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Combined Vojta and Bobath concepts therapy effect and physical exercises on foot balance and motor control in children with infantile cerebral palsy

Efecto de la terapia combinada de los conceptos de Vojta y Bobath y de ejercicios físicos sobre el equilibrio del pie y el control motor en niños con parálisis cerebral infantil

*Peter Bartík, **Andreea Popescu, ** Camelia-Daniela Plăstoi, **Bogdan Niculescu, *Peter Šagát, *Pablo Prieto González, *Ibrahim AL Jasser, ***Dragoș Ioan Tohănean, ***Ioan Turcu, ****Eliška Kubíková

*Prince Sultan University (Saudi Arabia), **Constantin Brancuși University of Târgu-Jiu (Romania), ***Transilvania University of Brașov (Romania), ****Comenius University (Slovakia)

Abstract. Background: Ensuring independent locomotion is one of the primary goals of therapeutic intervention in children with infantile cerebral palsy (ICP). This study aimed to evaluate the foot and balance developmental changes in children with ICP after independent walking began utilizing Bobath, Vojta, and combined concepts for therapy. Methodology: 12 children (5 girls, 7 boys) aged 2-5 years diagnosed with ICP were distributed into three groups. Group I – 4 subjects treated with Vojta therapy, Group II – 4 subjects treated with Bobath therapy, and Group III – 4 subjects treated with a combined therapy. The assessment of the subjects included the Berg scale, the Gross Motor Function Classification System (GMFCS), and a Stabilometry footboard PoData 2.00. Results: Group I reported an improvement in balance, and Group II reported an improvement in muscle tone. Group III reported a significant improvement in coordination and balance through rebalancing the plantar weight distribution on each leg. Conclusions: This study highlights and recommends combining Bobath and Vojta's approaches for advanced impact on foot balance and motor control in children with infantile cerebral palsy.

Keywords: Infantile cerebral palsy; Combined therapy; Vojta concept; Bobath concept, Children; Physiotherapy

Resumen. Antecedentes: Garantizar la locomoción independiente es uno de los principales objetivos de la intervención terapéutica en niños con parálisis cerebral infantil (PCI). El objetivo del presente estudio fue evaluar los cambios en el desarrollo del pie y el equilibrio en niños con PCI después del inicio de la marcha independiente utilizando los conceptos de Bobath, Vojta y una terapia combinada. Metodología: Doce niños (5 niñas, 7 niños) de 2 a 5 años diagnosticados con PCI fueron distribuidos en tres grupos. Grupo I: 4 sujetos tratados con terapia Vojta, Grupo II: 4 sujetos tratados con terapia Bobath, y Grupo III: 4 sujetos tratados con una terapia combinada. La evaluación de los sujetos incluyó la escala de Berg, el Sistema de Clasificación de la Función Motora Bruta (GMFCS) y una plataforma de estabilometría PoData 2.00. Resultados: El Grupo I mostró una mejora en el equilibrio, y el Grupo II mostró una mejora en el tono muscular. El Grupo III mostró una mejora significativa en la coordinación y el equilibrio mediante la redistribución del peso plantar en cada pierna. Conclusiones: Este estudio destaca y recomienda la combinación de los enfoques de Bobath y Vojta para lograr un impacto avanzado en el equilibrio del pie y el control motor en niños con parálisis cerebral infantil.

Palabras clave: Parálisis cerebral infantil; Terapia combinada; Concepto Vojta; Concepto Bobath; Niños; Fisioterapia

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Dragoș Ioan Tohănean
dragos.tohanean@unitbv.ro

