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**Professor Nadia Badawi AM**

Macquarie Group Foundation Chair of Cerebral Palsy

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## Interventions and Management

### 1. Augmented effects of EMG biofeedback interfaced with virtual reality on neuromuscular control and movement coordination during reaching in children with cerebral palsy.

Yoo JW, Lee DR, Cha YJ, You SH.

NeuroRehabilitation. 2017 Jan 30. doi: 10.3233/NRE-161402. [Epub ahead of print]

**BACKGROUND:** The purpose of the present study was to compare therapeutic effects of an electromyography (EMG) biofeedback augmented by virtual reality (VR) and EMG biofeedback alone on the triceps and biceps (T:B) muscle activity imbalance and elbow joint movement coordination during a reaching motor task. **OBJECTIVE:** To compare therapeutic effects of an electromyography (EMG) biofeedback augmented by virtual reality (VR) and EMG biofeedback alone on the triceps and biceps muscle activity imbalance and elbow joint movement coordination during a reaching motor task in normal children and children with spastic cerebral palsy (CP). **METHODS:** 18 children with spastic CP (2 females; mean±standard deviation=9.5 ± 1.96 years) and 8 normal children (3 females; mean ± standard deviation=9.75 ± 2.55 years) were recruited from a local community center. All children with CP first underwent one intensive session of EMG feedback (30 minutes), followed by one session of the EMG-VR feedback (30 minutes) after a 1-week washout period. Clinical tests included elbow extension range of motion (ROM), biceps muscle strength, and box and block test. EMG triceps and biceps (T:B) muscle activity imbalance and reaching movement acceleration coordination were concurrently determined by EMG and 3-axis accelerometer measurements respectively. Independent t-test and one-way repeated analysis of variance (ANOVA) were performed at  $p < 0.05$ . **RESULTS:** The one-way repeated ANOVA was revealed to be significantly effective in elbow extension ROM ( $p = 0.01$ ), biceps muscle strength ( $p = 0.01$ ), and box and block test ( $p = 0.03$ ). The one-way repeated ANOVA also revealed to be significantly effective in the peak triceps muscle activity ( $p = 0.01$ ). However, one-way repeated ANOVA produced no statistical significance in the composite 3-dimensional movement acceleration coordination data ( $p = 0.12$ ). **CONCLUSIONS:** The present study is a first clinical trial that demonstrated the superior benefits of the EMG biofeedback when augmented by virtual reality exercise games in children with spastic CP. The augmented EMG and VR feedback produced better neuromuscular balance control in the elbow joint than the EMG biofeedback alone.

[PMID: 28222541](#)

### 2. Swan-Neck Deformity in Cerebral Palsy.

Chiu L, Adams NS, Luce PA.

Eplasty. 2017 Jan 30;17:ic3. eCollection 2017.

A 34-year-old woman with cerebral palsy presented with swan-neck deformity of the left index and long fingers (Fig 1). The proximal interphalangeal (PIP) joint was found locked in hyperextension, but the patient could actively flex it if the

hyperextension was corrected. The patient was treated with the flexor digitorum superficialis (FDS) sling procedure utilizing suture anchor support.

[PMID: 28197298](#)

### **3. Upper limb kinematics of adults with cerebral palsy on bilateral functional tasks.**

Lott C, Johnson MJ, Lott C, Johnson MJ, Lott C, Johnson MJ.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:5676-5679. doi: 10.1109/EMBC.2016.7592015.

Adults with cerebral palsy (CP) often show upper limb impairments which impact their ability to execute activities of daily living (ADLs). Three adults with CP and five healthy adults performed three types of bilateral and unilateral ADLs: drink, pour, and pick and place tasks. An affordable bilateral assessment system (BiAS) was used to measure wrist kinematic trajectories. Four metrics, total completion time, maximum velocity, smoothness, and phase difference, were used to evaluate each functional task. Overall, adults with CP took a longer time than the healthy subjects to complete all unilateral functional tasks with their non-dominant hand. Moreover, while the healthy controls had similar mean velocities in the dominant and non-dominant hands during the bilateral tasks, adults with CP typically exhibited slower mean velocities in the dominant hand during the bilateral tasks than during the unilateral dominant tasks. Similar to existing literature, we found that adults with CP compensated by slowing the dominant arm to match the non-dominant arm in order to complete the tasks, showing the importance of utilizing bilateral training in upper limb rehabilitation treatments.

[PMID: 28227798](#)

### **4. Eye movements show similar adaptations in temporal coordination to movement planning conditions in both people with and without cerebral palsy.**

Payne AR, Plimmer B, McDaid A, Davies TC.

Exp Brain Res. 2017 Feb 20. doi: 10.1007/s00221-017-4891-x. [Epub ahead of print]

The effects of cerebral palsy on movement planning for simple reaching tasks are not well understood. Movement planning is complex and entails many processes which could be affected. This study specifically sought to evaluate integrating task information, decoupling movements, and adjusting to altered mapping. For a reaching task, the asynchrony between the eye onset and the hand onset was measured across different movement planning conditions for participants with and without cerebral palsy. Previous research shows people without cerebral palsy vary this temporal coordination for different planning conditions. Our measurements show similar adaptations in temporal coordination for groups with and without cerebral palsy, to three of the four variations in planning condition tested. However, movement durations were still longer for the participants with cerebral palsy. Hence for simple goal-directed reaching, movement execution problems appear to limit activity more than movement planning deficits.

[PMID: 28220201](#)

### **5. Bone age in unilateral spastic cerebral palsy: is there a correlation with hand function and limb length?**

Lee JS, Choi IJ, Shin MJ, Yoon JA, Ko SH, Shin YB.

J Pediatr Endocrinol Metab. 2017 Feb 23. pii: /j/jpem.ahead-of-print/jpem-2016-0349/jpem-2016-0349.xml. doi: 10.1515/jpem-2016-0349. [Epub ahead of print]

**BACKGROUND:** The purpose of this study was to analyze the bone age and the upper extremity segmental lengths between the affected and the unaffected side and to reveal the correlation between the difference of bone age and the upper limb length discrepancy in the unilateral spastic cerebral palsy (CP). We also evaluated the relationship between difference of bone age and hand function. **METHODS:** Seventy-eight patients participated in this study. The bone ages of hand-wrists of the patients were determined by the Greulich and Pyle atlas. Upper extremity segmental lengths were measured by radiograph. The side-to side

length discrepancy was calculated as a percentage. Hand function was classified according to the Manual Ability Classification System (MACS). RESULTS: There was significant difference in the bone age between the affected and unaffected side ( $p<0.001$ ). Segmental lengths of the upper extremities showed significant differences between the affected and unaffected side ( $p<0.001$ ). The hand function of 56 patients was evaluated by MACS and the MACS level showed correlation with difference of side-to-side bone age ( $r=0.29$ ,  $p=0.03$ ) and all segmental upper limb length discrepancies ( $p<0.05$ ). The hand function in the bone-age-delayed group was significantly better than the hand function in the bone-age-symmetrical group ( $p<0.01$ ). CONCLUSIONS: The bone age of the affected side compared to the unaffected side is delayed and the hand function of the affected side is correlated with the difference of side-to-side bone age and the upper limb length discrepancy. Hand function might be helpful for predicting potential limb shortness and delayed bone age.

