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Adults and Transition

SP01

A case control pilot study assessing nociceptive flexion reflex in females with cerebral palsy

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Background and Objective(s): Despite the prevalence of chronic pain in cerebral palsy (CP), little work has been done to assess the small-fibers conducting nociceptive signals. In this pilot investigation we aimed to test the feasibility of using a contact heat evoked potentials stimulator (CHEPS) to non-invasively assess nociceptive evoked potentials in participants with CP. This indirectly provides a measure of the functionality of the human thermal and nociceptive pathways that mediate sensory and pain perception. These evoked potentials can be quantified via the nociceptive flexion reflex (NFR) and objectively measured with surface electromyography (sEMG). This exploratory study aimed to (1) establish the feasibility of testing the NFR using a CHEPS in individuals with CP, and (2) examine any differences in NFR between individuals with CP and typically developing controls to generate future hypotheses.
Study Design: Case-control study.
Study Participants & Setting: Individuals with CP (n=10; M age=20.66 years, SD=2.36) and age matched controls (n=10; M age=20.51 years, SD=2.22) participated at an independent specialty rehabilitation hospital. Participants with CP had mild or no cognitive impairment and were ambulatory. As there are known sex differences in pain evoked potentials, females were recruited for this pilot.
Materials/Methods: One participant with CP was unable to complete the protocol and was excluded from the analyses. A CHEPS (Medoc, Israel) was used to deliver rapid heat stimulation. The stimuli were applied repeatedly to the distal volar forearm and the distal lateral lower leg. Participants were asked to rate their pain after each stimulus. Surface EMG electrodes were placed on the biceps femoris and biceps brachii muscles. The rectified mean and peak EMG were obtained from 90 to 150 ms after stimulation to quantify the NFR. Z-scores were calculated relative to the 5 to 65 ms pre-stimulus data. Data were averaged across trials.
Results: Preliminary results indicate no significant difference in mean sEMG Z-scores for CP (M=1.92 Hz, SD=0.62) compared to controls (M=2.37 Hz, SD=1.23; t[18]=1.02, p=0.32). There was also no difference in peak sEMG Z-scores for CP (M=9.08 Hz, SD=2.27) compared to controls (M=10.99 Hz, SD=2.79; t[18]=1.68, p=0.11). However there was a medium effect size for mean EMG (d=0.45) and large effect size for peak EMG (d=0.75) indicating reduced physiologic response in CP. There was no significant difference in the numeric pain ratings of females with CP (M=2.71, SD=1.59) and controls (M=2.70, SD=0.90; t[12.51]=0.20, p=0.84; d=0.09).
Conclusions/Significance: Results indicated the feasibility of this approach in females with CP (90% completed the protocol). Initial findings suggest that subjective pain experiences from CHEPS are similar between females with CP and TD controls while physiologic responses, as quantified by NFR, may be attenuated in females with CP.

SP02

Contributing factors and self-management of fatigue in adolescents and adults with cerebral palsy

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Background and Objective(s): Fatigue is a common symptom associated with cerebral palsy (CP); it has been estimated that up to 40% of adolescents and adults with CP experience fatigue that impacts their quality of life and daily activities. The purpose of this study was to explore the self-reported factors that generate fatigue and to describe fatigue self-management strategies from the perspectives of adolescents and adults with CP.
Study Design: This study was a secondary data analysis of the text responses to the open-ended questions on the Fatigue Impact and Severity Self-Assessment (FISSA) using a conventional content analysis approach.
Study Participants & Setting: Data from a convenience sample of 159 participants (mean age 22.4 years, SD=9.6 years) across all Gross Motor Function Classification System (GMFCS) levels who previously participated in two larger studies about fatigue were included in this study. Participants were recruited to the initial studies from outpatient programs at local rehabilitation programs and through advertisements with a local charity organization for individuals with CP.
Materials/Methods: Participants were able to contribute multiple answers to each question. The responses to the questions were collated across participants and coded using inductive line-by-line coding then grouped together to generate larger categories for each question. Frequency counts associated with each category were then summarized descriptively by GMFCS level for all questions and by topographical distribution (uni- vs bilateral involvement) for the question about contributing factors.
Results: The most commonly reported contributors to fatigue included: activity-related factors (27%), general demands of life (17%), sleep/rest (15%), general health concerns (14%), CP-related factors (11%), mental health concerns (9%) and

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environmental factors (4%). Specifically, individuals in GMFCS levels I to III experienced the most fatigue from activity related factors, individuals in GMFCS level IV from general demands of life and CP-related factors and those in GMFCS level V from CP-related factors. The top five strategies participants reported to manage fatigue included rest or relaxation (27%), sleeping or napping (19%), changing or limiting their activities (9%), being physically active (7%), or using specific adaptations or assistive devices (7%). The proportion of respondents who contributed to the 'demands of life', 'sleep and rest' and 'mental health concerns' themes closely matched the proportions of individuals with unilateral or bilateral involvement in the study (27% and 73% respectively). Individuals with bilateral involvement contributed more responses to the 'being related to CP' (92%), 'other health issues' (83%) and 'environmental' (85%) factors. Individuals with unilateral involvement contributed more responses than expected to the 'activity-related' theme (35%).
Conclusions/Significance: Results from this study suggest that there are potentially modifiable factors, including activity level and sleep that significantly contribute to fatigue for persons with CP; these could form the basis of interventions targeted at the prevention and management of fatigue.

SP03
Withdrawn by Author

SP04
Physical status, functional mobility and balance of ambulant adults with cerebral palsy and spastic diplegia more than 25 years after an orthopedic interval surgery approach

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Background and Objective(s): Currently, little is known about the physical status of adults with cerebral palsy (CP), who have been treated with an orthopaedic Interval Surgery Approach (ISA) in childhood. The main aim of this study was to determine the physical status, functional mobility and balance of ambulant adults with CP and spastic diplegia who have been treated with orthopaedic interventions following ISA and living in a developing country. Secondly, to investigate differences in these outcomes for adults with CP classified in different Gross Motor Function Classification System (GMFCS) levels and matched TD adults. Lastly, to determine association between these outcomes and personal characteristics.
Study Design: Case-control comparative study.
Study Participants & Setting: Twenty-eight adults with CP (13 male; age: mean [SD] = 39y 2mo [7y 8mo]; GMFCS level I/II/III: 39%/43%/18%), who received orthopaedic treatment based on ISA more than 25 years ago, and 28 TD adults (13 male; age: 38y 4mo [7y 10mo]) matched for sex, age, socio-economic-status and body mass index (BMI) participated in the study. All examinations and performance tests were completed at the Sport Science Institute of South Africa, by a CP-specialized orthopedic surgeon and physiotherapist.
Materials/Methods: Physical examination included passive range of motion (PROM), muscle strength (handheld dynamometry), selectivity and muscle tone assessments of lower extremities. Standing balance was assessed using the Clinical Test for Sensory Integration for Balance (CTSIB), and functional mobility and dynamic balance were assessed using a Timed-Up-and-Go (TUG) test.
Results: PROM and muscle strength were reduced in adults with CP compared to TD adults in the majority of movement directions of lower extremity ($p<0.05$). Selectivity was impaired across all movement directions ($p<0.01$), and most notable in adults with CP classified in GMFCS level III. Muscle tone was increased in adults with CP compared to TD adults ($p<0.05$), but was similar across the different GMFCS levels. Balance between adults with CP and TD peer were most notably different between GMFCS level III and TD, while TUG was slower all GMFCS groups compared to TD. Associations were found between TUG time and muscle strength, GMFCS level and BMI ($p<0.05$).
Conclusions/Significance: The physical status (PROM, strength, muscle tone, selectivity), balance and TUG time in adults with CP treated with ISA is substantially poorer than in TD adults. Impairments in most cases tended to increase with GMFCS level. The association found with TUG time, suggest that a training program focusing on strength, balance and weight loss can possibly result in improved daily life activities and getting out of a chair. The findings this study can be used to design effective interventions, that aim to improve or maintain a strength, balance and PROM while losing weight and with this promoting health aging in adults with CP.

SP05
The impact of environmental factors on workplace participation of transition-aged young adults with brain-based disabilities: a scoping review

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Background and Objective(s): Transition-aged young adults with brain-based disabilities experience poorer employment outcomes when compared to peers without a disability. The International Classification of Functioning, Disability and Health (ICF) places importance on the environment in explaining participation in different life domains, including work. Thus, this scoping review aims to synthesize existing evidence on the impact of the environment on workplace participation of young adults with brain-based disabilities.
Study Design: A scoping review.

Study Participants & Setting: Not applicable.
Materials/Methods: Arksey and O'Mally's (2005) methodology for scoping reviews was applied to conduct a search of peer-reviewed studies published between January 1995 and June 2018. Five databases were included to cover a range of research areas including health, social and rehabilitation sciences: OVID MEDLINE, EMBASE, PsychINFO, PubMed and CINHAL. Two independent reviewers systematically selected English-written empirical studies that explored the environmental impact on open and competitive work participation in individuals aged 18 to 35 years old with acquired or congenital brain-based disabilities. Studies whose participant's main diagnosis was a mental health diagnosis, and studies with a focus on health and safety recommendations, vocational rehabilitation and work re-integration programs were excluded. Consensus was reached through a discussion. Finally, Elo and Kyngäs' (2008) categorization process was used to organize findings into the environmental domains of the ICF; Products and technology & natural environment, Supports and relationships, Attitudes, and Services, systems and policies.
Results: Thirty-one articles met the inclusion criteria. All aspects of the ICF environmental domains had an impact on the workplace participation of transition-aged young adults with a variety of brain-based disabilities (e.g., cerebral palsy, spina bifida, intellectual disability, traumatic brain injury). The majority of the studies, 77%, highlighted the importance of services and supports at the institutional and organizational levels of the workplace, including policies, in the employment and inclusion of this group, without clear strategies to overcome existing barriers. Sixty-eight percent of the studies explored the impact of social support from family, friends, employers and colleagues, 55% discussed the importance of a physically accessible workspace and assistive technology, and 11% focused on attitudes of colleagues and employers on workplace participation.
Conclusions/Significance: Environmental factors at the organizational and institutional level appear to be critical in fostering workplace participation in this population. Findings can inform the development of guidelines and processes for implementing and reinforcing support services and regulations at the workplace.

SP06
Transition to adulthood outcomes in young people with spinal cord injuries: risk and protective factors

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Background and Objective(s): Pediatric-onset spinal cord injury (SCI) is a life-altering event that can present significant physical and psychological challenges. These challenges can be particularly pronounced as young people transition to adulthood, though specific factors predicting successful transition are still unclear. Thus, the objective of this study is to longitudinally examine factors associated with transition outcomes for young people with SCI.
Study Design: This study is part of a longitudinal study examining psychosocial variables among young people following SCI. Caregivers and young people with SCI completed standardized questionnaires at two distinct time points (adolescence and young adulthood).
Study Participants & Setting: The study was conducted at one pediatric multi-site specialty U.S. healthcare system. Adolescent patients aged 13 to 18 years and then later at age 22 to 28 years with a pediatric-onset SCI (n=40) and their caregivers (n=40) were recruited for the study (T1 M age=16.2y; T2 M age=24.5y]. Majority of participants were male (57.5%), White (70%), and had paraplegia (63%). Etiologies included motor vehicle injuries (47.2%), medical (25%), violence (11.1%), falls (8.3%), and sports (8.3%).
Materials/Methods: Injury information was gathered from medical records. Adolescent predictor measures included: Revised Children's Manifest Anxiety Scale (RCMAS), Pediatric Quality of Life Inventory (QoL), and Children's Assessment of Participation and Enjoyment (CAPE). The same participants completed the following outcome measures: Rotterdam Transition Profile (RTP), Satisfaction with Life (SWL) Scale, and PROMIS Neuro-QoL questionnaires, including Companionship, Emotional Support, and Ability to Participate in Social Roles and Activities (APSRA) scales.
Results: Independent-samples t-tests revealed that participants with tetraplegia reported significantly lower functioning on the RTP, lower companionship, and lower APSRA than those with paraplegia. Using linear regressions adolescent involvement in social activities (i.e., diversity and intensity) is predictive of increased RTP totals, satisfaction with adult providers in promoting positive transition, SWL, emotional support, companionship, and APSRA in young adulthood. Young people's social difficulties (PedsQL) also significantly predicted lower RTP, SWL, and APSRA. Additionally, lower adolescent emotional QoL and RCMAS worry predicted lower SWL, and APSRA, while RCMAS physiological anxiety predicted lower RTP. Higher caregiver depression at T1 predicted lower young adult T2 SWL, Emotional Support, Companionship, and APSRA.
Conclusions/Significance: The initial results of this study identify a number of adolescent emotional, social, and demographic variables that predict transition outcomes in young adulthood. Involvement in social activities in adolescence appears to be protective for these young people. In contrast, satisfaction with adult healthcare providers ensuring a smooth transition between the two systems was predicted by patient anxiety and reduced social interaction, suggesting the need for additional support for these patients. Patients with tetraplegia and anxiety, and whose caregivers experienced higher depressive symptoms emerged as particularly vulnerable to difficulties in transition, suggesting the importance of addressing caregiver depression and increased prevention and advocacy efforts for these at-risk individuals.

SP07

Visualize to realize: visual feedback supplemented power training for adolescents and adults with cerebral palsy

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Background and Objective(s): It has been established that power training can result in a change of muscle architecture and rate of force production in children with cerebral palsy (CP). Translation of this intervention to the clinic poses a problem as children with CP have limited experience with high-velocity based movements, and pediatric physical therapists struggle to know if they are providing adequate challenge for patients. This study aims to enhance this knowledge through the instrumentation of standard clinical equipment to provide tangible, visual feedback to participants and therapists regarding the velocity of their movement during power training. We hypothesize that participants who perform power training with visual feedback (VFB) of their movement velocity will demonstrate greater improvements in power production than those who perform the power training without visual feedback (NFB).

Study Design: Cohort.

Study Participants & Setting: A cohort of adolescents and adults with CP (n=17; age=17.0 ± 4.1 years, GMFCS I–IV) were recruited to participate in a physical therapy study at an academic medical center. Participants were randomly assigned to either train with visual feedback of the velocity of their performance or training without visual feedback.

Materials/Methods: Both groups underwent 24 (8 weeks; 3 days-a-week) high-velocity leg press power training sessions performed on a Total Gym®. The sled was instrumented with a custom-built linear transducer system that measured movement velocity in real-time. For training, the target load was initially 40% of the 1-repetition maximum (1RM) and progressed towards 80% by the final week. Participants performed 6 sets of 5 maximum-effort repetitions, each as fast-as-possible both unilaterally and bilaterally. For the VFB group, the velocity of the leg press performance was displayed on a monitor and included a target velocity that was manipulated by the therapist. Muscular performance changes were assessed using the percent change of the pre-post training bilateral 1RM leg press and peak power.

Results: Visual feedback greatly enhanced power training outcomes. Statistical analysis confirms this observation by showing that the Pre/Post percent change for peak power production of the VFB group was significantly greater than the NFB group (VFB=55.0±11%; NFB=12.5±10%; p=0.020). Nevertheless, the change score for the 1RM was similar between the respective groups (VFB=49.8±7.60%; NFB=53.6±9.21%; p=0.787).

Conclusions/Significance: These results are the first to show that real-time feedback of movement velocity results in greater therapeutic changes in leg power production, but a similar change in muscular strength. This suggests that knowledge of velocity for the participant and therapist during power training is a key ingredient for ensuring optimal challenge and teaching power production to adolescents and adults with CP.

Basic Science - Brain/Muscle/ Genetics

SP08

Altered DNA methylation profiles in blood and satellite cells from individuals with spastic CP

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Background and Objective(s): Spastic cerebral palsy (CP) is a leading cause of physical disability that often develops prenatally; however, early postnatal diagnosis remains challenging, and a reliable biomarker platform to identify affected individuals does not currently exist. Previous studies have established that stress on a developing fetus can alter DNA methylation patterns and that these patterns can remain stable over time. We therefore sought to determine if children with spastic CP have specific methylation patterns that distinguish them from a non-CP cohort.

Study Design: A case-control study design using consecutive sampling was employed following IRB approval and informed consent/assent.

Study Participants & Setting: DNA was isolated from de-identified blood samples (CP n=16, age=14.7 ± 3.3, control n=16, age=15.0 ± 2.2) and cultured satellite cells that were isolated from surgical explants of skeletal muscle (CP n=6, age=15.3 ± 2.7, control n=6, age=13.9 ± 1.7) from participants undergoing orthopedic surgery at the Nemours – Alfred I. duPont Hospital for Children.

Materials/Methods: DNA libraries were prepared from methyl-sensitive restriction endonuclease (MSRE) fragmented genomic DNA using HpaII to cleave CpG sites. Next generation sequencing was performed on an Illumina ×10 platform, and FASTQ data files were processed via a commercial bioinformatics pipeline and software platform (Genome Profiling, LLC). The proportion of methylation for each CpG site was determined for each sample cell population.

Results: Approximately 1.5 million CpG sites were identified across the samples. DNA methylation analysis of the 32 blood samples indicated significant differential methylation between the CP and control cohorts at 6588 CpG sites. Analysis of the 12 satellite cell populations indicated significant differential methylation at 1880 CpG sites (FDR-corrected p<0.05). Of these, 19 distinct CpG sites were significantly hypermethylated and 13 were significantly hypomethylated in the CP cohort in both the blood cell and muscle cell samples.

Conclusions/Significance: DNA methylation patterns differed in the CP and non-CP cohorts in both peripheral blood and satellite cells. Early-life stress associated with the onset of CP may have resulted in DNA methylation changes in both hematopoietic stem cells and muscle stem cells, and some of these changes may have persisted into adolescence. Studies are ongoing to evaluate the methylation status of the 32 differentially methylated sites identified across the two tissue types for their presence earlier in life and their potential utility as biomarkers for spastic CP.

SP09

An effective approach for high-resolution 3D MRI reconstruction on highly motion-corrupted neonatal data

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Background and Objective(s): Precise volumetry and quantification of the cortical grey matter in preterm neonates could be associated with later neurodevelopmental outcomes. While single-shot fast-spin echo T2 MRI sequences provide a method to minimize motion-induced artefacts, the thick slice acquisitions prevent accurate characterisation of the anatomical details. Reconstruction of a high-resolution 3D, motion-free image from these 2D acquisitions is essential for the investigation of developmental anomalies. In this work we investigated a method for 2D slice to 3D MRI reconstruction on motion-affected preterm neonatal T2-HASTE images acquired at 30 weeks and 40 weeks postmenstrual age (PMA), which combines the existing Brain Toolkit (BTK) toolbox and a novel approach for rejecting motion-affected slices in the structural MRI.
Study Design: Feasibility study in a subset of a prospective cohort study.
Study Participants & Setting: Infants born <31 weeks gestational age (GA) were enrolled as part of the study. A total of 20 participants from this cohort (14 male) were recruited to test the feasibility of this method, including 13 at 30 weeks and 7 at 40 weeks PMA.
Materials/Methods: Infants were scanned using a 3T Siemens Trio, utilizing an MR compatible incubator equipped with a neonatal head coil (LMT Lammers Medical Technology, Lübeck, Germany). T2-HASTE sequence brain MRIs at 30 weeks and 40 weeks of PMA were acquired (axial, coronal and sagittal slices of 1.8 mm thickness for each participant). A slice was detected as 'motion-affected' if it appeared significantly darker in intensity, compared to the adjacent slices, in an automated algorithm. Motion-affected slices were replaced by interpolated anatomy derived as the mid-point between the two adjacent slices.
Results: Qualitative findings from N=20 datasets identified 70% successful reconstructions with no artefacts and 30% with significant artefacts affecting the image quality. The latter cases revealed that the outlier-detection failed, leading to dark slices in the high-resolution image (n=1), checkboard artefacts due to poor image normalisation (n=4) and the T2 sequences not being aligned well, leading to blurry output images in n=1 case.
Conclusions/Significance: This work demonstrates the feasibility of generating high-resolution MRIs in preterm infants, even in motion-affected scans, with the combination of existing and additional outlier-detection approach. This allows for the precise quantification of brain measures (such as the grey matter), which could be associated with long-term motor and cognitive outcomes. Future work will investigate alternative motion-detection and anatomical interpolation methods to increase the usability of motion-corrupted neonatal scans.

SP10

Automated segmentation of subcortical grey and white matter segmentation in children with cerebral palsy

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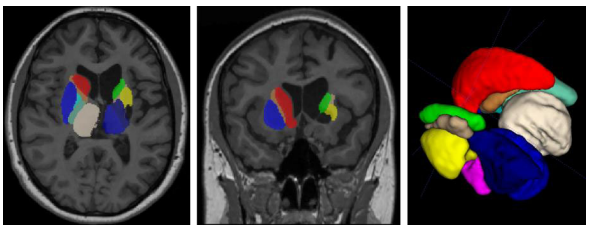
Background and Objective(s): The deep grey matter (DGM), internal capsule and corpus callosum may be severely impacted in children with cerebral palsy (CP). Automated segmentation of these structures can quantify the extent of atrophy and assist disease diagnosis, however the task remains difficult due to severe injury resulting in extreme variations from healthy anatomy, and the presence of iso-intense lesions. In this study, we present a pathology-robust, patch-driven approach for the segmentation of the DGM and corpus callosum, and investigate if the volumes of these structures are associated with motor, cognitive, communication and visual function.
Study Design: Cross-sectional study.
Study Participants & Setting: This novel automated approach was applied to children with unilateral CP (N=91; 51 male, 40 female, mean age of 11y 5mo [SD 3y 1mo], Manual Ability Classification System level I=38, II=53).
Materials/Methods: Automated segmentation of the DGM (caudate, basal ganglia and thalamus), anterior and posterior limbs of the internal capsule, and the genu, body and splenium of the corpus callosum, was performed on 3T T1 MPRAGE MRI sequences using a novel patch-based method that accounted for periventricular lesions and ventricular enlargement. Multivariable regression was used to associate the predictive MRI measures (DGM, internal capsule and corpus callosum volumes) and covariates (participant age and sex) with several clinical outcomes, including measures of motor, cognitive, communicative and visual function. These models were trained on a 75% partition of the data (n=68) and validated on the remaining unseen 25% (n=23).
Results: The accuracy of the automated DGM and corpus callosum segmentations were validated on a subset (n=23) with

severe brain injury, compared to manually drawn contours by a clinician. Significant correlations between MRI-derived subcortical grey and white matter volumes were observed with the Assisting Hand Assessment (r=0.42, p=0.01), the Strength and Difficulties Questionnaire (r=0.41, p=0.007), the Vocabular subtest from the Wechsler Intelligence Scale for Children-III (r=0.44, p=0.004) and the Test for Visual Perception (r=0.52, p<0.001).

Conclusions/Significance: Due to the prevalence of periventricular leukomalacia and ventriculomegaly in this cohort, these findings highlight the importance of quantifying the volumes of the DGM, internal capsule and corpus callosum when characterising brain structure from structural MRI. These anatomies are significantly correlated with multiple clinical scores, demonstrating the feasibility of predicting outcomes from MRI alone for children with CP, which can help to guide clinical decision making.



SP11

Clinically-calculable striatal and thalamic injury on MRI can predict dystonic cerebral palsy following neonatal hypoxic-ischemic encephalopathy

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Background and Objective(s): Basal ganglia and thalamic injury are established predictors of motor disability following neonatal brain injury. Standardized MRI assessment scales can be used to gauge injury, but these still largely require subjective consensus evaluations from trained experts and may not be easy to implement in clinical practice. Furthermore, the injury patterns underlying dystonic cerebral palsy (CP) are less clear given that existing studies on this are often plagued by lack of standardized MRI injury quantification, expert dystonia phenotyping, or homogenous CP etiology. Our goal was to determine a quantitative and clinically facile method to predict the development of dystonic CP based on MRI injury patterns following neonatal hypoxic-ischemic encephalopathy.

Study Design: Case-control study.

Study Participants & Setting: Children who underwent therapeutic hypothermia for moderate to severe neonatal hypoxic-ischemic encephalopathy at St. Louis Children's Hospital between 1/1/2010 and 12/31/2015 (N=243). Cooling criteria included a gestational age ≥35 weeks, evidence of peripartum distress, and the presence of moderate to severe encephalopathy or seizures within 6 hours of age.

Materials/Methods: Medical records were screened through 5 years of age for pediatric neonatal neurology or pediatric movement disorders specialist documentation of dystonia with or without co-morbid spasticity, hypertonia not otherwise specified as dystonia or spasticity (NOS), or typical motor development. Brain MRIs done between days 4 and 5 of life were examined (n=21 in this initial analysis). The striatum, thalamus, and a region of cerebrospinal fluid at the circle of Willis were traced on apparent diffusion coefficient (ADC) axial images within the Epic electronic medical interface using integrated GE clinical image viewing software. The minimum ADC values in the striatum and thalamus were normalized to the average ADC value at the circle of Willis for all images. These normalized ADC values were compared between children identified as having hypertonia NOS, dystonia, or typical motor development.

Results: Normalized ADC values in the striatum or thalamus were significant and absolute classifiers of children who went on to develop expert-identified dystonia with receiver operator characteristic areas under the curve of 1.0 (95% CI 1.0–1.0, p<0.01). A normalized ADC cutoff of 0.7 provided 100% specificity and sensitivity for classifying dystonia in this set of 21 participants.

Conclusions/Significance: MRI analysis requiring only basic neuroanatomical knowledge and the use of clinically-integrated imaging software can reliably predict which children will go on to develop dystonia following neonatal hypoxic-ischemic encephalopathy in a small subset of children followed from birth at a single tertiary care center. This measure may serve as a useful prognostication adjunct and help establish the appropriate vigilance for dystonia following neonatal brain injury.

SP12

Epigenetic marks at the ribosomal DNA promoter in skeletal muscle are negatively associated with degree of impairment in cerebral palsy

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Background and Objective(s): Cerebral palsy (CP) is the most common motor impairment in children. Skeletal muscles in individuals with CP are typically weak, thin and stiff. If epigenetic changes at the ribosomal DNA (rDNA) promoter is involved in this dysregulation is unknown.

Study Design: Cross-sectional, basic science study.

Study Participants & Setting: Open muscle biopsies were taken during surgery in children and adolescents with CP, who due to elbow flexion contractures were planned for biceps tendon lengthenings (n=19, mean age 15y, range 9–18y, GMFCS I–V; 9/2/0/4/4, MACS I–V; 3/7/4/1/4). Control muscle was harvested from age-matched typically developing donors (TD)

post-mortem following accidental deaths (n=10, mean age 15y, range 7–21y).
Materials/Methods: Methylation of the rDNA promoter was analyzed using the Agena Epityper Mass array and gene expression by qRT-PCR.
Results: Biceps muscle ribosome biogenesis, as indicated by 45S pre-rRNA abundance, was suppressed (–24%, p<0.05) in CP as compared to TD. Average methylation of the rDNA promoter was not different between CP and TD, but with a larger variation in CP (mean 21.6 SD 6.9 vs mean 19.1 SD 3.3). Within the CP group, more affected children (GMFCS IV–V, MACS IV–V) had significantly lower degree of methylation as compared to less affected children (GMFCS I–II, MACS I–II). Moreover, the degree of methylation was inversely correlated to the flexion contracture of the elbow joint (r=0.57, p<0.05) in the CP group, but not related to age (r=–0.14, p=0.62) or 45S pre-rRNA levels (r=0.30, p=0.34) in either group.
Conclusions/Significance: We observed a negative correlation between rDNA promoter methylation and degree of muscle contracture in the CP group. This could imply that better neural input and more voluntary muscle movements is needed for promoter methylation to develop.

SP13

Skeletal muscle myonuclear domain does not differ between ambulatory children with cerebral palsy and children with typical development

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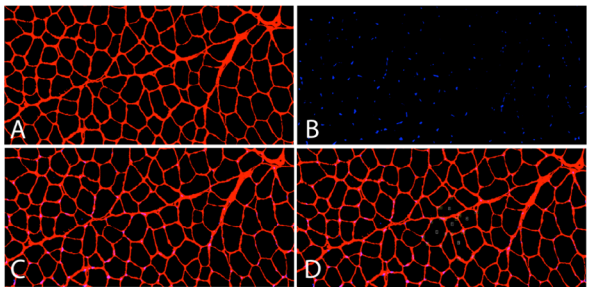
Background and Objective(s): Skeletal muscle myofibers have multiple myonuclei that increase with muscle growth during early postnatal development. The source of these new myonuclei are satellite cells (SC), i.e. muscle stem cells required for muscular growth, repair and regeneration. Even ambulatory children with cerebral palsy (CP) have poor muscle growth leading to contractures and weakness. Importantly, SC number is reduced in contractured muscles. Currently the timeline/mechanisms of this SC loss and its role in muscle growth impairment is unclear. We wanted to test the hypothesis if SC number are reduced from birth in children with CP leading to reduced number of myonuclei and impaired muscle growth. The objective of this study was to compare myonuclear domain (myofiber area/myonuclear count) in muscles previously shown to have reduced SC number in ambulatory children with CP versus TD.
Study Design: Cross-sectional study.
Study Participants & Setting: Participants were recruited prior to surgery from a large, urban, academic medical center. Participants were 5 adolescent children with CP (GMFCS I, II) undergoing muscle lengthening surgery, and 5 with TD receiving ACL reconstruction. Parental consent and age appropriate assent was obtained from all participants.
Materials/Methods: Gracilis muscle biopsies were sectioned and stained (DAPI, Laminin) for myofibers and myonuclei. Previously, we showed these muscles had a 70% reduction in SC number. Fluorescence microscopy was used for manual quantification of myofiber count, myonuclear number, and myonuclear domain. Regression analysis and a t-test were performed on the data. Myonuclear domain for TD and CP groups was calculated as (myofiber count x myofiber area) per nuclei count.
Results: Average myonuclear number (MN) per myofiber and myonuclear domain (MD) were not different between groups (MN: CP=2.60 ± 1.04, TD=1.98 ± 0.50, p=0.26; MD: CP=1815 ± 579, TD=2426 ± 2054, p=0.54). In this age range we did not observe an increase in MN with age or myofiber area.
Conclusions/Significance: Our results indicate myonuclear characteristics are not different between groups. Therefore, SC contributed myonuclei in ambulatory children with CP during postnatal development and suggests muscle stem cell number in contractured muscles are not reduced from birth.



SP14

Inflammatory responses are significantly altered through adulthood in a clinically translatable rat model of cerebral palsy

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Background and Objective(s): Cerebral palsy (CP), the most common sensorimotor impairment of childhood, often results from perinatal brain injury (PBI). While studies in humans have shown aberrant inflammatory signaling and altered peripheral immune responses in children with CP, the time course or chronicity of the proinflammatory changes are unknown. Here using an animal model of CP, we studied peripheral immune reactivity in adulthood with the goal of establishing whether immune changes persist long-term. We hypothesized that isolated peripheral blood mononuclear cells (PBMCs) would be hyperresponsive and primed for inflammation through the lifespan.

Study Design: Basic science studies.
Study Participants & Setting: This preclinical laboratory investigation was conducted in a rat model of CP secondary to PBI from chorioamnionitis. We previously have reported the abnormal gait with spasticity, deficits in cognition, impaired executive function, diminished motor inhibition and impaired social interactions using this translational platform.
Materials/Methods: Pregnant Sprague-Dawley rat dams underwent a laparotomy at preterm equivalent (embryonic day 18 [E18]). To induce chorioamnionitis, uterine arteries were occluded for 60 minutes followed by intra-amniotic injection of lipopolysaccharide (LPS, 4 μg/sac). Shams underwent laparotomy only, with equivalent duration of anesthesia. Laparotomies were then closed, and the rat pups were born at term. PBMCs were isolated from both male and female offspring at young adult (postnatal day 60 [P60]) and middle age equivalent (P120) timepoints. PBMCs were then subsequently stimulated in vitro with LPS. The primary outcome measure was a secreted inflammatory protein profile analysis performed using a clinical biomarker platform. Statistical differences were identified using a Student's t-test, or one-way ANOVA with Bonferroni correction where $p<0.05$ was considered significant (n=6–8/group)
Results: PBMCS from adult rats with CP secondary to chorioamnionitis are hyper-reactive and secrete significantly more interferon gamma (0.44±0.31 vs 1.42±0.27 pg/mL, $p<0.05$), IL-10 (1.12±0.38 vs 3.82±0.49, $p<0.001$), IL-6 (121.6±22.4 vs 228.4±34.6 pg/mL, $p<0.05$) and MCP-1 (193.3±63.7 vs 689.1±168.8 pg/mL, $p=0.05$) following LPS challenge at P60. Notably, PBMCs from adult rats with CP secreted significantly more TNFalpha following LPS stimulation at both P60 (96.2±14.5 vs 225.4±41.05, $p<0.05$) and P120 (2.39±0.50 vs 33.5±4.64 pg/mL, $p<0.0001$).
Conclusions/Significance: Adult rats with CP have aberrant immune cell priming consistent with sustained peripheral immune hyper-reactivity (SPIHR). These changes are dynamic and are concomitant with increased pro-inflammatory signaling throughout the lifespan. The consequences of sustained inflammation throughout crucial periods of development are multifold. However, further study is warranted to establish mechanistic relationships between increased inflammatory network signatures in CP, persistent immune sensitization and brain injury.

