

Outcome domains and measures after lower limb orthopaedic surgery for ambulant children with cerebral palsy: an updated scoping review

HAJAR ALMOAJIL^{1,2}  | NICHOLA WILSON³ | TIM THEOLOGIS^{1,4}  | SALLY HOPEWELL⁵ | FRANCINE TOYE⁶ | HELEN DAWES^{7,8}

1 Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK. **2** Department of Physical Therapy, College of Applied Medical Science, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia. **3** Department of Surgery, Faculty of Medical and Health Sciences, The University of Auckland, Auckland, New Zealand. **4** Paediatric Orthopaedic Surgery, Nuffield Orthopaedic Centre, Oxford University Hospitals NHS Foundation Trust, Oxford, UK. **5** Centre for Statistics in Medicine, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK. **6** Physiotherapy Research Unite, Nuffield Orthopaedic Centre, Oxford University Hospitals NHS Foundation Trust, Oxford, UK. **7** Centre for Movement, Occupational and Rehabilitation Sciences, Oxford Institute of Nursing, Midwifery and Allied Health Research, Oxford Brookes University, Oxford, UK. **8** Oxford Health NHS Foundation Trust, Oxford, UK.

Correspondence to Hajar Almoajil, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, UK.
E-mail: hajar.almoajil@ndorms.ox.ac.uk

PUBLICATION DATA

Accepted for publication 7th May 2020.
Published online 22nd June 2020.

ABBREVIATIONS

ICF-CY	International Classification of Functioning, Disability and Health – Children and Youth
PODCI	Pediatric Orthopaedic Data Collection Instrument
PROM	Patient-reported outcomes measure

AIM To determine the reported outcome domains and measures used to assess lower limb orthopaedic surgery of ambulant children and young people with cerebral palsy (CP) and map these outcomes to the International Classification of Functioning, Disability and Health – Children and Youth (ICF-CY) framework.

METHOD This updated scoping review included studies published between January 2016 and July 2019 in five databases: MEDLINE, PubMed, EMBASE, CINAHL, and the Cochrane Central Register of Controlled Trials. Studies were included if participants were ambulant individuals with CP aged between 0 and 20 years who had undergone lower limb orthopaedic surgery. Health outcome domains and measures were identified and classified using the ICF-CY framework.

RESULTS Forty-four eligible studies were identified with a total of 40 different outcome domains recorded. Among eligible studies, 44 (100%) measured body function and structural impairment and seven (16%) measured activity limitation and participation restriction. The most frequently reported outcome was gait pattern ($n=37$, 84%). Few studies reported adverse effects of surgery ($n=13$, 30%). Twenty-nine different outcome measures were identified. Patient-reported outcomes measures were used in 10 studies (23%).

INTERPRETATION The review highlights a heterogeneity in the reported outcome domains and measures used in CP studies. The majority of the reported outcomes focus on the ICF-CY domain of body function and structure. The review also highlights a notable shift towards patient-reported outcomes in recent years. Development of a core outcome set for lower limb orthopaedic surgery would guide researchers to use more consistent and complete measurement sets.

Cerebral palsy (CP) is the most common cause of childhood physical disability, affecting 2 to 3 per 1000 live births.¹ Approximately two-thirds of these children are ambulant, in Gross Motor Function Classification System (GMFCS) levels I, II, and III.² Musculoskeletal deformities and resulting gait abnormalities are common and progressive during childhood, leading to pathological and compensatory gait patterns.³ Many children with CP undergo lower limb orthopaedic surgery to address secondary musculoskeletal deformities and gait abnormalities, and to improve or maintain mobility.⁴

The World Health Organization has produced the International Classification of Functioning, Disability and Health – Children and Youth (ICF-CY) to consider health outcomes. It categorizes health outcomes into the following components: (1) body structure and function impairment, (2) activity limitation, and (3) participation restriction.⁵ Each of these levels is subdivided into chapters that cover a range of health domains. It has been suggested that outcome evaluation would be improved by using measurement tools across each ICF-CY domain alongside specific quality of life measurement tools, as this would

provide direct benefits to the patient and also contribute to improvements in clinical practice.⁶

More than 78 different outcome measures have been used in the assessment of interventions in CP.⁷ Between 1990 and 2011, 32 outcome measures were used to assess lower limb orthopaedic surgery for ambulatory children and young people with CP.⁴ The review by Zanudin et al.⁸ indicates that not all outcome measures perform consistently well with their psychometric properties (i.e. validity, relevance, reliability, and responsiveness to change).

In response to the variability in outcome measures used, many professional and scientific organizations, including the Core Outcome Measures in Effectiveness Trials initiative, have recommended standardized outcome measures for use in health research and practice.⁹ Although there is strong support for standardized measures for CP interventions,^{10–12} there is no consensus on the most important outcomes and outcome measures for assessment. This makes it challenging to compare and synthesize results across research performed in the field of lower limb orthopaedic surgery for ambulant children and young people with CP.^{13–15}

Adoption of an accepted, standardized, and minimum collection of outcomes measures, known as a core outcome set, requires both input from relevant stakeholders and evaluation of the outcome measures' psychometric properties.¹⁶ A key initial step in this process is to identify and summarize existing outcome domains and outcome measures used in published clinical trials through a scoping review.

A previous review^{4,17} identified 310 studies published between 1990 and 2015 which used outcome measures after lower limb orthopaedic surgery in children and adolescents with CP aged 0 to 20 years. From these 310 studies, 21 outcome measures assessed the ICF-CY domain of body structure and function, 10 measured activity and participation level, and three studies used a quality of life measure.⁴

The review by Wilson et al. identified outcome measures in published research between 1990 and 2015.^{4,17} However, in recent years, researchers and health care professionals have become more aware of patient priorities and have acknowledged the value of patient-reported outcomes. There has been a significant rise in studies published in recent years, with a 46% increase between pre- and post-2001.⁴ Therefore, before attempting to develop a core outcome set for future CP trials, it is important to update findings from the previous review to include studies published since 2016. Hence, the aim of this project was to: (1) undertake a scoping review of studies published between 2016 and 2019 in order to identify additional reported health outcome domains in lower limb orthopaedic surgery clinical trials for ambulant children and young people with CP, (2) identify which outcome measures were used to assess each ICF domain, and (3) compare the outcome measures used in the published literature before and after 2016.

