

The effects of core stability exercises on proprioception and balance in children with hemiplegic cerebral palsy

Los efectos de los ejercicios de estabilidad del tronco en la propiocepción y el equilibrio en niños con parálisis cerebral hemipléjica

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Abstract. Background: Trunk control is necessary to maintain the body position, to ensure stabilization in the change of position, to perform activities of daily living and for activity. At the same time, it allows maintaining an upright posture, regulating weight transfer, controlled movement against gravity, controlling and changing body position for balance and function. In this study, it was aimed to examine the effects of core exercises on proprioception and balance in children with hemiplegic cerebral palsy. Material and methods: The research was conducted using a single-group pre-test post-test experimental design. The population of the study consisted of 20 people aged 4-12, diagnosed with hemiplegic cerebral palsy, who received training and treatment at a private educational institution between November 2021 and October 2022, and met the criteria for inclusion in the study. The "Trunk Impairment Scale" and "Pediatric Berg Balance Scale" were used to collect the data. In the evaluation of the data; numbers, percentages, standard deviation, mean, minimum and maximum values, Independent Samples t-test and Wilcoxon test were used. Results: It was determined that the difference between the pre-test-post-test pediatric balance scale and static sitting balance, dynamic sitting balance, coordination sub-dimensions mean scores and trunk impact scale mean scores of individuals was statistically significant ($p < 0.05$). Conclusions: Core stability exercises applied to children with hemiplegic cerebral palsy had positive effects on proprioception and balance.

Keywords: Balance, Cerebral Palsy, Proprioception, Rehabilitation

Resumen. Antecedentes: El control del tronco es necesario para mantener la posición del cuerpo, garantizar la estabilidad al cambiar de posición, llevar a cabo actividades de la vida diaria y participar en actividad física. Al mismo tiempo, permite mantener una postura erguida, regular la transferencia de peso, el movimiento controlado contra la gravedad, controlar y cambiar la posición del cuerpo para el equilibrio y la función. En este estudio, se buscó examinar los efectos de los ejercicios de estabilidad central en la propiocepción y el equilibrio en niños con parálisis cerebral hemipléjica. Material y métodos: La investigación se llevó a cabo utilizando un diseño experimental de preprueba y postprueba en un único grupo. La población del estudio consistió en 20 personas de entre 4 y 12 años, diagnosticadas con parálisis cerebral hemipléjica, que recibieron entrenamiento y tratamiento en una institución educativa privada entre noviembre de 2021 y octubre de 2022, y que cumplían con los criterios de inclusión en el estudio. Se utilizaron la "Escala de Deterioro del Tronco" y la "Escala de Equilibrio Pediátrico de Berg" para recopilar los datos. En la evaluación de los datos se utilizaron números, porcentajes, desviación estándar, media, valores mínimos y máximos, la prueba t de muestras independientes y la prueba de Wilcoxon. Resultados: Se determinó que la diferencia entre las puntuaciones medias de las subdimensiones del equilibrio pediátrico y el equilibrio estático sentado, equilibrio dinámico sentado, coordinación y la escala de deterioro del tronco antes y después de la prueba fue estadísticamente significativa ($p < 0,05$). Conclusiones: Los ejercicios de estabilidad central aplicados a niños con parálisis cerebral hemipléjica tuvieron efectos positivos en la propiocepción y el equilibrio.

Palabras clave: Equilibrio, Parálisis Cerebral, Propiocepción, Rehabilitación.

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Introduction

Cerebral Palsy (CP) is a persistent but non-progressive impairment of motor function, posture, and movement resulting from non-progressive lesions in the developing brain. Its etiology covers a wide spectrum ranging from prenatal and perinatal events to postnatal traumas. Although the lesion in the brain is not progressive, the problems seen in individuals with CP progress over time (Di Benedetto et al., 2023; Singer et al., 2015). Damage to the central nervous system in CP causes disorders in the musculoskeletal, nervous and sensory systems, resulting in posture, movement and balance problems in individuals with CP. In addition, depending on the severity of the exposure, respiratory problems, mental problems, epilepsy, visual disorders, hearing disorders, speech disorders, behavioral problems and oral motor problems may accompany CP (Kerem Günel & Livanelioğlu, 2009; Radziejowski et al., 2022).