SP15

A feasibility study of a novel early participation-focused physiotherapy intervention for preterm infants in a regional Australian context

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Background and Objective(s): Early physiotherapy intervention for preterm infants is beneficial for improving motor and cognitive outcomes in early childhood, however most studies have been conducted in major metropolitan settings. Additionally, participation-focused interventions have been effective for older children, though no studies to date have used a participation-focused approach with preterm infants. Our aim was therefore to evaluate the feasibility of a novel early physiotherapy intervention for preterm infants called PreEMPT: Preterm infant Early intervention for Movement and Participation Trial in a regional Australian setting.
Study Design: Prospective, assessor-blinded, randomised, controlled feasibility trial.
Study Participants & Setting: Infants born <35 weeks and their caregivers, residing <2 hours from a regional Australian hospital.
Materials/Methods: Of 40 eligible infants, 16 were randomised to standard care (SC: n=8) or PreEMPT (n=8) following consent and baseline assessment at term equivalent age. PreEMPT participants received 14-weeks of weekly alternating clinic or telehealth physiotherapy, which involved participation-focused, goal-directed gross motor intervention for infants and parent enablement training to enhance infant-parent dyads. Participants in SC received 1 to 2 clinic physiotherapy sessions between 0 to 3 months corrected age (CA). Post-intervention infant assessments included General Movements assessment (3mCA), Test of Infant Motor Performance (4mCA), Alberta Infant Motor Scale (4, 6, 8mCA), Neurosensory Motor Developmental Assessment (4, 8mCA) and Bayley-III (8mCA). Parental well-being was measured using the Hospital Anxiety and Depression Scale. Social status was rated using the Australian Bureau of Statistics Index for Relative Socio-economic Advantage and Disadvantage (IRSAD). Feasibility was examined using: recruitment rate, session attendance, parent-reported satisfaction and treatment preferences.
Results: Follow-up rates were 14/16 at 4 months, 13/16 at 6 months and 10/16 at 8 months. Mean assessment attendance was 3.8/5 sessions for PreEMPT (range 2–5) and 4.8/5 sessions for SC (range 4–5) groups. Mean treatment attendance was 7.3/14 sessions for the PreEMPT group (range 0–12), which was equivalent for face-to-face (3.9/7; range 0–6) and telehealth sessions (3.4/7; range 0–6). Families in SC attended on average 1.8/2 face-to-face treatment sessions (range 1–2). Most (n=12/16) lived in highly disadvantaged socio-economic areas (IRSAD deciles 1–5) and 10/16 lived >25 km from hospital. Main reasons parents attributed to treatment non-attendance were maternal mental health (22 sessions), infant illness (13 sessions) and family relationship breakdown (8 sessions). There were no differences in infant or parent outcomes at 4, 6 or 8 months ($p>0.05$) as expected given the study was focused on feasibility and not powered to detect between-group differences. Following intervention, most parents (10/12; 5 each group) agreed/strongly agreed that physiotherapy had benefitted their child and family.
Conclusions/Significance: Early post-discharge physiotherapy for preterm infants in regional Australia is beneficial according to families but logistically challenging. Future research on early interventions for preterm infants in regional settings may benefit from lower intensity or duration and additional parent psychosocial support. Telehealth was accepted equally well to face-to-face intervention in the hospital setting.

SP16

Accurate and rapid automated detection of cramped-synchronized general movements in a large cohort of NICU infants

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Background and Objective(s): Early detection of neuromotor disorders in the neonatal intensive care unit (NICU) can allow targeted evaluation of infants and parent support. Prechtl's general movements assessment (GMA) allows visual recognition of movement patterns that, when cramped synchronized (CS) have high specificity in predicting neuromotor disorders. However, challenges inherent to various healthcare settings and to the rigorous GMA training process have hindered universal adoption in the newborn period. Our team focused on developing an automated tool to accurately read GMA in the NICU near term equivalent age. We hypothesized that a combination of pressure sensor technology and machine learning could develop an easy, rapid tool for clinical use.
Study Design: Prospective observational study with a simultaneously obtained derivation and validation cohort.
Study Participants & Setting: In a large tertiary care NICU, we consecutively recruited 375 infants. Included infants were 36 to 44 weeks postconceptional age regardless of diagnosis (range was extreme prematurity to mild jaundice). Excluded infants were on ventilators or had orthopedic conditions precluding movement.
Materials/Methods: We simultaneously recorded supine infants in their NICU beds moving for ~2 minutes on a flexible fabric pressure sensor mat and on standard video. Masked observers with advanced GMA training classified the videos. The mat allowed collection pressure data with spatial and time coordinates in a 32X32 matrix. To classify mat data, we considered features extracted from automatic machine-learning tools, and in parallel, clinician-designed features such as calculated pressure centers and distances. Periods of rest were subtracted from recordings via a filter for variability of movement. Because we predicted categorical outcome (CS vs not) with labeled data, the following models were compared: Linear Support Vector Machine (SVM), Kneighbors, Ensemble and SVM classifiers.
Results: Video GMAs were coded as 34% normal writhing, 62% poor repertoire and 4% CS. Algorithms using computer-generated features rapidly differentiated normal from abnormal movements with 98% sensitivity and 97% specificity. However, they were unable to differentiate PR from CS movements more than random chance. Using a supervised learning method with a Leave-one-out cross-validation model and the set of 40 clinician-designed features, we were able to differentiate CS movements from all others (Table 1). SVM had the best fit in allowing a clinically meaningful readout. The user interface leveraging this set of features and model was then validated in clinical practice and allowed a readout <15 minutes after data collection in the NICU.
Conclusions/Significance: A pressure sensor mat with a practical interface and a machine learning algorithm with clinician-designed features, rapidly identifies those infants with CS movements who could most benefit from neuroimaging and close neurodevelopmental surveillance.

	Sensitivity	CI	Specificity	CI
SVM	90.0%	55.5-99.7	94.5%	91.0- 97.0
RF	70.0%	34.7-93.3	99.2%	97.2-99.9
LinearSVM	0.0%	0.0-30.8%	100.0%	98.6-100.0
KNeighbors	20.0%	2.5-55.6	100.0%	98.6-100.0

SP17

Are Spanish physical therapists using evidence-based assessment tools for early cerebral palsy detection? Findings from a national survey

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Background and Objective(s): Evidence-based assessment tools such as magnetic resonance imaging, Pretchl's Qualitative Assessment of General Movements (GMA) and Hammersmith Infant Neurological Examination (HINE) are highly recommended for early and accurate diagnosis of 'high-risk of cerebral palsy' or cerebral palsy (CP). Physical Therapy plays an important role in the management of high-risk infants, optimizing infant motor and cognitive plasticity, preventing secondary complications and enhancing caregiver well-being. Therefore, the knowledge, training and clinical implementation of tools with high sensitivity for CP should be generalized in the profession. This study includes the results from a national survey to Spanish Physical Therapists to know the current use of GMA and HINE for high-risk of CP detection.
Study Design: This study is a national, cross-sectional, online survey.
Study Participants & Setting: 177 Spanish Physical Therapists, from 16 of the 17 Autonomous communities in Spain, responded to the questionnaire. Most of them worked in Early Intervention (56%) and had a Master's degree (53%). 75 participants were members of the Spanish Pediatric Physical Therapy Society (42%), and 79 were not members of any association or professional group (45%).
Materials/Methods: An online structured questionnaire was available from June 2019 to October 2019. Physical Therapists were contacted through National Associations and Physical Therapy Organizations, including the Spanish Pediatric Physical Therapy Society.
Results: More than half of the Physical Therapists (57%) did not follow any standardized protocol, procedure or reference guide for the referral of infants with high-risk of CP. Nevertheless, there were 173 participants (98%) who believed that developing standardized clinical guidelines of good practices in the management of CP would be useful in Spain. 29% and 28% of the participants were familiar with GMA and HINE, of which 17% had received training on GMA, and 9% on HINE. According to this, assessment procedures most used for high-risk children under 1-year-old did not include GMA either HINE (sixth and fifth most used). 51% of the

respondents had never used GMA or HINE with infants under 1-year-old, compared to 15% and 14% who had used them sometimes, and 6% who administrated GMA or HINE almost always. Besides, 79% of the participants were not familiar with the use of HINE and GMA optimal scores.

Conclusions/Significance: These findings may indicate that evidence-based tools as GMA and HINE are not yet being implemented by most Spanish Physical Therapists, and high-risk of CP detection could be mainly based on low-evidence assessment tools. There are challenges in Spain for the use of evidence-based assessments, which could support prompt referral to diagnostic-specific early intervention for infants and their families.

SP18

Diagnostic accuracy of the combination of neurological assessment at term equivalent age and General Movements assessment at 3 months to predict 2-year cognitive outcome in infants born very preterm

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Background and Objective(s): Children born prematurely score on average 12 points lower in IQ than their term born peers. Early, accurate identification of those children at risk of adverse cognitive outcomes is critical to enable structured surveillance and early commencement of targeted interventions. A combination of the Hammersmith Neonatal Neurological Examination (HNNE) at term equivalent age (TEA) and the General Movements assessment (GMs) at 3 months corrected age (CA) is strongly associated with cognitive outcome at 2 years CA in infants born very preterm. We examined the predictive accuracy of this combination of tests.

Study Design: Prospective cohort study.

Study Participants & Setting: Ninety-five infants born <31 weeks gestational age (58 male, median gestational age at birth 28 weeks 4 days) underwent the HNNE at TEA, a GMs assessment at 3 months CA and cognitive outcome assessment at 2 years CA using the Bayley Scales of Infant and Toddler Development, 3rd edition (Bayley III).

Materials/Methods: The GMs assessments were classified as 0=normal fidgety, 1=abnormal fidgety or 2=absent fidgety movements. A linear regression model was employed to calculate the predicted Bayley III cognitive composite score for each child. These predicted scores were then compared with each child's actual Bayley III cognitive outcome score using a cut off of <80 to calculate diagnostic accuracy statistics (Fig 1).

Results: The mean (standard deviation; SD) of the Bayley III cognitive outcome was 95 (15). Predicted cognitive outcome = 64.4 – (10.01 x 3-month GMs score) + (1.33 x TEA HNNE score). The SD of variation unexplained by model was 13.7. Sensitivity was 42% (95% confidence interval CI=15–72), specificity 100% (95% CI=94–100%), positive predictive value 83% (95% CI=34–100%) and negative predictive value 92% (85–97%).

Conclusions/Significance: In this cohort, the 100% specificity of the model shows that all children with an actual cognitive outcome >80 were identified by the model. This low false positive rate is an essential feature for a screening tool. The positive predictive value says that 83% of children who the model predicted to have a Bayley cognitive outcome below 80 actually did have an outcome below 80. Low sensitivity was expected as the individual components of the model predict an outcome of cerebral palsy more strongly than neurodevelopmental outcomes. The relatively low sensitivity means that the model is not suitable for identifying children who will have an actual Bayley cognitive outcome score below 80 at their 2-year assessment.

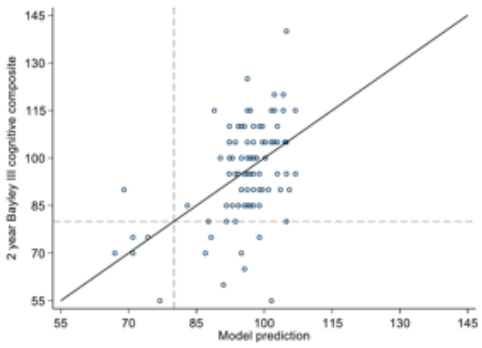

Figure 1: Bayley III scores predicted using the regression model, vs each child's actual 2-year outcome score (dashed lines indicate the cut -off used to calculate diagnostic accuracy statistics)

SP19

Prediction of motor outcomes at 2 years from the PPREMO toolbox

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Background and Objective(s): Preterm born infants are at increased risk of deficits and delays in motor development. Early identification of children at risk of adverse motor outcomes enables referral to targeted early interventions and prognostic counselling for families. The combination of early neonatal neurological testing, term equivalent age MRI deep gray matter score and the 3-month General Movements assessment (GMs) is strongly associated with 2-year motor outcomes in infants born very preterm. The aim is to evaluate the predictive accuracy of this combination of tests.

Study Design: Prospective cohort study.
Study Participants & Setting: Eighty-three infants born <31 weeks gestational age (49 male, median gestational age at birth 28 weeks 6 days) underwent neurological assessment using the Hammersmith Neonatal Neurological Examination (HNNE) at a median 31 weeks 6 days, an MRI at term equivalent age, a GMs assessment at 3 months corrected age (CA) and motor outcome assessment at 2 years CA using the Bayley Scales of Infant and Toddler Development, 3rd edition (Bayley III).
Materials/Methods: The optimality score for the reflexes subscale (range 0.5–4.5; higher scores better) of the HNNE was utilised. A structural MRI scoring system was applied to the structural MRI and the deep gray matter subscale score was utilised (Kidokoro 2014, George 2017). The 3-month GMs assessments were classified as 0=normal fidgety, 1=abnormal fidgety or 2=absent fidgety movements. A linear regression model calculated the predicted Bayley III motor score for each child. Each child's predicted scores were compared with their actual Bayley III motor score. A cut-off of <85 on the Bayley III motor composite score was used to calculate diagnostic accuracy statistics (Fig 1).
Results: The mean (standard deviation; SD) of the HNNE reflexes subscale was 2.43 (1.00), median (IQR) deep gray matter MRI score was 0 (0–1), 5% of infants were scored as having absent fidgety movements and the mean (SD) Bayley III motor outcome was 98 (15). The predicted motor outcome = 93.50 – (11.41 x 3-month GMs) – (6.23 x TEA MRI deep grey matter score) + (3.51 x HNNE reflexes score). The SD of variation unexplained by model was 12.0. Sensitivity was 40% (95% confidence interval CI=12–74), specificity 99% (95% CI=93–100%), positive predictive value 80% (95% CI=28–100%) and negative predictive value 92% (84–97%).
Conclusions/Significance: Specificity of the combined tools was excellent, indicating a very high probability that the tool accurately identifies children who will achieve a motor score >85. The negative predictive value was high; 92% of those with predicted scores >85, went on to have actual motor outcomes >85. The relatively low sensitivity (40%) suggests it is not appropriate to use the model to predict a Bayley III motor outcome <85. The low sensitivity was expected as it is well documented that the individual components of the model predict cerebral palsy better than motor outcome.

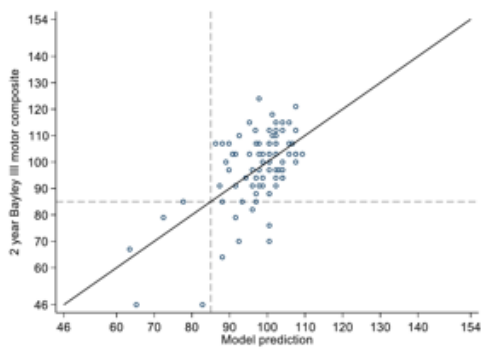

Figure 1: Bayley III scores predicted using the regression model, vs each child's actual 2-year outcome score (dashed lines indicate the cut -off used to calculate diagnostic accuracy statistics)

SP20

Systematic review of clinical assessment tools used between birth and 6 months to predict motor and cognitive delay in at risk preterm infants at 2 years corrected age

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Background and Objective(s): This systematic review evaluates accuracy of clinical tools used <6 months corrected age (c.a) to predict motor and cognitive delay (not cerebral palsy [CP]) in at-risk preterm infants at 24 months c.a.
Study Design: Systematic review of diagnostic accuracy.
Study Participants & Setting: A comprehensive search was conducted in six databases for studies that met the following criteria: preterm infants born ≤32 weeks and/or ≤1500 g, clinical assessment tools with strong psychometric properties administered as index tests ≤6 months c.a and valid, reliable and standardised reference tests for cognitive and/or motor delays (not CP) at 24 months c.a.
Materials/Methods: The methodological quality of included studies was evaluated using the Quality Assessment of Diagnostic Accuracy Studies-2. Predictive analysis included calculation of sensitivity and specificity, interpretation of SROC curves and meta-analysis.
Results: Six assessments were identified in 10 studies: the General Movement Assessment (GMs), the Bayley Scales of Infant and Toddler Development (Bayley III), Prechtl's Neurological Examination, the Neurobehavioural Assessment Scale (NBAS), the Neurobehavioural Assessment of the Preterm Infant (NAPI) and the Hammersmith Infant Neurological Examination (HINE). Prevalence of motor delay was 13.8% and cognitive delay was 11.7%. Methodological quality was variable with all studies having low risk of bias in the index test domain. Only the HINE and GMs demonstrated useful predictive validity. The HINE has excellent predictive accuracy for severe motor delay (3 and 6 months; sensitivity 93%, specificity 100%) but limited ability to predict milder delays. GMs can predict both motor and cognitive outcomes with good predictive accuracy for mild, moderate and severe delays (Fidgety age; DOR 2.51, SROC curves 0.8 to 0.9).
Conclusions/Significance: To our knowledge this is the first systematic review to evaluate accuracy of clinical tools used <6 months c.a to predict motor and cognitive delay (not CP) in at risk preterm infants at 24 months c.a. The HINE has the highest predictive accuracy for severe motor delay. GMs have the best predictive accuracy for mild to moderate motor and cognitive delays with equivalent predictive validity for motor and cognitive dysfunction in this at-risk population.

Gait and Balance

SP21

Effect of Xbox kinect on balance in spastic hemiparetic children

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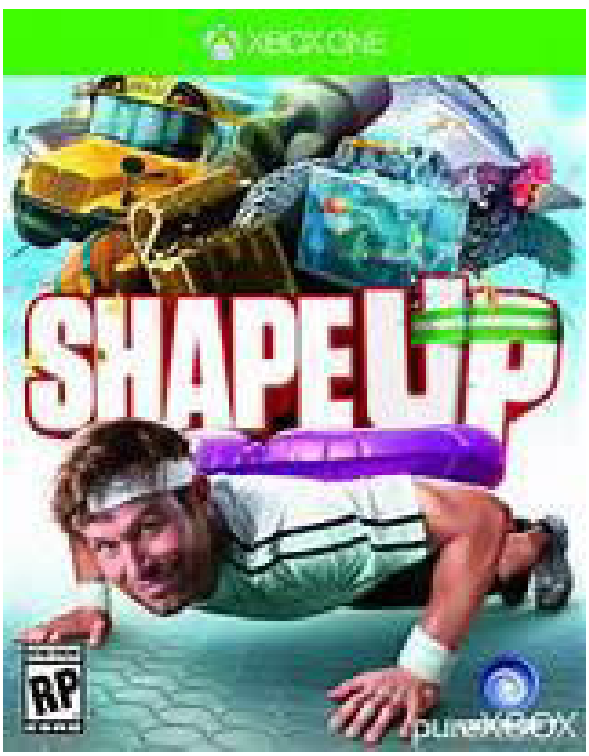
Background and Objective(s): The use of virtual reality in rehabilitation has gained attention in the last few years. The purpose of this study was to examine the effects of virtual reality using Xbox Kinect on balance in children with spastic hemiplegic cerebral palsy.
Study Design: Intervention study, RCT, random sample.
Study Participants & Setting: Thirty children with spastic hemiplegic cerebral palsy aged 6 to 12 years old were assigned randomly to a control group and an experimental group.
Materials/Methods: Both groups continued to receive their traditional physical therapy intervention. Children in the experimental group received additional training using the X-Box One Kinect training. Children were evaluated before and after three months of treatment using the pediatric balance scale.
Results: The results of this study showed that the two groups were comparable before intervention. Post-intervention results showed that children in the experimental group showed statistically significant improvements ($p>0.05$) as compared to children in the control group.
Conclusions/Significance: The results of this study supported by the existing literature conclude that the use of Xbox Kinect as a form of virtual reality training can be helpful for improving balance in children with spastic hemiparetic cerebral palsy.



SP22

Factors affecting subjective symptoms of idiopathic pes planovalgus deformity in children and adolescents

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Background and Objective(s): Idiopathic pes planovalgus (PV) is one of the most common foot deformities in children and adolescents. There is a discrepancy between subjective symptoms and radiographic severity of idiopathic planovalgus deformity. Measuring subjective symptoms in patients with pes planovalgus need a quantitative scoring system, which can be assessed by tools such as Oxford ankle foot questionnaire for children (OxAFQ-c). Therefore, the purpose of this study is to evaluate the affecting factors on symptoms of idiopathic planovalgus.
Study Design: Retrospective study.
Study Participants & Setting: All consecutive patients ≤18 of age who have visited the clinic for evaluation of pes planovalgus deformity, and have completed the OxFAQ were included in the study.
Materials/Methods: OxFAQ completed by each patient and their parents were collected. The anteroposterior (AP) talo-first metatarsal, lateral talo-first metatarsal, and hallux valgus

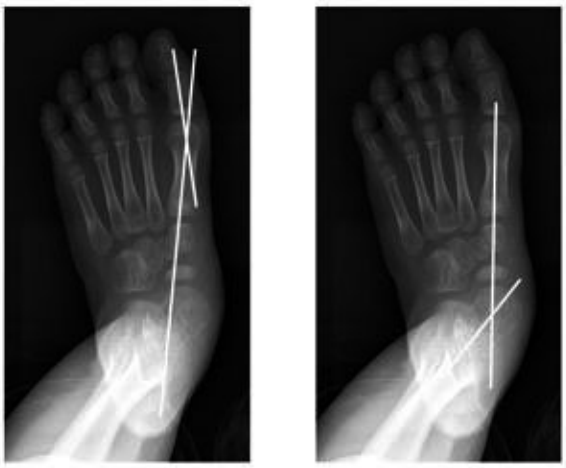

Figure 1

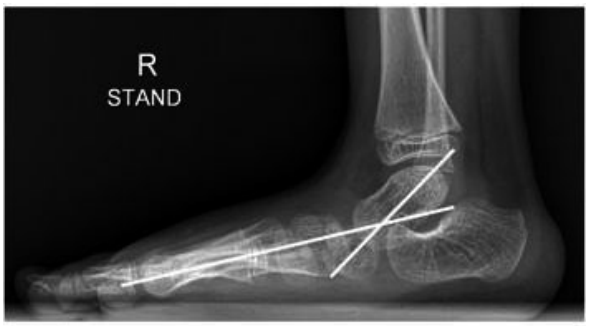

Figure 2

Table. Factors affecting the Oxford Ankle Foot Questionnaire for Children

		Estimate	95% CI	P value
Physical				
	Intercept	81.8	61.4 to 102.1	<.0001
	Age (≥10 years)	-6.0	-15.2 to 3.2	0.1992
	Sex (female)	-9.1	-18.1 to -0.1	**0.0468**
	Hallux valgus angle	-0.1	-0.8 to 0.7	0.8608
	AP talo 1st-MT angle	-0.7	-1.4 to -0.1	**0.0325**
	Lat. talo1st-MT angle	0.4	-0.3 to 1.0	0.2633
School and play				
	Intercept	97.3	83.0 to 111.5	<.0001
	Age (≥10 years)	-6.7	-13.1 to -0.3	**0.0412**
	Sex (female)	-5.9	-12.2 to 0.3	0.0639
	Hallux valgus angle	0.2	-0.4 to 0.7	0.5468
	AP talo 1st-MT angle	-0.1	-0.6 to 0.3	0.5507
	Lat. talo 1st-MT angle	-0.1	-0.5 to 0.4	0.8382
Emotional				
	Intercept	91.6	78.4 to 104.9	<.0001
	Age (≥10 years)	-6.4	-12.4 to -0.4	**0.0354**
	Sex (female)	-2.4	-8.3 to 3.4	0.4116
	Hallux valgus angle	0.0	-0.5 to 0.5	0.8772
	AP talo 1st-MT angle	0.2	-0.3 to 0.6	0.5015
	Lat. talo 1st-MT angle	-0.1	-0.5 to 0.4	0.8206
Foot wear				
	Intercept	92.6	66.0 to 119.1	<.0001
	Age (≥10 years)	-15.8	-27.7 to -3.8	**0.0102**
	Sex (female)	-3.6	-15.2 to 8.1	0.5464
	Hallux valgus angle	0.7	-0.2 to 1.7	0.1408
	AP talo 1st-MT angle	-0.0	-0.9 to 0.9	0.9944
	Lat. talo 1st-MT angle	-0.6	-1.5 to 0.2	0.1496

angles (Figs 1 and 2) were measured on weight-bearing radiographs taken within 1 month upon completion of OxFAQ. Independent variables were age, sex, radiographic indices and the dependent variable was OxFAQ scores. Multiple regression model was utilized for statistical evaluation.

Results: Overall, 123 patients were enrolled in this study, and 246 standing foot radiographs were evaluated along with scores in each domains of the OxFAQ. The factors affecting physical domain scores in child OxFAQ were female sex (p=0.047), AP talo-first metatarsal angle (p=0.033). Age ≥10 years old was a statistically significant factor affecting all domains of the OxFAQ other than physical domain score in both child and parent questionnaire (Table).

Conclusions/Significance: Although pes planovalgus deformity is three-dimensional, forefoot abduction component of the deformity should be more heavily assessed, for it is more closely related to subjective symptoms. Also, in female patients with more severe AP talo-first metatarsal angle, an aggravation of symptoms as patients age should be expected by physicians dealing with pes planovalgus deformity.

SP23

Instrumented gait analysis for the clinical management of children with cerebral palsy: a scoping review

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Background and Objective(s): Instrumented Gait Analysis (IGA) has been used for several decades with children with cerebral palsy (CP) for management of gait deviations and to help guide decision making about intervention strategies. This scoping review provides clinicians and clinical researchers with a resource that summarizes the roles of IGA for the clinical management of children with CP. This review was undertaken in preparation for development of a clinical practice guideline (CPG) on this topic.

Study Design: This is a scoping review.

Study Participants & Setting: Children with CP.

Materials/Methods: The scoping review began with a literature search with 4 key inclusion criteria: (1) original peer-reviewed research study; (2) population included children with CP; (3) used IGA to investigate gait; and (4) available in English. The following databases were included in the search: PubMed, Cochrane Database, AACPDM listing of systematic reviews, PROSPERO, and National Guidelines Clearinghouse. Once studies were identified, titles, abstracts, and full articles were screened for inclusion. The included studies were then classified into nine categories. To describe the methodological characteristics of the existing literature about IGA and how it has been used for the clinical management of children with

CP, frequencies (percentages) of the categories were then calculated.
Results: A total of 1296 citations were screened, and 599 research studies met our inclusion criteria and were included in this review. Analysis of included studies showed a wide range of prospective and retrospective designs analyzing myriad clinically important features of gait. The most common study designs were those that developed/evaluated the clinimetric properties of quantitative metrics of gait kinematics or kinetics or that identified specific atypical gait characteristics of children with CP. Also common, were studies using IGA measures to quantify the outcomes of intervention trials. The least commonly reported categories included studies that evaluated the cost-effectiveness or cost-benefits of IGA.
Conclusions/Significance: This scoping review describes the spectrum of existing peer-reviewed research on IGA for children with gait dysfunction related to CP and forms the basis to begin developing CPGs about the use of IGA for the clinical management of children with CP. A substantial body of peer-reviewed research was identified and characterized. Additional steps such as stakeholder surveys and quality assessment of the literature are in progress.

SP24

Kinematic analysis of static balance and temporal and spatial characteristics of gait in 2- to 3-year-old preterm and full-term infants

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Background and Objective(s): Children born preterm have reduced temporal and spatial characteristics of gait, e.g., stride and step lengths, compared with those born at term, even among children younger than the adjusted age of 2 years who can walk independently. However, whether the decline in walking ability improves with growth or persists is unclear. This study aimed to compare temporal and spatial characteristics of gait (e.g., cadence, stride length, and step length) and balance while walking between children born prematurely and those born at term.
Study Design: Cross-sectional study.
Study Participants & Setting: Adaptation criteria were preterm birth and ability to walk before the age of 6 years. Exclusion criterion was the inability to walk independently. Participants were 9 preterm infants (4 males and 5 females) and 9 age- and sex-matched full-term infants. The study was approved by the local Ethics Committee, and parents gave consent for their children to participate in the study.
Materials/Methods: To measure walk cycle, a pressure sensor-type mat, Walk Way, was placed at the center of a 7 m walk. Each participant was instructed to walk from the starting position to the target. Static balance was measured on the floor and mat for 30 seconds. In the standing position, each upper limb was naturally relaxed on the side of the body and the legs were 10 cm apart. In static balance, the sway around the center of gravity was measured using a sway meter (on the floor) and 10-cm-thick cushion mat (on the mat). During measurement, a tablet was placed on a table at the participant's eye level to keep the head as still as possible. In statistical analysis, time ratio between cadence and stance was used as the time factor for the walking variable, whereas stride and balance variables were used as the distance factor. Walking distance coefficient was corrected for height. Mann–Whitney U test was performed to compare balance and gait between both groups, and significance level was set to <5%.
Results: In the preterm and full-term groups, median height was 94.2 and 94.5 cm, weight was 12.0 and 14.0 kg, cadence was 158.7 and 153.8 steps/min, standing time was 60.0% and 59.0%, stride length was 63.6 and 61.4 cm, stride length was 31.0 and 34.4 cm, step length was 9.0 and 7.3 cm, total trajectory length was 5950.4 and 7848.2 mm, external area was 2273.0 and 1482.0 mm^2, respectively; maximum tremor severity between the left and right legs on the floor was 95.0 and 58.0 mm, that around the floor was 68.0 and 58.0 mm, that on the mat was 73.0 and 97.0 mm, and that around the mat was 70.0 and 92.0 mm, respectively. None of these differences were significant.
Conclusions/Significance: The two groups of children exhibited no differences in temporal or spatial characteristics of gait, balance ability, or physique, probably because of the lack of differences in physique and the fact that gaze was fixed during measurement.

SP25

Stochastic resonance stimulation improves control of balance during walking in children with cerebral palsy: a pilot study

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Background and Objective(s): While traditional rehabilitation interventions in cerebral palsy (CP) are motor-centric, a promising sensory-centric intervention is application of stochastic resonance (SR), which uses random, sub-sensory, electrical noise to improve the sensitivity of sensory receptors to differentiate weak sensory signals. While SR has shown promising results by improving postural sway during standing balance in children with CP, it is not known if similar improvements can be attained to enhance control of walking. The objective of this pilot study was to investigate the immediate effects of electrical SR stimulation application on the control of balance during walking in children with CP and with typical development (TD).
Study Design: Pilot RCT.
Study Participants & Setting: Three children with CP (2 hemiplegic, 1 diplegic, GMFCS I–II, age 11.3±3 years, 2 males) and 3 age-matched TD children (age 11.6±4 years, 1 male) were recruited via consecutive sampling in a university laboratory setting. The inclusion criteria were age 8 to 18 years, ability to walk unassisted for at least 2 minutes, absence of lower limb surgery or injury within past 1-year and adequate cognitive skills.