What this paper adds

- There is heterogeneity in outcome domains and measures used across cerebral palsy studies.
- There is a trend towards increased use of patient-reported outcome measures in recent studies.
- Outcome domains in addition to specific outcome measures are identified and reported.
- Surgical adverse events are insufficiently reported.
- Nine additional outcome measures are identified.

METHOD

According to the Cochrane Review recommendation, a review update should be reconducted using the same methods as the original review,¹⁸ therefore, this review was in line with the methodology of the original scoping review.⁴ The protocol was drafted using the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols.¹⁹ The review was conducted and reported using recent recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-analysis – Scoping Review.²⁰

Source and search

The search database and search terms were replicated from the original review and performed for the period between January 2016 and July 2019 using five electronic databases: MEDLINE (Ovid and in progress), PubMed, EMBASE, CINAHL, and the Cochrane Central Register of Controlled Trials. The key search terms included 'cerebral palsy' AND 'surgical procedures' OR 'surgery' OR 'operative'. The reference lists of all included studies were searched to identify any potentially relevant studies. Appendix S1 (online supporting information) shows specific key terms and how they were combined for each database.

Eligibility criteria

The title and abstract of potential studies identified were screened using the following inclusion criteria: (1) all study designs, provided that they reported at least one outcome measure; (2) studies that included both children and young people with CP; (3) children and young people diagnosed with ambulatory CP in levels I to III of the GMFCS; (4) participants aged between 0 and 20 years old; (5) any lower limb orthopaedic surgery; and (6) the full article was published in English.

Studies were not eligible if they met the following exclusion criteria: (1) observational investigations and qualitative studies that did not include an outcome measure; (2) grey literature; (3) studies involving participants older than 20 years; (4) reported treatment other than orthopaedic surgery to the lower limbs (e.g. upper limb surgery, physiotherapy); (5) reported surgery performed only for hip dysplasia.

Study selection process

The potential studies were exported into the reference manager, EndNote X8.2, in which duplicated studies were

removed. A two-stage screening process was then undertaken. First, the titles and abstracts of potential studies were assessed against the inclusion criteria. Second, a full-text screening of studies included after the first stage was undertaken.

Two independent reviewers (HA, NW) conducted the screening process. Discrepancies were resolved by discussion and approved before data extraction.

Data extraction

A predesigned standardized data-extraction form was developed using Microsoft Excel to document essential data in a systematic manner. Data were extracted by two independent reviewers (HA and NW). Participant data items included: (1) number of participants, (2) age range, (3) sex ratio, and (4) GMFCS level. Intervention data were related to (5) surgery type. Study data items included: (6) date of publication, (7) study aim, (8) the country of origin, and (9) study design. Outcome data items included: (10) outcome domains and (11) outcome measures used. Outcome measures were only selected if at least one published study reported their psychometric properties. This was verified by checking the reference lists of eligible studies and also searching the bibliographic PubMed database for each outcome measure. If the outcome measures' psychometric properties had not previously been evaluated, these were excluded from further review.

Data analysis

The content of each of the identified outcome domains and outcome measures was classified according to the ICF-CY domains. Adverse effect and harm outcomes were added as a fourth domain, consistent with previous recommendations.⁶ Data were then summarized using descriptive analysis, including the frequency and proportion of each reported outcome domain and outcome measures used to assess identified outcome domains.

RESULTS

Selection of sources of evidence

The literature search identified 5754 studies and the references lists screening yielded an additional 29 studies. All potential studies ($n=5783$) were imported into Endnote X8, 2241 duplicates removed, 3542 titles/abstracts screened, 3378 studies excluded, and 164 full texts screened. Of these, 120 studies were excluded: the majority of the excluded studies ($n=68$) were conference abstracts; 19 included non-ambulatory CP; 11 included adults with CP; 11 were related to hip dysplasia surgery for severe non-ambulant CP; one study included other disabilities; data were unavailable in one study; one study did not report outcome measures; and one was a validation study. Thus, the review included 44 studies on the effectiveness of lower limb orthopaedic surgery. The selection process details are outlined in Figure S1 (online supporting information). Full references for the included studies are provided in Table S1 (online supporting information).

Characteristics of sources of evidence

Only two (5%) of the 44 eligible articles were randomized controlled trials, and the remaining 42 articles (95%) were retrospective studies. The 44 studies addressed several orthopaedic surgical procedures in the lower limb, including bony surgery, soft tissue surgery, and combinations of bony and soft tissue surgery in the form of single event multi-level surgery. Sample size ranged from 6 to 314 (median 34). The majority of studies reported the GMFCS level (37 out of 44 papers, 84%).

Outcome domains

There were 184 reported outcomes describing 40 different outcome domains (Table 1). Outcomes were grouped into ICF-CY domains: (1) body structure and function and (2) activity and participation. Outcome groups were expanded to include domains relating to (3) adverse effect and harm.

All studies identified reported outcomes relating to the impairment of body function and structures. Twelve outcomes that reflected body function and structure impairment domain made up 48% of the total reported outcomes ($n=184$). The most common outcome was 'gait pathology and pattern' ($n=37$, 84%), followed by 'joint mobility' ($n=20$, 45%), 'muscle tightness' ($n=7$, 16%), 'muscle strength' ($n=6$, 14%), and 'pain level' ($n=4$, 9%).

Only seven (16%) studies reported outcome domains related to the activity and participation level of the ICF-CY. Nineteen different outcomes related to activity and participation were identified, making up 37% of the total outcomes reported ($n=184$). Walking related outcomes were the most frequent and were represented within five studies (11%). Other less frequently reported outcomes included: 'engaging in sports activity', 'self-care', 'standing and sitting ability', and 'activity engagement level' (Table 1).

Only 30% of the studies ($n=13$) reported adverse events after lower limb surgery. The most commonly reported adverse event, reported in seven studies (16%), was infection, followed by recurrent surgery reported in five studies (11%). Other less frequently reported adverse events included: surgery failures such as implant failure and non-union, fracture, overcorrected surgery, complex regional pain syndrome, and depression.

Outcome measure instruments

Overall, there were 30 different outcome measures identified in the 44 studies. Dogan's Scale²¹ was excluded as its psychometric properties have not been investigated. Thus, 29 outcome measures were included (Table 2). Outcome measures were categorized according to: (1) body function and structure, (2) activity and participation, and (3) adverse event and harm.

