Biomedical Communication

An Instrumented Assessment of Cerebral Palsy: A Systematic Review

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ABSTRACT

Cerebral palsy is a neurological problem which mainly affects the children and is a frequent reason of physical inability. It affects both motor as well as sensory system. Due to physical disability quality treatment is required for CP children. For an effective treatment proper assessment and selection of correct assessment tool is necessary. This review was aimed to recognize the various assessment scales which are available to assess different domains in person of cerebral palsy patient along with their psychometric properties. We had done a review of literature through Cochrane library, Ovid MEDLINE and GOOGLE SCHOLAR, CINAHL till March 2020. The studies in English-language related to the assessment scales for the cerebral palsy were reviewed. Many scales were evaluated for different symptoms and good psychometric properties in CP child. We reviewed many research and review article related to assessment for CP. Various titles, abstracts, and references were checked for the relevancy.Review was done for the assessment of alteration in muscle tone, impaired voluntary movement, pain, gross motor function, balance, cognition and gait. Cerebral palsy was the primary goal of findings in 198 studies. Out of these, 58 studies were not proved the definition of cerebral palsy. 96 studies reported assessment of cerebral palsy for different domain, 25 studies used etiology and incidence and 19 studies for other domain which are related to CP. Many cerebral palsy scales are available, but only a very small number of scales were thoroughly validated for use in clinical practice in India. This review will help therapist in selection of appropriate tool and study of various symptoms in CP child before starting the treatment..

KEY WORDS: ASSESSMENT SCALES, CEREBRAL PALSY, PSYCHOMETRIC PROPERTIES.

INTRODUCTION

CP is the mainly widespread reason of physical inability in children. Developmental delay and motor deficits are usually main presentations of CP child. It was first described in 1862 by, William James Little an orthopedic surgeon. The prevalence of CP globally is around 2 to 2.5/1000 live births (Jan 2006). In this disorder a permanent non progressive changes were occur in fetal brain (Ghasia et al. 2008). It is a neurological problem which mainly affects the children (krigger 2006a; Ghasia et al. 2008). The prevalence of CP ranges from 1.5-4 per 1,000 live births; this range is for children of 10 to 14 years. The overall birth prevalence of CP is approx. 2 per 1,000 live births (Donald et al. 2014; Stavsky et al. 2017). CP is neither a diagnosis nor an illness but it is an umbrella term for so many conditions (Garfinkle et al. 2020).

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The etiology of 70% of CP cases leftovers unidentified. In 20% of children, it may be associated with prematurity, perinatal trauma, or brain hypoxia (Blair and Cans 2018; Boruczkowski et al. 2019). Some other factors like fetal infections and birth defects also can cause CP. CP causes impairment in the posture, movement, intelligence, vision and hearing by damaging the fetal brain. On the basis of severity, CP can be classified as mild, moderate, severe or no CP but not any set of criteria present. Inflammation and coagulation abnormalities also cause CP along with hypoxic ischemic encephalopathy (Beckung and Hagberg 2007; Beckung and Hagberg 2007; Horber et al. 2020; Garfinkle et al. 2020).

CP child exhibits various symptoms like bladder dysfunctions, bowel dysfunction, drooling, sleep disturbances, hearing loss, visual abnormalities, orthopedic associated sensory impairment which are not properly understood (Wingert et al. 2008). CP can also be classified on the basis of both Pathophysiology and area of brain involve. The cortical involvement results in choreoathetosis CP, cerebellar involvement results in abnormal movements, pyramidal

involvement results in spasticity and involvement of basal ganglia result in hypotonic movement. It can also be classified on the basis of nature of the motor disability and part of the body involve. Examples of motor impairments are Paresis, Hypertonia, Hypotonia, Dystonia, Dyskinesia, and ataxia (Rethlefsen et al. 2010; Horber et al. 2020). Causes of CP are placental insufficiency, uterine infection, metabolic disorder, placenta previa and neonatal asphyxia; and intraventricular hemorrhage of the newborn, Periventricular Leukomalacia (PVL), blood infection, and perinatal stroke (Compagnone et al. 2014; Veldeet et al. 2019). Symptoms of CP shows some negative sign like weakness of skeletal muscles and delayed milestones and some positive signs like a velocity dependent increased muscle tone with spasticity, clonus, rigidity, spasms and hyper reflexia. Some children with CP show other symptoms as abnormal movements like athetosis, chorea, and dystonia and some are mixed CP those who shows a combination of features such as epilepsy, feeding, nutrition, growth problem, mental retardation (Garfinkle et al. 2020).

