

NEW CONCEPTS IN REHABILITATION OF CHILDREN WITH CEREBRAL PALSY

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ABSTRACT

Cerebral palsy is a major burden for the affected person, their family, health insurance, educational institutions and society in general. In the past few years, new rehabilitation concepts which could offer better results on the activity/participation level and better functional skills of everyday life are being discussed. The Therasuit® therapy is a new concept in rehabilitation, based on the theory of motor learning and motor control, individualized progressive strength training, primitive reflex integration, used in combination with other well-known neurophysiotherapy techniques. A case study outcome using Therasuit® therapy on a 7.5-year-old child with spastic cerebral palsy, one month after multiple Ulzibat fibrotomy, will be presented in this article.

Keywords: cerebral palsy, strength training, primitive reflex integration, Therasuit®

INTRODUCTION

Cerebral palsy (CP) is a common name used for different disorders of the postural system caused by a non-progressive damage to the brain in its early stages of development.¹ Around the world, a large number of children are diagnosed with CP, about 1.5 to 4 on 1000 live births. In the USA, 10.000 children are diagnosed with CP every year.² The prevalence in Europe is the same as in the rest of the world and the epidemiological data for Croatia are poor and incomplete, but can be compared with the rest of the world.^{3,4} Research shows that 77.4% of children with CP have spasticity or hypertonic musculature, 35–50% have epileptic seizures and some level of mental retardation, difficulties with learning, sight, hearing and speech. 6.9% of affected children show symptoms within the autistic spectrum and 40–45% display poor coordination and motor control, which limits them in participation and activities such as crawling, independent walking, running and playing.⁵ A study reported that 31% of children with CP use special equipment like walkers, crutches or wheelchairs.⁶ CP represents a major burden for the affected child, the family, health insurance, educational institutions, and society in general.⁴

The main goals and problems of rehabilitation dealing with the described population are multiple and the number of different types of intervention used around the world is very large, starting with drugs, orthopedic procedures, orthotics, occupational therapy, speech therapy, cognitive-behavioral therapy, neurofeedback, nutritionism, different alternative treatments and physiotherapy, which includes hydrotherapy, hippotherapy and neurodevelopmental concepts such as Bobath,⁷ Vojta,⁸ Doman-Delacato,⁹ Jane Ayres' Sensory integration¹⁰ and many others. Research in rehabilitation of children with CP has been focused on physiotherapy interventions, strength training methods and treatments since the '60s of the past century. In the past two decades, researchers' interest has been piqued by new controversial methods based on new theories about strength training and the integration of primitive reflexes. Karol and Berta Bobath and many other therapists who followed their theories, stated that isolated strengthening of spastic muscles could lead to increased co-contractions, spasticity and associated reactions with consequences of poorer motor control.^{7,11,12}

However, new evidence has been found that isolated strength training with increased replication of motoric tasks and activities does not increase spasticity^{13,14} nor co-contractions of antagonistic muscles,¹⁵ but instead normalizes the muscle tone and positively affects walking, functional activities and participation.¹⁴⁻¹⁸ When speaking of reactions commonly known as primitive reflexes, traditional theories define them as primitive reactions which must be cortically inhibited through normal development.^{8,10,19} New theories such as the Masgutova's theory,²⁰ which is based on the physiological research conducted by Pavlov, Sechenov, Vygotsky, Bernstein, Sherrington, Luria and Anokhin, give evidence that primitive reflexes, besides their protective role, also play a very important role in supporting neurogenesis, synaptogenesis, and myelination, as neurophysiological foundation for higher levels of motoric, emotional and cognitive development. Masgutova stated that primitive reflexes are always present as genetic codes or natural afferent-efferent motor patterns which are not inhibited by cortical development, but integrated as a link between lower

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and higher centers of our central nervous system during its development.^{20,21} Associated reactions, according to the primitive reflex integration theory, can be defined as reflexive genetically conditioned answers that emerge when the nervous circuits have been disrupted. This disruption inhibits the next level of sensory-motor development and cognitive function. Masgutova's theory practitioners commonly call the primitive reflexes the missing link in the facilitation of development.²¹

New theories about isolated strength training and the integration of primitive reflexes complement and enrich the neurophysiological concepts, such as Vojta, Bobath, proprioceptive neuromuscular facilitation (PNF), P. and G. Dennison and Ayres.^{21,22}

The Therasuit® concept

Along with new evidence of the effectiveness of strengthening exercises for children with CP, new concepts have begun to develop. The Therasuit® concept was developed in 2002 by husband and wife Izabela and Richard Koscielny, parents of a child with CP, who are both physiotherapists from Poland. The Therasuit® concept was based on the idea of Russian researchers in 1971 and their modified version of a cosmonaut suit called "Penguin", developed to prevent the detrimental effects of hypokinesia in the weightless conditions in space.