There were 23 clinician-administered measures (79% of the instruments), and six self/proxy administered measures: (1) Pediatric Orthopaedic Data Collection Instrument (PODCI),²² (2) Patient-Reported Outcome Measures

Table 1: Outcome domains across 44 studies

Outcome domain	<i>n</i>	%	References
Body function and structure			
Gait pathology/pattern	37	84	42–78
Gait appearance	2	5	49,79
Joint mobility	20	45	45,46,48,50–52,54,56,58–60, 63,67,68,70–72,80–82
Joint alignment	5	11	28,44,54,81,83
Lower limb alignment	2	5	48,49
Muscle strength	6	14	45,46,56,58,59,84
Muscle tightness	7	16	45,52,56,58,59,68,81
Energy drive movement	2	5	61,64
Ankle structure	1	2	64
Knee structure	1	2	60
Pain level	4	9	48,56,64,79
Fatigue	2	5	48,79
Activity and participation			
Changing body position	5	11	56,64,79,81,84
Mobility level	5	11	48,56,64,79,84
Game/sport	3	7	56,64,79
Outdoor activity	4	9	48,56,64,79
Jumping/running	5	11	46,56,64,79,81,84
Walking ability	6	14	46,56,64,79,84
Walking on uneven surface	6	14	46,56,64,79,84
Walking long distance	3	7	56,64,79
Using assistive device	4	9	56,64,79,84
Stepping	1	2	81
Using stair	4	9	46,79,81,84
Riding a bike	4	9	46,56,64,79
Sitting in all forms	2	5	56,79
Standing in all forms	3	7	48,56,79
Using transportation	3	7	56,64,79
School activity engagement	3	7	56,64,79
Self-care	4	9	56,64,79,84
Mobility in home	1	2	84
Social satisfaction	2	5	48,64
Adverse event and harm			
Recurrent surgery	5	11	44,55,63,70,73
Surgery failure	2	5	57,70
Infection	7	16	44,55,57,59,70,73,80
Fracture	2	5	70,80
Neurovascular symptoms	4	9	55,59,80,82
Healing process	3	7	49,59,80
Complex regional pain syndrome	1	2	49
Overcorrection	2	5	66,67
Depression	1	2	48
Total	184		

Information System,²³ (3) Gillette Functional Assessment Questionnaire,²⁴ (4) Pediatric Evaluation of Disability Inventory,²⁵ (5) computerized adaptive tests,²⁶ and (6) Mobility Questionnaire 47.²⁷

Twenty (69%) of the outcome measures used applied to the measurement of impairment of body structure and function. Outcome measures assessing gait pathology were the most common (37 out of 44 studies, 84%) and included gait analysis and its parameters: kinematics, kinetics, Gait Profile Score, Gait Deviation Index, and Gillette Gait Index. Clinical examination was the second most common outcome measure used and included: (1) joint range of motion data using a goniometer (*n*=17, 39%), (2) muscle strength using manual muscle testing (*n*=6, 14%), and (3) muscle spasticity using the Modified Ashworth Scale (*n*=5, 11%), Tardieu Scale (*n*=2, 5%), and Duncan Ely's sign (*n*=1, 2%). Pain was only measured in four

Table 2: Outcome measures across 44 studies

Outcome domain	<i>n</i>	%	References
Body function and structure			
Gait analysis (kinematics or kinetic)	37	84	42–45,47,48,50–78
Gait Deviation Index	12	27	48,52–54,56,64,65,67,74,76–78
Gillette Gait Index	1	2	63
Gait Profile Score	8	18	43,45,52,55,58,59,69,73
Gait cycle	1	2	46
Gait velocity	8	18	44,46,61,63,69–72
Movement analysis profile	3	7	43,58,73
Gait velocity scale	1	2	69
Staheli's rotational profile	1	2	57
Radiology	7	16	28,44,49,60,80,81,83
Foot pressure data	3	7	44,81,83
Foot progression angle	3	7	64,66,67
Range of motion	17	39	45,46,48,50,51,56,58–60,63,67,68,70–72,81,82
Modified Ashworth Scale	5	11	45,56,58,68,81
Tardieu scale	2	5	56,59
Duncan Ely's Sign	1	2	59
Manual Muscle Test	6	14	45,46,56,58,59,84
Oxygen consumption	2	5	61,64
Edinburgh Visual Gait Score	2	5	49,70
Timed-up and go	1	2	79
Activity and participation			
Gross Motor Function measures	2	5	48,79
Functional Mobility Scale	1	2	84
Gillette Functional Assessment Questionnaire	3	7	46,79,81
Pediatric Evaluation of Disability Inventory	1	2	84
Computerized adaptive tests	1	2	79
Mobility Questionnaire 47	1	2	84
Multi-dimensional outcome measure			
Pediatric Orthopaedic Data Collection Instrument	3	7	56,64,79
Patient Reported Outcome Measures Information System	1	2	48
Adverse event and harm			
Clavien-Dindo System	3	7	55,59,73
Total	137		

studies, as part of multi-dimension outcome measures such as PODCI, Patient-Reported Outcome Measures Information System, and computerized adaptive tests.

The patient and proxy (parent/carer) measures most commonly administered by questionnaires or interviews with health professionals were those used to assess the impact of surgery on activity and participation level such as walking, mobility, social function, and level of independence. However, there was inconsistency in the choice of measures: Gillette Functional Assessment Questionnaire (*n*=3, 7%), PODCI (*n*=3, 7%), while the Patient-Reported Outcome Measures Information System, Mobility Questionnaire 47, computerized adaptive tests, and Pediatric Evaluation of Disability Inventory had equal representation within the studies (*n*=1, 2%). Functional Mobility Scale (*n*=1, 2%) and Gross Motor Function measures (*n*=2, 5%) were the only clinician-administered tools for assessing motor function outcome. Surgical adverse events (complications) and harm were measured using the Clavien-Dindo system (*n*=3, 7%).

Timing of assessment

The timing of the outcome assessment ranged from less than 1 year to over 10 years postsurgery (Table S1). Short-term assessment (within 1y) was reported in 16 studies (36%), mid-term assessment (3–5y) in nine studies (20%), and long-term assessment (>10y) was only reported in three studies (7%). There was also variability in the follow-up point used within some studies ($n=16$, 36.5%), for example, Bittman et al.²⁸ assessed outcomes at a range of time points between 6 to 36 months postsurgery.