Figure 1. Schematic representation of SR signal delivery. SR signal was generated by custom software to trigger the stimulators that subsequently delivered electrical SR stimulation in the muscles and ligaments of the ankle joints

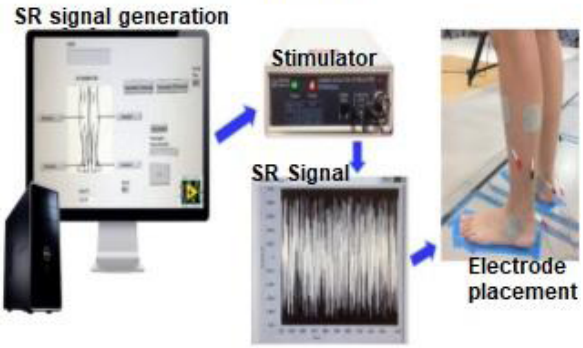

Figure2. Mean of root mean square (rms) COP-COM distance normalized to height during single stance on affected limb (Aff SS), double stance (DS) and single stance on less affected limb (Less_aff SS) with SR(Stim) and without SR stimulation (No Stim) for CP, TD and CP+TD group. Error bars depict standard error of the mean. Reduced COP-COM distance implies an improvement in control of balance.
*Indicates main effect for stim condition, with stim group improving over no stim

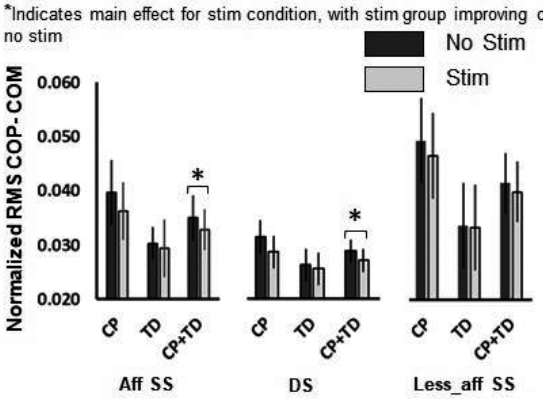

Table1. Mean and standard error of mean for RMS of COP-COM distance during three phases of gait in CP,TD and CP+TD group with SR (Stim) and without SR stimulation (No Stim). [a] Indicates main effect for stim condition. Reduced values depict improvement in balance, with stim group improving over no stim

		NoStim		Stim	
		Mean	Std Error	Mean	Std Error
Affected single stance	CP	0.040	0.006	0.036	0.005
	TD	0.030	0.003	0.029	0.005
	CP+TD	**0.035**[a]	0.004	**0.033**[a]	0.004
Double stance	CP	0.031	0.003	0.028	0.003
	TD	0.026	0.003	0.025	0.003
	CP+TD	**0.028**[a]	0.002	**0.027**[a]	0.002
Less Affected single stance	CP	0.048	0.008	0.045	0.008
	TD	0.033	0.008	0.033	0.008
	CP+TD	0.041	0.005	0.039	0.005

Materials/Methods: Electrical SR stimulation was applied to the muscles and ligaments of ankle joint via an electrical white noise signal generated by custom software driving four Biopac stimulators (Fig 1). Once the sensory threshold for SR stimulation during walking was determined, each participant walked at their preferred speed for 2 minutes on a self-paced treadmill for five bouts at different SR intensity levels (no stimulation, 25, 50, 75, and 90% of sensory threshold). Subject-specific optimal SR intensity, identified from these 4 intensities (25,50,75,90) as the one that results in maximum improvement in the primary outcome measure, was used for statistical analysis. Center of pressure (COP) and center of mass (COM) data were collected using instrumented motion capture and treadmill force plates. The root mean square of COP-COM divergence in medio-lateral direction during single stance of the most affected side (Aff SS), previously used to assess dynamic balance while walking, served as the primary outcome measure, while that during double stance (DS) and single stance of less affected side (Less_aff SS) served as secondary outcome measures. Statistical analysis using a repeated measures ANOVA was implemented, with group (CP and TD) as the between-subject factor, and no SR stimulation and optimal SR intensity as the within-subject factor.
Results: Results reveal that the main effect for stimulation condition was statistically significant during 2 out of the 3 phases of gait, with the stim group showing improved COP-COM distance during Aff SS ($F=10.563$, $p=0.03$) and DS ($F=20.00$, $p=0.01$), and a similar trend for Less_aff SS ($F=5.786$, $p=0.07$) (Fig 2). These effects were classified as large (partial eta square= 0.7, 0.8, 0.5 for Aff SS, DS and Less_aff SS respectively). Neither the main effect for group nor the group-by-stimulation interaction were significant (Table 1).
Conclusions/Significance: Our findings indicate that a sensory-centric modality like SR stimulation may be effective in improving control of balance during walking in children with CP. While the results need to be considered preliminary due to the small sample size, a large effect size was detected, which indicates promise for further exploration of effects of SR during walking and its rehabilitation potential in CP.

SP26

The natural progression of knee flexion in gait over repeated assessments in bilateral cerebral palsy

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Background and Objective(s): Crouch gait, defined as excessive knee flexion in stance phase, is one of the most common pathological gait patterns associated with bilateral cerebral palsy (CP). A recent systematic review (O'Sullivan, 2018) suggested that, in the absence of surgical intervention, the natural history of crouch gait is to increase over time. However, of the five included studies, four reported increased knee flexion over time based on two assessments only and only one single participant case study (Butler, 2016) highlighted periods of

improvement and worsening of crouch over eight gait analyses. The objective of this study was to examine the change in knee flexion in stance over multiple gait analyses in individuals with bilateral CP in the absence of surgical intervention.
Study Design: Observational cohort study.
Study Participants & Setting: Thirty-four participants with bilateral CP (Gross Motor Function Classification System [GMFCS] I–III) were assessed in a gait laboratory at 6-monthly intervals to a maximum of 6 visits. Those with 3 or more assessments were included for analysis
Materials/Methods: Knee flexion at mid-stance (KFMS) for was extracted at each analysis allowing the inter-assessment change in KFMS to be calculated. The Spearman rank correlations between the inter-assessment changes in KFMS and changes in height and weight, age at assessment, sex, GMFCS level, previous surgery and initial value of KFMS were calculated. Those variables demonstrating a significant correlation ($p<0.05$) were then included in a random coefficients regression model.
Results: Figure 1 shows KFMS versus age at each time point. Most participants (79%, $n=27$) demonstrated instances of both increase and decrease in knee flexion over time, 3 participants (9%) demonstrated consistent increase in KFMS and 4 participants (12%) demonstrated a decrease across all included analyses.

Spearman rank correlations found that the inter-assessment change in KFMS was significantly correlated with age (rho=–0.27, $p<0.01$) and sex (rho=0.22, $p=0.01$). A random co-efficients regression model found that age best predicted the natural inter-assessment variability in KFMS as follows: Change in KFMS (degrees) = 7.21–0.22(age).
Conclusions/Significance: The current results suggest that the majority of individuals with CP are likely to demonstrate periods of natural increase and decrease in KFMS over time and may demonstrate net improvement over time. This natural variation in knee flexion angle during gait appears to be most associated with age and younger participants demonstrated larger inter-assessment variation in KFMS. This has implications for individual surgical planning in CP, particularly in younger individuals, and suggests that a pattern of change in knee flexion should be established over repeated analyses before considering intervention. This natural variation in KFMS also needs to be considered in the interpretation of potential improvements in this variable following intervention.

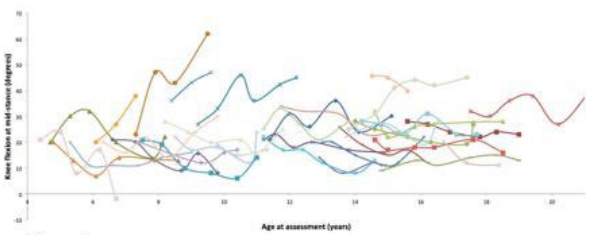

Figure 1

SP27
Withdrawn by Author

Medical and Pain

SP28
Bedtime Stories: An exploratory sequential mixed methods study of the reasons for, experience and impact of sleep disturbance for children with cerebral palsy and their parents

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Background and Objective(s): Current evidence suggests that sleep problems are common in children with cerebral palsy (CP) and are frequently reported in the clinical setting. Empirical evidence about best practice sleep management in this cohort does not exist. This study aimed to explore the frequency and type of sleep problems in children with CP, the experiences of the children and their parents regarding sleep problems, and their impact on the children and their parents.
Study Design: An exploratory sequential mixed methods design.
Study Participants & Setting: Participants were parents or caregivers of children aged 6 to 12 years with CP from Victoria, Australia.
Materials/Methods: This study had three phases: (1) qualitative scoping interviews, (2) a quantitative online survey using validated sleep assessment tools, and (3) follow up qualitative interviews. Qualitative data analysis was performed using the thematic analysis technique described by Braun and Clark (2006). The results of each phase of the study were used to inform the design of the subsequent phase.
Results: Phase One consisted of qualitative semi-structured interviews with nine parents. Thematic analysis identified two major themes: Seeking Solutions and Having to Survive. The key finding of this phase was that parents were asking for help with sleep problems, but often did not receive effective advice or treatment. Phase Two resulted in 126 complete data sets. Sleep problems were reported by 46% of the children in the cohort. The parents of children with a high score on a sleep assessment tool (indicating a sleep problem for the child) had a higher mean score than parents of children without sleep problems (mean difference: 12.1 [95% CI:9.2–15.0], [$p<0.005$]). This indicates that parent sleep is affected by child sleep. Parents found finding effective sleep solutions challenging. Phase Three thematic analysis of qualitative semi-structured interviews with 19 parents identified seven major themes: (1) My Child Doesn't Fit into the Box, (2) A Mother's Ears are Always On, (3) Sleep Disturbance is like Water Torture, (4) Sleep is One of Many Spot Fires, I Put it on the Back-burner, (5) Luck, Money or Jumping Up and Down, (6) There is Never One Silver Bullet and (7) Help: The Earlier the Better. The key finding for this phase was that parents of children with CP often described their child's

needs as different to those provided by health systems and services. This difference created significant challenges when seeking health solutions.
Conclusions/Significance: The mixed methods interpretation of the three phases of research resulted in six main findings: (1) finding effective sleep solutions can be challenging, (2) sleep problems are prevalent and persistent but are often untreated, and sleep is not a priority for parents or healthcare providers, (3) sleep problems have a significant negative impact on parent sleep and daily life, (4) sleep problems are often complex, (5) sleep problems can improve, and (6) overnight care is often the responsibility of mothers. The three phases of this study triangulated to present a multi-dimensional understanding of the research problem, for which there was little previous evidence. These data will be used to make important changes to clinical practice.

SP29

Characterizing pain phenotypes in cerebral palsy

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Background and Objective(s): Chronic pain is the most commonly reported physical symptomology of cerebral palsy (CP) throughout the lifespan, and yet pain is perhaps the least understood comorbidity of CP. Pain perception may arise from nociceptive, neuropathic, or nociplastic (central nervous system augmented pain processing) mechanisms. Although chronic pain is common in CP across the lifespan, the contributions of these mechanisms to the pain experienced by adults with CP is unknown. The aim of this study was to identify pain phenotypes among adults with CP based on putative mechanisms, and compare phenotypes in terms of pain intensity, anxiety and depressive symptoms, self-reported physical functioning, and perceived stress.
Study Design: Prevalence study with an ecological study design.
Study Participants & Setting: Survey data was collected from n=71 adults with CP who presented to the University of Michigan Health System (mean age = 39.3±16.2; 43 females, 28 males).
Materials/Methods: The median of 6 on the fibromyalgia survey (0–31) was used to classify patients into negative (≤6) or positive (>6) for nociplastic pain centralization (PC). The painDETECT Score (0–38) was used to classify patients as negative (≤12) or positive (>12) for neuropathic pain. These binary thresholds were then used to cross-classify each patient into one of four possible pain mechanism categories.
Results: Twenty-eight adults with CP (39.4%) were classified as nociceptive (-neuropathic/-nociplastic), 24 (33.8%) were classified as high nociplastic, 8 (11.3%) were classified as neuropathic, and 11 (15.5%) were classified as combination neuropathic/nociplastic. Analysis of variance results indicated that subgroups differed significantly on average scores on the Brief Pain Inventory (BPI) pain intensity scale, the Perceived Stress Scale, and on PROMIS measures of anxiety and depression; the nociceptive pain subgroup reported lower pain and emotional distress compared with the other groups. Neither sex nor age distribution differed by pain phenotype. Hierarchical regression results showed that scoring positive for nociplastic pain predicted significantly worse self-reported depression and perceived stress above and beyond the effects of pain intensity (BPI; all p<0.05); in contrast, scoring positive for neuropathic pain type did not significantly predict any HRQOL outcomes after accounting for pain intensity.
Conclusions/Significance: Findings suggest that type of pain is variable among adults with CP, and may arise through multiple mechanisms. Although nociceptive pain is common in CP, pain arising from neuropathic and/or nociplastic mechanisms correlates with poorer HRQOL outcomes compared to pain that arises from purely nociceptive mechanisms. Our data also show that nociplastic pain status contributes unique variance to HRQOL above and beyond the effects of pain intensity. Assessment of putative pain mechanisms could provide new insight into the pain experience in adults with CP and inform interventions to address pain and other symptoms in CP.

SP30

Clinical pain ratings in cerebral palsy: a retrospective 'big data' approach

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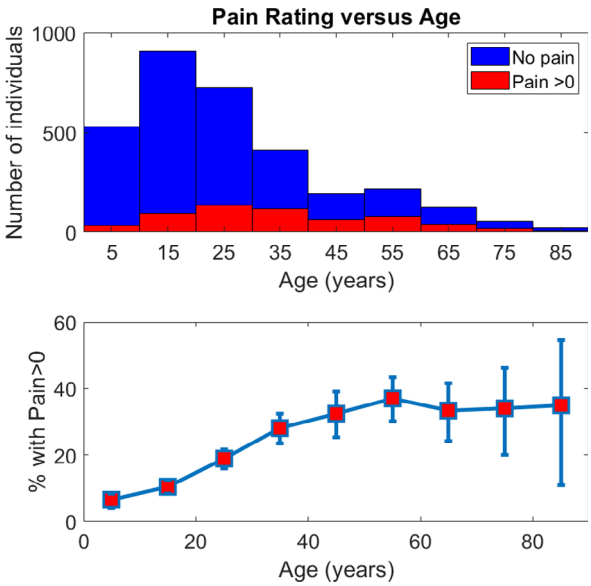
Background and Objective(s): Population-based studies have identified that the prevalence of chronic pain is higher in older than younger children with cerebral palsy (CP), but information on pain in adults with CP is lacking. We seek to understand the association between pain and age persists throughout the lifespan.
Study Design: Retrospective review based on an anonymized database extract of selected fields from electronic medical records.
Study Participants & Setting: Retrospective medical records of individuals with a diagnosis of CP with at least one documented numeric 0 to 10 clinical visit pain rating at Johns Hopkins Broadway or Bayview campuses between 1/1/2003 and 6/30/2019 were reviewed. Abstracted data include sex, clinical visit-associated pain scores with corresponding ages, and ICD 9/10 codes used to diagnose CP. Coexisting diagnoses, medication, and surgical history were not available in this extract.
Materials/Methods: Each individual's most recent clinical pain rating was collected. A multivariate logistic regression model was used to identify factors (sex, age, and CP subtype [quadriplegic vs diplegic vs hemiplegic] as described by ICD 9/10 diagnosis) associated with the presence of pain (rating >0)
Results: 3,176 individuals were included in this analysis (see Table). 19% (95% CI 17–20%) demonstrated a most recent pain rating >0. Of positive pain ratings, median (IQR) of pain

ratings was 5 (4–8). Only age at visit was significantly correlated with pain ratings (OR 1.04 [1.03–1.05)/year; $p<0.001$) against a hypothesis of no effect. Prevalence reached 37% (95% CI 30–44%) by the 6th decade of life (Fig). Male sex (OR 0.73 [0.50–1.07]) and CP subtype (diplegia vs hemiplegia OR 1.47 [0.87–2.56]; quadriplegia vs hemiplegia OR 1.01 [0.58–1.77]) did not reach significance.

Conclusions/Significance: Prevalence of reported current pain in individuals with CP appears to increase into adulthood. Single timepoint clinical ratings may underestimate pain prevalence (Lenz 2019 AACPDM). Caution is needed in interpreting findings from bulk clinical pain ratings without standardized assessment protocols or detailed information on covariates.



Demographics		
	Number	**%**
Gender		
Male	1,724	54
Female	1,452	46
Distribution		
Hemiplegic	145	5
Diplegic	342	11
Quadriplegic	304	10
Unspecified	2,385	75
	Mean	**Std. dev**
Age in years	26.3	18.0

SP31

Growth in children from 6 to 180 months of age with unilateral and bilateral cerebral palsy

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Background and Objective(s): To compare growth patterns during infancy, childhood and adolescence in children diagnosed with unilateral and bilateral cerebral palsy (CP) subtypes and how growth differs between children born preterm versus term, with versus without dysphagia and levels of gross motor function (GMFCS).

Study Design: Cross-sectional study with retrospective data.

Study Participants & Setting: Data were collected from medical records of 410 children with CP 6 to 180 months of age including participants in a consecutive series sample treated at a Pediatric University Hospital between January 2010 and June 2019. 21 children with endocrine, metabolic or genetic disorders were excluded. Finally 1573 measurements were available from 389 children with CP.

Materials/Methods: Length, weight, and head circumference were measured and z-scores were calculated at 6, 12 and 18 months of age, and from 24 to 180 months of age respectively. Main effect models were used to evaluate z-score changes with full adjustment. The magnitude of difference in growth gain from the reference group (unilateral CP) was expressed as the β coefficient with 95% CI. Linear mixed effect models were used to examine growth, GMFCS, dysphagia and preterm birth by diagnosis of CP.

Results: Of the 389 children, 105 had unilateral CP and 284 had bilateral CP. Decreases in mean z-scores for length, weight and head circumference were associated with bilateral CP subtype (β [95% CI]=–0.953 [–1.145, –0.761]; –0.999 [–1.176, –0.807]; –0.708 [–0.964, –0.452], $p<0.001$, respectively) in main effect models. This association remained significant after including interaction terms. Lower height-for-age was associated with GMFCS III to V and dysphagia (β [95% CI]=–0.943 [–1.129, –0.756] $p<0.017$; –0.545 [–0.785, –0.303] $p<0.00$). Children with bilateral CP, GMFCS level III to V and dysphagia have 2.85 more chances of having a lower z-score of height-for-age compared to children with unilateral CP. Weight-for-age was associated with GMFCS III to V and dysphagia (β [95% CI]=–1.449 [–10.526, –0.677] $p<0.048$; –0.629 [–1.189, –0.068] $p=0.028$). Children with bilateral CP, GMFCS level III to V and dysphagia have 2.98 more chances of having a lower z-score of weight-for-age. Head circumference-for-age in children with CP from 6 month to 24 month was associated with GMFCS III to V and dysphagia (β [95% CI]=–0.954 [–1.201, –0.708]; –0.630 [–0.954, –0.305]; $p<0.001$ respectively). Children with bilateral CP, GMFCS level III to V and dysphagia have 2.15 more chances of having a lower z-score of head circumference-for-age. Term and

preterm birth was not associated with weight or height gain from 6 months to 180 months of life in children with CP. After 132 months, children with term birth drop down presenting z-scores for weight and height-for-age close to preterm children.
Conclusions/Significance: Children with unilateral CP tend to grow similar to their typically developing peers. Reduced growth in children with bilateral cerebral palsy was strongly associated with GMFCS levels III to V and dysphagia but not with preterm birth. Close to puberty, children born at term drop down their z-scores and present a similar growth to preterm children.

SP32

Impact of etiology in children with cerebral palsy (CP) and medically intractable epilepsy (MIE) undergoing hemispherotomy/hemispherectomy

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Background and Objective(s): Patients with cerebral palsy (CP) and medically intractable epilepsy (MIE) arising from hemispheric perinatal vascular insults or malformations of cortical development (MCD) often require treatment with functional hemispherotomy (FH) or anatomic hemispherectomy (AH). Investigations of seizure and functional outcomes in children with CP and MIE following epilepsy surgery, and the potential impact of etiology on outcomes, have been limited. This study compares epilepsy and functional outcomes between pediatric patients with vascular versus dysplastic etiologies of CP and MIE following FH/AH.
Study Design: This intervention and prognostic type research was conducted as a retrospective cohort study.
Study Participants & Setting: This study incorporated a consecutive series of pediatric participants with CP and MIE undergoing FH or AH at the authors' institution (academic children's hospital with Level 4 accreditation from the National Association of Epilepsy Centers) from 07/01/2015 to 12/01/2019. Only participants with CP and MIE due to perinatal vascular insults or MCD and with adequate post-operative follow-up were analyzed.
Materials/Methods: Electronic medical records and functional assessments were reviewed retrospectively for epilepsy outcomes (Engel classification) and functional outcome measures (Pediatric Functional Independence Measure, WeeFIM). Data were summarized using descriptive statistics. Discrete and continuous variables were compared using chi-square and independent two-sample t-tests, respectively, with a significance level of α=0.05.
Results: Among 18 participants (mean age at surgery, 8.9 years $\pm$ 4.1 years; range 1.2–16.2 years) with vascular (7/18, 39%) and dysplastic (11/18, 61%) etiologies of CP and MIE, 12/18 (66.7%) experienced post-operative seizure freedom (Engel Class I), with mean follow-up 21.8 $\pm$ 12.6 months (range 2.0–48.4 months]). Seizure freedom rates in the vascular etiology cohort (6/7, 85.7%) exceeded those of the MCD group (6/11, 54.5%) without meeting significance (p=0.171). Physical medicine & rehabilitation (PMR) admission and functional assessments were completed for 15/18 (83%) of participants, split comparably between vascular (7/15, 47%) and dysplastic (8/15, 53%) cohorts. Length of stay during PMR admission differed between vascular (13.1 $\pm$ 3.9 days) and MCD (18.6 $\pm$ 6.8 days) groups without achieving significance (p=0.085). Mean changes in WeeFIM from pre-operative evaluation to PMR admission (vascular, –35.3 $\pm$ 13.2; MCD, –34.5 $\pm$ 25.0), PMR admission to discharge (vascular, 18.7 $\pm$ 9.0; MCD, 20.8 $\pm$ 11.4), and pre-operative evaluation to clinic follow-up (vascular, –18.4 $\pm$ 22.9; MCD, –3.6 $\pm$ 19.3) did not differ between groups.
Conclusions/Significance: Epilepsy and functional outcomes following FH/AH did not differ significantly between vascular and dysplastic etiologies of CP and MIE in this study, potentially limited by sample size. Further multi-institutional and prospective studies are required to support or refute these findings and determine the impact of etiology on outcomes following FH/AH in children with CP and MIE.

SP33

Malignancy risk due to medical imaging in children with cerebral palsy

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Background and Objective(s): All radiation exposure is associated with increased risk of cancer. Risk is greater in children due to their increased organ sensitivity and longer life expectancy. Children with cerebral palsy (CP) often have medical co-morbidities and secondary musculoskeletal problems that necessitate the use of medical imaging. The purpose of this study was to estimate lifetime risk of malignancy from medical x-ray exposure in children with CP.
Study Design: Retrospective cross-sectional study.
Study Participants & Setting: Participants were selected from a database of children with CP treated in an orthopaedic clinic in a Canadian children's hospital. Patients born in the year 2000 were selected first with the aim for 18 years of follow up. Participants born in subsequent years were then selected. Patients born before January 2000 were excluded due to incomplete records of electronic images.

Materials/Methods: Using the Picture Archiving and Communication System (PACS), the dates, modality, body part and view of each image for each patient was collected. In addition, the dose area product (DAP) for radiographic images and computed tomography dose index (CTDI) for CT scans were obtained through PACS. Effective dose (ED) was then calculated using conversion coefficients based on anatomic regions. When DAPs and CTDIs were unknown, ED was estimated using cohort averages for DAP and CTDI. Cumulative EDs were compared to Health Protection Agency (HPA) standards to calculate estimated lifetime risk of malignancy (ELRM) from the radiation. Results were categorized into a lifetime attributable risk classification based on Public Health England categories.
Results: A total of 45 patients (F=21, M=24) were included, with nine in each of the five Gross Motor Functional Classification System (GMFCS) levels. There was a mean of 44 irradiating images per patient (range: 4–175) between January 2000 and April 2019, with an average follow up period of 17.3 years. The most common images were of the pelvis, spine, lower leg (including the knee), and chest. There were 71 CT scans completed with 76% (54/71) being of the head. The mean cumulative ED was 9.81 mSv (range 0.09–48.83) with a mean ELRM of 0.13% (range 0.004–0.70). When performing subgroup analysis on GMFCS levels I to V, the mean ELRMs were: 0.11%, 0.14%, 0.13%, 0.10% and 0.16%. Cumulative radiation exposure placed zero children in the 'negligible' category, one in 'minimal,' six in 'very low,' sixteen in 'low' and twenty-two in 'moderate' categories for lifetime risk of developing radiation-related malignancy.
Conclusions/Significance: The lifetime attributable risk of malignancy as a result of medical radiation exposure in a cohort of children with CP was not negligible. This finding raises an important question of whether children with CP are being overexposed to radiation. Clinicians and surgeons should consider re-evaluating their threshold for imaging in this patient population.

SP34
Orthopaedic manifestations of transverse myelitis in children

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Background and Objective(s): Transverse myelitis (TM) is a rare, immune-mediated, inflammatory disorder of the spinal cord with a heterogeneous presentation associated with sensory, motor, and autonomic dysfunction; of idiopathic and acquired causes. Neurologic sequelae associated with TM typically include bladder dysfunction, lower limb/truncal weakness and/or spasticity. Accordingly, orthopedic manifestations are considered common, with many requiring surgical intervention. Despite this, studies describing orthopedic deformities associated with TM are non-existent. The purpose of this study was to describe the types and frequencies of orthopaedic manifestations of TM in children to help inform providers who care for this population.
Study Design: Retrospective case series.
Study Participants & Setting: Children with a confirmed diagnosis of TM presenting to an academic Children's Hospital, and had been referred to an orthopedic surgeon, were included.
Materials/Methods: A retrospective chart review was conducted for all pediatric patients with TM presenting over a 15 year period (2004–2019). Demographics, orthopedic manifestations, operative/non-operative treatments, and complications, were recorded. Descriptive statistics were used for data reporting.
Results: 119 patients were identified with TM, 37 of whom had seen an orthopaedic surgeon. Twenty of these 37 children (54%) were female. The mean age at diagnosis was 6.9 years (0.4–16.2 years). By etiology, 23 were idiopathic (62%), 10 infectious (27%), 3 (8%) inflammatory/autoimmune, and 1 (3%) vascular causes. Topographic patterns included: quadriplegic in 17 patients (49%), paraplegic in 13 (37%), hemiplegic in 3 (9%), triplegic in 1 (3%), and monoplegic in 1 (3%). The mean age at presentation was 8.4 years (0.7–16.6 years). With respect to the types of orthopedic manifestations encountered, scoliosis was present in 13 (20.6%), gait abnormalities, foot deformities, and upper extremity deformities in 7 (11.1%) for each, spasticity, contractures, and fractures in 6 (9.5%) for each, hip displacement in 3 (4.8%), and pain in 2 (4.8%) children. For treatment, 35 (95%) had physical/occupational therapy, 31 (84%) were braced for their respective orthopaedic problem, and 14 (35%) underwent operative intervention. Surgical procedures included: tendon lengthenings in 8 (35%), scoliosis correction in 7 (30%), fracture management in 4 (17%), hip reconstruction in 2 (9%), and foot reconstruction in 2 (9%). Additionally, 4 patients had baclofen pump placement for spasticity management. Post-operative complications occurred in 26% of cases, most commonly due to infection and implant-related concerns.
Conclusions/Significance: This is the first report in the literature describing the types and frequencies of orthopaedic manifestations associated with TM in children, 35% of which required operative intervention(s). Understanding the breadth of musculoskeletal burden incurred in TM can help in developing surveillance programs to identify and treat these deformities in a timely manner.

SP35
Self- versus proxy reported pain in children with cerebral palsy

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Background and Objective(s): Pain is one of the most common secondary conditions in individuals with cerebral palsy (CP). Pain is subjective and self-reports of pain are considered the gold standard. At times, proxy-reports are needed e.g., if the

individual has comorbid intellectual disability or is unable to communicate. The aim of this study was to assess if the prevalence of pain in children and adolescents with CP differed based on source of report.
Study Design: This was a prevalence study, using a cross-sectional design based on register data.
Study Participants & Setting: All children and adolescents with CP enrolled in the nationwide Swedish follow-up program for CP (CPUP) were included; 3,783 children (58% males), 1 to 18 years of age, across all Gross Motor Function Classification System (GMFCS) levels.
Materials/Methods: Logistic regression was used to regress source of reporting (self or proxy) on the presence of general pain adjusted for age, sex, GMFCS and Communication Function Classification System (CFCS) levels, including marginal effects between source of reporting and adjusted covariates.
Results: The pain item was self-reported in 45%, proxy-reported in 51%, and information was missing in 3% of the cases. Pain was reported in 44% of those who self-reported and in 41% of those who proxy-reported (p=0.04). The logistic regression showed that the average marginal effects of proxy versus self-reported pain were lower among children at GMFCS level IV (–0.14, 95% CI –0.17 to –0.03) and CFCS level I (–0.09, CI –0.16 to –0.01) and higher at CFCS level III (0.11, CI 0.00–0.22). There were no statistically significant differences in average marginal effects related to age, sex or the other GMFCS and CFCS levels between proxy and self-reporting.
Conclusions/Significance: Pain was more often reported by those who self-reported. However, after adjusting for age, sex, and GMFCS and CFCS levels, the proportion of reported pain was almost equal between self and proxy-reporting. If the self and proxy reported groups were not significantly different on relevant factors that might be associated with pain, the results indicate that the proxy reported pain is line with self-reported pain in children with CP.

SP36
Withdrawn by Author

Ortho - Hip/Knee

SP37
A review of radiology reports from hip surveillance X-Rays completed in community hospitals

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Background and Objective(s): Hip surveillance for children with cerebral palsy (CP) aims to identify hip displacement at an early stage. Migration percentage (MP), measured from antero-posterior (AP) pelvis radiographs, is the accepted radiological measure used to monitor hip displacement with a referral to orthopaedics recommended once the MP exceeds 30%. In British Columbia, a large Canadian province spanning almost 1 million square kilometers, children enrolled in the provincial hip surveillance program often receive imaging in their local community hospital. Here we present a review of radiology reports of pelvis x-rays completed in community hospitals as part of hip surveillance.
Study Design: Retrospective cohort study.
Study Participants & Setting: The radiographs of 960 children enrolled in a provincial hip surveillance program were included. All AP pelvis radiographs done as part of hip surveillance between September 2015 and December 2019 were reviewed. Images were excluded if MP was measured from non-specific images of the hips and pelvis (e.g. abdominal x-ray showing hips and pelvis).
Materials/Methods: MPs measured from all radiographs completed as part of the Child Health BC Hip Surveillance Program and recorded in the program's database were reviewed. Corresponding radiological documentation and reported MP (where present) were also retrieved and analyzed. In addition, to further evaluate the effectiveness of radiology reports in identifying hip displacement, all reports for images completed at community hospitals or clinics that prompted a referral to a pediatric orthopaedic surgeon were reviewed.
Results: A total of 1849 radiographs were included in the review. Of these, 69.3% (1282) were completed at the province's only dedicated children's hospital and 30.7% (567) were completed at 64 different hospitals or clinics throughout the province. In considering the images completed at the children's hospital, 17.6% (225/1282) of radiographs had a reported MP for both hips and 7.3% (93/1282) for only one hip. When compared to the values measured by the program coordinator, 89.5% (486/543 hips) of the MP values were within 10%. Only 3.9% (22/567) of the radiographs completed at community hospitals had a reported MP value for one or both hips with 85.7% (30/35 hips) of MP values measuring within 10% of the value measured by the program coordinator. There were 46 radiographs completed at community hospitals that had MP values >30% and resulted in a referral to a pediatric orthopaedic surgeon after review by the Hip Surveillance Program team. MPs of the displaced hips

measured between 31% and 100%. MP was measured for 2 radiographs (3 hips) with 59% of reports noting lateral uncovering. Acetabular index was measured or commented on in 41% of reports. Seven reports stated normal or unremarkable findings (range of MP 31–55%). Three reports recommended additional images.
Conclusions/Significance: Reporting of MP on AP pelvis radiographs completed for hip surveillance was rare, particularly in the community setting. Community reporting of MP and lateral uncovering was inadequate to allow for detection of hip displacement from radiological reporting alone. When implementing hip surveillance guidelines for children with CP, consideration should be given to who is reviewing images and ensuring appropriate referral to orthopaedics.

SP38

Establishing surgical indications for hamstring lengthening and femoral derotational osteotomy in ambulatory children with cerebral palsy using the Delphi technique-early learning

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Background and Objective(s): Surgical procedures have been shown to improve the gait and physical functioning of children with cerebral palsy (CP); however, substantial variation exists in the clinical and patient-level factors that influence the decision to perform surgery. This variation likely leads to both under- and over-use of these procedures. Our hypothesis is that it is feasible to use expert orthopedic surgeon opinion through a Delphi technique, to establish consensus for surgical indications ambulatory children with CP.
Study Design: This study used established consensus methodology (Delphi) to identify indications for hamstring lengthening (HL) and femoral derotational osteotomy (FDO) in ambulatory children with CP.
Study Participants & Setting: This study was conducted by researchers at 15 tertiary referral centers around the world. We formed a 15-member panel, combined total of over 310 years of experience in the surgical management of children with CP, all centers used 3-D motion analysis. No participants dropped out from the study.
Materials/Methods: We created a structured format for categorizing the indications and used this to created open ended questions regarding the surgical indications for MHL and FDO. The Delphi method consisted of 3 rounds of review. An anonymous electronic survey was created in REDcap using a Likert 5 level scale. Consensus was awarded when at least 80% of experts agreed to either the top or bottom two Likert scales.
Results: A total of 104 questions were surveyed, there was consensus on 53 questions. Indications for HL included a shortened hamstring during gait as determined by computer modeling techniques or evaluation of excessive knee flexion. Consensus for consideration of FDO was reached when the IR was greater than 15 degrees on instrumented 3-D motion analysis, or a femoral neck angle (anteversion) of greater than 30 degrees and internal rotation of greater than 60 degrees.
Conclusions/Significance: Surgical indications have a high degree of variation between surgeons and institutions, uniform surgical indication guidelines for children with CP has the potential to decrease unneeded procedures and improving the care of children with CP. Consensus among world experts with decades of experience is a powerful initial step towards decreasing variation and finding best practices for orthopedic care in children with CP.