Topographic classification shows how many structures are involved and then classified as Hemiplegics, Paraplegics, Tetraplegics, Diplegic, or Monoplegics. Since the (1800s), the clinicians try for the timely identification of CP but still identification is not made until 12 to 24 months in high earning countries and as late as 5 years in low source settings. Children with spastic CP have restrictions to execute numerous daily actions including sitting, standing and walking (Bayon et al. 2016; Veldeet et al. 2019). Sitting is an essential aptitude for many practical action, mainly because it facilitates transfers and allows the self-governing use of upper limbs to control objects (Salazar et al. 2019). A diagnosis of CP made if there is Persistence of primitive reflexes delay of motor development. It is first assumed when there is a disappointment to achieve positive key milestones at predictable age (Patel et al. 2020).

METHODOLOGY

We reviewed various research articles by going through different search engines like Ovid MEDLINE Cochrane library, and EBSCO CINAHL. The following search vocabulary were used: cerebral palsy, assessment scales for CP, different assessment tools for CP, psychometric properties of different assessment scale of CP. Research studies (review and research) that reported assessment of cerebral palsy for both children and adults were included in the literature. Articles published till March (2021) was included without restriction of date. Relevant articles were screened by title and abstract. The most relevant articles were downloaded and evaluated for inclusion in the review. The lists of reference of these articles were also checked for other potentially relevant researches, and these studies were also retrieved. All articles that examined CP in children and used CP assessment scales were incorporated in the review. Each symptom was examined for assessment. Information regarding number of scales available and number of scale having good psychometric properties, were also recorded. The chosen scales for the Assessment of CP were Spasticity, Dyskinesia, Dystonia, Motor abilities; Gait, Cognition, Balance and Pain were used.

Scales for the Assessment of CP: Spasticity: Apart from so many disorder Spasticity is most important reason of disability in children and adults suffering from CP. It occurs due to upper motor neuron syndrome which causes difficulty in daily routine and compromises the excellence of life in CP children (Verrotti et al. 2006). The measurement of muscle tone is very essential to find out usefulness of treatment on spasticity and also to plan further medical or surgical treatment and decide physiotherapy goals. For the assessment of spasticity there are so many scales are available such as Ashworth, Modified Ashworth and Tardieu and MTS. Two scales AS and MAS are used to check tightness to inactive movements and therefore measured tone of muscles in CP children. Literature reveal that there were high inter rater reliability of the Ashworth and modified Ashworth scales but this is not true for all conditions. However, data related to the reliability was missing for most of the scales. Particularly this was seen for test retest reliability (Platz et al. 2005; Mutlu et al. 2008).

Dyskinesia: It is also known as Dyskinetic Cerebral Palsy (DCP). After spasticity Dyskinesia is another most frequent type of symptoms of CP. Dystonia is a neurological movement disorder characterized by involuntary muscle contractions, slow repetitive movements, and abnormal postures of the trunk, neck, face, or arms and legs. Sometimes spasticity is misunderstood with dystonia, which can be created because of psychogenic reason (Jankovic 2006; Verrotti et al. 2006). DCP is classified in two subgroups like dystonic and choreoathetotic. In Dyskinetic CP, sudden tight involuntary contraction and involuntary twitching and writhing are present simultaneously (Stewart et al. 2017). The six scales for the assessment of dyskinesia were present. These were the Burke–Fahn–Marsden Dystonia Rating Scale (BFMDRS), Barry–Albright Dystonia Scale (BADS), Unified Dystonia Rating Scale (UDRS), Movement Disorder-Childhood Rating Scale (MD-CRS), Movement Disorder-Childhood Rating Scale 0–3 Years (MD-CRS 0–3), and the Dyskinesia Impairment Scale (DIS) (Stewart et al. 2017).

