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Interventions and Management

Interventions and Management

1. Bulbar Muscle Weakness in the Setting of Therapeutic Botulinum Injections.

Lentz J, Weingrow D. Clin Pract Cases Emerg Med. 2018 Sep 28;2(4):330-333. doi: 10.5811/cpcem.2018.8.39178. eCollection 2018 Nov.

We present a case of new-onset bulbar muscle weakness in the setting of therapeutic botulinum injections for spasticity in a teenaged patient with cerebral palsy. Through a careful history, a systemic effect of the local injections was suspected, and the patient's symptoms improved with a decrease in the dosing of the botulinum injections.

PMID: [30443619](#)

2. The impact of AlterG training on balance and structure of vestibulospinal tract in cerebral palsy children.

Azizi S, Rasooli AH, Soleimani M, Irani A, Shahrokhi A, Mirbagheri MM. Conf Proc IEEE Eng Med Biol Soc. 2018 Jul;2018:2499-2502. doi: 10.1109/EMBC.2018.8512772.

We aimed to investigate the effects of an antigravity treadmill (AlterG) on the balance and structure of the vestibulospinal tract. The AlterG can reduce the weight bearing of patients and hence can facilitate their locomotion. Three children with cerebral palsy (CP) received AlterG training three days per week for eight weeks with each session lasting 45 minutes. The balance of children was evaluated using the Berg balance test and the Timed Up and Go (TUG) test. The diffusion tensor imaging (DTI) method was employed to quantify changes of the structure of the vestibulospinal tract. Evaluations were performed before and after the 8-week training. DTI metrics including fractional anisotropy (FA), mean diffusivity (MD), radial diffusivity (RD) and axial diffusivity (AD) were measured to evaluate the vestibulospinal tract structure. The results showed that the mean FA of the vestibulospinal tract increased and other metrics decreased for all subjects. Our findings indicated that the balance and structure of the vestibulospinal tract were improved up to 30% for all children following the 8-week AlterG training. This indicates that the balance improvement of the CP children following the AlterG training was accompanied with persistent neuroplasticity in their brain. The clinical implication is that the AlterG training has a potential to be used as an effective therapeutic tool for the treatment of balance impairment in CP children.

PMID: [30440915](#)

3. Influence of accuracy constraints on bimanual coordination and gait performance in children with unilateral spastic cerebral palsy.

Ya-Ching H. Gait Posture. 2018 Nov 14;68:106-110. doi: 10.1016/j.gaitpost.2018.11.012. [Epub ahead of print]

BACKGROUND: Children with unilateral spastic cerebral palsy (USCP) have both upper and lower extremities movement impairments of their more affected side. Many daily activities require whole body movement control. However, most studies for children with USCP only evaluated either upper or lower extremity impairments. **RESEARCH QUESTION:** The present study aimed to assess the effects of accuracy constraints on walking and bimanual coordination for children with USCP during a whole body task. **METHODS:** Ten children with USCP (age: 7-12 years; GMFCS levels: I - II) and ten age-matched

typically-developed children (TDC) participated in the study. They were asked to walk and carry a water bottle with and without a cap using a tray at a preferred speed while 3-D kinematic analyses were performed. The two tasks of carrying a water bottle with and without a cap were each performed 5 trials with randomized order between participants. RESULTS: TDC significantly decreased their walking speed, stride length, height differences between the two hands (symmetric bimanual coordination), vertical hand movement, and elbow joint excursion under higher accuracy constraints with no water bottle cap. Children with USCP showed significantly decreased walking speed, vertical hand movement, and elbow joint excursion under higher accuracy constraints. Children with USCP also significantly decreased walking deviation of line of progression. SIGNIFICANCE: It is exciting to see that children with USCP GMFCS levels I and II were able to maintain their bimanual coordination and modify their gait performance under higher accuracy constraints. Therefore, future treatments or assessments could consider manipulating accuracy constraints even during complex whole body tasks for children with USCP.

PMID: [30469104](#)

4. The Evolution of Selective Dorsal Rhizotomy for the Management of Spasticity.

Enslin JMN, Langerak NG, Fieggan AG. Neurotherapeutics. 2018 Nov 20. doi: 10.1007/s13311-018-00690-4. [Epub ahead of print] Review.

Selective dorsal rhizotomy is a key technique in the surgical management of spasticity in patients with cerebral palsy. The technique evolved from the late 1800s when pioneers like Dana and Abbe performed dorsal rhizotomy in their treatment of refractory pain. These surgeons noted a reduction in muscle tone associated with the operation. When Sherrington then published his Nobel prize-winning work on the corticospinal tract and its role in the neuromuscular system in the 1890s, the course was set for modifying spasticity by aiming surgery at the dorsal roots. This procedure underwent multiple modifications through the next century and today it is, arguably, the most commonly performed operation to treat cerebral palsy children with spasticity. Selective dorsal rhizotomy is a technique that still teaches us a great deal about neurophysiology on a daily basis and it is thanks to the pioneers, described in this article, that we have this tool in our armamentarium.

PMID: [30460456](#)

5. Detection of Atypical and Typical Infant Movements using Computer-based Video Analysis.

Orlandi S, Raghuram K, Smith CR, Mansueto D, Church P, Shah V, Luther M, Chau T. Conf Proc IEEE Eng Med Biol Soc. 2018 Jul;2018:3598-3601. doi: 10.1109/EMBC.2018.8513078.

