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Interventions and Management

1. Interventions and Management

Ann Phys Rehabil Med. 2016 Sep;59S:e9. doi: 10.1016/j.rehab.2016.07.023.

Feasibility of a self-rehabilitation program by mirror therapy in children with hemiplegic cerebral palsy.

Pasquet T, Gaillard F, Newman CJ, Jequier Gygax M, Le Cornec C, Bonan I, Rauscent H.

OBJECTIVE: In children with hemiplegic cerebral palsy (HCP), some studies have shown an improvement in manual function following a self-rehabilitation program by mirror therapy. However, adherence to this protocol has not been reported. So, we studied the feasibility and compliance of this self-rehabilitation program in the hemiplegic child. **MATERIAL AND METHODS:** The aim of this study was to evaluate the effect of mirror therapy on the upper limb of children with HCP. Twenty-eight children (11.9±2.7 years) went through a self-rehabilitation program by mirror therapy at home. This program was developed by the Swiss team of Newman and Gigax. It consists of 7 exercises, for a total of 15min, repeated 5 days per week for 5 weeks. A diary was given to each child to note the daily time spent on the protocol and the number of series actually done for each exercise. Adherence was assessed by the number of series performed. Difficulties and adverse events that occurred during this period were also collected. **RESULTS:** All the children have achieved the 5 week protocol and all were satisfied with their participation. The global observance of the protocol is good with 86.3% of the exercises performed on the average of five weeks (SD±12.6). There is no significant difference between the observance of the first week and that of the fifth week (87% vs. 81%) (P=0.22). It exists a significant decrease in the average length of time spent on the protocol between the first and the fifth week (18min 24 vs. 12min 42) (P<0.05). No event or significant adverse effects was detected during the protocol. **DISCUSSION/CONCLUSION:** This self-rehabilitation protocol by mirror therapy shows good feasibility and good compliance. Self-rehabilitation seems to be an interesting tool easy to implement and well accepted by the children with HCP.

[PMID: 27677029](#)

2. Ann Phys Rehabil Med. 2016 Sep;59S:e6-e7. doi: 10.1016/j.rehab.2016.07.017.

Relationship between hand function assessment and upper limb kinematic analysis in children with hemiplegic cerebral palsy.

Gaillard F, Rauscent H, Crétual A, Le Cornec C, Cordillet S, Bonan I.

OBJECTIVE/INTRODUCTION: Children with hemiplegic cerebral palsy (HCP) have upper limb limited motion and decreased hand function in daily activities. The aim of this study was to evaluate the relationship between the severity of the kinematic motion abnormalities and bimanual performance of the impaired upper limb. **PATIENTS AND METHODS:** Twenty-three children with HCP (mean age 11.9±2.7 years) were evaluated using the Assisting Hand Assessment (AHA) [1]

to score functional activity performance. We used a standardized 3D-analysis protocol to evaluate upper limb movements, containing two reach tasks, three gross motor tasks, and two reach-to-grasp tasks. Summary kinematic indexes were calculated according to Jaspers' method [2] to evaluate the severity of upper limb movement abnormalities in children with HCP, compared to a database of 28 typically developing children (mean age 11.8±2.2 years). RESULTS: The results show high correlation between the Global-Arm Profile score (APS), a kinematic index, which summarizes the overall severity of upper limb movement pathology for all tasks, and the AHA score ($r=-0.75$). The APS were highly correlated with the AHA during reach-to-grasp tasks ($r=-0.75$) and two of the three gross motor tasks ($r=-0.74$). Concerning the Global-Arm Variable score, which represents the deviation for a single joint angle, significant correlations were found for wrist flexion ($r=-0.85$), elbow flexion ($r=-0.61$) and pronation ($r=-0.47$). DISCUSSION/CONCLUSION: The severity of movement abnormality in children with HCP is strongly correlated with the level of functional activity performance. This correlation is best demonstrated in reach-to-grasp or gross motor tasks. The influence of wrist and elbow movement abnormality confirms the importance of taking into account these distal limitations in therapeutics.

[PMID: 27676959](#)

3. Ann Phys Rehabil Med. 2016 Sep;59S:e143. doi: 10.1016/j.rehab.2016.07.320.

Percutaneous needle tenotomy in the treatment of neuro-orthopedic complications of upper limb related to central nervous system impairment: Open study on 12 patients.

Coroian F, Coulet B, Jourdan C, Choquet O, Laffont I.

OBJECTIVE: The musculotendinous retractions are common complications of central neurological damage with consequences for comfort and function. Treatment of uncomfortable retractions is often surgical, mainly based on tendon gestures. The objective of this study was to evaluate the efficiency of percutaneous needle tenotomy in these indications. MATERIAL/PATIENTS AND METHODS: The indication was accepted at a medical-surgical consultation. Tenotomy was performed using an 18 Gauge needle. The patients were older than 18 years, had a history of central neurological disease, and had a musculotendinous retraction regarding a superficial tendon of upper limb. The primary endpoint was the Goal Attainment Scale (GAS). Secondary outcomes were pain, the pulp-palm distance and range of motion gain. The evaluation was conducted in pre-tenotomy, immediately post-tenotomy, 3 months and 6 months. RESULTS: Twelve patients (8 women) were included in our study. The mean age was 62.91 years (28-87). Neuro-orthopedic disorders were related to a stroke ($n=4$), head trauma ($n=2$), to Parkinsonian syndrome ($n=3$) at a cerebral palsy ($n=3$). The objectives identified were nursing ($n=12$), pain ($n=11$), the skin condition ($n=5$), gripping ($n=2$), posture ($n=1$) and dressing ($n=1$). The targets were achieved in all cases. The average score GAS per patient ranged from 0 to 2. GAS score was unchanged at 3 months and 6 months. DISCUSSION-CONCLUSION: Our experience confirms the locations already described for percutaneous needle tenotomy of the flexor of the fingers. We also report the effectiveness of percutaneous tenotomy in the wrist and elbow flexors without vascular and nerve injury elbow.

[PMID: 27676802](#)

4. Ann Phys Rehabil Med. 2016 Sep;59S:e121. doi: 10.1016/j.rehab.2016.07.273.

Distinction between pathological and functional co-activation during active upper limb movements in hemiparetic children.

Sarcher A, Raison M, Leboeuf F, Perrouin-Verbe B, Brochard S, Gross R.

