into degrees of deficiency. A score of 1 corresponds to a flail shoulder and a score of 5 indicating a normal shoulder [22]. The Mallet classification system includes 5 sub scores for shoulder movements: abduction, external rotation, hand to neck, hand on spine, and hand to mouth, to give a maximum score of 25. Active range of motion measurements can be translated into the Mallet scale [21].

Modified versions of the Mallet scale have also been created. In addition to the classical shoulder assessments of the Mallet system, Birch's modified Mallet system evaluates resting position and fixed forearm supination on a scale of 1–5, with 1 being most affected and 5 being normal [23]. Nath et al's modified Mallet system integrates Birch's modification to further define deformity [24]. Terzis and Papakonstantinou created a modified Mallet scale that measures the same shoulder movements as the original Mallet scale, but it uses a scale of 1–4 [25]. Abzug et al's modification measures a 6th sub score to the original Mallet system: hand to belly; this additional internal rotation position improves assessment of postoperative midline function [26, 27].

Gilbert Shoulder Classification	
Grade (Function)	**Clinical Finding**
0 (none)	Flaccid shoulder
1 (poor)	No active external rotation at abduction to 45°
2 (fair)	No external rotation at abduction to 90°
3 (satisfactory)	Weak active external rotation at abduction to 90°
4 (good)	Weak active external rotation at abduction to <120°
5 (excellent)	Complete active external rotation at abduction to >120°

Table 2.
Gilbert Shoulder Classification [17].

Mallet Score	
Grade	**Clinical Finding**
I	Flail shoulder
II	0° of external rotation Active abduction <30° Hand to mouth with marked trumpet sign Hand to back of neck impossible Hand to back impossible
III	External rotation < 20° Active abduction 30°– 90° Hand to mouth possible with partial trumpet sign (> 40° shoulder abduction) Hand to back of neck with difficulty Hand to back with difficulty
IV	External rotation > 20° Active abduction > 90° Hand to mouth easy with <40° shoulder abduction Hand to back of neck easy Hand to back easy
V	Normal shoulder

Table 3.
Mallet score [21].

After noting the deficiencies in the Mallet and MRC scoring systems, the active movement scale (AMS) was created in 1995 as a novel evaluative tool to be used on infants and children at any time point (**Table 4**). While a child is playing, upper limb movement is observed in the gravity-eliminated and anti-gravity planes. At the shoulder, abduction, and adduction, flexion, external rotation, internal rotation are tested; at the elbow, flexion and extension; at the forearm, pronation and supination; at the wrist, finger, and thumb, flexion and extension. AMS is quantified on an 8 point scale (0 for no visible contraction to 7 for full motion) based on the percent of active motion noted within individual joint passive range of motion [28]. It is recommended that the estimated passive range of motion (PROM) be verified with goniometry for accurate scoring [29]. It has showed moderate to excellent reliability in children with OBPP between 1 month and 15 years of age [30]. Active range of motion measurements can be reliably converted to the AMS scale. The extended numerical scale improves distinguishing ability and allows for extended statistical analysis.

However, upper-extremity movements of forearm pronation and supination are less reliably evaluated with AMS [19]. AMS has been shown to be more popular in North America while Europe has shown preference towards MRC. Although it has been shown to work on an extended age range, AMS is typically used in younger children [31]. Though this is the case, AMS is often time consuming in younger children as it requires patience and creativity from the provider and cooperation from the child to elicit all the desired motions [32].

The Toronto Test Score was created in 1994 to predict a child's prognosis prior to microsurgical intervention (**Table 5**). Shoulder flexion, extension, abduction, and external rotation is measured; elbow flexion, radioulnar supination, and wrist extension is also recorded. On a scale of 0 (no motion or contraction) to 7 (full motion), if a 3 month child scores < 3.5, this result recommends nerve surgery [33]. It has been validated for use in children with OBPP. Composite Toronto and AMS scores have demonstrated a strong correlation [34].

In 1993, the Raimondi hand and wrist score was developed specifically for OBPP with a scale ranging from 1, for total palsy, to 5, for nearly normal hand function (**Table 6**). By incorporating sensation and motor function in its evaluation, the Raimondi scale is able to determine extent of hand function [35]. The Gilbert-Raimondi score classifies elbow function in OBPP by analyzing flexion, extension,

AMS Score	
Grade	**Clinical Finding**
0	Gravity eliminated: no contraction
1	Gravity eliminated: contraction, no motion
2	Gravity eliminated: motion < ½ range
3	Gravity eliminated: Motion > ½ range
4	Gravity eliminated: full motion
5	Against gravity: motion < ½ range
6	Against gravity: motion > ½ range
7	Against gravity: full motion

Table 4.
AMS Score [28].