In Turkiye, the frequency of CP in children aged 2-16 has been reported as 4.4 per 1000 live births (Serdaroglu et al., 2006). Although CP is classified according to different conditions such as affected body parts, severity of involvement, and causative pathology, traditionally CP is

classified according to predominant motor disability; spastic type (approximately 50%), dyskinetic type (approximately 20%), ataxic type (approximately 10%), and mixed type (approximately 20%). According to the affected body area in spastic type CP; It is divided into subgroups as hemiplegia, quadriplegia, diplegia. In Hemiplegic Cerebral Palsy (HCP), there is homolateral involvement of the arm and leg (Singer et al., 2015). Children with HCP generally have high gross motor functions, participate more in activities than other types of CP, and their cognitive abilities are generally preserved (Kenis-Coskun et al., 2016; Kerem Günel & Livanelioğlu, 2009).

Ensuring postural control and balance is one of the basic functions of the central nervous system and balance reactions are manifested as automatic postural responses (Kerem Günel & Livanelioğlu, 2009). Influence on the central nervous system in children with CP causes postural control deficiency and balance problems. Abnormal motor control and muscle tone, posture disorders, prolonged primitive reflexes, contractures and deformities are the main factors of postural control and balance disorders (Elbasan, 2019; Hsue et al., 2009). When the literature was examined, it was found that children with CP have low postural control and balance ability compared to typically

developing children (Kenis-Coskun et al., 2016; Kyvelidou et al., 2010; Liao et al., 2003) and it is observed that postural control measurements are usually performed in diplegic and HCP children (Ferrari et al., 2010; Kenis-Coskun et al., 2016; Shiratori et al., 2016).

The beneficial effects of exercise on the muscles, cardiovascular and respiratory systems have been determined (Demirel & Ozyener, 2016). When it comes to core exercises, it can be defined as exercises that work the muscle groups specific to the center of the body while doing balance, endurance and strength exercises. In this region, which is defined as the middle part of the trunk, the vertebrae, pelvis bone, abdominal cavity and upper extremity, including the muscles, nerves, skeleton and related structures are understood. The strength of these structures depends on the strength of the muscles and proper core training and is important in terms of performance (Kisacik et al., 2023).

Core exercises are exercises aimed at working the abdominal, back and hip muscles that keep the body in balance. These muscle groups are responsible for the formation of movement, the development of the coordination of the muscular system, the correct and proper posture of the skeletal-muscular system, the emergence of the force and its distribution throughout the body (Škundrić et al., 2021).

The aim of this study was to investigate the impact of core stability exercises on postural control and balance in children with HCP. By conducting a comprehensive analysis of the effects of these exercises, we aimed to provide insights into the potential benefits of incorporating core stability exercises into the rehabilitation and intervention strategies for children with HCP. Through this research, we sought to contribute to the enhancement of functional abilities and overall quality of life in this specific population.

Materials and Methods

Experimental design

The research was conducted using a one-group pre-test post-test experimental pattern. The study was carried out between November 2021 and October 2022 with patients aged 4-12 years who were diagnosed with cerebral palsy and receiving training and treatment at a private educational institution in Balıkesir-Turkiye. The study protocol was approved by the Agri Ibrahim Cecen University Research Ethics Committee (E-95531838-050.99-23115).

Participants

The study population consisted of 29 individuals diagnosed with hemiplegic cerebral palsy who met the inclusion criteria and received training and treatment at a private educational institution in Balıkesir, Turkiye, between November 2021 and May 2022. The research employed a purposive sampling technique, including the entire accessible population as the sample, without utilizing a specific sampling technique. A preliminary power analysis

(power = 0.8, α = 0.05; effect size = 0.5) determined a sample size of 20 children required for this study.

Criteria for inclusion in the study were defined as having undergone an injection containing botulinum toxin-A or a surgical intervention within the preceding 6 months, the absence of a history involving fractures or trauma, classification within levels 1 and 2 according to the Gross Motor Function Classification System (GMFCS), and possessing cognitive capabilities of an extent enabling comprehension and execution of the directives provided during assessments. Individuals afflicted with visual or auditory deficits, alongside supplementary neurological or orthopedic afflictions, were precluded from participation in the study.

The study encompassed an assessment of trunk control, trunk endurance, upper extremity endurance, balance, and functional mobility in the included cases with cerebral palsy. Demographic and clinical attributes of the subjects, including age, weight, gender, topographical classification of cerebral palsy, Gross Motor Function Classification System level, concomitant disorders and conditions related to cerebral palsy, history of trauma and surgeries, medication employment, and utilization of adjunctive equipment (orthoses, etc.), were investigated through a patient evaluation form meticulously formulated by the researchers.