OBJECTIVE: Children with spastic unilateral cerebral palsy (SUCP) have an involved upper limb (IUL) restricted in active range of motion and in velocity when performing elbow extension, due to a combination of muscle impairments. One of them is excessive muscle co-activation (CA). CA usually has a functional role, particularly in joint stabilization. The aim of this study is to identify when pathological CA occurs during active elbow extension of the IUL to highlight its impact on movement restriction and to discriminate impaired muscles. MATERIAL/PATIENTS AND METHODS: Thirteen typically developing (TD) children and 13 children with SUCP performed active elbow extension/flexions at 3 externally paced frequencies. Elbow angle and velocity were computed using a subject-specific model tracking the position of 29 upper limb markers. With these data, the extension movement was decomposed into the Extension Acceleration Phase (EAP) (velocity increase) and the Extension Deceleration Phase (EDP) (velocity decrease). The percentage of CA for the brachioradialis (BR)/triceps and biceps/triceps couples for each phase was extracted from the surface electromyographic signals. Statistical analysis was conducted using linear mixed effects models. RESULTS: During the EAP, excessive and positive frequency-dependent CA was found in the SUCP group, whereas CA in the TD group was low and invariant. These results point to pathological CA in the SUCP group, probably linked to restricted velocity. During the EDP, only excessive BR/triceps CA was found in the SUCP group.

CA was positive frequency-dependent in both groups. These results point to mostly functional CA, for joint stabilization at the end of the movement. However, BR seems to stand out in its possible involvement in extension active range of motion restriction. **DISCUSSION-CONCLUSION:** This study provides insight into pathological CA in children with SUCP. Perspectives include individual clinical interpretation of the results, to assist in each child's therapeutic decision.

[PMID: 27676756](#)

5. Ann Phys Rehabil Med. 2016 Sep;59S:e8. doi: 10.1016/j.rehab.2016.07.021.

Three-dimensional analysis of the upper limb movement asymmetry during a bimanual grasp task in children with hemiplegic cerebral palsy.

Gaillard F, Rauscent H, Crétual A, Le Cornec C, Cordillet S, Bonan I.

OBJECTIVE: Children with hemiplegic cerebral palsy (HCP) have upper limb deficiencies and movement abnormalities causing difficulties in bimanual activities. The objective of this study was to analyze the abnormalities of movement and the kinematic asymmetry of both upper limbs during a bimanual grasp task in children with HCP. **PATIENTS AND METHODS:** Seven hemiplegic children (mean age 13.7±2.4 years) were evaluated through 3D motion analysis during a bimanual and symmetrical grasp task. Different kinematic indexes were calculated to assess the severity of the movement deviation (Arm Profile Score [APS]) and the degree of asymmetry between the two upper limbs (Asym'APS). Kinematic data from hemiplegic children were compared to a 17 typically developing children (TDC) database (mean age 12.1±2.6 years). **RESULTS:** The APS score was significantly higher for the impaired upper limb of children with HCP compared to the non-dominant limb of TDC (respectively 21.6° versus 12.8°). The Asym'APS score was significantly higher in the HCP children compared to the TDC (respectively 21.2° and 7.9°). The study of the indexes based on the joint level has made it clearer on which angles deviations and asymmetries were the highest and what compensation strategies were adopted by the unimpaired limb. **DISCUSSION/CONCLUSION:** Hemiplegic children have an angular deviation of the impaired limb more severe and a more important asymmetry between the two upper limbs than typically developing children have during a bimanual and symmetrical grasp task.

[PMID: 27677010](#)

6. Ann Phys Rehabil Med. 2016 Sep;59S:e5. doi: 10.1016/j.rehab.2016.07.013.

Gross Motor Function Measure Evolution Ratio: Use as a control for natural progression in cerebral palsy.

Marois P, Marois M, Pouliot-Laforte A, Vanasse M, Lambert J, Ballaz L.

OBJECTIVE: To develop a new way to interpret Gross Motor Function Measure (GMFM-66) score improvement in studies conducted without control groups in children with cerebral palsy (CP). **MATERIAL AND METHODS:** The curves, which describe the pattern of motor development according to the children's Gross Motor Function Classification System level, were used as historical control to define the GMFM-66 expected natural evolution in children with CP. These curves have been modeled and generalized to fit the curve to particular children characteristics. **RESULTS:** Assuming that the GMFM-66 score evolution followed the shape of the Rosenbaum curves, by taking into account the age and GMFM-66 score of children, the expected natural evolution of the GMFM-66 score was predicted for any group of children with CP who were <8 years old. Because the expected natural evolution could be predicted for a specific group of children with CP, the efficacy of a treatment could be determined by comparing the GMFM-66 score evolution measured before and after treatment with the expected natural evolution for the same period. A new index, the Gross Motor Function Measure Evolution Ratio, was defined as follows: Gross Motor Function Measure Evolution Ratio=measured GMFM-66 score change/expected natural evolution. **DISCUSSION/CONCLUSION:** For practical or ethical reasons, it is almost impossible to use control groups in studies evaluating effectiveness of many therapeutic modalities. The Gross Motor Function Measure Evolution Ratio gives the opportunity to take into account the expected natural evolution of the gross motor function of children with CP, which is essential to accurately interpret the therapy effect on the GMFM-66.

[PMID: 27676936](#)

7. Ann Phys Rehabil Med. 2016 Sep;59S:e6. doi: 10.1016/j.rehab.2016.07.015.

Physiological anatomy of botulinum toxin effect on the spastic muscle of children with cerebral palsy.

Mietton C, Schaeffer L, Streichenberger N, Cunin V, Kassai B, Poirot I.

OBJECTIVE: Botulinum toxin is one of the treatments available to treat spasticity in patients with cerebral palsy (CP) from 2 years of age. The long-term action of the toxin on the neuromuscular junction (NMJ) and muscle structure is still unknown. We formulated the hypothesis that repeated injections of botulinum toxin could modify muscle structure. The main aim of our 3-year monocentric descriptive study is to evaluate the long-term effect of repeated injections of botulinum toxin on the muscle and the neuromuscular junction in patients with CP. **MATERIAL AND METHODS:** Histopathological features and molecular biology were studied on muscle biopsies taken during scheduled orthopaedic surgeries. Evaluation criteria were the presence of fragmented neuromuscular junctions (both qualitative and quantitative) and axonal sprouting (qualitative). **RESULTS:** Two muscle biopsies were performed in 2 children aged respectively 7 and 10 years. The biopsies were located respectively in the right gracilis (after 1 injection) and in the right sural triceps (after 3 injections). Histological features found were fragmented neuromuscular junctions (between 1 to 6), lack of axonal sprouting at the junction, the presence of CD56 satellite cells and presence of molecules suggesting the presence of denervated fibers. Whereas type I and type II fiber atrophy and fibrosis were found on the first biopsy, on the second were seen signs of atrophy of undifferentiated fibers without any sign of fibrosis. Additional results will be available soon. **DISCUSSION/CONCLUSION:** This study should improve knowledge about the effects of long-term botulinum toxin on muscle (and therefore its safety in use) on the NMJ and on the physiopathology of the muscle of children with CP.

