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# Cerebral palsy research news

Monday 6 March 2023

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## Interventions and Management

**1. Bimanual movements in children with cerebral palsy: a systematic review of instrumented assessments**
Marine Cacioppo, Anthéa Loos, Mathieu Lempereur, Sylvain Brochard

Review J Neuroeng Rehabil. 2023 Feb 27;20(1):26. doi: 10.1186/s12984-023-01150-7.

Background: Assessment of bimanual movements, which are frequently impaired in children with cerebral palsy, is highly challenging in clinical practice. Instrumented measures have been developed to evaluate and help to understand impaired upper limb movement during bimanual tasks in these children. The aim of this review was to report instrumented measurement tools (3D motion analysis, sensors, etc.) used for bimanual task movement analysis, and the metrological properties of the measures in children with cerebral palsy. Methods: A systematic review was conducted (Prospero CRD42022308517). PubMed, Web of Science, Cochrane and Scopus databases were searched with relevant keywords and inclusion/exclusion criteria. Article quality and biomechanical methods were evaluated with a customized scale and metrological properties with the COSMIN checklist. Results: In total, 452 children, mostly with unilateral cerebral palsy, mean age 10.9 (SD 3.2) years, underwent quantitative bimanual assessments in the 31 included studies (mean quality score 22/32 points [SD 4.7]). The tools used were 3D motion analysis (n = 26), accelerometers (n = 2), and other instruments (cube, digitizer, etc.) (n = 3). Children performed 1-5 bimanual tasks in laboratory settings, mostly activities of daily living or game scenarios. Analyses focused mostly on spatiotemporal variables, 6 of which were specifically developed for bilateral measures (task completion time, goal synchronization, movement overlap time, interlimb coupling, continuous relative phase and asynchrony). These instrumented measurements had moderate to good discriminant and convergent validity, but reliability and responsiveness assessments were lacking. Conclusions: A large number of quantitative bimanual assessments involving different tools, bimanual tasks and specific variables developed to evaluate bimanual function were found. Development of other relevant variables and validation of these tools are needed to further determine their usefulness, both as research outcomes and to guide therapies in clinical practice. Future research, involving younger children and real-life assessments, will improve our understanding of bimanual function in children with cerebral palsy.

PMID: 36849971

**2. The Effect of Bimanual Intensive Functional Training on Somatosensory Hand Function in Children with Unilateral Spastic Cerebral Palsy: An Observational Study**
Catherine V M Steinbusch, Anke Defesche, Bertie van der Leij, Eugene A A Rameckers, Annemarie C S Knijnenburg, Jeroen R J Vermeulen, Yvonne J M Janssen-Potten

J Clin Med. 2023 Feb 17;12(4):1595. doi: 10.3390/jcm12041595.

(1) Background: Next to motor impairments, children with unilateral spastic cerebral palsy (CP) often experience sensory

impairments. Intensive bimanual training is well known for improving motor abilities, though its effect on sensory impairments is less known. (2) Objective: To investigate whether bimanual intensive functional therapy without using enriched sensory materials improves somatosensory hand function. (3) Methods: A total of twenty-four participants with CP (12-17 years of age) received 80-90 h of intensive functional training aimed at improving bimanual performance in daily life. Somatosensory hand function was measured before training, directly after training, and at six months follow-up. Outcome measures were: proprioception, measured by thumb and wrist position tasks and thumb localization tasks; vibration sensation; tactile perception; and stereognosis. (4) Results: Next to improving on their individual treatment goals, after training, participants also showed significant improvements in the perception of thumb and wrist position, vibration sensation, tactile perception, and stereognosis of the more affected hand. Improvements were retained at six months follow-up. Conversely, proprioception measured by the thumb localization tasks did not improve after training. (5) Conclusions: Intensive functional bimanual training without environmental tactile enrichment may improve the somatosensory function of the more affected hand in children with unilateral spastic CP.

PMID: 36836129

**3. Analysis of motor characteristics of reaching movements in children with cerebral palsy**
Leia B Bagesteiro, Tamires L Tellini, Liana E Brown

Heliyon. 2023 Feb 2;9(2):e13455. doi: 10.1016/j.heliyon.2023.e13455. eCollection 2023 Feb.

Studies confirm that children with cerebral palsy (CwCP) have difficulty with simple, everyday movements like reaching for objects. Accurate reaching requires that shoulder and elbow joints are coordinated to move the hand along a smooth path to the desired target location. Here we examined multijoint coordination by comparing reaching performance in the affected and unaffected limbs of CwCP (nine children, six girls and three boys, aged 8-10 years) to reaching performance in the non-dominant and dominant limbs of typically-developing age- and gender-matched control (CTR) children. The hypothesis was that CwCP would show the effects of coordination deficits in both their affected and unaffected limbs. All children performed two sessions (one session with each arm) of speeded reaching movements to three targets arranged to manipulate the required pattern of shoulder and elbow coordination. The movements were tracked with a motion tracker allowing us to assess the following measures: movement distance, duration, and speed, hand-path deviation from linearity, final position accuracy and precision, and measures of shoulder and elbow excursion. We found that CwCP made reaches that covered a greater distance and took more time, that their shoulder and elbow rotations were larger, and that their movements showed greater deviation from linearity than the movements performed by CTR children. Children with CP were also more variable than CTR children on every measure except movement duration. The pattern of shoulder and elbow rotation observed in the CwCP group represents a coordination pattern that is significantly different from the pattern used by CTR children and may represent a greater reliance by CwCP on proximal muscular control systems. The discussion section considers the role that the cortical-spinal system may play in multijoint coordination.

PMID: 36846663

**4. A multicenter initiative to reduce intrathecal baclofen pump surgical site infection: a Cerebral Palsy Research Network quality improvement project**
Robert J Bollo, Paul H Gross, Brandon G Rocque, Samuel R Browd, Jeffrey S Raskin, Jeffrey R Leonard, Lama Albarqawi, Amy F Bailes; Cerebral Palsy Research Network (CPRN)

J Neurosurg Pediatr. 2023 Feb 24;1-9. doi: 10.3171/2023.1.PEDS22368. Online ahead of print.

Objective: Intrathecal baclofen (ITB) therapy is an effective treatment for spasticity and dystonia in children with cerebral palsy (CP). However, ITB pump surgery is associated with one of the highest rates of surgical site infection (SSI) in medicine, leading to significant morbidity and expense. Surgical protocols have reduced the rate of SSI in children with other CNS implants, and single-center protocols have been effective in ITB surgery in pediatrics. The authors describe the first multicenter quality improvement (QI)-driven standardized protocol for ITB pump surgery in children with CP across the Cerebral Palsy Research Network (CPRN), implemented with the aim of reducing ITB-associated SSI. Methods: SSI was defined as a culture-positive infection, ITB pump system removal for suspected infection, or wound dehiscence with exposed hardware. Each center reported historical infection rates for at least 3 years before initiating the SSI protocol (preintervention phase). After initiation of a 13-step surgical protocol, a consecutive series of 130 patients undergoing 149 surgical procedures for ITB at four CPRN tertiary pediatric neurosurgery centers were prospectively enrolled at surgery during a 2-year study period (intervention

phase). QI methodology was used, including development of a key driver diagram and tracking performance using run and control charts. The primary process measure goal was documented compliance with 80% of the protocol steps, and the primary outcome measure goal was a 20% reduction in 90-day infection rate. Patient characteristics were collected from the CPRN Research Electronic Data Capture registry, including age at surgery, BMI, Gross Motor Function Classification System level, and pattern of spasticity. Results: The aggregated preintervention 90-day ITB SSI rate was 4.9% (223 procedures) between 2014 and 2017. During the intervention phase, 136 of 149 ITB surgeries performed met inclusion criteria for analysis. The mean documented compliance rate with protocol steps was 75%, and the 90-day infection rate was 4.4%, with an average of 42 days from index surgery to infection. Conclusions: This is the first multicenter QI initiative designed to reduce SSI in ITB surgery in children with CP. Ongoing enrollment and expansion of the protocol to other CPRN centers will facilitate identification of patient- and procedure-specific risk factors for SSI, and iterative plan-do-study-act cycles incorporating these data will further decrease the risk of SSI for ITB surgery in children.

PMID: 36840731

**5. Hip Surveillance and Management of Hip Displacement in Children with Cerebral Palsy: Clinical and Ethical Dilemmas**
Jason J Howard, Kate Willoughby, Pam Thomason, Benjamin J Shore, Kerr Graham, Erich Rutz

J Clin Med. 2023 Feb 19;12(4):1651. doi: 10.3390/jcm12041651.