Introduction

Motor control, postural control, abnormal balance, and muscle tone may cause impairment of motor function in children with cerebral palsy [1], causing musculoskeletal disorders such as drooping plantar arch, hip dislocation, contractures, and scoliosis [2]. Low muscle strength and endurance, fatigue from prolonged effort, and high energy expenditure to perform an activity are felt by most individuals [3,4], but in an extraordinary way in children with infantile cerebral palsy (ICP). Fatigue causes pain, functional disorders, and limited quality of life in cerebral palsy [5]. These elements require a unique therapeutic approach [6]. In order to control the muscular system in the orthostatic position, it is necessary for the body alignment to push the center of gravity against gravity, the muscle tone to be activated to prevent the body from opposing gravity, and the postural tone to act antigravity [7]. Balance and postural control in orthostatism are the fundamental components of movement, involving the ability to anticipate and balance [8, 9, 10]. A good balance can help daily activities [11,12]. Preterm infants show more patterns of movement/change in the center of pressure in the prone position compared to full-term infants [12]. The stability of the trunk is essential for the functioning of the limbs, which is directly related to the body parts and the nervous system [13,14]. When the trunk is stable, the upper and lower limbs have standard functionality, essential for maintaining body balance [15]. Ensuring independent locomotion is one of the primary goals of therapeutic intervention in children with ICP. Children with unilateral ICP almost always develop independent locomotion; some children with bilateral ICP walk independently, some walk with assistance, and some cannot achieve this function during their lifetime. Numerous problems, such as equinus, squat gait, skipped gait, and scissor gait, are seen in children with ICP who walk independently. The gait assessment can be used to identify the gait pattern and cause-effect relationship and establish the treatment plan [16]. Children with ICP exhibit squatting posture, contributing to decreased ability to recover balance (more time

/increased balance), delayed responses in the ankle muscles, inadequate sequencing of muscle response, and increased activation of agonists/antagonists. Changes in muscle response that help improve balance recovery and postural control include reduced contraction at the start of the step, improved organization of muscle response, and reduced co-contraction agonists/antagonists. With all these observations, the clinical implications demonstrate that improving the ability to recover balance is possible in children with ICP [17]. Understanding the gait cycle and its different phases is necessary to ensure a positive outcome of kinetic therapy applied to subjects with neuromotor disorders [18]. Although these balance problems are well documented, therapies that effectively overcome these gait balance disorders must be delineated in literature or practice.

The development of the child's foot with ICP is strongly influenced by the point at which the child starts standing and the start of walking. The growth rate of the foot reaches a maximum in the first months of life. Fifty percent of the final leg length is already reached by 12-18 months of age. The growth rate decreases rapidly by the age of 5 years. Between the ages of 5 and 12, girls' feet grow an average of 0.9 cm per year. In boys, this period lasts until the age of 14 [19]. Malalignment of the foot and ankle segments can disrupt function in the gait cycle's stance and swing phases. In all models of segmental misalignment, a heel strike at initial contact does not occur, disrupting the first swing [20]. Currently, essential phases in foot development and their age-related appearance remain unclear. The children's gait pattern is constantly changing. The analysis of kinematic movement in the sagittal plane demonstrated that the initial heel hitting with the foot tipping evolves around 18 months. Children react. The therapist must find the tolerance limit of each child in his handling in order to use the correct reflex-inhibitory models because these models must not be related to static postures but to phases of normal and correct movements. Their application is not done passively - the child must react through stimulation and adapt through active responses [21]. The two principles of neuro-motor development treatment result from the state of the body's musculature, which controls the opening and closing of synaptic connections. The state of the body's muscles is reflected by the excitatory and inhibitory processes at the level of the CNS that occur during a postural change [22]. Normal quality of muscle tone is necessary for the movement to be effective [23]. One of the most popular therapeutic approaches used in the management of ICP is Bobath therapy (Neurodevelopmental Therapy), developed in the 1940s by Berta and Karl Bobath, based on their observations working with children with ICP. This approach's core is that the motor abnormalities observed in children with ICP are due to atypical development of postural control and reflexes due to primary central nervous system dysfunction. This approach aims to facilitate typical motor development and function and prevent the development of secondary disorders due to muscle contractures and joint and limb deformities. According to Bobath, the main objective of therapeutic management is to facilitate controlled motor activity and inhibit symptoms such as spasticity and reactions associated with mass movement [23].

ICP is a group of non-progressive neurological disorders due to causes that appear pre-, intra-, or postnatally in the first 3-5 years of life, cases that act on the system central nervous system, leading to inadequate control of mobility and posture [24]. Specific exercises to increase muscle strength could help improve the walking function of patients with ICP [25]. However, currently, there is no clear evidence to support the superiority of any specific method utilized for ICP improvement [26].

The second main therapeutic approach for ICP is Vojta therapy. The Vojta principle is based on so-called reflex locomotion. Professor Vojta concluded that, in the case of infantile spasticity, functional blockages could exist in the perimeter of movement development. Vojta therapy is based on the fact that ideal postural ontogenesis is genetically determined and undergoes systematic transformations in the first year of life. If verticalization is primarily disturbed, locomotion is also disturbed. Vojta therapy aims to program the ideal movement patterns for the age of the newborn and the infant with impaired central nervous system to the greatest extent possible [27]. Vojta therapy proved to be an effective element to improve the spatiotemporal gait parameters of children with spastic diplegia [28].