[PMID: 27676961](#)

8. PM R. 2016 Sep;8(9S):S318. doi: 10.1016/j.pmrj.2016.07.403. Epub 2016 Sep 24.

Poster 485 Safety and Tolerability of AbobotulinumtoxinA (Dysport) in Children (2-17 Years) with Lower Limb Spasticity Due to Cerebral Palsy: A Pooled Analysis of 8 Clinical Trials.

Matthews D, Camba GC, Pascual-Pascual I, Tilton AH, Gormley M, Mahmood A, Picaut P, Snyder D, Delgado MR.

[PMID: 27673230](#)

9. Medicine (Baltimore). 2016 Sep;95(39):e5033. doi: 10.1097/MD.0000000000005033.

Laminoplasty with lateral mass screw fixation for cervical spondylotic myelopathy in patients with athetoid cerebral palsy: A retrospective study.

Zhou H, Liu ZJ, Wang SB, Pan SF, Yan M, Zhang FS, Sun Y.

Although several studies report various treatment solutions for cervical spondylotic myelopathy in patients with athetoid cerebral palsy, long-term follow-up studies are very rare. None of the reported treatment solutions represent a gold standard for this disease owing to the small number of cases and lack of long-term follow-up. This study aimed to evaluate the outcomes of laminoplasty with lateral mass screw fixation to treat cervical spondylotic myelopathy in patients with athetoid cerebral palsy from a single center. This retrospective study included 15 patients (9 male patients and 6 female patients) with athetoid cerebral palsy who underwent laminoplasty with lateral mass screw fixation for cervical spondylotic myelopathy at our hospital between March 2006 and June 2010. Demographic variables, radiographic parameters, and pre- and postoperative clinical outcomes determined by the modified Japanese Orthopedic Association (JOA), Neck Disability Index (NDI), and visual analog scale (VAS) scores were assessed. The mean follow-up time was 80.5 months. Developmental cervical spinal canal stenosis ($P = 0.02$) and cervical lordosis ($P = 0.04$) were significantly correlated with lower preoperative modified JOA scores. The mean modified JOA scores increased from 7.97 preoperatively to 12.1 postoperatively ($P < 0.01$). The mean VAS score decreased from 5.30 to 3.13 ($P < 0.01$), and the mean NDI score decreased from 31.73 to 19.93 ($P < 0.01$). There was a significant negative correlation between developmental cervical spinal canal stenosis and recovery rate of the modified JOA score ($P = 0.01$). Developmental cervical spinal canal stenosis is significantly related to neurological function in patients with athetoid cerebral palsy. Laminoplasty with lateral mass screw fixation is an effective treatment for cervical spondylotic myelopathy in patients with athetoid cerebral palsy and developmental cervical spinal canal stenosis.

[PMID: 27684879](#)

10. Gait Posture. 2016 Sep 19;50:239-245. doi: 10.1016/j.gaitpost.2016.09.016. [Epub ahead of print]

Feasibility and reliability of using an exoskeleton to emulate muscle contractures during walking.

Attias M, Bonnefoy-Mazure A, De Coulon G, Cheze L, Armand S.

Contracture is a permanent shortening of the muscle-tendon-ligament complex that limits joint mobility. Contracture is involved in many diseases (cerebral palsy, stroke, etc.) and can impair walking and other activities of daily living. The purpose of this study was to quantify the reliability of an exoskeleton designed to emulate lower limb muscle contractures unilaterally and bilaterally during walking. An exoskeleton was built according to the following design criteria: adjustable to different morphologies; respect of the principal lines of muscular actions; placement of reflective markers on anatomical landmarks; and the ability to replicate the contractures of eight muscles of the lower limb unilaterally and bilaterally (psoas, rectus femoris, hamstring, hip adductors, gastrocnemius, soleus, tibialis posterior, and peroneus). Sixteen combinations of contractures were emulated on the unilateral and bilateral muscles of nine healthy participants. Two sessions of gait analysis were performed at weekly intervals to assess the reliability of the emulated contractures. Discrete variables were extracted from the kinematics to analyse the reliability. The exoskeleton did not affect normal walking when contractures were not emulated. Kinematic reliability varied from poor to excellent depending on the targeted muscle. Reliability was good for the bilateral and unilateral gastrocnemius, soleus, and tibialis posterior as well as the bilateral hamstring and unilateral hip adductors. The exoskeleton can be used to replicate contracture on healthy participants. The exoskeleton will allow us to differentiate primary and compensatory effects of muscle contractures on gait kinematics.

[PMID: 27665088](#)

11. Ann Phys Rehabil Med. 2016 Sep;59S:e8. doi: 10.1016/j.rehab.2016.07.020.

Correction of hip internal rotation in walking cerebral palsy adolescent using a soft tissue procedure an alternative to femoral rotation osteotomy.

Dohin B, Haddad E, Al Khoury Salem H, Merhez Kilani M.

