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SAFE EDUCATION STRATEGIES IN BALANCE IMPROVEMENT FOR CHILDREN WITH CEREBRAL PALSY

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Abstract

To quantify the effects of physiotherapy using Build N'Balance® proprioceptive stimulation materials on the balance, gait and coordination of three children with cerebral palsy (CP) and to examine how the level of balance development influences their coordination and ability. The subjects of this study were three 9-year-old boys with gait and balance impairments due to spastic cerebral palsy (CP). According to the Gross Motor Function Classification System (GMFM) the children were differentiated by severe motor dysfunction related to CP, extension deficit at the knees, high base of support, and kyphotic posture with anteriorly projected center of gravity. Dynamic balance control and speed of movement were assessed before and after the application of the physiotherapy program using the adapted 10MWTest- Build N'Balance® proprioception stimulation balance test. Mini-BESTest - Balance Evaluation Systems Test was used to assess functional balance, pre and post intervention. Each subject achieved an average on the final 10MWTest (time, errors, accuracy of execution) equal to or lower than baseline, with improvements observed in movement accuracy and coordination. According to the Mini-BESTest improvements were observed in spatial orientation, static balance and dynamic balance. Proprioceptive sensory stimulation increases the safety level of children with CP. There are different results depending on the motor disability. Our goal was how to reflect and develop safe education strategies for special children needs to increase their motivation to be involved and take part in motor activities.

Keywords: Cerebral palsy, education strategies, physiotherapy, special needs

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1. Introduction

The most significant limiting factor to participation in physical activities for children with cerebral palsy (CP) is the gross motor dysfunction (Carlon et al., 2013; Keawutan et al., 2017). Identifying optimal gross motor interventions that promote physical activity for children with CP is critical to overcome poor physical activity volumes (Zwier et al., 2010) and participation rates (Michelsen et al., 2014) for this population. Efficient lifelong participation in physical activities requires that each child master four components of Physical Literacy (Liu & Chen, 2021) including gross motor activity competence (or ability), knowledge and understanding of physical activities, frequent opportunities for various participation and, confidence and motivation (Whitehead, 2001).

CP is a complex and heterogeneous group of conditions with different underlying aetiologies as well as types and severity of disorders, (Baxter et al., 2007). Children with CP may have persistent and debilitating impairments that affect their physical, cognitive and psycho-emotional functioning.

2. Problem Statement

Children with special educational needs who need physiotherapy applied in special schools must be approached differently from those with normally developed motor skills and abilities.

Any rehabilitation exercise method or protocol must be adapted to their needs. Pupils' motivation to participate in physiotherapy 'sessions' plays a key role. Therefore the methods of teaching, learning and applying physical exercises for therapeutic purposes must be chosen for each individual child and adapted to their needs in order to achieve optimal results in the development and promotion of skills versus disabilities.

Parents and clinicians consider motivation to be the most influential personal characteristic determining motor and functional outcomes in children with CP (Bartlett & Palisano, 2002; Rosenbaum et a;., 2002). Evidence from the neuroplasticity literature has identified motivation as a critical modulator of functional plasticity. Neuronal reorganization occurs at the molecular and behavioural level and responds to factors such as development, environment, disease and therapy (Cramer et al., 2011). Theoretically, clinicians can shape the sensorimotor environment using motivation to enhance reorganization and optimize rehabilitation outcomes through increased engagement (Danzl, 2012). In contrast, lack of motivation may limit children from reaching their functional potential (Van den Broek, 2005).

”Primum non nocere"- a Latin phrase that means "first, do no harm" determines the need to develop safe principles and methods of education in the application of physiotherapy to children with special educational needs. The specificity of physical activity for therapeutic purposes can be achieved for a small group/class by adapting the means and materials of work in relation to the objectives pursued and to the particularities of the pupils' physical development.