Hip displacement is the second most common musculoskeletal deformity in children with cerebral palsy. Hip surveillance programs have been implemented in many countries to detect hip displacement early when it is usually asymptomatic. The aim of hip surveillance is to monitor hip development to offer management options to slow or reverse hip displacement, and to provide the best opportunity for good hip health at skeletal maturity. The long-term goal is to avoid the sequelae of late hip dislocation which may include pain, fixed deformity, loss of function and impaired quality of life. The focus of this review is on areas of disagreement, areas where evidence is lacking, ethical dilemmas and areas for future research. There is already broad agreement on how to conduct hip surveillance, using a combination of standardised physical examination measures and radiographic examination of the hips. The frequency is dictated by the risk of hip displacement according to the child's ambulatory status. Management of both early and late hip displacement is more controversial and the evidence base in key areas is relatively weak. In this review, we summarise the recent literature on hip surveillance and highlight the management dilemmas and controversies. Better understanding of the causes of hip displacement may lead to interventions which target the pathophysiology of hip displacement and the pathological anatomy of the hip in children with cerebral palsy. We have identified the need for more effective and integrated management from early childhood to skeletal maturity. Areas for future research are highlighted and a range of ethical and management dilemmas are discussed.

PMID: 36836186

**6. Effects of joint loading on the development of capital femoral epiphysis morphology**
Charles Mitchell, Koroush Emami, Alex Emami, Shayan Hosseinzadeh, Benjamin Shore, Eduardo N Novais, Ata M Kiapour

Arch Orthop Trauma Surg. 2023 Mar 1. doi: 10.1007/s00402-023-04795-0. Online ahead of print.

Introduction: The deleterious influence of increased mechanical forces on capital femoral epiphysis development is well established; however, the growth of the physis in the absence of such forces remains unclear. The hips of non-ambulatory cerebral palsy (CP) patients provide a weight-restricted (partial weightbearing) model which can elucidate the influence of decreased mechanical forces on the development of physis morphology, including features related to development of slipped capital femoral epiphysis (SCFE). Here we used 3D image analysis to compare the physis morphology of children with non-ambulatory CP, as a model for abnormal hip loading, with age-matched native hips. Materials and methods: CT images of 98 non-ambulatory CP hips (8-15 years) and 80 age-matched native control hips were used to measure height, width, and length of the tubercle, depth, width, and length of the metaphyseal fossa, and cupping height across different epiphyseal regions. The impact of age on morphology was assessed using Pearson correlations. Mixed linear model was used to compare the quantified morphological features between partial weightbearing hips and full weightbearing controls. Results: In partial weightbearing hips, tubercle height and length along with fossa depth and length significantly decreased with age, while peripheral cupping height increased with age ($r > 0.2$, $P < 0.04$). Compared to normally loaded (full weightbearing) hips and across all age groups, partially weightbearing hips' epiphyseal tubercle height and length were smaller ($P < .05$), metaphyseal fossa depth was larger ($P < .01$), and posterior, inferior, and anterior peripheral cupping heights were smaller ($P < .01$). Conclusions: Smaller

epiphyseal tubercle and peripheral cupping with greater metaphyseal fossa size in partial weightbearing hips suggests that the growing capital femoral epiphysis requires mechanical stimulus to adequately develop epiphyseal stabilizers. Deposit low prevalence and relevance of SCFE in CP, these findings highlight both the role of normal joint loading in proper physis development and how chronic abnormal loading may contribute to various pathomorphological changes of the proximal femur (i.e., capital femoral epiphysis).

PMID: 36856839

**7. The Variable Influence of Orthotic Management on Hip and Pelvic Rotation in Children with Unilateral Neurogenic Equinus Deformity**

Domenic Grisch, Manuela Stäuble, Sandra Baumgartner, Hubertus J A van Hedel, Andreas Meyer-Heim, Thomas Dreher, Britta Krautwurst

Children (Basel). 2023 Feb 6;10(2):307. doi: 10.3390/children10020307.

Background: Equinus deformity with or without concomitant drop foot is a common finding in children with unilateral spastic cerebral palsy and spastic hemiplegia of other causes. Hypothetically, these deformities may lead to pelvic retraction and hip internal rotation during gait. Orthoses are used to reduce pes equinus during gait and to restore hindfoot first contact. Objective: We aimed to investigate whether the use of orthotic equinus correction reduces rotational hip and pelvic asymmetries. Methods: In a retrospective study, 34 children with unilateral spastic cerebral palsy or spastic hemiplegia of other causes underwent standardized instrumented 3D gait analysis with and without orthotic equinus management. We analyzed the differences in the torsional profile during barefoot walking and while wearing orthoses, as well as investigated the influence of ankle dorsiflexion and femoral anteversion on pelvic and hip kinematics and hip kinetics. Results: Wearing orthoses corrected pes equinus and pelvic internal rotation at the end of the stance phase and in the swing phase compared to barefoot walking. Hip rotation and the rotational moment did not significantly change with orthoses. Orthotic management or femoral anteversion did not correlate to pelvic and hip asymmetry. Conclusion: The findings indicate that the correction of the equinus by using orthoses had a variable effect on the asymmetry of the hip and pelvis and internal rotation; both appear to have a multifactorial cause that is not primarily driven by the equinus component.

PMID: 36832437

**8. Long-Term Effect of Hyperbaric Oxygen Therapy on Gait and Functional Balance Skills in Cerebral Palsy Children-A Randomized Clinical Trial**

Mohamed E Khalil, Mohamed A Abdel Ghafar, Osama R Abdelraouf, Mariam E Mohamed, Eman M Harraz, Reem S Dawood, Reham A A Abouelkheir

Children (Basel). 2023 Feb 17;10(2):394. doi: 10.3390/children10020394.

This study aimed to explore the long-term effects of hyperbaric oxygen therapy on spatiotemporal gait parameters and functional balance in children with cerebral palsy. Thirty-nine children with hemiplegic cerebral palsy were randomly allocated to one of two groups: control or study. The children in both groups received traditional physical therapy three times per week for six months. In addition, the children in the study group received hyperbaric oxygen therapy five times/week for eight weeks. The GAITRite system and pediatric balance scale were used to assess spatiotemporal gait parameters and functional balance at baseline, post-intervention, and six months after the cessation of hyperbaric oxygen therapy. Post-intervention means of all measured parameters were significantly higher than pre-intervention means, but only for the study group ($p < 0.05$). However, both groups' means at the six-month follow up were significantly greater than those at pre-intervention ($p < 0.05$). At the post-intervention and follow-up evaluations, comparisons between groups revealed a statistically significant difference in all measured parameters for the study group against the control group ($p < 0.05$). It can be concluded that adding hyperbaric oxygen therapy to physical therapy rehabilitation could be effective in improving spatiotemporal gait parameters and functional balance in children with cerebral palsy.

PMID: 36832523

**9. A cross sectional study investigating dynamic balance when stepping to targets in children with cerebral palsy compared to typically developing children**
Rachel Rapson, Jos M Latour, Bernie Carter, Vasiliki Pitsouni, Jonathan F Marsden

Gait Posture. 2023 Feb 11;101:154-159. doi: 10.1016/j.gaitpost.2023.02.006. Online ahead of print.

Background: Children with Cerebral Palsy (CP) have altered anticipatory postural adjustments (APAs) during gait initiation. These APAs may affect dynamic balance in tasks such as stepping. Research questions: How are APAs in children with CP affected during stepping to precise targets? How do children with CP modulate APAs when stepping to medial and lateral targets? What is the association between APAs and symptom severity, movement quality and impairment profile? Method: Children undertook a stepping task to laterally and medially placed targets with either leg, in a randomised order. Movement of the centre of pressure (COP) and markers at the pelvis and foot were measured via a force plate and 3D motion analysis. Motion of the centre of mass (COM) was estimated via pelvic markers. APAs were assessed prior to leading leg lift-off in medio-lateral and antero-posterior directions. Stepping error was calculated. Baseline characteristics of children with CP included Gross Motor Function Measure (GMFM), Quality Function Measure (QFM), leg muscle hypertonia (Tardieu test) and strength (manual dynamometry). Results: Sixteen ambulant children with CP (12.2 years ± 2.2) and 14 typically developing (TD) children (11.6 years ± 2.9) were assessed. In children with CP, APAs in the medio-lateral direction were 20-30% smaller. Children with CP were less able to modulate their APAs with steps to medial and laterally placed targets, than TD children. Medio-lateral COP motion was associated with movement quality assessed by QFM subsections, GMFM (correlation coefficient r = 0.66-0.80) and hip abductor strength (r = 0.75). Antero-posterior APAs were significantly smaller when stepping with the non-paretic leg in children with CP. APA size was positively related to the length of the contralateral, paretic gastrocnemius (r = 0.77). Stepping error was higher in children with CP and inversely correlated to the size of the medio-lateral APA. Discussion: Children with CP show smaller medio-lateral APAs especially when stepping to medially placed targets. APA size may be limited by proximal muscle strength and gastrocnemius length.