SP39

Hip SPICA casting is not necessary after hip reconstruction in children with cerebral palsy

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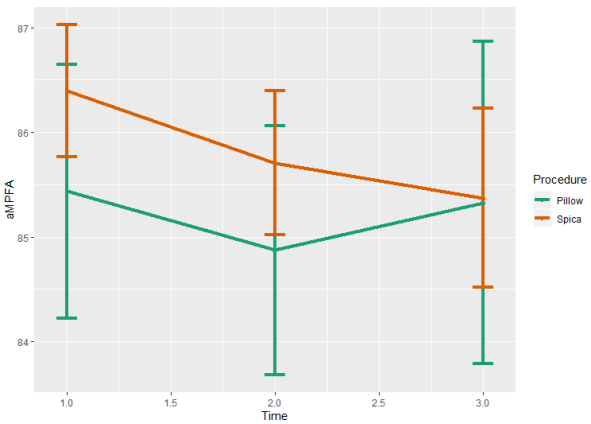
Background and Objective(s): Post-operative immobilization following hip reconstruction remains controversial for children with cerebral palsy (CP). Hip SPICA casting was traditionally used to protect surgical alignment and fixation but may confer a burden to patients and their families and may negatively impact their perioperative quality of life. This study aims to identify safety and efficacy of hip reconstructive procedures without using hip SPICA casting.
Study Design: Retrospective study.
Study Participants & Setting: An ICD-9 search was used to identify patients diagnosed with CP who underwent Varus Derotational Osteotomy (VDRO) with or without acetabuloplasty at our institution from 1995 to 2018. This initial search yielded 233 patients (122 male), with 436 surgical hip reconstructions for data abstraction and analysis. Of the 436 hips, 357 hips were immobilized in a hip SPICA cast post-operatively, while 79 hips were treated only with abduction wedge pillow.
Materials/Methods: All anatomic classes of CP and all levels of the gross motor function classification scale (GMFCS) were included. Minor and major complications, non-union, delayed union, infection, unplanned reoperation, and fracture were recorded for 1-year post-operatively. Anatomic medial proximal femoral angle (aMPFA), acetabular index (AI), and migration percentage index (MP) were used to assess radiographic alignment at completion of surgery, at 6 weeks post-operatively, and at 1 year post-operatively.

Results: There was not a statistically significant difference in BMI (p=0.57), sex distribution (p=0.70), or median follow-up time (p=0.314) between the abduction wedge pillow and SPICA cast group. The abduction wedge pillow group consisted of 2 GMFCS I, 4 GMFCS III, 11 GMFCS IV and 28 GMFCS V, while the SPICA cast group consisted of 9 unknown GMFCS, 4 GMFCS I, 7 GMFCS II, 14 GMFCS III, 28 GMFCS IV, and 126 GMFCS V. Rates of complications were consistent among groups with no statistically significant difference in instances of delayed unions (p=0.10), subluxations (p=0.55), infection prevalence (p=0.25), or non-unions (p=1.00). There was no statistically significant difference between groups in neither infection prevalence nor type of infection (p=0.09). Additionally, there was no statistically significant difference in aMPFA (p=0.44), AI (p=0.19), or MP (p=1.00) at 1 year follow up.
Conclusions/Significance: This analysis reveals that the radiographic and clinical results of patients treated with an abduction wedge pillow immobilization following hip reconstruction were not inferior to those treated with hip SPICA casting. A postoperative protocol that excludes hip SPICA casting following hip reconstruction is safe and may lessen the burden of surgery for patients with CP and their families.



SP40
Natural history of patella alta in patients with cerebral palsy

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Background and Objective(s): Patella alta (PA), a vertical and proximally displaced patella due to weakened patella tendon, is reported in 61 to 93% of ambulatory patients with cerebral palsy (CP), and commonly co-exists with crouch gait. PA impairs lever arm needed for knee extension, worsening ambulatory function in patients and causing muscle fatigue and patellofemoral pain due to excessive retro-patellar stress. Only a few studies were conducted on natural history of PA in CP patients. Also, there has only been a few studies conducted to make reference for patellar height in CP patients using Koshino-Sugimoto (KS) method. Therefore, we aim to describe the change of PA in CP using KS ratio and assess risk factors contributing to the progression of PA.
Study Design: A retrospective cohort study.
Study Participants & Setting: Consecutive CP patients who have visited our institute from May 2003 to December 2019 who are aged ≤18 years, follow up for more than 2 years, and have taken at least two lateral knee radiographs were included in the study. Exclusion criteria included inadequate radiographs of either invisible patella, inadequate rotation, or radiographs taken after interventional procedures on patella.
Materials/Methods: Reliability testing was conducted by three of the authors before measurements were done. After implementation of inclusion and exclusion criteria, KS index of both knee radiographs were measured in each patient. A linear mixed model was implemented to compensate for non-universal protocol. Fixed effects were set as sex and GMFCS level, with laterality as random effect.
Results: Total of 222 CP patients were included. KS index was measured on 652 lateral knee radiographs. The mean age of patients at initial assessment was 8.7±3.1 years, with an average of 7.9±4.1 years of follow-up. Reference values of KS index of CP patients between age 4 and 18 years are presented according to GMFCS levels (Table 1). In all GMFCS groups, KS index decreased as patients age (p<0.0001) (Fig 1, Table 2). In groups where KS index increased, as in progressed PA, GMFCS levels IV (p=0.0045) and V (p=0.0040) were statistically significant risk factors.

Table 1. Estimation of the KS index by GMFCS level and Age (in Years) from Linear Mixed Model

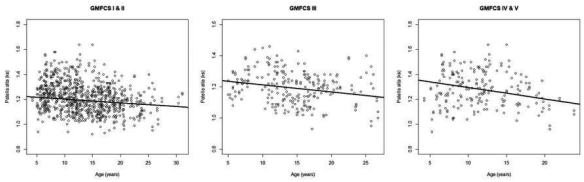
	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
GMFCS I & II	1.220	1.217	1.214	1.211	1.208	1.205	1.202
95% CI	1.216 to 1.232	1.212 to 1.232	1.208 to 1.232	1.204 to 1.232	1.200 to 1.232	1.196 to 1.232	1.192 to 1.232
GMFCS III	1.241	1.236	1.232	1.227	1.223	1.218	1.213
95% CI	1.233 to 1.249	1.226 to 1.247	1.220 to 1.244	1.213 to 1.242	1.206 to 1.239	1.199 to 1.236	1.193 to 1.234
GMFCS IV & V	1.350	1.341	1.332	1.323	1.313	1.304	1.295
95% CI	1.336 to 1.364	1.324 to 1.359	1.311 to 1.353	1.298 to 1.347	1.285 to 1.341	1.273 to 1.336	1.260 to 1.330

	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18
GMFCS I & II	1.199	1.196	1.193	1.190	1.187	1.184	1.181	1.178
95% CI	1.188 to 1.232	1.184 to 1.232	1.180 to 1.232	1.176 to 1.232	1.172 to 1.232	1.169 to 1.232	1.165 to 1.232	1.161 to 1.232
GMFCS III	1.209	1.204	1.199	1.195	1.190	1.186	1.181	1.176
95% CI	1.186 to 1.231	1.179 to 1.229	1.173 to 1.226	1.166 to 1.223	1.159 to 1.221	1.153 to 1.218	1.146 to 1.216	1.139 to 1.213
GMFCS IV & V	1.286	1.276	1.267	1.258	1.249	1.240	1.230	1.221
95% CI	1.247 to 1.324	1.234 to 1.318	1.222 to 1.313	1.209 to 1.307	1.196 to 1.301	1.184 to 1.296	1.171 to 1.290	1.158 to 1.284

Table 2. Factors affecting the KS(Koshino-Sugimoto) index according to GMFCS level

	Estimate	95% CI	p Value
GMFCS level I-II			
Intercept	1.2317	1.2021 to 1.2614	<0.0001
Age	-0.0030	-0.0040 to -0.0020	<0.0001
Sex	-0.0205	-0.0506 to 0.0097	0.1829
Side	0.0058	-0.0033 to 0.0149	0.2120
GMFCS level III			
Intercept	1.2596	1.1978 to 1.3214	<0.0001
Age	-0.0046	-0.0067 to -0.0026	<0.0001
Sex	0.0041	-0.0607 to 0.0689	0.9007
Side	0.0054	-0.0115 to 0.0222	0.5208
GMFCS level IV-V			
Intercept	1.3871	1.2854 to 1.4887	<0.0001
Age	-0.0092	-0.0127 to -0.0057	<0.0001
Sex	-0.0041	-0.1074 to 0.0992	0.9374
Side	0.0076	-0.0152 to 0.0304	0.5034

Conclusions/Significance: Our findings of change in KS index warrant that PA improves as patients age in all GMFCS levels. However, in patients in GMFCS levels IV and V, progressive PA is expected, and should be paid more attention to.



SP41

Remodeling of femoral head deformity after hip reconstructive surgery in patients with cerebral palsy

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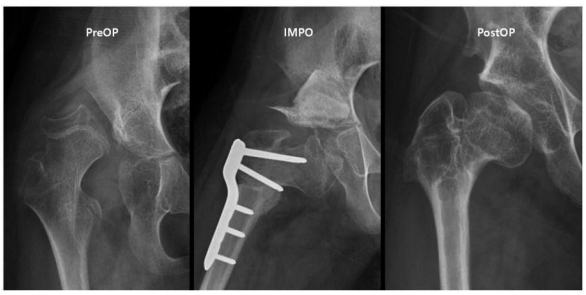
Background and Objective(s): Hip displacement is common in non-ambulatory patients with cerebral palsy (CP). Hip displacement eventually causes pain and hinder caregiving and therapeutic weight bearing that is crucial to quality of life. It has been noted by previous studies that reduction of displacement through hip reconstructive surgery (HRS) which includes femoral variation and derotational osteotomy (FVDO) either with or without pelvic osteotomies improves both pain frequency and intensity. Radiologic improvements in sphericity have been studied, but there has been a lack of quantitative evaluation. In this study, we quantitatively assessed the extent of improvement in hip sphericity after HRS and identify involved factors.
Study Design: Retrospective cohort study.
Study Participants & Setting: The study was conducted at a tertiary referral center for CP. All patients who were diagnosed of CP, and underwent HRS either with or without pelvic osteotomies were included.
Materials/Methods: Preoperative and postoperative migration percentage (MP), femoral neck-shaft angle (NSA), and sphericity using Moss circle method were assessed along with their age at surgery, GMFCS, performance of Dega pelvic osteotomy, and status of triradiate cartilage. Multiple regression analyses were performed to depict the risk factors affecting femoral head remodeling after HRS.
Results: Overall, 108 patients were enrolled in this study, and 642 anteroposterior hip radiographs were evaluated. Mean follow-up period was 5.2±3.2 years. The average preoperative MP was 58.3±31.7% which was improved to 9.1±15.6% at last follow-up. Neck-shaft angle improved from 156.5±11.5° to 126.0±18.5°. Sphericity improved from 82.3±8.5% to 89.1±9.0%. In our study, factors affecting femoral head sphericity were preoperative MP (p=0.005), immediate postoperative MP (p=0.032), and performance of Dega osteotomy (p=0.046). With 1% increase in preoperative MP, sphericity deteriorated by 0.08% (95% CI 0.03–0.14%) at last follow-up.
Conclusions/Significance: Hip sphericity improves with HRS. Preoperative MP, quality of reduction and acetabular coverage are the influencing factors in femoral head remodeling. Therefore, surgeons should plan intervention early before hip displacement progresses; and during HRS, a definite reduction and coverage should be obtained. Hip sphericity after HRS has been quantitatively assessed using Moss circle method. Surgeons should plan intervention early before hip displacement progresses; and during HRS, a definite reduction and coverage should be obtained.



SP42

Screw anterior distal femoral hemi epiphysiodesis in children with cerebral palsy, knee flexion contractures and crouch gait: a retrospective case control study

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Background and Objective(s): In children with cerebral palsy who demonstrate hamstring tightness and crouched gait, increasing attention is being paid to less invasive methods of correction. Guided growth principles represent one such approach, and in tandem with a serial extension casting protocol, provide an alternative method of addressing these contractures.
Study Design: A consecutive case series patients undergoing anterior screw hemiepiphysiodesis (AE) were entered into the study. The study was performed at a tertiary referral center.
Study Participants & Setting: Ten patients with anterior screw hemiepiphysiodesis, hamstring lengthening and serial extension casting (AE group), and 19 patient with hamstring lengthening and serial extension casting (NAE group) alone were included. Exclusion criteria was follow less than 1 year, or knee flexion contracture less than 10 degrees.
Materials/Methods: Pre and post-operative popliteal angle and knee flexion contracture where measured on physical exam; the posterior distal femoral angle (on radiographs); and kinematic parameters (knee extension in stance, knee range of motion and pelvic tilt) were assessed using 3-D motion

analysis. A paired one tail t-test was used to assess significance between method and pre-post op measures. A p-value of <0.05 was considered significant.
Results: Follow up was a mean of 15 months for both groups, and age was similar for both groups. All clinical measures, including knee flexion contracture, popliteal angle, knee extension in stance and knee range of motion improved significantly for both groups (p<0.05) between pre and post-operative measures, but the magnitude improvement was larger for the AE group. Between the groups KFC improving by 22.6° vs 9.5° (p<0.05); popliteal angle improving 29.5° vs 13.7° (p<0.05); knee extension in stance 27.2° versus 18.3° (p=0.54); and knee range of motion 13.8 vs 6.0 (p=0.56); in the AE versus the NAE groups, respectively. Pelvic tilt worsened in both groups but the difference between the AE and NAE was not significant. The posterior distal femoral angle was measured in 18 of 20 AE knees on lateral x-ray. Mean extension of 20.9 degrees was noticed on an average of 26 months follow up (p<0.05). No surgery related complications were identified but knee pain was present in 4 of 10 pts (5/20 knees), but only one directly attributed to the screws.
Conclusions/Significance: Anterior hemiepiphysiodesis results in significant improvement in knee extension, compared to preoperative measurements and compare to hamstring lengthening alone, but increase pelvic tilt can occur, and this technique may be associated with knee pain. Anterior hemiepiphysiodesis is a surgical option that is a low risk procedure and can provide improvements in knee extension, immediate weight bearing and less involved rehabilitation.

SP43

Severe hip subluxation in non-ambulatory cerebral palsy; What factors lead to lasting success of reduction?

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Background and Objective(s): Up to 80% of non-ambulatory children with spastic CP suffer progressive hip subluxation or dislocation which may lead to pain, seating imbalance and hygiene issues. These children are commonly medically fragile, so determination of factors that lead to lasting hip stability after reconstruction is critical. Surgery usually includes varus rotational osteotomy (VRO) and soft tissue releases (STR); additional procedures such as pelvic osteotomy (PO) and capsulorrhaphy can increase blood loss, operative time and complication rate. We studied the impact of various factors on the survivorship of hip reconstruction in patients with > 50% initial migration percentage (MP).
Study Design: Intervention study, case-control study.
Study Participants & Setting: Non-ambulatory CP children with greater than 75% MP at onset from SHC-SLC, SHC-Spokane and Primary Children's Hospital who underwent hip preservation surgery.
Materials/Methods: 147 non-ambulatory children with CP underwent surgical reconstruction of 246 hips. 167 hips had initial MP over 50%, and an average follow-up of 6.3 years (2–16y). Stepwise regression model to assess age, sex, initial MP, capsulorrhaphy, STR and PO was used to determine effects on final MP. Pelvic osteotomy consisted of Dega or Pemberton techniques. Survivorship was defined as a final MP of <25%.
Results: Regression analysis showed that only PO and initial MP affected survivorship. 98 hips with initial average MP of 75.7% had PO while 62 hips with initial average MP of 65% did not have PO. Final average MP after hip reconstruction with PO was 21% while the final MP without PO was 36% (p<0.0001). 69/98 PO hips met survivorship criteria compared with only 31/62 without PO (2.4 odds ratio, p=0.0094). Seventy PO hips were matched for all factors except capsulorrhaphy, 23/35 hips with capsulorrhaphy met final survivorship criteria compared to 25/35 without capsulorrhaphy despite matched initial MP. A matched group of 14 hips without PO (7 with capsulorrhaphy and 7 without) suggest that capsulorrhaphy done without PO may benefit outcomes, but differences failed to reach significance and the cohort was small.
Conclusions/Significance: Pelvic osteotomies, combined with VRO and STR, gave the best survivorship (final MP<25%) in severely subluxated hips in non-ambulatory CP children. This suggests that the added risk of PO (blood loss and increased operative time) during hip reconstruction has value in this fragile patient population. Reducing the risk of recurrence of deformity and the need for a second complex hip reconstruction is highly valuable. Although capsulorrhaphy has been suggested for high degrees of MP, our data does not show a significant benefit if a concomitant PO is done. The addition of reshaping PO is highly significant in the long-term survivorship of hip reconstruction on non-ambulatory children with CP.

SP44

Three-dimensional ultrasound for quantifying lateral hip displacement in children with cerebral palsy: a validation study

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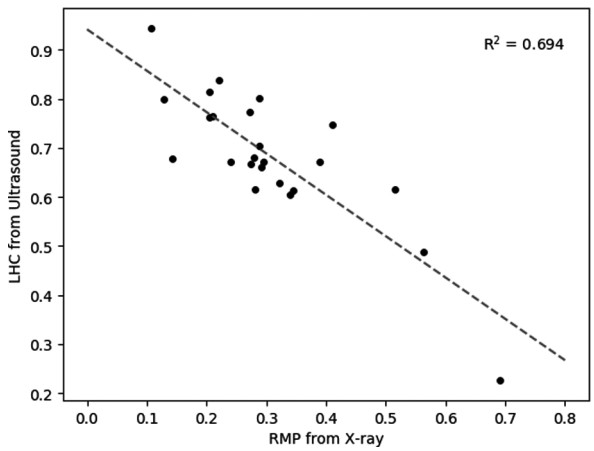
Background and Objective(s): Hip dysplasia is the second most common orthopaedic problem in children with cerebral palsy. Radiographic screening is routinely adopted to monitor hip development in these children to allow for timely intervention. Reimer's migration percentage (RMP) is the most common index used to quantify hip displacement. Our goal was to assess the validity of a new index, lateral head coverage (LHC) derived from 3D ultrasound assessment. We hypothesised that LHC would be inversely correlated with RMP.
Study Design: This study was a prospective validation study.

Study Participants & Setting: 22 participants, 15 male, aged between 4 and 15 years were recruited prospectively for the study. Participants were identified from paediatric orthopaedic clinics at a tertiary level teaching hospital. The inclusion criteria stipulated that the participants must have a diagnosis of cerebral palsy, be aged between 2 and 16 years, had a 2D radiograph of the hips as part of their routine clinical management within the last 2 months, and not have undergone bony surgery to the acetabulum.
Materials/Methods: Each participant had a 3D ultrasound assessment within 2 months of their clinically acquired planar radiograph. RMP and LHC were measured by the same assessor. The reliability of LHC investigated by 3 assessors across 10 images. A paired t-test was used to assess similarity between the two measurement techniques, RMP and LHC. The reliability of LHC was assessed using intra class correlation coefficients.
Results: LHC was strongly correlated with RMP (r=0.83 p<0.001). LHC was found to have similar between assessor reliability to RMP (ICC=0.97).
Conclusions/Significance: This is an initial validation of the use of 3D ultrasound in monitoring hip development in children with cerebral palsy. The results show that LHC is comparable to RMP in estimating hip dysplasia with similar levels of reliability to the X-ray.



Other Developmental Disorders

SP45

A collective case study of inclusion in mainstream community programs for children with autism

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Background and Objective(s): Inclusion is often understood as a mindset where people feel a sense of belonging regardless of ability or disability. Inclusive communities improve emotional, social and academic outcomes, develop friendships and skills, and improve tolerance of diversity for all. Inclusive communities support broad societal benefits, such as decreased stigma associated with disability and difference. Children with autism participate in fewer community-based programs than their peers, often attributed to child and/or family factors such as a lack of finances, perceived competence, and emotional and social functioning. Social-ecological factors influencing inclusion are often ignored. The objectives of this study were: (1) to compare how parents of children with autism versus program staff define inclusion in community programs, and (2) to identify social-ecological facilitators and barriers to inclusion in community programs for children with autism.
Study Design: Collective case study.
Study Participants & Setting: Data are from semi-structured interviews with parents whose child participated in community programs and corresponding community program leaders; a textual analysis of policies and practices extracted from program documents (guides, websites, registration forms, mission, vision and value statements, inclusion policies); and observation field notes. All of these programs and participants were from greater Edmonton, Alberta, Canada.
Materials/Methods: Cases were anchored around four mainstream community programs (dance, swimming, cycling, day camps) that all identified as inclusive. Cases were analyzed individually, followed by a cross-case analysis, through an iterative process of coding, categorizing, and constant comparative analysis, informed by grounded theory techniques.
Results: Eight parents (seven mothers, one father) with a child with autism (mean age=7y; range 3–10y), and 10 program staff were interviewed. One program was perceived as an exemplary example of inclusion by parents and program staff, whereas three programs were perceived as exemplary by program staff, but not by parents. Parents primarily viewed inclusion as an overarching philosophy that supports social belonging, whereas staff primarily discussed practices related to accommodations and aide support, more in line with current conceptualizations of integration. Analysis revealed one overarching theme, 'It's a philosophy, not a practice or policy', and three sub-themes, 'Experience with autism decreases stigma', 'Open communication is key', and 'Resources can help, but also hinder inclusion'.
Conclusions/Significance: Our data suggest that programs that identify as inclusive are not always experienced as such by parents of children with autism, particularly when they are not perceived to demonstrate a philosophy that embraces diversity and ability. This research may increase reflection of one's own and organizational assumptions of autism and of current inclusive practices and policies, to facilitate understanding and inclusion of children with autism in community programs.

SP46

A prospective, cross-over survey study of child- and proxy-reported quality of life according to spinal muscular atrophy type and medical interventions

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Background and Objective(s): Spinal muscular atrophy (SMA) is an autosomal-recessive, progressive neuromuscular disease associated with extensive morbidity. Children with SMA have potentially increased lifespans due to improved nutrition, respiratory support, and novel pharmaceuticals. Objectives of this study were to report on the quality of life and family experience for children with SMA with attentiveness to patient- and proxy-concordance and to stratify quality of life reports by SMA type and medical interventions using different patient reported outcome measures.
Study Design: Prospective, cross-over survey study.
Study Participants & Setting: 58 children (26 SMA Type I, 23 SMA Type II, 8 SMA Type III, 1 SMA Type IV) and their family caregivers at a free-standing Midwestern children's hospital participated in the study.
Materials/Methods: Twenty-eight families completed the 25-item PedsQL™ 3.0 Neuromuscular Module (NMM). Forty-four participants completed the 36-item PedsQL™ Family Impact Module (FIM) and 47 completed the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD™) questionnaire over the study period.
Results: The PedsQL™ FIM was sensitive enough to demonstrated significant differences between SMA types I and II in functioning domains including physical, emotional, social, and family relations ($p<0.03$). Child self-report and proxy-report surveys demonstrated significant differences between SMA types in the communication domains ($p<0.003$). Children self-reported their QOL higher than proxy report of child QOL. Gastrostomy tube ($p=0.001$) and ventilation support ($p=0.029$) impacted proxy-reported QOL perspectives, while nusinersen use did not. Spinal surgery was associated with improved parental QOL and family impact ($p<0.03$).
Conclusions/Significance: The measurement and monitoring of quality of life for children with SMA and their families represents an implementable priority for care teams. The PedsQL™ FIM appeared to be a sensitive measure without floor effect in this population.

SP47

Assessment of motor function in patients with Duchenne Muscular Dystrophy

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Background and Objective(s): Duchenne Muscular Dystrophy (DMD) is a commonly inherited genetic muscular disorder. With the development of new treatments that slow disease progression, functional rating scales are integral in monitoring effectiveness of treatments. We aimed to assess the correlations and distributions of commonly used functional scales and describe the potential utility of each.
Study Design: Cross-sectional study.
Study Participants & Setting: 27 males with DMD (ages 5–38 years) were recruited in an academic medical center muscular dystrophy clinic to take part in a questionnaire study evaluating quality of life.
Materials/Methods: Data is collected for this study through questionnaires, interview, and medical record review during clinic visits. Functional scales obtained include the Brooke Upper Extremity Functional Rating Scale and the Vignos Scale of Lower Extremity Function, 6- and 10-point scales respectively, which are quick to administer and have good interrater reliability. The Egen Klassifikation (Fig 3) rates overall functional ability in the non-ambulatory stage of DMD, though the administration time is longer. Correlations were computed using nonparametric spearman correlation coefficients. All statistical significance tests were 2-sided with a significance level of $\alpha=0.05$.
Results: Scores in all three functional scales increased with age, with a correlation with age of 0.75 ($p<0.0001$) for the Brooke scale, 0.63 ($p=0.0005$) for the Vignos scale, and 0.70 ($p=0.0001$) for the Egen Klassifikation. The three scales correlated well between each other, with a correlation of 0.94 ($p<0.0001$) between the Brooke and Egen, 0.69 ($p=0.0001$) between the Brooke and the Vignos, and 0.69 ($p=0.0001$) between the Vignos and the Egen. These scales also correlated with other patient characteristics, such as a negative correlation between the Egen with forced vital capacity (–0.68, $p=0.0007$). The scores of the participants were relatively evenly distributed for the Brooke and the Egen scales (Figs 1 and 2). However, over half of the participants scored a 9 on the Vignos, with no participant scoring 4 to 8 or 10 (Fig 3). Scores 4 to 8 describe participants who walk unassisted but cannot climb stairs, those who cannot rise from a chair, and those who walk or stand with long leg braces; a score of 10 describe those 'confined to bed'.
Conclusions/Significance: The Brooke and Egen scales, both scales of upper extremity function, correlate well with each other, demonstrating that a quick single-point scale can be appropriate in describing a patient's upper extremity functional status, though it does not provide specifics of fine motor capabilities included in the Egen. Although the Vignos scale correlates with age and with the other commonly used functional scales, the distribution of scores demonstrates that some of the scores are inapplicable to this patient population and could be updated. The Brooke scale provides a helpful

single-point reference for assessing disease progression. The Vignos scale could be improved to better reflect the typical progression of lower extremity function, which is critical in guiding patient care, treatment, and research initiatives. More research should evaluate the sensitivity of these tools to change and their utility in documenting the progression of walking unassisted to using a wheelchair exclusively in patients with DMD.

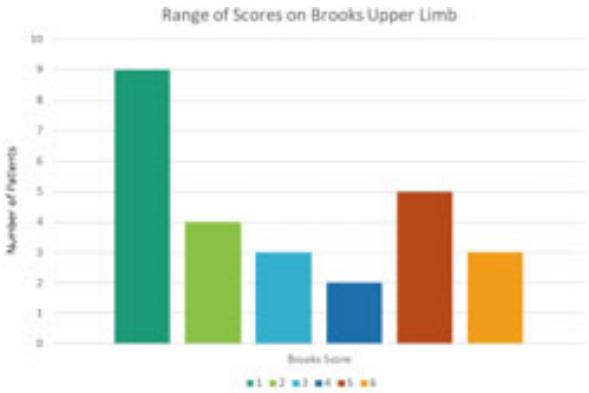

Figure 1

Figure 2

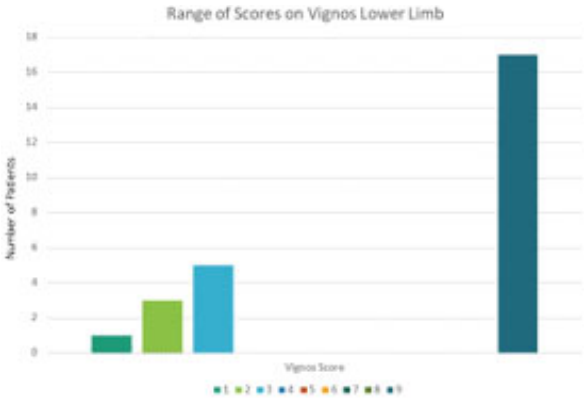

Figure 3

SP48

Improved motor function in children with AADC deficiency treated with eladocagene exuparvovec (PTC-AADC): compassionate use study

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Background and Objective(s): Aromatic L-amino acid decarboxylase (AADC) deficiency is a rare inherited disorder caused by mutations in the AADC gene. Resulting neurotransmitter deficiencies impede typical motor development. As current treatments yield little improvement, gene therapy has been proposed to improve motor function. This study evaluated the efficacy and safety of PTC-AADC, a recombinant adeno-associated virus containing human cDNA encoding the AADC enzyme, in children with AADC deficiency for up to 5 years post-treatment.

Study Design: This was an observational study evaluating data from a single-arm, investigator-initiated, compassionate-use trial.

Study Participants & Setting: The trial enrolled children >2 years of age with AADC deficiency (*n*=8) from Taiwan.

Materials/Methods: Enrolled children received bilateral intraputaminal PTC-AADC (total dose, 1.8x1011vg). Primary efficacy endpoint was the proportion achieving key milestones at 5 years using the Peabody Developmental Motor Scale, Second Edition (PDMS-2), compared with historical control (*n*=82). Secondary endpoints included changes from baseline in PDMS-2, Alberta Infant Motor Scale (AIMS), and Comprehensive Developmental Inventory for Infants and Toddlers (CDIIT) scores and body weight, and neurological examination findings. Pharmacodynamic endpoint was putaminal 18F-DOPA uptake on positron emission tomography (PET). Safety endpoints included treatment-emergent adverse events (TEAEs) and viral shedding. Mean follow-up duration was 62.5 months.

Results: At baseline no enrolled patients had full head control, could sit unassisted, or stand or walk with support. Five years post–PTC-AADC, 4 of 8 patients exhibited full head control

and could sit unassisted (p=0.0002 vs control), while 2 could stand with support (p=0.045 vs control) (Table). Mean PDMS-2, AIMS, and CDIIT total scores (all p<0.0001) and mean body weight (p=0.027) increased from baseline to 5 years. The number of patients with hypotonia and movement disorders decreased in the first year after PTC-AADC. Mean putaminal 18F-DOPA PET uptake increased as early as month 6 and continued through 5 years (p=0.0134). All patients experienced ≥1 TEAE; none considered PTC-AADC related and most of mild/moderate intensity. Eight patients experienced 9 possibly/probably treatment-related dyskinesia episodes, generally in the first few months and resolving within 4 months. Seven patients experienced ≥1 serious AE, none PTC-AADC related. No deaths occurred during the study (1 died after the 60 month study period). No viral shedding was detected in blood.

Conclusions/Significance: Children with AADC deficiency achieved sustained improvements in motor function after PTC-AADC, along with rapid and maintained increased putaminal dopamine production. No new safety signals were identified.

Table: Number of Patients Achieving Key Motor Milestones

Motor Milestone	Timepoint	PTC-AADC Group (n=8)	Historical Control Group (n=82)	*P* Value
Full head control	Baseline	0	–	–
	1 year	4	–	–
	2 years	4	–	–
	5 years	4	0	0.002
Sitting unassisted	Baseline	0	–	–
	1 year	2	–	–
	2 years	4	–	–
	5 years	4	0	0.002
Standing with support	Baseline	0	–	–
	1 year	0	–	–
	2 years	0	–	–
	5 years	2	0	0.0454
Walking with assistance	Baseline	0	–	–
	1 year	0	0	–
	2 years	0	–	–
	5 years	0	0	N/A

SP49

Intracranial hypertension in pediatric patients receiving nusinersen for spinal muscular atrophy

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Background and Objective(s): Nusinersen is an intrathecally delivered antisense oligonucleotide approved by the FDA for treatment of Spinal Muscular Atrophy (SMA). SMA is an autosomal recessive condition marked by the absence of SMN1 protein and varying amounts of less functional but similar SMN2 protein. Nusinersen is delivered via lumbar puncture in 4 loading doses over 2 months followed by maintenance doses every 4 months thereafter. Side effects for nusinersen are class specific and include thrombocytopenia, coagulopathy, and glomerulonephritis. We started noticing increased opening pressures on lumbar puncture and have been trending this phenomenon. Hydrocephalus has since been added to the medication insert for nusinersen.

Study Design: This is an ongoing review of patients with SMA receiving nusinersen.

Study Participants & Setting: Patients with SMA receiving nusinersen administration via lumbar puncture in a single tertiary center.

Materials/Methods: Patients underwent lumbar puncture with or without sedation per standard protocol. Opening pressures were obtained in the normal course of the procedure prior to nusinersen administration.

Results: Forty patients have received nusinersen in our program since it was commercially approved. We noticed that some patients had rapid flow of CSF leading to assessment of opening pressure. Since then it has become a standard part of our practice. Twenty-one patients (current age 2–22y) are currently receiving ongoing therapy via lumbar puncture (avg 9 doses, min 4, max 12). Eleven (52%) have had increased opening pressures on lumbar puncture (31–53 cm water) with onset from 5th to 12th dose. Ages of affected patients range from 2 to 15 years. There is no correlation between type of SMA (Type 1=1 [4%], Type 2=7 [33%], Type 3=3 [14%]) or BMI and increased intracranial pressure. Interestingly, males (n=9, 91%) have been diagnosed with increased intracranial pressure more than females. Limitations include older patients in the practice with Ommaya reservoirs (n=8) and short length of time phenomenon has been observed. Thus far, no papilledema or changes on MRI have been seen although one patient was started on Diamox prophylactically due to pressure >50 cm water.