Toronto Score		
Grade	**Clinical Finding**	**Score**
0	Gravity eliminated: no contraction	0
1	Gravity eliminated: contraction, no motion	.3
2	Gravity eliminated: motion < ½ range	.3
3	Gravity eliminated: Motion > ½ range	.6
4	Gravity eliminated: full motion	.6
5	Against gravity: motion < ½ range	.6
6	Against gravity: motion > ½ range	1.3
7	Against gravity: full motion	2

Table 5.
Toronto Test Score [33].

Raimondi Hand Score	
Grade	**Clinical Finding**
0	Complete paralysis or functionally useless finger flexion Non-usable thumbs without grasping function Little or no sensation
1	Limited finger flexion No finger or wrist extension Key grip possible
2	Active wrist extension Passive flexion of fingers (tenodesis) Passive key grip in pronation
3	Complete active finger and wrist flexion Active thumb movement, including abduction and opposition Intrinsic equilibrium No active supination
4	Complete active finger and wrist flexion Active wrist extension but weak finger extension Good opposition of thumb with active ulnar intrinsic muscles Partial pronation and supination
5	Grade 4, but with active finger extension Complete pronation and supination

Table 6.
Raimondi Hand Score [35].

and lack of extension to assign a value of I (poor recovery), II (satisfactory recovery) or III (good recovery) [36]. Gilbert-Raimondi can also be used to classify hand function on a scale of 0 to 5 [37].

Active range of motion (AROM) has shown to have the largest support from the international brachial plexus surgeon community according to the iPLUTO study [31]. It has a continuous scale and normative values are readily available. However, the methodology in assessment varies. Some use goniometers for a precise measurement; however, it is cumbersome to use, especially with a fussy child. Passive range of motion (PROM) is also commonly assessed and reported as these children commonly develop internal rotation shoulder and elbow flexion contractures [31].

Traditional surgeon- or therapist-reported physical exam outcome measures, like Mallet, Toronto, and AMS, have been validated for OBPP and can discriminate the deficit in active range of motion in the upper extremity [30]. However, these scales focus primarily on individual muscle power. Systematic review has shown that measures of shoulder or elbow range of motion are most frequently used for outcome assessment for OBPP [38]. Notably, a study surveyed attendees of the International Symposium of Brachial Plexus Surgery over the course of nine months. Fifty-nine participants responded and all but two were surgeons. Most responders were based in Europe or North America and identified as a member of a brachial plexus team. There was a consensus (76%) to include passive range of motion for shoulder adduction and abduction and elbow extension. 95% of respondents believed active range motion should also be measured by evaluating shoulder abduction and adduction, elbow flexion and extension, wrist extension, and finger flexion and extension. 83% expressed that the Mallet score was a suitable outcome measure, and 76% said it should be expressed using its sub scores for each movement, rather than using an aggregate score. There was also insufficient evidence for the use of Azbug et al's modified Mallet scale, which includes hand-to-belly to assess active internal rotation [31].

2.2 Importance of ICF framework

At each age group, there is a different motivation for assessment. During infancy, the degree of impairment is identified and recovery is monitored to determine qualification for surgery; thus, range of motion, strength, and limb integration must be evaluated. As the child develops, the assessment must evolve with them. For a school-aged patient, participation in age-related school and leisure activities as well as qualify of life is important to their development. Adolescents with OBPP may face functional limitations stemming from factors that these surgeon-centered outcome measures do not assess, such as psychosocial factors, poor self-perception, or social environmental influences [39]. While functional impairment must also be measured, psychometric assessment must now be included to holistically measure OBPP outcomes [10].

Several tools have been developed for global clinical assessment that evaluate domains aside from "body function and structure", which has been well documented by the MRC, Mallet, and AMS scales. The Brachial Plexus Outcome Measure (BPOM) activity scale, specific for school-aged children with OBPP, measures function relative to activity limitations stemming from brachial plexus nerve injury. It consists of eleven tasks, which contain components of the fifteen movements used in the AMS scale, and performance is graded using the Functional Movement Scale ranging from 1 to 5. Patients fill out the self-evaluation scale with 3 visual analog scales to score perceived hand and arm function as well as aesthetic appearance of the affected limb [40]. BPOM measures a component of the ICF definition of participation by considering the child's upper limb performance within the context of their life [38]. Its authors recommend clinicians to supplement the BPOM activity scale with a global standardized participation questionnaire when needed to measure the ICF "activity and participation" domain [40].

