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## Interventions and Management

### 1. Preliminary testing by adults of a haptics-assisted robot platform designed for children with physical impairments to access play.

Sakamaki I, Adams K, Medina MFG, Cruz JLC, Jafari N, Tavakoli M, Janz H.

Assist Technol. 2017 Jul 11:1-9. doi: 10.1080/10400435.2017.1318974. [Epub ahead of print]

Development of children's cognitive and perceptual skills depends heavily on object exploration and experience in their physical world. For children who have severe physical impairments, one of the biggest concerns is the loss of opportunities for meaningful play with objects, including physical contact and manipulation. Assistive robots can enable children to perform object manipulation through the control of simple interfaces. Touch sensations conveyed through haptic interfaces in the form of force reflection or force assistance can help a child to sense the environment and to control a robot. A robotic system with forbidden region virtual fixtures (VFs) was tested in an object sorting task. Three sorting tasks-by color, by shape, and by both color and shape-were performed by 10 adults without disability and one adult with cerebral palsy. Tasks performed with VFs were accomplished faster than tasks performed without VFs, and deviations of the motion area were smaller with VFs than without VFs. For the participant with physical impairments, two out of three tasks were slower with the VFs. This implies that forbidden region VFs are not always able to improve user task performance. Alignment with an individual's unique motion characteristics can improve VF assistance.

[PMID: 28696831](#)

### 2. GriFT: A device for quantifying physiological and pathological mirror movements in children.

Jaspers E, Klingels K, Simon-Martinez C, Feys H, Woolley DG, Wenderoth N.

IEEE Trans Biomed Eng. 2017 Jul 5. doi: 10.1109/TBME.2017.2723801. [Epub ahead of print]

GOAL: Mirror movements (MM) typically occur during unilateral actions and manifest as involuntary muscle activity of the passive limb, which "mirror" voluntary actions executed by the contralateral homologous body part. They are a normal motor feature in young children and gradually disappear during the first decade of life. In children suffering from neurological disorders, e.g. due to an early brain lesion as in unilateral cerebral palsy, the amplitude and occurrence of MM has been proposed to yield relevant information for diagnosis and therapy. However, in clinical practice MM are typically assessed using an ordinal rating scale, which provides mainly qualitative information. In contrast, there is no validated procedure that allows a quantitative assessment that might offer more objective and detailed information regarding the occurrence and amount of MM. Here we introduce the Grip Force Tracking Device (GriFT Device), a portable system to quantitatively assess MM during repetitive unimanual squeezing whilst playing a computer game. The GriFT Device consists of two identical equally sized handles equipped with two compressive force sensors (range 0-23kg, Fz 1000Hz). Children had to complete three trials of unimanual squeezing, whereby the visual display on the screen determined the rhythm of squeezing (0.67Hz at 15% maximum voluntary contraction, force level adjusted per hand). MM were characterized based on their frequency,

strength, and temporal features (synchronization and time lag). These MM characteristics differed significantly between children with different clinical MM scores, and MM frequency and strength were most discriminative. Further categorization of physiological MM based on their frequency and strength proved highly sensitive (89-97%). We demonstrated feasibility and validity of the GriFT Device in a large cohort of typically developing children aged 5 to 15 years, as well as its clinical applicability in children with unilateral cerebral palsy with various levels of hand function. The quantification of MM as proposed in the current study is a promising tool to further investigate and categorize MM in children with unilateral cerebral palsy.

[PMID: 28692958](#)

### **3. Reliability of the gross motor function classification system and the manual ability classification system in children with cerebral palsy in Tanzania.**

Piscitelli D, Vercelli S, Meroni R, Zagnoni G, Pellicciari L.