All assessments of body structure and function were reported within different follow-up points, for example, 3D gait analysis to assess gait pattern at a range of time points from less than 1 year up to 10 years postsurgery. Of the studies reporting activity and participation outcome ($n=7$), the majority were performed at 6 to 12 months ($n=5$, 71.4%) and/or 2 to 3 years ($n=3$, 42.8%).

Comparison of the literature before and after 2016

A comparison of pre- versus post-2016 literature was based on the outcome measures, as outcome domains were not identified in the original review. The number of outcome measures used decreased slightly from 34 in pre-2016 to 29 after 2016. As with the original review, the study designs were mostly retrospective and body structure and function were the most frequently measured outcomes.

Nineteen of the measurement tools included in the previous reviews^{4,17} were not identified in the updated review and nine additional measurement tools were identified that were not included in the previous review (Table 3).

Although the number of outcome measures used to assess the impact of lower limb surgery remains stable between reviews, there were differences in the type and frequency of outcome measures used. For example, the Gillette Gait Index was identified in studies both before and after 2016; however, the frequency was varied ($n=20$, 6% and $n=1$, 2% respectively; Table 4). In the updated review, quality of life was measured using multi-dimensional patient-reported outcomes measures (PROMs) such as Patient-Reported Outcome Measures Information System, rather than disease-specific outcome measures such as CP-Quality of Life²⁹ or Paediatric Quality of Life Inventory.³⁰

The GMFCS has been used in recent studies to describe study samples in terms of motor function level. Compared to pre-2016 findings, the GMFCS increased from 39% of the identified studies since its origin from 2003 to 2016, and 84% over the 2016 to 2019 period.

DISCUSSION

This updated review included additional studies with relevant clinical information on the outcome domains and outcome measures used in lower limb orthopaedic surgery in CP. The review identified 44 studies after 2016, suggesting that research in this field continues to expand. The updated review not only identified the outcome measures used in assessing lower limb orthopaedic surgery in CP

Table 3: Outcome measures used at two time points in the literature pre- and post-2016

Outcome measures	Pre-2016 ^{4,17} $n=310$	Post-2016 $n=44$
Body function and structure		
Type of walking device	29	–
Surface electromyography	20	–
Presence of pain	14	–
Biomechanical model	7	–
Physiological Cost Index	4	–
Normalcy Index	3	–
Physician Rating Scale	2	–
Hip Flexor Index	2	–
Observational gait	2	–
Vertical plantar pressure	1	–
Selective control assessment of the lower extremity	1	–
Total mechanical work	2	–
Movement Analysis Profile	–	3
Gait Velocity Scale	–	1
Staheli's Rotational Profile	–	1
Foot progression angle	–	1
Edinburgh Visual Gait Score	–	2
Activity and participation		
Functional Independence Measure for Children	4	–
Positional Activity Logger	1	–
Modified Goal Attainment Scale	1	–
Gross Motor Performance measure	1	–
Computerized adaptive tests	–	1
Mobility Questionnaire 47	–	1
Quality of Life		
Child Health Questionnaire	2	–
Pediatric Quality of Life Inventory	1	–
Cerebral Palsy Quality of Life for Children	1	–
Multi-dimensional outcome measures		
Patient Reported Outcome Measures System	–	1
Adverse event and harm		
Clavien-Dindo System	–	3

but also provides novel information on *what* was measured based on the ICF-CY framework. Despite the relatively short period of time (2016–July 2019), the studies measured 40 different outcomes with no single outcome reported in all identified studies. The revised search yielded 29 outcome measures, of which nine were unique to this review which can be attributed to the continued development and expansion of CP outcome measures.

The majority of outcome domains and outcome measures identified mainly addressed the ICF-CY domains of impairment and functional levels, which was similar to the previous scoping reviews.^{4,17} Our observation may reflect that the natural history of children with CP is characterized by deterioration in posture and gait due to musculoskeletal pathologies, such as bone deformities and joint contractures. Therefore, health professionals might focus on improving children's gait outcomes by addressing their musculoskeletal pathology.²

As observed in the previous review, there was an imbalance in the choice of the ICF-CY domains that were measured in the identified studies, favouring body structure and function. Although this may reflect the focus of

Table 4: Common outcome measures according to two-time period

Outcome measures	Pre-2016 ^{4,17} <i>n</i> =310 <i>n</i> (%)	Post-2016 <i>n</i> =44 <i>n</i> (%)
Body function and structure		
Clinical examination	208 (67)	31 (70)
Gait analysis (kinematics with or without kinetics)	192 (62)	37 (84)
Gait velocity	95 (31)	8 (18)
Gait Profile Score	11 (4)	8 (18)
Gait Deviation Index	20 (6)	12 (27)
Gillette Gait Index	20 (6)	1 (2)
Radiology	77 (25)	7 (16)
Foot pressure data	8 (3)	3 (7)
Oxygen consumption	6 (3)	2 (5)
Timed Up and Go	1 (1)	1 (2)
Activity and participation		
Gross Motor Function measure	23 (7)	2 (5)
Pediatric Evaluation of Disability Inventory	1 (1)	1 (2)
Gillette Functional Assessment Questionnaire	13 (4)	3 (7)
Functional Mobility Scale	16 (5)	1 (2)
Pediatric Orthopaedic Data Collection Instrument	10 (3)	3 (7)

orthopaedic interventions in addressing body impairment and function, the other categories of the ICF-CY may be essential in representing outcomes of importance from the patient's perspective. It is recommended that comprehensive measures of health status include all the components identified by the ICF-CY framework.^{4,11} A recently developed multi-dimensional outcome measure, the Gait Outcomes Assessment List,² directly assesses function in ambulant children with CP in all the ICF-CY levels. This measure has initial documentation of discriminant and concurrent validity; however, it has not yet been extensively adopted in research looking at the outcomes of lower limb surgery.