OBJECTIVE: Hip internal rotation (HIR) during gait is one of the main functional disorders related to cerebral palsy (CP) in children. Most of the procedures proposed rotational osteotomy of the femur (FRO), (and/or tibia). However, multilevel surgery (SEMLS) including bone procedure, implicates more difficult and longer rehabilitation. When bone deformity is moderate, the authors hypothesized that FRO could be avoided. They developed a soft tissues procedure to improve HIR. The aim of the study was assessment of the procedure. **PATIENTS AND METHODS:** In walking CP the authors selected patients presented with femoral anteversion less than 40° who were proposed for soft tissue procedure alone. Patients were previously tested with botulinum toxin injection of the hamstring muscles. The soft tissue procedure was: lengthening of semimembranosus, transfer of semitendinosus associated with tenotomy of the gracilis and gluteus minimus muscles. All the patients with pre and postoperative full data (clinical, kinematics and kinetics) were included. Data (i.e. foot intoeing, dynamic hip internal rotation in stance phase, hip rotation moment) were collected. Follow-up was at least one year after SEMLS. **RESULTS:** We collected 20 selected patients with 24 lower limbs studied. Rotation of the pelvis did not differ significantly (P=0.21). Hip rotation in stance phase (50%), presented significant improvement from 16.5° intoeing to 0.5° external rotation (P<0.0001). Feet angulation related to walking direction was significantly improved, from 13° intoeing to 0.5° external rotation (P<0.0001). **DISCUSSION/CONCLUSION:** HIR is a frequent gait disorder in CP. The etiology of the HIR seems to be related to muscles contractures and spasticity. Recently, soft tissue procedures were reported of interest in HIR. The soft tissue procedures presented improved significantly HIR making pointless FRO. Rehabilitation should be making easier. **RELEVANCE:** the authors improve significantly the HIR using a soft tissues procedure and advocated reducing indication for FRO in internal rotation of lower limbs in order to make easier rehabilitation after SEMLS.

[PMID: 27677011](#)

12. Ann Phys Rehabil Med. 2016 Sep;59S:e6. doi: 10.1016/j.rehab.2016.07.016.

Effect of ankle-foot orthoses on gait in children with cerebral palsy: A meta-analysis.

Bourseul JS, Lintanf M, Saliou P, Brochard S, Pons C.

OBJECTIVE: Different ankle-foot orthoses (AFO) are often prescribed in children with cerebral palsy (CP) although their efficiency on gait remains unclear. **PURPOSE:** (1) To determine the effect of AFOs on gait in children with CP and (2) to evaluate the effect of each types of AFO. **MATERIAL AND METHODS:** Studies in English with control condition (barefoot or shoes) assessing effect of AFO about children with CP gait were search on the Pubmed, CINAHL+, Web of Science, Cochrane Library databases. Quality of each study was assessed by modified PEDRO scale. Only studies with a score more than 4 were selected. 10 gait parameters were extracted in each study. Effect size and 95% confidence interval were calculated for each parameter. **RESULTS:** Seventeen studies (490 subjects) were included. Comparing AFOs to control condition, stride length increased (15 studies) $d=1.04$ [95% CI: 0.69; 1.38], velocity increased (16 studies) $d=0.27$ [95% CI: 0.14; 0.41], cadence decreased (15 studies) $d=-0.69$, [95% CI: -0.95; -0.43]. Ankle dorsiflexion increased at initial contact (11 studies) $d=1.64$, [95% CI: 1.16; 2.11] and in swing phase (7 studies) $d=5.21$, [95% CI: 1.91; 8.52]. Ankle power generation in stance phase decreased (6 studies) $d=-0.26$, [95% CI: -0.38; -0.14]. The duration of tibialis anterior activation and energy data did not changed significantly. Four types of orthosis were found: dynamic AFO, hinged AFO, solid AFO, supra-malleolar orthosis. Hinged AFO was the orthosis that improved the greater number of gait parameters and was the only one to improve velocity with an effect size >0.8 (large effect). **DISCUSSION/CONCLUSION:** This study shows clinically significant effect of AFO on stride length, ankle dorsiflexion at initial contact and swing phase. Hinged AFO seems to have the greatest effect on gait. New data are needed to refine the choice of the orthosis according to the child gait pattern.

[PMID: 27676960](#)

13. PM R. 2016 Sep;8(9S):S313. doi: 10.1016/j.pmrj.2016.07.389. Epub 2016 Sep 24.

Poster 468 Incidental Finding of Grade IV Cervical Anterolisthesis During Workup for Possible Cerebral Palsy: A Case Report.

Owens RP, Karlin AM.

[PMID: 27673214](#)

14. Dev Med Child Neurol. 2016 Sep 28. doi: 10.1111/dmcn.13286. [Epub ahead of print]

Adverse drug reactions of botulinum neurotoxin type A in children with cerebral palsy: a pharmaco-epidemiological study in VigiBase.

Montastruc J, Marque P, Moulis F, Bourg V, Lambert V, Durrieu G, Montastruc JL, Montastruc F.

AIM: The aim of this study was to assess the risk of adverse drug reactions (ADRs) with botulinum neurotoxin type A (BoNT-A) in children with cerebral palsy (CP) using the World Health Organization global individual case safety report (ICSR) database, VigiBase. **METHOD:** We extracted all children ICSRs for ADRs with BoNT-A used as anti-spastic drug in CP recorded between 1995 and 2015 in VigiBase. We also performed a case/non-case method (disproportionality analysis) to assess the link between exposure to BoNT-A and each ADR of interest in children and adults, calculating reporting odds ratios (RORs). **RESULTS:** In VigiBase, 162 ICSRs were registered. They involved mainly males ($n=95$, 59%) and mean (SD) age was 7 years 11 months (4y 4mo). The most frequent ADR was dysphagia (27 ICSRs, 17%) followed by asthenia and muscular weakness (25 ICSRs each, 16%). Nineteen ICSRs (12%) were lethal. There was a significant association between BoNT-A and death in children (ROR=11.1 95%, confidence interval [CI] 7.0-17.7) but not in adults. **INTERPRETATION:** In children with CP, most ADRs seem to be linked to a systemic spread of BoNT-A. Our study suggests a higher risk of ADRs with BoNT-A in children than in adults.

[PMID: 27682175](#)

15. PM R. 2016 Sep;8(9S):S267-S268. doi: 10.1016/j.pmrj.2016.07.498. Epub 2016 Sep 24.

Poster 328 Does Mobility Status or Spasticity Contribute to the Metabolic Profile and Body Composition in Individuals with Cerebral Palsy?

Marciniak CM, Gaebler-Spira DJ, Garrett A, Brander KM, Brown MC, Wysocki NM.

[PMID: 27673082](#)

16. Ann Phys Rehabil Med. 2016 Sep;59S:e5-e6. doi: 10.1016/j.rehab.2016.07.014.

Perceived effectiveness, tolerance of cares in children and adults with cerebral palsy.

Houx L, Saudreau H, Galien P, Pons C, Roquet M, Garlantezec R, Brochard S; Groupe de recherche sur la paralysie cérébrale en Bretagne.