Dystonia: Dystonia is diagnosed on the bases of its clinical features. Dystonia is classified in to primary and secondary dystonia. Primary dystonia is different in the form of the deficiency of extra neurological abnormalities and the short of probable acquired causes. The assessment of dystonia is still not well understood due to the complexity of the symptoms and lack of researches (Jethwa et al. 2009; Donald et al. 2014).

For diagnosis of muscle tone 21 tools were available but not specific for the CP child. Some literature identified 21 tools for the assessment of tone of the muscle in the children between the ages of 0 to 12 years. Most of the tools were planned for children up to 5 years of age and were used for the examination of development pattern along with the muscle tone examination or as subscale. Four tool were considered as the assessment tool of active and passive tone of muscle but not having the good psychometric properties. The Amiel- Tison Neurological Assessment (ATNA) at term, Neonatal Intensive Care Unit Network Neurobehavioral Scale (NNNS), Premie-Neuro for newborn infants, and the

Hammersmith Infant Neurological Examination (HINE) for infants aged 2 months to 2 years. The Neurological Sensory Motor Developmental Assessment (NSMDA) has been developed for the assessment of passive and active muscle tone (of the infant) with some degree of validity (Goo et al. 2018). Early assessment is essential for the appropriate treatment of dystonia (Frucht et al. 2021).

Motor abilities: For the assessment of the motor abilities in CP child 17 instruments are present (Beckung and Hagberg 2007). Functional limitation of CP child not only depends on the age of the child but also according to Gross motor function classification. The Gross Motor Function Classification System (GMFCS) is used to explain motor function in children with CP (Carnahan et al. 2007; Curtis et al. 2015). The gross motor functioning is mainly assessed by two tools: Gross Motor Function Classification System (GMFCS) and Functional Mobility Scale (FMS). GMFCS describe about five types of CP which depends on functional limitations, the need for hand-held mobility devices (such as walkers, crutches or canes) or wheeled mobility, and to a much lesser extent, quality of movement. Literature suggest that it also depends on year of the child (Wiedemann et al. 2019).

Along with GMFCS the Sarah scale also used for assessment of the motor skills and it is a suitable tool for the assessment of the functional performance and the motor skills of children and adolescents with CP (Pinto et al. 2016). Gross Motor Function Measure (GMFM-88) was also used for the assessment of gross motor functioning (Bayon et al. 2016). Gross Motor Function Measure (GMFM-88) and (GMFM-66) were used as outcome measures to determine the changes in gross motor function in children with CP undergoing treatment (Alotaibi et al. 2014; Wiedemann et al. 2019).

Literature suggests that 17 instruments are used to assess the functional motor abilities in children with CP. Due to lackness for evaluation in change of functional abilities, it was found that most measures are developed and validated for discriminative purposes. The tool developed in last decade have good psychometric properties and only two evaluative assessment measures, the Gross Motor Function Measure (GMFM) and the Pediatric Evaluation of Disability Inventory (PEDI), fulfill the criteria of reliability and validity with respect to responsiveness to change (Ketelaaret al. 1998; Bodkin et al. 2003). The gold standard tool for the assessment of motor abilities is The Gross Motor Function Measure (GMFM). It have simple language and easy to understand by the parents (Rachel 2020).

Gait: For Gait, CP children are suffering from so many motor problems these causes gait deviations. So assessment of gait in these child is essential. There are 14 specific abnormalities are seen in CP child which are of different types (Paralysis on one side of body, paralysis of lower half of body or paralysis of whole body), age, and history along with previous surgery (orthopedic surgery in lower extremity). There are diminished knee flexion in swing, limiting upward bending motion of ankle joint, and feet turn inward while walking or running, restricted hip mobility and crouch hip adduction, out-toeing, deformity of calcaneus bone, and crouch increased with prior surgery, rotational misalignment of the leg (internal hip rotation without-toeing).