Based on the effectiveness of both Bobat and Vojta therapy principles and the fact that there is no clear evidence about the superiority of either of these two main concepts, this study aimed to evaluate the developmental changes of the foot and balance in children with ICP after independent walking began utilizing both of these concepts for therapy

Materials and Methods

The experiment was performed in the KinetoStep physiotherapy clinic, Romania. In 2023, we began evaluating foot loading characteristics in children with ICP using plantar pressure measurements using the PoData platform. The study included 12 subjects, followed for 1 year, 5 girls and 7 boys, with an age of 2-5 years, distributed into three groups. Group I – consisting of 4 subjects treated with Vojta therapy, Group II – 4 subjects treated with Bobath therapy, and Group III – 4 subjects treated with a combined program of both, Vojta and Bobath therapy concepts. Subjects assessment included the functional balance assessment Berg scale, the scale Gross Motor Function Classification System (GMFCS) for assessing functional level, and a biomechanical assessment performed with the Stabilometry footboard PoData 2.00 bipodal platform with built-in podoscope that can be connected directly to a computer via USB ports. The device is represented by six load cells that can be positioned to detect the distribution of body weight at the points corresponding to the first metatarsal, the 5th metatarsal and the heel of each foot. It is also used to measure the average position of the body's center of gravity and its small movement around this position. This equipment works on the principle of gathering information from the

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plantar level, and the data provided comes from stimulating the sensors of the platform. This platform has helped us analyze parameters such as left-right load distribution, which we believe is relevant for assessing the balance development according to the regional load at the plantar level. Subjects were evaluated twice by the platform — evaluation 1 (EV1) and evaluation 2 (EV2), 12 months apart. The criteria for including the subjects in the study were: subjects with the diagnosis of ICP, aged 2-5 years, the motor deficit in one or both lower limbs, to walk independently, not to have mental retardation, to understand the commands and to execute them.

The objectives and purpose of the study were to analyze development of the three groups of children, in terms of their response to the three recovery programs, by objectifying them using the functional evaluation scales and biomechanical evaluation, following the distribution of the left-right weight load. The objectives of the recovery program were to reduce spasticity, improve joint mobility, reeducation of gait and balance, sensory and proprioception reeducation. The recuperative program took into account the principles of graduated training, which corresponds to the child's effort capacity and functional state and actively involved the child. Depending on the results of the children's assessments, they underwent a rehabilitation program that included exercises aimed at increasing exercise capacity and exercise tolerance and maintaining and improving overall mobility and flexibility.

The therapeutic program applied for 12 months was as follows: Group 1 included 4 subjects with the diagnoses: spastic hemiparesis (2 subjects – V1, V2) and tetraparesis (2 subjects – V3, V4) – where Vojta therapy was applied, by activation from 3 positions (supine, lateral decubitus, and ventral decubitus) for 50 minutes every day, to stimulate the motor reflex of locomotion patterns (figure 1).

Figure 1. Reflex dragging

Group 2 included 4 subjects with the diagnosis: spastic hemiparesis (2 subjects – B1, B2) and spatic tetraparesis (2 subjects – B3, B4) – the treatment plan consisted of exercises to improve joint mobility in the leg (for flexion/extension, inversion/reversion movements), increased muscle strength in the muscle mass of the thigh, calf and leg, and improved proprioception (figure 2). The exercises included aids such as a chair, ladder, and treadmill. Therapy was performed every day for 50 minutes.

Figure 2. Balancing Board

Figure 3. Reflex rollover

Group 3 included 4 subjects with the diagnoses: spastic hemiparesis (2 subjects – A1, A2) and spastic tetraparesis (2 subjects A3, A4). The treatment plan consisted of exercises to improve leg mobility (for flexion/extension, inversion/reversion movements), increase muscle strength, and improve proprioception (figure 2). The positioning of the patient is the element from which the therapeutic exercise is initiated. In the recovery plan proposed in this study, in the case of the Bobath exercises, most of them start in the supine position (DD), lateral position (DL), prone position (DV), on all fours, on the knees, sitting on the edge of the bed or sitting on the chair, the position knight servant (support on one knee, with the other limb flexed in front and support on the plant), and orthostatism. The exercises included aids such as chair, ladder, treadmill. Therapy was performed every day for 30 minutes. From the point of view of Bobath therapy, the exercises were identical/similar to those of patient group number 2. After completing the Bobath exercise program, activation from Vojta therapy was continued for 20 minutes. It was activated from 3 positions, dorsal, lateral and ventral – the same activation positions as at group I. (figure 3).