Conclusions/Significance: Opening pressures need to be monitored in patients receiving nusinersen via lumbar puncture. Ophthalmology evaluation and neuroimaging may be indicated in selected patients.

SP50

Is the use of technology feasible to provide a home exercise program for young people with arthrogryposis?

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Background and Objective(s): Arthrogryposis multiplex congenita (AMC) is characterized by joint contractures associated with limited joint range of motion (ROM) and muscle weakness leading to functional limitations in daily activities. Exercises have the potential to limit the recurrence of contractures by maintaining ROM and muscle strength. However, lack of regular follow-up and distance between young people and specialized health care centres make regular exercise programs difficult to implement. To overcome this challenge, telerehabilitation, a telecommunication technology, can be used to deliver rehabilitation services remotely. This pilot study aims to: (1) evaluate the feasibility of using telerehabilitation to provide a home exercise program (HEP) for young people with AMC; (2) assess the effectiveness of the HEP. We hypothesize that (1) telerehabilitation will be a feasible

approach to deliver a HEP; (2) participants will achieve individualized goals.
Study Design: Case series study.
Study Participants & Setting: Young people between the ages of 8 and 21 years old presenting with a clinical diagnosis of AMC at a pediatric orthopaedic hospital, able to communicate in English or French, and living in Canada were included in the study. Those who had cognitive deficits or underwent a surgery within the last 6 months were excluded. Out of a list of 114, 43 young people were eligible, from whom we were able to approach 27 using consecutive sampling. Eleven consented to participate. To date, 6 young people (4 males, mean=16.2 years) from four Canadian provinces completed the HEP.
Materials/Methods: At baseline, participants completed standardized questionnaires to evaluate pain, function and physical activity. Rehabilitation therapists measured ROM using a virtual goniometer and used the Goal Attainment Scale (GAS) to identify personalized goals. This information was used to develop a 12-week individualized HEP, with follow-ups every 3 weeks to monitor and adjust the HEP as needed. At the end of the 12-weeks, participants completed the same questionnaires, as well as a satisfaction questionnaire. Descriptive statistics (non-parametric) were used to evaluate feasibility and effectiveness.
Results: Preliminary results indicate that participants would like to use telerehabilitation again and five (83%) reported on the cost-effectiveness of this approach. A compliance rate of 66% (1.97x/week) to the HEP was observed. Median GAS score for the HEP was 65.49 and for individual goals was 53.1, indicating improvements in muscle endurance, strength, transfer and use of the upper limbs in activity. Two participants (33%) reported increasing their weekly physical activity.
Conclusions/Significance: Preliminary results demonstrate that telerehabilitation is a feasible approach to provide HEP to participants of different functional levels across Canada. HEP is effective for different individualized goals. This modality can be expanded to young people with other chronic conditions.

SP51
Withdrawn by Author

SP52
Prevalence of pressure injuries in individuals with myelomeningocele

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Background and Objective(s): Myelomeningocele (MMC) is a birth defect associated with reduced motor/sensory control, executive dysfunction, bladder/bowel control, and respiration. There is also an increased risk of scoliosis, epilepsy, and pressure injuries (PIs). PIs can cause sepsis and result in premature death. Little is known about the prevalence of PIs in individuals with MMC. Study aims were to investigate (1) how many participants reported PIs (currently-previous 4 weeks); (2) how many of the participants using orthoses in the lower extremities reported PIs; (3) the associations between PIs and sex, age, type of MMC, incontinence (bladder and bowel), sensory control, use of orthoses, muscle function level (MFL), and walking ability.
Study Design: This was a prevalence study, with a retrospective cross-sectional study design.
Study Participants & Setting: Individuals with MMC in Sweden can choose to participate in a combined registry and follow-up program called the Myelomeningocele Follow-up Program (MMCUP). MMCUP provides a structured way of systematically organizing prospective multidisciplinary care for individuals with MMC. The healthcare providers examine function and health according to a follow-up schedule based on age. All children with MMC or lipoMMC born in Sweden in 2007 or later have been prospectively followed by pediatric neurologists and nurses since the neonatal period, and data have been recorded including orthopedic surgery interventions. Children with MMC who have immigrated to Sweden, born 2007 to 2019, have been followed similarly since their arrival. The study included all participants in the MMCUP with data available in the data forms of interest.
Materials/Methods: This was a retrospective cross-sectional study based on data from the Swedish MMCUP. Data were extracted from four data forms from the latest MMCUP-examinations. Data were presented as frequencies (n [%]) and analyzed with chi-square and logistic regression.
Results: Of the 419 participants, 101 (24.1%) reported PIs. In those participants who had orthoses on the lower extremities, PIs were reported in 31.3%. Statistically significant associations were found between PIs and sensation (χ^2 [1, n=149] =7.65, p=0.01), use of orthoses (χ^2 [1, n=288]=5.50, p=0.02), MFL (χ^2 [4, n=243]=17.80, p<0.01) and walking ability (χ^2 [5, n=251]=16.74, p=0.01). PIs increased with age (OR=1.03, CI 1.01–1.04).
Conclusions/Significance: PIs are common in individuals with MMC. Individuals using orthoses on the lower extremities appear to be at an increased risk. PIs are also more common at reduced sensation, higher MFL, reduced walking ability and at older ages.

Physical Activity and Physical Therapy

SP53

CAMP: climbing, activity, music, physical therapy, and parents – effectiveness of an ICF-based pilot intervention for infants and toddlers with CP

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Background and Objective(s): Infants and toddlers with cerebral palsy (CP) are an underserved population within communities with limited resources to guide motor development. Early targeted intervention critically maximize neuroplasticity. A pilot camp model was developed to deliver a multi-modal intervention using the ICF model, address activity level goals by improving participation with enhanced environmental factors; music therapy provided a neural scaffold and gravity-assists allowed new motor patterns to emerge. The community setting was a local rock climbing gym; fun, evidence-based activities included balance challenges, mobility (creeping or ambulation), and rock climbing. Peers without CP promoted a social and inclusive environment. Parents participated and were taught infant learning principles.

Study Design: Qualitative research (observational study).

Study Participants & Setting: 10 children mean (SD) corrected age 22.9 (10.2) months, range 10 to 36 months, participated in 1 of 2, week-long camps and were identified through convenience sample via the early CP program at Nationwide Children's Hospital. Inclusion criteria for children with CP (or high-risk for CP) were full head control and healthy enough to tolerate a daily 3 to 4 hour camp; siblings within the age range were also recruited but not included in the analysis.

Materials/Methods: Daily schedule included music and participation games, mobility (crawling/ambulation), balance, and climbing. Individualized plans were designed by research staff using principles of active motor learning, facilitation, and appropriate challenge level. For mobility, children were placed in supportive harnesses to offload body weight; counterweight was reduced as skills progressed. Four functional levels were determined pre-camp (day 1) based on Gross Motor Functional Measure (GMFM); GMFM was also administered post-camp (day 5). Music therapists facilitated motivation and patterning during mobility, with task-specific songs created to provide rhythmic structure and auditory reinforcement of movement. Daily motor goal levels 0 (no progress) to 3 (successfully completes goal-directed action) were measured. Music support levels needed for activity ranged from 0 (maximal) to 3 (minimal). GMFM scores, motor goal, weight and music support levels were compared by paired T-test with bootstrap analysis (due to small sample size), with alpha=0.05.

Results: A 1-week climbing camp intervention significantly increased motor measures (goal level, gravity support, GMFM, all $p<0.05$) in infants and toddlers with CP (Table 1). Music therapy support level with mobility also demonstrated significantly less support was required to engage and pattern ($p=0.04$).

Conclusions/Significance: Involvement in a multi-modal community-based climbing camp can improve functional motor ability in young children with CP. Future directions include expanding to a multi-center comparative effectiveness project.

Table 1. *Improvement in functional motor ability and participation*

	Pre-Camp Mean (SD)	Post-Camp Mean (SD)	P-Value
Motor Goal Level	1.10 (0.32)	2.20 (0.80)	**0.04**
Motor Gravity Support, lbs	14.50 (6.85)	2.25 (3.62)	**0.002**
MT Motor Support	1.65 (0.82)	1.15 (1.00)	0.12
MT Balance Support	1.30 (0.95)	1.60 (1.08)	**0.04**
GMFM	53.33 (7.57)	55.66 (7.33)	**0.01**

MT, Music therapist; GMFM, Gross Motor Functional Measure

SP54

Effectiveness of the serial casting method to correct the rigid and severe equinus deformity in children with cerebral palsy

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Background and Objective(s): A severe and rigid equinus deformity is a common indication for surgical treatment in children with cerebral palsy (CP). However, surgery performed in the early stages of development is associated with a high recurrence rate and a risk of over-lengthening. This study aimed to evaluate the effectiveness of the serial casting method to correct the rigid and severe equinus deformity in children with CP.

Study Design: A triple-blind randomized clinical trial.

Study Participants & Setting: The study was conducted at a rehabilitation referral center with 30 children who had spastic CP and an equinus gait pattern. Inclusion criteria were age between 3 to 8 years, GMFCS I and II, and lack of dorsiflexion of the foot more than 80 degrees or –10° to neutral with the knee extended. Participants with spasticity of foot invertors, hamstrings, and hip flexor-adductor muscles, and those who had undergone previous treatment for spasticity or surgery were excluded.

Materials/Methods: Participants were randomly assigned to serial casting group or control group in a ratio of 1:1 to compare the serial casting method with the natural history of equinus deformity. Intermittent casts were applied and changed every 2 weeks until ≥5° of dorsiflexion with the knee in

extension. The primary outcome measure was the range-of-motion test (ROM). Secondary assessment included the Modified Tardieu Scale-R1 (MTS), Modified Ashworth Scale (MAS), Edinburgh Visual Gait Scale (EVGS), Gross Motor Function Measure (GMFM-88), and Functional Assessment Questionnaire (FAQ) at baseline, post-cast, 3-month, and 12-month follow-up.

Results: Mean values of ROM before (–26.3±8.9°) and after (12.0±5.6°) serial casting group were significantly different (p<0.0001) while mean values in the control group were similar before (–21.6±7.9°) and after (–22.0±9.2°) the 12-month period (p=0.83). Mean ROM values at the end of the 12-week period of the serial cast group (12.0±5.6°) and the control group (–22.0±9.2°) were also significantly different (p<0.0001). Significant effects were also found for MTS-R1 (p<0.001), MAS (p=0.001), EVGS (p=0.001), GMFM-88 (p=0.005), and FAQ (p<0.001) at the 9-month follow-up compared to baseline values.

Conclusions/Significance: The study demonstrates the efficacy of the serial casting method in the treatment of severe and rigid equinus deformity in children with CP between 3 and 8 years old. The static correction was followed by a better foot position for walking and also improved gross motor function measures and gait function. The results remained stable at 9 months post-intervention.

SP55

Fuzzy, funny and fun! A thematic analysis of the experiences of children with cerebral palsy and their families in a goal-directed cycling program, 'Let's Ride a Bike'

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Background and Objective(s): The 'Let's Ride a Bike' randomized controlled trial (RCT) for children with CP reported clinically meaningful and significant improvements in gross motor function following 8 weeks of adapted-cycling, functional-electrical stimulation (FES) cycling and goal-directed training. This qualitative study aimed to capture of the experiences of the trial participants to provide insights on program feasibility, engagement, perceived barriers and facilitators to participation.

Study Design: Qualitative study using an inductive thematic analysis.

Study Participants & Setting: Participants included children with CP aged 6 to 18 years, Gross Motor Function Classification System (GMFCS) levels II to IV, and their caregivers who participated in the 'Let's Ride a Bike' RCT at a tertiary children's hospital in Australia.

Materials/Methods: Children and families voluntarily participated in semi-structured interviews at the end of the RCT. Interview questions were directed at children, and/or parent proxies. The thematic analysis followed six recursive steps, embedding trustworthiness criteria to instill confidence in the analysis. Interviews were recorded and transcribed after data collection was complete and coded independently by two investigators using NVivo 12. Codes were systematically analyzed and organized into themes by two investigators using mind maps. Data-excerpts were checked to ensure they formed coherent patterns and a third investigator reviewed the final themes in detail.

Results: 17 interviews were conducted with 29 participants (11 children: 3 male; 7–14 years, GMFCS II=6, III=4, IV=7; 18 primary caregivers). Four major themes emerged: facilitators and challenges to program engagement; perceived outcomes; the FES-cycling experience; and previous participation in cycling. 'Therapist's connection with participants', 'cycling is fun' and 'participant driven goal setting' were major facilitators to engagement, while 'getting there' and 'taking time off school' were challenges. Participants positively linked improved physical function to greater independence and participation in life activities. Participants were very positive about cycling outdoors. The FES-experience was 'fun and challenging', and participants had mixed feelings about electrode 'stickiness' and the FES sensation. Previous cycling participation was limited by access to appropriate bikes.

Conclusions/Significance: This study identified facilitators and challenges to participant engagement that hold practical relevance for researchers and clinicians. Parents were willing to overcome challenges of 'getting there' and 'busy life schedules' if they were motivated for their child to achieve functional outcomes and saw value in the program for their children. Consideration should be given to program location, appointment timing and accessibility to ensure program convenience. When prescribing adapted bikes and FES-cycling programs, environmental and personal factors must be considered.

SP56

Is adapted cycling training achievable in children with cerebral palsy with poor motor function?

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Background and Objective(s): Children with CP stand with lower muscle strength, as well as poor cardiorespiratory fitness compared to their typically developing peers. In ambulatory children with poorer gross motor function (GMFCS II–IV), these infirmities lead to low walking capacities. Indeed, body weight is an important contributor to the work load during walking and highly contributes to early exhaustion, which limits their maximal walking distance. Locomotion impairments of children with CP promote physical health deconditioning by limiting opportunities of physical activity. Considering Verschuren's recommendation, cycling exercise could be a promising approach to improve cardiorespiratory fitness. The objectives of this study were (1) to assess if tricycle cycling

exercise is in accordance with Verschuren's recommendations, in terms of intensity and duration, and (2) to report if muscle weakness and gross motor function could impact training feasibility.
Study Design: Pilot study.
Study Participants & Setting: Thirteen children with spastic CP, who were able to ride a tricycle (Trivel, Montréal, Canada) were included (aged 5–11 years; GMFCS level II–IV). A 9-week training program (2 sessions/week) was implemented on stationary tricycle in a school for children with motor disabilities (Victor-Doré, Montreal, Canada).
Materials/Methods: Intervals training with standardized encouragements were planned for each session. Intensity and duration of exercise were evaluated during each session. Lower limbs isometric muscle strength (LMS) was assessed before training.
Results: Cycling time was 18.0±2.3 min (GMFCS II=19.4±1.5 min; GMFCS III and IV=16.8±2.3 min, p=0.018). The %HRR during cycling bouts was 45.2±9.8% (GMFCS II=41.1±11.0%; GMFCS III and IV=48.6±7.7%, p=0.046). LMS correlates significantly with cycling time (r=0.879, p=0.0001), cycling cadence (r=0.747, p=0.003) and cycling power (r=0.764, p=0.002). No complaint of pain or injury related to the cycling training was reported by the participants or their parents.
Conclusions/Significance: This research demonstrated the potential of tricycle training to promote cardiorespiratory health fitness in children with CP with low motor function. Tricycle cycling exercise is more challenging for children with lower gross motor functional level, which influences the activity duration and intensity. Inferior cycling performance in children with GMFCS III and IV may correspond to an early fatigue during the exercise. Outcomes support the interest of using tricycle for daily locomotion in adapted environments e.g. school, home, streets, for poor walkers to prevent physical health deconditioning.

SP57
Mental health benefits of physical activity in young people with cerebral palsy: a scoping review

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Background and Objective(s): Young people with cerebral palsy (CP) are at an increased risk of developing psychological disorders compared to young people who are developing typically. Although physical activity (PA) may be an effective treatment strategy for this issue, as evidenced by numerous studies in the general population, few studies have examined the relationship between PA and mental health for children with CP and no studies have synthesized the results to assist with recommendations for PA prescription.
Study Design: Scoping review.
Study Participants & Setting: This scoping review included studies examining the mental health benefits of interventions measuring PA in any form in young people with CP aged 2 to 18 years.
Materials/Methods: This study uses the Arksey & O'Malley methodological scoping review framework to map the documented mental health benefits associated with PA interventions for young people with CP. The search for articles was conducted in February 2019 using the CINHAL, Medline, and PsycINFO databases including all literature available to date.
Results: The scoping review involved an initial screening of 240 titles. After 3 stages (title, abstract, and full manuscript review), 18 articles remained. Articles that had no measured PA or mental health component or did not present results for young people with CP were excluded. A data extraction form was used to document the relevant information from all included full manuscripts. The majority of studies measured the effects of PA on quality of life (QOL), while a variety of physical activity interventions were conducted. Nine studies found that PA can improve total QOL and/or specific subscales of QOL measures. However, several other studies did not find any significant effects of PA on QOL. Three studies (two swimming/aquatic interventions and one cycling exergame intervention) found that the interventions were highly enjoyable for participants and are particularly feasible in this population. No studies specifically assessed mental health symptoms of anxiety and/or depression.
Conclusions/Significance: The results of this review highlight the need for more research regarding the mental health benefits of PA in young people with CP. There are currently no studies that investigate whether PA can benefit specific aspects of mental health, such as anxiety or depression, in this population. Some studies have found that PA can benefit QOL or aspects of QOL, however, this was not a consistent finding.

SP58
Mobility devices for children with physical disabilities – Use, effectiveness and satisfaction

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Background and Objective(s): Children with physical disabilities commonly use mobility devices, such as walkers and wheelchairs. Yet, there is a lack of studies on the use and effectiveness of mobility devices on activities and participation, and more research is needed on how satisfied children with physical disabilities and their families are with mobility devices and how they are serviced. The objectives of the study were to examine the use and effectiveness of mobility devices among children with physical disabilities and the satisfaction with their mobility devices and related services.
Study Design: A quantitative cross-sectional study design.
Study Participants & Setting: Those eligible to participate in this study were all children with physical disabilities aged 6 to 18 years, who used mobility devices (walkers, manual and/or powered wheelchairs), and their parents needed to understand Icelandic. The children's medical diagnosis was cerebral palsy, spinal muscular atrophy, Charcot-Marie-Tooth disease, spina

bifida or Duchenne disease. This study took place in Iceland, where health care is publicly funded, meaning that residents are insured by the state. It was done in collaboration with the Icelandic Disability Alliance, an umbrella organisation of 43 associations of people with disabilities and the Icelandic Health Insurance, a state institution which provides assistive devices to those who need them. The members of these institutions were involved in the development of the research protocol.

Materials/Methods: Web-based survey was sent to parents of children with physical disabilities. The use and effectiveness of mobility devices were measured with a questionnaire designed for this study. The satisfaction with the properties of the devices and related service was measured with the 12 item Quebec user evaluation of satisfaction with assistive technology (QUEST) 2.0.

Results: Response rate was 61.8% (n=34). Most of the children used mobility devices associated with school and social life. For the majority (around 80%), mobility devices had a positive effect on activities and participation; negative effects were minor. Analysis indicated overall satisfaction across all items in Quest. There was no significant difference in participants' satisfaction with each item of the QUEST 2.0 questionnaire between types of mobility devices with p ranging from 0.16 to 1.00, supported by 95% confidence intervals. No significant difference was in participants' satisfaction between properties of the device and the related service (walkers p=0.47, manual wheelchairs p=0.08, and powered wheelchairs p=1.00) The majority were satisfied with the size, safety and effectiveness of their mobility device but less satisfied with the weight and adjustments. Most participants were satisfied with the service, except the follow-up.

Conclusions/Significance: The results can be used to guide healthcare workers when providing mobility devices and promote improvements in services where it is needed. Further research is needed to facilitate evidence-based practice when providing mobility devices.

SP59

Social and ecological determinants of physical activity for young people with cerebral palsy

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Background and Objective(s): Physical inactivity is a leading cause of morbidity and mortality, increasing the risk for poor physical, social, and mental health. However, fewer than 20% of U.S. young people meet physical activity (PA) guidelines; young people with disabilities are even less active. PA is influenced by personal, family, social, organizational, community, and environmental factors acting within a social-ecological framework. To what extent is not well understood. The purpose of this study was to determine the extent to which social and ecological factors are associated with participation of young people with CP in PA using the PA for people with a disability model (PAPDM) as the theoretical framework.

Study Design: Cross-sectional survey.

Study Participants & Setting: Convenience sample of 465 young people (242 males, 181 females, 42 not reported) with CP, GMFCS I (142), II (99), III (50), IV (72), V (58), age 12 to 17 years and one parent of each young person recruited from a national pediatric specialty health care system within the continental U.S.

Materials/Methods: Postal letters and emails were sent to parents of 6,040 eligible young people. Participants completed validated, web-based questionnaires assessing parent and young people participation in PA, physical function, cognitive function, fatigue, pain, strength, peer and family relationships, self-esteem, persistence, companionship, instrumental and emotional support, and characteristics of the natural and built environment. Latent variables for personal, family, social, organizational, community and environmental factors were constructed using exploratory and confirmatory factor analysis. Direct and indirect relationships among constructs were analyzed using structural equation modeling.

Results: The response rate was 8.9%. The sample of young people from 44 U.S. States closely reflected 2017 Census estimates for age, race, ethnicity, and geographic distribution, and the reported prevalence of CP for sex and GMFCS level. The measurement model explained 5 to 88% of the variance of 2 to 6 measured indicators per latent construct for personal, family, social, organizational, community and environmental factors. The final structural model explained 53.1% of the variance in young people PA with adequate model fit (CFI=0.928; TLI=0.922; RMSEA=0.027; SRMR=0.061). PA stage (B^2=0.427), parent PA level (B^2=0.142), and activity capacity (B^2=0.105) exhibited direct effects on young people PA. Self-confidence (B^2=0.631), PA stage (B^2=0.427), persistence (B^2=0.387), athletic competence (B^2=0.348), activity capacity (B^2=0.256), and positive friendship experiences (B^2=0.215) exhibited the strongest total effects.

Conclusions/Significance: Study findings validate the PAPDM. Complex relationships among constructs within a social-ecological framework explain PA of young people with CP. Self-confidence, persistence, athletic competence, parental PA, and close friendship experiences are modifiable factors that may promote PA. Personal, family and social factors are important for participation in a behavior that promotes health and well-being in a population at risk for social exclusion, stigma, and chronic health conditions.

SP60

The effect of performance-focused swimming training on gross motor function in young people with Cerebral Palsy, GMFCS IV: A longitudinal study using single case experimental design and meta-analysis

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Background and Objective(s): Non-ambulatory young people with cerebral palsy (CP) are less physically active than their ambulant peers, and are at risk of gross motor decline during adolescence. Emerging evidence indicates that this decline

may be arrested through regular physical activity, however this premise is yet to be investigated scientifically. The aim of this study was to evaluate the effect of performance-focused swimming training on gross motor function in non-ambulatory young people with CP.
Study Design: Single case design: concurrent multiple-baseline design across participants.
Study Participants & Setting: Two males (aged 15 and 16 years with spastic quadriplegic CP) and one female (aged 16 years with dyskinetic CP), all GMFCS IV, volunteered to participate. Participants were living in the local area, were not regularly physically active at the time of enrolment and had not previously engaged in performance-focused swimming training. All testing and training occurred at the University of Queensland.
Materials/Methods: This study used an extension of a concurrent multiple-baseline design across participants and comprised 5 phases. Participants initially commenced a baseline phase (A1), then proceeded to the first intervention phase (B1) at differing time points (at 10 weeks, 16 weeks, 22 weeks for participants 1, 2 and 3 respectively). The B1 phase was a 16-week 'performance-focused' swimming training program, which comprised land-based and swimming training, and was delivered by a team of therapists and swim coaches. This was followed by a 5-week maintenance phase, A2, during which there was no training; before another 16-week training phase, B2. Participants then completed a final 5-week maintenance phase, A3. Gross motor function (GMFM-66) was measured repeatedly during all phases. Data were compared between each A and B phase using interrupted time-series simulation (ITSSIM) analysis, to calculate a standardised mean difference effect size. A random-effects meta-analysis model was used to aggregate effect size estimates across participants.
Results: Meta-analysis results show increases in GMFM-66 score on intervention introduction: in transition A1 to B1, and in transition A2 to B2. The increase in transition A1 to B1 was significant and the effect size was large (d=1.77, CI=1.05–2.49, $p<0.001$), however the increase in transition A2 to B2 was non-significant, the effect size was small and the confidence interval included zero (d=0.44, CI=–0.24 to 1.12, $p=0.20$). The data show decreases in GMFM-66 score on intervention withdrawal: in transition B1 to A2, and in transition B2 to A3. Decreases were significant (B1–A2 $p=0.005$, B2–A3 $p=0.01$) and effect sizes were large in both cases (B1–A2 d=–1.27, CI=–2.15 to –0.38) (B2–A3 d=–1.48, CI=–2.62 to –0.34).
Conclusions/Significance: This study generated Level II evidence demonstrating that performance-focused swimming training can enhance gross motor function in non-ambulatory adolescents with CP. The intervention appears to be an age-appropriate activity which elicits meaningful therapeutic benefit and successfully fosters long-term engagement for participants. This is an important finding, as results show that training must be continued to maintain benefits. Long-term engagement in performance-focused training may prevent gross motor declines which occur in this population, however further research is required in this area.

Pearson correlation between physical parameters and distance on the 6-min RR test

Physical parameter		Side	Pearson r	p-value
GMFCS			0.6	<0.01
Spasticity	Hip-extensor	Most affected	-0.7	<0.01
		Least affected	-0.6	<0.01
	Knee-extensor	Most affected	-0.5	<0.01
		Least affected	-0.6	<0.01
SMC	Ankle dorsiflexion	Most affected	0.6	<0.01
		Least affected	0.6	<0.01
Muscle thickness	Thigh muscles (vastus lateralis and vastus intermedius)	Most affected	0.6	<0.01
		Least affected	0.5	<0.01
	Calf muscle (medial gastrocnemius)	Most affected	0.4	<0.01
		Least affected	0.5	<0.01

SP61
What physical parameters are important for performance in RaceRunning?

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Background and Objective(s): The RaceRunner, a three-wheeled running bike, enables individuals with cerebral palsy (CP) to propel themselves forward in a running-like motion with enough intensity to promote training adaptations. The influence of physiological parameters on RaceRunning (RR) performance is currently not well understood. The purpose of the study was to investigate correlations between physical parameters and RaceRunning performance.
Study Design: Cross-sectional study.
Study Participants & Setting: Sixty-two individuals (mean age 22y, range 9–45y, 32 males/30 females) with CP (Gross Motor Function Classification System, GMFCS I–V; 2-28-12-23-2) took part in the study.
Materials/Methods: All study participants completed a 6-min RaceRunning test. Before the test, selective motor control (SMC) of ankle dorsi-flexion, passive range of motion and spasticity of hip, knee and ankle were assessed. Thickness of thigh and calf muscles were measured with ultrasound. Heart rate was monitored throughout the test and blood lactate was measured before and directly after the test.
Results: Performance on the 6-min RR test was influence by GMFCS but was independent of age. Correlations ($r>\pm0.500$, $p<0.01$) were detected between the 6-min RR test performance and spasticity in extensor muscles of hip and knee, SMC of ankle dorsiflexion, muscle thickness of thigh and calf muscles of the less affected limb. Average and maximum heart rate, as well as lactate correlated positively to performance on the 6-min RR test.
Conclusions/Significance: Spasticity in extensor-muscles of hip and knee and poor selective motor control in ankle effects RaceRunning performance negatively. Skeletal muscle mass is an important factor for RaceRunning performance. Our findings stress the need for optimization of physical exercise regimes for individuals with CP in order to stimulate maintenance of skeletal muscle mass and function enabling full performance.

Spasticity Management

SP62

Botulinum Toxin-A for paediatric hypertonicity management: Current Australian practice

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Background and Objective(s): Botulinum Toxin-A (BoNT-A) injections are an established aspect of standard care in the management of focal hypertonicity and have been administered in Australian children and adolescents for more than 20 years. The original indication was for lower limb spasticity in children with cerebral palsy. This has expanded to management of upper limb hypertonicity to improve hand function, head and neck and paraspinals to manage abnormal posturing and also to manage pain, drooling and ease burden of care. This study explored the current Australian clinical practice in administration of BoNT-A management of Paediatric hypertonicity.
Study Design: National cross-sectional survey.
Study Participants & Setting: All Australian Paediatric Rehabilitation consultants – from the 8 Paediatric Rehabilitation units providing intramuscular BoNT-A to children and adolescents to manage hypertonicity - were identified (n=35).
Materials/Methods: All identified injectors were emailed a link to an online REDCap survey. The survey explored injector experience, patient numbers, injection frequency, procedural sedation and support methods, dose ranges and dose modifications.
Results: Complete responses were obtained from 31 respondents with a mean of 11 years injecting experience (range 1 to 24 years), treating a mean of 118 patients per year (range 0 to 275). There was a range of injection frequency (3 months to years). Procedural sedation and/or analgesia was used by 97% - nitrous oxide (used by 84%), general anaesthetic (84%), local anaesthetic cream (84%), CoolSense (45%), Buzzy Bee (30%) or Propofol (7%) – and 60% used injecting support - a Child Life Therapist and/or an assistant to hold the patient. The maximum total Botox® units used ranged from 300 to 450 (mean 400, SD 20.37), with a maximum total Botox® units per kilogram range of 12 to 20 (mean 16, SD 1.64). Average upper limb Botox® minimum and maximum doses (units/kg/muscle) was 1 and 5 respectively (SD 1.04 and 5.84). Average lower limb Botox® minimum and maximum doses (units/kg/muscle) were 1.6 to 7.8 Units respectively (SD 0.73 and 4.23). Respondents indicated they made dose modifications based on responses to previous courses, previous adverse events, history of aspiration and/or dysphagia, the presence of dystonia and for GMFCS V patients.
Conclusions/Significance: BoNT-A usage clinical practice in managing hypertonicity in paediatric patients in Australia shows high usage of sedation/anaesthesia, high consistency in total maximum doses used and variability in maximum dose/kg/muscle used in upper and lower limbs.

SP63

Case Series: Evaluation of outcomes of individuals with inability to aspirate from intrathecal baclofen pump catheter access port

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Background and Objective(s): Intrathecal Baclofen (ITB) is used for the treatment of spasticity. It involves an implanted pump connected to a catheter that delivers baclofen to the intrathecal space. It can be challenging to troubleshoot issues related to the system. The objective of this study is to describe the clinical outcomes of patients with attempted catheter access port aspirations that yielded no return of cerebrospinal fluid (CSF).
Study Design: Case series of a subgroup of participants enrolled in a prospective study of individuals with cerebral palsy and spasticity in which CSF was obtained at various time points to evaluate for biomarkers of pain and correlate with behavioral pain scales.
Study Participants & Setting: 36 individuals who underwent ITB pump implantation from mid-2013 through mid-2017 and agreed to be part of a prospective study evaluating pain biomarkers. The study occurred at a specialty health care center for children with disabilities.
Materials/Methods: After participants agreed to be in the study, CSF samples were obtained at the time of their ITB pump implantation and subsequently at clinic follow up via catheter access port aspiration. This report is a focused review of clinical findings of the subgroup from which CSF could not be obtained by catheter access port aspiration.
Results: Eleven patients (30.5%) with ITB pumps who were participating in the study had no return of CSF on attempted catheter access port aspiration. Practitioners performing the aspirations were very experienced in this procedure; they also identified four individuals (11.1%) where they were not confident that they had successfully entered the catheter access port. Of the 11 in which no CSF could be aspirated, six went to surgery with one each of the following findings: catheter kink at dura, subdural catheter, notation of multiple catheter issues (crimping, kink), and catheter issue at connection to pump. Two had replacement of all hardware (pump and catheter). A seventh is scheduled for surgery. All patients who went to surgery achieved good tone control post-operatively on significantly lower doses of ITB than had been programmed to be delivered prior to the surgery. Another individual experienced an episode that presented like withdrawal and symptoms improved with programmed ITB boluses; dosage is still increasing 5.5 years after implant. Three patients continue to have steadily increasing doses 2.5+ years after implant.
Conclusions/Significance: When ITB pump catheter access port aspirations are performed there appears to be a high association between inability to aspirate CSF and catheter problems that interfere with baclofen delivery to the intrathecal space. This association was confirmed at surgery in six individuals with a seventh scheduled for surgery. The remaining four continue with dose increases 2.5 to 5.5 years after

implantation. This is a concern as reports indicate that doses typically stabilize in a functioning system by 1 year post implant. It is also concerning that these experienced practitioners were not confident that they were in the access port when attempting aspiration in an additional four cases. Catheter access port aspirations can assist in the evaluation of the ITB system during troubleshooting.

