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Interventions and Management

1. Anticipatory Motor Planning and Control of Grasp in Children with Unilateral Spastic Cerebral Palsy

Jennifer Gutterman, Trevor Lee-Miller, Kathleen M Friel, Katherine Dimitropoulou, Andrew M Gordon

Brain Sci. 2021 Aug 31;11(9):1161. doi: 10.3390/brainsci11091161.

Children with unilateral spastic cerebral palsy (USCP) have impairments in motor planning, impacting their ability to grasp objects. We examined the planning of digit position and force and the flexibility of the motor system in covarying these during object manipulation. Eleven children with a left hemisphere lesion (LHL), nine children with a right hemisphere lesion (RHL) and nine typically developing children (controls) participated in the study. Participants were instructed to use a precision grip with their dominant/less affected hand to lift and keep an object level, with either a left, centered or right center of mass (COM) location. Digit positions, forces, compensatory torque and object roll were measured. Although children with USCP generated a compensatory torque and modulated digit placement by lift-off, their index finger was either collinear or higher than the thumb, regardless of COM location, leading to larger rolls after lift-off especially for the RHL group. The findings suggest that while the kinetics of grasp control is intact, the kinematics of grasp control is impaired. This study adds to the understanding of the underlying mechanisms of anticipatory planning and control of grasp in children with USCP and may provide insights on how to improve hand function in children with USCP.

PMID: [34573182](#)

2. The comparison of regional spinal curvatures and movements in sitting posture in ambulatory children with cerebral palsy having minimal-to-moderate functional limitations

Derya Ozer Kaya, Umut Ziya Kocak, Yusuf Emuk, Nihal Olgac Dundar, Sema Bozkaya Yilmaz, Pinar Gencpinar

Gait Posture. 2021 Sep 21;90:408-414. doi: 10.1016/j.gaitpost.2021.09.192. Online ahead of print.

Aim: To examine the regional spinal curvatures and movements in the sagittal and frontal planes during sitting position, and the ability to act independently in patients with CP and to compare the differences between children and adolescents with minimal-to-moderate functional limitations. **Method:** Twenty-one participants diagnosed with CP aged 5-16 years were included. The participants' Gross Motor Function Classification System (GMFCS) levels were determined and those at levels I (minimal functional limitation group: minFLG) or II-III (moderate functional limitation group: modFLG) were included. Spinal curvatures, mobilities, and inclinations in the sagittal and frontal planes were evaluated in the sitting position using a hand-held, computer-assisted non-invasive electromechanical device. Participants' functional independence levels were assessed with the Functional Independence Measure (WeeFIM). **Results:** In the sagittal plane, there were no differences in terms of spinal curvatures between the minFLG and modFLG ($p > 0.05$). Spinal mobility degrees for flexion (thoracic and lumbar regions and total spine), extension (sacral region), and total spine mobility scores were significantly greater in the

minFLG ($p < 0.05$). In the frontal plane, lumbar spinal curvature significantly increased, and total spine mobility in the right/left lateral motions and functional independence decreased in the modFLG ($p < 0.05$). Interpretation: The children/adolescents with minimal functional limitations had greater spinal mobility during flexion, extension, and lateral flexions. Spinal curvatures were similar between groups in the sagittal plane. The lumbar region posture scores in the frontal plane observed as lordoscoliosis were higher, and functional independence was lower in the modFLG.

PMID: [34571351](#)

3. Association of sagittal spinal alignment in the sitting position with the trunk and lower extremity muscle masses in children and adults with cerebral palsy: A pilot study

Mitsuhiro Masaki, Yukine Ogawa, Yukika Inagaki, Yoshino Sato, Minoru Yokota, Seina Maruyama, Moeka Takeuchi, Maki Kasahara, Kota Minakawa, Mami Okamoto, Yoshie Chiyoda, Kunio Mino, Kaori Aoyama, Tatsuya Nishi, Yasushi Ando

Clin Biomech (Bristol, Avon). 2021 Sep 25;90:105491. doi: 10.1016/j.clinbiomech.2021.105491. Online ahead of print.

Background: We examined the association of sagittal spinal alignment in the sitting position with the trunk and lower extremity muscle masses in children and adults with cerebral palsy (CP). We also compared muscle masses between children and adults with CP who could and could not sit without the support of their upper extremities. **Methods:** The subjects were 34 children and adults with CP. Sagittal spinal alignment in the sitting position, such as thoracic kyphosis, lumbar lordosis, and sacral anterior inclination angles were measured using a Spinal Mouse. The thicknesses of the trunk and lower extremity muscles were measured using an ultrasound imaging device. Furthermore, the subjects were classified into the sitting-possible group ($n = 18$), who could sit without the support of the upper extremities, or a sitting-impossible group ($n = 16$), who could not sit without the support of the upper extremities. **Findings:** Stepwise regression analysis revealed that the lumbar multifidus muscle thickness and body weight were significant and independent factors of the lumbar lordosis angle in the sitting position. The thicknesses of the thoracic erector spinae, gluteus maximus and minimus, long head of the biceps femoris, semitendinosus, and rectus femoris muscles were significantly lower in the sitting-impossible group than those in the sitting-possible group. **Interpretation:** Decreased lumbar lordosis angle in the sitting position was associated with decreased lumbar multifidus muscle mass in children and adults with CP. Furthermore, not only trunk extensor but also hip joint muscles may contribute to sitting without upper extremity support.

PMID: [34597916](#)

4. The effect of neck-trunk stabilization exercises in cerebral palsy: randomized controlled trial

Nasim Ejraei, Aysel Y Ozer, Onur Aydogdu, Dilsad Turkdogan, M Gulden Polat

Minerva Pediatr (Torino). 2021 Sep 30. doi: 10.23736/S2724-5276.21.06206-6. Online ahead of print.

Background: To investigate the effects of neck and trunk stabilization exercises on communication, speech performance, activities of daily living and quality of life in children with cerebral palsy (CP). **Methods:** In this prospective, single-blinded, randomized controlled trial, forty children with CP were randomly assigned to Study and Control groups. The study group was received structured neck and trunk stabilization exercises in addition to NDT-B approach. Control group was received NDT-B approach. An oral-motor rehabilitation/therapy was trained to all children. Both groups' trainings were provided for six weeks, with a 45-minute session two times a week. Outcome measures were Communication Function Classification System and Visual Analogue Scale to evaluate communication level; Katz Scale to measure activities of daily living; Viking Speech Scale (VSS) to classify children's speech performance and Pediatric Quality of Life Inventory (PedsQL) to measure the quality of life. **Results:** The results showed that the communication level and Physical Functioning Score of PedsQL are increased significantly in the study group. VSS is found higher than control at 18th weeks for long term follow up in the study group. **Conclusions:** This study highlights the positive effects of stabilization exercises on children's speech performance, Physical Functioning of PedsQL and communication level. Additionally, children' communication skills between them and their caregivers have affected positively and so that this situation provides more qualified daily lives to the children.

PMID: [34590804](#)

5. A Backward Walking Training Program to Improve Balance and Mobility in Children with Cerebral Palsy

Ji-Young Choi, Sung-Min Son, Se-Hee Park

Healthcare (Basel). 2021 Sep 9;9(9):1191. doi: 10.3390/healthcare9091191.

Background: We studied the effects of motor tasks using backward walking training on balance and gait functions of children with cerebral palsy. This was a single-blinded, randomized controlled trial with a crossover design conducted at a single facility. **Methods:** Among 12 children with cerebral palsy, the forward (FWG) (n = 6) and backward walking groups (BWG) (n = 6) underwent training three times a week for 4 weeks, 40 min a day. After a 6-week break, the crossover training was conducted. Functional walking variables were measured. Time-Up-and-Go (TUG) test, Figure-8 Walk Test (FW8T), and Pediatric Balance Scale (PBS) were used for measuring balance. **Results:** Both groups showed significant improvement in walking speed, stride length, and step length. The BWG demonstrated significant improvement in walking speed ($p < 0.05$) compared with the FWG. The TUG test, FW8T, and PBS showed significant improvement. After the 4-week intervention, both groups displayed a remarkable decrease in TUG duration and FW8T. Both groups also exhibited improvement in the PBS; more so in the BWG. **Conclusions:** Backward walking training with motor dual tasks could be a more effective interventional approach than forward walking training to improve balance and walking functions of children with spastic hemiplegia.

