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Efekt terapeutyczny działania krioterapii miejscowej na staw kolanowy, uzależniony od rozpoznania choroby zwyrodnieniowej

Profil chorych kierowanych do leczenia w zakresie rehabilitacji ogólnoustrojowej

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Wyniki zastosowania gipsów hamujących u 5-letniego dziecka ze spastycznym niedowładem połowiczym – studium przypadku

Outcomes following inhibiting casts treatment in a 5 years old child with spastic hemplegic cerebral palsy – a case report

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Streszczenie:

U dzieci z mózgowym porażeniem dziecięcym z definicji występują zaburzenia ruchowe. Podstawowym celem programu usprawniania tych dzieci jest wspomaganie rozwoju jak najlepszej jakości wzorców postawy i lokomocji. Prezentowane studium dotyczy 5-letniej dziewczynki, zdiagnozowanej jako średnio ciężkie mózgowe porażenie dziecięce: prawostronny spastyczny niedowład połowiczy. Opracowanie przedstawia wpływ programu nieinwazyjnej terapii, polegającej na połączeniu indywidualnego programu usprawniania (wg koncepcji NDT), wspomaganego zastosowaniem gipsów hamujących na poprawę wzorców postawy i chodu.

U dziecka dwukrotnie (przed i po zakończeniu terapii) przeprowadzono ocenę funkcjonalną, która obejmowała: kliniczną ocenę spastyczności; rozkład sił nacisku masy ciała na płaszczyznę podporu, testy posturograficzne oraz analizę chodu. W wyniku zastosowanej terapii uzyskano obniżenie stopnia spastyczności w obrębie mięśni kończyny dolnej niedowładnej. Zarówno deficyt zakresu ruchu jak i kąt spastyczności w stawie kolanowym i skokowym zdecydowanie zmniejszyły się, co wpłynęło na poprawę kontroli posturalnej i wzorca chodu pacjenta. Uzyskane wyniki wykazały, że zastosowanie usprawniania, wspomaganego zastosowaniem gipsów hamujących, może być skuteczną formą obniżenia poziomu spastyczności oraz poprawy kontroli posturalnej i wzorców chodu u młodszych dzieci z niedowładem połowiczym. Wczesne rozpoznanie spastyczności mięśnia trójgłowego oraz zastosowanie adekwatnego leczenia zachowawczego może wyeliminować potrzebę inwazyjnych form leczenia i związanych z nimi zagrożeń w tej populacji dzieci.

Słowa kluczowe:

spastyczność, dynamiczna ocena zakresu ruchu, rozkład sił nacisku masy ciała na płaszczyznę podporu, posturografia, trójpłaszczyznowa analiza chodu

Abstract

In children with Cerebral palsy (CP), according to the definition, motor disorders occur.

The primary aim of the rehabilitation in this group of children is to support the development of the best quality of motor and posture patterns. Presented study describes the effects of non-invasive physical therapy, based on Neurodevelopmental Treatment (NDT) connected with serial inhibiting casts application, on postural control and gait pattern improvement in 5 years old child with spastic hemiplegia.

Functional assessment, before and after treatment, included: clinical measures of spasticity, weight – bearing distribution between body sides, posturography testing and gait analysis. Applied therapy influenced on: reduction of spasticity in the affected limb and improvement in postural control and gait parameters. Both range of movement (ROM) deficit and spasticity angle (AOS) in knee and ankle decreased and effected on postural control and gait improvement.

Obtained results demonstrate that non-invasive procedures of physical intervention, connected with serial inhibiting casts application, can be successful method of spasticity reduction, postural control and gait improvement in young children with spastic unilateral CP. Early detection of spasticity of triceps contracture and proper physical intervention may eliminate the need for invasive intervention and its associated risks in this population.

Key words:

spasticity, dynamic assessment of range of movement, distribution of pressure forces of body weight on support plane, posturography, three-dimensional gait analysis

Background

In children with Cerebral palsy (CP), according to the definition, motor disorders occur [1]. These abnormalities are the resultants of primary symptoms, i.e. directly resulting from Central Nervous System (CNS) damage, and of secondary symptoms concerning the effects of the activity of the compensatory mechanisms during psychomotor development. Due to the location of CNS damage and based on the topographical distribution of paresis, spastic CP can be categorized as unilateral CP (hemiplegia), and bilateral CP (diplegia, bilateral hemiplegia) [1].