The existence of the evidence-based intervention approaches is the key issue to developing effective exercise programs for people with CP. So far, these only exist for typically developing children, adolescents and adults. Equally important is a thorough understanding of the unique physical attributes and limitations of individuals with CP. In order to develop universally accepted exercise prescription

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guidelines for children and adults with CP, physiotherapists relies on a basic and well-accepted framework of prescription nomenclature to operationalize exercise variables in this population, including frequency, intensity, time, and type (Garber et al., 2011).

3. Research Question

How can we apply physiotherapy in a more attractive and creative way for CP children?

The more attractive the format of the physiotherapy classes, the greater the interest in engaging in physical activity for any child. In physical, mental, emotional and social- behavioural development, playing games plays an important role as it stimulates creativity, adaptability to new situations and challenges.

'Play is the work of children' according to Jean Piaget (Ahmad et al., 2016).

Steiner Waldorf education, particularly in the Early Years settings, has an emphasis on the importance of play and what this activity gives to the children with regard to their development (Metcalfe, 2014).

Games, in general, and motor games, in a particular way, are important learning tools for children. In the sensory-motor period and the pre-operational period, described by Piaget, concrete actions with objects are the main sources of learning (Wauters-Krings, 2014a). Moreover, motor activity is the child's favourite mode of expression. Motor games promote motivation and involvement. In games, the expected pleasure encourages children to become totally, globally and intensely involved. Motor games encourage attention and concentration. Interest in games and concrete activity requires concentration on the learning objective. Motor games encourage information acquisition. They encourage multi-sensory exploration. Motor games encourage cognitive conflict. During the process of games, the lack of justification and evaluation allows the child to use trial-and-error problem-solving strategies without fear. They allow him to check, transform, compare intuitive perceptions to arrive at an increasingly more objective and unfocused perception.

Motor games foster socio-cognitive conflict. In their games, children usually are using their playing abilities, that's why they dialogue, exchange, imitate and confront their points of view in order to respond to the challenge. Motor games stimulate memory. The pleasure experienced in a situation encourages learning. In long-term memory, episodic memory complements semantic memory, which organises elements in the form of a conceptual map, folders and bringing information in the form of images, as in a movie. Symbolic games develop the imagination; they give the opportunity to live in playful situations experiences that are impossible to live in reality. They develop the ability to put oneself in other people's position, to coordinate one's ideas to create a story, to be willing to compromise. They have a psychological re-balancing function, allowing internal tensions to be transposed into play. Spontaneous games, directed games, challenged games allow experimentation and problem-solving. Spontaneous games, if planned, require concentration, imagination and more complex cognitive processes than simple spontaneous games (Wauters-Krings, 2014b).

The differentiated application of methods of approaching, involving and keeping the child in the task, to achieve their therapeutic goals, underlines the creative character of physiotherapy.

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4. Purposes of the Study

In this research, using an experimental method, we are aiming to apply safe and pleasant educational strategies of conducting physiotherapy and physical education classes. Appling this educational methods to primary school students in the 3rd grade in a special school in Romania, we intend to encourage the children to participate with interest, to increase their motivation to practice functional exercises, to keep children as long as possible motor active in the physical activities classes.

Second purpose was to develop new teaching methods accessible to physical education teachers and physiotherapists working with children with cerebral palsy or special educational needs.

In this research we have used innovative educational strategies to implement motor rehabilitation programs for students with CP through motor games.

Using this safe education method we aim quantify the effects of physiotherapy using Build N'Balance® proprioceptive stimulation materials on the balance, gait and coordination of three children with cerebral palsy (CP) and whether there are different outcomes depending on the motor disability, using a playful approach in the physiotherapy program.