PMID: [34574964](https://pubmed.ncbi.nlm.nih.gov/34574964/)

6. Determining the relationship between the impairment of selective voluntary motor control and gait deviations in children with cerebral palsy using simple video-based analyses

Cansu Sardoğan, Rasmi Muammer, Nazif Ekin Akalan, Rukiye Sert, Fuat Bilgili

Gait Posture. 2021 Aug 26;90:295-300. doi: 10.1016/j.gaitpost.2021.08.019. Online ahead of print.

Background: The impairment of selective voluntary motor control (SVMC) in children with cerebral palsy (CP) has been shown to correlate with their gait characteristics using complex 3D gait analysis systems (3DGA); however, this relationship has not been investigated using simple video-based observational gait analysis (VBOGA). The aim of this study was to determine the relationship between VBOGA and SVMC of the lower extremities in children with CP. **Methods:** Forty-two CP children 10.9 ± 5.7 years old with Gross Motor Function Classification System (GMFCS) levels I-III participated in the study. Their gait characteristics were assessed using the Edinburgh Visual Gait Score (EVGS), and selective voluntary motor control was tested using the Selective Control Assessment of the Lower Extremity (SCALE). Spearman's rho correlation test with Cohen's classification were used in the statistical analyses. **Results:** The GMFCS levels ($r = 0.604$, $p < 0.001$), foot clearance ($r = -0.584$, $p < 0.001$), and maximum ankle dorsiflexion ($r = -0.567$, $p < 0.001$) during the swing phase had strong correlations with total SCALE scores. There was also a moderate correlation between total SCALE scores and total EVGS ($r = -0.494$, $p < 0.001$), knee extension in the terminal swing phase ($r = -0.353$, $p < 0.001$), peak sagittal trunk position ($r = -0.316$, $p < 0.005$), and maximum lateral shift ($r = -0.37$, $p < 0.001$). **Conclusion:** Impaired lower extremity SVMC was noticeably related to the foot and ankle movements in the swing phase and initial stance during walking as well as the total EVGS scores and sagittal and frontal trunk movements. The SCALE correlations with VBOGA were similar those observed in the complex 3DGA in the literature; therefore, we suggest that SVMC impairment of gait could be evaluated using simple VBOGA. These findings may help to tailor physical therapy programs for CP children to increase their motor control and walking quality.

PMID: [34564001](https://pubmed.ncbi.nlm.nih.gov/34564001/)

7. Effects of Ankle-Foot Orthoses on acceleration and energy cost of walking in children and adolescents with cerebral palsy

Tobias Goihl, Espen Alexander F Ihlen, Ellen Marie Bardal, Karin Roeleveld, Astrid Ustad, Siri Merete Brændvik

Prosthet Orthot Int. 2021 Sep 21. doi: 10.1097/PXR.000000000000044. Online ahead of print.

Background: Impaired postural control is a key feature of cerebral palsy that affects daily living. Measures of trunk movement and acceleration have been used to assess dynamic postural control previously. In many children with cerebral palsy, ankle-foot orthoses are used to provide a stable base of support, but their effect on postural control is not yet understood. **Objectives:** The objectives of the current study were to investigate the effects of ankle-foot orthoses on postural control and energy cost of

walking in children with cerebral palsy. Study design: Clinical study with controls. Methods: Trunk accelerometry (amplitude and structure) and energy cost of walking (J/kg/m) were recorded from five-minute walking trials with and without ankle-foot orthoses for children with cerebral palsy and without orthoses for the reference group. Results: Nineteen children with unilateral spastic cerebral palsy and fourteen typically developed children participated. The use of ankle-foot orthoses increased structure complexity of trunk acceleration in mediolateral and anterior-posterior directions. The use of ankle-foot orthoses changed mediolateral-structure toward values found in typically developed children. This change was not associated with a change in energy cost during walking. Conclusions: The use of ankle-foot orthoses does affect trunk acceleration that may indicate a beneficial effect on postural control. Using measures of trunk acceleration may contribute to clinical understanding on how the use of orthoses affect postural control.

PMID: [34561379](#)

8. Mobility and gait in adults with cerebral palsy: Evaluating change from adolescence

Nancy Lennon, Chris Church, M Wade Shrader, William Robinson, John Henley, Jose de Jesus Salazar-Torres, Tim Niiler, Freeman Miller

Gait Posture. 2021 Sep 20;90:374-379. doi: 10.1016/j.gaitpost.2021.09.177. Online ahead of print.

Background: Previous studies have looked at the short-term effectiveness of conservative and surgical treatment of children with cerebral palsy (CP), but few have explored the long-term outcomes into adulthood using gait analysis and patient-reported outcome measures. Research question: How do gait, mobility, and patient-reported outcomes in adults with CP who received specialized pediatric orthopedic care change from adolescence? Methods: We identified 645 adults with 1) CP, 2) age 25-45 years, and 3) an adolescent instrumented gait analysis (IGA) at our center. Measurement outcomes included physical examination, IGA, and select domains of the Patient-Reported Outcomes Measurement Information System (PROMIS). Results: Participants included 136 adults with CP; Gross Motor Function Classification System levels I (21 %), II (51 %), III (22 %), and IV (7%); 57 % males; and average age $16 \pm 3/29 \pm 3$ years (adolescent/adult visits). There was no significant difference in gait deviation index, stride length, or gross motor function between adolescent and adult visits. There were statistically significant but not clinically meaningful declines in gait velocity. At adulthood, PROMIS results revealed limitations in physical function compared with a normative sample but no differences in depression, participation, or pain interference. Significance: In this relatively homogeneous group of adults with CP who received orthopedic care from one center, gait and gross motor function showed no clinically meaningful change from adolescence, which differs from recent reports of declining mobility in adulthood. Expert orthopedic care, guided by IGA, may prevent losses in functional mobility for adults with CP.

PMID: [34564009](#)

9. Restoration of Heel-Toe Gait Patterns for the Prevention of Asymmetrical Hip Internal Rotation in Patients with Unilateral Spastic Cerebral Palsy

Reinald Brunner, William R Taylor, Rosa M S Visscher

Children (Basel). 2021 Sep 2;8(9):773. doi: 10.3390/children8090773.

Forward modelling has indicated hip internal rotation as a secondary physical effect to plantar flexion under load. It could therefore be of interest to focus the treatment for patients with unilateral spastic cerebral palsy on achieving a heel-toe gait pattern, to prevent development of asymmetrical hip internal rotation. The aim of this preliminary retrospective cohort investigation was to evaluate the effect of restoring heel-toe gait, through use of functional orthoses, on passive hip internal rotation. In this study, the affected foot was kept in an anatomically correct position, aligned to the leg and the gait direction. In case of gastrosoleus shortness, a heel raise was attached to compensate for the equinus and yet to provide heel-floor contact (mean equinus = -2.6 degrees of dorsiflexion). Differences in passive hip internal rotation between the two sides were clinically assessed while the hip was extended. Two groups were formed according to the achieved correction of their gait patterns through orthotic care: patients with a heel-toe gait (with anterograde rocking) who wore the orthosis typically for at least eight hours per day for at least a year, or patients with toe-walking (with retrograde rocking) in spite of wearing the orthosis who used the orthosis less in most cases. A Student's t-test was used to compare the values of clinically assessed passive hip rotation ($p < 0.05$) between the groups and the effect size (Hedges' g) was estimated. Of the 70 study participants, 56 (mean age 11.5 y, majority GMFCS 1, similar severity of pathology) achieved a heel-toe gait, while 14 remained as toe-walkers. While patients with heel-toe gait patterns showed an almost symmetrical passive hip internal rotation (difference +1.5 degrees, standard

deviation 9.6 degrees), patients who kept toe-walking had an increased asymmetrical passive hip internal rotation (difference +10.4 degrees, standard deviation 7.5 degrees; $p = 0.001$, Hedges's $g = 0.931$). Our clinical findings are in line with the indications from forward modelling that treating the biomechanical problem might prevent development of a secondary deformity. Further prospective studies are needed to verify the presented hypothesis.