Statistical analysis

We collected and analyzed the data utilizing Microsoft Excel 2016, which provided a comprehensive platform for organizing and processing the information. Excel's data analysis tools enabled us to calculate, sort, and visually interpret the data efficiently. The results were then presented in the form of diagrams, allowing for a clear and concise visual representation of the findings. This approach ensured that the data was accessible and easy to interpret, supporting our analysis and aiding in communicating the results.

Results

The analysis of the data collected before and after the application of the rehabilitation program, on the evaluation of the balance using the Berg scale for pediatrics, indicates an improvement in the score. The results of the all groups are reported in Figure 4, Figure 5, Figure 6.

Analysis of data collected before and after the program application, on the evaluation of balance using the GMFCS scale for pediatrics, indicates an improvement in the score. The results of all three groups are reported in Figures 7,8,9.

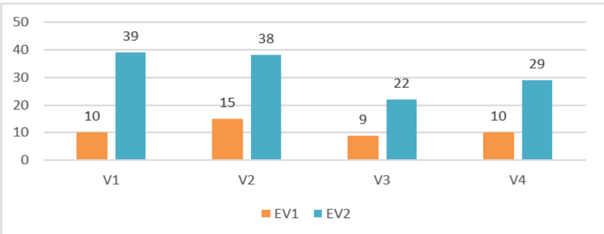

Figure 4. Development of the Berg Scale score for Group I

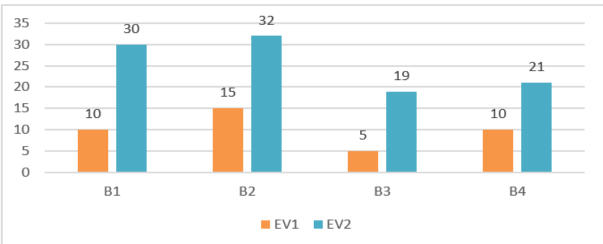

Figure 5. Development of the Berg Scale score for Group II

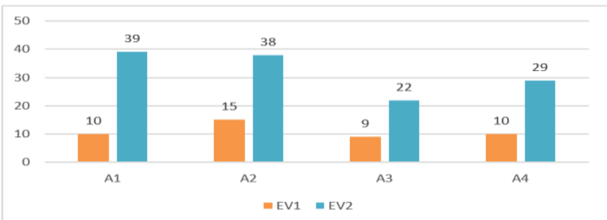

Figure 6. Development of the Berg Scale score for Group III

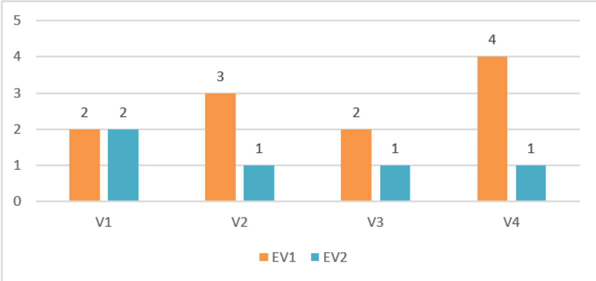

Figure 7. Development of the GMFCS Scale score for Group I

Figure 8. Development of the GMFCS Scale score for Group II

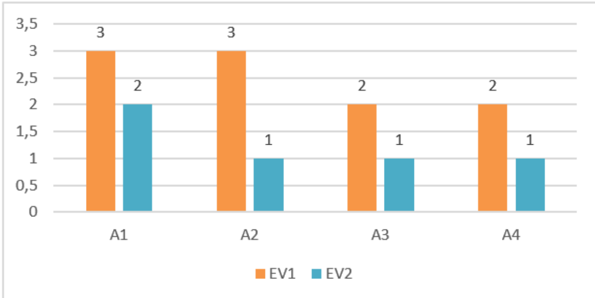

Figure 9. Development of the GMFCS Scale score for Group III

The results reported the evolution of the data indicating the distribution of body weight at the level of the two lower limbs, at the two times of EV1 and EV2 assessment in terms of percentage. In order to assess as objectively as possible the development from restoring the balance and implicitly the efficiency of the point of view of the combined therapy, we consider it necessary to focus our attention on how patients manage to balance left and right lower extremity. Figures 10,11,12,13,14,15 report the body weight distributions (expressed in %) on each leg at the two assessment times (EV1 and EV2).