Sensory discriminatory function in patients with OBPP can be evaluated using Semmes-Weinstein monofilaments and two-point discrimination. The Semmes-Weinstein monofilament test uses five monofilaments of different diameters, where thicker filaments exert higher pressure when applied to skin [41]. Behavior cues, such as retractive movements with active motion and facial grimacing, in response to pinprick across dermatomes can be classified using the Sensory Grading Scale by Narakas when testing infants [10]. It is classified under the "body function" ICF domain [38].

Noting the lack of sensitivity of the Gilbert-Raimondi hand classification, the nine hole peg test has been validated to evaluate fine upper motor function in patients with OBPP [42]. It requires participants to repeatedly place and subsequently remove nine pegs into nine holes one at a time, as fast as they can. This test has shown to have high interrater and test–retest reliability for both the adult and pediatric population [43]. It is classified under the "activity" ICF domain [44]. However, the iPLUTO survey showed a consensus to not use this tool [31]. Recognizing the dynamics of a dominant and assisting hand in bimanual hand activity, the Assisting Hand Assessment (AHA) was developed in 2003 as a hand function evaluation tool for children with unilateral upper limb dysfunction, including those with OBPP and cerebral palsy (CP). It has been shown to be reliable in children between ages of 18 months and 12 years. Classified under the "activity" ICF domain, the AHA reflects the person's usual performance in daily activities [45].

The Children's Hand-use Experience Questionnaire (CHEQ), a tool for evaluating hand function in unilateral upper limb injury, covers the level of activity in the ICF framework. It is administered in two steps. First, a play session requiring bimanual handling of 22 specific toys is observed; then, the session is reviewed by trained assessors to rate each object-related action on a 4-point scale. It is unique as the questionnaire includes the child's emotional experience of impaired hand function in bimanual activities. Validity has been demonstrated in adolescents aged 6–18 years with OBPP and CP. It should be noted that ratings for children under 13 years of age are completed by parents, who tend to overestimate their child's problems [46].

Disability is commonly assessed by the Disabilities of the Arm, Shoulder, and Hand (DASH) outcome measure in brachial plexus injuries. It is a 30 item, self-reported questionnaire measuring physical function where every question is answered on a scale from 1 to 5, and the total minimum score ranges between 30 and 150 [47]. It has shown responsiveness and validity across the whole upper extremity in adults and covers the "activity and participation" ICF domain [48, 49]. A shorter version, QuickDASH, is comprised of 11 items assessed on a 5-point scale; it has shown higher discriminatory power in detecting disability and has been proven as a valid instrument for children ages 8–18 [50].

To determine arm and hand spontaneous function in the home environment, the parent-reported Hand Use at Home (HUH) questionnaire was developed, which is categorized under the activity and participation of ICF. It includes a host of bimanual activities and has been validated in children aged 3–10 years with unilateral cerebral palsy and OBPP [51].

The Pediatric Outcomes Data Collection Instrument (PODCI) was developed to provide a standardized outcome measurement for pediatric musculoskeletal conditions, and it has been validated for OBPP [52]. The tool has seven dimensions: upper extremity function, transfers and mobility, physical function and sports, comfort or lack of pain, happiness, satisfaction, and expectations [53]. It falls under the "activity, participation, and environmental" domains of the ICF framework [38].

The 36 item Pediatric Quality of Life Inventory, PedsQL, assesses the impact of a child's chronic condition on the family, where a higher score represents low impact [54]. It is developed for pediatric patients with chronic health conditions. It is a promising health-related quality of life instrument designed for a broad age range, including categories for both parents and patients. It measures the core health dimensions outlined by the WHO, including functionality at school [55]. This measurement is a validated outcome measure that is categorized under the "activity and participation" ICF domain [44].

Patient-Reported Outcomes Measurement Information System (PROMIS) developed by the NIH includes several measures to holistically evaluate physical, mental, and social health [56]. The health quality of children with obstetric brachial plexus palsy as measured by PROMIS is not well understood. For other brachial plexus related injuries, such as brachial plexus birth injury, PROMIS domains have shown promise as useful tools for evaluation [56].