The diagnosis of cerebral palsy (CP) is difficult before 2 years of age. The general movements assessment (GMA) is a method for predicting CP from the spontaneous movements of infants in the first months of life. This assessment has shown high accuracy in predicting CP, but its use is limited by a lack of trained clinicians and its subjective nature. An objective and cost-effective alternative is the automatic videobased assessment of infant movements. Retrospective videos with clinical GMA outcomes were evaluated against eligibility criteria for the automatic analysis consisting of a skin model for segmentation and large displacement optical flow (LDOF) for motion tracking. Kinematic features were extracted to classify the movements as typical or atypical using different classification algorithms. Preliminary classification results obtained from the analysis of 127 videos of preterm infants showed up to 92% of accuracy in predicting CP. A computerbased assessment would provide clinicians with an objective tool for early diagnosis of CP, to facilitate early intervention and improve functional outcomes.

PMID: [30441155](#)

6. Therapeutic Effects of repetitive Transcranial Magnetic Stimulation on Corticospinal Tract Activities and Neuromuscular Properties in Children with Cerebral Palsy.

Parvin S, Shahrokhi A, Tafakhori A, Irani A, Rasteh M, Mirbagheri MM. Conf Proc IEEE Eng Med Biol Soc. 2018 Jul;2018:2218-2221. doi: 10.1109/EMBC.2018.8512805.

The objective of this research was to study the therapeutic effects of repetitive transcranial magnetic stimulation (rTMS) on corticospinal tract (CST) activities, reflex hyper-excitability, muscle stiffness, and the clinical status of children with spastic hemiplegic cerebral palsy (CP). Three children participated in this study. The treatment lasted for 6 weeks. Two of the patients, the experimental group, received rTMS therapy 4 days a week during the first 3 weeks, and then received typical occupational therapy (OT) after each rTMS session during the second 3 weeks. One patient, the control group, received the same treatment except that a sham coil was used. Each rTMS session lasted for 20 minutes and each OT session lasted for 45 minutes. We evaluated CST activities by transcranial magnetic stimulation (TMS), reflex hyperexcitability by H-reflex response, and muscle stiffness by sonoelastography images. The tests were taken before and after the treatment. Major TMS parameters (i.e., motor evoked potential (MEP) latency, MEP p-p amplitude, cortical silent period (cSP), and intensity of pulse) for experimental patients were improved in comparison with the control patient. H response latency and max H response on max M-wave (H/M) were improved for the experimental group compared to the control group. Two parameters of texture analysis of the sonoelastography images (i.e., entropy and contrast) were improved for the experimental group. Clinical evaluations such as 10 meter walk test (10MWT), timed up and go (TUG), and 6 minute walk test (6MWT) were performed before and after the course of treatment and were improved for the experimental group compared to the control group. These results indicated that

rTMS therapy can improve CST activities, reflexes, muscle stiffness, and walking capacity of spastic hemiplegic CP. Therefore, it can be considered as an effective therapeutic tool for enhancing neuromuscular abnormalities resulting from CP.

PMID: [30440846](#)

7. The Impact of Repetitive Transcranial Magnetic Stimulation on Affected and Unaffected Sides of a Child with Hemiplegic Cerebral Palsy.

Parvin S, Mehdinezhad M, Taghiloo A, Nourian R, Mirbagheri MM. Conf Proc IEEE Eng Med Biol Soc. 2018 Jul;2018:2523-2526. doi: 10.1109/EMBC.2018.8512877.

The purpose of this study was to investigate the therapeutic effects of neuro-navigated repetitive transcranial magnetic stimulation (rTMS) combined with occupational therapy (OT) on gait impairment of a child (male, age: 13.2) with spastic hemiplegic cerebral palsy (CP). The treatment included 4 days a week of rTMS sessions for 3 weeks and 4 days of rTMS and OT sessions per week for 3 weeks. Transcranial magnetic stimulation (TMS) was used to evaluate corticospinal tract (CST) activities and H-reflex test was used to assess reflex hyper-excitability. Common clinical tests demonstrate the clinical status of the patient. Evaluations were performed in 4 time steps: baseline, 3 weeks after the beginning of the treatment, at the end of the treatment, and 1 month after the end of the treatment. The patient did not receive any specific treatment after the end of the treatment up to the follow up evaluations. The tests' results were compared between the affected and unaffected legs of the patient. Four parameters of the TMS test were calculated (motor evoked potential (MEP) latency, MEP peak-to-peak amplitude, cortical silent period (cSP), and stimulation intensity). These parameters were all improved for the affected side and cSP improved for the unaffected side, but MEP p-p amplitude and intensity got worse slightly for the unaffected side. Recruitment curves of H response and M-wave of the H-reflex test for both sides were obtained. Improvements could be seen after the treatment for both sides. Max H response on max M-wave (H/M) and H response latency got better after the treatment for both sides. Walking speed for self and fast velocity, timed up and go, and walking endurance improved during and after the treatment. All the improvements persisted after one month of the end of the treatment in the follow up evaluations. These findings indicate that rTMS combined with OT can have effective and long-lasting impact on neuromuscular impairments in spastic CP children.