The findings identify some trends in the use of PROMs for lower limb surgery. Various PROMs are available in this field, covering the majority of the outcome domains including pain, mobility, walking ability, independence, and social function. The PODCI and Gillette Functional Assessment Questionnaire were the most commonly used PROMs. This is likely because of the ability of PODCI to assess the impact of surgery across multiple domains of functioning (physical, mobility, and sport), pain, and happiness: the Gillette Functional Assessment Questionnaire assesses walking ability and mobility domains, which are recognized as important domains for children and their parents.^{31,32}

Identified PROMs do not assess certain key outcomes such as joint range of motion, spasticity, and gait pathology, which are more likely to be assessed by the clinicians. Therefore, PROMs could be viewed as complementary measures to be used together with clinician-reported measures. Although several PROMs provide a self-assessment from the perspective of children or proxy, they differ in their level of objectivity, outcome assessed, feasibility, and

cost. Little standardization was found across the five studies using PROMs, leading to limited ability to synthesize studies to explore the effectiveness of surgical interventions.⁹

Our findings highlight the limited use of quality of life outcome measures. Compared to the original review, where four studies reported quality of life as an outcome, no studies in this review specifically measured quality of life. McGinley et al.¹⁴ reported that 'The relationships between orthopaedic deformities, function, and gait and both health-related quality of life and quality of life are poorly understood and are certainly not linear'. The majority of the studies assessed the short-term outcome postsurgery, and it may be that a 12- to 24-month time frame is insufficient to measure significant changes in an individual's quality of life. Our findings are consistent with the study by Cuomo et al.³³ who found that multilevel surgery had no impact on the children's psychosocial well-being and state of happiness outcomes over a 12-month period postsurgery. Further research is needed to investigate the impact of the surgery on children's quality of life over a longer period of time.

The review identified limited reports of adverse events which may indicate potential selection bias in reported outcomes within studies.^{13,14} Repeated surgeries and side effects (e.g. infection, neurovascular complications) were reported as adverse events of surgery; however, this accounts for less than 25% of the total outcomes identified, and was reported in only 15 out of 44 studies (34%). This imbalanced reporting between the benefits and harms can lead to a poor understanding of the impact of the surgery on an individual's health.³⁴ Furthermore, clear knowledge of postoperative complication risk is important since it can inform surgery choice by clinicians and is considered a key element for the patient to understand before giving consent for surgery.³⁵

The heterogeneity in outcome measures across studies (*n*=29) was likely compounded by the variation of follow-up periods across studies. Investigating the maintenance of the surgical outcomes at different time points should be evaluated, but consistency in follow-up time points across studies is recommended to support comparisons in future systematic reviews and meta-analyses.³⁶ Future studies are needed to identify the most clinically meaningful follow-up time points since surgery usually takes time to have an effect on a child's level of activity and function.

The findings highlight the heterogeneity in outcome domains and measurement tools used in the literature. This heterogeneity has led to widely known problems of outcome reporting bias that makes it difficult to conduct meta-analyses of trial findings. This resonates with previous reviews regarding post-lower limb orthopaedic surgery outcome assessment in children with CP.^{4,13–15,17} One approach to improve this is to develop a core outcome set³⁷ for lower limb orthopaedic surgery, which should be measured and reported as a minimum for all trials. It is also important to consider the rigorous evaluation of the

psychometric properties of the available outcome measures. An evaluation of the psychometric properties of common gait-related measures in CP has recently been published.^{8,38} These measures were appraised using the modified Consensus-based Standard for the selection of health measurement Instruments checklist.^{16,39,40} Further research should carefully consider this evaluation when determining core outcome measures set in this field.

To our knowledge, this is the first systematic scoping review that aims to underpin the development of a core outcome set for children with CP undergoing lower limb orthopaedic surgery. This revised review provides novel evidence including: (1) a comprehensive overview of the outcome domains assessed in this field of research alongside the outcome measures used, (2) a notable shift in use of patient-reported outcomes which is becoming common clinical practice, and (3) under-reporting of adverse events which remains a major problem in research and clinical practice. Furthermore, the ICF-CY framework was used to categorize the outcome domains and measures: the use of a common framework to describe content has proven to be advantageous to guide the selection of measures.⁴¹

This review has some limitations. First, as in the original review, this review only included peer-reviewed articles published in English. Therefore, it may not include all relevant outcome domains and outcome measures. Another limitation of this review is including all peer-reviewed studies regardless of the study's methodological quality.

CONCLUSION

A broad range of effectiveness outcome domains was identified from the literature with the focus predominantly on

children's body structure and function. The review highlights the dominance of clinical-based assessment with an increasing shift and awareness toward the use of patient-reported outcomes among researchers over recent years. It is evident that such domains are measured in different ways, with few consistently applied outcome measures. This heterogeneity reflects the challenges in conducting a review of effectiveness. It was also notable that few studies reported adverse event outcomes, which is of concern given the importance of understanding the adverse events in the surgical consenting process. Work needs to be done to standardize the outcome domains and outcome measures. An international core outcome set in this field should be developed to help improve future clinical trials.

ACKNOWLEDGEMENTS

HA is funded for postgraduate scholarship by Imam Abdulrahman Bin Faisal University, Saudi Arabia. TT is funded by the Oxford Medical Research Centre. HD is supported by Elizabeth Casson Trust and the NIHR Oxford Health Biomedical Research Centre. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR, or Department of Health. The authors have stated that they had no interests which might be perceived as posing a conflict or bias.

SUPPORTING INFORMATION

The following additional material may be found online:

Appendix S1: Search terms in each database.

Figure S1: PRISMA flowchart.

Table S1: Included studies.