A summary of OBPP outcome measure classification by ICF domain can be found in **Figure 2**. In a systematic review of classifying OBPP outcome measures by ICF domain, only 8% (18/217) of papers represented the ICF component of "activity and participation" and only 4% (9/217) of studies incorporated the concept of environmental factors during OBPP measurement; the remaining 88% (190/217) studied the ICF domain of "body structure and function". In total, only 2% (4/217) of papers evaluated all three ICF domains [38]. It should be noted that the ICF framework does not include the impact of the child's disability on the family. Family members have been found to experience "third-party functioning and disability" as a result of their loved one's health condition [57].

2.3 OBPP evaluation contrasted with CP evaluation

Similar to OBPP, children with the most common type of hemiplegic cerebral palsy (HCP) have a weak upper limb from their pre- or perinatal period. In CP, damage or abnormalities of the cerebral motor cortex affects muscle coordination

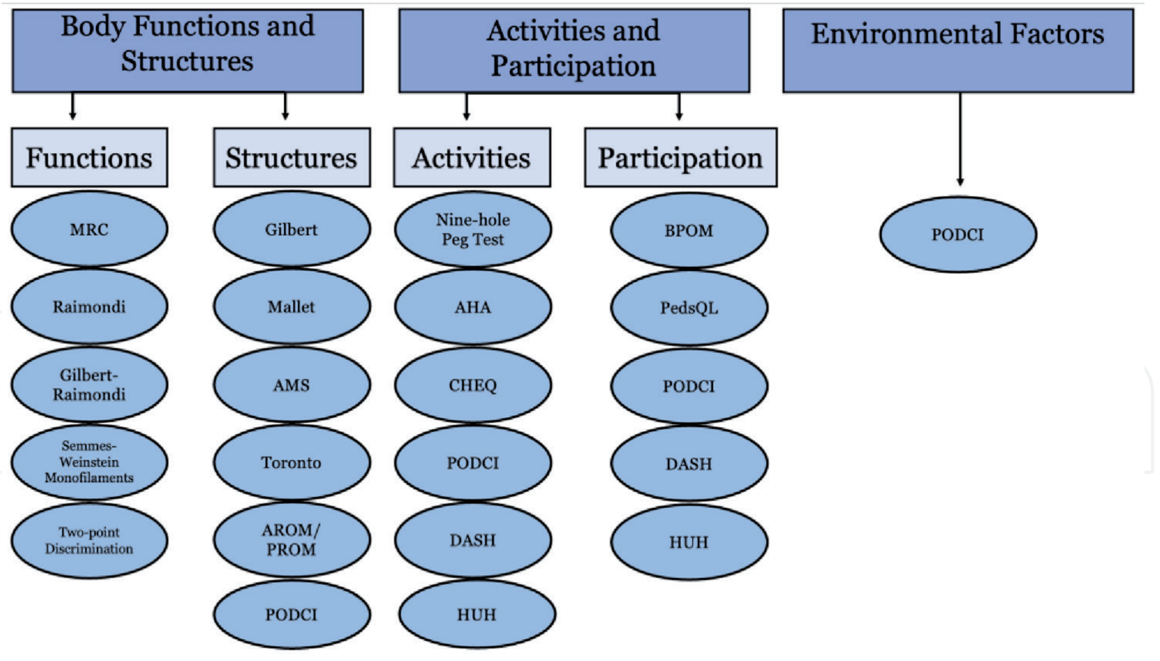

Figure 2.
Classification of OBPP outcome measures by ICF domain.

and movement. Other central nervous system deficits in HCP include sensory impairments, failure of sensorimotor integration, and potential learning disabilities [58]. There has been extensive study of upper extremity dysfunction in children with CP, including the age at which children plateau in function and the use of multimodal therapeutics such as synergistic Botox, occupational therapy, and augmented feedback therapeutics such as virtual reality [58].

Children with HCP often take longer to complete bimanual activities. They may ask for assistance if they are comfortable or they may avoid certain activities due to negative effects on their self-esteem and self-concept. This interplay between body structure and function with environmental and personal factors again proves the importance of the ICF framework.