PMID: [34572205](#)

10. Impact of the Marker Set Configuration on the Accuracy of Gait Event Detection in Healthy and Pathological Subjects

Rosa M S Visscher, Marie Freslier, Florent Moissenet, Sailee Sansgiri, Navrag B Singh, Elke Viehweger, William R Taylor, Reinald Brunner

Front Hum Neurosci. 2021 Sep 13;15:720699. doi: 10.3389/fnhum.2021.720699. eCollection 2021.

For interpreting outcomes of clinical gait analysis, an accurate estimation of gait events, such as initial contact (IC) and toe-off (TO), is essential. Numerous algorithms to automatically identify timing of gait events have been developed based on various marker set configurations as input. However, a systematic overview of the effect of the marker selection on the accuracy of estimating gait event timing is lacking. Therefore, we aim to evaluate (1) if the marker selection influences the accuracy of kinematic algorithms for estimating gait event timings and (2) what the best marker location is to ensure the highest event timing accuracy across various gait patterns. 104 individuals with cerebral palsy (16.0 ± 8.6 years) and 31 typically developing controls (age 20.6 ± 7.8) performed clinical gait analysis, and were divided into two out of eight groups based on the orientation of their foot, in sagittal and frontal plane at mid-stance. 3D marker trajectories of 11 foot/ankle markers were used to estimate the gait event timings (IC, TO) using five commonly used kinematic algorithms. Heatmaps, for IC and TO timing per group were created showing the median detection error, compared to detection using vertical ground reaction forces, for each marker. Our findings indicate that median detection errors can be kept within 7 ms for IC and 13 ms for TO when optimizing the choice of marker and detection algorithm toward foot orientation in midstance. Our results highlight that the use of markers located on the midfoot is robust for detecting gait events across different gait patterns.

PMID: [34588967](#)

11. Energetics of walking in individuals with cerebral palsy and typical development, across severity and age: A systematic review and meta-analysis

Mauro Nardon, Federico Ruzzante, Leslie O'Donnell, Alessandra Adami, Sudarshan Dayanidhi, Matteo Bertucco

Review Gait Posture. 2021 Sep 21;90:388-407. doi: 10.1016/j.gaitpost.2021.09.190. Online ahead of print.

Background: Individuals with cerebral palsy (CP) report physical fatigue as a main cause of limitation, deterioration and eventually cessation of their walking ability. A consequence of higher level of fatigue in individuals with CP leads to a less efficient and long-distance walking ability. Research question: This systematic review investigates the difference in 1) walking energy expenditure between individuals with CP and age-matched typically developing (TD) individuals; and 2) energetics of walking across Gross Motor Function Classification System (GMFCS) levels and age. Methods: Five electronic databases (PubMed, Web of Science, CINAHL, ScienceDirect and Scopus) were searched using search terms related to CP and energetics of walking. Results: Forty-one studies met inclusion criteria. Thirty-one studies compared energy expenditure between CP and age-matched controls. Twelve studies correlated energy expenditure and oxygen cost across GMFCS levels. Three studies investigated the walking efficiency across different ages or over a time period. A significant increase of energy expenditure and oxygen cost was found in individuals with CP compared to TD age-matched individuals, with a strong relationship across GMFCS levels. Significance: Despite significant differences between individuals with CP compared to TD peers, variability in methods and testing protocols may play a confounding role. Analysis suggests oxygen cost being the preferred/unbiased physiological parameter to assess walking efficacy in CP. To date, there is a knowledge gap on age-related changes of walking efficiency across GMFCS levels and wider span of age ranges. Further systematic research looking at longitudinal age-related changes of energetics of walking in this population is warranted.

PMID: [34564011](#)

12. The Impact of Patellar Tendon Advancement on Knee Joint Moment and Muscle Forces in Patients with Cerebral Palsy

Derya Karabulut, Yunus Ziya Arslan, Marco Götze, Sebastian I Wolf

Life (Basel). 2021 Sep 9;11(9):944. doi: 10.3390/life11090944.

Patellar tendon advancement (PTA) is performed for the treatment of crouch gait in patients with cerebral palsy (CP). In this study, we aimed to determine the influence of PTA in the context of single-event multilevel surgery (SEMLS) on knee joint moment and muscle forces through musculoskeletal modeling; Methods: Gait data of children with CP and crouch gait were retrospectively analyzed. Patients were included if they had a SEMLS with a PTA (PTA group, n = 18) and a SEMLS without a PTA (NoPTA group, n = 18). A musculoskeletal model was used to calculate the pre- and postoperative knee joint moments and muscle forces; Results: Knee extensor moment increased in the PTA group postoperatively (p = 0.016), but there was no statistically significant change in the NoPTA group (p > 0.05). The quadriceps muscle forces increased for the PTA group (p = 0.034), while there was no difference in the NoPTA group (p > 0.05). The hamstring muscle forces increased in the PTA group (p = 0.039), while there was no difference in the NoPTA group (p > 0.05); Conclusions: PTA was found to be an effective surgery for the treatment of crouch gait. It contributes to improving knee extensor moment, decreasing knee flexor moment, and enhancing the quadriceps and hamstring muscle forces postoperatively.

PMID: [34575092](#)

13. What happens to the patella height in patients with cerebral palsy as they age

Jae Jung Min, Soon-Sun Kwon, Ki Hyuk Sung, Kyoung Min Lee, Hansang Lee, Chin Youb Chung, Moon Seok Park

J Pediatr Orthop B. 2021 Sep 21. doi: 10.1097/BPB.0000000000000917. Online ahead of print.

Objective: We aimed to investigate the progression of patella alta (PA) in patients with cerebral palsy (CP) using the Koshino-Sugimoto (KS) index and assess associated risk factors. Method: Participants in our retrospective study met the following inclusion criteria: patients with CP who visited our institute from May 2003 to December 2019, were ≤18 years of age, were followed up for >2 years and had at least two lateral knee radiographs. KS indices of both knee radiographs were measured for each patient. A linear mixed model was implemented. Results: Our participants included 222 CP patients. KS index values were measured via 652 knee radiographs. Reference values of the KS index for those between 4 and 18 years of age were determined according to Gross Motor Function Classification System (GMFCS) levels. In all GMFCS levels, the KS index decreased with patients' ages (P < 0.0001). In groups where the KS index increased, GMFCS levels IV (P = 0.0045) and V (P = 0.0040) were statistically significant. Conclusions: Change in the KS index values indicates that PA improves as patients age within all GMFCS levels. However, in patients with GMFCS levels of IV and V, progressive PA is expected.

PMID: [34561382](#)

14. Is the Prevalence of Equinus Foot in Cerebral Palsy Overestimated? Results from a Meta-Analysis of 4814 Feet

Axel Horsch, Matthias C M Klotz, Hadrian Platzer, Svenja Seide, Nancy Zeaiter, Maher Ghandour

Review J Clin Med. 2021 Sep 13;10(18):4128. doi: 10.3390/jcm10184128.

Background: Equinus is a common foot deformity in patients with cerebral palsy (CP). However, its prevalence is scarcely reported in the literature. Therefore, we conducted this review to estimate the prevalence of equinus foot in CP. Methods: Eight databases were searched. Our primary outcome was the prevalence of equinus foot in CP patients. Subgroup analysis was conducted based on study design, the laterality of CP, and whether equinus foot was defined or not. Results: The prevalence of equinus foot in CP was 93% (95% CI: 71-99). The prevalence was 99% (95% CI: 55-100), 96% (95% CI: 57-100), and 65% (95% CI: 37-86) in unilateral, both, and bilateral CP, respectively. Based on study design, equinus foot prevalence was 92% (95% CI: 34-100) in case series and 62% (95% CI: 47-74) in cohort studies. Four studies reported definition criteria for equinus foot, with a pooled prevalence rate of equinus foot of 99% (95% CI: 36-100) compared to a rate of 89% (95% CI: 59-98) among studies that lacked a definition criterion. Conclusions: This is the first meta-analysis to address the prevalence of equinus foot in CP patients. Although its prevalence is very high, our findings should be interpreted with caution due to the presence of multiple limitations, such as the lack of standardized definition criteria for equinus foot, the inappropriate study

design, the wide confidence interval of equinus foot rate, and the small number of studies investigating it as a primary outcome.