Dev Neurorehabil. 2017 Jul 10;1-7. doi: 10.1080/17518423.2017.1342710. [Epub ahead of print]

**OBJECTIVES:** Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System (MACS) are broadly studied in high-income countries, but data concerning their functioning are lacking in developing countries. Therefore, we analyzed their reliability and sensitivity to change in children with cerebral palsy in Tanzania. **METHODS:** GMFCS and MACS are two ordinal grading systems used to assess motor functions while observing children's performances. Forty-nine children were classified by two independent physiotherapy students at baseline, after one month and after one year. Reliability and sensitivity to change were analyzed using intraclass correlation coefficient (ICC), effect size (ES), standard response mean (SRM), standard error of measurement (SEM), and minimal detectable change (MDC). **RESULTS:** Inter- (ICC = 0.97/0.95 for GMFCS/MACS) and intra-rater reliability (ICC = 0.98/0.96 GMFCS/MACS) were excellent. Sensitivity to change was small (ES = -0.14/0.11, SRM = -0.24;/0.24 GMFCS/MACS). SEM was 0.2 points, resulting in MDC = 0.5/0.7 for GMFCS/MACS, respectively. **CONCLUSIONS:** GMFCS and MACS demonstrated excellent reliability, but not sensitivity to change.

[PMID: 28692325](#)

### **4. Can Lokomat therapy with children and adolescents be improved? An adaptive clinical pilot trial comparing Guidance force, Path control, and Freed.**

Aurich-Schuler T, Grob F, van Hedel HJA, Labruyère R.

J Neuroeng Rehabil. 2017 Jul 14;14(1):76. doi: 10.1186/s12984-017-0287-1.

**BACKGROUND:** Robot-assisted gait therapy is increasingly being used in pediatric neurorehabilitation to complement conventional physical therapy. The robotic device applied in this study, the Lokomat (Hocoma AG, Switzerland), uses a position control mode (Guidance Force), where exact positions of the knee and hip joints throughout the gait cycle are stipulated. Such a mode has two disadvantages: Movement variability is restricted, and patients tend to walk passively. Kinematic variability and active participation, however, are crucial for motor learning. Recently, two new control modes were introduced. The Path Control mode allows the patient to walk within a virtual tunnel surrounding the ideal movement trajectory. The FreeD was developed to support weight shifting through mediolaterally moveable pelvis and leg cuffs. The aims of this study were twofold: 1) To present an overview of the currently available control modes of the Lokomat. 2) To evaluate if an increase in kinematic variability as provided by the new control modes influenced leg muscle activation patterns and intensity, as well as heart rate while walking in the Lokomat. **METHODS:** In 15 adolescents with neurological gait disorders who walked in the Lokomat, 3 conditions were compared: Guidance Force, Path Control, and FreeD. We analyzed surface electromyographic (sEMG) activity from 5 leg muscles of the more affected leg and heart rate. Muscle activation patterns were compared with norm curves. **RESULTS:** Several muscles, as well as heart rate, demonstrated tendencies towards a higher activation during conditions with more kinematic freedom. sEMG activation patterns of the M.rectus femoris and M.vastus medialis showed the highest similarity to over-ground walking under Path Control, whereas walking under FreeD led to unphysiological muscle activation in the tested sample. **CONCLUSIONS:** Results indicate that especially Path Control seems promising for adolescent patients undergoing neurorehabilitation, as it increases proximal leg muscle activity while facilitating a physiological muscle activation. Therefore, this may be a solution to increase kinematic variability and patients' active participation in robot-assisted gait training.

[PMID: 28705170](#)

## 5. Task-Specific and Functional Effects of Speed-Focused Elliptical or Motor-Assisted Cycle Training in Children With Bilateral Cerebral Palsy: Randomized Clinical Trial.

Damiano DL, Stanley CJ, Ohlrich L, Alter KE.

Neurorehabil Neural Repair. 2017 Jul 1;1545968317718631. doi: 10.1177/1545968317718631. [Epub ahead of print]