Since cerebral palsy and obstetric brachial plexus palsy both exhibit unilateral upper limb palsy, they share several outcome measurements. AROM and PROM are also often measured by goniometry for CP patients, similar to OBPP patients. For both diagnoses, it is important to note that this outcome can be affected by age, gender, baseline level of physical activity, and any co-existing illness. MRC has been utilized for measuring muscle power in CP patients although this was developed initially for brachial plexus lesions [59]. Mean time to complete nine-hole pegboard, which measures finger dexterity, has been used in CP patients as well [60, 61].

Other scales more specific to CP that fall under the "body function and structure" domain of the ICF framework include the Ashworth and Modified Ashworth scales for spasticity and Kendall scale for muscle strength [62]. The Quality of Upper Extremity Skills Test (QUEST) is used to assess the body structure and function domain by taking into consideration disassociated movement, grasp, protective extension, and weight bearing. The test–retest reliability ranges from 0.75 to 0.95 depending on the factor considered [63]. The Melbourne Assessment of Unilateral Upper Limb Function (MUUL) is a video-based measurement with 16 items, each containing subskills that cover various characteristics of movement including target accuracy, fluency, and movement. A score out of 122 is calculated and then converted into a percentage that describes the quality of upper limb movement in CP patients [64]. The Box and Blocks timed test measures unilateral dexterity by having children move blocks from one side a box to another using the dominant hand and the non-dominant hand [65]. The Barry-Albright Dystonia (BAD) scale rates the severity of dystonia in eight different body regions—eyes, mouth, neck, trunk, both arms, and both legs [66].

There are also a variety of scales utilized to assess OBPP that are also used for CP that address the activity and participation domain of the ICF framework. One such outcome measure, as previously mentioned, is the Assisting Hand Assessment (AHA). Children with unilateral CP are videorecorded as they play with toys and/or boardgames that provoke use of both hands and are then assigned a raw score between 22 and 88 which are then converted to logit based AHA units [45]. AHA is often used in research and has good reliability and validity in children but requires extensive training to administer the assessment. The Pediatric Outcomes Data Collection Instrument (PODCI) helps families communicate information about their environment and share how it affects the gait and quality of life of children with musculoskeletal health issues. In comparison to its use for OBPP, PODCI only demonstrates moderate sensitivity to detect changes of walking function due to its expansive scoring system [67]. This outcome measure also has high ceiling effects [68]. Children's Hand-use Experience Questionnaire (CHEQ) was developed to be a useful tool to assess patients who have limitations in one hand making it difficult to perform bimanual activities.

There are other outcome measures that fall under the activity and participation domain used for CP but not OBPP. Pediatric Quality of Life Inventory (PedsQL), a part of the participation ICF domain, is used by families to score their children with CP taking into consideration a variety of other factors that affect life [69–71]. One that falls under the ICF framework is Pediatric Evaluation of Disability Inventory (PEDI). PEDI is administered to children less than seven years of age and is formatted as a semi-structured interview administered by proxy [72]. It assesses for ability to provide self-care and maintain social function. The Canadian Occupational Performance Measure (COPM) is a 5-step process used by occupational therapists to evaluate the effect of therapy on various individualized outcomes of importance such as self-care, productivity, and leisure and rate performance and satisfaction on a scale of 1–10 [73]. Jebsen Taylor Hand Function Test (JTHFT) is a timed test of hand dexterity in everyday activities used in children greater than 5 years of age [74]. Although COPM and JTHFT are not diagnosis specific to CP, they have been utilized to evaluate CP patients over time [74, 75]. PROMIS has also been utilized for CP patient evaluation [76]. The Hand Assessment for Infants (HAI) is used to describe unilateral hand function in CP patients by quantifying the contribution of each hand separately and together during a 10–15-minute play session with specific toys eliciting a wide range of motor actions [77]. Both Hands Assessment (BoHA) is a video-taped tool that was developed for children under 12 years of age with bilateral CP and measures the effectiveness of each individual hand during multiple bimanual tasks. Although the scale is highly precise and captures the mobility subdomain of the activity domain of the ICF framework, it requires administrators to undergo formal training and scoring can be time-intensive [78]. ABILHAND-Kids, from the self-care subdomain of the activity domain, is a questionnaire administered to the parents of CP children, thus leading to possible over- or under-estimation of their child's bimanual everyday activities [78]. The Gross Motor Function Scale (GMFS) evaluates a child's ability to complete basic motor functions such as crawling, jumping, or climbing up stairs on a four point scale for each task [79]. Peabody Developmental Motor Scales second edition (PDMS-2) assesses fine motor skills in children with results expressed as raw scores, standard scores and total motor quotient [80]. Children's Assessment of Participation and Assessment (CAPE) is a 55-item questionnaire administered to the child and parent