Therasuit® is a rehabilitation concept that integrates different manual, myofascial and neurodevelopmental techniques in the Universal Exercise Unit (UEU) (Figure 1) that accentuates progressive strength training and repetitive functional activities while wearing a specially designed suit. The program is highly intensive because it is carried out for five days a week, 3–4 hours a day and for at least 3–4 weeks.

According to the Therasuit® concept, the patient is first prepared with manual, myofascial techniques, massage, soft tissue mobilizations, activation of core muscles and reflex integration. The preparation is followed by intensive isolated strength training in the UEU. The UEU is a three-dimensional cage that serves as a suspension and pulley system in which every movement and muscle group can be isolated and gravitational forces eliminated. The system facilitates the patient in motor learning and increasing the range of motion, centimeter by centimeter, through concentric, static and eccentric contractions against or/and without the gravitational force. The strength training is continued wearing the Therasuit® special suit, which serves as an *exoskeleton* made of a vest, shorts and additions for the head, elbows, wrists and knees with rubber cables that can be

connected to facilitate or inhibit muscle activity. The suit with rubber cables gives a strong proprioceptive input and loading at the same time. The theory behind the suit therapy is that it induces a strong afferent, proprioceptive input which stimulates the formation of cerebral systems whose post-natal development has been delayed. The elastic cables provide the body and articulations with a vertical loading of about 15 to 45 kg (33 to 88 pounds), which is significant to patients that have no appropriate stimulation from their own soft tissue because of abnormal muscle tone. The Therasuit® with its individualized placing of rubber cables becomes a dynamic orthosis which can give support and stabilize correct posture in a natural way. At the same time, it facilitates and strengthens correct functional patterns of movement by providing dosed resistance. The concept of the described intervention follows neurophysiological principles, training theories and antioxidant diet principles to support the functioning of the neural tissue and the musculoskeletal system. It is also characterized by a constant increase of the number of exercise repetitions, increase of resistance and change of contraction types.²³ According to the Koscielny physiotherapists²³ the positive effects, indications, contraindications, precautions and goals of the Therasuit® treatment are the following:

Positive effects:

1. Provides deep proprioceptive and tactile input
2. Stimulates the reorganization of the central nervous system
3. Enables ontogenic development and central activation
4. Enables external activation of muscles needed in stabilization
5. Normalizes muscle tone providing the sense of center of gravity, inhibiting hypertonicity, affecting vestibular nuclei and activating postural muscles
6. Changes posture
7. Provides dynamic correction
8. Corrects patterns of walking and movement in general
9. Affects balance and coordination
10. Affects uncontrolled movements in ataxia, athetosis and dystonia
11. Supports the control of the head and trunk
12. Affects the density and mineralization of bones through dynamic activation of muscle groups
13. Contributes to conversion of muscle fibers

Indications:

1. CP
2. Developmental delays
3. Balance and coordination delays and disorders
4. Traumatic brain injury
5. Stroke
6. Hypertonicity
7. Hypotonicity
8. Dyskinesia: ataxia, athetosis and dystonia
9. Non-progressive neurological disorders and syndromes: spina bifida, spinal cord injury, Down syndrome

Contraindications:

1. Progressive and genetic metabolic syndromes
2. Severe degeneration of bones and articulations
3. Severe osteopenia/osteoporosis
4. Loss of integrity on the level of body structure (severe subluxations, scoliosis and structural fixed contractures)

Precautions:

1. Hypertension, hemodynamic disorders
2. Uncontrolled epileptic seizures
3. Subluxations
4. Metabolic disorders
5. Hydrocephalus (VP shunt)
6. Kidney damage
7. Poor bone mineralization
8. Status post botox or alcohol injections

Goals:

1. Support for weak structures (trunk)
2. To provide resistance (for deeper proprioceptive input and strengthening)
3. Reeducation of pathologic synergies and patterns of movement
4. Facilitation of new functional and economic patterns
5. Reflex integration

The Therasuit® was approved by the American Food and Drug Administration (FDA) and the Brazilian National Health Surveillance Agency (ANVISA) registered Therasuit® as a medical device.