Although the symptoms of hemiplegia are individually different, generally it functionally affects one arm and leg on the same side of the body. The injury in the left hemisphere of the brain will cause a right-side hemiplegia and the injury in the right hemisphere, causes a left-side hemiplegia. In most of the patients with hemiplegia the arms and the distal parts of the limbs are more affected [2, 3]. A serious problem in the treatment of children with hemiparesis is spasticity.

Spasticity is caused by a damage or an injury of the part of the brain that controls voluntary movements. This damage disrupts important signals between the nervous system and muscles, creating an imbalance that increases muscle activity or spasms, resulting with decreased growth of the affected muscles [4]. Although the muscle shortening increases gradually, it causes limitations in the range of motion (ROM) and increased stiffness in the joints of the affected limbs [5].

In child with hemiplegia, deficits of range of movement (ROM) more frequently affect the wrist and the hand than the shoulder. Similarly, the ankle and foot will exhibit more difficulties than the knee [4, 5]. For this reason child with hemiplegia may start walking later and with abnormal pattern of upright body posture. It can make child's movement, posture, balance and gait difficult. One particular concern is persistent spasticity, which leads to contractures, the constant contractions of muscles and periarticular soft elements, which results in associated deformations of joints and bones, such as: scoliosis, hip dislocation and limb deformities – ankle and foot deformations on the affected side.

Although there is no cure for hemiplegia, it's effects can be minimized through early intervention and proper physical therapy procedures. Because of the fact that the immature brain is very flexible, many of functions of the damaged area can be taken over by fully functional parts of the brain [6, 7].

Physiotherapy is the standard treatment for spastic hemiplegia, as it is for other forms of CP. There are many methods of physiotherapy, from neurodevelopmental

therapies such as NDT-Bobath [8], or Vojta [9] to other physiotherapy methods, which are aimed at preventing further muscle stiffening or limiting the contractures and limb deformities which can occur in spastic hemiplegia [10, 11].

On the other hand clinicians routinely see children with CP, and they created the need for:

• spasticity management;
• contracture management;
• orthotic management programs, aimed at improving gait in this group of children [12].

In this report, we present the outcomes following a non-invasive treatment program, based on own neurodevelopmental treatment methods (NDT) and complementary inhibiting casts application which can improve posture control and gait pattern in 5 years old child, diagnosed with mild spastic cerebral palsy.

Case description

Presented clinical case refers to a girl, definitively diagnosed as a mild unilateral spastic CP (right side hemiplegia, I level of Gross Motor Function Classification System (GMFCS).

Our patient, at the age of 6 months has been directed for further detailed imaging diagnostics, because of her postural asymmetry and asymmetrical movements. First examination, based on computed tomography (CT), revealed diffused encephalomalacia changes within the temporal lobe of the left hemisphere of brain.

Next clinical examination, which included brain ultrasonography (USG), showed the asymmetry of the lateral ventricles and slight pathological changes caused by II grade intraventricular hemorrhage, in its resorption phase. Moreover, atrophic changes within the occipital and parietal lobes, with hypoxic-ischemic etiology have been revealed. Finally, the patient underwent magnetic resonance imaging (MRI), with the following results: wide encephalomalacia changes within the left hemisphere with the asymmetry of the hemispheres (widening of the left lateral ventricle and reduced volume of the left half of the brainstem). The above-mentioned results indicate that the cause should be sought in patient's ischemic perinatal incident. Based on patient's clinical condition and examination results, mild cerebral palsy with right-sided hemiparesis has been diagnosed. Furthermore, patient's psychomotor development has been assessed and several disturbances in locomotion, eye – hand coordination and speech have been revealed.

Functional assessment showed a bit slimmer right limbs,

coercive flexion of the right upper limb with fixed hand and its worse efficiency. In addition, limping on the right side and limited right ankle dorsiflexion has been observed. Therefore, from sixth months of life the girl was treated in accordance with NDT concept and continued until 4 years in NEUROmed Rehabilitation Center in Katowice.

