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Interventions and Management

1. *Res Dev Disabil.* 2013 Sep 7;34(11):3867-3874. doi: 10.1016/j.ridd.2013.08.007. [Epub ahead of print]

Predictors for changes in various developmental outcomes of children with cerebral palsy-A longitudinal study.

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We aimed to identify predictors for the changes of various developmental outcomes in preschool children with cerebral palsy (CP). Participants were 78 children (49 boys, 29 girls) with CP (mean age: 3 years, 8 months; SD: 1 year, 7 months; range: 1 year to 5 years, 6 months). We examined eight potential predictors: age, sex, CP subtype, Gross Motor Function Classification System (GMFCS) level, selective motor control, Modified Ashworth Scale, and the spinal alignment (SA) and range of motion subscales of the Spinal Alignment and Range of Motion Measure (SAROMM). Developmental outcomes for cognition, language, self-help, and social and motor functions were measured at baseline and a 6-month follow-up with the Comprehensive Developmental Inventory for Infants and Toddlers. Regression model showed GMFCS level was a negative predictor for change of language (adjusted $r^2=0.30$, $p<.001$), motor function (adjusted $r^2=0.26$, $p<.001$), social function (adjusted $r^2=0.07$, $p=0.014$), and self-help (adjusted $r^2=0.26$, $p<.001$). Age was a negative predictor for change of cognition (adjusted $r^2=0.21$, $p<.001$) and language functions (adjusted $r^2=0.26$, $p<.001$). SAROMM-SA was a negative predictor for cognitive change (adjusted $r^2=0.30$, $p<.001$). The GMFCS levels and age are robust negative predictors for change of most developmental domains in these children.

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2. *J Pediatr Orthop B.* 2013 Sep 9. [Epub ahead of print]

Palliative hip surgery in severe cerebral palsy: a systematic review.

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Center, Amsterdam, The Netherlands.

We performed a systematic review of the results of palliative hip surgery in severe cerebral palsy. Individuals with severe cerebral palsy frequently suffer from pain and other impairments because of dislocation or malformation of the hips. When preventive or reconstructive surgery fails, palliative intervention is performed. A number of salvage interventions have been described. We found articles on resection surgery of the femoral head, arthrodesis of the hip joint, and total hip replacement. The published literature does not clearly favor one procedure over the others. The resection arthroplasty technique developed by Castle is reported to yield the best results and fewer complications, and seems to eventually lead to a good outcome.

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3. Res Dev Disabil. 2013 Sep 9;34(11):3773-3780. doi: 10.1016/j.ridd.2013.08.019. [Epub ahead of print]

Reduction in primary genu recurvatum gait after aponeurotic calf muscle lengthening during multilevel surgery.

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Knee hyperextension (genu recurvatum, GR) is often seen in children with bilateral spastic cerebral palsy (CP). Primary GR appears essential without previous treatment. As equinus deformity is suspected to be one of the main factors evoking primary GR, the purpose of this study was to determine whether lengthening the calf muscles to decrease equinus would decrease coexisting GR in children with bilateral spastic CP. In a retrospective study, 19 CP patients with primary GR (mean age: 9.4 years, 13 male, 6 female, 26 involved limbs) in whom an aponeurotic calf muscle lengthening procedure was performed during single-event multilevel surgery were included and investigated using three-dimensional gait analysis before and at a mean follow-up of 14 months after the procedure according to a standardized protocol. After calf muscle lengthening, a significant improvement in ankle dorsiflexion (9.5°) and a significant reduction (10.5°) in knee hyperextension ($p < 0.001$) were found during mid-stance of the gait cycle. Six limbs (23%) showed no improvement concerning knee hyperextension and were designated as nonresponders. In these patients no significant improvement in ankle dorsiflexion was found after surgery either. Improvement in ankle dorsiflexion and reduction in knee hyperextension in stance phase correlated significantly ($r = 0.46$; $p = 0.019$). These findings indicate that equinus deformity is a Major underlying factor in Primary GR and that calf muscle lengthening can effectively reduce GR in patients with CP.

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4. Res Dev Disabil. 2013 Sep 7;34(11):3906-3915. doi: 10.1016/j.ridd.2013.07.031. [Epub ahead of print]

Requirements for and impact of a serious game for neuro-pediatric robot-assisted gait training.