PMID: [30440921](#)

8. The Effects of Low Frequency Repetitive Transcranial Magnetic Stimulation on White Matter Structural Connectivity in Children with Cerebral Palsy.

Marzbani H, Shahrokhi A, Irani A, Mehdinezhad M, Kohanpour M, Mirbagheri MM. Conf Proc IEEE Eng Med Biol Soc. 2018 Jul;2018:2491-2494. doi: 10.1109/EMBC.2018.8512866.

Repetitive transcranial magnetic stimulation (rTMS) is a non-invasive treatment technique for recovery of movement disorders by altering cortical plasticity. In this research, we studied the effects of low-frequency rTMS on white matter (WM) structural connectivity and clinical parameters in children with cerebral palsy (CP). Four spastic hemiplegic CP children were randomly divided into experimental and control groups. In the experimental group, at first, 1Hz rTMS treatment was performed 4 days/week for 3 weeks on two hemiplegia patients over a contralesional primary motor cortex (M1). Then, 1Hz rTMS treatment was performed 4 days/week for 3 weeks followed by a 30min occupational therapy (OT). In the control group, two CP children received sham rTMS for 3 weeks and then sham rTMS combined with OT for 3 weeks in the same schedule as the experimental group. Evaluations performed using diffusion tensor imaging (DTI), and clinical measurements of gait performance before and after the treatment. Graph theoretical analysis was used to characterize topological changes of structural connectivity. Our findings demonstrate the 1Hz rTMS is effective in improving motor activity in spastic hemiplegic CP children, and is more effective when combined with OT.

PMID: [30440913](#)

9. Unusual dermoscopic feature of a melanocytic naevus on load bearing plantar skin never pressured because of cerebral palsy.

Ito A, Sugita K, Goto H, Yamamoto O. Australas J Dermatol. 2018 Nov 18. doi: 10.1111/ajd.12953. [Epub ahead of print] No abstract available.

PMID: [30450541](#)

10. Immediate effects of immersive biofeedback on gait in children with cerebral palsy.

Booth ATC, Buizer AI, Harlaar J, Steenbrink F, van der Krogt MM. Arch Phys Med Rehabil. 2018 Nov 14. pii: S0003-9993(18)31449-7. doi: 10.1016/j.apmr.2018.10.013. [Epub ahead of print]

OBJECTIVE: To investigate the immediate response to avatar-based biofeedback on three clinically important gait parameters; step length, knee extension and ankle power, in children with cerebral palsy (CP). **DESIGN:** Repeated measures design. **SETTING:** Rehabilitation clinic. **PARTICIPANTS:** Twenty-two children with spastic paresis (10y4m±3y1m), able to walk without assistive devices. **INTERVENTION:** Children walked on a treadmill with virtual reality environment. Following baseline gait analysis, they were challenged to improve aspects of gait. Children visualized themselves as an avatar, representing movement in real-time. They underwent a series of two-minute trials receiving avatar based biofeedback on step length, knee extension and ankle power. To investigate optimization of biofeedback visualization, additional trials in which knee extension was visualized as a simple bar with no avatar; and a further trial with avatar alone, and no specific biofeedback were carried out. **MAIN OUTCOME MEASURES:** Gait pattern, as measured by joint angles, powers and spatiotemporal parameters, were compared between baseline and biofeedback trials. **RESULTS:** Participants were able to adapt gait pattern with biofeedback, in an immediate response, reaching large increases in ankle power generation at push-off (37.7%) and clinically important improvements in knee extension (7.4o) and step length (12.7%). Biofeedback on one parameter had indirect influence on other aspects of gait. **CONCLUSION:** Children with CP show capacity in motor function to achieve improvements in clinically important aspects of gait. Visualizing biofeedback with an avatar was subjectively preferential compared to a simplified bar presentation of knee angle. Future studies are required to investigate if observed transient effects of biofeedback can be retained with prolonged training to test whether biofeedback-based gait training may be implemented as a therapy tool.

PMID: [30447196](#)

11. A proposal for a kinetic summary measure: the Gait Kinetic Index.

Cimolin V, Condoluci C, Costici PF, Galli M. *Comput Methods Biomech Biomed Engin.* 2018 Nov 16:1-6. doi: 10.1080/10255842.2018.1536750. [Epub ahead of print]

A new summary index for kinetic gait data is proposed (Gait Kinetic Index - GKI), BASED on six kinetic selected variables: hip, knee and ankle moments and powers on the sagittal plane. This method was applied on a control group (CG) of 18 subjects and on 57 patients with diplegic Cerebral Palsy (CP). CP showed statistical different GKI value in comparison with CG. The same is for the sub GKI with the exclusion of GKI Knee Power. The GKI seems to be a promising tool useful to measure extensively the gait pathology taking into consideration kinetic aspects of gait pattern.

PMID: [30444127](#)

12. Correction of Toe-Walking Gait in Children with Spastic Cerebral Palsy by using Electrical Stimulation Therapy.

Mukhopadhyay R, Mahadevappa M, Lenka PK, Biswas A. *Conf Proc IEEE Eng Med Biol Soc.* 2018 Jul;2018:3529-3532. doi: 10.1109/EMBC.2018.8513043.