During this time, the child has been gaining the basic functional skills, so-called milestones, in the following sequence:

• support on forearms in prone – 7 months of age
• rolling through the affected side – 8 months of age
• transition to sitting position from prone through the affected side and by support of affected hand and maintaining long sitting position – 9 months of age
• moving using sitting position – 10 months of age
• long kneeling – 11 months of age, kneeling with support of affected open hand 12 months of age
• getting up and standing with support – 16 months of age
• side gait with support – 18 months of age
• walking without assistant – 20 months of age

In the fourth year of life there was a strong worsening in body posture pattern, in postural control pattern, and especially in gait pattern. In functional assessment, consisting of the observation of spontaneous activity of the child (video) and analysis of compensatory mechanisms (video) a significant increase (compared to 6 months prior to the study) of the plantar flexion in the affected leg, during both standing and walking in stance and as well as in swing. Greater instability disorders in a standing position were also observed.

Therefore, the decision of objective functional analysis, including: clinical measures of spasticity (Dynamic Assessment of Range of Movement; DAROM); weight-bearing distribution between body sides, posturography testing and three-dimensional instrumental gait analysis (3DGA) were made.

Therapeutic intervention

Based on obtained results, twelve – month individual neurodevelopmental treatment program connected with serial inhibiting casts application (NDT + IC) was programmed, in purpose to normalize the muscle tone distribution and consequently, to reduce the affected lower limb spasticity and to improve postural control and gait parameters. The individual therapy program included:

1. preparation to inhibiting casts (3 weeks);
2. inhibiting casts application and therapy during IC (3 weeks);
3. improvement of postural control and gait pattern (6 weeks).

Our NDT therapy was aimed at:

• inhibiting abnormal reflex activity in posture and motor patterns (especially asymmetrical tonic neck reflex activity – ATNR),

• elimination of pelvic functional block and asymmetry (these two aims can be achieved by using RIP – reflex inhibiting patterns in kneeling positions with dissociation between hips),
• facilitation of proper righting and balance reactions in standing,
• normal gait patterns facilitation during walking on the track,
• transfer of sensorimotor experiences from therapy to everyday activities, which can be realized by walking in IC [14].

Our hypothesis was as follows: using IC combined with own neurodevelopmental treatment program in children with unilateral CP, can be an alternative treatment method in dealing with gait and postural control disturbances, which may help to avoid the need for invasive surgical intervention. To confirm following assumption, NDT connected with IC treatment was applied in 4 years old child diagnosed with mild spastic cerebral palsy and the effects of this procedure has been evaluated by comparing clinical examination and gait analysis results- before and after IC application.

Examination

The child was functionally assessed two times – before and after treatment – using:
• Clinical examination of spasticity;
• Analysis of the Static Load Distribution (weight – bearing distribution);
• Posturographic test (COP measurements);
• 3D gait analysis (3DGA).

For the clinical examination of spasticity four tests of The Dynamic Evaluation of Range of Movement (DAROM) tests and the pendulum test with accelerometer – based system designed and constructed in collaboration with the Institute of Electronics of Silesian University of Technology, with ZK software were performed. The testing positions and standardisation procedures for all of measurements are presented in Table 1.

Fundamental assumption of DAROM is examination of passive movement in particular joint in two phases: phase I – by slow movement (with velocity V1), deficit range of motion in this phase correlates with deformations of static character (sceleto – articular system and articular – ligament apparatus as well as muscle system) and phase II – by quick movement (with velocity V3), deficit range of motion in this phase correlate with presence of dynamic deformations (nervous system). The difference between DROM II and DROM I indicates angle of spasticity (ASO) and describes the spasticity level (Tab. 2) [15, 16].

Analysis of the Static Load Distribution (weight – bearing distribution), and posturographic test (COP measurements)

Table 1. Accelerometer placement, patient's position and stabilization for dynamic assessment of range of movement (DAROM tests) and pendulum test.