[PMID: 28231063](#)

## 6. Can an anti-gravity treadmill improve stability of children with cerebral palsy?

Birgani PM, Ashtiyani M, Rasooli A, Shahrokhnia M, Shahrokhi A, Mirbagheri MM.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:5465-5468. doi: 10.1109/EMBC.2016.7591963.

We aimed to study the effects of an anti-gravity treadmill (AlterG) training on balance and postural stability in children with cerebral palsy (CP). AlterG training was performed 3 days/week for 8 weeks, with up to 45 minutes of training per session. The subject was evaluated before and after the 8-week training. The effects of training on the balance and postural stability was evaluated based on the Romberg test that was performed by using a posturography device. The parameters quantifying Center-of-Pressure (CoP) were calculated using different analytical approaches including power spectral density and principal components analyses. All of the key parameters including the Stabilogram, the Fast Fourier Transform (FFT) Energy, the Eigenvectors, and the Eigenvalues of CoP were modified between 14%-84%. The results indicated that the balance features were improved substantially after training. The clinical implication is that the AlterG has the potential to effectively improve postural stability in children with cerebral palsy.

[PMID: 28227746](#)

## 7. Improving modified tardieu scale assessment using inertial measurement unit with visual biofeedback.

Choi S, Kim J, Seoyoung Choi, Jonghyun Kim, Choi S, Kim J.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:4703-4706. doi: 10.1109/EMBC.2016.7591777.

Reliable spasticity assessment is important to provide appropriate intervention for spasticity. Modified Tardieu scale (MTS) assessment is simple and convenient enough to be used in clinical environment, but has poor or moderate reliability due to irregular passive stretch velocity and goniometric measurement. We proposed a novel inertial measurement unit (IMU)-based MTS assessment with gyroscope-based visual biofeedback to improve the reliability of MTS by providing regular passive stretch velocity. With five children with cerebral palsy and two raters, the IMU-based MTS assessment was compared with conventional MTS assessment. The results showed that the proposed one has good test-retest and inter-rater reliabilities ( $ICC > .08$ ) while the conventional MTS has poor or moderate reliability. Moreover, it was shown that the proposed visual biofeedback is effective enough to provide regular passive stretch velocity.

[PMID: 28227562](#)

## 8. A robotic exoskeleton to treat crouch gait from cerebral palsy: Initial kinematic and neuromuscular evaluation.

Lerner ZF, Damiano DL, Bulea TC.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:2214-2217. doi: 10.1109/EMBC.2016.7591169.

A robotic exoskeleton was designed for individuals with crouch gait caused by cerebral palsy with the intent to supplement existing muscle function during walking. The aim of this study was to evaluate how powered knee extension assistance provided during stance and swing phases of the gait cycle affect knee kinematics, and knee flexor and extensor muscle activity. Muscle activity and kinematic data were collected from four individuals with crouch gait from cerebral palsy during their

normal walking condition and while walking with the exoskeleton under stance, swing, and stance & swing assistance. The exoskeleton was effective in reducing crouch by an average of 13.8° in three of the four participants when assistance was provided during the stance phase; assistance during the swing phase alone was ineffective. Peak knee extensor activity was maintained for all of the conditions during the stance and swing phases. Integrated (i.e. area under the curve) knee extensor activity decreased in two of the subjects indicating a more well-modulated activation pattern. Modest increases in peak and integrated antagonist knee flexor activity were exhibited in all participants; the subject without kinematic improvement had the greatest increase. While the exoskeleton was well tolerated, additional training with a focus on reducing knee flexor activity may lead to further improvements in crouch gait reduction.

[PMID: 28226960](#)

### **9. Estimation of gait parameter using sonoelastography in children with cerebral palsy.**

Mansouri M, Birgani PM, Kharazi MR, Lotfian M, Naeimipoor M, Mirbagheri MM.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:1729-1732. doi: 10.1109/EMBC.2016.7591050.

We aimed to study the relationship between neuromuscular abnormalities associated with spasticity and gait impairments in spastic children with hemiplegia cerebral palsy (CP). Neuromuscular abnormalities of the tibialis anterior and medial gastrocnemius muscles of the spastic ankle were quantified using sonoelastography with two major features; i.e. entropy and histogram ratio of sonoelastography images. Gait impairments were evaluated in the gait laboratory using motion capture system, and the spatial and temporal features were extracted. The correlation analysis showed a significant relation between both the entropy and histogram ratio of sonoelastography images with walking speed and step time. The findings demonstrate that the neuromuscular abnormalities associated with spasticity may contribute to gait impairments in children with CP.

[PMID: 28226844](#)

### **10. Pendulum test measure correlates with gait parameters in children with cerebral palsy.**

Lotfian M, Mirbagheri MM, Kharazi MR, Dadashi F, Nourian R, Irani A, Mirbagheri A.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:1708-1711. doi: 10.1109/EMBC.2016.7591045.

Individuals with cerebral palsy (CP) usually suffer from different impairments including gait impairment and spasticity. Spastic hypertonia is a defining feature of spasticity and manifests as a mechanical abnormality. The objective of this study was to determine the relationship between spastic hypertonia and gait impairments in spastic children with CP, addressing an important controversial issue. Spastic hypertonia was quantified using the pendulum test. The gait impairments were evaluated using the motion capture system in a gait laboratory. Our results showed significant correlations among gait parameters; i.e. walking speed, step length, and the pendulum test measures. This indicates that neuromuscular abnormalities are associated with spasticity and may contribute to gait impairments. The clinical implication is that the impaired gait in children with CP may be improved with the treatment of neuromuscular abnormalities.

[PMID: 28226839](#)

### **11. Inter- and intrarater clinician agreement on joint motion patterns during gait in children with cerebral palsy.**

Nieuwenhuys A, Papageorgiou E, Molenaers G, Monari D, de Laet T, Desloovere K.