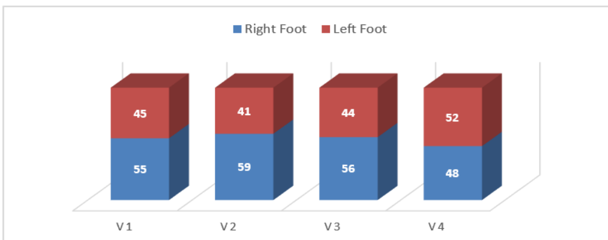

Figure 10. Percentual distribution of the weight of Group I at evaluation 1

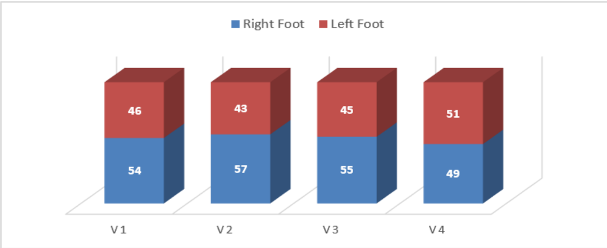

Figure 11. Percentual distribution of the weight of Group I at evaluation 2

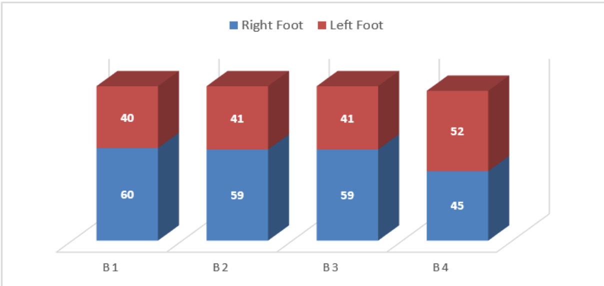

Figure 12. Percentual distribution of the weight of Group II at evaluation 1

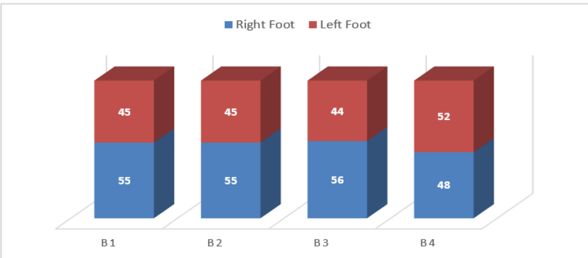

Figure 13. Percentual distribution of the weight of Group II at evaluation 2

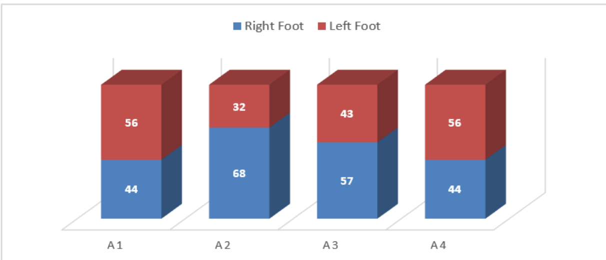

Figure 14. Percentual distribution of the weight of Group III at evaluation 1

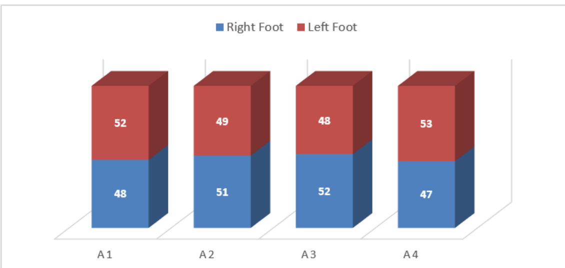

Figure 15. Percentual distribution of the weight of Group III at evaluation 2

The development from a functional clinical point of view indicates an improvement in the balance assessed by the Berg scale, more pronounced in patients V2, A1, A2, A3. From the point of view of the GMFCS scale, a significant favorable development can be observed, with most subjects reaching GMFCS level I. The results of the pressure distribution measurements show significant changes in the foot load characteristics in the first year of walking. These changes are increased contact area, maximum soil reaction force, tip pressure and total foot momentum. Improvement is indicated by decreasing or increasing the weight distribution so that a rebalancing attempt can be observed, especially in patients V4, A1, A2, A3.