PMID: 36842256

**10. Robotic Ankle Training Improves Sensorimotor Functions in Children with Cerebral Palsy-A Pilot Study**
Yunju Lee, Deborah Gaebler-Spira, Li-Qun Zhang

J Clin Med. 2023 Feb 12;12(4):1475. doi: 10.3390/jcm12041475.

Children with cerebral palsy (CP) have sensorimotor impairments including weakness, spasticity, reduced motor control and sensory deficits. Proprioceptive dysfunction compounds the decreased motor control and mobility. The aims of this paper were to (1) examine proprioceptive deficit of lower extremities of children with CP; (2) study improvement in proprioception and clinical impairments through robotic ankle training (RAT). Eight children with CP participated in a 6-week RAT with pre and post ankle proprioception, clinical, biomechanical assessment compared to the assessment of eight typically developing children (TDC). The children with CP participated in passive stretching (20 min/session) and active movement training (20 to 30 min/session) using an ankle rehabilitation robot (3 sessions/week over 6 weeks, total of 18 sessions). Proprioceptive acuity measured as the plantar and dorsi-flexion motion at which the children recognized the movement was 3.60 ± 2.28° in dorsiflexion and -3.72 ± 2.38° in plantar flexion for the CP group, inferior to that of the TDC group's 0.94 ± 0.43° in dorsiflexion ($p = 0.027$) and -0.86 ± 0.48° in plantar flexion ($p = 0.012$). After training, ankle motor and sensory functions were improved in children with CP, with the dorsiflexion strength increased from 3.61 ± 3.75 Nm to 7.48 ± 2.75 Nm ($p = 0.018$) and plantar flexion strength increased from -11.89 ± 7.04 Nm to -17.61 ± 6.81 Nm after training ($p = 0.043$). The dorsiflexion AROM increased from 5.58 ± 13.18° to 15.97 ± 11.21° ($p = 0.028$). The proprioceptive acuity showed a trend of decline to 3.08 ± 2.07° in dorsiflexion and to -2.59 ± 1.94° in plantar flexion ($p > 0.05$). The RAT is a promising intervention for children with CP to improve sensorimotor functions of the lower extremities. It provided an interactive and motivating training to engage children with CP in rehabilitation to improve clinical and sensorimotor performance.

PMID: 36836010

**11. The influence of wearing an ultrasound device on gait in children with cerebral palsy and typically developing children**
Babette Mooijekind, Eline Flux, Annemieke I Buizer, Marjolein M van der Krogt, Lynn Bar-On

Gait Posture. 2023 Feb 11;101:138-144. doi: 10.1016/j.gaitpost.2023.02.007. Online ahead of print.

Background: Ultrasonography with motion analysis enables dynamic imaging of medial gastrocnemius (MG) muscles and tendons during gait. This revealed pathological muscle-tendon dynamics in children with spastic cerebral palsy (CP) compared to typically developing (TD) children. However, wearing an ultrasound probe on the lower leg could interfere with gait and bias muscle length changes observed with ultrasound. Research question: Does wearing an ultrasound probe on the MG influence gait in children with CP and TD children? Methods: Eighteen children with spastic CP and 16 age-matched TD children walked at comfortable walking speed on an instrumented treadmill. One baseline gait condition (BASE) and two conditions with an ultrasound probe and custom-made probe holder were measured: on the mid-muscle fascicles (FAS) and on the muscle-tendon junction (MTJ). The effect of condition and group on spatiotemporal parameters, hip, knee and ankle kinematics, ankle moment, ankle power, and modeled MG muscle-tendon unit (MTU) length was assessed using two-way repeated measures ANOVA's. Statistical non-parametric mapping was applied for time-series. Post-hoc paired-samples t-tests were conducted, and the root mean square difference was calculated for significant parts. Results: Children took wider steps during FAS (CP, TD) and MTJ (TD) compared to BASE, and during FAS compared to MTJ (CP). Hip extension was lower (2.7°) during terminal stance for MTJ compared to FAS for TD only. There was less swing knee flexion (FAS 4.9°; MTJ 4.0°) and ankle plantarflexion around toe-off (FAS 3.0°; MTJ 2.4°) for both ultrasound placements, with no group effect. Power absorption during loading response was slightly increased for both ultrasound placements (0.12 W/kg), with no group effect. MTU shortened less in swing for both ultrasound placements (FAS 3.6 mm; MTJ 3.7 mm), with no group effect. Significance: Wearing an ultrasound probe causes minimal lower-limb gait alterations and MTU length changes that are mostly similar in CP and TD.

PMID: 36841120

**12. Morphological Medial Gastrocnemius Muscle Growth in Ambulant Children with Spastic Cerebral Palsy: A Prospective Longitudinal Study**
Nathalie De Beukelaer, Ines Vandekerckhove, Ester Huyghe, Geert Molenberghs, Nicky Peeters, Britta Hanssen, Els Ortibus, Anja Van Campenhout, Kaat Desloovere

J Clin Med. 2023 Feb 16;12(4):1564. doi: 10.3390/jcm12041564.

Only cross-sectional studies have demonstrated muscle deficits in children with spastic cerebral palsy (SCP). The impact of gross motor functional limitations on altered muscle growth remains unclear. This prospective longitudinal study modelled morphological muscle growth in 87 children with SCP (age range 6 months to 11 years, Gross Motor Function Classification System [GMFCS] level I/II/III = 47/22/18). Ultrasound assessments were performed during 2-year follow-up and repeated for a minimal interval of 6 months. Three-dimensional freehand ultrasound was applied to assess medial gastrocnemius muscle volume (MV), mid-belly cross-sectional area (CSA) and muscle belly length (ML). Non-linear mixed models compared trajectories of (normalized) muscle growth between GMFCS-I and GMFCS-II&III. MV and CSA growth trajectories showed a piecewise model with two breakpoints, with the highest growth before 2 years and negative growth rates after 6-9 years. Before 2 years, children with GMFCS-II&III already showed lower growth rates compared to GMFCS-I. From 2 to 9 years, the growth rates did not differ between GMFCS levels. After 9 years, a more pronounced reduction in normalized CSA was observed in GMFCS-II&III. Different trajectories in ML growth were shown between the GMFCS level subgroups. These longitudinal trajectories highlight monitoring of SCP muscle pathology from early ages and related to motor mobility. Treatment planning and goals should stimulate muscle growth.

PMID: 36836099

**13. Improved Gait and Radiological Measurements After injection of Botulinum Toxin Into Peroneus Longus in Young Children With USCP and Equinovalgus Gait**
Christophe Boulay, Morgan Sangeux, Guillaume Authier, Michel Jacquemier, Andrea Merlo, Brigitte Chabrol, Jean-Luc Jouve, Jean-Michel Gracies, Sébastien Pesenti

Pediatr Neurol. 2023 Feb 6;142:1-9. doi: 10.1016/j.pediatrneurol.2023.01.019. Online ahead of print.

Background: Children with cerebral palsy develop foot deformities due to a combination of factors including muscle shortening, hypertonia, weakness, and cocontraction of muscles acting at the ankle joint resulting in an altered gait pattern. We hypothesized these factors affect the peroneus longus (PL) and tibialis anterior (TA) muscles couple in children who develop equinovalgus gait first followed by planovalgus foot deformities. Our aim was to evaluate the effects of abobotulinum toxin A injection to the PL muscle, in a cohort of children with unilateral spastic cerebral palsy and equinovalgus gait. Methods: This was a prospective cohort study. The children were examined within 12 months before and after injection to their PL muscle. Twenty-five children of mean age 3.4 (S.D.: 1.1) years were recruited. Results: We found significant improvement in foot radiology measures. Passive extensibility of the triceps surae did not change, whereas active dorsiflexion increased significantly. Nondimensional walking speed increased by 0.1 (95% confidence interval [CI], [0.07, 0.16]; $P < 0.001$), and the Edinburgh visual gait score improved by 2.8 (95% CI, [-4.06, -1.46]; $P < 0.001$). Electromyography showed increased recruitment for gastrocnemius medialis (GM) and TA but not for PL during the reference exercises (standing on tip toes for GM/PL, active dorsiflexion for TA) and decreased activation percentages for PL/GM and TA across sub-phases of gait. Conclusions: One key advantage of treating the PL muscle only might be to address foot deformities without interfering with the main plantar flexors that are instrumental to support body weight during gait.