Varus and valgus foot deformities, and hip internal rotation (Maathuis et al. 2005). Spastic CP most commonly suffering from disorder of gait. Observational tools are found from the available literature from which the Edinburgh Visual Gait Scale (EVGS), the Visual Gait Assessment Scale (VGAS) and the Observational Gait Scale (OGS) are commonly used for the assessment of gait in CP child (Brown et al. 2008). Edinburgh Visual Gait Score have good psychometric properties than the other tools. Physician Rating Scale in children with hemiplegic cerebral palsy also shows good psychometric properties (Dickens and Smith 2006; Mcintyre et al. 2013; Rathinam et al. 2014; Armand et al. 2016c). For correction of gait deviations objective assessment is important. For intent analysis of gait Clinical gait analysis (CGA) should be done (Mazure et al. 2020).

Balance: Balance is also an important component of gait disorder in CP child Apart from other problems postural control (Woollacott et al. 2007). Balance is a combination of multiple body systems including vestibular, visual, auditive, Proprioceptive and higher level pre motor systems. The functional goal of the balance system includes: (1) conservation of postural alignment like sitting or standing; (2) assisted voluntary movement and (3) re-establish equilibrium after peripheral disturbances, such as a trip, slip or push. From the available literature we found 22 tools for the assessment of the balance.

Two tools were also validated in adults with CP. A strong level of evidence was present for content validity for the majority of the tools but limited evidence was present for their Intrarater, Interrater, and test–retest reliability. In addition, no evidence was present for internal consistency, measurement error, criterion validity, and responsiveness for the majority of the tools. These are the Berg Balance Scale (BBS), the Functional Reach Test (FRT), the Functional Walking Test (FWT), the Heel-to-Toe Stand (HTS), the Level of Sitting Ability (LSA), the Level of Sitting Scale (LSS), the Modified Posture Assessment Scale (MPAS), the Pediatric Balance Scale (PBS), the Pediatric Reach Test (PRT).

The Pediatric Clinical Test of Sensory Interaction for Balance (P-CTSIB), the Posture Assessment Scale (PAS), the Posture and Posture Ability Scale (PPAS), the Seated Posture Control Measurement (SPCM), the Seg- mental Assessment of Trunk Control (SATCO), the Sit- ting Assessment for Children with Neuromotor Dysfunction (SACND), the Sitting Assessment Scale (SAS), the Spinal Alignment for Range of Motion Measure (SAROMM), the Timed One-Leg Stance (TOLS), the Timed Up and Down Stairs (TUDS), the Timed Up and Go (TUG), the Trunk Control Measurement Scale (TCMS), and Trunk Impairment Scale (TIS). Two of the clinical balance tools, PPAS and SPCM, were evaluated for adults (Saether et al. 2013). As all the CP's are not having the same symptoms so there is need of many assessment instruments with different

options to adapt to CP's mixed inhabitants (Apolo-Arenas 2021).

Cognition: Cognition impairment is most commonly seen in CP child. Instead of having difficulty in standardized IQ tests designed for the general population, children with developmental disabilities will earn low IQ score. Nine give psychometric result for CP children. The included tests were The Columbia Mental Maturity Scale, The Leiter International Performance Scale, The Peabody Picture Vocabulary Test, The Pictorial Test of Intelligence, The Raven's Colored Progressive Matrices, The Stanford–Binet Intelligence Scales, The Wechsler Adult Intelligence Scale, the Wechsler Intelligence Scale for Children, and The Wechsler Preschool and Primary Scale of Intelligence (Foo et al. 2013). Without proper evaluation and treatment of cognitive functioning intellectual disability may occur (Stadskleiv 2020).

Pain: In CP children pain is also a significant factor that impacts the quality of life of these children. Pain in children with CP is not commonly known and left untreated so it becomes chronic (Houlihan et al. 2007; Penner et al. 2013). Chronic pain affects health both emotionally and psychologically. For more than 3 months, pain remains known as chronic pain. The literature includes a total of 54 chronic pain assessment tools which have strong psychometric properties from which 15 chronic pain assessment tools were chosen for inclusion in the best practice toolbox. The tools are Body Diagram, Non communicating Children's Pain Checklist-Revised [NCCPC-R], Pediatric Pain Questionnaire [PPQ]), track pain over time (Bath Adolescent Pain Questionnaire [BAPQ], Child Activity Limitations Interview [CALI], Pediatric Pain Interference Scale [PPIS]), or both (Pediatric Pain Profile [PPP]).