5. Research Method

5.1. Participants

The subjects of this study were three 9-year-old boys with gait and balance disabilities due to spastic cerebral palsy (CP). According to the Gross Motor Function Classification System (GMFM) the children were differentiated by severe motor dysfunction secondary to CP as follows: one with spastic dyplegia (GMFM I) The picture of spastic diplegia, a form of CP is characterized by hypertonia and spasticity present in varying degrees in the legs. The thighs are strongly adducted, the legs flexed slightly and spread apart, the foot in varus equinus (constant raising of the heels). Gait, when possible, is characteristic (Holmes & Shaywitz, 1977). The person walks on tiptoes; knees dragging against each other with bilateral helicopodic movement and short steps (scissor walk, scissor walk). When the upper limbs are not affected by paralysis, athetotic or choreic movements or even just a slight incoordination of movements may be seen in them. Motor symptoms are always associated with a more or less marked intellectual disability which, in severe cases, may even lead to severe intellectual disability; epileptic seizures; speech disorders, etc. Strabismus and nystagmus are frequently observed. This syndrome, representing the result of an illness suffered, is stationary and unchanging (Dones et al., 2006; Segen, 2006).

The second subject is diagnosed with spastic hemiplegia (GMFM II) Hemiplegia is a motor deficit that affects one part of the body. The cause is damage to the brain contralateral to the deficit. Usually, the first motor neuron that carries motor input to the spinal cord is injured. The deficit takes on different recovery characteristics depending on when it occurs. (Emos & Agarwal, 2022).Secondary signs that characterize hemiplegia are: strength deficit with problems recruiting motor units spasticity with hyperreflexia with the appearance of pathological patterns generally extensor in the lower limb and flexor in the upper limb appearance of primitive reflexes due to their lack of inhibition (Babinski reflex, tonic

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neck reflex, crossed extension ...) slowing of muscle responses due to the prevalence of tonic muscle fibres compared to phasic ones (Russell & Ducros, 2011).

Associated disorders in hemiplegia are: brain lesions - rarely selective of the motor system, in most cases they are associated with lesions of brain areas with other skills; psychic - there is a superficial, discriminative and profound altered sensitivity (Britannica, 2018), increased muscle stiffness not only due to neurological response to stretching, but also increased muscle shortening and passive stiffness, deficit of higher cortical functions (aphasia, apraxia). Hemiplegia can produce complications leading to tertiary injuries such as pressure sores, muscle-tendon retractions, muscle weakness (Indredavik et al., 1991).

Our third subject diagnosed with Cornelia de Lange Syndrome (GMFM II). Cornelia de Lange Syndrome (CdLS) is relatively rare and affects, according to sources, between 1/10.000 and 1/60.000 neonates. The principal clinical characteristics of this syndrome are the delay in growth and development, hirsute, anomalies in the structure of the limbs and distinctive facial characteristics (Cruz & Bosch, 1998; Raspall, 1990; Smith, 1978).

Cornelia de Lange syndrome (CdLS) is an archetypical genetic syndrome that is characterized by intellectual disability, well-defined facial features, upper limb anomalies and atypical growth, among numerous other signs and symptoms (Kline et al., 2018). Motor development is invariably delayed (Huisman et al., 2017). Scoliosis, especially thoracic scoliosis, develops in one-third of patients, often by 10 years of age (Roposch et al., 2004a), and is more common in adults with decreased mobility (Mariani et al., 2016). Experience of scoliosis surgery is limited, but our mutual experience indicates that standard management is effective, taking prognosis with respect to development and mobility into account. Spine malformations are extremely rare and typically asymptomatic (Bettini et al., 2014), with kyphosis present in one-quarter of these individuals (Roposch et al., 2004b). Flexion contractures have been reported in 18–25% of individuals with CdLS, particularly in the knees, which can interfere with ambulation, but also in the elbow and/or hip, as have tight Achilles tendons (Torres et al., 2010).

All three subjects have common posture deficiencies: knee extension deficit, high base of support, kyphotic posture with anteriorly projected centre of gravity.

5.2. Methods and materials

Balance control was assessed before and after the intervention using the adapted 10MWTest- creating a balance pathway consisting of Build N'Balance® proprioception stimulating materials to measure speed of movement. The 10-meter walk test (10MWT) is a simple assessment to measure locomotor capacity in clinical and research settings. Outcome measures originally recommended are the time taken to complete the test (Watson, 2002) or the mean velocity (Middleton et al., 2015). The mean velocity of gait has been termed the sixth vital sign because of its clinical and research relevance.