PMID: 36848724

**14. Outpatient hospital utilization after single event multi-level surgery in children with cerebral palsy**
Kelly R Greve, Amy F Bailes, Nanhua Zhang, Jason Long, Bruce Aronow, Alexis Mitelpunkt

J Pediatr Rehabil Med. 2023 Feb 24. doi: 10.3233/PRM-220051. Online ahead of print.

Purpose: This study aimed to examine outpatient hospital utilization (number of specialties seen and number of visits to each specialty) in the year after single event multi-level surgery (SEMLS) in children with cerebral palsy (CP), and to determine if utilization differs across the medical center in the year after compared to the year before SEMLS. Methods: This retrospective cross-sectional study used electronic medical record data of outpatient hospital utilization in children with CP who underwent SEMLS. Results: Thirty children with CP (Gross Motor Function Classification System Levels I-V, mean age of 9.9 years) were included. In the year after surgery, a significant difference ($p = 0.001$) was found for the number of specialties seen, with non-ambulatory children seeing more specialties than ambulatory children. No statistically significant difference was found between the number of outpatient visits to each specialty in the year after SEMLS. Compared to the year before SEMLS, fewer therapy visits occurred in the year after SEMLS ($p < 0.001$) but significantly more visits to orthopaedics ($p = 0.001$) and radiology ($p = 0.001$). Conclusion: Children with CP had fewer therapy visits but more orthopaedic and radiology visits the year after SEMLS. Nearly half of the children were non-ambulatory. Examination of care needs in children with CP undergoing SEMLS is justified with consideration of ambulatory status, surgical burden, and post-operative immobilization.

PMID: 36847028

**15. Effects of Hippotherapy on Postural Control in Children With Cerebral Palsy: A Systematic Review**
Fernanda Peia, Nathalie Caroline Veiga, Ana Paula Gomes, Bruna Neves Dos Santos, Nívia Maria Silva Marques, Igor Phillip Dos Santos Glória, Juliana Barbosa Goulardins

Pediatr Phys Ther. 2023 Mar 4. doi: 10.1097/PEP.0000000000000999. Online ahead of print.

Purpose: To summarize and update the current knowledge on the effectiveness of hippotherapy on postural control in children with cerebral palsy. Methods: Using a systematic review methodology, the electronic databases PubMed, Virtual Health Library, PEDro, Scielo, Embase, and Web of Science were searched for eligible articles from 2011 up to September 2021. Quality assessment of eligible studies was performed using the PEDro scale. Results: There were 239 identified studies. Eight

clinical trials were selected. The total sample consisted of 264 individuals, with 134 allocated to the experimental group (hippotherapy) and 130 individuals to the control group (conventional therapy). Most studies had moderate to high methodological quality. Conclusions: Hippotherapy can be an effective intervention to improve several aspects related to postural control, such as static balance (especially in the sitting posture), dynamic balance, and alignment (body posture) in children aged 3 to 16 years, particularly with spastic hemiplegia or diplegia. What this adds to the evidence: This review summarizes studies that explore potential effects of hippotherapy on postural control in children with cerebral palsy.

PMID: 36867588

**16. King-Devick Test in Wheelchair Sports: Identifying Normative Values and Effects of Exertion on Outcomes**
Jean-Paul Barfield, Shelley Linens, Angela Mickle

Clin J Sport Med. 2023 Feb 28. doi: 10.1097/JSM.0000000000001135. Online ahead of print.

Objective: To establish normative baseline values on the King-Devick (KD) Test for contact wheelchair sport participants. The secondary purpose was to examine the effect of physical exertion on test score. Design: Quasiexperimental. Setting: Competitive disability sport venues before practices or games. Participants: One-hundred 43 wheelchair rugby or wheelchair basketball (WBB) players completed the study. Participants were predominantly men (87.5%) and played WBB (84%). Intervention: 30-m wheelchair sprint test to fatigue. Main outcome measure: King-Devick Baseline Score. Results: Mean KD baseline score was 59.16 ± 15.56 seconds with significant differences ($P < 0.05$) identified by sport and impairment type, but not sex. Athletes with spina bifida and cerebral palsy had significantly higher mean baseline KD times than athletes with spinal cord injury. KD scores improved by 3.5% in athletes who reported "light" to "somewhat hard" exertion (RPE = 13). In a subset of athletes who performed sprints until an RPE of 18 was reached, 8 of 12 players (66.7%) demonstrated an improvement in KD score; however, large increases by a few participants caused the noticeable change. Conclusions: Normative values for wheelchair contact sport athletes are meaningfully slower than able-bodied sports participants. KD score improved with exertion with the greater improvement after moderate-intensity compared with vigorous-intensity exercise. These findings can be applied clinically to monitor athlete safety.

PMID: 36853901

**17. Psychometric properties of the English language version of the C-BiLLT evaluated in typically developing Canadian children**
Jael N Bootsma, Fiona Campbell, Dayle McCauley, Sarah Hopmans, Danijela Grahovac, B J Cunningham, Michelle Phoenix, Olaf Kraus de Camargo, Johanna Geytenbeek, Jan Willem Gorter

J Pediatr Rehabil Med. 2023 Feb 24. doi: 10.3233/PRM-210101. Online ahead of print.

Purpose: This study aimed to 1) investigate the convergent and discriminant validity, internal consistency, and test-retest reliability of the Canadian English version of the Computer-Based instrument for Low motor Language Testing (C-BiLLT-CAN), and 2) explore feasibility of the C-BiLLT assessment for children with cerebral palsy (CP) and complex communication needs in the Canadian health care context. Methods: Eighty typically developing children between 1.5 and 8.5 years of age completed the C-BiLLT-CAN, the Peabody Picture Vocabulary Test-IV (PPVT-4), the receptive language sub-test of the New Reynell Developmental Language Scales (NRDLS), and/or the Raven's 2. Correlations between raw scores were calculated for estimates of convergent and discriminant validity. Internal consistency was calculated for all items and separately for items pertaining to vocabulary and grammar. To calculate the standard error of measurement (SEM) and intraclass correlation coefficient (ICC), 33 participants were re-tested with the C-BiLLT within three weeks. Feasibility was explored with nine participants with CP. Results: C-BiLLT-CAN's convergent validity was good to excellent (Spearman's rho > 0.78) and discriminant validity was higher than hypothesized (Spearman's rho > 0.8). Internal consistency (Cronbach's alpha = 0.96), test-retest reliability (ICC > 0.9), and measurement error (SEM < 5%) were excellent. The feasibility study could not be fully completed due to the COVID-19 pandemic. Preliminary data demonstrated some technical and practical barriers for using the C-BiLLT in children with CP in Canada. Conclusion: The C-BiLLT-CAN demonstrates good to excellent psychometric properties in a sample of typically developing children, indicating that it is an adequate test for measuring language comprehension in English-speaking Canadian children. Further research is needed to investigate the feasibility of the C-BiLLT-CAN in children with CP.

PMID: 36847022

**18. Differential Impacts of Sentence Length on Speech Rate in Two Groups of Children With Neurodevelopmental Disorders**
Meghan Darling-White, Alexandra Jaeger

Am J Speech Lang Pathol. 2023 Feb 27;1-16. doi: 10.1044/2022_AJSLP-22-00209. Online ahead of print.

Purpose: The primary purpose of this study was to examine the effect of sentence length on speech rate and its characteristics, articulation rate, and pauses in children with neurodevelopmental disorders. Method: Nine children diagnosed with cerebral palsy (CP) and seven children diagnosed with Down syndrome (DS) repeated sentences varying in length from two to seven words. Children were between the ages of 8 and 17 years. Dependent variables included speech rate, articulation rate, and proportion of time spent pausing. Results: For children with CP, there was a significant effect of sentence length for speech rate and articulation rate but not for the proportion of time spent pausing. In general, the longest sentences were produced with a faster speech and articulation rate than the shortest sentences. For children with DS, there was a significant effect of sentence length for the proportion of time spent pausing but not for speech rate or articulation rate. In general, children with DS spent significantly more time pausing in the longest sentences, particularly seven-word sentences, than in any other sentence length. Conclusions: Primary findings include the following: (a) Articulation rate and pause time are differentially impacted by sentence length, and (b) children with CP and children with DS respond differently to increases in cognitive-linguistic load.

PMID: 36848341

**19. Postoperative Airway Management after Submandibular Duct Relocation in 96 Drooling Children and Adolescents**
Saskia E Kok, Joris Lemson, Frank J A van den Hoogen

J Clin Med. 2023 Feb 12;12(4):1473. doi: 10.3390/jcm12041473.