**BACKGROUND:** Locomotor training using treadmills or robotic devices is commonly utilized to improve gait in cerebral palsy (CP); however, effects are inconsistent and fail to exceed those of equally intense alternatives. Possible limitations of existing devices include fixed nonvariable rhythm and too much limb or body weight assistance. **OBJECTIVE:** To quantify and compare effectiveness of a motor-assisted cycle and a novel alternative, an elliptical, in CP to improve interlimb reciprocal coordination through intensive speed-focused leg training. **METHODS:** A total of 27 children with bilateral CP, 5 to 17 years old, were randomized to 12 weeks of 20 minutes, 5 days per week home-based training (elliptical = 14; cycle = 13) at a minimum of 40 revolutions per minute, with resistance added when speed target was achieved. Primary outcomes were self-selected and fastest voluntary cadence on the devices and gait speed. Secondary outcomes included knee muscle strength, and selective control and functional mobility measures. **RESULTS:** Cadence on trained but not nontrained devices increased, demonstrating task specificity of training and increased exercise capability. Mean gait speed did not increase in either group, nor did parent-reported functional mobility. Knee extensor strength increased in both. An interaction between group and time was seen in selective control with scores slightly increasing for the elliptical and decreasing for the cycle, possibly related to tighter limb coupling with cycling. **CONCLUSIONS:** Task-specific effects were similarly positive across groups, but no transfer was seen to gait or function. Training dose was low ( $\leq 20$  hours) compared with intensive upper-limb training recommendations and may be insufficient to produce appreciable clinical change.

[PMID: 28691601](#)

## 6. Simulated impacts of ankle foot orthoses on muscle demand and recruitment in typically-developing children and children with cerebral palsy and crouch gait.

Rosenberg M, Steele KM.

PLoS One. 2017 Jul 13;12(7):e0180219. doi: 10.1371/journal.pone.0180219. eCollection 2017.

Passive ankle foot orthoses (AFOs) are often prescribed for children with cerebral palsy (CP) to assist locomotion, but predicting how specific device designs will impact energetic demand during gait remains challenging. Powered AFOs have been shown to reduce energy costs of walking in unimpaired adults more than passive AFOs, but have not been tested in children with CP. The goal of this study was to investigate the potential impact of powered and passive AFOs on muscle demand and recruitment in children with CP and crouch gait. We simulated gait for nine children with crouch gait and three typically-developing children with powered and passive AFOs. For each AFO design, we computed reductions in muscle demand compared to unassisted gait. Powered AFOs reduced muscle demand 15-44% compared to unassisted walking, 1-14% more than passive AFOs. A slower walking speed was associated with smaller reductions in absolute muscle demand for all AFOs ( $r^2 = 0.60-0.70$ ). However, reductions in muscle demand were only moderately correlated with crouch severity ( $r^2 = 0.40-0.43$ ). The ankle plantarflexor muscles were most heavily impacted by the AFOs, with gastrocnemius recruitment decreasing 13-73% and correlating with increasing knee flexor moments ( $r^2 = 0.29-0.91$ ). These findings support the potential use of powered AFOs for children with crouch gait, and highlight how subject-specific kinematics and kinetics may influence muscle demand and recruitment to inform AFO design.

[PMID: 28704464](#)

## 7. Effect of floor reaction ankle-foot orthosis on crouch gait in patients with cerebral palsy: What can be expected?

Böhm H, Matthias H, Braatz F, Döderlein L.

Prosthet Orthot Int. 2017 Jul 1;309364617716240. doi: 10.1177/0309364617716240. [Epub ahead of print]

**BACKGROUND:** Floor reaction ankle-foot orthoses are commonly prescribed to improve knee extension of children with cerebral palsy having crouch gait. Their effectiveness is debated. Therefore, the objective of this study is to optimize current prescription criteria for the improvement of crouch gait. **STUDY DESIGN:** Cross-sectional interventional study. **METHODS:** A total of 22 patients with bilateral spastic cerebral palsy, between 6 and 17 years, Gross Motor Function Classification System II-IV participated in this study. Instrumented gait analysis was done under three conditions: barefoot, shoed, and with orthotics.

Patients were divided into two groups: good and non-responders with more and less than 8.8° improvement of knee extension during walking, respectively. A multiple predictor analysis was done on parameters that were different between groups. RESULTS: In total, 12 of 22 patients showed good response in knee extension with a mean change of 17° (standard deviation = 5°). Good responders showed a significantly smaller walking velocity, knee extension strength, ankle plantarflexion strength, and greater external foot progression angle compared to non-responders. Foot progression angle together with ankle plantarflexion strength explained 37% of the variance in improvement of knee extension. CONCLUSION: With appropriate patient selection, an improvement of crouch gait by ankle-foot orthoses of 17° (standard deviation = 5°) can be expected. Patients with slow velocity, weak plantarflexors, and external foot progression benefit most. Joint contractures were no contraindications. Clinical relevance This study showed that gait in patients with low functional level benefit most from ankle-foot orthoses. Unlike in patients with higher functional status, contractures of hip, knee, and ankle did not reduce the positive effects on gait. The suggested prescription criteria may help to better select appropriate patients for orthotics.