Toe-walking is a very common gait abnormality seen in children with Cerebral Palsy (CP). The present study aims to improvise the toe-walking gait by applying Electrical Stimulation (ES) therapy of the Tricep Surae (TS) muscles. The study was carried out on sixteen children with spastic CP with unilateral toe-walking gait problem, divided into the intervention group that received both ES therapy along with conventional physiotherapy treatment and the control group that received only conventional physiotherapy treatment. Both groups were treated for 60 (30 + 30) minutes per day, for 5 days a week, up to 12 weeks. The gait data were analyzed for spatiotemporal and parameters influencing the walking capacity. The results showed that those children who received the intervention had a significant increase in gait speed by 17.67 % (p = 0.019) and decrease in stride length by 10.25 % (p = 0.037), resulting in improvement of body balance. There was a significant percentage increase in initial contact (heel strike) of 85.71 % (p = 0.000) and flat foot position (loading response) of 49.2 % (p = 0.005), confirming reduction in toe-walking. There was also an increase in the swing power by 39.8 % (p = 0.028) and ground impact by 19.5 % (p = 0.003) suggesting a change in foot contact pattern. The results indicate that ES therapy on TS muscle along with conventional physiotherapy may correct the toe-walking gait in children with spastic hemiplegic CP.

PMID: [30441140](#)

13. Assessment of neuroplasticity of corticospinal tract induced by antigravity treadmill (AlterG) in cerebral palsy children.

Azizi S, Birgani PM, Marzbani H, Nourian R, Kohanpour M, Mirbagheri MM. *Conf Proc IEEE Eng Med Biol Soc.* 2018 Jul;2018:2495-2498. doi: 10.1109/EMBC.2018.8512730.

The aim of this study was to assess neuroplasticity that occurred in the corticospinal tract (CST) following antigravity treadmill (AlterG) training. AlterG can facilitate walking by having up to an 80% reduction of weight-bearing in patients. Systematic and intensive gait training for sufficient periods of time may lead to neuroplasticity and walking capacity improvement. AlterG gait training was done for eight weeks, 3 sessions per week, and 45 minutes each session. Three cerebral palsy (CP) children participated in this study. The function and structure of CST on the brain's more affected side were evaluated using Transcranial Magnetic Stimulation (TMS) and Diffusion Tensor Imaging (DTI). Also, some common clinical tests were

performed to evaluate walking capacity and endurance. DTI features such as fractional anisotropy (FA) and mean diffusivity (MD) as well as some TMS features were extracted to estimate structural changes of the CST. The evaluations were performed before and after 8week AlterG training. The results showed an improvement in the DTI metrics of the CST following AlterG training. Also, TMS parameters were improved and these changes in CST function and structure were concurrent with changes in walking capacity. These results suggest that AlterG training can be used as a therapeutic tool to provide an effective and persistent gait improvement in CP children.

PMID: [30440914](#)

14. Machine learning algorithms for activity recognition in ambulant children and adolescents with cerebral palsy.

Ahmadi M, O'Neil M, Fragala-Pinkham M, Lennon N, Trost S. *J Neuroeng Rehabil.* 2018 Nov 15;15(1):105. doi: 10.1186/s12984-018-0456-x.

BACKGROUND: Cerebral palsy (CP) is the most common physical disability among children (2.5 to 3.6 cases per 1000 live births). Inadequate physical activity (PA) is a major problem effecting the health and well-being of children with CP. Practical, yet accurate measures of PA are needed to evaluate the effectiveness of surgical and therapy-based interventions to increase PA. Accelerometer-based motion sensors have become the standard for objectively measuring PA in children and adolescents; however, current methods for estimating physical activity intensity in children with CP are associated with significant error and may dramatically underestimate HPA in children with more severe mobility limitations. Machine learning (ML) models that first classify the PA type and then predict PA intensity or energy expenditure using activity specific regression equations may be more accurate than standalone regression models. However, the feasibility and validity of ML methods has not been explored in youth with CP. Therefore, the purpose of this study was to develop and test ML models for the automatic identification of PA type in ambulant children with CP. **METHODS:** Twenty two children and adolescents (mean age: 12.8 ± 2.9 y) with CP classified at GMFCS Levels I to III completed 7 activity trials while wearing an ActiGraph GT3X+ accelerometer on the hip and wrist. Trials were categorised as sedentary (SED), standing utilitarian movements (SUM), comfortable walking (CW), and brisk walking (BW). Random forest (RF), support vector machine (SVM), and binary decision tree (BDT) classifiers were trained with features extracted from the vector magnitude (VM) of the raw acceleration signal using 10 s non-overlapping windows. Performance was evaluated using leave-one-subject out cross validation. **RESULTS:** SVM (82.0-89.0%) and RF (82.6-88.8%) provided significantly better classification accuracy than BDT (76.1-86.2%). Hip (82.7-85.5%) and wrist (76.1-82.6%) classifiers exhibited comparable prediction accuracy, while the combined hip and wrist (86.2-89.0%) classifiers achieved the best overall performance. For all classifiers, recognition accuracy was excellent for SED (94.1-97.9%), good to excellent for SUM (74.0-96.6%) and brisk walking (71.5-86.0%), and modest for comfortable walking (47.6-70.4%). When comfortable and brisk walking were combined into a single walking class, recognition accuracy ranged from 90.3 to 96.5%. **CONCLUSIONS:** ML methods provided acceptable classification accuracy for detection of a range of activities commonly performed by ambulatory children with CP. The resultant models can help clinicians more effectively monitor bouts of brisk walking in the community. The results indicate that 2-step models that first classify PA type and then predict energy expenditure using activity specific regression equations are worthy of exploration in this patient group.