SP64

Changes of mass of muscle after botulinum toxin injection in children with spastic hemiplegic cerebral palsy

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Background and Objective(s): The purpose of the present study was to evaluate the muscle mass changes after botulinum toxin type A (BoNT-A) injection in children with spastic hemiplegic cerebral palsy (CP).
Study Design: Prospective observational study.
Study Participants & Setting: Children who were diagnosed with hemiplegic CP with spastic equinus gait in the affected side aged between 2 and 18 years were prospectively enrolled for the study.
Materials/Methods: The participants were injected with BoNT-A on the affected lower extremity. The lean mass was measured by Dual-Energy X-Ray absorptiometry at baseline, 4 weeks, and 12 weeks after injection. In consideration of the physiological increase of muscle mass during development, the ratios of lean mass of the injected leg to the total body and the injected to the non-injected leg were analyzed, respectively.
Results: A total of 15 children with hemiplegic CP were recruited. Four weeks after injection, the lean mass of the injected leg tended to decrease, but after 12 weeks, it significantly increased compared to after 4 weeks. The lean mass of non-injected leg increased significantly after 4 and 12 weeks, respectively, compared to the baseline measurement. The ratio of the lean mass of the injected leg to the total body was significantly reduced 4 weeks after injection. However, after 12 weeks, muscle loss was significantly recovered. Similarly, the ratio of the lean mass of the injected leg to the non-injected leg also decreased after 4 weeks but increased again after 12 weeks.
Conclusions/Significance: The present study showed that muscle mass of the injected-leg decreased for a short time after BoNT-A injection in children with hemiplegic CP but recovered 12 weeks later. This suggests that BoNT-A injections used in children with CP can be used safely because they do not result in significant muscle atrophy in the long term.

SP65

Complications of intrathecal Baclofen pump in children with spastic cerebral palsy. Comparative analysis of patients weighting more or less than 20 kg at the time of implantation

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Background and Objective(s): The purpose of this study was to investigate the incidence of complication in paediatric spastic cerebral palsy (CP) patients less than 20 kg of weight at the time of intrathecal baclofen pump (ITB) implantation, and to compare it with spastic CP patients heavier than 20 kg when ITB implantation
Study Design: Retrospective.
Study Participants & Setting: We retrospectively reviewed all pediatric patients with spastic CP treated at our Institution from January 2002 to January 2018, requiring ITB implantation. 27 consecutive children recorded, of which 8 underwent ITB implantation with weight below 20 kg (Group A), and 19 with weight above 20 kg (Group B).
Materials/Methods: We looked for demographic and clinical data of both groups: sex, age, disability score according to GMFCS level, surgical procedure (subfascial or epifascial implantation of ITB), incidence and nature of complications. The indication for implantation of an ITB pump was functional impairment caused by treatment-refractory, generalized spasticity and a modified Ashworth score greater or equal to 3.
Results: All 27 consecutive children with ITB implantation were recorded, of which 17 were GMFCS V (8 in Group A and 9 in Group B; 63%), 8 were GMFCS IV, 1 was GMFCS III, and 1 was GMFCS II (all Group B). Mean age at the time at ITB implantation was 7.4 ± 3.2 years (range 3–13) and 11.5 ± 4.9 years (range 6–20y) in Groups A and B, respectively. Eight patients (6 males, 66.7%) weighted less than 20 kg (16.2 ± 2.4 kg, range 12–19 kg) at the time of ITB implantation and were included Group A, and 19 patients (13 males, 76.5%) weighted more than 20 kg (28.8 ± 14.7 kg, range 20–76 kg) at the time of ITB implantation and were included in Group B. Overall, the majority of adverse events associated with intrathecal baclofen infusion consisted of catheter problems requiring surgery. Pump removal was due to battery withdrawal. No surgical site infections were recorded. Overall, 7 out of 27 patients (25.9%) developed a complication and required a second operation. In particular 2 patients were in Group A (2/8; 25%) and 5 were in Group B (3/19; 26.3%). In Group A (<20 kg) one patient with severe opistotonos had catheter dislodgment from the spine and required revision; the second patient required catheter revision due to pump malfunction. In Group B (>20 kg) one patient required revision of the scar at the level of the spine 19 months after pump implantation, no infection was found and the patient was eventually treated by corticosteroid cream. The second patient required catheter exchange due to malfunction; the new catheter was placed on the convex side of the scoliosis deformity. The third patient required catheter

revision due to disconnection. Two adverse events, CSF seromas with dorsal and ventral location, were also recorded and resolved spontaneously in Group A patients.
Conclusions/Significance: Our results show similar outcomes and low rate of complications in all patients with spastic cerebral palsy, regardless of the body weight. In our cohort of 27 patients with implantation of 37 pumps (10 pumps change because battery withdrawal) did not encounter any case of surgical site infection related to pump implantation. All procedures were performed by a single surgeon and all devices but two underwent subfascial implantation. It is possible that these factors may have positively contributed to decrease the rate of surgical site infections. In conclusion, subfascial implantation of ITB pump in spastic CP patients weighting less than 20 kg seems to be as safe and effective as it is in heavier (>20 kg) pediatric patients with spastic CP.

SP66

Dosing from a phase 3, pivotal study of abobotulinumtoxinA injection in upper-limb muscles in pediatric patients with cerebral palsy

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Background and Objective(s): We report dosing data from a phase 3 pivotal study of repeat, upper limb abobotulinumtoxinA (aboBoNT-A) injections in children with CP.
Study Design: NCT02106351 was a double-blind, repeat treatment (up to 4 cycles) study.
Study Participants & Setting: Children (2–17 years) with CP and spasticity in ≥1 upper-limb treated at 32 specialist clinics across Europe, America and the Middle East.
Materials/Methods: In the first cycle, children were randomized to aboBoNT-A 8U/kg, 16U/kg or low 2U/kg control dose groups. Doses were divided between the primary target muscle group (PTMG; elbow or wrist flexors) and additional muscles tailored to clinical presentation. The PTMG could change in cycles 2 to 4; children allocated to the 8U/kg and 16U/kg groups in Cycle 1 continued with their dose unless changes were required to manage efficacy/tolerability (min 2U/kg, max 16U/kg). Additional injections into the lower limbs were permitted during cycles 2 to 4 (max total body dose of 30U/kg or 1000U, whichever was lowest). AboBoNT-A exposure was analyzed by the individual muscles treated, regardless of whether they were selected as PTMG; dose ranges (min-max) are presented across all 4 cycles for the 8U/kg and 16U/kg groups.
Results: 212 children were randomized, of which 210 received ≥1 aboBoNT-A injection. Per the protocol, the elbow and wrist flexors were the most commonly injected upper limb muscles. Across all 4 cycles, the brachialis was injected in 89.5% of children (dose range 0.8–6U/kg), the brachioradialis in 83.8% (0.4–3U/kg), the flexor carpi ulnaris in 82.4% (0.5–3U/kg) and the flexor carpi radialis in 79.5% (0.5–4U/kg). The next most frequently injected muscle was the pronator teres, which was targeted in 70.0% of children (0.3–3U/kg). Other frequently injected upper limb muscles were the adductor pollicis (54.3%, 0.3–1U/kg), pronator quadratus (44.8%, 0.1–2U/kg), flexor digitorum superficialis (39.0%, 0.5–4U/kg), flexor digitorum profundus (28.6%, 0.5–2U), flexor pollicis brevis/opponens pollicis (27.6%, 0.3–1U/kg) and biceps (27.1%, 0.5–6U/kg). The most frequently injected lower limb muscles (cycles 2–4) were the gastrocnemius/soleus/tibialis posterior (45.5%, 1.1–14U/kg), the hamstrings (20.8%, 1.6–10U/kg) and the hip adductors (7.9%, 2–8U/kg). AboBoNT-A was generally well-tolerated at these doses. Muscular weakness was reported in 4.3% of children in the 8U/kg group and 5.7% in the 16U/kg group.
Conclusions/Significance: These data provide information on the dose ranges used during this phase 3 study, which were well-tolerated. In line with the protocol, most children received injections into the elbow and wrist flexors. However, there was a wide variety of other upper-limb muscles injected as physicians tailored injection patterns. Once permitted by the study protocol, half (50%) of children also received simultaneous injections into the lower limb.

SP67

Effect of single event multi level chemoneurolysis with abobotulinumtoxina on energy expenditure and walking efficiency in children with cerebral palsy

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Background and Objective(s): Current studies show that children with cerebral palsy (CP) have increased energy expenditure and reduced walking efficiency, thought to be due in part to increased spasticity in muscles. The purpose of this study is to determine whether a reduction in spasticity after single event multi-level chemoneurolysis (SEMLC) would have a positive effect on walking efficiency, oxygen consumption (VO2), gait parameters and quality of life.
Study Design: This was a prospective study that looked to enroll 15 to 17 pediatric patients with spastic, diplegic cerebral palsy. The study consisted of four visits. Participants were evaluated by the Principal Investigator and consented by the study team during the first visit. The second visit consisted of the baseline measurements of oxygen consumption, 6 minute walking test, Cerebral Palsy Quality of Life (CPQOL), range of motion and degree of spasticity. At the end of the baseline assessments, participants underwent SEMLC procedure. At 1-month and 3-months post-SEMLC, participants returned to complete the same assessments that had been completed at baseline.

Study Participants & Setting: Ambulatory children, aged 6 to 17 years old, with spastic diplegic CP of GMFCS levels I to III were the target population for this study at a large academic medical center. Injections visits were either done under sedation or in outpatient clinic.
Materials/Methods: VO2 was evaluated using a wearable Cosmed K5 device during a 6 Minute Walking Test (6MWT), while a GaitRite Mat was used to collect data on gait velocity and cadence. A Polar Heart Rate monitor and the Comsed K5 were used to record pre-, during and post-6MWT oxygen consumption and HR. Rate of Perceived Exertion (RPE) was also monitored throughout the test. Completion of the 6MWT ended with a 5-minute cool-down. Modified Ashworth Scale and Modified Tardieu Scale were used to measure spasticity in addition to range of motion. Participants and their caregivers completed the CPQOL.
Results: Eight participants completed the study: GMFCS I (n=1), GMFCS II (n=6), GMFCS III (n=1). Dosing of Dysport ranged from 500 to 1000 units (11.0–23.1 units/kg). Average VO2 of all participants increased 11.2% between the pre- and 1-month post-SEMLC (0.7 ml/kg/min) and 7.9% between the pre- and 3-month post-SEMLC visit (0.6 ml/kg/min). Gait cadence scores improved 4.8% between pre- and 1-month post-SEMLC (+4.8 steps/min), and 1.4% between pre- and 3-month post-SEMLC (+1.4 steps/min). Gait velocity improved 14% between pre- and 1-month post-SEMLC (+11 cm/sec) and 6.8% between pre- and 3-month post-SEMLC (+5.3 cm/sec). 6MWT distance increased between pre- and 1-month (+44 m, 18%) and pre- and 3-months (+34.5 m, 14%).
Conclusions/Significance: Preliminary results show improvement in gait velocity and cadence at both the 1 and 3-month post-SEMLC assessments. We expected to see a decrease in VO2, but the opposite was observed; however, this may be interpreted as a positive outcome with consideration of improved gait velocity and cadence. Improved walking efficiency allowed participants to cover longer distances, which increased VO2 demands. Upon completion of study, full analysis will be done including secondary outcomes of quality of life and range of motion.

SP68

Efficacy and safety of abobotulinumtoxinA in pediatric lower limb spasticity: 2nd interim results from a phase IV, prospective, observational, multicenter study

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Background and Objective(s): AbobotulinumtoxinA (aboBoNT-A) is approved in the US for treatment of pediatric lower limb spasticity (PLLS) in children aged 2 to 17 years. Treatments and goals need to be individualized according to patient needs. The primary objective was to assess subject-centered, function-related goal attainment (T-Score) after repeated aboBoNT-A injections. Long-term safety was also assessed for up to 18 months. A first interim analysis included efficacy results from treatment cycle 1; here we present updated data after as many as 5 cycles, including safety results.
Study Design: This is a phase IV, prospective, observational, multicenter study.
Study Participants & Setting: Patients with PLLS, between ages 2 and 17 years, were enrolled. Eligible patients were recruited from the investigators' clinical practices. Patients may have been previously treated with any botulinum neurotoxin (BoNT).
Materials/Methods: This phase IV study was designed to collect real-world data on the clinical use of aboBoNT-A in patients with PLLS. Prescription decisions were made prior to, and independent from, study enrollment. Functional goals (utilizing the T-score) were identified at baseline by patient/parent/caregiver in consultation with investigators. Adverse events were reported.
Results: This second interim analysis included 201 patients, of which 78.1% (n=157) had received prior BoNT treatment. At time of enrollment, 69.2% were aged 2 to 9 years. The cumulative T-score for the total population was 51.6 (SD 9.69). By the last treatment assessment, mean T-score for the total population was 48.1 (8.08); BoNT-naïve (n=44) had a T-score of 52.1 (3.58) versus 47.5 (8.47) in BoNT–non-naïve; in patients aged 2 to 9 years, T-score was 46.7 (8.31) versus 52.1 (6.41), respectively, in patients aged 10 to 17 years. In the safety population (n=243), 44 TEAEs were reported in 26 patients (10.7%); most were mild to moderate, with 1 reported as severe. Pain in extremity, limb discomfort, muscle swelling, and myalgia reported in 3 patients were deemed treatment-related. No reported TEAEs led to study drug withdrawal or death. Most TEAEs reported were due to otitis media, pharyngitis streptococcal, upper respiratory tract infection, and falls (2).
Conclusions/Significance: Goal attainment outcomes reflect overachievement (T-score slightly larger than 50.0) for the overall PLLS population. AboBoNT-A was well tolerated, with a low incidence of TEAEs. These results further support aboBoNT-A as an effective treatment option with a positive risk-benefit profile for pediatric patients with lower limb spasticity.

SP69

Intrathecal baclofen dosing changes after spinal fusion surgery

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Background and Objective(s): Studies have shown that intrathecal baclofen (ITB) relieves symptoms of spasticity and some dystonia, while improving quality of life. Spinal surgery is common in this population and seems to be safe in the presence of the catheter. However, there is little written about how

baclofen dosing changes after such surgery. Objective of this study is to evaluate the need for changes in ITB dosing following a spinal fusion surgery in pediatric neuromuscular scoliosis patients with emphasis on the direction of baclofen dose adjustments and predisposing factors for those changes.
Study Design: Retrospective case control study.
Study Participants & Setting: Neuromuscular scoliosis patients with cerebral palsy (CP) and an ITB pump who receive a spinal fusion surgery at a tertiary referral center for CP.
Materials/Methods: Patients were divided into three groups based on the difference in ITB dose from hospital admission to discharge after spinal fusion surgery: (1) increased, (2) decreased, or (3) remained constant. Multivariate and univariate analyses were performed to identify demographic, preoperative factors, and postoperative factors that predisposed patients to each group.
Results: From 2014 to 2019, 841 spinal fusions were performed, with 186 not having CP, 602 did not have an ITB pump and 4 opted out of research leaving 49 patients for analysis. Thirty were male (61.2%) and 19 were female (38.8%). All but one of the patients had a GMFCS score of IV or V and most had a 20 mL pump (85.7%) instead of a 40 mL pump. While most of the patients had no change in ITB dose from hospital admission to discharge (71.4%), some required a decrease (16.3%) or an increase (12.3%) in dose. Factors that were significantly associated with a change in the ITB dose from hospital admission to discharge included sex, type of ITB pump, and duration of hospital stay. Specifically, fewer of the patients requiring an increase in dose were males, those requiring a decrease in dose were more likely to have a 40 mL pump instead of a 20 mL pump, and patients that required an increase in ITB dose had a longer hospital stay on average as compared to those that required a decrease or no change. Three catheters were revised during surgery and they all had the same dose after surgery.
Conclusions/Significance: The main findings from this retrospective chart review were that (1) most patients did not require a change in their baclofen dose between hospital admission and discharge, (2) those who had an increase in ITB dose were usually discharged from the hospital at a later date for unclear reasons, (3) patients with a larger pump more commonly needed a decrease in dose, (4) revision of the catheter did not change baclofen dosing postop.

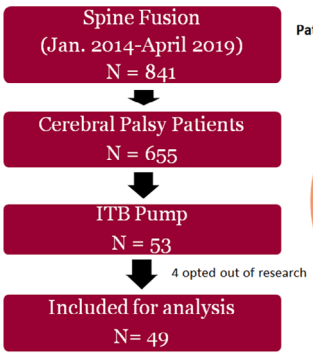

Figure 1. Patient group selection process.

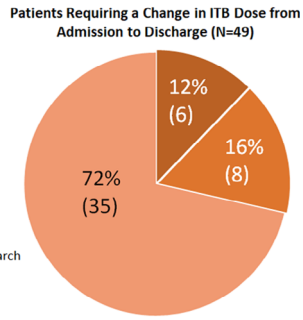

Figure 2. Patients distributed into groups either requiring an increase, decrease, or same dose.

Table 1: Patient population demographics.

Most Common Demographics	Frequency or Average (N=49)
Male	61.2%
GMFCS V GMFCS IV GMFCS III	71.4% 26.5% 2.0%
20 mL ITB Pump	85.7%
Age at Pump Placement	9.2±3.5 years
Age at Spinal Fusion Surgery	14.2±3.8 years
No Change in ITB Dose	71.4%

Table 2: Average change in micrograms per day intrathecal baclofen dose.

	% of Patients (N=49)	Average Change (µg/day)	Standard Deviation
Increase	12.2	+40.1	22.6
Decrease	16.3	-46.3	56.8
No Change	71.4	0	0.0

Table 3: Number of patients who required an increase decrease, and no change in ITB dose, separated by pre-operative spinal deformity (cobb angle).

Mag. of Spinal Deformity	Inc. (N=6)	Dec. (N=8)	No Change (N=20)
<50°	1	1	2
50-90°	5	4	22
>90°	0	3	11

Table 4: Statistically significant demographics and factors that were associated with a change in the ITB dose from hospital admission to discharge.

Demographic	Increase (N= 6)	Decrease (N=8)	No Change (N=35)	P-Value
Male	16.7% (1/6)	87.5% (7/8)	80.0% (22/35)	0.025
40mL Pump	0.0% (0/6)	50.0% (4/8)	8.6% (3/35)	0.016
Days of Hospital Stay (Average)	11.1±4.1	7.2±2.6	7.8±2.3	0.045

SP70

Management of upper extremity with botulinum toxin a and occupational therapy: factors influencing treatment outcome in children with cerebral palsy

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Background and Objective(s): In children with cerebral palsy (CP) having upper extremity hypertonia combination of Botulinum toxin type A (BoNT-A) and occupational therapy (OT) is found to be more effective than OT alone in reducing impairment, improving activity level and goal achievement. The aim of this study was to analyze the factors affecting treatment outcome of an integrated approach of BoNT-A and OT in these children.
Study Design: Prospective, observational study.
Study Participants & Setting: 26 patients with unilateral CP (16 males/10 females, mean age 7.6±3.7y), rehabilitation clinic university hospital.
Materials/Methods: Demographic and clinical properties including Gross Motor Functional Classification System (GMFCS) and Manual Ability Classification System (MACS) levels of children with unilateral CP were recorded. Patients were assessed regarding presence of learned nonuse/unilateral neglect, sensorial deficits, type and degree of hypertonia, muscle contracture in upper extremity. Passive and active range of motion (ROM) about elbow, wrist joints and fingers were recorded. Spasticity grade was assessed by Modified Ashworth Scale (MAS) and Tardieu Scale. All children received an individualized BoNT-A treatment with respect to treatment objectives and an individualized intensive OT program for

3 weeks. Assisting Hand Assessment (AHA) was used to evaluate the treatment outcome, and logistic regression analysis was performed to define the predictors of treatment outcome.
Results: Statistically significant improvement was obtained in AHA score ($p<0.001$) with a mean change from baseline as 11.2±7.6 after treatment. Presence of cognitive dysfunction ($p=0.002$), baseline GMFCS level ($p<0.001$), baseline spasticity grade ($p=0.001$), baseline voluntary motor function ($p=0.001$), type of hypertonia ($p=0.022$) were found to be predictors of treatment outcome but not unilateral neglect and baseline MACS level of the patient.
Conclusions/Significance: The results of this study showed that in children with unilateral CP, a significant improvement was achieved in AHA with a combined treatment of individualized BoNT-A and OT.

Surgical Prep/Post-op

SP71

ENGAGE: Engaging families in the implementation of surgical plans of care for children with complex cerebral palsy undergoing orthopedic surgery

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Background and Objective(s): Children with complex cerebral palsy undergoing orthopedic surgery have increased perioperative clearance needs. The family advisory council for the ENGAGE project identified a need for more family engagement, and streamlined communication between family, medical providers, and anesthesia for child-specific care coordination. The objectives were (1) to engage families throughout perioperative process as experts of their child; (2) to examine how a surgical shared plan of care increases communication between families, complex care providers, surgeons, and anesthesia; (3) to examine the role of a complex care provider on care coordination.
Study Design: Prospective quality improvement project on the effects of shared surgical plans of care on case coordination in the perioperative period.
Study Participants & Setting: 20 families with children undergoing orthopedic surgery between 04/2019 and 12/2019 at a free-standing children's hospital were enrolled in the ENGAGE project.
Materials/Methods: Each patient underwent a comprehensive health assessment with a complex care provider, who followed the family throughout the perioperative process. A surgical shared plan of care was created at time of visit with the family to identify studies, specialist visits, and family/home needs, and the responsible party for each task. This plan was shared with the family, surgeon team, and anesthesia; a copy was embedded within the child's electronic medical record. A team of complex care providers met weekly to review and identify outstanding perioperative tasks listed in the surgical shared plan of care. A team member would meet with the family at their post-operative visit for a qualitative interview with standardized questions; qualitative interviews were also completed with medical staff including surgeons, anesthesia, and case management.
Results: Each patient required an average of 6 hours (range 2–10 hours) of preparation time by a complex care provider. 20 specialist referrals and recommendations, and 15 studies were completed prior to surgery. At least one surgery was not cancelled as a result of the preoperative preparation. Qualitative interviews with 12 medical staff, including surgeons, identified high satisfaction rates and felt better prepared in moving forward with surgery. Families have also been satisfied with the process, and felt more heard and supported due to the increased communication and coordination. At least half felt less stressed due to less last-minute scramble to complete necessary tasks in order to be cleared for surgery. As a result of the initiative: (1) orthopedic surgeons increased their referral rate to a complex care comprehensive health assessment prior to surgery by 50%, (2) case management were able to begin prior authorizations for equipment and other weeks ahead of surgery, (3) weekly review of patients ensured all tests and studies were completed prior to surgery and action plans created.
Conclusions/Significance: Families of children with medical complexity who have recently undergone orthopedic surgery highlighted the challenges they face when preparing for surgery, and how more engagement and care coordination can improve their experience. Improved communication and coordination with the help of a surgical shared plan of care improved preparation for surgery, reducing cancelled surgeries. Further work in the ENGAGE project is necessary to evaluate long-term systems management.

Item to Complete	Notes/Special Considerations	Responsible Party	Completed
Goals for Surgery		N/A	
Health assessment	Cardiac Respiratory GI/Nutrition Epilepsy Tone management		
Specialty referrals			
Studies			
Individualized Medical Needs			
Ease of placing an IV			
Pain or anesthesia concerns			
Equipment Needs			
School Needs			
Home Needs			
Family Member Needs			
ENGAGE tools	Get to Know Me Individualized Pain Scale	Family Family	
Follow-up			

SP72

Factors influencing blood loss and associated changes in laboratory values after single-event multilevel surgery and hip reconstructive surgery in patients with cerebral palsy

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Background and Objective(s): Lower limb procedures for cerebral palsy (CP) often cause intra-operative bleeding and

changes in laboratory values associated with blood loss. The purpose of this study was to evaluate blood loss and its affecting factors and to investigate related changes in laboratory values after orthopedic lower limb procedures in patients with CP.

Study Design: Retrospective cohort study.

Study Participants & Setting: The study was conducted in a tertiary referral center for CP. 1188 consecutive patients with CP who had undergone single-event multilevel surgery (SEMLS) and hip reconstructive surgery (HRS) were included.

Materials/Methods: Hemoglobin/hematocrit levels and related laboratory indices before and after surgery were collected. The Gross Motor Function Classification System (GMFCS) levels, body mass index (BMI), valproate intake, and surgery types were noted. Surgeries were further categorized into SEMLS with/without bony procedures and unilateral or bilateral HRS. Multiple regression analyses were performed to depict the risk factors for blood loss, transfusion, and changes in laboratory values after surgery.

Results: Mean age at the time of surgery was 12.3 (standard deviation [SD] 7.9) years. There was an average decrease of 2.0 mg/dL in hemoglobin levels with an average preoperative hemoglobin level of 13.7 (SD 1.3) mg/dL and that 2 days after surgery of 11.7 (SD 1.9) mg/dL. In total, 70 patients received a transfusion. In the regression model, the type of surgery (unilateral HRS, $p<0.0001$; bilateral HRS, $p<0.0001$) and BMI ($p=0.0006$) were found to affect hemoglobin levels postoperatively. The frequency of transfusion was significantly affected by the type of surgery (unilateral HRS, $p=0.0079$; bilateral HRS, $p<0.0001$) and the addition of Dega pelvic osteotomy ($p<0.0001$). Preoperative albumin levels also affected blood loss ($p=0.0069$). In the HRS group, the administration of valproate affected the decrease in hemoglobin levels ($p=0.0461$).

Conclusions/Significance: The identified risk factors in this study were the type of surgery, low BMI, preoperative albumin levels, and administration of valproate. These findings warrant that patients with CP undergoing bilateral HRS with concomitant Dega osteotomy should be monitored with more care postoperatively.

Table . Factors Affecting Hemoglobin Level on Postoperative Day 2

			Estimate	95% CI	P Value
Intercept			5.25	4.020 to 6.487	**<0.0001**
Preop. Hemoglobin			0.62	0.553 to 0.689	**<0.0001**
Preop. Albumin			-0.39	-0.664 to -0.106	**0.0069**
Preop. Platelet			0.00	-0.001 to 0.001	0.5896
Age at surgery		years	0.01	0.000 to 0.021	0.0587
BMI			0.03	0.011 to 0.047	**0.0017**
Type of surgery					
	SEMLS (soft)	Base			
	SEMLS (bone)	(1/0)	-1.53	-1.700 to -1.356	**<0.0001**
	HRS (unilateral)	(1/0)	-2.05	-2.461 to -1.649	**<0.0001**
	HRS (bilateral)	(1/0)	-3.11	-3.465 to -2.758	**<0.0001**
	Addition of Dega	(1/0)	-0.21	-0.623 to 0.208	0.3271
GMFCS					
	Level I	Base			
	Level II	(1/0)	-0.24	-0.426 to -0.051	**0.0129**
	Level III	(1/0)	-0.38	-0.611 to -0.154	**0.0010**
	Level IV	(1/0)	-0.28	-0.564 to -0.004	**0.0469**
	Level V	(1/0)	-0.23	-0.585 to 0.121	0.1973
Valproate medication		(1/0)	-0.02	-0.444 to 0.408	0.9336

SP73

Fascia iliaca pain block results in lower overall narcotic usage and shorter hospital stays than epidural anesthesia after hip reconstruction in children with cerebral palsy

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Background and Objective(s): Cerebral palsy (CP) represents a wide spectrum of neurodevelopmental conditions caused by injury to the developing brain in the perinatal period. Muscle imbalances and spasticity can lead to hip contractures, subluxation, hip dislocation, sitting imbalance and pain. Subluxation and dislocation often requires reconstruction in order to contain the hips and avoid future pain and imbalance. Children with severe involvement (GMFCS IV–V) have a worse prognosis due to the progressive nature of subluxation to frank dislocation. Reconstruction may involve musculotendinous lengthening or myotomies, femoral osteotomies, or pelvic osteotomies and it can be difficult to control the pain in the perioperative period. This study aims to evaluate the use of a fascia iliaca block (FICNB) pain protocol in controlling postoperative pain following hip reconstruction.

Study Design: This is a retrospective, non-randomized review of patients with CP GMFCS IV/V who underwent hip reconstructions between January 2017 and March 2019 by a single senior surgeon. During this timeframe, we transitioned clinically from an epidural pain protocol (January 2017–December 2017, $n=22$) to a FICNB protocol (January 2018–March 2019, $n=39$). Preoperative demographics, co-morbidities, surgical and postoperative pain data were collected. Data collection for patients receiving epidural protocol was done using retrospective chart review, for which consent waiver was obtained; participants receiving FICNB protocol were recruited prospectively.

Study Participants & Setting: Consecutive participants of any age, sex, or race diagnosed with CP (GMFCS IV or V) with hip subluxation or dislocation who underwent hip reconstruction from January 2017 to March 2019 were included.

Materials/Methods: This is a retrospective study of patients with CP who underwent hip reconstruction by a single senior surgeon between January 2017 and March 2019. Age at the time of surgery was 8.5 ± 4.6 years. Both groups were of similar ages, weights and underwent similar index procedures. We recorded age, weight, overall OR time, FLACC (Face,

Legs, Activity, Cry, Consolability) scores on PODs 0, 1, 2, and 3, narcotic doses given, overall narcotic (mg) used, and length of stay.

Results: Pain scores were similar between groups on POD #0, 2, and 3 but were statistically improved on POD#1 (1.8 ± 1.3 vs 3.1 ±1.4, $p<0.001$). Total number of narcotic doses (7.9 ± 4.4 vs 10.7 ± 2.3, $p=0.004$), and total Mg given (18.3 ± 11.8 vs 24.7 ± 12.3, $p<0.05$), and Mg per kilogram given (0.77 mg/kg ± 0.42 vs 1.11 mg/kg ± 0.36, $p=0.001$) were less for the fascia iliaca group versus the epidural group. The OR procedural time (which includes anesthesia time for blocks/epidurals) was lower in the block group (4.6 hours ± 1.2 vs 5.7 hours ± 1.1, $p=0.0002$). Overall hospital stays were lower in the fascia iliaca group (3.4 days ± 1.5 vs 4.1 days ± 1.0, $p<0.05$).

Conclusions/Significance: This study demonstrates that in the setting of hip reconstruction in children with CP, patients that received preoperative fascia iliaca blocks used a lower amount of narcotics, required fewer rescue doses and ultimately had a shorter hospital length of stay than those undergoing epidural anesthesia. Preoperative fascia iliaca blocks promote decreased postoperative opioid use and are associated with decreased intraoperative time and shorter hospital stays which may decrease overall costs and risks to the patient.

SP74

Peri-operative management of children with spinal muscular atrophy

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Background and Objective(s): Current multi-disciplinary management of children with SMA often requires the surgical management of spinal deformities. We present the outcomes of our peri-operative experience treating these children around the time of their spinal surgery and share our neuromuscular perioperative protocol.

Study Design: A retrospective chart review was performed to evaluate all children with SMA types 1 and 2; that underwent thoracolumbar spinal deformity correction (posterior spinal fusion or growing rod insertion) from 1990 to 2015.

Study Participants & Setting: Twelve SMA 1 and 22 SMA 2 patients were included in a single center.

Materials/Methods: Electronic medical records were reviewed to assess pre-operative, intraoperative, and postop variables. T-tests, Wilcoxon Rank Sum, Fisher's Exact tests were performed as appropriate. P-values <0.05 were considered significant, however *p*-values were also adjusted using the Benjamini-Hochberg adjustment to control any false discovery.

Results: Type I patients tended to be smaller and had a higher percentage (36% vs 4.5%) of ASA class 4 patients. Preoperative TPN was utilized in 75% of type 1 and 18% type 2 patients. A difficult intubation was experienced in roughly one quarter of the patients (20% SMA I, 27% SMA II). Approximately two hours of anesthetic time were required in addition to the actual surgical time regardless of SMA type. Postoperative courses were similar for both types with all patients admitted to the ICU and the majority remaining intubated following surgery. ICU length of stays averaged 6 (4.0–7.5) days for type 1 and 3 (3–5) days for type 2 ($p=0.144$). Average post-operative length of stay was (8 [7–9] vs 7 [6–8]) $p=1.0$.