PMID: [34575239](#)

15. Submandibular excision with and without parotid duct ligation for sialorrhoea

A Thangirala, H Zhu, E M Lambert

Br J Oral Maxillofac Surg. 2021 Jun 29;S0266-4356(21)00247-3. doi: 10.1016/j.bjoms.2021.06.015. Online ahead of print.

In this case series with retrospective review we compared the outcomes of patients with sialorrhoea who had a submandibular excision (SE) alone and those who had submandibular excision with parotid duct ligation (SE + PL) between 2012 and 2018. Primary endpoints of complication rates and caregivers' perceptions of success were collected. A total of 41 submandibular excisions were performed for sialorrhoea (26 patients underwent SE, while 15 underwent SE + PL). Significant differences in the groups existed at baseline with patients in the SE plus PL group being more likely to have a tracheostomy ($p = 0.015$), to use sublingual atropine ($p = 0.038$) and respiratory medications (albuterol $p = 0.0075$, gentamicin $p = 0.018$), to have more pneumonias six months prior to the procedure ($p < 0.001$), and more hospitalisations six months prior to the procedure ($p = 0.046$). More postoperative surgical site complications were associated with ligation ($p = 0.012$). There was no difference in systemic infection ($p = 0.25$), and no difference in caregivers' perceptions of success in reducing sialorrhoea (18/24 SE compared with 10/14 SE + PL, $p = 1.00$). There were more surgical site complications in those undergoing SE plus PL than in those who had SE alone. Given this data, parotid duct ligation may not yield additional benefit when combined with submandibular excision.

PMID: [34563353](#)

16. Evaluation of Micronutrient Levels in Children with Cerebral Palsy

Kursat Bora Carman, Kursad Aydın, Betül Kilic Aydın, Ali Cansu, Meltem Cobanogullari Direk, Selver Durmus, Nihal Olgaç Dündar, Pinar Gencpinar, Serdal Gungor, Esra Gurkas, Ozgen Hur, Meral Karadag, Cefa Nil Karademir, Pinar Ozkan Kart, Cetin Okuyaz, Nefise Aribas Oz, Yakup Peduk, Huseyin Per, Mine Hepsen Serin, Hasan Tekgul, Bulent Unay, Coskun Yazar, Gonca Kilic Yildirim

Pediatr Int. 2021 Sep 29. doi: 10.1111/ped.15005. Online ahead of print.

Background: Many studies evaluating the nutritional status of children with CP have focused on energy requirements and protein intake. The present work aimed to assess nutritional status and micronutrient levels of children with cerebral palsy. **Methods:** This multicenter, cross-sectional and observational study was conducted in ten different cities of Turkey. Data were available for 398 participants. Anthropometric measurements, feeding mode, nutritional status and micronutrient levels were evaluated. **Results:** The study was conducted with 398 participants (303 patients and 95 healthy controls). The statistical analysis showed that according to the Gomez classification, weight-for-age (WFA) revealed malnutrition in 92.6% of children with cerebral palsy based on CDC percentiles. Measurements of micronutrient levels showed that zinc levels were low in patients, whereas vitamin A levels were low in controls. Phosphorous and manganese levels were significantly lower in malnourished children than in normal children. The results revealed that children consuming enteral nutrition solution had higher selenium and lower zinc levels than nonconsumers. **Conclusions:** Malnutrition is not only a protein- or calorie-based problem; micronutrient deficiencies might cause severe health problems. Children with chronic neurological disabilities must be carefully evaluated for these issues. Therefore, nutritional interventions should be adapted to nutrition.

PMID: [34585809](#)

17. Genetic and Non Genetic Hearing Loss and Associated Disabilities: An Epidemiological Survey in Emilia-Romagna Region

Elisabetta Genovese, Silvia Palma, Valeria Polizzi, Giovanni Bianchin, Michela Cappai, Shaniko Kaleci, Alessandro Martini, Andrea Ciorba, Paolo Stagi

Audiol Res. 2021 Sep 16;11(3):463-473. doi: 10.3390/audiolres11030043.

Hearing loss is one of the most common congenital sensory disorders. It can be associated with several comorbidities, in particular developmental disabilities (DD). In Emilia-Romagna (ER), a region in Northern Italy, Child and Adolescent Mental Health Services (CAMHS) provide the diagnostic framework and treatment for these conditions. The aim of the present study is to evaluate the prevalence of hearing loss, both isolated or in association with comorbidities, in the juvenile population. The study draws its data from the ER Childhood and Adolescent Neuropsychiatry Information System (SINPIAER), an Administrative Healthcare Database collecting the clinical data of all those who have attended CAMHS since 2010. The most frequent type of hearing loss was bilateral sensorineural hearing loss, which was present in 69-72% of the cases, while bilateral conductive hearing loss was the second most common type, ranging from 8 to 10%. Among DD, congenital malformations, mental retardation, visual impairment, and cerebral palsy were the most common. In particular, autism spectrum disorders show increasing incidence and prevalence among CAMHS users in ER region. In-depth knowledge of hearing loss epidemiology and related conditions, such as developmental disabilities, in the juvenile population is crucial for disease prevention, health planning, and resource allocation.

PMID: [34562881](#)

18. Identifying pain trajectories in children and youth with cerebral palsy: a pilot study

Heather M Shearer, Pierre Côté, Sheilah Hogg-Johnson, Patricia McKeever, Darcy L Fehlings

BMC Pediatr. 2021 Sep 29;21(1):428. doi: 10.1186/s12887-021-02861-3.

Background: Although chronic pain is common in children with cerebral palsy (CP), little is known about short-term pain fluctuations and their impact on children's well-being. High-quality cohort studies are needed to understand the clinical course of pain in this population. We aimed to determine the feasibility of conducting a multicentre cohort study. In this pilot study we assessed: 1) study processes, 2) resource and 3) management indicators including recruitment and follow-up rates, data completeness, participant characteristics, and successes and barriers in the study conduct. **Methods:** A multi-centre pilot cohort study was conducted with 10 Canadian children/youth with CP attending one of two children's rehabilitation centers. We collected self-reported pain intensity (Faces Pain Scale-Revised [FPS-R], Numeric Rating Scale [NRS]); pain interference (PROMIS PI); pain location (pain diagram); physical and psychological well-being (KIDSCREEN-27), sleep characteristics, preceding months' interventions, and some clinical characteristics at baseline. Average pain intensity was reported weekly for five weeks. Well-being, sleep and interventions were measured at baseline and again at five weeks. We used feasibility indicators to evaluate: 1) study processes (e.g. recruitment, attrition rates); 2) resources (e.g. data completion, budgetary challenges); and 3) management (e.g. data optimization, variability of participants and pain scores). **Results:** Between March and May 2019, 24 children and their parents/guardians were contacted and 20 met eligibility criteria. Of those, 10 agreed to in-person screening (50%) and were subsequently enrolled. The follow-up rate was 90% and self-reported missing data was minimal. Ninety percent of participants chose e-questionnaire follow-ups versus mailed paper questionnaires. Sixty percent required reminders to complete e-follow-ups. Participants were aged 8-17 years, five were female, GMFCS levels I-IV (none with level V), 90% had spastic CP and 80% reported having pain in the preceding week. Pain intensity (FPS-R) between participants ranged from 0-8/10 at baseline and 0-6/10 across all four weekly follow-ups. **Conclusions:** This pilot study demonstrates the feasibility of conducting a multicentre cohort study to identify short-term pain trajectories and measure their association with well-being in children and youth with CP. Additional strategies to improve recruitment and accessibility for those with GMFCS levels V should be implemented in future studies.