The 10MWT has measured locomotor capacities in adults and children with several neuro-motor diseases. (de Baptista et al., 2020).

Mini-BESTest: Balance Evaluation Systems Test was used to assess functional balance. The mini-BESTest assesses balance control in four areas (i.e. sub-scales): anticipatory postural adjustments, reactive postural control, sensory orientation, and dynamic gait (Franchignoni et al., 2010). The Mini-BESTest contains 14 items from sections of the original BESTest Each item is scored on a 3-level ordinal

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scale from 0 (severely impaired balance) to 2 (i.e., no balance impairment), and the maximum possible score is 28 points (King & Horak, 2013). Due to allowing the examination of almost all components of balance control systems (static and dynamic stability, basic motor control systems, stability limits, reactive and anticipatory controls, sensory integration, and cognitive influences) (Sibley et al., 2015). within a short duration, the Mini-BESTest is deemed more useful in a clinical setting than other balance measures. Moreover, the Mini-BESTest is focused specifically on dynamic balance control, including the capability to react to postural perturbations, stand on a compliant or inclined surface, or walk while performing a cognitive task, which represents a significant advantage over other popular balance scales (Franchignoni et al., 2010).

An initial test was performed, then a final test. Between the two tests, we applied a balance education program during physiotherapy and physical education classes, 4h/week, for one month. It consisted of repeating each element of the route, separately using in a many versatile elements of the Build N’ Balance® through game therapy, followed by 10 minutes of cycling on the elliptical bike. Physical therapy plays a critical role in managing the sequelae of cerebral palsy (CP) (Anttila et al., 2008). More than 40% of 3- to 17-year-old children with CP experience challenges crawling, walking, running, or playing (Boulet et al., 2009). For many, the resulting limitations in physical activity negatively impact musculoskeletal and cardiovascular function, and increase risk for secondary medical conditions (Maltais et al., 2014). Feasible and effective interventions are needed to improve the mobility and cardiorespiratory fitness of children with CP. Principles drawn from the neuroscience literature emphasize the merit of having individuals with neurologic injury engage in high-intensity repetition of gait-like movements to promote behavioural and neurologic recovery of walking, yet this approach is often impractical in real-world settings (Lang et al., 2009; Zbogar et al., 2017). Traditional elliptical incorporate varying levels of flywheel resistance to challenge users while training.

Build N’ Balance® provide opportunities to improve the motor skills and exercise the balancing skills of children of all ages. This materials offers innumerable ways in which to assemble planks and tops to create balancing courses at different heights with options to incline planks and join them to the tops at every conceivable angle. With Build N’ Balance®, children can build a long balancing bridge as an individual element in an obstacle course – or they can build themselves a circular course. A long balancing bridge effectively reduces the speed at which the child moves and hones the child’s focus and attention. On a circular course, children can concentrate on completing multiple rounds and, via repetition, gain confidence and achieve mastery. To challenge a small child, build a low, straight balancing course. To challenge an older child, build a path with both inclining elements and elements placed at angles so that the path changes direction. Each plank type has a specific tactile profile. If the child is barefoot, Build N’ Balance® offers good tactile stimulation that helps to support and challenge the child’s balance. A uniform surface helps the child to balance, whereas a varied surface is often more challenging (Harboe, 2021).

6. Findings

Each of these students achieved an average on the final 10MWTest (time, errors, confidence in execution) equal to or lower than their baseline, with significant improvements observed in postural

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control, confidence in movement and coordination. According to the Mini-BESTestms improvements were observed in sensory orientation, static balance and dynamic balance in movement.