[PMID: 28693377](#)

### **8. MiYoga: a randomised controlled trial of a mindfulness movement programme based on hatha yoga principles for children with cerebral palsy: a study protocol.**

Mak C, Whittingham K, Cunningham R, Boyd RN.

BMJ Open. 2017 Jul 10;7(7):e015191. doi: 10.1136/bmjopen-2016-015191.

INTRODUCTION: Cerebral palsy (CP) is the most common childhood physical disability, with life-long impacts for 1.77 in 1000 children. Although CP is primarily a physical disability, children with CP have an increased risk of experiencing cognitive difficulties, particularly attention and executive function deficits. Impairment in cognitive abilities can lead to subsequent impairment in independent functioning, education, employment and interpersonal relationships. This paper reports the protocol of a randomised controlled trial of a novel family-centred lifestyle intervention based on mindfulness and hatha yoga principles (MiYoga). MiYoga aims to enhance child and parent outcomes for children with CP. METHODS AND ANALYSIS: The aim is to recruit 36 child-parent dyads (children aged 6-16 years; bilateral or unilateral CP; Gross Motor Function Classification System I-III), who will be randomly assigned to two groups: MiYoga and waitlist control. The MiYoga programme will be facilitated in a group format for 8 weeks. Assessments will be administered at baseline, prior to MiYoga, following completion of MiYoga, and at 6-month follow-up (retention). The primary outcome will be the child's sustained attentional ability as measured by the Conner's Continuous Performance Test II. Other outcomes of interest for children with CP consists of attentional control, physical functioning, behavioural and well-being. For parents, the outcomes of interest are mindfulness, psychological flexibility and well-being. Data will be analysed using general linear models, specifically analysis of covariance and analysis of variance. ETHICS AND DISSEMINATION: Full ethical approval for this study has been obtained by the Children's Health Queensland Hospital and Health Service Research Ethics Committee (HREC/12/QRCH/120) and The University of Queensland (2012000993). If MiYoga is proven effective, its dissemination would assist children with CP and complement their ongoing therapy by improving the ability of the child to pay attention at school and in therapy, and alleviating environmental stressors for both the child and his/her parents. FINDINGS TO DATE: Recruitment is complete. Data are still being collected at present. We aim to complete data collection by February 2017.

[PMID: 28698326](#)

### **9. Prevalence of pain in 240 non-ambulatory children with severe cerebral palsy.**

Poirot I, Laudy V, Rabilloud M, Roche S, Ginhoux T, Kassai B, Vuillerot C.

Ann Phys Rehabil Med. 2017 Jul 6. pii: S1877-0657(17)30056-8. doi: 10.1016/j.rehab.2017.03.011. [Epub ahead of print]

BACKGROUND: Several studies have given frequencies of pain in children with cerebral palsy, but comparing the findings is difficult. We aimed to estimate the prevalence of pain in non-ambulatory children with cerebral palsy and describe their characteristics by presence or absence of pain. METHODS: Data were extracted from an ongoing longitudinal national cohort following non-ambulatory children with severe cerebral palsy aged 3 to 10 years over 10 years. We described and compared data for the first 240 children at inclusion by presence or absence of pain. Pain was assessed by a visual analog scale and the Douleur Enfant San Salvador scales and by investigator interview. RESULTS: Overall, 65 children experienced pain, for a prevalence of 27.1% (95% confidence interval 22-33%). All children experiencing pain had orthopaedic pain and 45.6% had pain from another origin. The main pain sites were hips (43.4%) and feet (26.9%). Joint mobilisation was the source of pain for 58.3% of children experiencing pain, and sitting was identified as painful for 10.3%. Pain was greater with scoliosis (43.1% vs



24.1% with and without pain;  $P=0.006$ ) and spasticity treatment (32.3% vs 17.2%;  $P=0.020$ ). **CONCLUSION:** Children with cerebral palsy frequently experience pain and also early pain, mostly articular and orthopedic. The assessment of pain should be systematic because of its high prevalence. Interventions to prevent scoliosis, hip luxation, and foot deformities and to reduce spasticity, such as the use of analgesics before joint mobilization exercises, may reduce the prevalence of this pain.