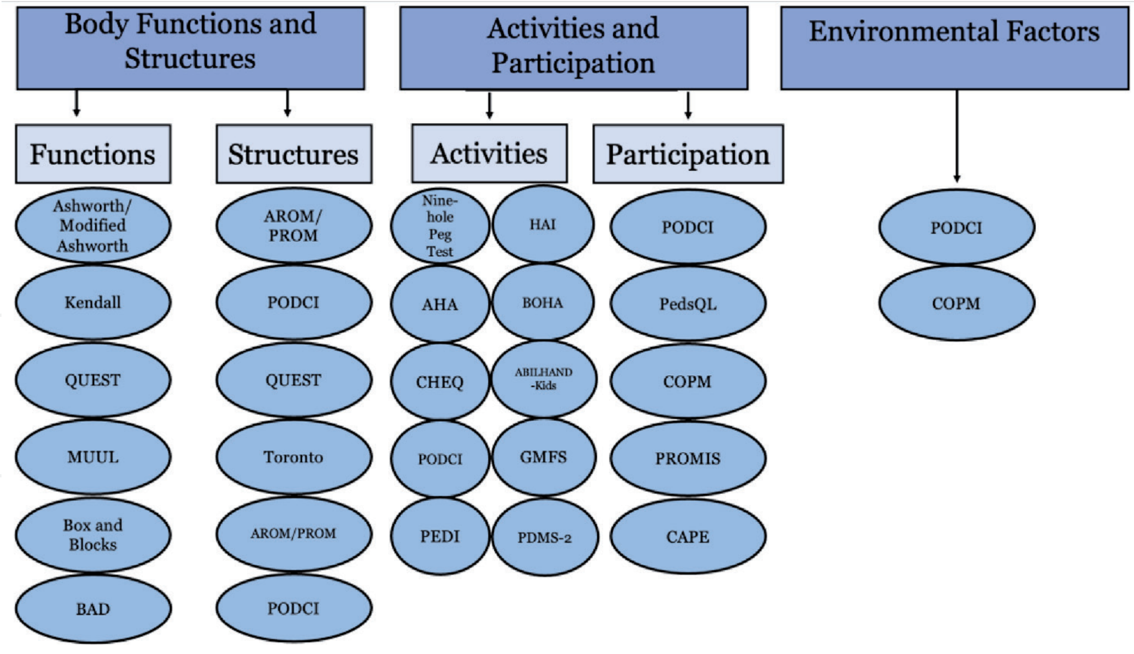

Figure 3.
Classification of CP outcome measures by ICF domain.

and is designed to examine how children with physical disabilities like CP participate in everyday activities outside of the school setting and document the diversity, intensity, and enjoyment of activities [81].

A summary of CP outcome measure classification by ICF domain can be found in **Figure 3**. There is a discordance between outcome measures that focus on ICF levels of activity and participation and functional measures that attempt to quantify motion. Both OBPP and CP have effects on patients beyond movement and strength. Quality of life, stress to caregivers, involvement in school and family activities, self-image and self-esteem can all be affected, indicating the need for more biopsychosocial approaches. Although capturing outcomes incorporating multiple domains of the ICF framework is beneficial, the amount of time and training required for measures of activity and participation often leads to these outcomes not being utilized to its full extent in the clinical setting. The existing body of literature shows that compared to OBPP surgeons, CP surgeons report on more domains of the ICF framework. Mallet, MRC, AMS, AROM, PROM, and Gilbert are mostly used in reporting outcomes on OBPP patients, putting emphasis on quantifying motion. In CP, more emphasis may be placed on activity and participation due to the added complexity of the diagnosis with neurological involvement.

3. Conclusions

Currently, most tools used to assess OBPP progression measure range of motion and strength, which are classified under the body function and structure domain of the ICF model. Numerous instruments have been developed, such as the DASH and PODCI score, to include other factors of disability, like self-perception and functional impairment. However, these scales are not typically included during standard OBPP assessments, in contrast to CP outcome reporting, which generally focuses more on the activity and participation domain of the ICF model. Further standardization and incorporation of outcomes that fall under the activity and participation domain would be beneficial to assess OBPP more holistically.

Conflict of interest

The authors declare no conflict of interest.

Notes/thanks/other declarations

None.

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