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Professor Nadia Badawi AM

Macquarie Group Foundation Chair of Cerebral Palsy

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Interventions and Management

1. Kinematic gait pattern in children with cerebral palsy and leg length discrepancy: Effects of an extra sole.

Eek MN, Zügner R, Stefansdottir I, Tranberg R.

Gait Posture. 2017 Apr 17;55:150-156. doi: 10.1016/j.gaitpost.2017.04.022. [Epub ahead of print]

The gait pattern in children with cerebral palsy (CP) often differs from normal, with slow velocity, problem with foot clearance and increased stress on joints. Several factors, such as muscle tone, impaired motor control, muscle contractures, skeletal deformities and leg length discrepancy affect gait. Leg length discrepancy can be treated surgically or with elevation of the shoe on the short leg. The purpose of this study was to examine whether compensating for leg length discrepancy, with elevation of the sole, leads to a change in movement pattern during walking in children with spastic CP. RESULTS: Ten children with spastic CP, able to walk without aids, and 10 typically developing (TD) children aged between seven and 14 years were assessed with 3D gait analysis: 1) barefoot, 2) with shoes and 3) with an extra sole beneath the shoe for the shorter leg. All children with CP had a leg length discrepancy of more than or equal to 1.0cm. In the barefoot condition, the velocity was slower and the stride length was shorter, in children with CP compared with TD. The stride length and gait velocity increased in children with CP with shoes and shoe+sole and the stance time became more symmetrical. Among children with CP, there was more flexion in the longer leg relative to the short leg during barefoot walking. Differences in the kinematic pattern between the long and the short leg decreased with the extra sole.

[PMID: 28448898](#)

2. Prevalence of Joint Gait Patterns Defined by a Delphi Consensus Study Is Related to Gross Motor Function, Topographical Classification, Weakness, and Spasticity, in Children with Cerebral Palsy.

Nieuwenhuys A, Papageorgiou E, Schless SH, De Laet T, Molenaers G, Desloovere K.

Front Hum Neurosci. 2017 Apr 12;11:185. doi: 10.3389/fnhum.2017.00185. eCollection 2017.

During a Delphi consensus study, a new joint gait classification system was developed for children with cerebral palsy (CP). This system, whose reliability and content validity have previously been established, identified 49 distinct joint patterns. The present study aims to provide a first insight toward the construct validity and clinical relevance of this classification system. The retrospective sample of convenience consisted of 286 patients with spastic CP (3-18 years old, GMFCS levels I-III, 166 with bilateral CP). Kinematic and kinetic trials from three-dimensional gait analysis were classified according to the definitions of the Delphi study, and one classified trial was randomly selected for each included limb (n = 446). Muscle weakness and spasticity were assessed for different muscle groups acting around the hip, knee, and ankle. Subsequently, Pearson Chi square tests, Cramer's V, and adjusted standardized residuals were calculated to explore the strength and direction of the associations between the joint patterns, and the different patient-specific characteristics (i.e., age, GMFCS level, and

topographical classification) or clinical symptoms (muscle weakness and spasticity). Patient-specific characteristics showed several significant associations with the patterns of different joints, but the strength of most identified associations was weak. Apart from the knee during stance phase and the pelvis in the sagittal plane, the results systematically showed that the patterns with "minor gait deviations" were the most frequently observed. These minor deviations were found significantly more often in limbs with a lower level of spasticity and good muscle strength. Several other pathological joint patterns were moderately associated with weakness or spasticity, including but not limited to "outtoeing" for weakness and "intoeing" for spasticity. For the joints in the sagittal plane, significantly stronger associations were found with muscle weakness and spasticity, possibly because most of the evaluated muscles in this study mainly perform sagittal plane motions. Remarkably, the hip patterns in the coronal plane did not associate significantly with any of the investigated variables. Although further validation is warranted, this study contributes to the construct validity of the joint patterns of the Delphi consensus study, by demonstrating their ability to distinguish between clinically relevant subgroups in CP.

[PMID: 28446871](#)

3. Correlation of technical surgical goals to the GDI and investigation of post-operative GDI change in children with cerebral palsy.

Bickley C, Linton J, Scarborough N, Sullivan E, Mitchell K, Barnes D.