PMID: [30442154](#)

15. The Effects of Lower Body Positive Pressure Treadmill Training on Dynamic Balance of Children with Cerebral Palsy.

Dadashi F, Kharazi MR, Lotfian M, Shahroki A, Mirbagheri A, Mirbagheri MM. *Conf Proc IEEE Eng Med Biol Soc.* 2018 Jul;2018:2487-2490. doi: 10.1109/EMBC.2018.8512837.

We aimed to characterize the therapeutic effects of Anti-gravity (AlterG) body weight supported treadmill training on the impaired balance of children with cerebral palsy (CP). Four spastic CP children participated; two received AlterG training 3 times a week for 8 weeks and the other two received typical occupational therapy accordingly. Their dynamic balance was evaluated before the start of the treatment and 2 months after it. Features related to the center of pressure (COP) and the center of mass (COM) were considered as dynamic balance parameters. Our results showed that the maximum velocity and acceleration of the COP and COM, the average variability (RMS) and peak to peak of the COM-COP separation, and RMS of velocity and acceleration of the COM and COP were all improved for both AlterG training patients (15-90%), though there was a limited improvement of 0.2-24% in some features of the control patients. Our results demonstrate that intensive sessions of the AlterG training program could have the potential to be used as a therapeutic tool that can produce dynamic balance improvements in CP children compared to that of typical occupational therapy.

PMID: [30440912](#)

16. Is more frequent physical therapy associated with increased gross motor improvement in children with cerebral palsy? A national prospective cohort study.

Størvoold GV, Jahnsen RB, Evensen KAI, Bratberg GH. *Disabil Rehabil.* 2018 Nov 16:1-9. doi: 10.1080/09638288.2018.1528635. [Epub ahead of print]

PURPOSE: To investigate the association between physical therapy frequency and gross motor improvement in children with cerebral palsy (CP). **MATERIALS AND METHODS:** This is a prospective cohort study of 442 children aged 2-12 years, Gross Motor Function Classification System levels I-V, from the Cerebral Palsy Follow-up Program and the Cerebral Palsy Register of Norway. Outcome was change in reference percentiles for the Gross Motor Function Measure (GMFM-66) between two subsequent assessments (N = 1056) analyzed in a linear mixed model. **RESULTS:** It was a dose response association between physical therapy frequency and gross motor improvement. Mean change was 4.2 (95% CI: 1.4-7.1) percentiles larger for physical therapy 1-2 times per week and 7.1 (95% CI: 2.6-11.6) percentiles larger for physical therapy >2 times per week, compared to less frequent physical therapy when analyzed in a multivariable model including multiple child and intervention factors. The only statistically significant confounder was number of contractures which was negatively associated with gross motor improvement. **CONCLUSIONS:** When gross motor improvement is a goal for children with CP, more frequent physical therapy should be considered. Implications for rehabilitation In general, the gross motor development of Norwegian children with cerebral palsy was as expected according to the reference percentiles for the GMFM-66. When gross motor improvement is a goal for children with cerebral palsy, high-frequency physical therapy should be considered. Contractures should be addressed in order to optimize gross motor improvement for children with cerebral palsy.

PMID: [30444146](#)

17. Repeatability of EMG activity during exoskeleton assisted walking in children with cerebral palsy: implications for real time adaptable control.

Bulea TC, Lerner ZF, Damiano DL. Conf Proc IEEE Eng Med Biol Soc. 2018 Jul;2018:2801-2804. doi: 10.1109/EMBC.2018.8512799.

Effective solutions for gait rehabilitation in children with cerebral palsy (CP) remain elusive. Wearable robotic exoskeletons offer the potential to greatly increase the dosage and intensity of gait training in this population, which may improve outcomes. We recently reported that a robotic exoskeleton significantly improved knee extension in children with crouch gait from CP. Longitudinal studies are necessary to fully understand long term biomechanical effects of exoskeleton gait training. Given that children's gait can change both as they develop and throughout their therapy, advanced control strategies which can adapt assistance over time may be beneficial. But, stride-to-stride variability makes it difficult to ascertain the effects of exoskeleton assistance and therefore complicates implementation of adaptable control algorithms. Here, we examine the use of the variance ratio (VR), a previously published measure, to assess the effect of exoskeleton assistance on knee extensor and flexor EMG variability in children with CP. Our results show that VR was significantly increased ($p < 0.001$) compared to baseline during walking with exoskeleton assistance. After five practice sessions, we found that VR was reduced though still greater than baseline levels. Given its sensitivity to exoskeleton assistance and ease of computation, VR may be a useful measure in the future for evaluating stride-to-stride variability in real time to inform algorithmic decision making for autonomous adaptable control.