The aim of this study was to evaluate our institutions airway management and complications after submandibular duct relocation (SMDR). We analysed a historic cohort of children and adolescents who were examined at the Multidisciplinary Saliva Control Centre between March 2005 and April 2016. Ninety-six patients underwent SMDR for excessive drooling. We studied details of the surgical procedure, postoperative swelling and other complications. Ninety-six patients, 62 males and 34 females, were treated consecutively by SMDR. Mean age at time of surgery was 14 years and 11 months. The ASA physical status was 2 in most patients. The majority of children were diagnosed with cerebral palsy (67.7%). Postoperative swelling of the floor of the mouth or tongue was reported in 31 patients (32.3%). The swelling was mild and transient in 22 patients (22.9%) but profound swelling was seen in nine patients (9.4%). In 4.2% of the patients the airway was compromised. In general, SMDR is a well-tolerated procedure, but we should be aware of swelling of the tongue and floor of the mouth. This may lead to a prolonged period of endotracheal intubation or a need for reintubation which can be challenging. After extensive intra-oral surgery such as SMDR we strongly recommend a extended perioperative intubation and extubation after the airway is checked and secure.

PMID: 36836008

**20. Evaluation of Behavioral Characteristics in Response to Visual Stimuli in Infants with Cerebral Visual Impairment**
Deniz Altınbay, İbrahim Taşkın

Turk J Ophthalmol. 2023 Feb 24;53(1):1-7. doi: 10.4274/tjo.galenos.2022.14296.

Objectives: To evaluate the behavioral characteristics of infants with cerebral visual impairment (CVI) in response to visual stimuli and the frequency of these features. Materials and methods: In this retrospective study, 32 infants aged 8-37 months who were referred to the low vision unit in 2019-2021 and diagnosed with CVI based on their demographic characteristics, systemic findings, and standard and functional visual examinations were evaluated. The frequency of ten behavioral characteristics exhibited by infants with CVI in response to visual stimuli as defined by Roman-Lantzy was examined in the patients. Results: The mean age was 23.46±11.45 months, the mean birth weight was 2,550±944 g, and the mean gestational age at birth was 35.39±4.68 weeks. There was hypoxic-ischemic encephalopathy in 22%, prematurity in 59%, periventricular leukomalacia in 16%, cerebral palsy in 25%, epilepsy in 50%, and strabismus in 68.7% of the patients. Color preference for

fixation was observed in 40% and visual field preference was observed in 46% of the patients. The most preferred color was red (69%) and the most preferred visual field was right visual field (47%). Difficulty with distance viewing was observed in 84% of patients, visual latency in 72%, need for movement in 69%, absence of visually guided reach in 69%, difficulty with visual complexity in 66%, difficulty with visual novelty in 50%, light-gazing/nonpurposeful gaze in 50%, and atypical visual reflexes in 47%. There was no fixation in 25% of the patients. Conclusion: Behavioral characteristics in response to visual stimuli were observed in most infants with CVI. Knowing and recognizing these characteristic features by ophthalmologists will assist in early diagnosis, referral to visual habilitation, and planning habilitation techniques. These characteristic features are important in order to not miss this critical period in which the brain is still plastic and good responses to visual habilitation can be obtained.

PMID: 36847612

**21. Relationship between gross motor function of cerebral palsy children and quality of life of their primary caregivers**
Somal Kumari, Syed Shahzad Ali, Aftab Ahmed Mirza Baig

J Pak Med Assoc. 2023 Jan;73(1):78-82. doi: 10.47391/JPMA.6303.

Objective: To determine the relationship between gross motor function of children with cerebral palsy and quality of life of their primary caregivers. Methods: The cross-sectional analytical study was conducted from December 2020 to August 2021 at the Sindh Institute of Physical Medicine and Rehabilitation and the Rabia Moon Trust, Karachi, and comprised children with cerebral palsy and their caregivers. The children were assessed on the basis of Gross Motor Function Measure-66 and Gross Motor Functional Classification System, while the caregivers were asked to complete the self-administered World Health Organisation Quality of Life-BREF questionnaire. All the categorical variables were presented through frequencies and percentages. Spearman's Correlation was applied to evaluate the correlation. Data was analysed using SPSS 16. Results: Of the 43 children, 26(60.5%) were male and 17(39.5%) were females. The overall mean age was 5.70±1.820 years. Among the caregivers, 40(93%) were females and 3(7%) were males. The mean age of the caregivers was 27.70±4.77 years. None of domains of quality of life showed significant correlation with total score of Gross Motor Function Measure-66 ($p>0.05$). Conclusions: The disease severity among children with cerebral palsy was not a factor associated with quality of life of the caregivers. The physical health was relatively lower among the caregivers, but it was not associated with motor disabilities.

PMID: 36842012

**22. The application of virtual reality to home-based rehabilitation for children and adolescents with cerebral palsy: A systematic review and meta-analysis**
Jie Hao, Biying Huang, Andréas Remis, Zhengting He

Physiother Theory Pract. 2023 Feb 27;1-21. doi: 10.1080/09593985.2023.2184220. Online ahead of print.

Background: Home-based rehabilitation enables children and families to participate in therapeutic activities built into their daily routines without the barriers of arrangement and transportation to facilities. Virtual reality is an emerging technology which has shown promising outcomes in rehabilitation. Purpose: This systematic review aims to examine the feasibility and effects of virtual reality-enhanced home rehabilitation on Body functions and structures, Activity, and Participation outcomes in children and adolescents with cerebral palsy. Methods: Interventional studies were searched across five biomedical databases on November 26, 2022. Two independent reviewers conducted study selection, data extraction, and quality assessment. The Physiotherapy Evidence Database scale and National Institutes of Health Study Quality Assessment Tools were used to evaluate the quality of included studies. Meta-analysis was performed to examine the effects of the intervention. Results: Eighteen studies were included in this review. Home-based virtual reality rehabilitation appears feasible with effects on upper extremity and gross motor function, strength, bone density, cognition, balance, walking, daily activity performance, and participation. Meta-analyses revealed significant improvements in hand function (SMD = 0.41, p= .003), gross motor function (SMD = 0.56, p= .0002), and walking capacity (SMD = 0.44, p= .01) following home-based virtual reality intervention. Conclusion: Home-based virtual reality may serve as an adjunct to conventional facility-based therapy to promote participation in therapeutic exercises and maximize rehabilitation outcomes. Further properly designed randomized controlled trials using valid and reliable outcome measures with adequately powered sample sizes are warranted to enhance the current body of evidence using home-based virtual reality in cerebral palsy rehabilitation.

PMID: 36847396

**23. Effect of Transcranial Direct Current Stimulation versus Virtual Reality on Gait for Children with Bilateral Spastic Cerebral Palsy: A Randomized Clinical Trial**
Asmaa Radwan, Hoda A Eltalawy, Faten Hassan Abdelziem, Rebecca Macaluso, Megan K O'Brien, Arun Jayaraman

Children (Basel). 2023 Jan 27;10(2):222. doi: 10.3390/children10020222.

Impaired gait is a common sequela in bilateral spastic cerebral palsy. We compared the effects of two novel research interventions-transcranial direct current stimulation and virtual reality-on spatiotemporal and kinetic gait impairments in children with bilateral spastic CP. Forty participants were randomized to receive either transcranial direct current stimulation or virtual reality training. Both groups received standard-of-care gait therapy during the assigned intervention and for the subsequent 10 weeks afterward. Spatiotemporal and kinetic gait parameters were evaluated at three different times: (i) before starting the intervention, (ii) after two weeks of intervention, and (iii) 10 weeks after intervention completion. Both groups exhibited higher velocity and cadence, as well as longer stance time, step length, and stride length after intervention ($p < 0.001$). Only the transcranial direct current stimulation group exhibited increased maximum force and maximum peak pressure after intervention (p's $\leq 0.001$), with continued improvements in spatiotemporal parameters at follow-up. The transcranial direct current stimulation group had higher gait velocities, stride length, and step length at follow-up compared to the virtual reality group ($p \leq 0.02$). These findings suggest that transcranial direct current stimulation has a broader and longer-lasting effect on gait than virtual reality training for children with bilateral spastic cerebral palsy.