To assess the effectiveness of our original physiotherapy program, we used three subjects (three 9-year old boys) with distinct diagnoses: diplegia, hemiplegia and Cornelia de Lange syndrome. We intentionally chose subjects with distinct diagnoses and different degrees of motor dysfunction, to evaluate whether the effectiveness of the new physiotherapy program depends on a particular diagnosis, and/or the initial limitations in performance of gross motor skills.

As a first step, we established a baseline by evaluating the condition of each subject prior to entering the program. For a comprehensive assessment, we employed two complementary tests. The first test is the standardized 10MWTest- Build N'Balance®, where subjects were scored on three categories: 1) the time it took to complete a task, 2) number of errors when executing a task, and 3) number of instances when the subject needed external help to perform a task. These initial scores are listed in Table 1, columns Start1, Start2, and Start3, corresponding to each of the three subjects. These scores underline the variation in the degree of initial mobility of our subjects. The second test is the Mini-BESTest - Balance Evaluation Systems Test, for which our subjects were scored on 14 different items. For each item, the subjects' performance was scored on a 3-points scale (i.e., 0, 1, 2), where a value of 2 indicates the best performance. These baseline values are reported in Table 2, columns Start1, Start2, and Start3. There is agreement between the overall scores of the two tests, in the sense that the subject with the diplegia performed the best, whereas the one with Cornelia de Lange syndrome struggled the most.

Table 1. 10m Walk Test Evaluation

	Start 1	End1	Start 2	End 2	Start 3	End 3
Time	37.93	37.02	42.32	41.02	38.38	33.67
Error	2	0	1	2	6	3
Support	3	2	2	2	4	4

Note. Time was set per seconds. Errors and Support were set by times/seconds for every error or need of support. Start1, 2, 3 are the results from the first test. End 1, 2, 3 are the results of the second test applied.

The second step was to have the subjects start our physiotherapy program. The program consisted of four weekly sessions, and lasted 1 month. Each session was based on playing motor games using Build N'Balance® materials, followed by ten minutes of training on elliptical bicycle. The children created the trails they wanted to follow. This stimulated motor skills, creativity and working strategy. Their safety was essential. By building the application trail themselves, the motivation to complete it was increased. The challenges were raised to high standards because during the game the children had different roles - as judges, competitors, coordinators. By this way of physiotherapy approach, the execution of the proposed therapeutic plan for the development of balance, physical skills, coordination, reaction and speed, as well as the muscle strengthening and stretching was carried out by the child without imposing a strict exercise program.|

At the end of the program, we conducted a second evaluation to determine the subjects' response. For consistency, we scored each subject using the same two tests. The post-program scores are listed in columns End1, End2, and End3 of Table 1 and Table 2, for the 10MWTest and Mini-BESTest respectively. Overall the results are very encouraging. Let us first consider the 10MWTest scores. The

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first thing to note is that all three subjects improved their time for completing the test. The subjects with diplegia and hemiplegia lowered their time by about 1 second, whereas the one with Cornelia de Lange syndrome by roughly 4.7 seconds. While the numbers are nominally low, they represents substantive improvements. For example, the subject with Cornelia de Lange syndrome improved their time by 12 percentage points.

Table 2. MiniBESTest Evaluation

	Test items	Start1	End1	Start2	End2	Start3	End3
1	Sit to stand	2	2	1	1	1	1
2	Rise to toes	1	1	1	1	0	0
3	Stands on one leg	1	2	1	1	0	0
4	Compensatory stepping correction – forward	1	1	2	2	0	0
5	Compensatory stepping correction – backward	1	1	1	1	0	0
6	Compensatory stepping correction – lateral	2	2	2	2	1	1
7	Stance, eyes open, firm surface	1	2	0	1	1	2
8	Stance, eyes closed, foam surface	1	2	0	1	0	1
9	Incline, eyes closed	0	1	1	1	1	1
10	Change in gate speed	1	2	1	1	1	1
11	Walk with head turns – horizontal	1	2	0	1	0	1
12	Walk with pivot turns	1	1	0	1	0	0
13	Sep over obstacles	1	1	1	2	1	1
14	Time up and go with dual task	1	1	1	2	0	0
	Total points (of max28)	15	21	12	18	6	9

Note: Start1, 2, 3 are the results from the first test. End 1, 2, 3 are the results of the second test applied.