PMID: [34587937](#)

19. What can post-stroke central pain teach us about chronic pain in adolescents with cerebral palsy?

Andrew Chih Wei Huang

Dev Med Child Neurol. 2021 Sep 29. doi: 10.1111/dmcn.15069. Online ahead of print.

PMID: [34585739](#)

20. Assessment of Sleep-Related Problems in Children with Cerebral Palsy Using the SNAKE Sleep Questionnaire

Larissa Alice Dreier, Tugba Kapançi, Katharina Lonnemann, Margarete Koch-Hogrebe, Lucia Wiethoff-Ubrig, Markus Rauchenzauner, Markus Blankenburg, Boris Zernikow, Julia Wager, Kevin Rostasy

Children (Basel). 2021 Sep 1;8(9):772. doi: 10.3390/children8090772.

Cerebral palsy (CP) represents the most common motor impairment in childhood. The presence of sleep problems has not yet been investigated with an instrument specifically designed for this population. In this hospital-based, prospective study, N = 100 children (M = 7.9, range: 2-18 years) with CP were included. All patients underwent pediatric neurologists' screening incorporating instruments (Data Collection Form; Gross Motor Functions Classification System, GMFCS; Bimanual Fine Motor Function, BFMF) recommended by the "Surveillance of Cerebral Palsy in Europe (SCPE)". Parents completed the "Sleep Questionnaire for Children with Severe Psychomotor Impairment (SNAKE)". Children's sleep behavior was increasingly conspicuous, with greater gross motor (SNAKE scales: disturbances remaining asleep, daytime sleepiness) and fine motor (additionally SNAKE scale arousal and breathing problems) functional impairment. Overall, a proportion of children showed sleep behavior outside the SNAKE's normal range. No relevant sleep differences were identified between different CP subtypes and comorbidities. Applying a population-specific questionnaire, children's functional impairment seems to be more relevant to their sleep behavior than the CP subtype or CP comorbidities.

PMID: [34572204](#)

21. The impact of exergames on the functional balance of a teenager with cerebral palsy - a case report

Fábio Pereira, Mónica S Cameirão, Sergi Bermúdez I Badia

Disabil Rehabil Assist Technol. 2021 Sep 30;1-10. doi: 10.1080/17483107.2021.1980623. Online ahead of print.

Purpose: To understand the impact of an intensive rehabilitation program based on exergames in balance and lower limb function in a teenager with cerebral palsy. Methods: The rehabilitation program comprised different customised exergames and was delivered in 5 weekly sessions of 30 min for 4 weeks. Pre-, post-, and 1-month Follow-up assessments included the following metrics: Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Gross Motor Function Measure (GMFM), Posturography, and Gait analysis. Results: We observed increased scores after the intervention of 9/72 points in GMF - Module E (Walk, Run and Jump) and of 9/56 points in BBS, sustained at Follow-up. Changes in function, specifically in the quality and independence of the performance of specific movements such as turning 360°, increased distance reaching forward, walk behind, step over obstacles, and step stairs up and down were also observed. Gait kinematics and Spatio-temporal parameters tended to get closer to the 50th percentile. Conclusions: We observed positive changes in motor function of a teenager with cerebral palsy, with sustained increased scores at a 1-month Follow-up. Findings are suggestive that intensive rehabilitation programs using exergames with high customisation features are a potentially valuable rehabilitation tool for training balance in teenagers with Cerebral Palsy. Implications for rehabilitation: Exergames may be a useful for providing balance training for teenagers who have a mixed form of cerebral palsy. Exergames that require body displacement may be suitable for modulating gait kinematics and spatio-temporal parameters. The customisation of virtual rehabilitation tools seems to impact the motivation and effort of the user positively.

PMID: [34591721](#)

22. Capturing spike train temporal pattern with wavelet average coefficient for brain machine interface

Shixian Wen, Allen Yin, Po-He Tseng, Laurent Itti, Mikhail A Lebedev, Miguel Nicolelis

Sci Rep. 2021 Sep 24;11(1):19020. doi: 10.1038/s41598-021-98578-5.

Motor brain machine interfaces (BMIs) directly link the brain to artificial actuators and have the potential to mitigate severe body paralysis caused by neurological injury or disease. Most BMI systems involve a decoder that analyzes neural spike counts to infer movement intent. However, many classical BMI decoders (1) fail to take advantage of temporal patterns of spike trains, possibly over long time horizons; (2) are insufficient to achieve good BMI performance at high temporal resolution, as the underlying Gaussian assumption of decoders based on spike counts is violated. Here, we propose a new statistical feature that represents temporal patterns or temporal codes of spike events with richer description-wavelet average coefficients (WAC)-to

be used as decoder input instead of spike counts. We constructed a wavelet decoder framework by using WAC features with a sliding-window approach, and compared the resulting decoder against classical decoders (Wiener and Kalman family) and new deep learning based decoders (Long Short-Term Memory) using spike count features. We found that the sliding-window approach boosts decoding temporal resolution, and using WAC features significantly improves decoding performance over using spike count features.

PMID: [34561503](#)

23. Impact of Rehabilitation Intensity on 3-Year Mortality among Children with Moderate to Severe Cerebral Palsy: A Population-Based Cohort Study

Chiao-Lin Hsu, Chia-Ling Hung, Shih-Ju Huang, Chun-Hao Yin, Chi-Hsiang Chu, Tsu-Jen Kuo, Yao-Min Hung

Int J Environ Res Public Health. 2021 Sep 21;18(18):9932. doi: 10.3390/ijerph18189932.

Though numerous studies demonstrated the positive effect of rehabilitation on cerebral palsy (CP) children, there was no literature addressing the role of rehabilitation on mortality among children with CP. Therefore, we aimed to evaluate the impact of rehabilitation intensity on mortality among children with moderate to severe CP. This retrospective cohort study was conducted by National Health Insurance Research Database in Taiwan. Children (<12 years) with newly diagnosed moderate to severe CP between 1 January 2000 and 31 December 2013 were included. All patients were followed up for 3 years after CP diagnosis or death or until 31 December 2013. The intensity of rehabilitation therapy within 6 months after CP diagnosis was categorized into <6 times and ≥ 6 times. The Cox proportional hazard analysis was used to determine the association between rehabilitation intensity and all-cause mortality after adjusting age, sex, other demographic factors and comorbidities. Among 3936 severe CP children, 164 (4.2%) died during the 3-year follow-up period. The mortality rate was higher among patients receiving rehabilitation < 6 times within 6 months than those ≥ 6 times within 6 months after adjusting demographic profile and comorbidities (adjust HR (aHR): 1.96, 95% CI 1.33-2.89, $p < 0.001$). We found that patients who were younger (aHR: 0.84, 95% CI 0.76-0.92, $p < 0.001$), who were receiving inpatient care more than twice in 1 year before their CP diagnosis (aHR: 2.88; 95% CI: 1.96-4.23; $p < 0.001$), and who have pneumonia (aHR: 1.41, 95% CI 1.00-1.96, $p = 0.047$), epilepsy (aHR: 1.41, 95% CI: 1.02-1.95, $p = 0.039$) and dysphagia (aHR: 1.55, 95% CI: 1.06-2.26, $p = 0.024$) have higher risk of mortality. Rehabilitation ≥ 6 times within 6 months has a potentially positive impact on pediatric CP survival. Besides having a younger age, being hospitalized more than twice within a year before diagnosis and having pneumonia, epilepsy and dysphagia were modifiable risk factors in clinical practice for these children.

PMID: [34574857](#)

24. Burden of Malnutrition among Children and Adolescents with Cerebral Palsy in Arabic-Speaking Countries: A Systematic Review and Meta-Analysis

Sami Mukhdari Mushta, Israt Jahan, Risad Sultana, Sarah McIntyre, Al-Mamoon Badahdah, Nihad A Almasri, Catherine King, Harunor Rashid, Nadia Badawi, Gulam Khandaker

Review Nutrients. 2021 Sep 15;13(9):3199. doi: 10.3390/nu13093199.