PMID: 36832351

**24. Postnatal growth restriction and neurodevelopment at 5 years of age: a European extremely preterm birth cohort study**
Rym El Rafei, Rolf Felix Maier, Pierre Henri Jarreau, Mikael Norman, Henrique Barros, Patrick Van Reempts, Arno Van Heijst, Pernille Pedersen, Marina Cuttini, Samantha Johnson, Raquel Costa, Michael Zemlin, Elizabeth S Draper, Jennifer Zeitlin; SHIPS Research Group

Arch Dis Child Fetal Neonatal Ed. 2023 Mar 3;fetalneonatal-2022-324988. doi: 10.1136/archdischild-2022-324988. Online ahead of print.

Objective: To investigate whether extrauterine growth restriction (EUGR) during the neonatal hospitalisation by sex among extremely preterm (EPT) infants is associated with cerebral palsy (CP) and cognitive and motor abilities at 5 years of age. Study design: Population-based cohort of births <28 weeks of gestation with data from obstetric and neonatal records and parental questionnaires and clinical assessments at 5 years of age. Setting: 11 European countries. Patients: 957 EPT infants born in 2011-2012. Main outcomes: EUGR at discharge from the neonatal unit was defined as (1) the difference between Z-scores at birth and discharge with <-2 SD as severe, -2 to -1 SD as moderate using Fenton's growth charts (Fenton) and (2) average weight-gain velocity using Patel's formula in grams (g) per kilogram per day (Patel) with <11.2 g (first quartile) as severe, 11.2-12.5 g (median) as moderate. Five-year outcomes were: a CP diagnosis, intelligence quotient (IQ) using the Wechsler Preschool and Primary Scales of Intelligence tests and motor function using the Movement Assessment Battery for Children, second edition. Results: 40.1% and 33.9% children were classified as having moderate and severe EUGR, respectively, by Fenton and 23.8% and 26.3% by Patel. Among children without CP, those with severe EUGR had lower IQ than children without EUGR (-3.9 points, 95% Confidence Interval (CI)=-7.2 to -0.6 for Fenton and -5.0 points, 95% CI=-8.2 to -1.8 for Patel), with no interaction by sex. No significant associations were observed between motor function and CP. Conclusions: Severe EUGR among EPT infants was associated with decreased IQ at 5 years of age.

PMID: 36868809

**25. Implementation of Early Detection and Intervention for Cerebral Palsy in High-Risk Infant Follow-Up Programs: U.S. and Global Considerations**
Nathalie L Maitre, Diane Damiano, Rachel Byrne

Review Clin Perinatol. 2023 Mar;50(1):269-279. doi: 10.1016/j.clp.2022.11.005.

Early detection and intervention for cerebral palsy is best practice for all high-risk infants according to international guidelines, consensus statements and research-supported evidence. It allows support for families and optimization of developmental trajectories into adulthood. All phases of implementation of CP early detection can be found across the world in high-risk infant follow-up programs, demonstrating feasibility and acceptability through standardized implementation science. The largest clinical network for CP early detection and intervention in the world has now sustained an average age at detection less than 12 months corrected age for more than 5 years. Targeted referrals and interventions for CP can now be offered to patients in optimal periods of neuroplasticity, and new therapies researched as the age of detection decreases. Implementation of guidelines and incorporation of rigorous CP research studies both allow high-risk infant follow-up programs to fulfill their mission of improving outcomes of those with the most vulnerable developmental trajectories from birth.

PMID: 36868710

**26. Associated Impairments among Children with Cerebral Palsy in Rural Bangladesh-Findings from the Bangladesh Cerebral Palsy Register**
Aditya Narayan, Mohammad Muhit, John Whitehall, Iskander Hossain, Nadia Badawi, Gulam Khandaker, Israt Jahan

J Clin Med. 2023 Feb 17;12(4):1597. doi: 10.3390/jcm12041597.

Background: We aimed to describe the burden, severity, and underlying factors of associated impairments among children with cerebral palsy (CP) in rural Bangladesh. Methods: This study reports findings from the Bangladesh Cerebral Palsy Register-the first population-based surveillance of children with CP in any LMIC, where children with confirmed CP aged < 18 years are registered by a multidisciplinary team following a standard protocol. Associated impairments were documented based on clinical assessment, available medical records, and a detailed clinical history provided by the primary caregivers. Descriptive analysis, as well as unadjusted and adjusted logistic regression, were completed using R. Results: Between January 2015 and February 2022, 3820 children with CP were registered (mean (SD) age at assessment: 7.6 (5.0) y; 39% female). Overall, 81% of children had ≥1 associated impairment; hearing: 18%, speech: 74%, intellectual: 40%, visual: 14%, epilepsy: 33%. The presence of a history of CP acquired post-neonatally and having a gross motor function classification system levels III-V significantly increased the odds of different types of associated impairments in these children. Most of the children had never received any rehabilitation services and were not enrolled in any mainstream or special education system. Conclusions: The burden of associated impairments was high among children with CP, with comparatively low receipt of rehabilitation and educational services in rural Bangladesh. Comprehensive intervention could improve their functional outcome, participation, and quality of life.

PMID: 36836130

**27. Home-based therapy and its determinants for children with cerebral palsy, exploration of parents' and physiotherapists' perspective, a qualitative study, Ethiopia**
Zelalem Dessalegn Demeke, Yohannes Awoke Assefa, Yohannes Abich, Mulgeta Bayisa Chala

PLoS One. 2023 Feb 27;18(2):e0282328. doi: 10.1371/journal.pone.0282328. eCollection 2023.

Objective: This study aimed to explore the perceptions of parents and physiotherapists regarding home-based therapy programs for children with cerebral palsy and to understand the factors affecting adherence to home-based therapy programs. Materials and method: Thematic analysis method was used to identify, analyse and report findings. Twelve physiotherapists and five caregivers were purposively sampled and interviewed. Results: All transcripts were coded line by line, and the codes were then organized into categories for the development of descriptive themes and the generation of analytical themes. The data analysis followed the steps of the thematic analysis process. Seven themes emerged during the analysis: Why Home-Based Therapy? Ways of Teaching, Types of the therapy, Strategies of assessing adherence, Environmental factors, Attitude and knowledge; and Family participation. Physiotherapists use home-based therapy to prevent complications and improve functioning. They use various ways of teaching, such as explaining, demonstrating, and using pictures and videos. Physiotherapists consider several factors such as severity, age, and availability of resources before they decide the type of home therapy programs. However, parent's participation was low; and strategies to monitor and evaluate adherence were also low. Low family support, limited recourse, lack of knowledge and poor attitude negatively affected adherence to home-based therapy. Conclusions: Our finding revealed that physiotherapists use quite limited methods of teaching, and do not properly monitor adherence of the home-based therapy. Additionally, family participation to select type of therapy and to set goal were low.

PMID: 36848380

**28. Obesity in ambulatory children with cerebral palsy in Turkey: A cross-sectional study**
Bilinc Dogruoz Karatekin, Gulnihal Kacar, Afitap Icagasioglu

J Pediatr Rehabil Med. 2023 Feb 18. doi: 10.3233/PRM-210093. Online ahead of print.

Purpose: Obesity prevalence and the relationship between obesity and motor function in children with ambulatory cerebral palsy (CP) were investigated. Methods: This was a cross-sectional study. The obesity profile of 75 children aged 2-18 years with ambulatory CP was investigated. GMFCS levels were recorded, and BMI was calculated using height and weight data and converted into Z-scores. Age- and gender-specific growth charts were used for children and adolescents. Results: The mean BMI of the participants was 17.78, with an obesity rate of 18.67% and an overweight rate of 16%. Gross motor function was found to be associated with height, weight, and BMI ($p < 0.05$). No relationship was found between obesity +overweight and gender and CP subtype ($p > 0.05$). Conclusion: Turkish children with CP had a higher rate of obesity compared to typically developing peers and also their counterparts in other countries. There is a need for studies to identify the causes of obesity and to develop effective intervention programs for prevention of it in children with CP.

PMID: 36847021

**29. Perspectives: Understanding the Pathophysiology of Intraventricular Hemorrhage in Preterm Infants and Considering of the Future Direction for Treatment**
Young Soo Park

J Korean Neurosurg Soc. 2023 Mar 2. doi: 10.3340/jkns.2023.0020. Online ahead of print.

Remarkable advances in neonatal care have significantly improved the survival of extremely low birth weight infants in recent years. However, intraventricular hemorrhage (IVH) continues to be a major complication in preterm infants, leading to a high incidence of cerebral palsy and cognitive impairment. IVH is primarily caused by disruption of the fragile vascular network of the subependymal germinal matrix, and subsequent ventricular dilatation adversely affects the developing infant brain. Based on recent research, periventricular white matter injury is caused not only by ischemia and morphological distortion due to ventricular dilatation but also by free iron and inflammatory cytokines derived from hematoma and its lysates. The current guidelines for the treatment of post-hemorrhagic hydrocephalus (PHH) in preterm infants do not provide strong recommendations, but initiating treatment intervention based on ultrasound measurement values before the appearance of clinical symptoms of PHH has been proposed. Moreover, in the past decade, therapeutic interventions that actively remove hematomas and lysates have been introduced. The era is moving beyond cerebrospinal fluid shunt toward therapeutic goals aimed at improving neurodevelopmental outcomes.