Gait Posture. 2017 Apr 13;55:121-125. doi: 10.1016/j.gaitpost.2017.04.015. [Epub ahead of print]

AIM: The purpose of this study was to introduce a standardized set of surgical technical achievement goals (TAGs) as part of a comprehensive outcome assessment model for children with spastic cerebral palsy (CP) undergoing orthopaedic surgical intervention to improve gait. Examination of relationships of these surgical goals to the Gait Deviation Index (GDI) and use of two assessments in tandem provided a thorough picture of technical surgical outcomes. This study also investigated changes in GDI in children with spastic CP after surgery. **METHODS:** Data from 269 participants with spastic CP, aged 4 to 19 years with Gross Motor Function Classification System (GMFCS) levels I, II, and III who underwent lower extremity orthopaedic surgical intervention to improve gait were retrospectively analyzed. Data were examined as one heterogeneous group and sub-grouped based on pattern of involvement and GMFCS level to determine change in GDI and relationships between GDI and TAGs. **RESULTS:** Differences in TAG achievement and GDI change by GMFCS level suggest a pairing of GDI with another technical measure to be beneficial. Analysis of the outcome tools individually revealed a significant difference between the pre-operative GDI and post-operative GDI mean for the entire group, as well as each of the subgroups. A significant difference in TAG achievement by GMFCS level was also noted. **CONCLUSION:** This paper provides evidence that lower extremity orthopedic intervention for the ambulatory child with spastic diplegic or hemiplegic CP improves gait and that a pairing of the GDI and TAGs system is beneficial to capture an accurate technical outcome assessment in both higher and lower functioning patients.

[PMID: 28437759](#)

4. Effects of dose and duration of robot-assisted gait training on walking ability of children affected by cerebral palsy.

Peri E, Turconi AC, Biffi E, Maghini C, Panzeri D, Morganti R, Pedrocchi A, Gagliardi C.

Technol Health Care. 2017 Apr 7. doi: 10.3233/THC-160668. [Epub ahead of print]

BACKGROUND: Robot-Assisted Gait Training (RAGT) is a widespread approach for locomotion rehabilitation but information about intervention frequency and duration is still lacking. **OBJECTIVE:** To evaluate the effect of frequency and duration of a RAGT on motor outcome of children affected by Cerebral Palsy (CP). **METHODS:** Forty-four CP children (age 4 -17) underwent one among four different intensive trainings with equal dose of intervention, combining Task-Oriented Physiotherapy (TOP) and RAGT: 40 sessions (4 sessions/week) over 10 weeks of sole TOP (group1) or RAGT (group2) or RAGT and TOP (2 + 2 sessions/week; group3); 40 sessions in shorter period (4 weeks) of RAGT and TOP (5 + 5 sessions/week; group4). Each child was assessed before, after the training and after 3 months with: Ashworth, gross motor function measure (GMFM)-88, GMFM-66, six minutes walking test and gait analysis. **RESULTS:** No differences among the 4 protocols were highlighted although both groups with exclusive physiotherapy and RAGT obtained significant improvements in GMFM-88, GMFM-E and GMFM-66 while the mixed approaches did not show significant changes. **CONCLUSION:** Single-treatment approaches seem to be more effective than mixed approaches, independently from the duration (4 or 10 weeks). RAGT seems to have similar effect with respect to the traditional TOP, at least over 10 weeks.

[PMID: 28436398](#)

5. Functional status and amount of hip displacement independently affect acetabular dysplasia in cerebral palsy.

Chung MK, Zulkarnain A, Lee JB, Cho BC, Chung CY, Lee KM, Sung KH, Park MS.

Dev Med Child Neurol. 2017 Apr 22. doi: 10.1111/dmcn.13437. [Epub ahead of print]

AIM: Acetabular dysplasia is the one of main causes of hip displacement in patients with cerebral palsy (CP). Although several studies have shown a relationship between hip displacement and acetabular dysplasia, relatively few have evaluated the association between quantitative acetabular dysplasia and related factors, such as Gross Motor Function Classification System (GMFCS) level. **METHOD:** We performed a morphometric analysis of the acetabulum in patients with CP using multiplanar reformation of computed tomography data. The three directional acetabular indices (anterosuperior, superolateral, and posterosuperior) were used to evaluate acetabular dysplasia. Consequently, linear mixed-effects models were used to adjust for related factors such as age, sex, GMFCS level, and migration percentage. **RESULTS:** A total of 176 patients (mean age 9y 5mo, range 2y 4mo-19y 6mo; 104 males, 72 females) with CP and 55 typically developing individuals (mean age 13y 6mo, range 2y 5mo-19y 10mo; 37 males, 18 females) in a comparison group were enrolled in this study. Statistical modelling showed that all three directional acetabular indices independently increased with GMFCS level ($p < 0.001$) and migration percentage ($p < 0.001$). **INTERPRETATION:** Acetabular dysplasia was independently affected by both the amount of hip displacement and the GMFCS level. Thus, physicians should consider not only the migration percentage but also three-dimensional evaluation in patients at high GMFCS levels.