Test	Testing position	Position of accelerometer	Stabilization
T1Popliteal angle	Supine position, hip and knee in tested leg are flexed to 90o, ankle is in neutral position, contralateral leg stays in resting position	5 cm proximal to the lateral malleolus, parallel to the long axis of the fibula	Obręcz biodrowa, udo Pelvic girdle and thigh
T2 Deficit of knee extension	Supine position, hip joint in the tested leg is in extended position, knee is flexed to 90o, the lower thigh stays off the table, ankle in the neutral position, contralateral leg stays in resting position	5 cm proximal to the lateral malleolus, parallel to the long axis of the fibula	Obręcz biodrowa, udo Pelvic girdle and thigh
T3 Deficit of ankle dorsiflexion (knee extended)	At the time of knee extension movement, supine position: hip and knee flexed to 90°	10 cm distal to the lateral malleolus, parallel to the long axis of the fibula	Obręcz biodrowa, udo i podudzie Pelvic girdle, thigh and the lower thigh
T4 Deficit of ankle dorsiflexion (knee flexed 90º)	At the time of extension movement in knee, supine position: hip joint is extended and the knee is flexed to 90°	10 cm distal to the lateral malleolus, parallel to the long axis of the fibula	Obręcz biodrowa, udo i podudzie Pelvic girdle, thigh and the lower thigh
T5 Pendulum test	 [16]	5 cm proximal to the lateral malleolus, parallel to the long axis of the fibula	Obręcz biodrowa i udo Pelvic girdle and thigh

Table 2. Definitions of the outcome measures collected from the clinical examination of spasticity.

Mesurement	Parameter	Description
Range of motion deficit (DROM) for DAROM tests: T1, T2, T3, T4	DROM I	Range of motion deficit following a slow velocity stretch (V1); expressed in degrees.
	DROM II	Range of motion deficit after a fast velocity stretch (V3); expressed in degrees.
	ASO	Value calculated as the difference between the DROM II and DROM I; expressed in degrees.
Pendulum Test: T5	Ex	First swing excursion. Defined as the difference between the starting angle (the position at which the examiner released the participant's heel) and the first angle of reversal of the swinging limb; expressed in degrees.
	t	Duration of oscillations. Calculated as the duration of the pendulum swings (in seconds) from the time of lower limb release to the end of the final oscillation; expressed in sec.
	n	Determined by counting the maxima of the sinusoidal waves produced by the swinging limb after the heel was released. The criterion for each oscillation was a flexion and extension wave with a minimum displacement toward the extension of a minimum of three degrees; number of oscillations.
Stability indices based on CoP shifts in standing position	Q	Percentage load distribution between affected and unaffected body sides.
	SP	Sway path length of the center of pressure (CoP)
	WoE	Width of an ellipse (lateral sway path of the CoP)
	HoE	Height of the ellipse (posterior sway path of the CoP)

was performed during quiet stance, using the force plate pressure distribution measurement system, PDM-S (Zebris Medizintechnik GmbH, Isny, Germany), with FootPrint software.

3D gait analysis (3DGA) using Compact Measuring System for 3D Real Time Motion Analysis (CMS- HS 3D) with WinGait software (Zebris Medizintechnik GmbH, Germany) has been used for examination.

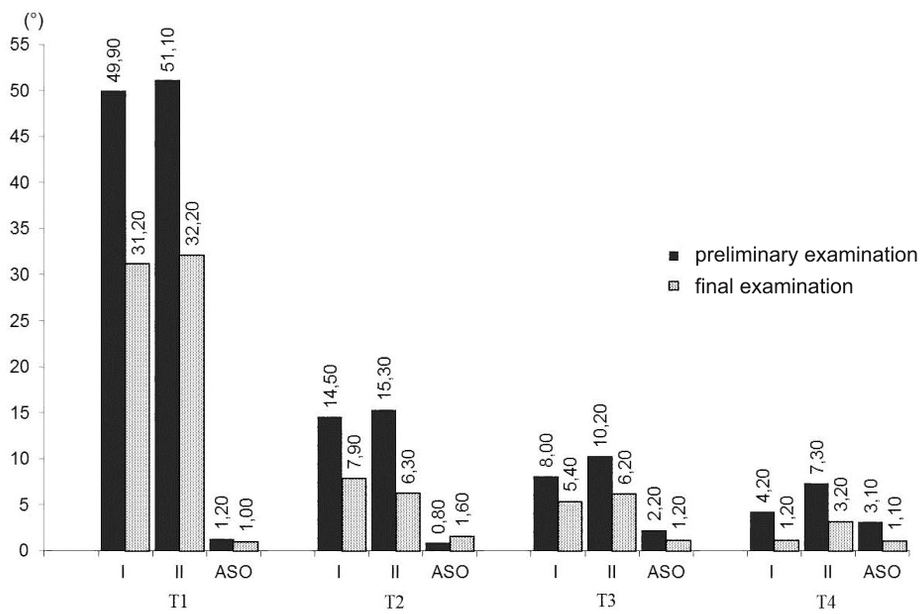
All of the procedures of spasticity measurements (DAROM and pendulum test) were repeated until three trials (without interference) for each leg and were obtained for subject with approximately one minute between trials. The obtained results were averaged.