OBJECTIVE: A better understanding of the perception of the rehabilitative and medical care's by persons with cerebral palsy (CP) and their families may help in providing better adherence to these cares. The main objective of this study was to assess overall satisfaction, self-perception of effectiveness and tolerance of the rehabilitative and medical cares in individuals with CP. **MATERIAL AND METHODS:** This was a cross-sectional questionnaire-based study. A total of 950 questionnaires were sent to French Britain children and adults with CP. Perceived effectiveness and tolerance were evaluated for each types of care using a Likert scale from 1 to 7 and overall satisfaction by a visual analog scale. Comparison of means and uni-and-multivariate analyzes for correlation analysis were carried out. **RESULTS:** A total of 512 (53.9%) questionnaires were analyzed; 230 (44.9%) were children and 54% were walkers (GMFCS I, II or III). The overall satisfaction was 6.83/10 (SD 2.21). Orthoptic, orthosis and physical therapy were reported to be the most effective cares (5.34/5.30/5.29) while botulinum toxins, intrathecal baclofen, and speech therapy the least effective (4.42/4.52/5.02). Intrathecal baclofen, orthosis and botulinum toxin were the less well-tolerated therapies (4.75/5.11/5.28). Antiepileptic drugs were reported to be the most effective and best-tolerated drug contrary to analgesics. Overall, satisfaction was inversely correlated to the GMFCS in the multivariate analysis ($P=0.013$). The perceived effectiveness of occupational therapy, botulinum toxin injections and physiotherapy are inversely related to GMFCS in the univariate analyzes. The tolerance and effectiveness of the orthosis have a positive correlation with the GMFCS in the uni-and-multivariate analyzes. **DISCUSSION/CONCLUSION:** This study shows a good overall satisfaction on medical and paramedical care but highlights a large discrepancy between user self-perception and evidence base medicine. More communication about the therapies between professionals and individuals with cerebral palsy is needed and comparing opinions of patients and their families to literature can give us the keys to improve communication around these therapies.

[PMID: 27676935](#)

17. Disabil Rehabil. 2016 Sep 26;1-9. [Epub ahead of print]

Oropharyngeal dysphagia in children with cerebral palsy: comparisons between a high- and low-resource country.

Benfer KA, Weir KA, Bell KL, Nahar B, Ware RS, Davies PS, Boyd RN.

PURPOSE: There is paucity of research investigating oropharyngeal dysphagia (OPD) in young children with cerebral palsy (CP), and most studies explore OPD in high-resource countries. This study aimed at determining the proportion and severity of OPD in preschool children with CP in Bangladesh, compared to Australia. **METHOD:** Cross-sectional, comparison of two cohorts. Two hundred and eleven children with CP aged 18-36 months, 81 in Bangladesh (mean = 27.6 months, 61.7% males), and 130 in Australia (mean = 27.4 months, 62.3% males). The Dysphagia Disorders Survey (DDS) - Part 2 was the primary OPD outcome for proportion and severity of OPD. Gross motor skills were classified using the Gross Motor Function Classification System (GMFCS), motor type/distribution. **RESULTS:** (i) Bangladesh sample: proportion OPD = 68.1%; severity = 10.4 SD = 7.9. Australia sample: proportion OPD = 55.7%; severity = 7.0 SD = 7.5. (ii) There were no differences in the proportion or severity of OPD between samples when stratified for GMFCS (OR = 2.4, $p=0.051$ and $\beta=1.2$, $p=0.08$, respectively). **CONCLUSIONS:** Despite overall differences in patterns of OPD between Bangladesh and Australia, proportion and severity of OPD (when adjusted for the functional gross motor severity of the samples) were equivalent. This provides support for the robust association between functional motor severity and OPD proportion/severity in children with CP, regardless of the resource context. **Implications for Rehabilitation** The proportion and severity of OPD according to gross

motor function level were equivalent between high- and low-resource countries (LCs). Literature from high-resource countries may be usefully interpreted by rehabilitation professionals for low-resource contexts using the GMFCS as a framework. The GMFCS is a useful classification in LCs to improve earlier detection of children at risk of OPD and streamline management pathways for optimal nutritional outcomes. Rehabilitation professionals working in LCs are likely to have a caseload weighted towards GMFCS III-V, with less compensatory OPD management options available (such as non-oral nutrition through tubes).

[PMID: 27669884](#)

18. PM R. 2016 Sep;8(9S):S316-S317. doi: 10.1016/j.pmrj.2016.07.399. Epub 2016 Sep 24.

Poster 480 Addressing Open Mouth Posture in Children with Cerebral Palsy Through Chemodeneration of the Lateral Pterygoid Muscles: A Case Series of Pediatric Patients.

Reyes F, Shoal HA, Kim H.

[PMID: 27673224](#)

19. Comput Methods Programs Biomed. 2016 Nov;136:1-9. doi: 10.1016/j.cmpb.2016.08.008. Epub 2016 Aug 16.

Characterization of EEG patterns in brain-injured subjects and controls after a Snoezelen(®) intervention.

Gómez C, Poza J, Gutiérrez MT, Prada E, Mendoza N, Hornero R.

BACKGROUND AND OBJECTIVE: The aim of this study was to assess the changes induced in electroencephalographic (EEG) activity by a Snoezelen(®) intervention on individuals with brain-injury and control subjects. **METHODS:** EEG activity was recorded preceding and following a Snoezelen(®) session in 18 people with cerebral palsy (CP), 18 subjects who have sustained traumatic brain-injury (TBI) and 18 controls. EEG data were analyzed by means of spectral and nonlinear measures: median frequency (MF), individual alpha frequency (IAF), sample entropy (SampEn) and Lempel-Ziv complexity (LZC). **RESULTS:** Our results showed decreased values for MF, IAF, SampEn and LZC as a consequence of the therapy. The main changes between pre-stimulation and post-stimulation conditions were found in occipital and parietal brain areas. Additionally, these changes are more widespread in controls than in brain-injured subjects, which can be due to cognitive deficits in TBI and CP groups. **CONCLUSIONS:** Our findings support the notion that Snoezelen(®) therapy affects central nervous system, inducing a slowing of oscillatory activity, as well as a decrease of EEG complexity and irregularity. These alterations seem to be related with higher levels of relaxation of the participants.

[PMID: 27686698](#)

20. PM R. 2016 Sep;8(9S):S236. doi: 10.1016/j.pmrj.2016.07.266. Epub 2016 Sep 24.

Poster 232 Cerebral Palsy Adult Transition (CPAT) Cross-Sectional Study Preliminary Findings: Chronic Pain Correlates with Memory Difficulties in Adults with Cerebral Palsy.