Variable	SMA type I (n=12)	SMA type II (n=22)	P-value	Adj P	Overall
Pre-Operative					
Weight - kg	18.0 (3.4)	29.2 (12.7)	0.001	0.026	28.6 (17.0)
ASA Class			0.033	0.254	
2	0 (0.0%)	0 (0.0%)			0 (0.0%)
3	7 (63.6%)	21 (95.5%)			31 (86.1%)
4	4 (36.4%)	1 (4.5%)			5 (13.9%)
Pre-operative NIPPV			0.043	0.262	
None	0 (0.0%)	4 (18.2%)			7 (18.9%)
Nocturnal	10 (83.3%)	18 (81.8%)			28 (75.7%)
Continuous	2 (16.7%)	0 (0.0%)			2 (5.4%)
Pre-operative TPN					
Parental Nutrition Initiated Pre-op	**9 (75.0%)**	**4 (18.2%)**	**0.002**	**0.046**	13 (35.1%)
Intra-Operative					
Difficult Intubation	2 (20.0%)	6 (27.3%)	1	1	8 (22.9%)
Direct Laryngoscopy Technique - Yes	9 (90.0%)	17 (77.3%)	0.637	0.801	29 (82.9%)
TPN Intra-op	5 (41.7%)	4 (18.2%)	0.224	0.514	9 (24.3%)
Crystalloid Saline or Lactated Ringers - ml	900.0 (555.0 - 1950.0)	2150.0 (1425.0 - 3325.0)	0.047	0.262	2000.0 (922.5 - 3311.8)
Crystalloid Saline or Lactated Ringers - **ml/kg**	45.0 (34.2 - 99.5)	76.7 (57.4 - 97.1)	0.252		
Urine Output - ml	350.0 (110.0 - 537.5)	400.0 (237.5 - 712.5)	0.366	0.595	400.0 (220.0 - 925.0)
Urine Output - **ml/kg**	19.2 (8.2 - 28.6)	11.9 (7.8 - 22.2)	0.651		
Estimated Blood Loss - ml	325.0 (150.0 - 440.0)	400.0 (300.0 - 862.5)	0.187	0.457	400.0 (250.0 - 750.0)
Estimated Blood Loss - **ml/kg**	17.9 (8.8 - 25.0)	17.6 (11.2 - 24.2)	0.589		
Transfusion	9 (75.0%)	16 (72.7%)	1	1	28 (75.7%)
Packed Red Blood Cells - ml	350.0 (187.5 - 425.0)	325.0 (12.5 - 612.5)	0.796	0.941	350.0 (50.0 - 700.0)
Packed Red Blood Cells - **ml/kg**	18.4 (10.7 - 22.3)	10.6 (1.1 - 18.3)	0.244		
Time with Temp < 36	0.0 (0.0 - 90.0)	90.0 (15.0 - 157.5)	0.068	0.264	75.0 (0.0 - 135.0)
Anesthesia Total Time - hr	7.1 (2.1)	7.5 (2.1)	0.605	0.801	7.7 (2.2)
Surgery Total Time - hr	4.9 (2.0)	5.6 (1.6)	0.308	0.541	5.6 (2.0)
Spinal Deformity					
Cobb Angle Pre	64.7 (19.7)	59.3 (26.8)	0.55		61.4 (24.0)
Cobb Angle Post	21.0 (11.5)	25.3 (24.3)	0.502		23.7 (20.4)
Cobb Angle Difference	-43.1 (18.5)	-37.8 (32.8)	0.6		-40.0 (27.5)
Pulmonary Status Post-op			0.319	0.541	
Controlled ventilation via endotracheal tube or trac	**9 (75.0%)**	**20 (90.9%)**			**31 (83.8%)**
Non-invasive positive pressure ventilation (NIPP	3 (25.0%)	2 (9.1%)			6 (16.2%)
Spontaneous	0 (0.0%)	0 (0.0%)			0 (0.0%)
Post-Operative Course					
Admitted to ICU - Yes	11 (100.0%)	21 (100.0%)	1	1	35 (100.0%)
ICU Length of Stay - nights	6.0 (4.0 - 7.5)	3.0 (3.0 - 5.0)	0.023	0.227	4.0 (3.0 - 6.0)
Total Length of Stay - nights	8.5 (7.8 - 10.0)	8.0 (6.0 - 9.0)	0.059	0.263	8.0 (6.0 - 9.0)
Post-op Length of Stay - nights	8.0 (7.0 - 9.0)	7.0 (6.0 - 8.0)	0.175	0.457	8.0 (6.0 - 9.0)
NIPPV at Discharge			0.179	0.457	
None	0 (0.0%)	4 (18.2%)			7 (18.9%)
Nocturnal	10 (83.3%)	17 (77.3%)			27 (73.0%)
Continuous	2 (16.7%)	1 (4.5%)			3 (8.1%)
Post-op Pulmonary Complications			1	1	
Pneumonia	1 (8.3%)	1 (4.5%)			2 (5.4%)
Respiratory Failure Requiring Support	0 (0.0%)	0 (0.0%)			0 (0.0%)
Re-intubation	0 (0.0%)	0 (0.0%)			0 (0.0%)
Atelectasis	3 (25.0%)	7 (31.8%)			10 (27.0%)
None	8 (66.7%)	14 (63.6%)			25 (67.6%)

	Pre-operative consultation	Intraoperative	Post-operative
Pulmonary	• Pulmonary consultation for all patients prior to surgery • Conduct pulmonary function testing if patient is able to perform • Consider preoperative training on non-invasive positive pressure ventilation (NIPPV) if not currently managed with respiratory support during sleep due to increased risk for hypoventilation post operatively secondary to pain management and anesthesia • Consider preoperative training with mechanical insufflation-exsufflation if history of ineffective cough, recurrent pneumonia or low MEP (i.e., MEP < 60 cm H20)	• Respiratory support per endotracheal intubation with positive pressure ventilation • Neuromuscular patients with chronic respiratory insufficiency require ventilatory support and not oxygenation alone, during induction and recovery. Patients should be kept intubated post operatively or extubated to NIPPV • Monitoring during anesthesia should include capnography to complement oximetry to avoid hypercarbia and hypoxemia.[3]	• Implement airway clearance post operatively with secretion mobilization technique preferably intrapulmonary percussive ventilation (IPV, Metaneb) followed by mechanical insufflation-exsufflation and airway suctioning within 1 hour of admission to post operative care unit and every 4 hours post operatively via ETT, tracheostomy tube or orally. • Consider delaying extubation until respiratory secretions well controlled, weaned to room air and pain control is optimized. • Optimize ventilation before adding oxygen as the most likely cause of hypoxemia is hypoventilation. Hypoventilation is exacerbated by narcotic pain use. • Extubate patients to NIPPV and work toward use during sleep only. NIPPV may be needed following hospital discharge and recovery.
Anesthesia/Pain	• Anesthesia consultation for all patients prior to surgery with general anesthesia • Evaluate airway carefully and plan for intubation difficulties given patients' physical limitations and potential abnormalities (e.g., decreased mouth opening, enlarged tongue) • Consider indirect visualization of the larynx including the possible fiberoptic intubation (i.e., fiber optic visualization is often necessary)	• Consider use of total IV anesthesia technique for induction and maintenance of general anesthesia • Avoid depolarizing muscle relaxants (i.e., succinylcholine) and non depolarizing muscle relaxants • If non depolarizing muscle relaxants used, titrate dose and continuously monitor neuromuscular function • Avoid inhaled anesthetics in DMD patients; these agents may be considered in SMA patients • Intubation without neuromuscular blockade is preferred when possible • Short acting opioids are suitable for intraoperative use in SMA patients	• Sedating analgesia may have additive effect on baseline respiratory insufficiency however postoperative pain control should not be compromised because of respiratory suppression concerns.[1,2] • Opiate-based analgesia in combination with acetaminophen and NSAID should be considered as part of routine post-procedural management with anticipation of providing appropriate NIV and cough assistance. • Patients may also benefit from benzodiazepines for muscle spasm and discomfort.
Nutrition	• Nutritional status assessment for all patients prior to surgery with goal to optimize nutrition and plan nutrition support during hospitalization. • Swallow evaluation may be helpful to determine ideal post-operative feeding strategy • Pre-admit patients for total parenteral nutrition (TPN) if they require overnight enteral feeds. Patients with SMA have a fatty acid oxidation metabolic disorder as part of having SMA and do not tolerate prolong periods of time without nutrition.	• Consider continuing TPN infusion if start preoperatively. • Monitor glucose status intraoperatively to avoid hypoglycemia.	• Initiate bowel regime to avoid and treat constipation, with consideration or prokinetic GI medications as ileus is common • Any patient who cannot achieve adequate oral nutrition within 24-48 hours after surgery should receive enteral feeding with small-diameter nasoduodenal tube or parenteral nutrition • Consider gastric decompression with nasogastric tube in patients with GI dysmotility • If patient is receiving TPN, continue TPN until patient tolerates receiving at least 50% of goal enteral feed.
Cardiac	• Cardiac consultation for all DMD patients prior to surgery • For patients with history of symptoms suggestive of cardiac involvement or at risk for cardiac dysfunction, cardiac evaluation should be completed within 3-6 months prior to anesthesia.	• Close cardiac monitoring	• Monitor cardiac and fluid status postoperative • For DMD patients, obtain postoperative cardiac consultation • Use telemetry monitoring
Other	• Discuss goals of care, tracheostomy potential, prolonged dependency on mechanical ventilation and advance directives with patient/family		• Consult Palliative care for goals of care planning, pain management considerations

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Conclusions/Significance: Children with type 1 and 2 SMA have similar hospital courses and can be safely surgically treated with proper perioperative management. The surgical team should consider perioperative TPN and NIPPV, anticipate difficult intubations, anticipate longer than usual anesthetic times, and potentially longer ICU stays in caring for these children.

SP75

Reasons for delayed treatment for spastic hip instability: results of parents' survey

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Background and Objective(s): Hip subluxation and dislocation is one of the most important orthopedic problems in children with cerebral palsy. Medical, social and economic impact of spastic hip instability is very high. Despite the programs for prevention there are still patients with spastic hip dislocation and end stage painful osteoarthritis. Parents should be involved in the surveillance program and decision making regarding treatment for spastic hip. Active participation of parents is an important part of this program.
Study Design: Ecological study.
Study Participants & Setting: Parents of 100 patients were interviewed anonymously.
Materials/Methods: Parents of 50 patients operated for hip dislocation (Grade V according Robin and Graham classification) were interviewed anonymously (filling of the proposed form). Control group (50 persons) included parents of children operated for hip subluxation (MP<40%).
Results: From 100 questionnaires, 86 were eligible for analysis. 71% of parents agreed with the statement that the child was operated for hip dislocation too late. 64% delegated responsibility for delay to the healthcare professionals, 27% accepted their own responsibility. 60% parents of children with dislocation delegated overall responsibility for health issues to healthcare professionals, in contrast to only 29% in control group. Meanwhile the majority of patients in the dislocation group were informed about it at least 3 years before surgery. In the same group were convinced that physicians did not provide them with proper information regarding their condition.
Conclusions/Significance: Parents and healthcare professionals can have different opinions regarding necessity of hip surgery for children with spastic hip. Our study demonstrates that there is a gap between information provided by healthcare professionals and acceptance of the information by parents. It is important to recognize potential biases and find the ways to overcome them in order to minimize late consequences of delayed surgery. From the prospective of parents with hip dislocation surgery was mostly accepted as 'the last resort'. It should be taken into account when discussing to the parents. More clear information should be provided for the parents as well as 'parents surveillance' should be organized along with patients surveillance.

SP76

Revealing utilization of outpatient services for children with cerebral palsy after single event multi-level surgery

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Background and Objective(s): Children with cerebral palsy (CP) have single event multi-level orthopedic surgery (SEMLS) to improve alignment. Following SEMLS, children require outpatient visits with several medical providers to return to baseline function. There is a lack of research to inform patterns of outpatient care following SEMLS. The aim of this study was to characterize outpatient visits for children with CP 1 year post SEMLS and examine differences between number of visits and specialties by surgical burden and ambulatory status.
Study Design: Retrospective cross-sectional study.
Study Participants & Setting: Thirty-five children with CP underwent SEMLS at a large pediatric academic medical center between 10/2017 and 6/2018 (mean age 10 [3.65 SD] years, 43% males, 66% White, 94% Non-Hispanic, and Gross Motor Function Classification System [GMFCS] levels I–V [8.5%, 20%, 23%, 40%, and 8.5% respectively]).
Materials/Methods: Data were extracted from the medical record and confirmed by researchers. Frequencies and percentages were reported for outpatient visits across specialties 1 year post SEMLS. A Wilcoxon Rank Sum Test examined differences between number of visits and specialties by surgical burden (Low: soft tissue and/or single osteotomy, High: bilateral or multiple unilateral osteotomies) and ambulatory status (ambulatory: GMFCS levels I–III, non-ambulatory: GMFCS levels IV–V).
Results: Thirty-five children had 985 unique outpatient visits over 1 year and a mean of 6 (3.37 SD) specialties. Most frequent visits were therapy (52%), orthopedics (17%), and radiology (13%). Fifteen percent of visits were unrelated to SEMLS, including pediatric rehabilitation (4%), neurology (3%), lab draws (2%), complex care clinic (2%), ophthalmology (2%), otolaryngology (1%), and neurosurgery (1%). Majority of surgeries were high burden (71%) with a mean of 5 (2.28 SD) procedures. Fifty-one percent of children were ambulatory. There were no statistically significant differences between number of visits and surgical burden (p=0.27) or ambulatory status (p=0.36) over 1 year. A statistically significant difference was found for number of specialties by ambulatory status (p<0.001) with non-ambulatory children visiting a greater number of specialties; however, no differences were found for surgical burden (p=0.12).
Conclusions/Significance: Children with CP see many providers 1 year post SEMLS. Most outpatient visits are for therapy, however, 15% of visits are not directly related to SEMLS. Children who are non-ambulatory do not necessarily have higher surgical burden, but they see a greater number of specialties than children who ambulate. Surgical burden and ambulatory status may not capture the complexity of each

patient. Unveiling use of outpatient services for children with CP 1 year post SEMLS supports the need for coordinated care. The high number of therapy visits warrants more detailed investigation. Results from this study contribute to the understanding of outpatient services after SEMLS.

SP77

Tranexamic acid use decreases transfusion rate in children with cerebral palsy undergoing proximal femoral varus derotational osteotomy

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Background and Objective(s): Previous studies have demonstrated that the use of intra-operative tranexamic acid (TXA) is safe in cerebral palsy (CP) patients undergoing proximal femoral varus derotational osteotomy (VDRO), but were underpowered to determine if TXA has an effect on transfusion rates or estimated blood loss (EBL). The purpose of this study was to investigate if intra-operative TXA administration alters transfusion rates or EBL in CP patients undergoing VDRO surgery.
Study Design: Retrospective cohort study.
Study Participants & Setting: Consecutive CP patients undergoing a VDRO at a tertiary care center.
Materials/Methods: We conducted a retrospective review of 390 CP patients who underwent VDRO surgery between January 2004 and August 2019 at a single institution. Patients underwent additional bony and soft tissue procedures as indicated. Patients with pre-existing bleeding or coagulation disorders were excluded, as well as those without sufficient clinical data. Patients were divided into two groups: those that received intra-operative TXA and those that did not.
Results: Of 390 patients (mean age 9.4 ± 3.8 years; mean ± standard deviation), 80 received intravenous TXA intra-operatively (TXA group) and 310 did not (No-TXA group). There was no significant difference in mean weight at surgery (p=0.25), Gross Motor Function Classification System level (p=0.99), American Society of Anesthesiologist classification (p=0.50), pre-operative feeding status (p=0.16), or number of procedures performed (p=0.12) between the two groups. The overall transfusion rate was lower in the TXA group (13.8%; 11/80) than in the No-TXA group (25.2%; 78/310) (p=0.04). The intra-operative transfusion rate was similar between the two groups (TXA: 10.3% vs No-TXA: 7.5%; p=0.53), but the post-operative transfusion rate was significantly lower in the TXA group (7.5%; 6/80) than the No-TXA group (18.4%; 57/310) (p=0.02). The EBL was slightly lower in the TXA group, although this did not reach significance (TXA: 142.9 ± 113.1 mL vs No TXA: 177.4 ± 169.1 mL; p=0.09). The standard deviation was greater in the No-TXA group due to more extreme EBL outliers. The percentage of blood loss based on weight was similar between the two groups (TXA: 9.2% vs No TXA: 10.1; p=0.40).
Conclusions/Significance: The use of intra-operative TXA in CP patients undergoing VDRO surgery lowers overall transfusion rate and post-operative transfusion rate.

Testing and Validation

SP78

A new approach for the assessment of postural control while standing in childhood

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Background and Objective(s): Children with neurodevelopmental disorders may have problems in maintaining postural stability if compared to their typically developing peers. The assessment of postural stability is sometimes performed with some technical platforms but mainly in adults; however, existing data in literature, in particular in developmental age, are very few. The aim of this work is to assess postural control while standing with an innovative system, the Virtual Reality Rehabilitation System (VRRS, Khymeia) in children.
Study Design: Case series.
Study Participants & Setting: A total of 51 children (age range 4–15 years) have been selected by voluntary participation within an inclusive skating school. Participants have been divided in three groups: 29 typically developing (TD), 9 with cerebral palsy (CP), and 13 with special educational needs (SEN). The assessment has been conducted during their skating training sessions thanks to the portable VRRS system (tablet).
Materials/Methods: All participants have been tested with a technological assessment tool, that is the stabilometric balance of the VRRS for the evaluation of the ability of maintaining standing static balance connected to the tablet; moreover, TD and SEN were tested also with Movement ABC-2nd edition test to quantify their motor and coordination abilities. A multivariate ANOVA and a correlation analysis have been carried out.
Results: All VRRS values about distances were different among the three groups (p<0.05). The CP group had significantly higher scores than the two other groups. Moreover, in the TD and SEN groups there were a significant relationship between the parameter 'distances' at the VRRS test and the M-ABC scores (Total and Balance Section percentile). The present findings suggest that the amount of oscillations, i.e. the variation of the center of pressure (COP) while the participant is in standing position, has a relationship with the clinical picture: in fact, CP children have more and wider oscillations than SEN and TD children and SEN children have more and wider oscillations than TD children.
Conclusions/Significance: The stabilometric balance of the VRRS system is a tool able to assess postural control in children and its results comply with those obtained from clinical assessments. Moreover, the VRRS system (tablet and stabilometric balance) is suitable for being administered also in a non-clinical environment.

SP79

Associations between Canadian occupational performance measure change scores and cerebral palsy functional classification system severity levels

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Background and Objective(s): The Canadian Occupational Performance Measure (COPM) is a patient/family-driven assessment tool to identify problems and measure changes in perception of occupational performance over the course of therapy intervention. The Gross Motor Function Classification System (GMFCS), the Manual Ability Classification System (MACS/Mini-MACS), and the Communication Function Classification System (CFCS) are five-level classification systems that describe gross motor function, manual performance in daily activities, and everyday communication function, respectively, in children with cerebral palsy. We examined the relationships between the tools, specifically whether changes in COPM performance and satisfaction scores differ by GMFCS, MACS/Mini-MACS, and CFCS levels. Our findings may have noteworthy implications for practice and future research studies in the field of pediatric rehabilitation.
Study Design: Prognosis, retrospective cohort study, consecutive sampling.
Study Participants & Setting: This is a retrospective cohort study using consecutive sampling of all children who received therapy at outpatient California Children's Services Medical Therapy Units (MTUs) throughout Los Angeles County (LAC), had a diagnosis of cerebral palsy, and a COPM completed between July of 2017 and June of 2018. There were a total of 1,162 participants in this study.
Materials/Methods: We extracted demographics and COPM, GMFCS, MACS/Mini-MACS, and CFCS data collected from routine patient therapy evaluations. Our outcomes were whether the change in performance or satisfaction scores were clinically significant (defined as change scores ≥ 2; yes/no). We used multiple logistic regression models to determine statistical significance and magnitude of associations between the outcomes and severity levels, adjusting for other factors such as age, sex, and length of time between initial and re-assessment on the COPM.
Results: Patients were between the ages of 1 and 18 years and there were slightly more males than females. Both age and GMFCS levels were associated with clinically significant COPM performance change scores (p=0.04 and p<0.01, respectively) but not with clinically significant satisfaction change scores. MACS/Mini-MACS levels were associated with clinically significant COPM performance change scores (p<0.01) but not with clinically significant satisfaction change scores. CFCS levels were associated with both clinically significant COPM performance (p<0.01) and satisfaction change scores (p=0.02).
Conclusions/Significance: The results suggest that regardless of gross motor or manual ability function severity level therapists can impact patient and family satisfaction. However, this may be dependent on a child's ability to communicate in real-life situations. Future studies could include identifying the types of services (e.g., direct intervention, referrals, patient/family education, environmental adaptations) that impact patient/family satisfaction.

SP80

Psychometric properties and clinical implications of the general movement optimality score using rasch analysis

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Background and Objective(s): The General Movement Assessment (GMA) is a reliable assessment of the integrity and function of the young CNS and the most recommended assessment for identifying a high risk for cerebral palsy. In addition to the global categorization of general movement patterns, the general movement optimality score (GMOS) offers a more detailed assessment of movements at both preterm and term ages. Information on the psychometric properties of the GMOS, however, is limited. We aim to explore the psychometric properties and clinical implications of the GMOS using Rasch analysis. Rasch transforms ordinal data (i.e., ratings with non-equal intervals) into a linear measure with equal-interval units called logits. It does so by taking into consideration both the level of item difficulties and person abilities on the same scale. Therefore, an infant's score for any given item is assumed to be a logarithmic function of the difference between the particular infant ability and particular item difficulty.
Study Design: Retrospective secondary data analysis.
Study Participants & Setting: 383 infants born between 26 to 42 gestational weeks with various medical complexities and neurodevelopmental risk factors (i.e., preterm birth, perinatal asphyxia at term, parental concerns, or healthy control group) were videotaped between 27 to 45 weeks post menstrual age in hospitals, outpatient clinics, and community centers.
Materials/Methods: Videos were scored on both the global GMA categories (normal, poor repertoire, cramped-synchronized or chaotic), as well as on the 21 GMOS items which look at amplitude, speed, spatial range, proximal and distal rotations, onset and offset, tremulous and cramped components of the upper and lower extremities. The GMOS data was analysed retrospectively with uni- and multidimensional Rasch models. GMOS raw scores were transformed into logit measure, examining the item fit and scale functioning for each item and infant in the study. Next, descriptive statistics and ANOVAs were used to explore the implications of the Rasch results to clinical practice, including understanding class composition.
Results: The GMOS best fits a unidimensional model with three different classes of infants, with all but two items (tremulous movements of the upper and lower extremities) contributing to the infants' separation into three different

groups. Rating scale functioned well for the 19 remaining items. Item difficulty hierarchy varied depending on infants' class. No floor effect and no gaps between item difficulty estimates were found. Ceiling effect was found for class 3 only. Class composition revealed the unique GMOS performance among infants with different outcomes; it was not different based on infants' age of testing, but was so based on cranial ultrasound, concurrent GMA, and outcomes at 2 years of age. Item order and item location differed by class.
Conclusions/Significance: The GMOS has strong psychometric properties which allows a quantitative measure for quality of movement distinguishing infants with different functional motor performance and outcomes. The GMOS can confidently be used to quantify quality of movement, grade motor performance, study individual developmental trajectories, including improvement or deterioration in movement patterns, and assist with early diagnosis of neuromotor problems.

SP81

Reliability of a progressive lateral step up test and its relationship with physical activity in children with cerebral palsy

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Background and Objective(s): Children with cerebral palsy (CP) have low levels of physical activity which is consistent with a number of comorbidities, such as cardiometabolic disease. Deficiencies in lower body functional muscle strength logically are a central contributor to the low physical activity in children with CP; however, studies demonstrating this relationship are lacking. The purpose of this study was to assess the reliability of a progressive lateral step up test (LSUT) for the assessment of lower body functional muscle strength and to determine its relationship with physical activity in children with CP.
Study Design: Cross-sectional.
Study Participants & Setting: Thirty five children with spastic CP (5–11y) who could ambulate independently or with an assistive device (i.e., Gross Motor Function Classification System I, II or III) and 21 typically developing children in the same age range and between the 5th and 95th sex- and age-based percentiles for height and body mass participated in the study. Testing occurred in a university setting.
Materials/Methods: A LSUT was completed to assess functional muscle strength of the more affected lower limb in children with CP and the nondominant lower limb in typically developing children. The test consisted of 3 trials in which children performed lateral stepping onto a step as many times as possible in 20 seconds. Each trial corresponded with an increase in step height (i.e., 10, 15 and 20 cm). A composite score was calculated based on step height and the number of steps completed. Steps requiring assistance received a lower score. To assess test-retest reliability, the LSUT was completed again on a separate day in 20 children with CP. An accelerometer-based activity monitor was worn on the ankle of the more affected limb of children with CP and the nondominant limb of typically developing children for 4 days (3 weekdays and 1 weekend day) to assess physical activity.
Results: Compared to typically developing children, children with CP had a 69% lower LSUT score ($p<0.05$). The test-retest reliability associated with the LSUT was excellent in children with CP ($r=0.95$, $p<0.05$) and there was no difference between tests ($p=0.475$). Compared to typically developing children, children with CP had 43% lower total physical activity counts ($p<0.05$). There was a moderate positive relationship between LSUT score and total physical activity counts in children with CP ($r=0.533$, $p<0.05$), but a significant relationship was not detected in typically developing children ($r=0.220$, $p=0.337$).
Conclusions/Significance: The findings suggest that the progressive LSUT described in the present study is a reliable measure of lower body functional muscle strength in children with CP. In addition, lower body functional muscle strength may be an important determinant of physical activity participation in children with CP.

SP82

Reliability of the Danish version of the challenge advanced motor skills test in children with cerebral palsy

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Background and Objective(s): The Challenge is a newly developed observational tool assessing advanced gross motor function of ambulatory school-aged children with cerebral palsy (CP) (1). Translation and related reliability of the Challenge into a non-English language has not yet been studied. The aim of this study was to investigate the reliability of the Danish version of the Challenge for assessing gross motor function in ambulatory children with CP. The objectives were to evaluate: (1) inter-rater reliability among physiotherapists from live assessments, live versus video assessments and video versus video assessments (2) same day test-retest assessments and (3) minimal detectable change (MDC).
Study Design: Measurement study, cross sectional design.
Study Participants & Setting: The Challenge was translated (back-translation process) into Danish. Assessment took place with children participating after parents' consent, recruited from outpatient clinic (Central Region Denmark). Inclusion criteria were: (1) confirmed diagnosis of CP; (2) Gross Motor Function Classification System (GMFCS) level I or II; (3) aged 5 to 18 years; and (4) understanding and able to follow Danish instructions.
Materials/Methods: Live performance rating was conducted with three independent assessors in pairs of two (raters A, B and C) who scored 45 participants (26 males and 19 females; mean age [SD] 10y 9mo [4y]). Fifteen also had their

assessments video recorded for subsequent inter-rater video reliability evaluation by two assessors (raters B and D). For test-retest reliability evaluation, 22 children were assessed twice (morning and afternoon of same day) blinded ratings by assessor A. The Challenge Best Total score (/100) was used in all reliability analyses. Assessors were physiotherapists who had undergone training and had scoring of Challenge online video-scoring approved by its developer.

Results: Inter-rater reliability was excellent for live assessments (n=45): ICC: 0.998 (95% CI 0.997–0.999), live versus video-recorded assessments (n=15): ICC: 0.990 (95% CI 0.972–0.996), and video versus video assessments (n=15): ICC: 0.994 (95% CI 0.983–0.998). Test-retest reliability (n=22) was also excellent with an ICC of 0.989 (95% CI 0.974–0.995). MDC90 calculated from the test-retest data was estimated as 5.0 points.

Conclusions/Significance: This study showed the Danish version of the Challenge had the same excellent reliability as the original English language version (1). Reliability estimates in this study evaluated inter-rater reliability and test-retest reliability for live-testing as well as inter-rater reliability for Challenge assessments from live- and video scoring. After passing criterion-based training, physiotherapists can reliably score the Challenge from either live or video-recorded assessments. We found a MDC90 of 5.0 points, which appears clinically realistic as a target signifying a child's advanced motor skill progress.

SP83

Sensitivity of the means-end problem solving assessment tool (MEPSAT) for discriminating among infants with varying levels of motor delay

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Background and Objective(s): Means-end problem-solving (MEPS) tasks can serve as early indicators of infants' cognitive development and delays in performance and learning of MEPS in at-risk infants have been highlighted (Clearfield et al., 2015; Cunha et al., 2018). The Means-End Problem-Solving Assessment Tool (MEPSAT) was recently developed for early assessment of MEPS. The purpose of this study was to verify whether the MEPSAT is sensitive to distinguish developmental trends and differences among infants with varying levels of motor delay.

Study Design: Diagnostic study. A convenience sample was enrolled from a larger randomized controlled trial (Harbourne et al., 2018).

Study Participants & Setting: Thirty infants with motor delays, 7 to 16 months of corrected age (Mean=10.4, SD=2.4 months), able to sit with support of their arms for 3 seconds, and not demonstrating means-end learning at the first visit participated in this study. They were enrolled in a longitudinal randomized controlled trial (Harbourne et al., 2018). These infants were further classified by the severity of their motor delay (n=10 mild; n=10 moderate; and n=10 severe) based on a scale incorporating Gross Motor Functional Classification System (GMFCS) level (Palisano et al., 1997, 2007), distribution of motor deficit, and active movement observed (Harbourne et al., 2018).

Materials/Methods: Children were assessed across 5 visits at their homes (baseline and 1.5, 3, 6, and 12 months later). At each visit, they engaged in a MEPS task: pulling a towel to retrieve a distant, supported toy. The MEPSAT was used to score from videos, resulting in two outcomes: (1) means-end learning (whether successful MEPS was demonstrated); and (2) level of means-end performance (0–9-interval scale). Linear mixed modeling was applied to evaluate developmental trends and differences between typically developing infants and those with motor delays.

Results: The interaction between time and severity was not significant for either outcome. However, there was a significant main effect of severity for means-end learning ($F[2,26]=4.22$, $p=0.026$) and level of means-end performance ($F[2,27]=9.07$, $p=0.001$). The means-end learning trajectory of infants with severe motor delay differed significantly from those with mild ($\beta=3.98$, SE=1.37, $p=0.007$) or moderate motor delay ($\beta=2.96$, SE=1.42, $p=0.048$). There were significant differences between all group combinations for the level of means-end performance, with the less severely delayed group always out-performing the more severely delayed one (mild vs moderate: $\beta=1.96$, SE=0.95, $p=0.048$; mild vs severe: $\beta=4.03$, SE=0.95, $p<0.001$; and moderate vs severe: $\beta=2.07$, SE=0.95, $p=0.037$).

Conclusions/Significance: The MEPSAT was sensitive to identify differences in MEPS among infants with varying levels of motor delay. The MEPSAT might be a simple, effective, and sensitive tool for screening early problem-solving delays and for evaluating change across time in infants with a range of developmental abilities.

SP84

The How, What, When and Where of infant participation – Towards a clearer understanding of the constructs and content of infant participation: a Delphi study

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Background and Objective(s): Participation, attendance and involvement in life situations, is considered the ultimate health outcome. Recent advances in defining this important construct have been widely adopted, though much of our theoretical and empirical knowledge of participation is based on older children and adults. We conducted a Delphi survey study to gain consensus from expert opinion on what participation looks like for infants.

Study Design: 3 round Delphi survey study.
Study Participants & Setting: Invitations to participate in the study were emailed to health professionals and/ or researchers with expertise in infants: (1) authors who had published on participation of young children (as identified in a recent systematic review), (2) members of the Australasian Academy of CP and Developmental Medicine and (3) through the networks of a state health service. Snowball sampling was encouraged. Participants were eligible to participate if they had two or more years of experience working with infants.
Materials/Methods: In Round 1, respondents answered open-ended questions on: (1) Describing infant participation; (2) Participation Attendance – what type of life situations an infant might attend and how this might change over time; (3) Involvement – how an infant might demonstrate their involvement and how this might change over time; (4) Similarities and Differences in the participation of infants and toddlers and preschool aged children, and school aged children; (5) parental role (6) assessment and (7) intervention for participation. The responses from Round 1 underwent content analysis, and combined with items identified in a recent systematic review, were rated in Rounds 2 and 3. Items reaching ≥85% agreement were deemed to have reached consensus.
Results: Respondents were 35 researchers/clinicians from 5 countries (mean [SD] 18 [10] years experience). In describing infant participation, 29 items were proposed with 16 reaching consensus. Respondents agreed the participation constructs of attendance and involvement in a life situation describe infant participation. For Attendance, respondents proposed 26 different life situations an infant might attend, with consensus that an infant would be more likely to attend a greater variety as they approached 12 months (5 items reaching consensus for 0–3 months vs 16 items for 10–12 months). For Involvement, respondents proposed 10 items with 7 reaching consensus, suggesting high level of certainty regarding how infants might demonstrate their involvement. Respondents were not able to reach consensus on any of the proposed differences in participation between infants and toddlers/pre-schoolers (18). Regarding parental role, 29 of the 34 proposed items reached consensus, suggesting respondents agreed with the extent and variety of ways infant participation is mediated by parents. In the Assessment category, respondents were not able to reach consensus regarding the 18 assessments proposed, despite some of the proposed assessments being specifically designed to assess infant participation. Respondents were only able to reach consensus on 3 of 27 proposed intervention approaches/ strategies.
Conclusions/Significance: Consensus exists for the constructs of infant participation including the range of life situations infants might attend, and how an infant is involved. Further research is needed regarding infant participation assessment and intervention.