Dev Med Child Neurol. 2017 Feb 22. doi: 10.1111/dmcn.13404. [Epub ahead of print]

AIM: This study aimed to quantify the inter- and intrarater clinician agreement on joint motion patterns in children with spastic cerebral palsy (CP), which were recently specified by a Delphi consensus study. It also examined whether experience with three-dimensional gait analysis (3DGA) is a prerequisite for using the patterns. METHOD: The experimental group consisted of 82 patients with CP (57 males, 25 females; uni-/bilateral CP [n=27/55]; Gross Motor Function Classification System levels I

to III; mean age 9y 5mo [range 4y-18y]). Thirty-two clinicians were split into 'experienced' and 'inexperienced' rater groups. Each rater was asked to classify 3DGA reports of 27 or 28 patients twice. Inter- and intrarater agreement on 49 joint motion patterns was estimated using percentage of agreement and kappa statistics. RESULTS: Twenty-eight raters completed both classification rounds. Intrarater agreement was 'substantial' to 'almost perfect' for all joints ( $0.64 < \kappa < 0.91$ ). Interrater agreement reached similar results ( $0.63 < \kappa < 0.86$ ), except for the knee patterns during stance ( $\kappa = 0.49$ , 'moderate agreement'). Experienced raters performed significantly better on patterns of the knee during stance and ankle during swing. INTERPRETATION: Apart from some specific knee patterns during stance and ankle patterns during swing, the results suggested that clinicians could use predefined joint motion patterns in CP with good confidence, even in case of limited experience with 3DGA.

[PMID: 28224608](#)

## **12. Motor Learning Abilities Are Similar in Hemiplegic Cerebral Palsy Compared to Controls as Assessed by Adaptation to Unilateral Leg-Weighting during Gait: Part I.**

Damiano DL, Stanley CJ, Bulea TC, Park HS.

Front Hum Neurosci. 2017 Feb 8;11:49. doi: 10.3389/fnhum.2017.00049. eCollection 2017.

Introduction: Individuals with cerebral palsy (CP) demonstrate high response variability to motor training insufficiently accounted for by age or severity. We propose here that differences in the inherent ability to learn new motor tasks may explain some of this variability. Damage to motor pathways involving the cerebellum, which may be a direct or indirect effect of the brain injury for many with CP, has been shown to adversely affect the ability to learn new motor tasks and may be a potential explanation. Classic adaptation paradigms that evaluate cerebellar integrity have been utilized to assess adaptation to gait perturbations in adults with stroke, traumatic brain injury and other neurological injuries but not in children with CP. Materials and Methods: A case-control study of 10 participants with and 10 without hemiplegic CP within the age range of 5-20 years was conducted. Mean age of participants in the CP group was slightly but not significantly higher than controls. Step length and swing time adaptation, defined as gradual accommodation to a perturbation, and aftereffects, or maintenance of the accommodation upon removal of the perturbation, to unilateral leg weighing during treadmill gait were quantified to assess group differences in learning. Results: Adaptation and aftereffects were demonstrated in step length across groups with no main effect for group. In CP, the dominant leg had a greater response when either leg was weighted. Swing time accommodated immediately (no adaptation) in the weighted leg only, with the non-dominant leg instead showing a more pronounced response in CP. Discussion: This group of participants with unilateral CP did not demonstrate poorer learning or retention similar to reported results in adult stroke. Deficits, while not found here, may become evident in those with other etiologies or greater severity of CP. Our data further corroborate an observation from the stroke literature that repeated practice of exaggerating the asymmetry (error augmentation), in this case by weighting the more involved or shorter step leg, vs. minimizing it by weighting the less involved or longer step leg (error reduction) may be a useful training strategy to improve step symmetry in unilateral CP.

[PMID: 28228720](#)

## **13. Popliteal block for lower limb surgery in children with cerebral palsy: effect on sevoflurane consumption and postoperative pain (a randomized, double-blinded, controlled trial).**

Ozkan D, Gonen E, Akkaya T, Bakir M.

J Anesth. 2017 Feb 14. doi: 10.1007/s00540-017-2318-2. [Epub ahead of print]

PURPOSE: The aim of this study was to evaluate the effects of a preoperative popliteal block on sevoflurane consumption, postoperative pain, and analgesic consumption in children with cerebral palsy (CP) following lower limb surgery. METHODS: Fifty-four patients undergoing lower limb surgery were randomized to receive either a popliteal block + general anaesthesia (group P, n = 27) or general anaesthesia without a popliteal block (group C, n = 27). After anesthesia induction with 50% N<sub>2</sub>O, O<sub>2</sub>, and 8% sevoflurane, a popliteal block was given to group P patients with ultrasound guidance as a single dose of 0.3 ml/kg body weight of 0.25% bupivacaine. Group C patients received the same regimen of anesthesia induction but no preoperative popliteal block. Both the conductance fluctuation (SCF) peak numbers per second and the Wong-Baker FACES® Pain Rating Scale (WBFS) values of the patients were recorded upon arrival at the PACU, at 10 and 20 min after arrival at the PACU, and at postoperative hours 1, 4, 8, 12, and 24 when they were in the ward. The total paracetamol consumption of the patients was also recorded. RESULTS: The end-tidal sevoflurane concentration values were significantly higher in group C patients than in

group P patients, except for at 5 min after induction of anaesthesia ( $p < 0.001$ ). The SCF peak numbers per second and WBFS scores were significantly higher in group C patients than in group P patients, except at Tp24h ( $p < 0.001$ ). The total paracetamol consumption was  $489.7 \pm 122.7$  mg in group P patients and  $816.6 \pm 166.5$  in group C patients ( $p < 0.001$ ). **CONCLUSION:** Popliteal block is effective for postoperative analgesia, decreasing the paracetamol consumption and sevoflurane requirement in children with CP undergoing lower limb surgery. Trial registration ClinicalTrials.gov identifier: NCT02507700.

[PMID: 28197774](#)

#### **14. The correlation between transcranial magnetic stimulation parameters and neuromuscular properties in children with cerebral palsy.**

Marzbani H, Parvin S, Amiri S, Lotfian M, Kharazi MR, Azizi S, Mirbagheri MM.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:5473-5476. doi: 10.1109/EMBC.2016.7591965.

We studied the correlation between corticospinal signaling and neuromuscular properties in children with Cerebral Palsy (CP). Corticospinal signaling was evaluated using Transcranial Magnetic Stimulation (TMS). Neuromuscular properties were quantified using Hoffmann reflex (H-reflex), sonoelastography, clinical measurements, and isokinetic measures. In particular, we determined the relationship between the TMS parameters of the ankle joint and the neuromuscular features of ankle extensors and flexors as well as popular clinical measures of gait speed, endurance, balance and mobility. Seventeen CP patients and twelve healthy control subjects were evaluated. Our findings showed that the motor evoked potential (MEP) latency of TMS was significantly longer in CP than in healthy subjects. The MEP-latency was significantly correlated with the H-reflex response ( $r=0.71$ ,  $p\text{-value}=0.04$ ) and isokinetic features; i.e. max acceleration extension time ( $r=0.5$ ,  $p\text{-value}=0.005$ ), and max flexion time in the cycle ( $r=0.5$ ,  $p\text{-value}=0.002$ ). No significant correlation was observed between MEP-latency and clinical measurements of gait and sonoelastography of ankle muscles. The results suggest that the changes in corticospinal signaling could contribute to muscle weakness and hyperexcitability of reflexes observed in children with CP.