Thomas SP, Pan Z, Robertson DM, Frickman A, Carollo JJ, Heyn PC.

[PMID: 27672993](#)

21. PM R. 2016 Sep;8(9S):S233. doi: 10.1016/j.pmrj.2016.07.257. Epub 2016 Sep 24.

Poster 223 Monomelic Peripheral Neuropathy after Exposure to Cold Weather in a Diplegic Cerebral Palsy.

Kim CT.

[PMID: 27672984](#)

22. Ann Phys Rehabil Med. 2016 Sep;59S:e9. doi: 10.1016/j.rehab.2016.07.024.

Depression and anxiety in mothers of children with cerebral palsy: Comparative study.

Toulgui E, Jemni S, Samia F, Lazreg N, Mtaouaa S, Khachnaoui F.

OBJECTIVE: The aim of this study is to examine depression in mothers of children with CP, with hypothesis to have an elevated risk of anxiety and depressive profile among mothers of children with cerebral palsy. **PATIENTS AND METHODS:** This study is a descriptive cross-sectional survey conducted at The Physical and Rehabilitation Department of Sahloul Hospital in Tunisia. Where included 62 children with cerebral palsy with their mothers. The inclusion criteria for the study were being the mothers of a child having a CP and aged more than two years. Mothers with history of psychiatric disorder were not included. Seventy-three mothers of normal children, serving as the control group for comparing with case group, filled in the same questionnaires. **RESULTS:** This study included 62 children including 45 boys (sex ratio 2.6). An evaluation of the functional status by the Gross Motor Function Classification System (GMFCS) of the children with CP was done, 27.4% were level II, 20.9% were level IV and 19.4% were level V. Moreover, 58.1% of the children were tetraplegic, and 24.2% were diplegic. Mothers of children were evaluated by the Hospital Anxiety and Depression Scale (HADS). Mothers had a normal depression score in 29%, a borderline score in 25.8% and an abnormal score in 45.2%. Concerning anxiety, mothers had a normal score in 12.9%, a borderline score in 27.4% and an abnormal score in 59.7%. There were significant differences in the mean depression scores ($P=0.002$) between the two groups. The results also shown that the severity of the GMFCS was not associated with the HADS ($P=0.230$). The clinical presentation of the CP was also not associated with the HADS ($P=0.129$). **DISCUSSION/ CONCLUSION:** It seems that having a child with CP is probably associated with higher prevalence and severity of depression in mothers. Caring for children with CP (regardless to the severity of the clinical form) increases considerably the risk of emotional distress among mothers.

[PMID: 27677028](#)

23. PM R. 2016 Sep;8(9S):S152. doi: 10.1016/j.pmrj.2016.07.022. Epub 2016 Sep 24.

Impact of Selective Percutaneous Myofascial Lengthening (SPML) on Quality of Life in Children with Cerebral Palsy.

Isidro T, Wu L, Yngve D.

[PMID: 27672747](#)

24. PM R. 2016 Sep;8(9S):S151. doi: 10.1016/j.pmrj.2016.07.019. Epub 2016 Sep 24.

Participation in Daily Life: Influence on Quality of Life in Ambulatory Children with Cerebral Palsy.

Russell JC, Bjornson K.

[PMID: 27672745](#)

25. PM R. 2016 Sep;8(9S):S315-S316. doi: 10.1016/j.pmrj.2016.07.397. Epub 2016 Sep 24.

Poster 478 A Review of the Health-Related Quality of Life in Pediatric Patients with Cerebral Palsy and Associated Spasticity.

Clarke NM, Camba GC, Bains S, Stephens JM, Pulgar S, Marchese D, Tilton AH.

[PMID: 27673221](#)

26. Disabil Rehabil. 2016 Sep 24:1-8. [Epub ahead of print]

Randomized controlled trial of a web-based multi-modal therapy program for executive functioning in children and adolescents with unilateral cerebral palsy.

M Piovesana A, Ross S, Lloyd O, Whittingham K, Ziviani J, Ware RS, Boyd RN.

Purpose state: Determine the efficacy of Move-it-to-improve-it (Mitii™), a multi-modal web-based program, in improving Executive Function (EF) in children with unilateral cerebral palsy (UCP). **METHOD:** Participants (n = 102) were matched in pairs then randomized to: intervention (Mitii™ for 20 weeks; n = 51; 26 males; mean age = 11 years 8 months (SD = 2 years 4 months); Full Scale IQ = 84.65 (SD = 15.19); 28 left UCP; GMFCS-E&R (I = 20, II = 31) or waitlist control (n = 50; 25 males; mean age = 11 years 10 months (SD = 2 years 5 months); Full Scale IQ = 80.75 (SD = 19.81); 20 left UCP; GMFCS-E&R (I = 25, II = 25). Mitii™ targeted working memory (WM), visual processing (VP), upper limb co-ordination and physical activity. EF capacity was assessed: attentional control (DSB; WISC-IV); cognitive flexibility (inhibition and number-letter sequencing DKEFS); goal setting (D-KEFs Tower Test); and information processing (WISC-IV Symbol Search and Coding). EF performance was assessed via parent report (BRIEF). Groups were compared at 20 weeks using linear regression (SPSS 21). **RESULTS:** There were no significant between group differences in attentional control (DSB; p = 0.20; CI= -0.40,1.87); cognitive flexibility (Inhibition, p = 0.34; CI= -0.73,2.11; number/letter sequencing, p = 0.17; CI= -0.55,2.94); problem solving (Tower; p = 0.28; CI= -0.61,2.09), information processing (Symbol; p = 0.08; CI= -0.16, 2.75; Coding; p = 0.07; CI= -0.12,2.52) or EF performance (p = 0.13; CI= -10.04,1.38). **CONCLUSION:** In a large RCT, Mitii™ did not lead to significant improvements on measures of EF or parent ratings of EF performance in children with UCP. Implications for rehabilitation A large RCT of the multi-modal web based training; Move It to Improve It (Mitii™) improves motor processing, visual perception, and physical capacity but does demonstrate statistically significant improvements or clinical significance in executive function in children with mild to moderate unilateral cerebral palsy (UCP). Mitii™ training completed by an intervention group was highly variable with few children reaching the target dosage of 60 h. Technical issues including server and internet connectively problems lead to disengagement with the program. Web-based training delivered in the home has the potential to increase therapy dose and accessibility, however, Mitii™ needs to be tailored to include tasks involving goal-setting, more complex problem solving using multi-dimensional strategies, mental flexibility, switching between two cognitively demanding tasks, and greater novelty in order to increase the cognitive component and challenge required to drive changes in EF.