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We investigated whether children with neurological gait disorders who walked in a driven gait orthosis could adjust their participation level according to the demands of a newly developed rehabilitation game. We further investigated if cognitive capacity and motor impairment influenced game performance. Nineteen children with neurological gait disorders (mean age: 13.4y, 42% girls) participated. To quantify game participation, electromyographic muscle activity (M. rectus femoris) and heart rate were compared in a demanding part and a less demanding part of the game. Cognitive capacity was assessed with the Test of Nonverbal Intelligence (TONI-4). Furthermore, the Functional Independence Measure for Children (WeeFIM), Manual Muscle Tests and a therapist-derived score of

how well the child was able to train were assessed. Results showed that muscle activity and heart rate were higher during the demanding part of the game ($30.7 \pm 22.6 \mu\text{V}$; $129.4 \pm 15.7 \text{bpm}$) compared to the less demanding part ($16.0 \pm 13.4 \mu\text{V}$; $124.1 \pm 15.9 \text{bpm}$; $p < 0.01$ for both measures). Game performance correlated moderately with the TONI-4 ($r = 0.50$, $p = 0.04$) and the cognition subscale of the WeeFIM ($\rho = 0.59$, $p = 0.01$). The therapist-derived score correlated significantly with game performance ($\rho = 0.75$, $p < 0.01$) and the ability to modify muscle activity to the demands of the game ($\rho = -0.72$, $p < 0.01$). Receiver operating characteristic analyses revealed that the latter factor differentiated well between those children suitable for the game and those not. We conclude that children with neurological gait disorders are able to modify their activity to the demands of the VR-scenario. However, cognitive function and motor impairment determine to which extent. These results are important for clinical decision-making.

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5. PLoS One. 2013 Sep 4;8(9):e73139. doi: 10.1371/journal.pone.0073139.

Feasibility study of a wearable exoskeleton for children: is the gait altered by adding masses on lower limbs?

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We are designing a pediatric exoskeletal ankle robot (pediatric Anklebot) to promote gait habilitation in children with Cerebral Palsy (CP). Few studies have evaluated how much or whether the unilateral loading of a wearable exoskeleton may have the unwanted effect of altering significantly the gait. The purpose of this study was to evaluate whether adding masses up to 2.5 kg, the estimated overall added mass of the mentioned device, at the knee level alters the gait kinematics. Ten healthy children and eight children with CP, with light or mild gait impairment, walked wearing a knee brace with several masses. Gait parameters and lower-limb joint kinematics were analyzed with an optoelectronic system under six conditions: without brace (natural gait) and with masses placed at the knee level (0.5, 1.0, 1.5, 2.0, 2.5 kg). T-tests and repeated measures ANOVA tests were conducted in order to find noteworthy differences among the trial conditions and between loaded and unloaded legs. No statistically significant differences in gait parameters for both healthy children and children with CP were observed in the five "with added mass" conditions. We found significant differences among "natural gait" and "with added masses" conditions in knee flexion and hip extension angles for healthy children and in knee flexion angle for children with CP. This result can be interpreted as an effect of the mechanical constraint induced by the knee brace rather than the effect associated with load increase. The study demonstrates that the mechanical constraint induced by the brace has a measurable effect on the gait of healthy children and children with CP and that the added mass up to 2.5 kg does not alter the lower limb kinematics. This suggests that wearable devices weighing 25 N or less will not noticeably modify the gait patterns of the population examined here.

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6. Phys Ther. 2013 Sep 12. [Epub ahead of print]

Reliability of a Progressive Maximal Cycle Ergometer Test to Assess Peak Oxygen Uptake in Children With Mild to Moderate Cerebral Palsy.