Background: We aimed to estimate the burden and underlying risk factors of malnutrition among children and adolescents with cerebral palsy in Arabic-speaking countries. Methods: OVID Medline, OVID Embase, CINAHL via EBSCO, Cochrane Library, and SCOPUS databases were searched up to 3 July 2021. Publications were reviewed to identify relevant papers following pre-defined inclusion/exclusion criteria. Two reviewers independently assessed the studies for inclusion. Data extraction was independently completed by two reviewers. Descriptive and pooled analysis has been reported. Results: From a total of 79 records screened, nine full-text articles were assessed for eligibility, of which seven studies met the inclusion criteria. Study characteristics, anthropometric measurements used, and nutritional outcome reported varied between the studies. The included studies contained data of total 400 participants aged 1-18 years. Overall, (mean: 71.46%, 95% confidence interval: 55.52-85.04) of children with cerebral palsy had at least one form of malnutrition. Severe gross motor function limitation, feeding difficulties, cognitive impairment and inadequate energy intake were the commonly reported underlying risk factors for malnutrition among children with cerebral palsy. Conclusions: The burden of malnutrition is high among children with cerebral palsy in Arabic-speaking countries. More research is needed for better understanding of this public health issue in these countries.

PMID: [34579076](#)

25. Outcome of Community-Based Early Intervention and Rehabilitation for Children with Cerebral Palsy in Rural Bangladesh: A Quasi-Experimental Study

Tasneem Karim, Mohammad Muhit, Israt Jahan, Claire Galea, Catherine Morgan, Hayley Smithers-Sheedy, Nadia Badawi, Gulam Khandaker

Brain Sci. 2021 Sep 10;11(9):1189. doi: 10.3390/brainsci11091189.

We evaluated the outcome of a community-based early intervention and rehabilitation for children with cerebral palsy (CP) in Bangladesh. Children registered on the Bangladesh CP Register (BCPR) were recruited in two groups for this study: Group A received a comprehensive six-month long community-based caregiver-led intervention program at the "Shishu Shorgo" (Bengali title, which translates to 'Children's Heaven') Early Intervention and Rehabilitation Centres developed to support participants from the BCPR. Group B received standard care. A quasi-experimental study was conducted. Data were obtained at baseline, at the end of the program (i.e., 6 months), and at a 12-month follow-up. Outcome measures for children included gross motor functional measure (GMFM-66), Communication Function Classification System (CFCS), and Viking Speech Scale (VSS) and, for adult caregivers, the depression, anxiety, and stress scale (DASS 21). Between October 2016 and March 2017, 156 children with CP were recruited (77 in Group A and 79 in Group B). The total score of GMFM-66, CFCS level, and VSS level significantly improved statistically in Group A ($p < 0.05$ for all) and deteriorated in Group B ($p < 0.001$, $p = 0.095$, $p = 0.232$). The intervention showed promising outcomes particularly for children with CP under five years of age. There is a need for caregiver-led community-based programs for children with CP in LMICs.

PMID: [34573210](https://pubmed.ncbi.nlm.nih.gov/34573210/)

26. Neuroprem 2: An Italian Study of Neurodevelopmental Outcomes of Very Low Birth Weight Infants

Licia Lugli, Luca Bedetti, Isotta Guidotti, Marisa Pugliese, Odoardo Picciolini, Maria Federica Roversi, Elisa Della Casa Muttini, Laura Lucaccioni, Natascia Bertocelli, Gina Ancora, Giancarlo Gargano, Fabio Mosca, Fabrizio Sandri, Luigi Tommaso Corvaglia, Agostina Solinas, Serafina Perrone, Marcello Stella, Neuroprem Working Group; Lorenzo Iughetti, Alberto Berardi, Fabrizio Ferrari

Front Pediatr. 2021 Sep 13;9:697100. doi: 10.3389/fped.2021.697100. eCollection 2021.

Background: Despite the increased survival of preterm newborns worldwide, the risk of neurodevelopmental disabilities remains high. Analyzing the outcomes of the preterm population can identify risk factors and enable specific early interventions. **Aims:** Neuroprem is a prospective cohort study of very low birth weight (VLBW) infants that aims to evaluate the neurodevelopmental outcomes and risk factors for severe functional disability at 2 years of corrected age. **Methods:** Nine Italian neonatal intensive care units participated in the network. The Griffiths Mental Developmental Scales (GMDS-R) or the Bayley Scales of Infant and Toddler Development (BSDI III) and a neuro-functional evaluation (according to the International Classification of Disability and Health and Neuro-Functional Assessment, or NFA ICF-CY) were administered to VLBW infants at 24 months of corrected age. The primary outcome measure was severe functional disability, defined as cerebral palsy, bilateral blindness, deafness, an NFA ICF-CY of >2 , a BSDI III cognitive composite score of <2 SD, or a GMDS-R global quotient score of <2 SD. Perinatal risk factors for severe functional disability were assessed through multivariate logistic regression analysis. **Results:** Among 502 VLBW survivors who completed the 24-month follow-up, 48 (9.6%) presented severe functional disability, of whom 27 had cerebral palsy (5.4%). Rates of severe functional disability and cerebral palsy were higher in neonates with a lower gestational age ($p < 0.001$). Overall, 147 infants (29.3%) were referred to neuromotor intervention. In the multivariate regression model, gestational age at birth OR 0.79; 95% CI 0.67-0.90; $p = 0.001$) and periventricular-intraventricular hemorrhage (OR 2.51; 95% CI 1.19-5.26; $p = 0.015$) were significantly associated with severe functional disability. **Conclusion:** Neuroprem 2 provides updated information on the neurodevelopmental outcomes of VLBW infants in a large Italian cohort. The overall rate of neurodevelopmental disabilities was quite lower than reported in the previous literature. These data indicate the need for structured follow-up programs from a national neonatal network perspective.

PMID: [34589450](https://pubmed.ncbi.nlm.nih.gov/34589450/)

27. Long-Term Outcomes of Perinatal Hypoxia and Asphyxia at an Early School Age

Renata Dzikiėnė, Saulius Lukoėevičius, Jūratė Laurynaitienė, Vitalija Marmienė, Irena Nedzelskienė, Rasa Tamelienė, Inesa Rimdeikienė, Auėrelė Kudrevičienė

Medicina (Kaunas). 2021 Sep 18;57(9):988. doi: 10.3390/medicina57090988.

Background and Objectives: Late long-term outcomes of perinatal asphyxia (PA) in school-age are often unclear. To assess long-term outcomes at an early school age in children who had experienced perinatal hypoxia or asphyxia, where therapeutic hypothermia was not applied. **Materials and Methods:** The case group children were 8-9-year-old children (n = 32) who were born at full term and experienced hypoxia or asphyxia at birth, where therapeutic hypothermia (TH) was not applied. The control group consisted of 8-9-year-old children (n = 16) born without hypoxia. A structured neurological examination was performed at an early school age. The neuromotor function was assessed using the Gross Motor Function Classification System (GMFCS). Health-related quality-of-life was assessed using the Health Utilities Index (HUI) questionnaire. Intellectual abilities were assessed using the Wechsler Intelligence Scale for Children (WISC). **Results:** The case group, compared with controls, had significantly (p = 0.002) lower mean [SD] full-scale IQ (87(16.86) vs. 107(12.15)), verbal-scale IQ (89(17.45) vs. 105(11.55)), verbal comprehension index (89(17.36) vs. 105(10.74)), working memory index (89(15.68) vs. 104(11.84)), performance IQ (87(16.51) vs. 108(15.48)) and perceptual organization index (85(15.71) vs. 105(15.93)). We did not find any significant differences in the incidence of disorders of neurological examination, movement abilities and health-related quality of life at an early school age between the case and the control group children. **Conclusion:** In children who experienced perinatal asphyxia but did not have cerebral paralysis (CP), where therapeutic hypothermia was not applied, cognitive assessment scores at an early school age were significantly lower compared to those in the group of healthy children, and were at a low average level.

PMID: [34577911](https://pubmed.ncbi.nlm.nih.gov/34577911/)

28. Early Intervention in Unilateral Cerebral Palsy: Let's Listen to the Families! What Are Their Desires and Perspectives? A Preliminary Family-Researcher Co-Design Study

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Children (Basel). 2021 Aug 30;8(9):750. doi: 10.3390/children8090750.