They relied on observational (NCCPC-R, PPP), self-report (Body Diagram), or combination reporting styles (BAPQ, CALI, PPIS, PPQ). All tools had been validated with a pediatric population and a diverse variety of medical conditions; note that the NCCPC-R, PPIS, PPP and PPQ were primarily used to assess pain in CP children. It provides scores of psychometric properties, therapeutic usefulness and method use guidelines according to GMFCS standards. We accept that 54 chronic pain evaluation methods were officially evaluated for psychometric features, therapeutic effectiveness and expert opinion from which 15 chronic pain evaluation tool were chosen for use in the best practice toolbox (Kingsnorth et al. 2015; Pelrine et al. 2020).

RESULTS AND DISCUSSION

In this systematic analysis of clinical studies using cerebral palsy as the primary endpoint, we found various descriptions of cerebral palsy, 167 separate assessment scales for 8context, a large variance in evaluation methods and CP rates recorded, and very little psychometric examination of the current scales. We found a wide range of meanings among the 198 studies which clarified how they defined CP, either by scale or meaning alone. There are broad range of symptoms found in cerebral palsy from them spasticity, dystonia, dyskinesia, gait abnormalities, balance disorders, cognition abnormalities and chronic pain were the problem which were commonly faced by person suffering from CP (Gupta and Appleton 2001).

Numerous incremental measures of symptoms severity gradation have been developed over the past 40 years, but recurrent drawbacks include: (1) not all of the necessary symptoms may be present; and (2) a patient might not show the sign in the specific sequence specified by the measure, thereby may not meet the cerebral paralysis threshold (Knox and Evans 2002). Dysphagia, vomiting, and chronic constipation have been also reported in children with neurologic impairment like CP and also to be evaluated but none scale is found which have good psychometric property (Elbasan and Bezgin, 2018). None scale was found with good psychometric property for sleep related domain. Some questionnaire and tools for the assessment of CP are widely used such as The Gross Motor Function Classification System (GMFCS), for the assessment of gross motor function in cerebral palsy but some were neglected because they were not having the good psychometric properties (Rosenbaum et al. 2018). CP children present complex and heterogeneous motor disorders so there was a need of a measuring tool which can assesses all the symptoms related to CP (Armand et al. 2019).

Assessments of motor-functional aspects in CP were crucial to rehabilitation programs so it was necessary that it should be assess on priority bases (Pinto et al. 2016). However, for many scales reliability data was missing. This was particularly true for test retest reliability (Platz et al. 2019; Hutson and Snow 2020). There was no uniformity of composite measures as to how many symptoms were available to apply for CP. Numerous incremental measures of symptoms severity gradation have been developed over the past 40 years, but recurrent drawbacks include: (1) not all of the necessary symptoms may be present; and (2) a patient might not show the sign in the specific sequence specified by the measure, thereby might not meet the cerebral paralysis threshold (Knox and Evans 2020).

There were numerous shortcomings to our analysis. Like, we only collected researches that were conducted in English, analyzing various CP domains. Some domains were still not reviewed like scales for fine motor skills, hand functions and sensory assessment. We did not approach authors of the analysis to inquire for possibly undisclosed psychometric results. We were unable to find any older paper (pre-1985) that mentioned CP, so some earlier CP resources could have been missing. It was also likely that newer and undisclosed CP scales were in use and yet not published.

CONCLUSION

The findings of the present study found for 8 impairments there were total 167 scales available but only 53 had psychometric properties and none of the scale could assess all impairments of CP. The selection of appropriate measurement tools is essential for effective clinical practice yet, it is unclear how best to assess CP because no existing scale has undergone for all impairments of CP. So many

scales are available but most of them assess only one or two limitations of CP. There is still need to develop an assessment tool which cover the all domains of CP.

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