[PMID: 27665941](#)

27. Ann Phys Rehabil Med. 2016 Sep;59S:e7-e8. doi: 10.1016/j.rehab.2016.07.019.

Health network Breizh PC impact on the management of patients with cerebral palsy and professional practice.

Colin A, Nicolas B, Durufle A, Lepape L, Achille S, Gallien P.

OBJECTIVE: For 10 years the Breizh PC network has developed a training policy for health professionals based on the analysis of the medical needs of patients with cerebral palsy and professional practices. Several studies have highlighted various health problems. We detail the main actions and their impact on the satisfaction of users and professionals. **MATERIAL AND METHODS:** Since the creation of the network regulatory triennial assessments led us to perform satisfaction surveys among users and professional members of the network. We present the evolution of these results over the past decade. **RESULTS:** Near 1000 users have benefited from the actions of the network, a secure shared medical folder has been put in place in order to improve the quality of care. In parallel, network activity concerned 2840 health professionals through various training and information sessions. Over the years, an increase in patient satisfaction with respect to the quality of care is noted with 65% of patients a feeling of improving their quality of life, against 40% in 2006. In parallel, professionals report a positive impact on their professional practice in the management of patients with cerebral palsy in particular, but also in other pathologies. **DISCUSSION/CONCLUSION:** Since its creation the network has put in place training, information, and therapeutic education concerning different professional caregivers and community health involved in the management of cerebral palsy. The evaluation for more than 10 years shows both a satisfaction of professionals and patients. These results confirm the interest of the creation of this network of care.

[PMID: 27676983](#)

28. PM R. 2016 Sep;8(9S):S316. doi: 10.1016/j.pmrj.2016.07.398. Epub 2016 Sep 24.

Poster 479 Economic Burden of Pediatric Spasticity in Cerebral Palsy: A Review of the Literature.

Clarke NM, Camba GC, Stephens JM, Pulgar S, Bains S, Marchese D, Tilton AH.

[PMID: 27673223](#)

29. Disabil Rehabil. 2016 Sep 27:1-8. [Epub ahead of print]

Moving from parent "consultant" to parent "collaborator": one pediatric research team's experience.

Bartlett D, Chiarello LA, Hjordgaard T, Sieck Taylor B.

We share our experiences as academic physical therapists and parents of young people with cerebral palsy working together as a research team, describe and critically review how our working relationship has evolved and propose further enhancements to realize our shared vision. This manuscript is informed by a call for "family-centered research," transcripts of face-to-face meetings held over a period of 1 1/2 days, the INVOLVE document and our experiences over almost a decade, as well as other related literature. Authentic collaborative research partnerships between academic researchers and parents embodying trust, mutual respect and shared social responsibility take time and effort to develop and sustain. Rehabilitation research is more meaningful and may be more impactful when strong collaborative partnerships between researchers and health service users are in place. Implications for Rehabilitation Involving service users in rehabilitation research is important, but not without challenges. Attaining authentic collaboration requires face-to-face meetings, time, effort, and ongoing open communication. Research processes are superior and outcomes may be improved with service user involvement. Impact of research on rehabilitation practice is anticipated to be more meaningful with service user involvement.

[PMID: 27670419](#)

30. PM R. 2016 Sep;8(9S):S319-S320. doi: 10.1016/j.pmrj.2016.07.408. Epub 2016 Sep 24.

Poster 490 Profile of Pediatric Patients with Cerebral Palsy at a Tertiary Hospital Rehabilitation Medicine Department.

Hebreo AR, Ang-Munoz CD, Abiera JE, Dungca ML, Mancao BD.

[PMID: 27673233](#)

Prevention and Cure

31. Expert Rev Neurother. 2016 Sep 30. [Epub ahead of print]

Perspectives in neonatal and childhood arterial ischemic stroke.

Fluss J, Dinomais M, Kossotoroff M, Vuillerot C, Darteyre S, Chabrier S.

INTRODUCTION: Over the last decade considerable advances have been made in the identification, understanding and management of pediatric arterial ischemic stroke. Such increasing knowledge has also brought new perspectives and interrogations in the current acute and rehabilitative care of these patients. **AREAS COVERED:** In developed countries, focal cerebral arteriopathy is one of the most common causes of arterial ischemic stroke in childhood and imaging features are well characterized. However, there are ongoing debates regarding its underlying mechanisms, natural evolution and proper management. The implementation of thrombolytic therapy in acute pediatric stroke has been shown to be efficient in anecdotal cases but is still limited by a number of caveats, even in large tertiary centers. Finally, neonatal stroke represents a unique circumstance of possible early intervention before the onset of any neurological disability but this appears meaningful only in a selective group of neonates. **Expert commentary:** Pediatric stroke covers a range of cerebrovascular events starting in the fetal period until late adolescence that considerably differ from adult stroke. While perinatal stroke, a leading cause of cerebral palsy, appears to be multifactorial, a large number of childhood ischemic stroke are probably essentially triggered by infectious factors leading to vessel wall damage. Current research is aiming at better identifying risk factors in both conditions, and to define optimal acute and preventive therapeutic strategies in order to reduce significant long-term morbidity.

[PMID: 27687767](#)

32. Ann Phys Rehabil Med. 2016 Sep;59S:e2. doi: 10.1016/j.rehab.2016.07.008.

Pediatric stroke rehabilitation: A review of techniques facilitating motor recovery.

Papathanasiou E, Chevignard M, Vuillerot C, Tiberghien A, Godard I.