[PMID: 28227748](#)

#### **15. Carbon Modular Orthosis (Ca.M.O.): An innovative hybrid modular ankle-foot orthosis to tune the variable rehabilitation needs in hemiplegic cerebral palsy.**

Tavernese E, Petrarca M, Rosellini G, Di Stanislao E, Pisano A, Di Rosa G, Castelli E.

NeuroRehabilitation. 2017 Feb 10. doi: 10.3233/NRE-161432. [Epub ahead of print]

**BACKGROUND:** Hemiplegic Cerebral Palsy (CP) children commonly use AFO orthoses as walking aids. It is known that AFOs may have a detrimental effect on gait. To enhance mechanical properties of AFOs we developed an innovative, custom-made, carbon, ankle-foot orthosis (Ca.M.O) which offers the opportunity to tune its response to the patient's gait characteristics and/or functional maturity. **OBJECTIVE:** To assess the efficacy of Ca.M.O. in improving gait in a group of hemiplegic CP children and to compare its performances with those of commonly prescribed AFO. **METHODS:** A clinical and instrumental gait analysis was performed on a group of 15 spastic hemiplegic children (WINTERS-GAGE type I-II) walking barefoot, with commonly prescribed AFOs and with Ca.M.O. Temporal, kinematic and kinetic data were collected with a 8 cameras optoelectronic system and 2 force plates. **RESULTS:** Studied variables were comparable walking with Ca.M.O. and with the commonly prescribed AFO and are significantly different ( $p < 0.01$ ) with respect to barefoot condition. **CONCLUSIONS:** Both types of orthoses normalize the kinematics of the first and second ankle rocker. The main advantage of Ca.M.O. is its modularity that allows to tune its effect on gait in relationship with the progress or involution of the child's functional development.

[PMID: 28222565](#)

## 16. Measuring the quality of exercises.

Parmar P, Morris BT, Parmar P, Morris BT, Parmar P, Morris BT.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:2241-2244. doi: 10.1109/EMBC.2016.7591175.

This work explores the problem of exercise quality measurement since it is essential for effective management of diseases like cerebral palsy (CP). This work examines the assessment of quality of large amplitude movement (LAM) exercises designed to treat CP in an automated fashion. Exercise data was collected by trained participants to generate ideal examples to use as a positive samples for machine learning. Following that, subjects were asked to deliberately make subtle errors during the exercise, such as restricting movements, as is commonly seen in cases of patients suffering from CP. The quality measurement problem was then posed as a classification to determine whether an example exercise was either "good" or "bad". Popular machine learning techniques for classification, including support vector machines (SVM), single and double-layered neural networks (NN), boosted decision trees, and dynamic time warping (DTW), were compared. The AdaBoosted tree performed best with an accuracy of 94.68% demonstrating the feasibility of assessing exercise quality.

[PMID: 28226966](#)

## 17. Physiotherapeutic interventions and physical activity for children in Northern Sweden with cerebral palsy: a register study from equity and gender perspectives.

Degerstedt F, Wiklund M, Enberg B.

Glob Health Action. 2016 Jan - Dec;10(sup2):1272236. doi: 10.1080/16549716.2017.1272236.

**BACKGROUND:** Young people with disabilities, especially physical disabilities, report worse health than others. This may be because of the disability, lower levels of physical activity, and discrimination. For children with cerebral palsy, access to physiotherapy and physical activity is a crucial prerequisite for good health and function. To date, there is limited knowledge regarding potential gender bias and inequity in habilitation services. **OBJECTIVES:** To map how physiotherapeutic interventions (PTI), physical leisure activity, and physical education are allocated for children with cerebral palsy regarding sex, age, level of gross motor function, and county council affiliation. This was done from a gender and equity perspective. **METHODS:** A register study using data from the Cerebral Palsy follow-Up Program (CPUP). Data included 313 children  $\leq 18$  years with cerebral palsy from the five northern counties in Sweden during 2013. Motor impairment of the children was classified according to the expanded and revised Gross Motor Function Classification System (GMFCS). **RESULTS:** In three county councils, boys received more physiotherapy interventions and received them more frequently than girls did. Differences between county councils were seen for frequency and reasons for physiotherapy interventions ( $p < 0.001$ ). The physiotherapist was involved more often with children who had lower motor function and with children who had low physical leisure activity. Children with lower motor function level participated in physical leisure activity less often than children with less motor impairment ( $p < 0.001$ ). Boys participated more frequently in physical education than did girls ( $p = 0.028$ ). **CONCLUSION:** Gender and county council affiliation affect the distribution of physiotherapy interventions for children with cerebral palsy, and there are associations between gender and physical activity. Thus, the intervention is not always determined by the needs of the child or the degree of impairment. A gender-bias is indicated. Further studies are needed to ensure fair interventions.

[PMID: 28219314](#)

## 18. Low Energy Availability, Menstrual Dysfunction, and Low Bone Mineral Density in Individuals with a Disability: Implications for the Para Athlete Population.

Blauwet CA, Brook EM, Tenforde AS, Broad E, Hu CH, Abdu-Glass E, Matzkin EG.

Sports Med. 2017 Feb 17. doi: 10.1007/s40279-017-0696-0. [Epub ahead of print]

Low energy availability, functional hypothalamic amenorrhea, and low bone mineral density are three interrelated conditions described in athletic women. Although described as the female athlete triad (Triad), males experience similar health concerns. The literature suggests that individuals with a disability may experience altered physiology related to these three conditions when compared with the able-bodied population. The goal of this review is to describe the unique implications of low energy availability, low bone mineral density, and, in females, menstrual dysfunction in individuals with a disability and their potential impact on the para athlete population. A literature review was performed linking search terms related to the three conditions

with six disability categories that are most represented in para sport. Few articles were found that directly pertained to athletes, therefore, the review additionally characterizes literature found in a non-athlete population. Review of the available literature in athletes suggests that both male and female athletes with spinal cord injury demonstrate risk factors for low energy availability. Bone mineral density may also show improvements for wheelchair athletes or athletes with hemiplegic cerebral palsy when compared with a disabled non-athlete population. However, the prevalence of the three conditions and implications on the health of para athletes is largely unknown and represents a key gap in the sports medicine literature. As participation in para sport continues to increase, further research is needed to understand the impact of these three interrelated health concerns for athletes with a disability, accompanied by educational initiatives targeting athletes, coaches, and health professionals.

[PMID: 28213754](#)

### **19. Effect of Biomechanical Constraints on Neural Control of Head Stability in Children With Moderate to Severe Cerebral Palsy.**

da Costa CS, Saavedra SL, Rocha NA, Woollacott MH.