SP85

The pediatric evaluation of disability inventory-patient reported outcome software interface: Initial investigation of usability and reliability for young people with neurodevelopmental disabilities

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Background and Objective(s): Most patient reported outcome measures (PROMs) cannot be modified to reduce the visual-perceptual, motor, and cognitive demands that pose an accessibility challenge for young people with neurodevelopmental disabilities (DD). The Pediatric Evaluation of Disability Inventory-Patient Reported Outcome (PEDI-PRO) is a PROM designed for transition age young people with DD ages 14 to 22 years; it measures perceived performance of Daily Activities, Social/Cognitive, and Mobility functional skills. Previous research established that young people with DD interpreted the PEDI-PRO items in the intended manner. This study evaluated the usability and accessibility of the PEDI-PRO accessible software interface. Research Aim 1 (RQ1) Evaluate the usability of the PEDI-PRO software in clinical contexts. Research Aim 2 (RQ2) Establish the reliability and acceptability of the PEDI-PRO user interface with transition age young people with DD.
Study Design: RQ1: Survey methodology: cross-sectional. RQ2: test-retest design.
Study Participants & Setting: RQ1: We recruited clinicians across the US through professional networks. A total of 14 clinicians (OT=12, PT=2) administered the PEDI-PRO in diverse practice contexts (School-based=9, outpatient=4, other setting=1) to 39 young people with DD ages 14 to 22 years. RQ2: Convenience sample of young people with DD recruited through schools and agencies in a large metropolitan area. 54 young people completed the PEDI-PRO: mean age=19.7 years, SD=1.7 years; 60% male; 64% Caucasian; 64% intellectual disability.
Materials/Methods: RQ1: Clinicians administered the PEDI-PRO to three young people, and then completed the System Usability Survey (SUS). SUS scores range from 0 to 100, with higher scores indicating greater usability; the accepted industry standard for usability is a mean score of >68. RQ2: Research staff administered the PEDI-PRO software two times, 1 to 2 weeks apart. Items were counterbalanced across testing occasions. Young people also completed a questionnaire about the features of the PEDI-PRO. We used a Rasch rating scale model to obtain domain scores from the Likert response scale, then used ICC consistency model (3,1) to investigate the reliability of scores across testing occasions; ICCs >0.75 indicate fair reliability.
Results: RQ1: SUS rating M=84 (SD=11.68) exceeded industry standards. RQ2: Daily Activities: ICC=0.83. Social/Cognitive: ICC=0.85. Mobility: ICC=0.81. Almost all young people reported they 'liked' the accessibility features, including interface images, button sounds, item read-aloud audio, and rating category choices with images: Range=84–98%.
Conclusions/Significance: Clinicians and young people with DD found the interface easy to use and accessible. Our results

provide initial evidence that the PEDI-PRO user interface produces stable scores during a time period in which functional performance is not expected to change. PROMs that incorporate technology, such as the PEDI-PRO, can provide access to PROMs for young people with DD and address the underrepresentation of this population in the evaluation of rehabilitation and healthcare outcomes.

Therapy - Speech/Swallow/ Cognition

SP86

Anamnesis questions to identify dysphagia and aspiration in Argentinian children with cerebral palsy

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Background and Objective(s): Dysphagia and aspiration are common problems in children with cerebral palsy (CP); during the clinical assessment it is relevant to identify these disorders. The aim was to analyze the relationship between questions with dysphagia and aspiration in the last month in children and adolescents with CP.
Study Design: Cross-sectional study.
Study Participants & Setting: Children with CP aged 2 to 18 years were included. Sequential sampling from 9 rehabilitation and therapeutic centers from four provinces of Argentina was performed. Of 242 children with a diagnosis of CP, 23 children with endocrine, metabolic or genetic disorders were excluded.
Materials/Methods: Semi-structured surveys to parents were conducted and diagnosis of dysphagia and aspiration in the last month was identified. A bivariate risk analysis was performed to determine the degree of association between questions and oral-respiratory disorders with OR calculation with (95% CI). Sensitivity, specificity, positive predictive value (PPV) and negative (NPV) were calculated with (95% CI). Statistical significance was predefined as $p<0.05$. Data were analyzed using STATA 13.0.
Results: 219 children were studied, 130 males (59%). Mean age 10 years [SD 4.96]. Gross Motor Function Classification System level I, 42; II, 23; III, 27; IV, 45; V, 82. 37 (24%) children presented with dysphagia and 16 (10%) with aspiration in the last month. Difficulty eating was associated with dysphagia OR 26.1 (7.3–38.4, $p<0.001$), and aspiration OR 4.2 (1.2–18.8, $p<0.01$). Those who do not report a difficulty in eating will not present dysphagia with sensitivity 91% (76–98), specificity 70% (61–78), PPV 46% (34–59) and NPV 96% (90–99); and will not present aspiration with sensitivity 75% (48–93), specificity 59% (50–67), PPV 17% (9–28) and a NPV 95% (88–99). Difficulty in drinking was associated with dysphagia OR 13.2 (5.1–35.1, $p<0.001$) and aspiration OR 4.2 (1.2–18.8, $p<0.01$). Those who do not report a difficulty in drinking will not have dysphagia with sensitivity 73% (56–86), specificity 83% (75–89), PPV 57% (42–71) and NPV 91% (84–96); and will not present with aspiration sensitivity 75% (48–92), specificity 75% (67–82), PPV 25% (14–40) and NPV 96% (91–99). Food consistency modification was associated with dysphagia OR 8.7 (2.7–36.1, $p<0.001$). Those who do not need to modify consistencies will not have dysphagia with sensitivity 86% (67–96), specificity 59% (50–68), PPV 34% (23–46) and NPV 94% (87–98); and will not present aspiration with sensitivity 54% (25–81), specificity 51% (42–60), 10% (4–19) and NPV 92% (83–97). Needing help to eat was associated with dysphagia OR 7.2 (2–38.27, $p<0.005$). Those who do not need help to feed themselves will not have dysphagia with sensitivity 81% (54–96), specificity 34% (26–42), PPV 12% (7–20) and NPV 94% (83–99); and will not present aspiration with sensitivity 81% (54–96), specificity 34% (26–42), PPV 2% (7–20) and NPV 94.0% (83–99).
Conclusions/Significance: Children whose families report that they do not have difficulty eating and drinking do not consume modified consistencies of foods and do not need help to feed themselves, are less likely to have dysphagia and aspirations. Difficulty eating and drinking, food consistency modification and needing help to eat can help identify risk of dysphagia.

SP87

Cognitive and learning profiles of school-aged children with cerebral palsy

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Background and Objective(s): Research suggests nearly half of all children with cerebral palsy (CP) experience intellectual impairment, affecting academic and occupational outcomes. This study aimed to assess cognitive and academic functioning in children with CP aged 8 to 12 years.
Study Design: Population-based cohort study.
Study Participants & Setting: 85 participants (male n= 57; GMFCS I=32, II=16, III=10, IV=7, V=6, unknown=11, mean age 9 years 3.4 months, SD 1 year 9.8 months) with a diagnosis of CP were administered a comprehensive assessment protocol at a child health research centre.
Materials/Methods: Measures assessed nonverbal and verbal intelligence (Ravens Coloured Progressive Matrices [RCPM], Peabody Picture Vocabulary Test [PPVT]) and academic achievement (Wechsler Individual Achievement Test). One-sample t-tests were used to compare participants' results with population means.
Results: 31 (39.24%) participants were assessed to be within a range consistent with intellectual impairment based on prior diagnosis or RCPM score. 17 (21.52%) were unable to complete the RCPM due to intellectual impairment and 14 (17.72%) obtained scores ≤70, two SD below the population mean. PPVT scores, a measure of receptive vocabulary and verbal intelligence, were significantly below the population mean (M=91.95, SD=25.35) $t(61) = -2.50$, $p=0.015$. Academic achievement scores (n=61) were significantly below population means (M=100,

SD=15) for word reading (M=85.34, SD=19.85), t(60) = –5.77, $p<0.001$; spelling (M=82.98, SD=20.07) t(59) = –6.53, $p<0.001$; numerical operations (M=74.28, SD=21.52) t(59) = –9.26, $p<0.001$; and academic composite (M=81.61, SD=16.90), t (58) = –8.36, $p<0.001$. After excluding participants assessed to be within the range of cognitive impairment, scores remained significantly below the population mean for word reading (M=91.09, SD=16.85), t(45) = –3.59, $p=0.001$; spelling (M=89.00, SD=17.29) t(45) = –4.31, $p<0.001$; numerical operations (M=80.51, SD=18.43) t(44) = –7.09, $p<0.001$; and academic composite (M=86.84, SD=14.68), t(44) = –6.01, $p<0.001$.

Conclusions/Significance: Assessment of this cohort of school-aged children with CP confirms earlier research that close to half of children with CP may experience cognitive impairment. Nonverbal reasoning and numeracy scores were lower than verbal intelligence, spelling and word reading scores, with all below population means. This suggests many children with CP will experience academic challenges, even in the absence of intellectual impairment. Screening for specific learning disabilities including dyscalculia should be considered for school-aged children with CP experiencing academic delays.

SP88

Pre-speech and early speech development of young children diagnosed with cerebral palsy

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Background and Objective(s): Motor speech impairments are common among those diagnosed with cerebral palsy (CP). Canonical babbling—i.e., producing consonant-vowel syllables—is a robust milestone of typical speech development occurring between 7 and 10 months of age. The purpose of this study was to measure emergence of babbling in children diagnosed with CP and compare to typical development and included reduplicated babbling (RB) (i.e., repeated syllables such as [baba] or [dada]), and variegated babbling (VB) (i.e., combined syllables such as [bada] or [daba]). The early speech onset of the first word was also evaluated. We hypothesized that children with CP showed delays in all three stages compared to typically developing (TD) children.

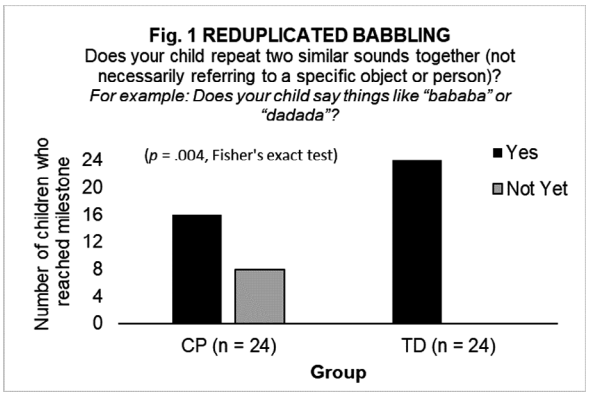
Study Design: Case-control study.

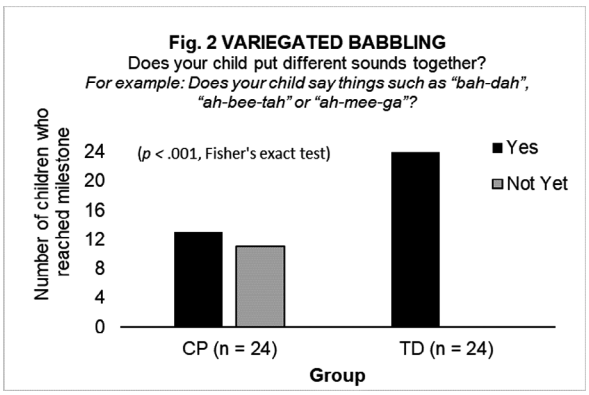
Study Participants & Setting: Purposive sampling was used to recruit 24 children (12 F) diagnosed with CP (mean CA: 36mo, range: 20–59mo) and their parents. Families were recruited from the neuromuscular registry of the CP clinic at the regional children's hospital and word of mouth. Convenience sampling was used to recruit 24 age- and sex-matched TD children (12 F; mean CA: 36mo, range: 18–58mo) via word of mouth, social media, and online crowdsourcing.

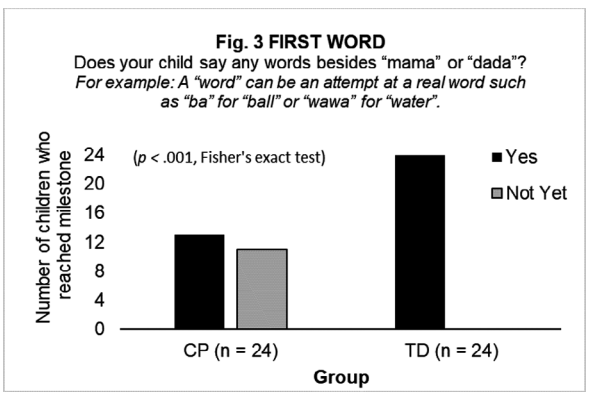
Materials/Methods: Parents were asked questions about their child's speech development using the LENA Developmental Snapshot, a developmental screener and parent questionnaire assessing children's early speech and language developmental milestones. Three specific questions from this questionnaire were selected to assess whether children had produced RB (typical ages of onset: 6–9mo), VB (9–12mo), and first word (9–12mo).

Results: The two-tailed Fisher's exact test was selected to analyze differences between the children. 100% of TD infants reached all three pre-speech and early speech milestones. The children with CP showed significant delays in reduplicated babbling, with 67% of the CP group having reached the RB stage (Fig 1, $p=0.004$), significant delays in the emergence of variegated babbling, with only 54% of the group having reached the VB stage (Fig 2, $p<0.001$), and significant delays in the emergence of first words, with only 54% of the CP group having produced their first word (Fig 3, $p<0.001$).

Conclusions/Significance: With a significant difference in the emergence of all three pre-speech and early speech milestones in children with CP compared to the TD group, using early indicators for speech impairment in CP is an important consideration for speech referrals and prognosis for speech development.







SP89

What is most frequent diagnoses in children with swallowing disorders?

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Background and Objective(s): Over the past two decades, the definition of the state of health has been expanded from a disease-based condition to one that includes the impact of the disease on an individual's ability to function. The World Health Organization identified the International Classification of Functioning, Disability, and Health (ICF) as a potential framework for coding functional status and establishing a common, standardized language to describe and study health and health-related domains. The ICF could have significant benefits working with children with feeding and swallowing problems. We aimed to investigate the most frequent diagnoses in children with swallowing disorders.
Study Design: Retrospective clinical study.
Study Participants & Setting: A total of 80 children with swallowing disorders (age range 1mo–15y, 45 males, 35 females) were recruited in university hospital, swallowing disorders clinic.
Materials/Methods: The children's data were scanned from the files and physical-clinical examination applied in the clinic. We performed flexible fiber-optic endoscopic swallowing (FFES) study. And some clinical scales evaluating oral motor dysfunction were performed. The assessments were carried out by a doctor and therapist.
Results: The mean±SD age of children were 33.74±36.60 months, and birth weight was 2712.50±897.37 (min–max=1840–4750) grams. When asked what diagnosis they followed and by which doctor/unit they were sent: 33 (41.3%) were from child neurology, 9 (11.3%) were from child gastroenterology, and 38 (47.5%) were from others. The most frequent diagnosis were: (1) cerebral palsy (n=11, 13.75%), (2) equally; epilepsy, syndromic disorders, esophageal atresia, multiple influences (n=10, 12.5%), (3) prematurity (n=9, 11.25%), (4) feeding disorder (n=8, 10%), (5) down syndrome (n=7, 8.75%), and (6) neuromuscular disorder (n=5, 6.25%), respectively. 50% of children were fed orally, 23 of (28.75%) with nasogastric probe (NG), and 17 of (21.25%) with percutaneous endoscopic gastrostomy tube (PEG). The mean of penetration-aspiration rating from FFES was 4.27±2.38 (min–max=1–8).
Conclusions/Significance: Swallowing evaluation and management of disorders is very important in rehabilitation. Considering the safety window, we suggest that regular controls of the swallowing function to prevent the development of problems and to direct the rehabilitation.

Therapy - Trunk Control and Upper Extremity

SP90

A repeat dose of pediatric constraint induced movement therapy

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Background and Objective(s): Pediatric Constraint-Induced Movement Therapy (P-CIMT) and Hand Arm Bimanual Therapy (HABIT) are two intensive therapeutic approaches that have consistently demonstrated the ability to help children with hemiparetic cerebral palsy (hCP) gain increased functional skills and movement (Novak et al.; 2013, Hoare et al.; 2019). Knowledge from repeated doses of P-CIMT is limited and it is unclear what effect multiple doses of P-CIMT has on children with hCP. In the consensus report, Eliasson et al. 2013, encouraged further research of repeated doses of P-CIMT with the same design. The aim of the study was to determine the efficacy of repeat doses of P-CIMT in children with hCP.
Study Design: Prospective case series.
Study Participants & Setting: A total of 11 children with hCP (age range 5–15 years, 6 male, 5 female, MACS 1=2, MACS 2=8, and MACS 3=1) participated in P-CIMT camp between 2012 and 2019. CIMT camp consists of 10 days of group intervention including 50 hours of wearing a constraint while participating in repetitive, shaped activities and a transfer package including 10 hours of bimanual training. Participants were recruited from a pediatric orthopedic hospital in southwestern United States.
Materials/Methods: The annual P-CIMT camp was kept consistent with the utilization of both camp and training manuals, at least 1:1 interventionists, and the same leadership. The Assisting Hand Assessment (AHA), was conducted pre, post, and 6 months following P-CIMT camp. The AHA assessed baseline bimanual ability and changes of assisting hand usage during bimanual activities. A repeated measures ANOVA was used to examine how participants changed on the AHA during their first and second camp session.
Results: The mean interval between first and second treatments was 564 days. Most children were MACS Level 2 (8). AHA mean score at baseline of the first treatment 55.93 (SD 12.78), the AHA score post camp treatment 1 66.53 (SD 12.85). The second treatment mean AHA score 58.13 (SD 12.8), and post 66.53.
Conclusions/Significance: Overall, there was a significant bimanual functional improvement effect as determined by the AHA, in both dose 1 and dose 2 of P-CIMT. Scores improved from pre to post, $F(1, 28) = 74.81$. $p<0.001$, n2=0.73. The test for interaction between session and time (AHA pre 1 to AHA pre 2 and AHA post 1 to AHA post 2) was not significant, p=0.49, indicting there was not a difference between year 1 and 2 in

how children changed in AHA score. However, the results demonstrate a trend toward a carryover effect between P-CIMT doses in AHA improvement; however, not statistically significant. This may be due to the mean time between the repeated doses was almost 18 months. Overall, the results demonstrate a wear-off effect 18 months post P-CIMT intervention that is reversed with repeated treatments. Future research may look further into this clinically important improvement and timing of repeat doses of P-CIMT.

SP91

Adaptive arm training for children with hemiparesis as a result of acquired brain injury

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Background and Objective(s): Perinatal infarction can cause neurological deficits affecting one side of the body (e.g. disabling hemiparesis) in children. Disuse of a limb during postnatal development can stunt the activity-dependent structural and functional development of the motor system. A lack of evidence highlights the critical need to devise and study protocols that aim to enhance motor recovery for children with chronic impairment. Bimanual training has been shown to lead to greater gains in arm function compared with practice with the paretic arm alone. Aim 1: provide limb training in children with hemiplegia from cerebral palsy (CP) and/or acquired brain injury (ABI) using a bimanual-to unimanual training approach. We hypothesize that child-friendly upper limb bimanual-to-unimanual training will lead to improved motor outcomes on the Assisting Hand Assessment (AHA), Jebsen-Taylor Test of Hand Function (JTTHF), and Box and Blocks test (BBT). Aim 2: improve the understanding of the pattern of recovery of isolated joint movements in the pediatric population with hemiplegia following CP/ABI. We hypothesize that individuals receiving device-based bimanual-to-unimanual training will show improvement in active range of motion across upper limb joints.
Study Design: Pilot feasibility study.
Study Participants & Setting: Children (n=15, 11 males, age: 11.53±4.43y) with CP or chronic hemiplegia diagnosis as a result of ABI. This study is part of the Burke-Blythedale Pediatric Neuroscience Research Collaboration and is based in Blythedale Children's Hospital, Valhalla, NY.
Materials/Methods: Studying the feasibility of a robotic device called the Bimanual Arm Trainer (BAT, developed at NYU Rusk & Mirrored Motion Works). Upon enrollment children complete baseline testing, enter 9 week control period immediately followed by pre-testing and 9 weeks of robotic training (18 sessions total: 2 sessions/week, 45 minutes each). Post testing occurs upon immediate completion of 18th session. BAT employs mirrored motion, combines motivational features with modern technology and a therapeutic method that links the movement of the arms to retrain the brain. The device provides bimanual-to-unimanual training of simultaneous shoulder external rotation and elbow extension, and independent training of pronation, supination and grasp and release of each hand. Range of motion and speed are recorded during training and feedback and motivation are provided through age-appropriate gaming modules.
Results: Preliminary analysis of the primary outcome measures has shown that bimanual hand and arm use has improved (AHA, p<0.01), skill of the affected upper limb (BBT; p<0.05), and hand dexterity (JTTHF; p<0.05) have also significantly improved.
Conclusions/Significance: Training with this device has provided clinically meaningful and statistically significant improvements in dynamic upper limb function and improved skill and dexterity of the affected upper limb. Analysis of kinematic data is ongoing. No adverse events to report.

SP92

Does prematurity impact trunk control and early reaching behavior?

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Background and Objective(s): The level of trunk control is strictly related to the sitting ability, which both are associated with better reaching performance (Rochat & Goubet, 1995; Harbourne et al., 2013). Preterm (PT) infants often present delays in the level on segmental trunk control (Greco et al., 2019), sitting ability (Valenti et al., 2019) and reaching performance (Heathcock et al., 2008). However, these behaviors have been studied separately in infancy (Hadders-Algra et al., 2007; Toledo et al., 2011). This study aimed to verify the level of trunk control and reaching performance in PT infants while sitting into two positions at 6 to 8 months of corrected age compared to their full-term peers.
Study Design: Prospective cohort study.
Study Participants & Setting: Twenty infants born preterm [PT, (Mean=35.3; SD=0.9 weeks of gestational age [GA]), and 36 infants born full-term (FT; Mean=39.4; SD=1.3 weeks of GA) at 6 to 8 months of age (corrected age for prematurity), with adequate birth weight for GA, participated in this study. These infants were recruited from health care centers and maternity hospital through volunteer sampling.
Materials/Methods: Infants were assessed via 3 in-lab visits: (1) at 6 months, (2) at 7 months, and (3) at 8 months of age. At each visit, the Segmental Assessment of Trunk Control (SATCo) was performed to determine the level of segmental trunk control. A reaching assessment was also performed, where the infants were positioned on a bench into two sitting positions: (1) in ring and (2) at 90° of flexion of hips, knees and ankles. They were encouraged to interact with toys presented at infants' chest level for 2 min in each position. An accurate manual support to the trunk was provided according to the SATCo in each visit. All assessments were video-recorded. Kinovea 0.8.21 and the Qualisys Track Manager software were used to analyze the total reaching frequency. Descriptive analysis for level of trunk control and a mixed model ANOVA for total reaching frequency were performed.
Results: The PT infants presented lower level of trunk control than FT infants across time, respectively (upper thoracic vs

low thoracic at 6 months; low thoracic vs upper lumbar at 7 months; upper lumbar vs total trunk control at 8 months). There was a significant difference for group versus time interaction ($F[2,177]=3.154$; $p=0.04$). PT infants (Mean=9.85; SD=0.87) presented higher reaching frequency when compared to FT infants (Mean=6.78; SD=0.61) at 8 months visit ($p=0.00$; d=4.08), but no differences between both sitting conditions.

Conclusions/Significance: PT infants presented lower level of trunk control over time, however, they presented higher number of reaches at 8 months visit compared to FT infants. The sitting positions did not influence reaching performance. This study might provide insights for clinicians for understanding the level of trunk control, importance of reaching behaviors for exploration and play, and considering these behaviors as strategies for early intervention.

SP93

Improved sitting balance in children with cerebral palsy: body functions to activity and participation

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Background and Objective(s): The aim of this study is to evaluate the changes in activity and participation domains of the International Classification of Functioning (ICF) in children with Gross Motor Function Classification System (GMFCS) levels IV and V cerebral palsy (CP) who received integrated botulinum toxin-A (BoNT-A) injections in to the lower limb (s) with a treatment goal of improved sitting balance.

Study Design: Prospective, observational study.

Study Participants & Setting: 29 patients with CP (mean age 6.7±3.8y), rehabilitation clinic university hospital.

Materials/Methods: The primary outcome measures were the mean changes from baseline at post-treatment week 10 to 12 of the Child and Adolescent Scale of Participation (CASP) Caregiver Priorities & Child Health Index of Life with Disabilities (CPCHILD). Other outcome measures were Goal Assessment Scale (GAS), Modified Ashworth Scale (MAS), Tardieu Scale (TS) and a semi-structured interview to parents and patients.

Results: Statistically significant improvements in CASP ($p<0.001$) and CPCHILD ($p<0.001$) were obtained at post-treatment week 10 to 12. Mean GAS T score was 56.9 at post-treatment week 10 to 12. Expected goal attainment was achieved in all patients on body parts and function domain of ICF and in 93.1% of patients on activity domain. The semi-structured survey revealed some other unforeseen improvements on activity and participation levels of the child and quality of life of the family.

Conclusions/Significance: The results of this prospective, observational study showed that the functional improvements in sitting balance by the integrated BoNT-A treatment provides positive effects on activity and participation levels of the patient and quality of life patients and their families.

SP94

Relationships between proprioception, unilateral, bilateral and functional performance changes after an intensive upper extremity training in children with unilateral cerebral palsy

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Background and Objective(s): In children with unilateral cerebral palsy, the deficits in bimanual performance are often beyond the deficits of hand dexterity on the affected side. Furthermore, sensory deficits (e.g. proprioception) are less extensively studied than motor deficits, but are also a factor limiting upper extremity (UE) function. Intervention studies have shown that intensive training of the UE is effective for improving both unilateral and bilateral performance, and even functional performance. However, the relationships between changes in unilateral skills, bilateral coordination, proprioception and performance in self-chosen functional activities are not well understood. The main objective of the study was to test the associations between changes of these four variables after an intensive training targeting the UE in young people with unilateral cerebral palsy.

Study Design: Prospective cohort study.

Study Participants & Setting: Eleven children with unilateral cerebral palsy (mean age 8.8 ± 1.3 years; MACS levels between I and III; 4 females), in an institutional setting.

Materials/Methods: Participants were evaluated pre and post intervention, which consisted of an intensive training of the UE performed in a local rehabilitation center following camp-based models. Training involved different manual play and functional activities actively engaging the more affected hand. Outcome measures included the Jebsen Taylor Test of Hand Function (JTTHF) for unilateral skills of the more affected upper extremity, the Assisting Hand Assessment (AHA) for bimanual performance, the Arm Position Matching task of the KINARM Exoskeleton Lab for proprioception of the more affected upper extremity, as well as the Canadian Occupational Performance Measure (COPM) for functional performance. To conduct the analysis, Spearman correlation coefficients were used with a statistical significance threshold set at 0.05.

Results: Main results are that both the initial total score of the JTTHF for the more affected hand and the initial scale score of the AHA were correlated to the amount of change in the performance score of the COPM after the intervention ($r=-0.76$, $p=0.03$ and $r=0.72$, $p=0.5$, respectively). Also, there was a trend toward an association between the initial AHA score and the Arm Position Matching task (variability measurement) of the more affected arm ($r=-0.60$, $p=0.096$). There was also a trend toward an association between the amount of change in

the AHA score and the amount of change in the Arm Position Matching task of the more affected arm (r=–0.67, p=0.077).
Conclusions/Significance: Our results point towards both better initial unimanual function and better initial bimanual skills being associated with a larger improvement in performance in self-chosen functional activities after the intervention. Also, improvement in proprioception of the more affected arm might be associated with a larger improvement in bimanual performance, but this needs to be confirmed in a larger sample.

SP95

Rotational movement between trunk and pelvis during rolling in preterm, very low birth weight, and full-term infants

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Background and Objective(s): Rotational movement of body segments during rolling is considered an indicator of infant's physical development. The key movements pointed out are rotation with trunk extension or flexion movement and without rotational or with rotational movement between the trunk and pelvis. This study aimed to compare the difference of the movement patterns among preterm, very low birthweight (preterm) at 12 months of corrected age, and full-term infants at 12 months of age using wearable motion sensors.
Study Design: Cross-sectional study.
Study Participants & Setting: Overall, 19 preterm infants without neurological disorders (12 males, 7 females) were recruited from a university hospital. We also recruited 20 full-term infants (10 males, 10 females) from a general pediatric outpatient clinic.
Materials/Methods: Wearable motion sensors were attached on the front surface of the infant's trunk (sternum) and the pelvis (lower abdomen). The examiner placed the infant on a mat in a supine position with the infant's trunk and pelvis as flat as possible. Further, the examiner encouraged the infant to roll over by attracting his or her attention. After computing trunk–pelvis orientation data obtained via the sensors, the movement pattern was classified into 'flexion' or 'extension,' depending whether the trunk has moved in the flexion–extension direction at the beginning of the rolling, and 'no roll' or 'roll,' depending whether the rotational angle of the trunk has exceeded 20 degrees. Gross motor development was also assessed using the Alberta Infant Motor Scale.
Results: No difference was found in height, body weight, and gross motor development between the preterm and full-term infants at 12 months of age. The flexion pattern during rolling was mainly found in full-term infants (15 of 20 infants, 75%) but less commonly in preterm infants (7 of 19 infants, 37%, p<0.05). This indicates that 12 of 19 preterm infants (63%) exhibited the extension pattern. Furthermore, most infants in both groups exhibited the rotational, rather than the no rotational, movement pattern between the trunk and pelvis (79% in preterm, 75% in full-term).
Conclusions/Significance: Preterm infants tended to exhibit trunk extension movement pattern during rolling. The flexion pattern of movement between the trunk and the pelvis during rolling from supine to prone could be achieved by elevation of either the trunk or the lower limbs, both of which required antigravity activity of the ventral muscles. This result might suggest that the preterm infants have delayed ventral trunk muscle maturation compared to the full-term infants, even if they were already at 12 months of corrected age.

SP96

The relationship between bimanual performance and self-care in children with cerebral palsy aged 8 to 12 years

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Background and Objective(s): To explore the relationship between bimanual performance and self-care for children aged 8 to 12 years with cerebral palsy (CP) with respect to other factors which may determine self-care.
Study Design: Cross-sectional study.
Study Participants & Setting: 74 children with CP (unilateral CP n=30 [41%], bilateral CP n=44 [59%]; 48 [65%] males; median age 9.7 years [25th, 75th centiles=9.1, 10.7 years]) were recruited at a tertiary referral centre in a population based study. Children were classified Manual Ability Classification System (MACS) level I=30 (40%), II=28 (38%), III=16 (22%); 21(28%) had intellectual impairment.
Materials/Methods: Self-care was measured using the Pediatric Evaluation of Disability Inventory – Computer Adaptive Test (PEDI-CAT) Daily Activities (DA) domain. The Assisting Hand Assessment (AHA) and the Both Hands Assessment (BoHA) measured bimanual performance for children with unilateral and bilateral CP respectively. Other measures include the Raven's Coloured Progressive Matrices, Behavior Rating Inventory of Executive Functions (BRIEF - behavioural regulation), Conners 3–Parent Short Form (inattention). A theoretical model of determinants of self-care was hypothesized and represented as a causal diagram. Linear regression was used to estimate the effect of bimanual performance upon self-care. Potential confounding was addressed by adjusting for variables identified by the directed acyclic graph (DAG) as being in a confounding relationship. Analyses used http://dagitty.com/ and Stata 16.0.
Results: The DAG (published at dagitty.net/mOowPEn) identified the minimal adjustment set of variables for estimating the total effect of bimanual performance on self-care as age, cognition, behaviour self-regulation, and attention span. Higher BoHA and AHA scores were associated with higher PEDI-CAT-DA scaled scores. An increase of 10 BoHA logits and 10 AHA logits were associated with an increase of 1.7 and

1.2 (p<0.001) PEDI-CAT-DA scaled scores respectively. For children assessed using the BoHA the full model accounted for 68% of the variance (F[5, 30]=15.9, p<0.001) of self-care and cognition was the only variable of those in a confounding relationship which was significant (p=0.001). For children assessed using the AHA the full model accounted for 40% of the variance (F[5, 18]=4) in self-care, and there were no significant effects on self-care by other variables; cognition had no effect on self-care for those children assessed using the AHA (p=0.99). There was a strong association between cognition and bimanual performance for both the AHA (0.6, 95% CI 0.3, 0.9, p<0.001) and BoHA (0.4, 95% CI 0.2, 0.6, p<0.001).

Conclusions/Significance: Bimanual performance was significantly associated with higher self-care scores. Associations between self-care and the AHA and BoHA differed, such that the relationship for each was examined separately. The model using the BoHA accounted for more variation in self-care than the model in which the AHA was used as a measure of bimanual performance. Cognition was significantly associated with bimanual performance, for both the AHA and BoHA.