REFERENCES

- Glinianaia SV, Best KE, Lingam R, Rankin J. Predicting the prevalence of cerebral palsy by severity level in children aged 3 to 15 years across England and Wales by 2020. *Dev Med Child Neurol* 2017; **59**: 864–70.
- Thomason P, Tan A, Donnan A, Rodda J, Graham HK, Narayanan U. The Gait Outcomes Assessment List (GOAL): validation of a new assessment of gait function for children with cerebral palsy. *Dev Med Child Neurol* 2018; **60**: 618–23.
- Narayanan U. The role of gait analysis in the orthopaedic management of ambulatory cerebral palsy. *Curr Opin Pediatr* 2007; **19**: 38–43.
- Wilson NC, Chong J, Mackey AH, Stott NS. Reported outcomes of lower limb orthopaedic surgery in children and adolescents with cerebral palsy: a mapping review. *Dev Med Child Neurol* 2014; **56**: 808–14.
- WHO. International classification of functioning, disability and health: children and youth version: ICF-CY. Geneva: World Health Organization 2007.
- Viehweger E, Jouve JL, Simeoni MC. Outcome evaluation in pediatric orthopedics. *Orthop Traumatol Surg Res* 2014; **100**: S113–23.
- Majnemer A, Mazer B. New directions in the outcome evaluation of children with cerebral palsy. *Semin Pediatr Neurol* 2004; **11**: 11–17.
- Zanudin A, Mercer TH, Jagadamma KC, van der Linden ML. Psychometric properties of measures of gait quality and walking performance in young people with cerebral palsy: a systematic review. *Gait Posture* 2017; **58**: 30–40.
- Williamson PR, Altman DG, Bagley H, Barnes KL, Blazeby JM, Brookes ST. The COMET Handbook: version 1.0. *Trials* 2017; **18**(Suppl. 3): 280.
- Schiariti V, Fayed N, Cieza A, Klassen A, O'Donnell M. Content comparison of health-related quality of life measures for cerebral palsy based on the International Classification of Functioning. *Disabil Rehabil* 2011; **33**: 1330–9.
- Schiariti V, Klassen AF, Cieza A, et al. Comparing contents of outcome measures in cerebral palsy using the International Classification of Functioning (ICF-CY): a systematic review. *Eur J Paediatr Neurol* 2014; **18**: 1–12.
- Schiariti V, Tatla S, Sauve K, O'Donnell M. Toolbox of multiple-item measures aligning with the ICF Core Sets for children and youth with cerebral palsy. *Eur J Paediatr Neurol* 2017; **21**: 252–63.
- Lamberts RP, Burger M, du Toit J, Langerak NG. A systematic review of the effects of single-event multilevel surgery on gait parameters in children with spastic cerebral palsy. *PLoS One* 2016; **11**: e0164686.
- McGinley JL, Dobson F, Ganeshalingam R, Shore BJ, Rutz E, Graham HK. Single-event multilevel surgery for children with cerebral palsy: a systematic review. *Dev Med Child Neurol* 2012; **54**: 117–28.
- Edwards TA, Theologis T, Wright J. Predictors affecting outcome after single-event multilevel surgery in children with cerebral palsy: a systematic review. *Dev Med Child Neurol* 2018; **60**: 1201–8.
- Prinsen CAC, Mokkink LB, Bouter LM, et al. COSMIN guideline for systematic reviews of patient-reported outcome measures. *Qual Life Res* 2018; **27**: 1147–57.
- Wilson NC. Measuring outcomes after lower limb surgery in children with cerebral palsy. New Zealand: University of Auckland, 2015: 51–60.