Phys Ther. 2016 Oct 6. doi: 10.2522/ptj.20150418. [Epub ahead of print]

**Background.** External support has been viewed as an important biomechanical constraint for children with deficits in postural control. Nonlinear analysis of head stability may be helpful to confirm benefits of interaction between external trunk support and level of trunk control. **Objective.** The purpose of this study was to compare the effect of biomechanical constraints (trunk support) on neural control of head stability during development of trunk control. **Design.** This was a quasi-experimental repeated-measures study. **Methods.** Data from 15 children (4–16 years of age) with moderate (Gross Motor Function Classification System [GMFCS] IV; n=8 [4 boys, 4 girls]) or severe (GMFCS V; n=7 [4 boys, 3 girls]) cerebral palsy (CP) were compared with previous longitudinal data from infants with typical development (TD) (3–9 months of age). Kinematic data were used to document head sway with external support at 4 levels (axillae, midrib, waist, and hip). Complexity, predictability, and active degrees of freedom for both anterior-posterior and medial-lateral directions were assessed. **Results.** Irrespective of level of support, CP groups had lower complexity, increased predictability, and greater degrees of freedom. The effect of support differed based on the child's segmental level of control. The GMFCS V and youngest TD groups demonstrated better head control, with increased complexity and decreased predictability, with higher levels of support. The GMFCS IV group had the opposite effect, showing decreased predictability and increased complexity and degrees of freedom with lower levels of support. **Limitations.** Infants with typical development and children with CP were compared based on similar segmental levels of trunk control; however, it is acknowledged that the groups differed for age, cognitive level, and motor experience. **Conclusions.** The effect of external support varied depending on the child's level of control and diagnostic status. Children with GMFCS V and young infants with TD had better outcomes with external support, but external support was not enough to completely correct for the influence of CP. Children with GMFCS IV performed worse, with increased predictability and decreased complexity, when support was at the axillae or midribs, suggesting that too much support can interfere with postural sway quality.

[PMID: 28204774](#)

### **20. Sleep disordered breathing in children with cerebral palsy.**

Koyuncu E, Türkkani MH, Sarikaya FG, Özgirgin N.

Sleep Med. 2017 Feb;30:146-150. doi: 10.1016/j.sleep.2016.01.020. Epub 2016 Jun 6.

**OBJECTIVES:** The purpose of this study was to investigate the frequency of Sleep Disordered Breathing (SDB) in children with Cerebral Palsy (CP), and determine whether a relationship between SDB and age, gender, weight status, type of CP, motor function level, and spasticity can be established. **METHODS:** The study included 94 children with CP and 94 healthy children with normal development, between the ages two and 18. SDB was assessed using the Sleep-Related Breathing Disorder (SRBD) scale of the Pediatric Sleep Questionnaire (PSQ). **RESULTS:** No statistically significant difference was found with respect to age and gender between the study and the control groups. It was found that 9.6% of the patients with CP had snoring, 12.8% had sleepiness, 37.2% had attention deficiency-hyperactivity, and 18.1% had SRBD. SRBD was statistically significantly higher in patients with CP compared with the control group. No significant relationship was detected between SRBD and age, gender, weight status, type of CP, motor function level, spasticity, and epilepsy. **CONCLUSIONS:** Our result confirm that SDB is more common in children with CP than typically developing children. Thus, SDB problems should be identified in routine clinical practice in patients with CP, by using the SRBD scale of the PSQ.

[PMID: 28215238](#)

## 21. Kinesthetic deficits after perinatal stroke: robotic measurement in hemiparetic children.

Kuczynski AM, Semrau JA, Kirton A, Dukelow SP.

J Neuroeng Rehabil. 2017 Feb 15;14(1):13. doi: 10.1186/s12984-017-0221-6.

**BACKGROUND:** While sensory dysfunction is common in children with hemiparetic cerebral palsy (CP) secondary to perinatal stroke, it is an understudied contributor to disability with limited objective measurement tools. Robotic technology offers the potential to objectively measure complex sensorimotor function but has been understudied in perinatal stroke. The present study aimed to quantify kinesthetic deficits in hemiparetic children with perinatal stroke and determine their association with clinical function. **METHODS:** Case-control study. Participants were 6-19 years of age. Stroke participants had MRI confirmed unilateral perinatal arterial ischemic stroke or periventricular venous infarction, and symptomatic hemiparetic cerebral palsy. Participants completed a robotic assessment of upper extremity kinesthesia using a robotic exoskeleton (KINARM). Four kinesthetic parameters (response latency, initial direction error, peak speed ratio, and path length ratio) and their variabilities were measured with and without vision. Robotic outcomes were compared across stroke groups and controls and to clinical measures of sensorimotor function. **RESULTS:** Forty-three stroke participants (23 arterial, 20 venous, median age 12 years, 42% female) were compared to 106 healthy controls. Stroke cases displayed significantly impaired kinesthesia that remained when vision was restored. Kinesthesia was more impaired in arterial versus venous lesions and correlated with clinical measures. **CONCLUSIONS:** Robotic assessment of kinesthesia is feasible in children with perinatal stroke. Kinesthetic impairment is common and associated with stroke type. Failure to correct with vision suggests sensory network dysfunction.

[PMID: 28202036](#)

## 22. Study of Parental Perceptions on Health & Social Needs of Children with Neuro-Developmental Disability and Its Impact on the Family.

Ansari NJ, Dhongade RK, Lad PS, Borade A, Yg S, Yadav V, Mehete A, Kulkarni R.

J Clin Diagn Res. 2016 Dec;10(12):SC16-SC20. doi: 10.7860/JCDR/2016/22538.9039. Epub 2016 Dec 1.

**INTRODUCTION:** The term Neuro Developmental Disorder (NDD) is used for conditions caused by a dysfunction in any part of the brain or nervous system, resulting in physical and/or psychological symptoms as a child develops. Family of children with NDD face many problems. It is very important to find them and create awareness so that gaps in essential services and supports can be decreased. **AIM:** To explore parental perceptions on health & social needs of children with NDD, to understand the impact of disability on the families having children with disability, and to find out the parental perceptions on availability of services for children with NDD and its utilization by families. **MATERIALS AND METHODS:** The parents of 30 children with NDD were interviewed using a questionnaire and data elicited in these interviews were analysed. The questionnaire had preliminary information about parents and child with NDDs, socio-demographic profile of the family and the parental perceptions on health and social needs of their child having NDDs. **RESULTS:** There were total 30 patients 17 were males and 13 were females. Most of the patients suffered from Cerebral Palsy (13 cases) and were diagnosed by General Practitioner (22 cases) while Developmental Neurologist/paediatrician had diagnosed remaining cases of NDD (8 cases). Most common disability for which parents were worried was inability to walk (17 cases). Common difficulties countered in daily care by parents were feeding and bathing (10 cases). Only 2 children were given assistance with tuition & psychologist (cases of ADHD). Most of the parents knew about special schools but didn't know which place such facilities were available and none of the children were attending special schools. Twenty two parents said they have no plans for the future studies but wish that at least child learns to read & write. With help of spiritual power (doing prayers and pooja) 25 parents got courage to face the difficulties and discrimination. Two parents required antidepressants. Six Mothers had to quit their jobs so as to concentrate and give more time to their children. Experience with services provided was satisfactory in 17 cases, while 13 parents reported problem of arranging money, adjusting time for long travelling and regular follow-up. **CONCLUSION:** The findings can be utilized in developing supportive activities for families with disabled children. It addresses the need for new prospective of stigma reduction in our society. The study has found that the care givers of child with NDDs suffer from significant physical and mental stress, and their health should be taken into consideration. The study has found need of "care givers' support group". The professionals can help parents in establishing positive thinking towards care giving. There is need of provision of comprehensive and latest rehabilitation/ support resources & information.