Cerebral palsy (CP) is a clinical diagnosis based on a combination of clinical and neurological signs, which occurs between the ages of 12 and 24 months. Cerebral palsy or a high risk of cerebral palsy can be accurately predicted before 5-6 months, which is the corrected age. This would allow the initiation of intervention at an early stage. Parents must be more involved in the development and implementation of the early therapy, increasing opportunities for parent-child interaction. The aim of this study was to learn from the perspectives of families with children under 12 months with unilateral cerebral palsy (UCP), what ingredients (barriers and facilitators) should be involved in early intervention so that we could co-design (researchers and families) a multidisciplinary guideline for a global intervention addressed to the needs of the child and the family. Semi-structured interviews were conducted at a time and venue convenient for the families. A total of ten families with experience in early intervention were invited to attend the interview with open questions: (1) What components should early intervention have for a baby diagnosed with UCP? (2) What components should early intervention have for the family? (3) What should the involvement of the family be in early intervention? (4) What barriers included in early intervention should be removed? From the data analysis, three key topics emerged and were subsequently named by focus group participants: (1) UCP early intervention components, (2) family involvement in early intervention of UCP, and (3) removing barriers and creating facilitators within early intervention. The participation of the families (mothers) in the co-design of the necessary ingredients within the scope of a multidisciplinary early intervention guide aimed at children with UCP under 12 months allows learning about their reality and not that of the therapist. The following list highlights the present barriers as perceived by the parents: intervention as spectators, therapeutic goals, clinic environment, and lack of empathy, and the possible facilitators determined by the parents during the implementation comprised teamwork, the family's goals, motivation during the intervention, and learning at home. Thus, an early intervention program to improve global functionality should address family involvement through multidisciplinary coaching and the modification of the environment, encouraging family goals and family support through the family-therapist team.

PMID: [34572182](https://pubmed.ncbi.nlm.nih.gov/34572182/)

29. Sex differences in the canalization of child growth and development: An example of genetic regulation [Article in English, Spanish]

Horacio Lejarraga

Arch Argent Pediatr. 2021 Oct;119(5):e473-e479. doi: 10.5546/aap.2021.eng.e473.

In case of a disease or nutritional deficit, the growth curve may show deviations from the percentile it was depicting, and once damage is removed, a strong regulatory force tends to restore its path. Such phenomenon is known as catch-up growth and is an example of canalization of growth. Girls are more favored than boys because, when faced with the same damage, their growth (and also their psychomotor development) shows less deviation than that of boys. Such difference is also shown in a higher prevalence among boys of growth retardation in general and some developmental disorders, including autism spectrum disorder and cerebral palsy. Infant mortality is lower in girls at all ages and life expectancy is several years longer in women from all countries. The cause of such differences in favor of girls has a strong genetic component and is enriching for the interpretation of clinical and epidemiological studies.

PMID: [34569747](#)

30. Numerical cognition in children with cerebral palsy

Silvia Cristina de Freitas Feldberg, Thiago da Silva Gusmão Cardoso, Flavia H Santos, Mauro Muszkat, Orlando Francisco Amodeo Bueno, Claudia Berlim de Mello

Res Dev Disabil. 2021 Sep 22;119:104086. doi: 10.1016/j.ridd.2021.104086. Online ahead of print.

Children with Cerebral Palsy (CP) often perform poorly in mathematics. It is not yet clear to what extent mathematics difficulties in this clinical condition are similar to those observed in developmental dyscalculia. To better elucidate this issue, we conducted an exploratory cross-sectional study with a sample of children and adolescents with congenital brain injuries and educational history of problems in Mathematics. Fifty students aged 7-15 years, of both genders (28 males) participated in the study, 31 with typical development (TD) and 19 of whom diagnosed with spastic CP. Nine had hemiplegia and ten diplegia. Assessment procedures included a neuropsychological battery covering numerical cognition (ZAREKI-R) and working memory (AWMA) skills, and a computerized task for comparing non-symbolic magnitudes as a measure of number sense. Despite average intelligence coefficient, participants with CP underperformed the TD in five of the 12 ZAREKI-R subtests, as well as in the number sense and working memory tasks. Scores were lower among hemiplegic children compared to diplegic, numerical cognition was impaired in all CP group, unveiling a dyscalculia secondary to neurodevelopmental impairments. Therefore, we can consider that mathematical learning difficulties in CP as being heterogeneous and associated with the immaturity of neuropsychological functions, with consequences for the development of numerical cognition.

PMID: [34562825](#)

31. Selective Motor Control is a Clinical Correlate of Brain Motor Tract Impairment in Children with Spastic Bilateral Cerebral Palsy

A Vuong, E G Fowler, J Matsumoto, L A Staudt, H Yokota, S H Joshi

AJNR Am J Neuroradiol. 2021 Sep 30. doi: 10.3174/ajnr.A7272. Online ahead of print.

Background and purpose: Selective voluntary motor control is an important factor influencing gross motor function, interjoint coordination, and the outcome of hamstring-lengthening surgery in spastic cerebral palsy. Using DTI, we investigated whether selective voluntary motor control would show strong correlations with WM motor tract microstructure and whether selective voluntary motor control is more sensitive to global WM impairment than gross motor function. **Materials and methods:** Children with spastic bilateral cerebral palsy born preterm and typically developing children were recruited. The Selective Control Assessment of the Lower Extremity (SCALE) and Gross Motor Function Measure (GMFM) were assessed in participants with cerebral palsy. Participants underwent brain MR imaging to collect DWI data. Tract-Based Spatial Statistics was used to analyze the WM for between-group differences and correlations with SCALE and GMFM. ROI analyses compared motor regions. **Results:** Twelve children with cerebral palsy (mean age, 11.5 years) and 12 typically developing children (mean age, 10.3 years) participated. Altered DTI outcomes were found throughout the whole brain for the cerebral palsy group.

SCALE, developed to evaluate selective voluntary motor control in cerebral palsy, showed significant positive correlations with fractional anisotropy in more WM voxels throughout the whole brain and for motor regions, including the corticospinal tract and corpus callosum, compared with GMFM. A significant negative correlation between radial diffusivity and SCALE, but not GMFM, was found within the corpus callosum. Conclusions: SCALE was a more sensitive clinical correlate of motor and whole-brain WM tract impairment in children with spastic bilateral cerebral palsy, suggesting greater anisotropy and myelination in these regions for those with higher selective voluntary motor control.

PMID: [34593378](#)

32. Skeletal Muscle Mitochondrial Physiology in Children With Cerebral Palsy: Considerations for Healthy Aging Sudarshan Dayanidhi

Review Front Neurol. 2021 Sep 13;12:735009. doi: 10.3389/fneur.2021.735009. eCollection 2021.

Skeletal muscle contractile proteins require a constant supply of energy to produce force needed for movement. Energy (ATP) is primarily produced by mitochondrial organelles, located within and around muscle fibers, by oxidative phosphorylation that couples electron flux through the electron transport chain to create a proton gradient across the inner mitochondrial membrane that is in turn used by the ATP synthase. Mitochondrial networks increase in size by biogenesis to increase mitochondrial abundance and activity in response to endurance exercise, while their function and content reduce with constant inactivity, such as during muscle atrophy. During healthy aging, there is an overall decline in mitochondrial activity and abundance, increase in mitochondrial DNA mutations, potential increase in oxidative stress, and reduction in overall muscular capacity. Many of these alterations can be attenuated by consistent endurance exercise. Children with cerebral palsy (CP) have significantly increased energetics of movement, reduced endurance capacity, and increased perceived effort. Recent work in leg muscles in ambulatory children with CP show a marked reduction in mitochondrial function. Arm muscles show that mitochondrial protein content and mitochondria DNA copy number are lower, suggesting a reduction in mitochondrial abundance, along with a reduction in markers for mitochondrial biogenesis. Gene expression networks are reduced for glycolytic and mitochondrial pathways and share similarities with gene networks with aging and chronic inactivity. Given the importance of mitochondria for energy production and changes with aging, future work needs to assess changes in mitochondria across the lifespan in people with CP and the effect of exercise on promoting metabolic health.