Significant improvements were also observed with respect to the number of errors when executing a task. On the post-program assessment, the subject with diplegia made no errors (down from 2), whereas the one with Cornelia de Lange syndrome halved his number of mistakes (3 vs. 6 errors). The subject with hemiplegia, however, had one extra error compared to the initial assessment. In terms of the number of instances when the subjects needed external support, we observe a limited effect. Specifically, only the score of the subject with diplegia improved, and just by 1.

As a more disaggregated measurement, the Mini-BESTest provides a more complex picture, but the overall results are similar. Specifically, if we look at the total score, all three subjects substantively improved their performance. Accounting for the different baselines, the improvement ratios (i.e., the difference between the end and start scores divided by the start value) are 40% (15 vs. 21 points) for the subject with diplegia, and 50% for the hemiplegia (12 vs. 18 points), and Cornelia de Lange syndrome (6 vs. 9 points) subjects. Importantly, the benefits of the program are more apparent for specific subgroups of responses. In particular, the subjects significantly improved in the sensory orientation category (items 7 to 9). Out of the three items in this category, all subjects improved on 2 of them, and one of the subjects on the remaining item. Improvement was also noticeable on the dynamic gait category (items 10 to 14). Out of the five items, all subjects improved on the "walk with head turns - horizontal" item, and at least one of the subjects in the remaining four items.

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Moving forward, these results present a trade-off. Should we keep the program as it and capitalize on the noticeable improvements in the sensory orientation and dynamic gait categories? Or, should we develop an alternative program aimed at improving anticipatory reactions and reactive postural control? Theoretically, we could alternate these programs (i.e., instead of 4 weekly sessions of the same program, we could have 2 sessions for each program). The big unknown, however, is whether the observed improvement in the sensory orientation and dynamic gait categories is conditional on sustained effort (i.e., having 4 weekly sessions). If that were the case, introducing a new program could undermine this success.

To summarize, these are encouraging initial results. However, we fully acknowledge that we had a minimum sample, and therefore a larger experiment would help validate these findings.

7. Conclusions

Play is essential to development because it contributes to the cognitive, physical, social, and emotional well-being of children and youth. Play also offers an ideal opportunity for parents to engage fully with their children. Despite the benefits derived from play for both children and parents, time for free play has been markedly reduced for some children. A variety of factors have reduced play, including a hurried lifestyle, changes in family structure, and increased attention to academics and enrichment activities at the expense of recess or free child-centred play which ensure that play is protected as they seek the balance in children’s lives to create the optimal developmental milieu (Ginsburg, 2007).

The gait of children with cerebral palsy is often characterized as slow and inefficient (Johnston et al., 2004) leading to difficulties keeping pace with family, friends, and peers and an overall decrease in physical activity. To alleviate these challenges, it is critical that physical therapy interventions address underlying walking deficits (Burnfield et al., 2018).

Proprioceptive sensory stimulation increases the safety level of children with CP. There are different results depending on the motor disability. The ludic approach in physiotherapy increases the motivation of children with CP to participate in physical activities. Imaginative play during physiotherapy sessions develops creativity, safety and increasing self-esteem and it is important to be nurtured for the child. With this, the focus is on having fun and learning important skills, many of which may be used to reinforce learning. Where possible, games involve everyone, and emphasise working together. All games have negotiable rules, and to negotiate is an important part of the games process for children under 11. The ‘game’ must remain fun for all, be inclusive and ‘fair’. Enjoyment and skill development must always have priority over ‘winning’ (Nicol & Taplin, 2012).

Further investigations with larger sample sizes and children with different GMFCS are needed to examine the full therapeutic effect of our physiotherapy program applied through motor games playing.

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