[PMID: 28208966](#)

## Prevention and Cure

### 23. [Neurodevelopmental Outcomes of Very Preterm or Very Low Birth Weight Infants: Comparison of Monochorionic and Dichorionic Twins with Singletons].

[Article in Portuguese; Abstract available in Portuguese from the publisher]

Taborda A, Oliveira G.

Acta Med Port. 2016 Nov;29(11):702-710. doi: 10.20344/amp.7079. Epub 2016 Nov 30.

**INTRODUCTION:** Twins are associated with a delayed development and cerebral palsy. The purpose of this work was to compare the neurologic morbidity in very preterm or very low birth weight dichorionic and monochorionic twins with singletons. **MATERIAL AND METHODS:** We conducted a retrospective cohort study of livebirths lowest through 32 weeks of gestation or very low weight infants admitted to Neonatal Intensive Care Unit of a level III hospital, between 2006 and 2010. Development was evaluated with the Growing Skills II Scale at 24 months of age. Cerebral palsy was defined by predetermined criteria by Surveillance of Cerebral Palsy in Europe. Infants were analyzed as twins and singletons cohort. Within the twin category the infants were further separated as dichorionic and monochorionic and were compared with singletons infants. Logistic regression models were used to control for demographic and clinical factors. **RESULTS:** The cohort of infants who were assessed for neurodevelopmental impaired, consisted of 194 singletons infants and 89 twins (50 dichorionic; 39 monochorionic). Monochorionic twins, when compared with the singletons, showed an increased risk of severe developmental delay in these areas: locomotion (adjusted OR 12.2) language (adjusted OR 6.5) and autonomy (adjusted OR 7.2). Cerebral palsy was diagnosed in 4.1% of singleton infants and 15.4% of monochorionic twins. The adjusted risk of severe developmental delay and cerebral palsy in monochorionic twins was 3.6 and 4.2, respectively. **DISCUSSION:** This work showed higher rate of moderate and severe neurodevelopment delay including cerebral palsy in monochorionic twins compared to singletons infants. Analysis by groups stratified according to gestational age and comparison of monochorionic and dichorionic twins displayed the role of chorionicity for these neurodevelopmental disorders. **CONCLUSIONS:** In our sample the monochorionic twins are associated with an independent risk of neurodevelopmental delay.

[PMID: 28229835](#)

### 24. Fidgety movements, cerebral palsy, and cognitive ability.

Zuk L.

Dev Med Child Neurol. 2017 Feb 23. doi: 10.1111/dmcn.13410. [Epub ahead of print]

[This commentary is on the original article by Datta et al.]

[PMID: 28229490](#)

### 25. Transcranial Magnetic and Direct Current Stimulation in Children.

Hameed MQ, Dhamne SC, Gersner R, Kaye HL, Oberman LM, Pascual-Leone A, Rotenberg A.

Curr Neurol Neurosci Rep. 2017 Feb;17(2):11. doi: 10.1007/s11910-017-0719-0.

Promising results in adult neurologic and psychiatric disorders are driving active research into transcranial brain stimulation techniques, particularly transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), in childhood and adolescent syndromes. TMS has realistic utility as an experimental tool tested in a range of pediatric neuropathologies such as perinatal stroke, depression, Tourette syndrome, and autism spectrum disorder (ASD). tDCS has also been tested as a treatment for a number of pediatric neurologic conditions, including ASD, attention-deficit/hyperactivity disorder, epilepsy, and cerebral palsy. Here, we complement recent reviews with an update of published TMS and tDCS results in children, and discuss developmental neuroscience considerations that should inform pediatric transcranial stimulation.

[PMID: 28229395](#)

## **26. Identifying stereotypic evolving micro-scale seizures (SEMS) in the hypoxic-ischemic EEG of the pre-term fetal sheep with a wavelet type-II fuzzy classifier.**

Abbasi H, Bennet L, Gunn AJ, Unsworth CP, Abbasi H, Bennet L, Gunn AJ, Unsworth CP, Unsworth CP, Bennet L, Abbasi H, Gunn AJ.

Conf Proc IEEE Eng Med Biol Soc. 2016 Aug;2016:973-976. doi: 10.1109/EMBC.2016.7590864.

Perinatal hypoxic-ischemic encephalopathy (HIE) around the time of birth due to lack of oxygen can lead to debilitating neurological conditions such as epilepsy and cerebral palsy. Experimental data have shown that brain injury evolves over time, but during the first 6-8 hours after HIE the brain has recovered oxidative metabolism in a latent phase, and brain injury is reversible. Treatments such as therapeutic cerebral hypothermia (brain cooling) are effective when started during the latent phase, and continued for several days. Effectiveness of hypothermia is lost if started after the latent phase. Post occlusion monitoring of particular micro-scale transients in the hypoxic-ischemic (HI) Electroencephalogram (EEG), from an asphyxiated fetal sheep model in utero, could provide precursory evidence to identify potential biomarkers of injury when brain damage is still treatable. In our studies, we have reported how it is possible to automatically detect HI EEG transients in the form of spikes and sharp waves during the latent phase of the HI EEG of the preterm fetal sheep. This paper describes how to identify stereotypic evolving micro-scale seizures (SEMS) which have a relatively abrupt onset and termination in a frequency range of 1.8-3Hz (Delta waves) superimposed on a suppressed EEG amplitude background post occlusion. This research demonstrates how a Wavelet Type-II Fuzzy Logic System (WT-Type-II-FLS) can be used to automatically identify subtle abnormal SEMS that occur during the latent phase with a preliminary average validation overall performance of 78.71%±6.63 over the 390 minutes of the latent phase, post insult, using in utero pre-term hypoxic fetal sheep models.

[PMID: 28226660](#)

## **27. Clinical hypoxic-ischemic encephalopathy score of the Iberoamerican Society of Neonatology (Siben): A new proposal for diagnosis and management.**

Perez JM, Golombek SG, Sola A.

Rev Assoc Med Bras (1992). 2017 Jan 1;63(1):64-69. doi: 10.1590/1806-9282.63.01.64.