[PMID: 28690031](#)

#### **10. PREDICT-CP: study protocol of implementation of comprehensive surveillance to predict outcomes for school-aged children with cerebral palsy.**

Boyd RN, Davies PS, Ziviani J, Trost S, Barber L, Ware R, Rose S, Whittingham K, Sakzewski L, Bell K, Carty C, Obst S, Benfer K, Reedman S, Edwards P, Kentish M, Copeland L, Weir K, Davenport C, Brooks D, Coulthard A, Pelekanos R, Guzzetta A, Fiori S, Wynter M, Finn C, Burgess A, Morris K, Walsh J, Lloyd O, Whitty JA, Scuffham PA.

BMJ Open. 2017 Jul 12;7(7):e014950. doi: 10.1136/bmjopen-2016-014950.

**OBJECTIVES:** Cerebral palsy (CP) remains the world's most common childhood physical disability with total annual costs of care and lost well-being of \$A3.87b. The PREDICT-CP (NHMRC 1077257 Partnership Project: Comprehensive surveillance to PREDICT outcomes for school age children with CP) study will investigate the influence of brain structure, body composition, dietary intake, oropharyngeal function, habitual physical activity, musculoskeletal development (hip status, bone health) and muscle performance on motor attainment, cognition, executive function, communication, participation, quality of life and related health resource use costs. The PREDICT-CP cohort provides further follow-up at 8-12 years of two overlapping preschool-age cohorts examined from 1.5 to 5 years (NHMRC 465128 motor and brain development; NHMRC 569605 growth, nutrition and physical activity). **METHODS AND ANALYSES:** This population-based cohort study undertakes state-wide surveillance of 245 children with CP born in Queensland (birth years 2006-2009). Children will be classified for Gross Motor Function Classification System; Manual Ability Classification System, Communication Function Classification System and Eating and Drinking Ability Classification System. Outcomes include gross motor function, musculoskeletal development (hip displacement, spasticity, muscle contracture), upper limb function, communication difficulties, oropharyngeal dysphagia, dietary intake and body composition, participation, parent-reported and child-reported quality of life and medical and allied health resource use. These detailed phenotypical data will be compared with brain macrostructure and microstructure using 3 Tesla MRI (3T MRI). Relationships between brain lesion severity and outcomes will be analysed using multilevel mixed-effects models. **ETHICS AND DISSEMINATION:** The PREDICT-CP protocol is a prospectively registered and ethically accepted study protocol. The study combines data at 1.5-5 then 8-12 years of direct clinical assessment to enable prediction of outcomes and healthcare needs essential for tailoring interventions (eg, rehabilitation, orthopaedic surgery and nutritional supplements) and the projected healthcare utilisation.

[PMID: 28706091](#)

#### **11. White matter integrity in dyskinetic cerebral palsy: Relationship with intelligence quotient and executive function.**

Laporta-Hoyos O, Pannek K, Ballester-Plané J, Reid LB, Vázquez É, Delgado I, Zubiaurre-Elorza L, Macaya A, Póo P, Meléndez-Plumed M, Junqué C, Boyd R, Pueyo R.

Neuroimage Clin. 2017 May 12;15:789-800. doi: 10.1016/j.nicl.2017.05.005. eCollection 2017.