PMID: [34589051](#)

33. Bone Mineral Density in Adults With Cerebral Palsy Jun Hee Won, Se Hee Jung

Front Neurol. 2021 Sep 10;12:733322. doi: 10.3389/fneur.2021.733322. eCollection 2021.

Low bone mineral density (BMD) is an emerging health issue in adults with cerebral palsy (CP). This cross-sectional study aimed to describe the characteristics of BMD in adults with CP, and to elucidate the risk factors for low BMD in this population. People aged ≥ 20 years and diagnosed with CP were recruited from February 2014 to November 2014. We assessed BMD using dual-energy X-ray absorptiometry (DXA) for the lumbar spine, femoral neck, and total femur. Moreover, the body composition was assessed using DXA. We included a total of 87 adults with CP (mean age 42.01 years; 52 men). The prevalence of low BMD was 25.3%. Male sex and age were associated with lower BMD. BMD was significantly lower in the non-ambulatory group than that in the ambulatory group for both lumbar spine and femoral neck. The total fat mass demonstrated a positive correlation with the Z-score and BMD for the femur neck and total femur. Body mass index (BMI) and total fat mass were positively correlated with BMD in the lumbar spine, femoral neck, and total femur. However, the Gross Motor Function Classification Scale levels were negatively correlated with BMD at the aforementioned three sites. In conclusion, adults with CP revealed decreased BMD, which was associated with male sex, age, decreased gross motor function, loss of ambulatory function, low BMI, decreased total fat mass, and decreased total fat-free mass.

PMID: [34566876](#)

34. The Association Between Kidney Disease and Mortality Among Adults With Cerebral Palsy-A Cohort Study: It Is Time to Start Talking About Kidney Health

Daniel G Whitney, Andrea L Oliverio

Front Neurol. 2021 Sep 10;12:732329. doi: 10.3389/fneur.2021.732329. eCollection 2021.

Objective: Recent evidence shows that adults with cerebral palsy (CP) have an increased risk for kidney disease, but nothing is known about how kidney disease integrates with their overall health. To begin understanding the importance of kidney health, the objective was to determine if kidney disease is associated with mortality among adults with CP after accounting for comorbidities common to CP and kidney disease. **Methods:** Data from 2016 to 2018 from adults ≥ 18 years with CP were used from a random 20% sample fee-for-service Medicare database. Kidney disease in 2016 was ascertained as chronic kidney disease (CKD) stages 1-4, end stage kidney disease (ESKD), nephritic and nephrotic syndrome, and renal osteodystrophy. A modified version of the Whitney Comorbidity Index (modWCI) was used, which includes 24 comorbidities relevant to CP and kidney disease. Mortality rate ratio (MRR) through the year 2018 was estimated for each kidney disease and Cox regression estimated the hazard ratio (HR) of mortality after adjusting for demographics, co-occurring neurological conditions, and the modWCI. **Results:** Prevalence of kidney disease was 7.3% among 16,728 adults with CP. MRR was elevated for any kidney disease (MRR = 3.14; 95%CI = 2.76-3.58) and most subtypes (MRR = 2.21-3.56; all $p < 0.05$). The adjusted HR of mortality remained elevated for any kidney disease (HR = 1.25; 95%CI = 1.09-1.45) and ESKD (HR = 1.38; 95%CI = 1.10-1.74). **Discussion:** Kidney disease, especially ESKD, is associated with mortality among adults with CP independent of comorbidities that are relevant to CP and kidney disease. Findings suggest that nephrology care should be considered as part of routine clinical care for this population.

PMID: [34566875](https://pubmed.ncbi.nlm.nih.gov/34566875/)

35. Hyperbaric Oxygen Therapy Is Beneficial for the Improvement of Clinical Symptoms of Cerebral Palsy: A Systematic Review and Meta-Analysis

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Meta-Analysis Complement Med Res. 2021 Sep 17;1-14. doi: 10.1159/000518785. Online ahead of print.

Introduction: Hyperbaric oxygen (HBO) has been used for the treatment of cerebral palsy for more than 20 years, but its efficacy and safety are still controversial. In this systematic review and meta-analysis, we evaluated the currently promulgated data related to the efficacy of HBO for patients with cerebral palsy. **Methods:** We searched the PubMed/Medline, Embase, Web of Science, Cochrane Library, China National Knowledge Infrastructure, and Wanfang databases (from their inception to April 2020) for randomized controlled trials published in English or Chinese. Two researchers used the Cochrane Collaboration tool for data extraction and an independent quality assessment. The extracted data were analyzed by Review Manager 5.3 software. **Results:** A total of 25 studies consistent with the inclusion criteria were included, with a total of 2,146 people, which included 1,185 participants in the HBO group and 961 in the control group. This meta-analysis showed that when compared with the controls, HBO therapy can improve the gross motor functions evaluated by the Gross Motor Function Measure ($n = 696$, SMD 0.29, 95% CI [0.07-0.51], $Z = 2.62$, $p = 0.009$) and Gross Motor Function Classification System ($n = 248$, MD -0.40, 95% CI [-0.52 to -0.27], $Z = 6.28$, $p < 0.00001$), global developmental level evaluated by Gesell ($n = 560$, RR 1.30, 95% CI [1.19-1.42], $Z = 6.03$, $p < 0.00001$) and developmental quotient ($n = 374$, MD 8.25, 95% CI [6.48-10.01], $Z = 9.15$, $p < 0.00001$) and language expression ($n = 270$, MD 4.34, 95% CI [2.30-6.38], $Z = 4.17$, $p < 0.00001$) and comprehension ($n = 270$, MD 4.87, 95% CI [2.87-6.88], $Z = 4.76$, $p < 0.00001$). HBO therapy only caused mild ear pain. However, the quality of the data for all outcomes evaluated by the Grading of Recommendations Assessment, Development, and Evaluation analysis was very low. **Conclusions:** HBO therapy may produce a much more efficient clinical experiment result than the control group with cerebral palsy patients, and HBO therapy is well tolerated and relatively safe for the included participants.

PMID: [34569525](https://pubmed.ncbi.nlm.nih.gov/34569525/)

Prevention and Cure

36. NAC and Vitamin D Improve CNS and Plasma Oxidative Stress in Neonatal HIE and Are Associated with Favorable Long-Term Outcomes

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Antioxidants (Basel). 2021 Aug 25;10(9):1344. doi: 10.3390/antiox10091344.

N-acetylcysteine (NAC) and vitamin D provide effective neuroprotection in animal models of severe or inflammation-sensitized hypoxic ischemic encephalopathy (HIE). To translate these FDA-approved drugs to HIE neonates, we conducted an early phase, open-label trial of 10 days of NAC (25, 40 mg/kg q12h) + 1,25(OH)₂D (calcitriol 0.05 mg/kg q12h, 0.03 mg/kg q24h), (NVD), for pharmacokinetic (PK) estimates during therapeutic hypothermia and normothermia. We paired PK samples with pharmacodynamic (PD) targets of plasma isoprostanoids, CNS glutathione (GSH) and total creatine (tCr) by serial MRS in basal ganglia (BG) before and after NVD infusion at five days. Infants had moderate (n = 14) or severe HIE (n = 16), funisitis (32%), and vitamin D deficiency (75%). NVD resulted in rapid, dose-responsive increases in CNS GSH and tCr that correlated positively with plasma [NAC], inversely with plasma isofurans, and was greater in infants with lower baseline [GSH] and [tCr], suggesting increases in these PD markers were titrated by neural demand. Hypothermia and normothermia altered NAC PK estimates. NVD was well tolerated. Excluding genetic syndromes (2), prolonged ECMO (2), lost-to-follow-up (1) and SIDS death (1), 24 NVD treated HIE infants have no evidence of cerebral palsy, autism or cognitive delay at 24-48 months. These data confirm that low, safe doses of NVD in HIE neonates decreased oxidative stress in plasma and CNS, improved CNS energetics, and are associated with favorable developmental outcomes at two to four years.

PMID: [34572976](https://pubmed.ncbi.nlm.nih.gov/34572976/)