Hypoxic ischemic encephalopathy is a major complication of perinatal asphyxia, with high morbidity, mortality and neurologic sequelae as cerebral palsy, mostly in poor or developing countries. The difficulty in the diagnosis and management of newborns in these countries is astonishing, thus resulting in unreliable data on this pathology and bad outcomes regarding mortality and incidence of neurologic sequelae. The objective of this article is to present a new clinical diagnostic score to be started in the delivery room and to guide the therapeutic approach, in order to improve these results.

[PMID: 28225884](#)

## **28. Primary Human Cytomegalovirus (HCMV) Infection in Pregnancy.**

Buxmann H, Hamprecht K, Meyer-Wittkopf M, Friese K.

Dtsch Arztebl Int. 2017 Jan 27;114(4):45-52. doi: 10.3238/arztebl.2017.0045.

**BACKGROUND:** In 0.5-4% of pregnancies, the prospective mother sustains a primary infection with human cytomegalovirus (HCMV). An HCMV infection of the fetus in the first or second trimester can cause complex post-encephalitic impairment of the infant brain, leading to motor and mental retardation, cerebral palsy, epilepsy, retinal defects, and progressive hearing loss. **METHODS:** This review is based on pertinent publications from January 2000 to October 2016 that were retrieved by a selective search in PubMed employing the terms "cytomegalovirus and pregnancy" and "congenital cytomegalovirus." **RESULTS:** 85-90% of all neonates with HCMV infection are asymptomatic at birth. The main long-term sequela is hearing impairment, which develops in 8-15% of these affected children. Hygienic measures can lower the risk of primary HCMV infection in pregnancy by 50-85%. The first randomized and controlled trial (RCT) of passive immunization with an HCMV-

specific hyper-immune globulin (HIG) preparation revealed a trend toward a lower risk of congenital transmission of the virus (30% versus 44% with placebo,  $p = 0.13$ ). The effect of HIG was more marked in the initial non-randomized trial (15% versus 40%,  $p = 0.02$ ). The RCT also showed HIG to be associated with a higher frequency of fetal growth retardation and premature birth (13% versus 2%,  $p = 0.06$ ). Valaciclovir is a further, non-approved treatment option. **CONCLUSION:** In the absence of an active vaccine against HCMV, counseling about hygienic measures may currently be the single most effective way to prevent congenital HCMV infection. Moreover, HCMV serologic testing is recommended in the guideline of the Association of the Scientific Medical Societies in Germany (Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften, AWMF). Further randomized trials of treatment with HIG and with valaciclovir are urgently needed so that the options for the prevention and treatment of congenital HCMV infection can be assessed.

[PMID: 28211317](#)

### **29. Seizures in Children With Cerebral Palsy and White Matter Injury.**

Cooper MS, Mackay MT, Fahey M, Reddihough D, Reid SM, Williams K, Harvey AS.

Pediatrics. 2017 Feb 16. pii: e20162975. doi: 10.1542/peds.2016-2975. [Epub ahead of print]

**OBJECTIVE:** The goal of this study was to describe the prevalence, syndromes, and evolution of seizure disorders in children with cerebral palsy (CP) due to white matter injury (WMI). **METHODS:** For this population-based cohort study, brain MRI scans and medical records were reviewed in children in the Victorian Cerebral Palsy Register born between 1999 and 2006 recorded as having WMI. Children were excluded if they had features of an undiagnosed syndrome, associated cortical malformation or injury, or no medical contact in the preceding year. Included were 166 children with CP and isolated WMI due to presumed vascular insufficiency or hemorrhage; 87 were born preterm. Seizure and CP details were obtained from medical records and interviews, and EEG recordings were reviewed. **RESULTS:** Forty-one children (25%) had seizures beyond the neonatal period. Four children had West syndrome, which resolved with treatment. Thirteen children had febrile seizures that they outgrew. Thirty children had focal epilepsy with seizure manifestations and EEG discharges typical of early-onset childhood occipital epilepsy or childhood epilepsy with centrotemporal spikes; 23 have outgrown these seizures. Two children had idiopathic generalized epilepsy; it was ongoing in 1 child. Fourteen children had evolution from 1 epileptic syndrome to another. At last follow-up (median age, 12.7 years; minimum age, 9.7 years), 80% had not had a seizure for >2 years. **CONCLUSIONS:** The electroclinical features of seizure disorders associated with CP and WMI are those of the age-limited, epileptic syndromes of childhood, with favorable outcome in the majority. The findings have important implications for counseling and drug treatment.

[PMID: 28209769](#)

### **30. Most cases of cerebral palsy are associated with antenatal events.**

Lees C.

BMJ. 2017 Feb 16;356:j834. doi: 10.1136/bmj.j834.

[PMID: 28209575](#)

### **31. Survival and Neurodevelopmental Outcomes among Periviable Infants.**

Younge N, Goldstein RF, Bann CM, Hintz SR, Patel RM, Smith PB, Bell EF, Rysavy MA, Duncan AF, Vohr BR, Das A, Goldberg RN, Higgins RD, Cotten CM; Eunice Kennedy Shriver National Institute of Child Health and Human Development Neonatal Research Network.

N Engl J Med. 2017 Feb 16;376(7):617-628. doi: 10.1056/NEJMoa1605566.

Background Data reported during the past 5 years indicate that rates of survival have increased among infants born at the borderline of viability, but less is known about how increased rates of survival among these infants relate to early childhood neurodevelopmental outcomes. **Methods** We compared survival and neurodevelopmental outcomes among infants born at 22 to

24 weeks of gestation, as assessed at 18 to 22 months of corrected age, across three consecutive birth-year epochs (2000-2003 [epoch 1], 2004-2007 [epoch 2], and 2008-2011 [epoch 3]). The infants were born at 11 centers that participated in the National Institute of Child Health and Human Development Neonatal Research Network. The primary outcome measure was a three-level outcome - survival without neurodevelopmental impairment, survival with neurodevelopmental impairment, or death. After accounting for differences in infant characteristics, including birth center, we used multinomial generalized logit models to compare the relative risk of survival without neurodevelopmental impairment, survival with neurodevelopmental impairment, and death. Results Data on the primary outcome were available for 4274 of 4458 infants (96%) born at the 11 centers. The percentage of infants who survived increased from 30% (424 of 1391 infants) in epoch 1 to 36% (487 of 1348 infants) in epoch 3 ( $P < 0.001$ ). The percentage of infants who survived without neurodevelopmental impairment increased from 16% (217 of 1391) in epoch 1 to 20% (276 of 1348) in epoch 3 ( $P = 0.001$ ), whereas the percentage of infants who survived with neurodevelopmental impairment did not change significantly (15% [207 of 1391] in epoch 1 and 16% [211 of 1348] in epoch 3,  $P = 0.29$ ). After adjustment for changes in the baseline characteristics of the infants over time, both the rate of survival with neurodevelopmental impairment (as compared with death) and the rate of survival without neurodevelopmental impairment (as compared with death) increased over time (adjusted relative risks, 1.27 [95% confidence interval {CI}, 1.01 to 1.59] and 1.59 [95% CI, 1.28 to 1.99], respectively). Conclusions The rate of survival without neurodevelopmental impairment increased between 2000 and 2011 in this large cohort of periviable infants. (Funded by the National Institutes of Health and others; ClinicalTrials.gov numbers, NCT00063063 and NCT00009633 .).