To characterize gait patterns, the GGI was calculated (separately for each lower limb), using the procedure described by Schutte. The GGI is a single number, derived from gait kinematics and spatio – temporal parameters, which quantifies the deviation of a pathological gait from a norm. The higher value of GGI shows the more abnormal gait pattern [17].

Results

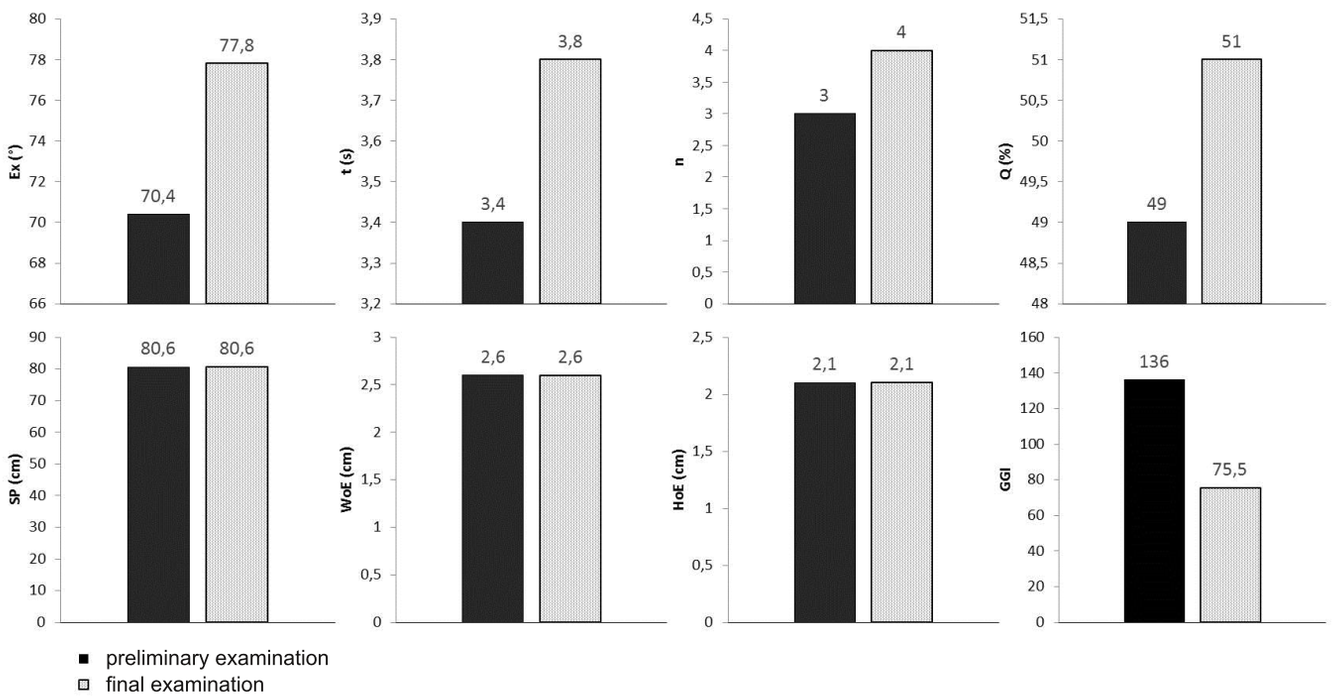
After using serial IC combined with individual neurodevelopmental treatment program (NDT+IC), in child with hemiplegia following results were observed: increase of passive ROM in affected lower limb in all tests and in both measurements by slow movement and by quick movement: popliteal angle (T1) was increased above 10º; knee extension angle (T2) about 7º; ankle dorsiflexion with extended knee (T3) and ankle dorsiflexion with knee flexed 90º (T4) – respectively about 5º and 6º (Fig.1).