[PMID: 28432692](#)

6. Proximal femoral osteotomy in children with cerebral palsy: the perspective of the trainee.

Zhou L, Camp M, Gahukamble A, Willoughby KL, Harambasic M, Molesworth C, Khot A, Graham HK.

J Child Orthop. 2017;11(1):6-14. doi: 10.1302/1863-2548-11-160226.

BACKGROUND: There are a range of implants for fixation of proximal femoral osteotomies (PFOs) in children. We investigated the training experiences and preferences of orthopaedic residents and fellows who were learning PFO, using a fixed angled blade plate (ABP) or a locking, cannulated blade plate (LCBP). We also studied short-term technical and radiographic outcomes. **METHODS:** This was a prospective, parallel-group, cohort study of 90 consecutive children and adolescents with cerebral palsy who underwent bilateral PFOs with ABP or LCBP. Surgical trainees completed a questionnaire to document the ease or difficulty of each operative step. **RESULTS:** There were 48 boys and 42 girls, with a mean age of eight years and a mean follow-up of 25 months. Trainees preferred the LCBP system for: insertion of the guidewire, the seating chisel and the blade plate, as well as overall technical ease of use ($p < 0.001$). Radiographic outcomes were similar with no between-group differences for migration percentage ($p = 0.996$) or neck shaft angle ($p = 0.849$), but there was a higher prevalence of technical errors in the ABP group. **CONCLUSIONS:** Trainee surgeons expressed a preference for LCBPs when learning PFO in children with cerebral palsy. Radiographic outcomes were similar in both groups, with close attending surgeon supervision.

[PMID: 28439303](#)

7. Longitudinal physical activity and sedentary behaviour in preschool-aged children with cerebral palsy across all functional levels.

Keawutan P, Bell KL, Oftedal S, Ware RS, Stevenson RD, Davies PSW, Boyd RN.

Dev Med Child Neurol. 2017 Apr 22. doi: 10.1111/dmcn.13439. [Epub ahead of print]

AIM: To investigate longitudinal changes of habitual physical activity (HPA) and sedentary time in children with cerebral palsy (CP) aged 1 year 6 months to 5 years across all functional abilities. **METHOD:** At study entry, 95 children (62 males, 33 females) were classified using the Gross Motor Function Classification System (GMFCS) at levels I (50), II (9), III (16), IV (6), and V (14). Physical activity was recorded on a total of 159 occasions at four possible time points: 1 year 6 months to 2 years; 2 years 6 months to 3 years; 4 years; and 5 years using ActiGraph for 3 days. Mixed-effects regression models were used for analyses. **RESULTS:** Participants classified at GMFCS levels I and II had stable HPA as they aged. HPA significantly decreased at 5 years in children classified at GMFCS levels III to V. Sedentary time significantly increased at 4 years and 5 years in all participants. Annual HPA significantly reduced in children classified at GMFCS levels III to V (-123 counts/min, 95% confidence interval [CI] -206 to -40) while annual sedentary time significantly increased in all participants (GMFCS

levels I-II: 2.4%, 95% CI 0.7-4.1; GMFCS levels III-V: 6.9%, 95% CI 4.6-9.2). INTERPRETATION: Children with CP at all GMFCS levels should be encouraged to be physically active from early childhood as HPA levels start to decline from 4 years. Breaks in sedentary time are required for all children with CP from the age of 3 years.

[PMID: 28432680](#)

8. Family Dog-Assisted Adapted Physical Activity: A Case Study.

Tepfer A, Ross S, MacDonald M, Udell MAR, Ruaux C, Baltzer W.

Animals (Basel). 2017 Apr 27;7(5). pii: E35. doi: 10.3390/ani7050035.