18. Moher D, Tsertsvadze A, Tricco AC, et al. When and how to update systematic reviews. *Cochrane Database Syst Rev* 2008;(1): Mr000023.
19. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015; **4**: 1.
20. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018; **169**: 467–73.
21. Dogan A, Albayrak M, Akman YE, Zorer G. The results of calcaneal lengthening osteotomy for the treatment of flexible pes planovalgus and evaluation of alignment of the foot. *Acta Orthop Traumatol Turc* 2006; **40**: 356–66.
22. Allen DD, Gorton GE, Oeffinger DJ, Tylkowski C, Tucker CA, Haley SM. Analysis of the pediatric outcomes data collection instrument in ambulatory children with cerebral palsy using confirmatory factor analysis and item response theory methods. *J Pediatr Orthop* 2008; **28**: 192–8.
23. Mulcahey MJ, Haley SM, Slavin MD, et al. Ability of PROMIS pediatric measures to detect change in children with cerebral palsy undergoing musculoskeletal surgery. *J Pediatr Orthop* 2016; **36**: 749–56.
24. Novacheck TF, Stout JL, Tervo R. Reliability and validity of the Gillette Functional Assessment Questionnaire as an outcome measure in children with walking disabilities. *J Pediatr Orthop* 2000; **20**: 75–81.
25. Østensjø S, Bjørnbakmo W, Carlberg EB, Vollestad NK. Assessment of everyday functioning in young children with disabilities: an ICF-based analysis of concepts and content of the Pediatric Evaluation of Disability Inventory (PEDI). *Disabil Rehabil* 2006; **28**: 489–504.
26. Mulcahey MJ, Slavin MD, Ni P, et al. Computerized adaptive tests detect change following orthopaedic surgery in youth with cerebral palsy. *J Bone Joint Surg Am* 2015; **97**: 1482–94.
27. Van Ravesteijn NT, Dallmeijer AJ, Scholtes VA, Roorda LD, Becher JG. Measuring mobility limitations in children with cerebral palsy: interrater and intrarater reliability of a mobility questionnaire (MobQues). *Dev Med Child Neurol* 2010; **52**: 194–9.
28. Bittmann MF, Lenhart RL, Schwartz MH, Novacheck TF, Hetzel S, Thelen DG. How does patellar tendon advancement alter the knee extensor mechanism in children treated for crouch gait? *Gait Posture* 2018; **64**: 248–54.
29. Chen KL, Wang HY, Tseng MH, et al. The Cerebral Palsy Quality of Life for Children (CP QOL-Child): evidence of construct validity. *Res Dev Disabil* 2013; **34**: 994–1000.
30. Desai AD, Zhou C, Stanford S, Haaland W, Varni JW, Mangione-Smith RM. Validity and responsiveness of the pediatric quality of life inventory (PedsQL) 4.0 generic core scales in the pediatric inpatient setting. *JAMA Pediatr* 2014; **168**: 1114–21.
31. LeRoy K, Boyd K, De Asis K, et al. Balancing hope and realism in family-centered care: physical therapists' dilemmas in negotiating walking goals with parents of children with cerebral palsy. *Phys Occup Ther Pediatr* 2015; **35**: 253–64.
32. Vargus-Adams JN, Martin LK. Measuring what matters in cerebral palsy: a breadth of important domains and outcome measures. *Arch Phys Med Rehabil* 2009; **90**: 2089–95.
33. Cuomo AV, Gamradt SC, Kim CO, et al. Health-related quality of life outcomes improve after multilevel surgery in ambulatory children with cerebral palsy. *J Pediatr Orthop* 2007; **27**: 653–7.
34. Kirkham JJ, Altman DG, Chan A-W, Gamble C, Dwan KM, Williamson PR. Outcome reporting bias in trials: a methodological approach for assessment and adjustment in systematic reviews. *BMJ* 2018; **362**: k3802.
35. Hanson M, Pitt D. Informed consent for surgery: risk discussion and documentation. *Can J Surg* 2017; **60**: 69.
36. Charrois TL. Systematic reviews: what do you need to know to get started? *Can J Hosp Pharm* 2015; **68**: 144–8.
37. Webbe J, Sinha I, Gale C. Core outcome sets. *Arch Dis Child Educ Pract Ed* 2018; **103**: 163–6.
38. Himuro N, Abe H, Nishibu H, Seino T, Mori M. Easy-to-use clinical measures of walking ability in children and adolescents with cerebral palsy: a systematic review. *Disabil Rehabil* 2017; **39**: 957–68.
39. Mokkink LB, de Vet HCW, Prinsen CAC, et al. COSMIN risk of bias checklist for systematic reviews of patient-reported outcome measures. *Qual Life Res* 2018; **27**: 1171–9.
40. Mokkink LB, Terwee CB, Patrick DL, et al. The COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments: an international Delphi study. *Qual Life Res* 2010; **19**: 539–49.
41. Janssens A, Thompson Coon J, Rogers M, et al. A systematic review of generic multidimensional patient-reported outcome measures for children, part I: descriptive characteristics. *Value Health* 2015; **18**: 315–33.
42. Aiona M, Do KP, Feng J, Jabur M. Comparison of rectus femoris transfer surgery done concomitant with hamstring lengthening or delayed in patients with cerebral palsy. *J Pediatr Orthop* 2017; **37**: 107–10.
43. Ancillao A, van der Krogt MM, Buizer AI, Witbreuk MM, Cappa P, Harlaar J. Analysis of gait patterns pre- and post- single event multilevel surgery in children with cerebral palsy by means of offset-wise movement analysis profile and linear fit method. *Hum Mov Sci* 2017; **55**: 145–55.
44. Bayhan IA, Kadhim M, Sees JP, et al. Hallux valgus deformity correction without fusion in children with cerebral palsy. *J Pediatr Orthop B* 2017; **26**: 164–71.
45. Bohm H, Hosl M, Doderlein L. Predictors for anterior pelvic tilt following surgical correction of flexed knee gait including patellar tendon shortening in children with cerebral palsy. *Gait Posture* 2017; **54**: 8–14.
46. Boyer ER, Novacheck TF, Schwartz MH. Changes in hip abductor moment 3 or more years after femoral derotation osteotomy among individuals with cerebral palsy. *Dev Med Child Neurol* 2017; **59**: 912–18.
47. Braatz F, Dreher T, Wolf SI, Niklasch M. Preoperative hip rotation moments do not predict long-term development after femoral derotation osteotomy in children with cerebral palsy. *Gait Posture* 2018; **61**: 215–19.
48. Church C, Ge J, Hager S, et al. Flexed-knee gait in children with cerebral palsy: a long-term follow-up study. *Bone Joint J* 2018; **100B**: 549–56.
49. Corradin M, Schiavon R, Borgo A, Deslandes J, Cersosimo A, Canavese F. The effects of uninvolved side epiphysiodesis for limb length equalization in children with unilateral cerebral palsy: clinical evaluation with the Edinburgh visual gait score. *Eur J Orthop Surg Traumatol* 2018; **28**: 977–84.
50. de Moraes Filho MC, Blumetti FC, Kawamura CM, et al. The effect of the Majestro-Frost procedure on internal hip rotation during gait in patients with cerebral palsy. *Gait Posture* 2018; **66**: 32–7.
51. de Moraes Filho MC, Blumetti FC, Kawamura CM, et al. The increase of anterior pelvic tilt after crouch gait treatment in patients with cerebral palsy. *Gait Posture* 2018; **63**: 165–70.
52. de Moraes Filho MC, Fujino MH, Kawamura CM, et al. The increase of anterior pelvic tilt after semitendinosus transfer to distal femur in patients with spastic diplegic cerebral palsy. *J Pediatr Orthop B* 2018; **28**: 327–31.
53. de Moraes Filho MC, Blumetti FC, Kawamura CM, Lopes JA, Neves DL, Cardoso Mde O. Does rectus femoris transfer increase knee flexion during stance phase in cerebral palsy? *Acta Orthop Bras* 2016; **24**: 27–31.
54. Desailly E, Thevenin-Lemoine C, Khouri N. Does patella lowering improve crouch gait in cerebral palsy? Comparative retrospective study. *Orthop Traumatol Surg Res* 2017; **103**: 741–6.
55. Dreher T, Thomason P, Švehlík M, et al. Long-term development of gait after multilevel surgery in children with cerebral palsy: a multicentre cohort study. *Dev Med Child Neurol* 2018; **60**: 88–93.
56. Ellington MD, Scott AC, Linton J, Sullivan E, Barnes D. Rectus femoris transfer versus rectus intramuscular lengthening for the treatment of stiff knee gait in children with cerebral palsy. *J Pediatr Orthop* 2018; **38**: e213–e18.
57. Kim HY, Cha YH, Byun JY, Chun YS, Choy WS. Changes in gait parameters after femoral derotational osteotomy in cerebral palsy patients with medial femoral torsion. *J Pediatr Orthop B* 2018; **27**: 194–9.
58. Klausler M, Speth BM, Brunner R, Tirosh O, Camathias C, Rutz E. Long-term follow-up after tibialis anterior tendon shortening in combination with Achilles tendon lengthening in spastic equinus in cerebral palsy. *Gait Posture* 2017; **58**: 457–62.
59. Klotz M, Krautwurst B, Hirsch K, et al. Does additional patella tendon shortening influence the effects of multilevel surgery to correct flexed knee gait in cerebral palsy: a randomized controlled trial. *Gait Posture* 2018; **60**: 217–24.
60. Klotz MCM, Hirsch K, Heitzmann D, Maier MW, Hagmann S, Dreher T. Distal femoral extension and shortening osteotomy as a part of multilevel surgery in children with cerebral palsy. *World J Pediatr* 2017; **13**: 353–9.
61. Kung KL, Choi AKY, Ma AKH, Lao MLM, Chan NNC, Kwun TL. Correction of combined flexed and stiff knee gait in spastic diplegic cerebral palsy by double tendon transfers around the knee as part of