CASE STUDY

Name/Surname: N. N.*

Gender: M

Diagnosis: CP, tetraparesis spastica, GMFM III

Anamnesis: The patient is a first child and born from the mother's first pregnancy. Mother* and father* are both healthy and without medical history. At 8 weeks of gestation the mother was hospitalized due to vaginal bleeding, after which the pregnancy was without complications. The child was born in term via cesarean section because of pelvic presentation. Birth mass was 3000 g, birth length 50 cm, and Apgar 9/10. When he was 2 months old, the child underwent an ultrasound examination of the head because of hypertonicity and the findings were within normal limits, without visible abnormalities.

When he was 4 months old, a specialist of physical medicine and rehabilitation at the University Hospital Center Osijek (at that time Clinical Hospital Osijek) reported that the child had poor spontaneous general movements, undeveloped radiopalmar grasping on the left hand, that his head did not follow the trunk in traction, and that elevated muscle tone of lower limbs was found. Consequently, it was recommended for him to undergo neurodevelopmental treatment, using Bobath and Vojta methods. The specialist also recommended an MRI of the head, but the mother objected because of fear of too much stress for the

child. At the age of 10 months the subject was able to rotate from supine to prone position without selectivity of movement. When he was 1 year old, he was crawling using bent elbows and legs in extension and by the age of 2 he was able to maintain diagonal sitting position, stand on all four limbs and move with poor coordination and jumping. At the age of 3 the subject was able to crawl with better coordination, but with lower limbs in internal rotation and equinovarus of both feet. At the age of 4 he was able to maintain high kneeling position and at the age of 5.5 he finally started walking in a tetraparetic pattern with legs in internal rotation and tiptoe support. Since then, the subject was able to walk with very poor balance just for a few meters with high risk of falling and upper extremities always in abduction. He needed a wheelchair for appropriate mobility for distances longer than 2 meters. The subject was constantly undergoing a complex rehabilitation program with NDT Bobath, Vojta, Halliwick and equine-assisted activities, as the parents own horses at home. At the age of 7.5, the subject underwent Ulzibat fibrotomy on several muscles: *m. pronator teres*, *mm. flexores carpi et digitorum*, *m. quadriceps femoris*, *m. semitendinosus*, *mm. adductores*, *m. gracilis*, *m. soleus*.

Six weeks after the operation the child started an intensive rehabilitation program based on the Therasuit® concept.

First evaluation before Therasuit® treatment:

Functional diagnosis: hypertonus (pronounced on lower limbs), lack of muscle strength postoperatively (Ulzibat fibrotomy), poor balance during walking.

Six weeks after fibrotomy, the subject is able to crawl with internal rotation of lower limbs and feet above the ground. He stands up independently with the right leg in front, which is in adduction and internal rotation. He is unable to do it with the left leg. He is also able to walk several meters (4–5 m) with internal rotation and adduction of both legs, left heel above the ground, and upper limbs in abduction, which is causing him to lose balance and fall. The boy stands up from a stool by swinging the upper limbs and knees together.

Observing the posture in frontal and sagittal plane, while he stands, the following is noted: visible weakness of the trunk, accentuated lumbar lordosis, asymmetrical position of the pelvis, which is inclined (Figure 2).

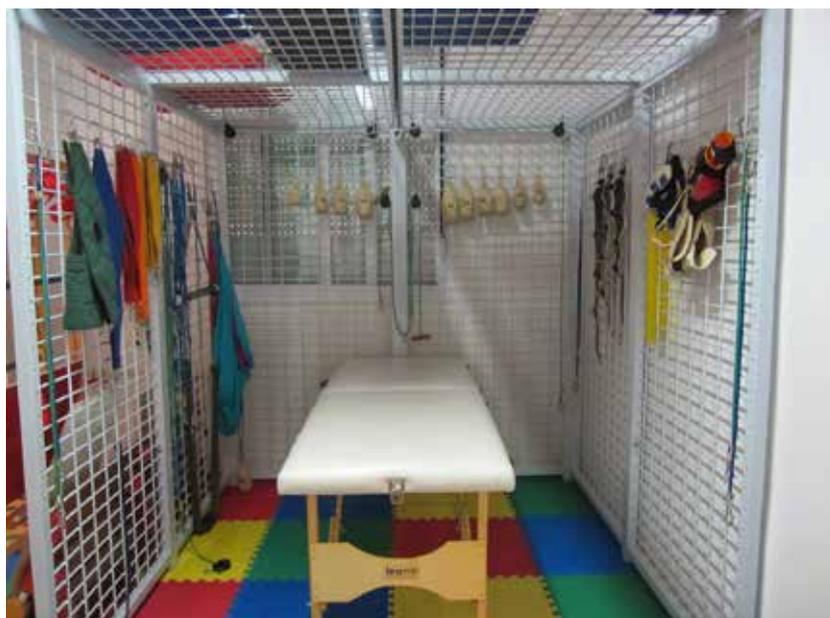


Figure 1. Universal Exercises Unit.