Purpose: The aim of this case study was to examine the individual effects of an adapted physical activity, animal-assisted intervention (APA-AAI) with the family dog on motor skills, physical activity, and quality of life of a child with cerebral palsy (CP). Method: This study used an A-B-A single-subject design. The assessment phase (phase A) occurred pre- and post-intervention. This consisted of standardized assessments of motor skills, quality of life questionnaires, physical activity (measured using the GT3X+ accelerometer) and the human-animal bond. The intervention (phase B) lasted 8 weeks and consisted of adapted physical activities performed with the family dog once a week for 60 min in a lab setting. In addition, the participant had at-home daily activities to complete with the family dog. Results: Visual analysis was used to analyze the data. Motor skill performance, physical activity, quality of life and human animal interaction gains were observed in each case. Conclusions: These preliminary results provided initial evidence that the family-dog can play a role in healthy lifestyles through APA-AAI in children with CP.

[PMID: 28448430](#)

9. Overview of Four Functional Classification Systems Commonly Used in Cerebral Palsy.

Paulson A, Vargus-Adams J.

Children (Basel). 2017 Apr 24;4(4). pii: E30. doi: 10.3390/children4040030.

Cerebral palsy (CP) is the most common physical disability in childhood. CP comprises a heterogeneous group of disorders that can result in spasticity, dystonia, muscle contractures, weakness and coordination difficulty that ultimately affects the ability to control movements. Traditionally, CP has been classified using a combination of the motor type and the topographical distribution, as well as subjective severity level. Imprecise terms such as these tell very little about what a person is able to do functionally and can impair clear communication between providers. More recently, classification systems have been created employing a simple ordinal grading system of functional performance. These systems allow a more precise discussion between providers, as well as better subject stratification for research. The goal of this review is to describe four common functional classification systems for cerebral palsy: the Gross Motor Function Classification System (GMFCS), the Manual Ability Classification System (MACS), the Communication Function Classification System (CFCS), and the Eating and Drinking Ability Classification System (EDACS). These measures are all standardized, reliable, and complementary to one another.

[PMID: 28441773](#)

10. What does the literature say about using robots on children with disabilities?

Miguel Cruz A, Ríos Rincón AM, Rodríguez Dueñas WR, Quiroga Torres DA, Bohórquez-Heredia AF.

Disabil Rehabil Assist Technol. 2017 Apr 25:1-12. doi: 10.1080/17483107.2017.1318308. [Epub ahead of print]

PURPOSE: The purpose of this study is to examine the extent and type of robots used for the rehabilitation and education of children and young people with CP and ASD and the associated outcomes. METHODS: The scholarly literature was systematically searched and analyzed. Articles were included if they reported the results of robots used or intended to be used for the rehabilitation and education of children and young people with CP and ASD during play and educative and social

interaction activities. **RESULTS:** We found 15 robotic systems reported in 34 studies that provided a low level of evidence. The outcomes were mainly for children with ASD interaction and who had a reduction in autistic behaviour, and for CP cognitive development, learning, and play. **CONCLUSION:** More research is needed in this area using designs that provide higher validity. A centred design approach is needed for developing new low-cost robots for this population. Implications for rehabilitation In spite of the potential of robots to promote development in children with ASD and CP, the limited available evidence requires researchers to conduct studies with higher validity. The low level of evidence plus the need for specialized technical support should be considered critical factors before making the decision to purchase robots for use in treatment for children with CP and ASD. A user-entered design approach would increase the chances of success for robots to improve functional, learning, and educative outcomes in children with ASD and CP. We recommend that developers use this approach. The participation of interdisciplinary teams in the design, development, and implementation of new robotic systems is of extra value. We recommend the design and development of low-cost robotic systems to make robots more affordable.

[PMID: 28440095](#)

11. Prevalence and characteristics of autism spectrum disorders in children with cerebral palsy.

Delobel-Ayoub M, Klapouszczak D, van Bakel MME, Horridge K, Sigurdardottir S, Himmelmann K, Arnaud C.