Fig. 1. Values of the range of motion deficit DROM (I – slow movement, II – quick movement) and ASO (difference between I and II) in tests: T1, T2, T3, T4 for dynamic range of movement assessment (DAROM tests) of an affected limb of the assessed child.



Although child before NDT+IC demonstrated a seemingly normal knee extensor muscle tone in both affected and the unaffected lower limb, the outcomes of pendulum test (Ex, n and t values) were significantly better after treatment (larger) compared with those before treatment (Fig.2). This satisfactory result was noted not only in clinical exam. After twelve-month an individual program of NDT + IC, gait analysis revealed a general improvement in the gait pattern, confirmed by GGI calculation. GGI presented clear difference between values before and after NDT + IC treatment. For both lower limbs, the GGI after IC treatment obtained values characteristic for almost normal gait (37.0 for unaffected and 75 for affected lower limb) (Fig.2).

Figure 2. Values of The Pendulum Test (Ex, t, n), stabilogram (Q, SP, WoE, HoE) and GGI in preliminary and final examination of the assessed child.



Discussion

Among children diagnosed with unilateral CP, several types of hemiplegia has been distinguished (Winters et al 1987, and Roda and Graham, 2001) [12, 18]. On the basis of patient's clinical condition and evaluation of posture, weight-bearing distribution and gait pattern, our patient has been defined as having a 2a type of hemiplegia.

Type 2a of hemiplegia is characterized by true equinus, neutral knee and over extended hip. This type of postural pattern is described as right side hemiplegic and tendency to overload the unaffected body side.

Gait pattern in this type of hemiplegia looks as follows: true equinus is observed during the stance phase of gait as a result of spasticity and mild contracture of the gastro-soleus muscles. There is a mild degree of drop foot swing because of impaired function in tibialis anterior of affected lower limb.

Agreeing with management algorithm, based on the above mentioned classification of gait patterns in 2a spastic hemiplegia, gastroc-soleus spasticity and mild contracture can be managed by intra-muscular botulinum toxin type A (TBxA) injections, especially in younger children with supplemental casting of affected leg [19, 20, 21, 22, 23, 24]. The majority of these children also require orthotic support, both to control the tendency to 'foot drop' during the swing phase of gait, but also to augment and prolog the response to TBxA. Surgical treatment is typically reserved for older children with fixed contracture of the gastroc – soleus constitutes, who have not improved after conservative measures.

Presented results indicate that using non – invasive methods, such as using serial IC combined with individual neurodevelopmental treatment program, can be a successful treatment component in young children diagnosed with hemiplegic spastic cerebral palsy.

Early detection of spasticity severity and risk of triceps contracture and first of all proper physiotherapy intervention may eliminate the need for invasive intervention and its associated risks in this population. Using serial IC may help to prevent adaptive shortening of the gastrocnemius and the development of persistent abnormalities in gait and postural control.

Conclusions

1. After twelve month of individual neurodevelopmental treatment program supported with serial inhibiting casts, presented outcomes of functional assessment of postural stability and gait pattern showed positive changes in child with spastic hemiplegia.
2. The early neurodevelopmental treatment program supported with serial inhibiting casts may provide an alternative to invasive methods of treatment of children with CP with hemiplegia.
3. Results presented in this case study seem to be promising enough to exhibit the need for further research in wider group of children diagnosed with mild spastic cerebral palsy.