OBJECTIVE: Paediatric stroke is a relatively rare medical condition, but it often leads to long lasting motor and cognitive impairments. Rehabilitation of motor impairments has been widely studied, with most studies performed in children with cerebral palsy (CP). However, CP covers a variety of medical conditions, including brain lesions due to paediatric stroke occurring early in life, but not stroke occurring later on during childhood. The specificity of rehabilitation after paediatric stroke remains understudied. This paper aims to present current motor rehabilitation practices (from birth to age 18) and examine which of these techniques are applicable and efficient for paediatric stroke. **MATERIALS/PATIENTS AND METHODS:** We first conducted searches using Ovid Database, for motor rehabilitation techniques used in childhood hemiplegia and/or CP. As a second step, a systematic search was conducted up to March 2016, combining the therapies retrieved in the first search AND key words referring to paediatric stroke. Separate searches were conducted for each rehabilitation technique previously identified, namely: constraint induced movement therapy (CIMT), hand arm bimanual training (HABIT), occupational therapy combined with botulinum toxin injections, non-invasive brain stimulation, virtual reality, robotics, action-observation therapy, functional electric stimulation and prismatic or mirror adaptations. **RESULTS:** In paediatric stroke, studies on rehabilitation of lower limb present low or insufficient evidence, whereas most studies refer to rehabilitation of upper-limb disabilities. CIMT presents moderate to strong evidence, sometimes coupled with imaging studies examining the associated brain changes. Individual case studies propose CIMT for toddlers or infants, both for motor rehabilitation or unilateral spatial neglect. Contrary to CP literature, there is no available evidence on bimanual training or botulinum toxin injections, whereas there is a growing body of research on non-invasive brain stimulation, (tDCS or TMS) providing preliminary evidence on the efficacy, as well as safety and feasibility of such methods for older children. Novel approaches such as functional electric stimulation, robotic therapy, virtual reality and action-observation therapy present low or insufficient evidence, but may be promising for more severe upper limb deficits or early intervention. **DISCUSSION/CONCLUSION:** Rehabilitation of motor deficits following paediatric stroke remains understudied, but a number of promising therapies are emerging.

[PMID: 27676869](#)

33. Ann Phys Rehabil Med. 2016 Sep;59S:e1. doi: 10.1016/j.rehab.2016.07.006.

Recommendations for clinical practice after neonatal arterial ischemic stroke: Clinical monitoring and early rehabilitation intervention.

Vuillerot C, Dinomais M, Marret S, Chabrier S, Debillon T.

OPINION/FEEDBACK: Neonatal arterial ischemic stroke (NAIS) affects one child in 6-17 100,000-birth term neonates, most of these children will keep long-term motor and cognitive impairment. In 2014, initiated by the French Center for Pediatric Stroke in association with the French Society of Neonatology, a steering committee was created to propose clinical guidelines after NAIS. From all the relevant questions, the importance is given to long-term outcomes after a NAIS with a need for a better description of motor and cognitive outcomes after a NAIS in order to propose a more consensual monitoring for these children to improve their management. Guidelines were proposed based on an extensive literature review and experts experience. About 30% of children after a NAIS will develop a unilateral cerebral palsy requiring a management by a team with expertise in physical medicine and rehabilitation. To quantify impairments, activity limitations and participation restrictions resulting from this NAIS, evaluations, with reliable tools must be carried out systematically, early and repeated annually through adolescence. A multidisciplinary team with a longitudinal follow-up, in all the different developmental dimensions, must conduct these evaluations in term of motor skills, cognitive impairment, behavior, autonomy, quality of life, and participation. Consequences on family functioning need to be evaluate in order to help children and family coping with this event. A number of data on brain plasticity and effect of early interventions in association with preliminary results in children with cerebral palsy are very much in favor of early treatment. It remains now important to determine the intensity and what types of early intervention. The importance is given in all cases to a comprehensive care of the child and his/her family with the goal to prevent limitations in terms of activity and participation.

[PMID: 27676704](#)

34. PLoS One. 2016 Sep 27;11(9):e0163775. doi: 10.1371/journal.pone.0163775.

Motor Experience Reprograms Development of a Genetically-Altered Bilateral Corticospinal Motor Circuit.

Serradj N, Martin JH.

Evidence suggests that motor experience plays a role in shaping development of the corticospinal system and voluntary motor control, which is a key motor function of the system. Here we used a mouse model with conditional forebrain deletion of the gene for EphA4 (Emx1-Cre:EphA4tm2K1dr), which regulates development of the laterality of corticospinal tract (CST). We combined study of Emx1-Cre:EphA4tm2K1dr with unilateral forelimb constraint during development to expand our understanding of experience-dependent CST development from both basic and translational perspectives. This mouse develops dense ipsilateral CST projections, a bilateral motor cortex motor representation, and bilateral motor phenotypes. Together these phenotypes can be used as readouts of corticospinal system organization and function and the changes brought about by experience. The Emx1-Cre:EphA4tm2K1dr mouse shares features with the common developmental disorder cerebral palsy: bilateral voluntary motor impairments and bilateral CST miswiring. Emx1-Cre:EphA4tm2K1dr mice with typical motor experiences during development display the bilateral phenotype of "mirror" reaching, because of a strongly bilateral motor cortex motor representation and a bilateral CST. By contrast, Emx1-Cre:EphA4tm2K1dr mice that experienced unilateral forelimb constraint from P1 to P30 and tested at maturity had a more contralateral motor cortex motor representation in each hemisphere; more lateralized CST projections; and substantially more lateralized/independent reaching movements. Changes in CST organization and function in this model can be explained by reduced synaptic competition of the CST from the side without developmental forelimb motor experiences. Using this model we show that unilateral constraint largely abrogated the effects of the genetic mutation on CST projections and thus demonstrates how robust and persistent experience-dependent development can be for the establishment of corticospinal system connections and voluntary control. Further, our findings inform the mechanisms of and strategies for developing behavioral therapies to treat bilateral movement impairments and CST miswiring in cerebral palsy.

[PMID: 27673329](#)

35. Prenat Diagn. 2016 Sep 29. doi: 10.1002/pd.4932. [Epub ahead of print]

Maternal Obesity and Neurodevelopmental and Psychiatric Disorders in Offspring.

Edlow AG.

There is a growing body of evidence from both human epidemiologic and animal studies that prenatal and lactational exposure to maternal obesity and high-fat diet are associated with neurodevelopmental and psychiatric disorders in offspring. These disorders include cognitive impairment, autism spectrum disorders, attention deficit hyperactivity disorder, cerebral palsy, anxiety and depression, schizophrenia, and eating disorders. This review synthesizes human and animal data linking maternal obesity and high-fat diet consumption to abnormal fetal brain development and neurodevelopmental and psychiatric morbidity in offspring. In addition, it highlights key mechanisms by which maternal obesity and maternal diet might impact fetal and offspring neurodevelopment, including neuroinflammation; increased oxidative stress, dysregulated insulin, glucose, and leptin signaling; dysregulated serotonergic and dopaminergic signaling; and perturbations in synaptic plasticity. Finally, the review summarizes available evidence regarding investigational therapeutic approaches to mitigate the harmful effects of maternal obesity on fetal and offspring neurodevelopment.

[PMID: 27684946](#)