**BACKGROUND:** Dyskinetic cerebral palsy (CP) is one of the most disabling motor types of CP and has been classically associated with injury to the basal ganglia and thalamus. Although cognitive dysfunction is common in CP, there is a paucity of published quantitative analyses investigating the relationship between white matter (WM) microstructure and cognition in this CP type. **AIMS:** This study aims (1) to compare brain WM microstructure between people with dyskinetic CP and healthy controls, (2) to identify brain regions where WM microstructure is related to intelligence and (3) to identify brain regions where WM microstructure is related to executive function in people with dyskinetic CP and (4) to identify brain regions where the correlations are different between controls and people with CP in IQ and executive functions. **PATIENTS AND METHODS:** Thirty-three participants with dyskinetic CP (mean  $\pm$  SD age: 24.42  $\pm$  12.61, 15 female) were age and sex matched with 33 controls. Participants underwent a comprehensive neuropsychological battery to assess intelligence quotient (IQ) and four executive function domains (attentional control, cognitive flexibility, goal setting and information processing). Diffusion weighted MRI scans were acquired at 3T. Voxel-based whole brain groupwise analyses were used to compare fractional anisotropy (FA) and of the CP group to the matched controls using a general lineal model. Further general linear models were used to identify regions where white matter FA correlated with IQ and each of the executive function domains. **RESULTS:** White matter FA was significantly reduced in the CP group in all cerebral lobes, predominantly in regions connected with the

parietal and to a lesser extent the temporal lobes. There was no significant correlation between IQ or any of the four executive function domains and WM microstructure in the control group. In participants with CP, lower IQ was associated with lower FA in all cerebral lobes, predominantly in locations that also showed reduced FA compared to controls. Attentional control, goal setting and information processing did not correlate with WM microstructure in the CP group. Cognitive flexibility was associated with FA in regions known to contain connections with the frontal lobe (such as the superior longitudinal fasciculus and cingulum) as well as regions not known to contain tracts directly connected with the frontal lobe (such as the posterior corona radiata, posterior thalamic radiation, retrolenticular part of internal capsule, tapetum, body and splenium of corpus callosum). **CONCLUSION:** The widespread loss in the integrity of WM tissue is mainly located in the parietal lobe and related to IQ in dyskinetic CP. Unexpectedly, executive functions are only related with WM microstructure in regions containing fronto-cortical and posterior cortico-subcortical pathways, and not being specifically related to the state of fronto-striatal pathways which might be due to brain reorganization. Further studies of this nature may improve our understanding of the neurobiological bases of cognitive impairments after early brain insult.

[PMID: 28702354](#)

## Prevention and Cure

### **12. The Impact of Low-Grade Germinal Matrix-Intraventricular Hemorrhage on Neurodevelopmental Outcome of Very Preterm Infants.**

Reuhsaet P, Brouwer AJ, van Haastert IC, Brouwer MJ, Koopman C, Groenendaal F, de Vries LS.

Neonatology. 2017 Jul 14;112(3):203-210. doi: 10.1159/000472246. [Epub ahead of print]

**BACKGROUND:** Very preterm infants often show germinal matrix-intraventricular hemorrhage (GMH-IVH) on cranial ultrasound (cUS). **AIM:** To determine the impact of low-grade GMH-IVH on early neurodevelopmental outcome in very preterm infants. **METHODS:** A retrospective case-control study in very preterm infants with and without low-grade GMH-IVH on cUS. Additional magnetic resonance imaging (MRI) was available in all infants with a gestational age (GA) <28 weeks and high-risk infants >28 weeks. Infants were seen at 2 years' corrected age to assess neurodevelopment. **RESULTS:** In total, 136 infants (GA 24-32 weeks) with low-grade GMH-IVH on cUS were matched with 255 controls. Outcome data was available for 342 (87%) infants. Adverse outcome (i.e., cerebral palsy [CP], neurodevelopmental delay) was present in 11 (9%) cases and 20 (9%) controls. No statistically significant differences in outcome were found between cases and controls. Additional MRI was performed in 165/391 infants (42%) and showed additional lesions in 73 (44%) infants that could explain subsequent development of CP in 2 out of 5 infants and epilepsy in 1 of 2 infants. **CONCLUSION:** Very preterm infants with low-grade GMH-IVH on cUS have a similar early neurodevelopmental outcome compared with controls. Additional MRI showed mostly subtle abnormalities that were missed with cUS, but these could not explain subsequent development of CP and developmental delay in all infants.

[PMID: 28704824](#)