Source: Método TheraSuit em BH: Gaiola. <http://therasuitbh.blogspot.com/p/gaiola.html>. Accessed January 19, 2017.



Figure 2. Posture and walking pattern in the first week.

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Observing the posture from behind, he has visible kyphosis of the thoracic spine with scapulas in abduction and prominent lower corners, which speaks for weakness of *serratus anterior* and *rhomboideus* muscles on both sides.

The evaluation of primitive reflex integration revealed that the Moro, tonic labyrinthine, Galant and asymmetrical tonic neck reflex are not fully integrated.

The subject finished the first grade of regular education in a public school in his hometown with the help of a school assistant. He has complete use of both hands in all activities of everyday life and is able to write at sufficient speed. The left elbow is slightly bent at 20°, which can be corrected passively.

Flexors of left elbow on the Ashworth scale = +1
 Pediatric balance scale (PBS) = 45/56

The goals of the treatment were:

- primitive reflex integration,
- activation and strengthening of core muscles and extremities,
- coordination and balance training, and
- reeducation of walking.

Treatment plan:

The subject was submitted to a Therasuit® treatment for a total of 45 hours (3 weeks, 3 hours a day, 5 days a week), which included:

- a preparation of soft tissue with massage and specific mobilizations for 30 min,
- exercises for primitive reflex integration and core activation for 15 min,
- 60 min of strengthening of trunk muscles, upper and lower extremities using all three types of muscle contraction, but giving advantage to isometric and eccentric work in supine, prone, lateral and quadruped position in the UEU® (the focus was on strengthening of the trunk, abductors and external rotators of the thighs and scapula stabilizers),
- 15 min of correction of posture on a vibrating platform with and without the suit (Figure 3), and
- 45 min of walking reeducation, along with other functional activities wearing the suit (Figure 4).

The schedule of treatment activities is shown in Table 1.

The treatment was carried out in a progressive way by increasing the number of repetitions, resistance to movement and level of motor task or activity.

Results

After three weeks of treatment the patient is able to maintain the upright position with good balance and lower extremities



Figure 3. Correction of posture on a vibrating platform.

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Figure 4. Walking in Therasuit®.

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properly aligned, extension of knees, full loading and full support of the feet with heels on the floor. The pelvis is symmetrical, less inclined and upper extremities relaxed and in proper alignment.

The subject is also able to crawl with feet on the ground and without internal rotation of the thighs. He stands up independently from the ground, stepping forward with left or right leg. The knees are still somewhat in adduction, but when he gets up from a stool or chair, the legs are properly aligned and he is able to walk 300 meters in a correct manner. After walking approximately 300 meters he reports he feels tired.

The process of motor learning of the new walking pattern is not completely automatic and when he tries to walk faster the left leg is still moving in internal rotation, but on a conscious level, when he slows down, he activates his external rotators and obtains better balance which enables him to walk longer. His upper limbs are relaxed, in proper alignment and the elbows are not flexed anymore, which can be seen on photos and video materials.

In the final evaluation the subject scored 54/56 on the PBS, which means that there is less risk of falling, and the muscle tone of the flexors of the left elbow scored 1 on the

	Monday to Friday
9:00–9:30	Soft tissue mobilization
9:30–9:45	Reflex integration and core stability training
9:45–10:45	UEU
10:45–11:00	Pause for antioxidant and alkalizing liquid meal
11:00–11:15	Therasuit® wearing
11:15–11:30	Correction of posture on vibrating platform
11:30–12:15	Walking reeducation and functional activities

Table 1. Schedule of the Therasuit® treatment activities.

Ashworth scale.

The positive results of the treatment are also visible on the level of participation because, when the child went back home, he was able to join the taekwondo sport club with other children and was completely integrated in recreational activities. The mother sent photos of him training taekwondo three months later (Figures 5a and 5b).



Figure 5 (a and b). The boy training taekwondo, completely integrated.
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Discussion

For the past few years strength training has been in the center of discussion as a possible treatment with positive effects on subjects with CP. Several studies reported increased range of movement, strength, better function and decrease in spasticity without signs of abnormal movement patterns as a result of progressive strength training in this population.^{13,14,16,24,25}

The positive effects mentioned above are in agreement with the results obtained in subjects after stroke.^{26,27}

A lot of different strength training programs are being questioned and studied in regard to duration, frequency, type of muscle contraction, exercises in open or closed muscle chain, the use of different equipment and the impact on activity/participation level.²⁸ The results show that these strength training programs and treatments for subjects with CP should be highly individualized to ensure better outcomes on activity/participation level.²⁸

At the same time, different devices, suits and dynamic orthoses that control abnormal muscle tone, stabilize posture and additionally affect the increment of motor function,^{29,30,31} like the Therasuit[®], are being discussed.