PMID: 36858804

**30. Perinatal brain damage - what the obstetrician needs to know**
Brigitte Strizek

J Perinat Med. 2023 Mar 1. doi: 10.1515/jpm-2022-0523. Online ahead of print.

Perinatal brain damage is still one of the leading contributors to perinatal death and postnatal disability worldwide. However, the term perinatal brain damage encompasses very different aetiological entities that result in an insult to the developing brain and does not differentiate between the onset, cause and severity of this insult. Hypoxic-ischemic encephalopathy (HIE), intraventricular haemorrhage, periventricular leukomalacia and perinatal stroke are often listed as the major aetiologies of perinatal brain damage. They differ by type and timing of injury, neuropathological and imaging findings and their clinical picture. Along the timeline of neurodevelopment in utero, there appears to be a specific "window of vulnerability" for each type of injury, but clinical overlap does exist. In the past, peripartum acute hypoxia was believed to be the major, if not the only, cause of perinatal brain damage, but intrauterine inflammation, prematurity, chronic hypoxia/growth retardation and genetic abnormalities appear to be at least equally important contributors.

PMID: 36853861

**31. Efficacy of Therapist Supported Interventions from the Neonatal Intensive Care Unit to Home: A Meta-Review of Systematic Reviews**
Dana B McCarty, Lisa Letzkus, Elaine Attridge, Stacey C Dusing

Review Clin Perinatol. 2023 Mar;50(1):157-178. doi: 10.1016/j.clp.2022.10.004.

Infants born preterm or with complicated medical conditions requiring care in the neonatal intensive care unit (NICU) are at high risk for long-term developmental disabilities. The transition from NICU to early intervention/outpatient settings results in a disruptive gap in a therapeutic intervention during a period of maximal neuroplasticity and development. This meta-review evaluated evidence from existing systematic reviews regarding therapeutic interventions that start in the NICU and continue at home with the goal of improving developmental outcomes for infants at high risk for cerebral palsy. We also evaluated the impact of these interventions on parents' mental health outcomes.

PMID: 36868703

**32. Interventions for Motor Disorders in High-Risk Neonates**
Lynda McNamara, Catherine Morgan, Iona Novak

Review Clin Perinatol. 2023 Mar;50(1):121-155. doi: 10.1016/j.clp.2022.11.002.

Early childhood affords rapid brain development and advancement of the motor system. In High-Risk Infant Follow-Up programs, watchful waiting and monitoring of infants at high risk is shifting toward active surveillance and early diagnosis, followed by immediate targeted very early interventions. Infants with delayed motor skills benefit from developmental care, NIDCAP, and generic or specific motor training. Infants with cerebral palsy benefit from enrichment, targeted skills interventions, and task-specific motor training at high intensity. Infants with degenerative conditions benefit from enrichment but also require accommodations such as powered mobility.

PMID: 36868702

**33. Evaluation of the Training in Early Detection for Early Intervention (TEDEI) e-learning course using Kirkpatrick's method**
Eleanor Officer, Maisie Johnson, Jessica Blickwedel, Ashley Reynolds, Rachel Pearse, Janice Pearse, Anna Purna Basu

BMC Med Educ. 2023 Feb 27;23(1):129. doi: 10.1186/s12909-023-04113-7.

Background: Early intervention in cerebral palsy could improve motor outcome but is only possible following early identification of those affected. There is a need for training of healthcare professionals (HCPs) in early detection of atypical motor development. We developed a video-based e-learning course - Training in Early Detection for Early Intervention (TEDEI) - to address this need. We evaluated whether participation in the course improved knowledge and changed behaviour of HCPs. Methods: Participants were 332 HCPs (38% physiotherapists, 35.8% occupational therapists), predominantly UK-based (83.7%). Analysis of training effects used mixed methods and followed Kirkpatrick's model, first assessing "Reaction" through a feedback questionnaire involving Likert scale and free text responses (n = 141). "Learning" was assessed through multiple choice questions (MCQs): all 332 HCPs completed a pre-course quiz of 6 MCQs followed by the course, then a 16 item post-course quiz including the 6 pre-course questions. "Behaviour" was assessed through in-depth qualitative interviewing of 23 participants. Results: "Reaction": TEDEI was found to be effective, engaging and well structured. "Learning": Scores improved significantly between the pre-course and post-course quiz, median improvement 1/6 ($z = 5.30$, $p < 0.001$). HCPs also reported a perceived improvement in their knowledge, confidence and ability. "Behaviour": HCPs could see how TEDEI would improve their clinical practice through having an assessment framework, ways of working better with parents, and developing observational skills useful for tele-health assessments. Conclusion: Our brief e-learning course on early detection for early intervention was viewed positively, improved knowledge and showed potential for positive changes in practice. Kirkpatrick's model provided a useful framework for undertaking this evaluation.

PMID: 36842995

**34. School readiness of children at high risk of cerebral palsy randomised to early neuroprotection and neurorehabilitation: protocol for a follow-up study of participants from four randomised clinical trials**
Roslyn N Boyd, Iona Novak, Catherine Morgan, Samudragupta Bora, Leanne Sakzewski, Robert S Ware, Tracy Comans, Michael Collingwood Fahey, Koa Whittingham, Stewart Trost, Kerstin Pannek, Alex Pagnozzi, Sarah Mcintyre, Nadia Badawi, Hayley Smithers Sheedy, Kirsten Rebecca Palmer, Andrea Burgess, Afroz Keramat, Kristie Bell, Ashleigh Hines, Katherine Benfer, Laura Gascoigne-Pees, Shaneen Leishman, Stina Oftedal

BMJ Open. 2023 Feb 27;13(2):e068675. doi: 10.1136/bmjopen-2022-068675.

Introduction: School readiness includes cognitive, socio-emotional, language and physical growth and development domains which share strong associations with life-course opportunities. Children with cerebral palsy (CP) are at increased risk of poor school readiness compared with their typically developing peers. Recently, earlier diagnosis of CP has allowed interventions to commence sooner, harnessing neuroplasticity. First, we hypothesise that early referral to intervention for children at-risk of CP will lead to improved school readiness at 4-6 years relative to placebo or care as usual. Second, we hypothesise that receipt of early diagnosis and early intervention will lead to cost-savings in the form of reduced healthcare utilisation. Methods and analysis: Infants identified as at-risk of CP ≤6 months corrected age (n=425) recruited to four randomised trials of neuroprotectants (n=1), early neurorehabilitation (n=2) or early parenting support (n=1) will be re-recruited to one overarching follow-up study at age 4-6 years 3 months. A comprehensive battery of standardised assessments and questionnaires will be administered to assess all domains of school readiness and associated risk factors. Participants will be compared with a historical control group of children (n=245) who were diagnosed with CP in their second year of life. Mixed-effects regression models will be used to compare school readiness outcomes between those referred for early intervention versus placebo/care-as-usual. We will also compare health-resource use associated with early diagnosis and intervention versus later diagnosis and intervention. Ethics and dissemination: The Children's Health Queensland Hospital and Health Service, The University of Queensland, University of Sydney, Monash University and Curtin University Human Research Ethics Committees have approved this study. Informed consent will be sought from the parent or legal guardian of every child invited to participate. Results will be disseminated in peer-reviewed journals, scientific conferences and professional organisations, and to people with lived experience of CP and their families. Trial registration number: ACTRN12621001253897.

PMID: 36849209

**35. Effectiveness of Extracorporeal Shockwave Therapy on Controlling Spasticity in Cerebral Palsy Patients: A Meta-Analysis of Timing of Outcome Measurement**
Min Cheol Chang, You Jin Choo, Sang Gyu Kwak, Kiyeun Nam, Sae Yoon Kim, Hee Jin Lee, Soyoung Kwak

Children (Basel). 2023 Feb 9;10(2):332. doi: 10.3390/children10020332.