PMID: [30440983](#)

18. Imaging functional motor connectivity in hemiparetic children with perinatal stroke.

Saunders J, Carlson HL, Cortese F, Goodyear BG, Kirton A. Hum Brain Mapp. 2018 Nov 17. doi: 10.1002/hbm.24474. [Epub ahead of print]

Perinatal stroke causes lifelong disability, particularly hemiparetic cerebral palsy. Arterial ischemic strokes (AIS) are large, cortical, and subcortical injuries acquired near birth due to acute occlusion of the middle cerebral artery. Periventricular venous infarctions (PVI) are smaller, subcortical strokes acquired prior to 34 weeks gestation involving injury to the periventricular white matter. Both stroke types can damage motor pathways, thus, we investigated resulting alterations in functional motor networks and probed function. We measured blood oxygen level dependent (BOLD) fluctuations at rest in 38 participants [10 arterial patients (age = 14.7 ± 4.1 years), 10 venous patients (age = 13.5 ± 3.7 years), and 18 typically developing controls (TDCs) (age = 15.3 ± 5.1 years)] and explored strength and laterality of functional connectivity in the motor network. Inclusion criteria included MRI-confirmed, unilateral perinatal stroke, symptomatic hemiparetic cerebral palsy, and 6-19 years old at time of imaging. Seed-based functional connectivity analyses measured temporal correlations in BOLD response over the whole brain using primary motor cortices as seeds. Laterality indices based on mean z-scores in lesioned and nonlesioned hemispheres explored laterality. In AIS patients, significant differences in both strength and laterality of motor network connections were observed compared with TDCs. In PVI patients, motor networks largely resembled those of healthy controls, albeit slightly weaker and asymmetric, despite subcortical damage and hemiparesis. Functional connectivity strengths were not related to motor outcome scores for either stroke group. This study serves as a foundation to better understand how resting-state fMRI can assess motor functional connectivity and potentially be applied to explore mechanisms of interventional therapies after perinatal stroke.

PMID: [30447082](#)

19. Neurodevelopmental Outcomes in Infants With Birth Weight ≤ 500 g at 3 Years of Age.

Inoue H, Ochiai M, Sakai Y, Yasuoka K, Tanaka K, Ichiyama M, Kurata H, Fujiyoshi J, Matsushita Y, Honjo S, Nonaka K, Taguchi T, Kato K, Ohga S; Neonatal Research Network of Japan. *Pediatrics*. 2018 Nov 16. pii: e20174286. doi: 10.1542/peds.2017-4286. [Epub ahead of print]

OBJECTIVES: To determine neurodevelopmental outcomes at 3 years of age in children born with a birth weight (BW) of ≤ 500 g. **METHODS:** Infants who were born with a BW of ≤ 500 g from 2003 to 2012 in the Neonatal Research Network of Japan and survived to discharge from the NICU were eligible in this study. The study population consisted of 460 children (56.7% of 811 surviving infants) who were evaluated at 36 to 42 months of age. Neurodevelopmental impairment (NDI) was defined as having cerebral palsy, visual impairment, hearing impairment, or a developmental quotient score of < 70 . **RESULTS:** The overall proportion of NDI was 59.1% (95% confidence interval [CI]: 54.6%-63.5%). The trend revealed no significant change during the study period. In a multivariate modified Poisson regression analysis, NDI was associated with severe intraventricular hemorrhage (adjusted risk ratio [RR]: 1.42; 95% CI: 1.19-1.68; $P < .01$), cystic periventricular leukomalacia (adjusted RR: 1.40; 95% CI: 1.13-1.73; $P < .01$), severe necrotizing enterocolitis (adjusted RR: 1.31; 95% CI: 1.07-1.60; $P < .01$), surgical ligation for patent ductus arteriosus (adjusted RR: 1.29; 95% CI: 1.09-1.54; $P < .01$), and male sex (adjusted RR: 1.19; 95% CI: 1.01-2.40; $P = .04$). **CONCLUSIONS:** This cohort showed that neurodevelopmental outcomes of infants with a BW of ≤ 500 g have not improved from 2003 to 2012. Multivariate analysis revealed that severe intracranial hemorrhage and cystic periventricular leukomalacia were the strongest risk factors for NDIs. Our data suggested that measures aimed at reducing neurologic morbidities will be important for improving outcomes of infants with a BW of ≤ 500 g.

PMID: [30446630](#)

20. Psychometric properties of the Quality of Life Inventory-Disability (QI-Disability) measure.

Downs J, Jacoby P, Leonard H, Epstein A, Murphy N, Davis E, Reddihough D, Whitehouse A, Williams K. *Qual Life Res*. 2018 Nov 20. doi: 10.1007/s11136-018-2057-3. [Epub ahead of print]