- multilevel surgery. *J Orthop Trauma Rehabilitation* 2017; **23**: 13–17.
62. Lee SY, Kwon SS, Chung CY, et al. Influence of surgery involving tendons around the knee joint on ankle motion during gait in patients with cerebral palsy. *BMC Musculoskelet Disord* 2018; **19**: 82.
 63. Mallet C, Simon AL, Ilharreborde B, Presedo A, Mazda K, Pennecot GF. Intramuscular psoas lengthening during single-event multi-level surgery fails to improve hip dynamics in children with spastic diplegia. Clinical and kinematic outcomes in the short- and medium-terms. *Orthop Traumatol Surg Res* 2016; **102**: 501–6.
 64. McMulkin ML, Gordon AB, Caskey PM, Tompkins BJ, Baird GO. Outcomes of orthopaedic surgery with and without an external femoral derotational osteotomy in children with cerebral palsy. *J Pediatr Orthop* 2016; **36**: 382–6.
 65. Nicholson K, Lennon N, Church C, Miller F. Gait analysis parameters and walking activity pre- and post-operatively in children with cerebral palsy. *Pediatr Phys Ther* 2018; **30**: 203–7.
 66. Niklasch M, Boyer ER, Novacheck T, Dreher T, Schwartz M. Proximal versus distal femoral derotation osteotomy in bilateral cerebral palsy. *Dev Med Child Neurol* 2018; **60**: 1033–7.
 67. Niklasch M, Klotz MC, Wolf SI, Dreher T. Long-term development of overcorrection after femoral derotation osteotomy in children with cerebral palsy. *Gait Posture* 2018; **61**: 183–7.
 68. Osborne M, Mueske NM, Rethlefsen SA, Kay RM, Wren TAL. Pre-operative hamstring length and velocity do not explain the reduced effectiveness of repeat hamstring lengthening in children with cerebral palsy and crouch gait. *Gait Posture* 2019; **68**: 323–8.
 69. Pilloni G, Pau M, Costici F, Condoluci C, Galli M. Use of 3D gait analysis as predictor of Achilles tendon lengthening surgery outcomes in children with cerebral palsy. *Eur J Phys Rehabil Med* 2019; **55**: 250–7.
 70. Saglam Y, Ekin Akalan N, Temelli Y, Kuchimov S. Femoral derotation osteotomy with multi-level soft tissue procedures in children with cerebral palsy: does it improve gait quality? *J Child Orthop* 2016; **10**: 41–8.
 71. Salami F, Brosa J, Van Drongelen S, et al. Long-term muscle changes after hamstring lengthening in children with bilateral cerebral palsy. *Dev Med Child Neurol* 2019; **61**: 971–7.
 72. Salami F, Wagner J, van Drongelen S, et al. Mid-term development of hamstring tendon length and velocity after distal femoral extension osteotomy in children with bilateral cerebral palsy: a retrospective cohort study. *Dev Med Child Neurol* 2018; **60**: 833–8.
 73. Schranz C, Kruse A, Kraus T, Steinwender G, Svehlik M. Does unilateral single-event multilevel surgery improve gait in children with spastic hemiplegia? A retrospective analysis of a long-term follow-up. *Gait Posture* 2017; **52**: 135–9.
 74. Sousa TC, Nazareth A, Rethlefsen SA, Mueske NM, Wren TA, Kay RM. Rectus femoris transfer surgery worsens crouch gait in children with cerebral palsy at GMFCS levels III and IV. *J Pediatr Orthop* 2017; **3**: 3.
 75. Steppacher R, North D, Kunzle C, et al. Retrospective evaluation of changes in gait patterns in children and adolescents with cerebral palsy after multilevel surgery. *J Child Neurol* 2018; **33**: 453–62.
 76. Sung K, Kwon S, Chung C, et al. Long-term outcome over 10 years after femoral derotation osteotomy in ambulatory children with cerebral palsy. *Gait Posture* 2018; **64**: 119–25.
 77. Sung KH, Lee J, Chung CY, et al. Factors influencing outcomes after medial hamstring lengthening with semitendinosus transfer in patients with cerebral palsy. *J Neuroeng Rehabil* 2017; **14**: 83.
 78. Svehlik M, Steinwender G, Lehmann T, Kraus T. Predictors of outcome after single-event multilevel surgery in children with cerebral palsy: a retrospective ten-year follow-up study. *Bone Joint J* 2016; **98**: 278–81.
 79. Saleh E, Dahan-Oliel N, Montpetit K, et al. Functional gains in children with spastic hemiplegia following a tendon achilles lengthening using computerized adaptive testing – a pilot study. *Child Neurol* 2018; **5**: 2329048X18811452.
 80. Aboelenein AM, Fahmy ML, Elbarbary HM, Mohamed AZ, Galal S. Calcaneal lengthening for the pes planovalgus foot deformity in children with cerebral palsy. *J Clin Orthop Trauma* 2019; **11**: 245–50.
 81. Lashkouski U, Ihnatouski M, Pauk J, Daunoraviciene K. Correction of planovalgus deformity through rotational reinsertion of the lateral layers of the achilles tendons in ambulatory children with cerebral palsy. *J Foot Ankle Surg* 2019; **58**: 528–33.
 82. Mansour T, Derienne J, Daher M, Sarraf D, Zoghbi Y, Ghanem I. Is percutaneous medial hamstring myofascial lengthening as anatomically effective and safe as the open procedure? *J Child Orthop* 2017; **11**: 15–19.
 83. El-Hilaly R, El-Sherbini MH, Abd-Ella MM, Omran AA. Radiological outcome of calcaneo-cuboid-cuneiform osteotomies for planovalgus feet in cerebral palsy children: relationship with pedobarography. *Foot Ankle Surg* 2019; **25**: 462–8.
 84. Dequeker G, Van Campenhout A, Feys H, Molenaers G. Evolution of self-care and functional mobility after single-event multilevel surgery in children and adolescents with spastic diplegic cerebral palsy. *Dev Med Child Neurol* 2018; **60**: 505–12.



32nd European Academy of Childhood Disability Annual Meeting

Virtual Meeting
25–28 November 2020

From Childhood to Adulthood with Disability

www.eacd2020.org