Extracorporeal shockwave therapy (ESWT) has been suggested as an alternative treatment for reducing spasticity in patients with cerebral palsy (CP). However, the duration of its effect was rarely known. A meta-analysis was performed to investigate the effectiveness of ESWT at controlling spasticity in patients with CP according to the follow-up period. We included studies in which ESWT was used to manage spasticity in patients with CP, and the effect was compared with that in a control group. Finally, three studies were included. In the meta-analysis, spasticity, measured using the modified Ashworth scale (MAS), was significantly reduced after ESWT compared with that in the control group; however, it was sustained for only 1 month. After ESWT, significant increases in passive ankle range of motion (ROM) and plantar surface area in the standing position were observed compared with those in the control group and sustained for up to 3 months. Although spasticity measured using MAS was significantly reduced for only 1 month, improvement in spasticity-associated symptoms, such as ankle ROM and plantar surface area contacting the ground, persisted for over 3 months. ESWT appears to be a useful and effective therapeutic option for managing spasticity in patients with CP.

PMID: 36832460

**36. Pediatric Patients With Hemiplegia: A Systematic Review of a Randomized Controlled Trial**
Ashish Varma, Nadeem R Khan, Anuj Varma, Nidhi S Sharma, Jayant D Vagha, Waqar M Naqvi, Smruti Besekar

Review Cureus. 2023 Jan 23;15(1):e34074. doi: 10.7759/cureus.34074. eCollection 2023 Jan.

Hemiplegia is the medical term for paralysis of one side of the body. It results in muscular wasting on the affected side, impairs gait, reduces motor abilities, and causes instability and a loss of grasping capacity. The patient's quality of life is impacted by hemiplegia because it impairs brain and spinal cord functions. Consequently, a range of therapeutic options, including physical therapy, medical health management, and other multidisciplinary care, are accessible. The effects of treatments on juvenile patients with hemiplegia who are participating in a randomized controlled trial (RCT) are examined in this systematic review. Using the Boolean operator "AND," the research process entailed searching for keywords like "Hemiplegia" and "Pediatrics." Based on the inclusion and exclusion criteria, a total of six RCTs were included in the study. According to the study's findings, hemiplegic patients benefited from Kinesio taping (KT), botulinum toxin type-A (BoNT-A), hyaluronic acid injections, and bimanual treatment.

PMID: 36843815

**37. Exploring structural connectomes in children with unilateral cerebral palsy using graph theory**
Ahmed Radwan, Lisa Decraene, Patrick Dupont, Nicolas Leenaerts, Cristina Simon-Martinez, Katrijn Klingels, Els Ortibus, Hilde Feys, Stefan Sunaert, Jeroen Blommaert, Lisa Mailleux

Hum Brain Mapp. 2023 Feb 25. doi: 10.1002/hbm.26241. Online ahead of print.

We explored structural brain connectomes in children with spastic unilateral cerebral palsy (uCP) and its relation to sensory-motor function using graph theory. In 46 children with uCP (mean age = 10 years 7 months ± 2 years 9 months; Manual Ability Classification System I = 15, II = 16, III = 15) we assessed upper limb somatosensory and motor function. We collected multi-shell diffusion-weighted, T1-weighted and T2-FLAIR MRI and identified the corticospinal tract (CST) wiring pattern using transcranial magnetic stimulation. Structural connectomes were constructed using Virtual Brain Grafting-modified FreeSurfer parcellations and multi-shell multi-tissue constrained spherical deconvolution-based anatomically-constrained tractography. Graph metrics (characteristic path length, global/local efficiency and clustering coefficient) of the whole brain, the ipsilesional/contralesional hemisphere, and the full/ipsilesional/contralesional sensory-motor network were compared between lesion types (periventricular white matter (PWM) = 28, cortical and deep gray matter (CDGM) = 18) and CST-wiring patterns (ipsilateral = 14, bilateral = 14, contralateral = 12, unknown = 6) using ANCOVA with age as covariate. Using elastic-net regularized regression we investigated how graph metrics, lesion volume, lesion type, CST-wiring pattern and age predicted sensory-motor function. In both the whole brain and subnetworks, we observed a hyperconnectivity pattern in children with CDGM-lesions compared with PWM-lesions, with higher clustering coefficient (p = [<.001-.047], η2p =[0.09-0.27]), characteristic path length (p= .003, η2p=0.19) and local efficiency (p = [.001-.02], ηp =[0.11-0.21]), and a lower global efficiency with age (p= [.01-.04], η2p =[0.09-0.15]). No differences were found between CST-wiring groups. Overall, good predictions of sensory-motor function were obtained with elastic-net regression (R2 = .40-.87). CST-wiring pattern was the strongest predictor for motor function. For somatosensory function, all independent variables contributed equally to the model. In conclusion, we demonstrated the potential of structural connectomics in understanding disease severity and brain development in children with uCP.

PMID: 36840930

**38. Effects of traditional Chinese medicine combined with modern rehabilitation therapies on motor function in children with cerebral palsy: A systematic review and meta-analysis**
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Front Neurosci. 2023 Feb 8;17:1097477. doi: 10.3389/fnins.2023.1097477. eCollection 2023.

Objective: Traditional Chinese Medicine (TCM) has considerable experience in the treatment of cerebral palsy (CP), but little evidence shows the effect of a combination of TCM and modern rehabilitation therapies on CP. This systematic review aims to evaluate the effect of integrated TCM and modern rehabilitation therapies on motor development in children with CP. Methods:

We systematically searched five databases up to June 2022, including PubMed, the Cumulative Index to Nursing and Allied Health, Cochrane Library, Embase, and Web of Science. Gross motor function measure (GMFM) and Peabody Development Motor Scales-II were the primary outcomes to evaluate motor development. Secondary outcomes included the joint range of motion, the Modified Ashworth scale (MAS), the Berg balance scale, and Activities of Daily living (ADL). Weighted mean differences (WMD) and 95% confidence intervals (CIs) were used to determine intergroup differences. Results: A total of 2,211 participants from 22 trials were enrolled in this study. Among these, one study was at a low risk of bias and seven studies showed a high risk of bias. Significant improvements were found in GMFM-66 (WMD 9.33; 95% CI 0.14-18.52, P < 0.05, I 2 = 92.1%), GMFM-88 (WMD 8.24; 95% CI 3.25-13.24, P < 0.01, I 2 = 0.0%), Berg balance scale (WMD 4.42; 95% CI 1.21-7.63, P < 0.01, I 2 = 96.7%), and ADL (WMD 3.78; 95% CI 2.12-5.43, P < 0.01, I 2 = 58.8%). No adverse events were reported during the TCM intervention in the included studies. The quality of evidence was high to low. Conclusion: Integrated TCM and modern rehabilitation therapies may be an effective and safe intervention protocol to improve gross motor function, muscle tone, and the functional independence of children with CP. However, our results should be interpreted carefully because of the heterogeneity between the included studies.

PMID: 36845424

# Prevention and Cure

**39. Factors Influencing the Efficacy of Umbilical Cord Blood-Derived Cell Therapy for Perinatal Brain Injury**
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Stem Cells Transl Med. 2023 Feb 27;szad006. doi: 10.1093/stcltm/szad006. Online ahead of print.

Introduction: We have previously described preclinical literature which supports umbilical cord blood-derived cell (UCBC) therapy as an efficacious treatment for perinatal brain injury. However, efficacy of UCBCs may be influenced by different patient population and intervention characteristics. Objectives: To systematically review the effects of UCBCs on brain outcomes in animal models of perinatal brain injury across subgroups to better understand the contribution of model type (preterm versus term), brain injury type, UCB cell type, route of administration, timing of intervention, cell dosage, and number of doses. Methods: A systematic search of MEDLINE and Embase databases was performed to identify studies using UCBC therapy in animal models of perinatal brain injury. Subgroup differences were measured by chi2 test where possible. Results: Differential benefits of UCBCs were seen across a number of subgroup analyses including intraventricular hemorrhage (IVH) vs. hypoxia ischemia (HI) model (apoptosis white matter (WM): chi2 = 4.07; P = .04, neuroinflammation-TNF-α: chi2 = 5.99; P = .01), UCB-derived mesenchymal stromal cells (MSCs) vs. UCB-derived mononuclear cells (MNCs) (oligodendrocyte WM: chi2 = 5.01; P = .03, neuroinflammation-TNF-α: chi2 = 3.93; P = .05, apoptosis grey matter (GM), astrogliosis WM), and intraventricular/intrathecal vs. systemic routes of administration (microglial activation GM: chi2 = 7.51; P = .02, astrogliosis WM: chi2 = 12.44; P = .002). We identified a serious risk of bias and overall low certainty of evidence. Conclusions: Preclinical evidence suggests UCBCs to show greater efficacy in the injury model of IVH compared to HI, the use of UCB-MSCs compared to UCB-MNCs and the use of local administrative routes compared to systemic routes in animal models of perinatal brain injury. Further research is needed to improve certainty of evidence and address knowledge gaps.

PMID: 36847059