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References

1. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B. Proposed definition and classification of cerebral palsy. Dev Med Child Neurol 2005;47(8):571-6.
2. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M. A report: the definition and classification of cerebral palsy. Dev Med Child Neurol 2007;Suppl. 109:8-14.
3. World Health Organization. International Classification of Functioning, Disability, and Health. Geneva, Switzerland: World Health Organization; 2001.
4. Wu YN, Ren Y, Goldsmith A, Gaebler D, Liu SQ, Zhang LQ. Characterization of spasticity in cerebral palsy: dependence of catch angle on velocity. Dev Med Child Neurol 2010;52(6):563-9.
5. Graham HK, Selber P. Musculoskeletal aspects of cerebral palsy. J Bone Joint Surg Br 2003;85(2):157–66.
6. Johnston MV. Clinical disorders of brain plasticity. Brain Dev 2004;26(2):73-80.
7. Jensen JL, Marstrand PC, Nielsen JB. Motor skill training and strength training are associated with different plastic changes in the central nervous system. J Appl Physiol 2005;99(4):1558-68.
8. Butler C, Darrah J. Effects of neurodevelopmental treatment (NDT) for cerebral palsy: an AACPDM evidence report. Dev Med Child Neurol 2001;43(11):778-90.
9. Kiebzak W, Szmigiel C, Błaszczyk B. Monitoring the process of Rehabilitation in children with disorders of central coordination. Pol J Physiother 2003;3(3):243-9.
10. Charles J, Gordon AM. A critical review of constraint-induced movement therapy and forced use in children with hemiplegia. Neural Plast 2005;12(2-3):245-61.
11. Damiano DL. Activity, activity, activity: rethinking our physical therapy approach to cerebral palsy. Phys Ther 2006;86(11):1534-40.
12. Rodda J, Graham HK. Classification of gait patterns in spastic hemiplegia and spastic diplegia: a basis for a management algorithm. Eur J Neurol 2001;8 Suppl. 5:98–108.
13. Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galappi B: Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol 1997;39(4):214–223.
14. Domagalska-Szopa M, Szopa A. Koncepcja usprawniania neurorozwojowego NdT- Bobath. Nowe spojrzenie. W: Śliwiński Z, Sieroń A, redaktor. Wielka fizjoterapia. Tom 3. Wrocław: Elsevier Urban & Partner; 2014. str. 124-38.
15. Domagalska M, Szopa A, Syczewska M, Pietraszek S, Kidoń Z, Onik G. The relationship between clinical measurements and gait analysis data in children with cerebral palsy. Gait Posture 2013;38(4):1038-43.
16. Szopa A, Domagalska-Szopa M, Kidoń Z, Syczewska M. Quadriceps femoris spasticity in children with cerebral palsy: measurement with the pendulum test and relationship with gait abnormalities. J Neuroeng Rehabil 2014;11(166):1-20.
17. Schutte LM, Narayanan U, Stout JL, Selber P, Gage JR, Schwartz MH. An index for quantifying deviations from normal gait. Gait Posture 2000;11(1):25-31.
18. Winters TF, Gage JR, Hicks R. Gait patterns in spastic hemiplegia in children and young adults. J Bone Joint Surg 1987;69(3):437-41.
19. Cosgrove AP, Corry IS, Graham HK. Botulinum toxin in the management of the lower limb in cerebral palsy. Dev Med Child Neurol 1994;36(5):386-96.
20. Koman LA, Mooney JF III, Smith BP, Goodman A, Mulvaney T. Management of spasticity in cerebral palsy with botulinum-A toxin: report of a preliminary, randomized, double-blind trial. J Pediat Orthoped 1994;14(3):299-303.
21. Corry IS, Cosgrove AP, Duffy CM, Taylor TC, Graham HK. Botulinum toxin A in hamstring spasticity. Gait Posture 1999;10(3):206-10.
22. Flett PJ, Stem LM, Waddy H, Connell TM, Seeger JD, Gibson SK. Botulinum toxin A versus fixed cast stretching for dynamic calf tightness in cerebral palsy. J Paediat Child Health 1999;35(1):71-7.
23. Boyd RN, Graham HK. Botulinum toxin A in the management of children with cerebral palsy: indications and outcomes. Eur J Neurol 1997; Suppl. 4:15–22.
24. Molenaers G, Desloovere K, De Cat J, i wsp. Single event multilevel botulinum toxin type A treatment and surgery: similarities and differences. Eur J Neurol 2001;Suppl. 5:88-97.