Discussion

This study observed plantar loading, balance, and gait improvement in subjects who followed the Vojta and Bobath combined therapy program applied for 12 months, comparing the results before and after treatment. The biomechanical complexities of the human foot, especially in the context of growth and development, have long captivated researchers from various disciplines. Understanding the developmental patterns of plantar pressure distribution and foot morphology in children is crucial for elucidating the mechanisms underlying locomotion and informing clinical interventions to optimize foot health. In this study, we present an in-depth analysis of plantar pressure patterns and foot morphology for a group of 12 children in close relation to the nuanced changes associated with growth and development. The results of our investigation reveal important changes in plantar pressure patterns among study participants. Specifically, increases in foot contact area, peak force, and momentum were observed, reflecting the dynamic changes in foot structure during growth. These findings align with theoretical expectations, highlighting the influence of growth-related factors on the distribution of forces on the plantar surface [29]. The observed increases in foot contact area suggest widening the bearing surface, highlighting the potential of expanding structures, redistributing, and supporting load-bearing capacity as the foot matures [30,31]. Similarly, significant changes in foot loading parameters were detected globally, indicating a redistribution of pressure distribution dynamics during the developmental trajectory. Such changes may arise from adaptations in musculoskeletal alignment, neuromuscular control, and tissue composition as the foot matures. These findings emphasize the complex interaction between biomechanical adaptations and growth processes, highlighting the need for large-scale evaluations to identify the diverse nature of foot development.

Furthermore, the present study elucidates notable improvements in plantar loading, balance, and gait among participants who adhered to a comprehensive therapeutic regimen integrating the Vojta and Bobath methodologies. By meticulously examining pre- and post-treatment results over 12 months, perceptible improvements in biomechanical function were observed. Specifically, individuals undergoing the combined therapeutic intervention showed pronounced improvements in plantar loading dynamics, indicating optimized weight distribution and improved proprioceptive

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feedback in the foot structure. Thus, postural stability and gait mechanics improvements were evident, reflecting the synergistic effects of the Vojta and Bobath principles on neuromuscular coordination and motor control.

The findings underscore the effectiveness of the integrated therapeutic approach in promoting holistic improvements in locomotor function and functional mobility. By leveraging the complementary principles of the Vojta and Bobath techniques, the therapeutic regimen facilitated comprehensive improvements in multiple areas of biomechanical performance. These findings have significant implications for clinical practice, highlighting the potential of integrative therapeutic strategies in optimizing rehabilitation outcomes for individuals with neuromuscular impairments or gait disorders. Furthermore, the longitudinal nature of the study design provides valuable insights into the sustained benefits of the combined therapeutic intervention over an extended duration, informing evidence-based interventions for long-term management and rehabilitation.

In addition to plantar pressure patterns, our analysis revealed significant changes in foot morphology among the study cohort. Specifically, variations in foot shape index—an indicator of longitudinal arch morphology—were observed, suggesting structural changes in response to growth-related influences. These morphological changes may reflect adaptations to optimize foot function and stability, thus adapting to the increased demands imposed by growth spurts and physical activity [32]. At the same time, the normalized loading parameters presented relevant score oscillations, indicating a dynamic interaction between foot morphology and plantar pressure distribution. The observed relationships between foot shape index and loading parameters highlight the complicated relationship between foot structure and function, emphasizing the need for integrated assessments to capture the global nature of the leg.