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BACKGROUND: Rehabilitation research in children with cerebral palsy (CP) is increasingly addressing cardiorespiratory fitness testing. However, evidence on the reliability of peak oxygen uptake ($\text{VO}_{2\text{peak}}$)

measurements, considered the best indicator of aerobic fitness, is not available in this population. OBJECTIVE: To establish the reliability of a progressive maximal cycle ergometer test when assessing VO₂peak in children with mild to moderate CP. DESIGN: Repeated-measures measures to assess test-retest reliability. METHODS: Eligible participants were ambulant, aged 6 to 14 years, and classified as level I, II or III according to the Gross Motor Function Classification System (GMFCS). Two progressive maximal cycle ergometer tests were conducted (separated by 3 weeks), with the workload increasing every minute in steps of 3-11 Watt, dependent on height and GMFCS. Reliability was determined using the intraclass correlation coefficient (ICC_{2,1}) and smallest detectable change (SDC). RESULTS: Twenty-one children participated (GMFCS I: n=4; GMFCS II: n=12 and III: n=5). Sixteen of them (9 boys, 7 girls; GMFCS I: n=3; GMFCS II: n=11 and III: n=2) performed two successful tests, separated by 9.5 days on average. Reliability for VO₂peak was excellent (ICC: 0.94; 95% CI: 0.83-0.97). The SDC was 5.72 ml/kg/min, reflecting 14.6% of the mean. LIMITATIONS: The small sample size did not allow separate analysis of reliability per GMFCS level. CONCLUSIONS: In children with CP of GMFCS levels I and II, a progressive maximal cycle ergometer test to assess VO₂peak is reliable and has the potential to detect change in cardiorespiratory fitness over time. Further study is needed to establish the reliability of VO₂peak in children of GMFCS level III.

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7. J Child Neurol. 2013 Sep 9. [Epub ahead of print]

Children With Central and Peripheral Neurologic Disorders Have Distinguishable Patterns of Dysphagia on Videofluoroscopic Swallow Study.

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To determine whether findings on videofluoroscopic swallow studies reveal different patterns of dysphagia between children with central and peripheral neurologic disorders, a retrospective study of 118 videofluoroscopic swallow studies was completed. There were 3 groups: cerebral palsy with only spastic features (n = 53), cerebral palsy with dyskinetic features (n = 34), and neuromuscular disorders (myotonic dystrophy I, n = 5; spinal muscular atrophy I-II, n = 8; Duchenne muscular dystrophy, n = 8; other neuromuscular disorder, n = 10). Interpretation of the videofluoroscopic swallow studies was not blinded. The video fluoroscopic swallow study findings were compared dichotomously between the groups. Children with cerebral palsy demonstrated dysphagia in 1 or all phases of swallowing. In neuromuscular disorder, muscle weakness results in pharyngeal residue after swallow. The underlying swallowing problem in neuromuscular disorder is muscle weakness whereas that in cerebral palsy is more complex, having to do with abnormal control of swallowing. This study serves as a first exploration on specific characteristics of swallowing in different neurologic conditions and will help clinicians anticipate what they might expect.

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8. Disabil Rehabil. 2013 Sep 11. [Epub ahead of print]

Monitoring of body position and motion in children with severe cerebral palsy for 24 hours.

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Purpose: To investigate differences in position and body movements between children with severe cerebral palsy (CP) and children with typical development (TD) during the daytime and while asleep at night. Method: Fifteen children with severe quadriplegic CP living at home (GMFCS level V, 7 males, 8 females; mean age 8 years 3 months; range 3-20 years) and 15 children with TD (6 males, 9 females; mean age 8 years 7 months; range 1-16 years) participated. Body position and movements were recorded for 24 h by a body position monitor and a physical activity monitor, respectively. The amount of time spent in one position and the durations of inactive periods during the daytime and during night-time sleep were computed and analyzed for group differences. Results: In children with CP, the mean longest time spent in one position was longer than that in children with TD during night-time

sleep (5.6 ± 3.5 h versus 1.6 ± 1.2 h). In contrast, no significant differences were found between the groups during the daytime (1.9 ± 1.1 h versus 1.6 ± 0.7 h). The mean longest time the body remained inactive was longer in the children with CP during both daytime and night time sleep (0.6 ± 0.3 h versus 0.3 ± 0.3 h for daytime, 1.4 ± 0.8 h versus 0.7 ± 0.3 h for night time). Conclusion: Children with severe CP living at home showed prolonged immobilized posture during night-time sleep when their caregivers would be likely to also be asleep. This may suggest that these children should receive postural care assistance at night. Implications for Rehabilitation A large number of daytime position changes are seen in children with severe cerebral palsy (CP), even if they are unable to change positions by themselves. One position is held with no movement during night-time sleep in children with severe CP. Prolonged immobility posture during night-time sleep might suggest the need for postural care assistance at night for these children.

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