PURPOSE: Children with intellectual disability encounter daily challenges beyond those captured in current quality of life measures. This study evaluated a new parent-report measure for children with intellectual disability, the Quality of Life Inventory-Disability (QI-Disability). **METHODS:** QI-Disability was administered to 253 primary caregivers of children (aged 5-18 years) with intellectual disability across four diagnostic groups: Rett syndrome, Down syndrome, cerebral palsy or autism spectrum disorder. Exploratory and confirmatory factor analyses were conducted and goodness of fit of the factor structure assessed. Associations between QI-Disability scores, and diagnostic and age groups were examined with linear regression. **RESULTS:** Six domains were identified: physical health, positive emotions, negative emotions, social interaction, leisure and the outdoors, and independence. Goodness-of-fit statistics were satisfactory and similar for the whole sample and when the sample was split by ability to walk or talk. On 100 point scales and compared to Rett syndrome, children with Down syndrome had higher leisure and the outdoors (coefficient 10.6, 95% CI 3.4, 17.8) and independence (coefficient 29.7, 95% CI 22.9, 36.5) scores, whereas children with autism spectrum disorder had lower social interaction scores (coefficient - 12.8, 95% CI - 19.3, - 6.4). Scores for positive emotions (coefficient - 6.1, 95% CI - 10.7, - 1.6) and leisure and the outdoors (coefficient 5.4, 95% CI - 10.6, - 0.1) were lower for adolescents compared with children. **CONCLUSIONS:** Initial evaluation suggests that QI-Disability is a reliable and valid measure of quality of life across the spectrum of intellectual disability. It has the potential to allow clearer identification of support needs and measure responsiveness to interventions.

PMID: [30460513](#)

21. Validating the ICF core set for cerebral palsy using a national disability sample in Taiwan.

Liao HF, Hwang AW, Schiariti V, Yen CF, Chi WC, Liou TH, Hung HC, Hsieh YH. *Disabil Rehabil*. 2018 Nov 18:1-9. doi: 10.1080/09638288.2018.1504328. [Epub ahead of print]

PURPOSE: To validate the activities and participation (d) codes of two age-specific brief International Classification of Functioning, Disability, and Health (ICF) core sets for school-aged children with cerebral palsy (CP), using national dataset of the child version of the Functioning Scale of the Disability Evaluation System (FUNDES) in Taiwan. **METHODS:** Students with CP aged 6-17.9 years ($n = 546$) in the national dataset were analyzed. Items of the child version of the FUNDES were linked to the ICF d-codes and matched to two brief ICF core sets for CP. The restriction rate of the linked d-codes were calculated. Random Forest regression was applied to select the important linked d-codes for predicting school participation frequency. **RESULTS:** The vast majority of the content of the Taiwanese dataset was covered by two core sets. The matched d-codes represent high restriction rates (80%) and most were important for predicting school participation. One important code, d740 (formal relationships, such as relationship with teachers), identified in this study were not included in two ICF core sets. **CONCLUSIONS:** Two brief ICF core sets for CP capture the majority of relevant functional information collected by the child version of the FUNDES. Some additional codes not covered in the international ICF core sets should be considered for inclusion in the revised Taiwanese version. Implications for rehabilitation Cerebral palsy (CP) is the most common cause of severe physical disability in childhood. ICF core sets for CP promote a comprehensive assessment and service provision. To ensure applicability, ICF core sets for CP were validated in Taiwan using the child and youth national dataset of the child version of the Functioning Scale of the Disability Evaluation System. This study shows content validity and proposes new ICF

codes additions for the Taiwanese version. Among top five ICF-based predictors for school participation frequency, four of them were consistent in both children and youth groups as d310-d350 (basic communication), d750 (informal social relationships), d820 (school education), and d710-d720, d880 and d920 (social play), which could be taken into consideration in clinical application.

PMID: [30451019](#)

Prevention and Cure

22. Refining the Prediction and Prevention of Emergency Operative Deliveries with the Fetal Reserve Index.

Britt DW, Evans MI, Schiffrin BS, Eden RD. *Fetal Diagn Ther.* 2018 Nov 21:1-7. doi: 10.1159/000494617. [Epub ahead of print]

Electronic fetal monitoring (EFM) is a poor predictor of outcomes attributable to delivery problems. Contextualizing EFM by adding maternal, obstetrical, and fetal risk-related information to create an index called the Fetal Reserve Index (FRI) improves the predictive capacity and facilitates the timing of interventions. Here, we test critical assumptions of FRI as a clinical tool. Our conceptualization implies that the earlier one reaches the red zone ($FRI \leq 25$) and the longer one spends in the red zone, the greater the likelihood of emergency operative deliveries (EOD). **METHODS:** We analyzed 1,402 patients using logistic regression predicting the probability of EOD and employed qualitative methodology techniques to refine predictive capabilities. **RESULTS:** Reaching the red zone early and staying there > 1 h increases the probability of EOD. When these risk factors are paired with intrauterine resuscitation (IR) in Stage 1, the reduction of EOD is substantial. **CONCLUSION:** FRI is a capable predictor of EOD because it accurately identifies the level of malleable risk. FRI analysis increases the risk of using IR in Stage 1. Matching risk and resources dramatically reduces the chances of EOD. Earlier IR improves the outcomes if the calculated risk is high.

PMID: [30463080](#)

23. Sequence variants in muscle tissue-related genes may determine the severity of muscle contractures in cerebral palsy.