[PMID: 28199816](#)

### 32. Intermittent auscultation (IA) of fetal heart rate in labour for fetal well-being.

Martis R, Emilia O, Nurdianti DS, Brown J.

Cochrane Database Syst Rev. 2017 Feb 13;2:CD008680. doi: 10.1002/14651858.CD008680.pub2. [Epub ahead of print]

**BACKGROUND:** The goal of fetal monitoring in labour is the early detection of a hypoxic baby. There are a variety of tools and methods available for intermittent auscultation (IA) of the fetal heart rate (FHR). Low- and middle-income countries usually have only access to a Pinard/Laënnec or the use of a hand-held Doppler device. Currently, there is no robust evidence to guide clinical practice on the most effective IA tool to use, timing intervals and length of listening to the fetal heart for women during established labour. **OBJECTIVES:** To evaluate the effectiveness of different tools for IA of the fetal heart rate during labour including frequency and duration of auscultation. **SEARCH METHODS:** We searched the Cochrane Pregnancy and Childbirth Group's Trials Register (19 September 2016), contacted experts and searched reference lists of retrieved articles. **SELECTION CRITERIA:** All published and unpublished randomised controlled trials (RCTs) or cluster-RCTs comparing different tools and methods used for intermittent fetal auscultation during labour for fetal and maternal well-being. Quasi-RCTs, and cross-over designs were not eligible for inclusion. **DATA COLLECTION AND ANALYSIS:** All review authors independently assessed eligibility, extracted data and assessed risk of bias for each trial. Data were checked for accuracy. **MAIN RESULTS:** We included three studies (6241 women and 6241 babies), but only two studies are included in the meta-analyses (3242 women and 3242 babies). Both were judged as high risk for performance bias due to the inability to blind the participants and healthcare providers to the interventions. Evidence was graded as moderate to very low quality; the main reasons for downgrading were study design limitations and imprecision of effect estimates. Intermittent Electronic Fetal Monitoring (EFM) using Cardiotocography (CTG) with routine Pinard (one trial) There was no clear difference between groups in low Apgar scores at five minutes (reported as < six at five minutes after birth) (risk ratio (RR) 0.66, 95% confidence interval (CI) 0.24 to 1.83, 633 babies, very low-quality evidence). There were no clear differences for perinatal mortality (RR 0.88, 95% CI 0.34 to 2.25; 633 infants, very low-quality evidence). Neonatal seizures were reduced in the EFM group (RR 0.05, 95% CI 0.00 to 0.89; 633 infants, very low-quality evidence). Other important infant outcomes were not reported: mortality or serious morbidity (composite outcome), cerebral palsy or neurosensory disability. For maternal outcomes, women allocated to intermittent electronic fetal monitoring (EFM) (CTG) had higher rates of caesarean section for fetal distress (RR 2.92, 95% CI 1.78 to 4.80, 633 women, moderate-quality evidence) compared with women allocated to routine Pinard. There was no clear difference between groups in instrumental vaginal births (RR 1.46, 95% CI 0.86 to 2.49, low-quality evidence). Other outcomes were not reported (maternal mortality, instrumental vaginal birth for fetal distress and or acidosis, analgesia in labour, mobility or restriction during labour, and postnatal depression). Doppler ultrasonography with routine Pinard (two trials) There was no clear difference between groups in Apgar scores < seven at five minutes after birth (reported as < six in one of the trials) (average RR 0.76, 95% CI 0.20 to 2.87; two trials, 2598 babies,  $I^2 = 72\%$ , very low-quality evidence); there was high heterogeneity for this outcome. There was no clear difference between groups for perinatal mortality (RR 0.69, 95% CI 0.09 to 5.40; 2597 infants, two studies, very low-quality evidence), or neonatal seizures (RR 0.05, 95% CI 0.00 to 0.91; 627 infants, one study, very low-quality evidence). Other important infant outcomes were not reported (cord blood acidosis, composite of mortality and serious morbidity, cerebral palsy, neurosensory disability). Only one study reported maternal outcomes. Women allocated to Doppler ultrasonography had higher rates of caesarean section for fetal distress compared with those allocated to routine Pinard (RR 2.71, 95% CI 1.64 to 4.48, 627 women, moderate-quality evidence). There was no clear

difference in instrumental vaginal births between groups (RR 1.35, 95% CI 0.78 to 2.32, 627 women, low-quality evidence). Other maternal outcomes were not reported. Intensive Pinard versus routine Pinard (one trial) One trial compared intensive Pinard (a research midwife following the protocol in a one-to-one care situation) with routine Pinard (as per protocol but midwife may be caring for more than one woman in labour). There was no clear difference between groups in low Apgar score (reported as < six this trial) (RR 0.90, 95% CI 0.35 to 2.31, 625 babies, very low-quality evidence). There were also no clear differences identified for perinatal mortality (RR 0.56, 95% CI 0.19 to 1.67; 625 infants, very low-quality evidence), or neonatal seizures (RR 0.68, 95% CI 0.24 to 1.88, 625 infants, very low-quality evidence). Other infant outcomes were not reported. For maternal outcomes, there were no clear differences between groups for caesarean section or instrumental delivery (RR 0.70, 95% CI 0.35 to 1.38, and RR 1.21, 95% CI 0.69 to 2.11, respectively, 625 women, both low-quality evidence). Other outcomes were not reported. AUTHORS' CONCLUSIONS: Using a hand-held (battery and wind-up) Doppler and intermittent CTG with an abdominal transducer without paper tracing for IA in labour was associated with an increase in caesarean sections due to fetal distress. There was no clear difference in neonatal outcomes (low Apgar scores at five minutes after birth, neonatal seizures or perinatal mortality). Long-term outcomes for the baby (including neurodevelopmental disability and cerebral palsy) were not reported. The quality of the evidence was assessed as moderate to very low and several important outcomes were not reported which means that uncertainty remains regarding the use of IA of FHR in labour. As intermittent CTG and Doppler were associated with higher rates of caesarean sections compared with routine Pinard monitoring, women, health practitioners and policy makers need to consider these results in the absence of evidence of short- and long-term benefits for the mother or baby. Large high-quality randomised trials, particularly in low-income settings, are needed. Trials should assess both short- and long-term health outcomes, comparing different monitoring tools and timing for IA.

[PMID: 28191626](#)