Park et al. point out that ankle movements help connect trunk muscles for postural control and are, therefore, very important. The movements of the ankle allow the control of the tone of the lower limbs and the improvement of voluntary movements. Therefore, it proposes a specific kinetic program to mobilize the ankles during therapy as necessary elements. This study evaluated leg loading before and after applying the kinetic program, finding increased body stability in the orthostatic position [33]. An essential aspect of physical therapy intervention is the neuroplasticity of the brain. Activating plasticity resides in the motor cortex. This characteristic has led to research in functional recovery and rehabilitation therapies that aim to capitalize on neuroplasticity. Moreover, Sakzewski states that intensive rehabilitation improves motor function in children with PCI by incorporating motor learning theories. Repetitive, goal-directed movements associated with sensory feedback and an attractive environment are likely to promote reorganization of neural pathways and motor development after brain injury [34]. The practices of physiotherapists working with young children with PCI were described in 2 case studies at 2 ages (18 months and 4 years) through an interview structured telephone with physiotherapists. Although a panel of experts identified task-specific training and functional exercise as the best practice intervention for all case scenarios, this intervention was reported by only 20% of physical therapists or less. The authors concluded that there are gaps in incorporating evidence-based best practices into clinical practice [35]. A similar conclusion was reached in a study of occupational therapy practice and physical therapists who responded to 2 standardized scenarios, the aim of the study being to explore therapists' goal setting and intervention in children with PCI and to examine their acceptance of children's use of compensatory movement strategies [36]. Lim proposed a study to investigate the effects of Vojta therapy on spatiotemporal gait parameters in children with spastic diplegia. The group consisted of 3 children diagnosed with spastic diplegia. Subjects were treated with Vojta therapy for 8 weeks. Motion analysis using the Vicon system was used to determine the spatiotemporal parameters of gait. Positive results were noted in the changes in each articular angle plane after the Vojta therapy. The findings of the study indicate that Vojta therapy can play an important role in creating spatiotemporal gait parameters in children with spastic diplegia [28].

The results of this study have significant implications for clinical practice and future research efforts aimed at promoting optimal foot health in children. Our findings provide valuable insight into the mechanisms underlying developmental changes in foot biomechanics by elucidating the dynamic interplay between plantar pressure patterns and foot morphology during growth. Such insights can inform the design of targeted interventions to mitigate musculoskeletal injury risk and promote healthy foot development in pediatric populations.

Furthermore, our findings underscore the importance of longitudinal studies to track the trajectory of foot development over time and elucidate the long-term implications of growth-related changes on foot health. Using advanced imaging techniques, longitudinal monitoring protocols, and multidisciplinary collaborations, future research efforts can further unravel the complexities of foot development and inform evidence-based interventions to optimize pediatric foot health. In the future, further studies utilizing specific physiotherapeutic methods could include investigating the longitudinal effects on plantar pressure patterns foot morphology beyond childhood [37], exploring the influence of factors such as footwear and physical activity on these parameters [38], and assessing the impact of specific pathologies or conditions on foot biomechanics in pediatric populations [39]. In addition, examining the potential interaction between genetic predispositions and environmental factors in shaping foot development could provide valuable information.

Conclusions

After 12 months of treatment, the following can be observed: Group I of Vojta therapy reports an improvement in balance, and Group II of Bobath therapy reports an improvement in muscle tone. Group III, representing the combined approach, reports a significant improvement in coordination and balance through rebalancing the plantar weight distribution on each leg. The results indicate that applying the Bobath and Vojta combined therapy program improved balance, coordination, and proprioception. This study highlights and recommends the combined application of Bobath and Vojta's approaches for advanced therapeutic impact in children diagnosed with cerebral palsy.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Commission Faculty of Medical and Behavioral Sciences, University "Constantin Brâncuși" of Târgu –Jiu with the registration number 484-23-04-2024.

Informed Consent Statement

Informed consent was obtained from all subject's parents involved in the study.

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Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Datos de los/as autores/as y traductor/a:

Peter Bartik	pbartik@psu.edu.sa	Autor/a
Andreea Popescu	andreeaungureanu91@yahoo.com	Autor/a
Camelia-Daniela Plăstoi	cami_plastoi@yahoo.com	Autor/a
Bogdan Niculescu	bogdanniculescu78@yahoo.com	Autor/a
Peter Šagát	sagat@psu.edu.sa	Autor/a-Traductor/a
Pablo Prieto González	pprieto@psu.edu.sa	Autor/a
Ibrahim AL Jasser	ialjasser@psu.edu.sa	Autor/a
Dragoș Ioan Tohănean	dragos.tohanean@unitbv.ro	Autor/a
Ioan Turcu	ioan.turcu@unitbv.ro	Autor/a
Eliška Kubíková	eliska.kubikova@fmed.uniba.sk	Autor/a