With the intent to give detailed and exact evidence, Bailes, Greve, Burch et al.³² analyzed the effects of the Therasuit[®], but did not find statistically important difference in the improvement of the motor function between an intensive physiotherapy treatment with the suit and an intensive treatment without the suit. However, they stated that the study lacked one more control group that was not submitted to any or at least to a classic treatment. They think that in future studies researchers should focus on additional evaluation procedures of postural changes in children with CP with different functional abilities and that even case studies could reveal some changes not noticed in their study. The results obtained in this case study of a 7.5-year-old boy mirror the effects of similar studies. The decrease in spasticity and increase in range of motion can be attributed to the combination of the fibrotomy procedure that was followed by the intensive and progressive Therasuit[®] treatment. The decrease in spasticity of the left elbow flexors, the changes in PBS and Ashworth scoring can be attributed to the Therasuit[®] treatment only, as it is a highly individualized treatment concept combining different methods based on neurophysiology and neurodevelopmental science with significant impact on function and participation. The photos and video materials from the later integration of the child in average sport activities give strong evidence of long-term

results and progress in participation in everyday life.

The restrictions of this case study are the lack of more detailed measurements (e.g., muscle strength measured with a dynamometer, a measured range of movement) and a need for a greater number of additional functional activity tests to be included.

Conclusion

In neurophysiotherapy, through five decades, the dominant clinical treatment methods have been Bobath, Vojta and PNF. Strength training was being questioned for a long time because it was believed that the effort needed for strength training could increase spasticity, co-contractions, associated reactions and abnormal movement patterns. However, new studies conducted in the domains of motor control and learning, human biomechanics and training theory, revealed that there is no evidence to support such claims. These studies, on the contrary, brought proof of major positive effects on the development of strength, new motor functional skills, better motor control and regulation of muscle tone.

The Therasuit[®] concept combines neurophysiotherapy techniques and methods known from earlier times and upgrades them using new clinical evidence of effectiveness of recently developed treatment programs. It is important to emphasize that physiotherapists should always be open-minded in their clinical work, always try to combine their knowledge without prejudice and include all evidence-based techniques. For example, it could be of a great benefit to patients to combine a virtual technology, such as Nintendo Wii, with the Therasuit[®] program because it could motivate children even more.

The Therasuit[®] concept is a highly individualized treatment program, which includes a comprehensive, task oriented method of strengthening body structures and functions through a distinct period of time (3–4 hours a day, at least for 21 days) to enable motor learning and to cover multiple elements of a therapeutic session needed for the acquisition of new skills and their application in everyday life.

For future studies, it would be interesting to compare the effects of different neurophysiotherapy treatment programs, e.g., 1) a classic treatment carried out for a longer period of time (6 to 12 months, 3 times a week with 1 hour session a day), 2) a more frequent classic treatment carried out in a shorter period (3 months, 5 days a week for 1 hour session a day) and 3) the Therasuit[®] treatment program (4 weeks, 5 days a week, 3 to 4 hour session a day).

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NOVI PRISTUPI U REHABILITACIJI DJECE S CEREBRALNOM PARALIZOM

Sažetak

Cerebralna paraliza predstavlja veliko opterećenje za oboljele, njihovu obitelj, zdravstveni sustav, odgojno-obrazovne ustanove i društvo u cjelini. Posljednjih godina raspravlja se o drugačijim pristupima u rehabilitaciji, koji bi imali veće učinke na razini aktivnosti, participacije i funkcionalnih sposobnosti u svakodnevnom životu. U radu su prikazani rezultati Therasuit® intervencije na djetetu od 7,5 godina sa spastičnim oblikom cerebralne paralize mjesec dana nakon višestrukih fibrotomija po Ulzibatu. Therasuit® koncept spada u novije rehabilitacijske pristupe koji počivaju na teoriji motoričkog učenja i kontrole, individualnog progresivnog jačanja mišićne mase, integraciji primitivnih refleksa i kombinaciji ostalih neurofizioloških tehnika.

Ključne riječi: cerebralna paraliza, integracija primitivnih refleksa, Therasuit®, trening snage

*Personal information is known to the Editorial Board. Parental informed consent for publication of the clinical details and clinical images was obtained in written form from the patient's mother prior to publishing.

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FIND OUT MORE:

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