Dev Med Child Neurol. 2017 Apr 25. doi: 10.1111/dmcn.13436. [Epub ahead of print]

AIM: To evaluate the prevalence of co-occurring autism spectrum disorders (ASDs) among children with cerebral palsy (CP), and to describe their characteristics. **METHOD:** The data of 1225 CP cases from four population-based registers (Iceland, Sweden, and two in France) and one population-based surveillance programme (North East England, UK) participating in the Surveillance of Cerebral Palsy in Europe Network (SCPE) were analysed. The ASD diagnoses were systematically recorded using category F84 of the International Classification of Diseases, 10th Revision. The registers provided data on children born between 1995 and 2006, while the cross-sectional survey in the UK concerned children aged 0 to 19 years, registered in 2010. **RESULTS:** Among the children with CP, 107 had an associated diagnosis of ASD - i.e., 8.7% of the study population (95% confidence interval 7.2-10.5). This proportion varied across centres from 4.0% to 16.7% but was independent of CP prevalence. Male sex, co-occurring epilepsy, intellectual disability, and better walking ability were associated with the coexistence of ASD. **INTERPRETATION:** Our findings support the need for a multidisciplinary approach to management of children with CP to adequately identify and address all facets of presentation, including ASD.

[PMID: 28439889](#)

12. Mobile communication jacket for people with severe speech impairment.

Lampe R, Blumenstein T, Turova V, Alves-Pinto A.

Disabil Rehabil Assist Technol. 2017 Apr 27:1-7. doi: 10.1080/17483107.2017.1319427. [Epub ahead of print]

PURPOSE: Cerebral palsy is a movement disorder caused by damage to motor control areas of the developing brain during early childhood. Motor disorders can also affect the ability to produce clear speech and to communicate. The aim of this study was to develop and to test a prototype of an assistive tool with an embedded mobile communication device to support patients with severe speech impairments. **METHODS:** A prototype was developed by equipping a cycling jacket with a display, a small keyboard, a LED and an alarm system, all controlled by a microcontroller. Functionality of the prototype was tested in six participants (aged 7-20 years) with cerebral palsy and global developmental disorder and three healthy persons. A patient questionnaire consisting of seven items was used as an evaluation tool. **RESULTS:** A working prototype of the communication jacket was developed and tested. The questionnaire elicited positive responses from participants. Improvements to correct revealed weaknesses were proposed. Enhancements like voice output of pre-selected phrases and enlarged display were implemented. **CONCLUSIONS:** Integration in a jacket makes the system mobile and continuously available to the user. The communication jacket may be of great benefit to patients with motor and speech impairments. Implications for Rehabilitation The communication jacket developed can be easily used by people with movement and speech impairment. All technical components are integrated in a garment and do not have to be held with the hands or transported separately. The system is adaptable to individual use. Both expected and unexpected events can be dealt with, which contributes to the quality of life and self-fulfilment.

[PMID: 28447491](#)

Prevention and Cure

13. Perinatal Brain Injury As a Consequence of Preterm Birth and Intrauterine Inflammation: Designing Targeted Stem Cell Therapies.

Paton MCB, McDonald CA, Allison BJ, Fahey MC, Jenkin G, Miller SL.

Front Neurosci. 2017 Apr 10;11:200. doi: 10.3389/fnins.2017.00200. eCollection 2017.

Chorioamnionitis is a major cause of preterm birth and brain injury. Bacterial invasion of the chorion and amnion, and/or the placenta, can lead to a fetal inflammatory response, which in turn has significant adverse consequences for the developing fetal brain. Accordingly, there is a strong causal link between chorioamnionitis, preterm brain injury and the pathogenesis of severe postnatal neurological deficits and cerebral palsy. Currently there are no treatments to protect or repair against brain injury in preterm infants born after pregnancy compromised by intrauterine infection. This review describes the injurious cascade of events in the preterm brain in response to a severe fetal inflammatory event. We will highlight specific periods of increased vulnerability, and the potential effects of therapeutic intervention with cell-based therapies. Many clinical trials are underway to investigate the efficacy of stem cells to treat patients with cerebral palsy. Stem cells, obtained from umbilical cord tissue and cord blood, normally discarded after birth, are emerging as a safe and potentially effective therapy. It is not yet known, however, which stem cell type(s) are the most efficacious for administration to preterm infants to treat brain injury-mediated inflammation. Individual stem cell populations found in cord blood and tissue, such as mesenchymal stem cells (MSCs) and endothelial progenitor cells (EPCs), have a number of potential benefits that may specifically target preterm inflammatory-induced brain injury. MSCs have strong immunomodulatory potential, protecting against global and local neuroinflammatory cascades triggered during infection to the fetus. EPCs have angiogenic and vascular reparative qualities that make them ideal for neurovascular repair. A combined therapy using both MSCs and EPCs to target inflammation and promote angiogenesis for re-establishment of vital vessel networks is a treatment concept that warrants further investigation.

[PMID: 28442989](#)