Pingel J, Andersen JD, Christiansen SL, Børsting C, Morling N, Lorentzen J, Kirk H, Doessing S, Wong C, Nielsen JB. *Am J Med Genet B Neuropsychiatr Genet.* 2018 Nov 23. doi: 10.1002/ajmg.b.32693. [Epub ahead of print]

Muscle contractures are a common complication to cerebral palsy (CP). The purpose of this study was to evaluate whether individuals with CP carry specific gene variants of important structural genes that might explain the severity of muscle contractures. Next-generation-sequencing (NGS) of 96 candidate genes associated with muscle structure and metabolism were analyzed in 43 individuals with CP (Gross Motor Function Classification System [GMFCS] I, n=10; GMFCS II, n=14; GMFCS III, n=19) and four control participants. In silico analysis of the identified variants was performed. The variants were classified into four categories ranging from likely benign (VUS0) to highly likely functional effect (VUS3). All individuals with CP were classified and grouped according to their GMFCS level: Statistical comparisons were made between GMFCS groups. Kruskal-Wallis tests showed significantly more VUS2 variants in the genes COL4 (GMFCS I-III; 1, 1, 5, respectively [$p < .04$]), COL5 (GMFCS I-III; 1, 1, 5 [$p < .04$]), COL6 (GMFCS I-III; 0, 4, 7 [$p < .003$]), and COL9 (GMFCS I-III; 1, 1, 5 [$p < .04$]), in individuals with CP within GMFCS Level III when compared to the other GMFCS levels. Furthermore, significantly more VUS3 variants in COL6 (GMFCS I-III; 0, 5, 2 [$p < .01$]) and COL7 (GMFCS I-III; 0, 3, 0 [$p < .04$]) were identified in the GMFCS II level when compared to the other GMFCS levels. The present results highlight several candidate gene variants in different collagen types with likely functional effects in individuals with CP.

PMID: [30467950](#)

24. Inter-Limb Muscle Synergy of Hands-and-Knees Crawling in Typical Developing Infants and Infants with Developmental Delay.

Xiong QL, Wu XY, Yao J, Sukal TM, Xiao N, Chen L, Zheng XL, Liu Y, Hou WS. *Conf Proc IEEE Eng Med Biol Soc.* 2018 Jul;2018:4697-4700. doi: 10.1109/EMBC.2018.8513123.

The aim of this study was to quantify and compare the inter-limb muscle coordination during crawling between typically developing infants and infants with developmental delay. Typically developing (TD, $N=20$) infants and infants with at risk of developmental delay (ARDD, $N=33$) or confirmed developmental delay (CDD, $N=14$) participated in this study. Surface electromyography of eight muscles from arms and legs and the corresponding joint kinematic data were collected while they were crawling on hands and knees at their self-selected velocity. The number of used inter-limb muscle synergies during crawling was identified by nonnegative matrix factorization algorithm. Our results showed that there was no significant difference in the number of used muscle synergies between ARDD and TD infants during crawling. However, a

reduced number of synergies were identified in infants with CDD, as compared to that in TD and ARDD infants, indicating constrained neuromuscular control strategy during crawling in developmental delayed infants. The absence of inter-limb muscle synergies may be one of the mechanisms underlying the impairments of crawling in developmental delayed infants, who are at high risk of cerebral palsy. This result also suggests that the metrics of muscle synergy during infant crawling, such as the number of synergy, may be feasible as a biomarker for early diagnosis of infants with cerebral palsy.

PMID: [30441398](#)

25. How socio-economic disadvantage modifies health outcomes in children with cerebral palsy.

Oskoui M, Messerlian C. *Dev Med Child Neurol*. 2018 Nov 16. doi: 10.1111/dmcn.14099. [Epub ahead of print] No abstract available.

PMID: [30444270](#)

26. A systematic review of comorbidity between cerebral palsy, autism spectrum disorders and Attention Deficit Hyperactivity Disorder.

Craig F, Savino R, Trabacca A. *Eur J Paediatr Neurol*. 2018 Nov 2. pii: S1090-3798(18)30153-3. doi: 10.1016/j.ejpn.2018.10.005. [Epub ahead of print] Review.

OBJECTIVES: The aim of this systematic review was to examine the incidence and prevalence of comorbidity between Cerebral Palsy (CP), Autism spectrum disorders (ASDs) and Attention-Deficit/Hyperactivity Disorder (ADHD). **METHODS:** We searched for articles indexed in PubMed, EBSCOhost, Scopus, Web of Science and other potentially relevant internet sources using a combination of expressions including "cerebral palsy" AND "autism" OR "ASD" OR "pervasive development disorder" AND "Attention Deficit Hyperactivity Disorder" OR "ADHD". **RESULTS:** We identified 2542 studies on CP and ASD and 998 studies on CP and ADHD. After screening titles and abstracts and removing duplicated studies, 47 full papers (CP and ASD n = 28; CP and ADHD n = 19) were downloaded and screened for eligibility. Twenty-eight (CP and ASD n = 16; CP and ADHD n = 12) studies were identified in the peer-review literature. Based on this systematic review, ASD and ADHD seem to be more common in people with CP than in the general population, yet the gold standard methods for diagnosing ASD or ADHD are not suitable for children with motor problems. **CONCLUSIONS:** Assessing the occurrence of ASD and ADHD would improve the significant cost of healthcare, therapies, and overall daily living for families with children affected by CP. However, psychometric studies are needed in the future to promote development of measures suitable for individuals with CP. In addition, this review highlights the paucity of peer-reviewed studies investigating the occurrence of ASD and ADHD in children with different CP subtypes or functional abilities, and there are still some open questions about pathogenic mechanisms common to CP, ASD and ADHD.

PMID: [30446273](#)