Data collection tools

In the study, Introductory Information Form; "Trunk Impairment Scale (TIS)" and "Pediatric Berg Balance Scale (PBBS)" were used.

Introductory Information Form: It created questions that included the demographic characteristics of individuals.

Trunk Impairment Scale (TIS): The Trunk Impairment Scale (TIS) was used to assess the functional strength of the trunk, postural control, and the quality of trunk movements. TIS is a scale developed to evaluate the trunks of individuals with stroke. Later, it was adapted for children with CP and presented to clinical use and its validity was demonstrated. TIS evaluates the trunk functionally in terms of strength in sitting position. It consists of three sub-sections: static, dynamic and coordination. The highest scores that can be obtained from the static, dynamic and coordination sub-headings are respectively; 7, 10 and 6 points. The total TIS score ranges from 0 to 23 (Sæther & Jørgensen, 2011).

Pediatric Berg Balance Scale (PBBS): The Pediatric Berg Balance Scale (PBBS), the version of the Berg Balance Scale (BBS) designed for children by Franjoine et al., was used to evaluate their functional balance in activities of daily living. The scale consists of 14 sections and each section is scored between 0-4; The highest score that can be obtained from the scale is 56. The order of the sections in the standard BBS was rearranged in functional order, from easy to difficult. The time standards in the sections related to the maintenance of the static posture have been reduced in accordance with the pediatric population and the directions have been simplified (Franjoine et al., 2003).

Application of the study

Jeffreys' core stabilization training protocol was applied to the study group (Jeffreys, 2002). In Jeffreys' protocol, lumbar-pelvic proprioception training, specific spinal stabilization exercises, different muscle contractions and abdominal maneuvers were used. Then, dynamic stabilization exercises were started and the children were expected to maintain stabilization in various positions such as supine, prone and squat. For dynamic exercises, exercise ball and extremity (upper or lower extremity) movements were used in the advanced stages.

This protocol includes exercises starting from the first level and gradually progressing to the third level. The first level involves static contraction training on a stable surface, the second level entails dynamic training on a stable surface, and the third level consists of dynamic and resistance training on an unstable surface (Golsefidi et al., 2013). Swiss balls were used to create an unstable platform. The study group performed the prescribed exercises three times a week, under the supervision of a physiotherapist, for 8 weeks. Each session lasted for 60 minutes, with a 10-minute warm-up and 10-minute cool-down period. The warm-up and cool-down routines included stretches for the hip flexors, hamstrings, and quadriceps, as well as jogging.

Evaluaton of data

Table 1. Reliability coefficients of the total and sub-dimensions of the scale

Sub-dimensions of the scales	Pre-Test - α	Post-Test- α
Pediatric Berg Balance Scale TSA	0.98	0.98
TIS-Static sitting balance	0.94	0.86
TIS-Dynamic sitting balance	0.96	0.97
TIS-Coordination	0.92	0.90
Trunk Impairment Scale TSA	0.97	0.96

α : Coefficient of Confidence, TSA: Total Score Average

Table 3. Comparison of the pre-test, post-test scales mean scores of the individuals (n= 29)

	Pediatric Berg Balance Scale Total Score Average X \pm SD	Static Sitting Balance Avarage Score X \pm SD	Dynamic Sitting Balance Avarage Score X \pm SD	Coordination Average Score X \pm SD	Trunk Impairment Scale Total Score Average X \pm SD
Pre-test	17.72 \pm 12.25	0.89 \pm 2.02	1.51 \pm 3.11	0.62 \pm 1.32	3.03 \pm 6.21
Post-test	30.96 \pm 11.65	4.89 \pm 2.27	8.17 \pm 3.49	3.65 \pm 1.58	16.72 \pm 7.08
Test	t=-.34.544*	Z=-4.292**	Z=-4.313**	Z=-4.663**	Z=-4.418**
p value	p=0.001	p=0.001	p=0.001	p=0.001	p=0.001
Cohen d value	1.107	1.861	2.014	2.081	2.055
Impact size (r)	0.484	0.681	0.709	0.721	0.716

Abbreviations: *Paired Samples t test, **Wilcoxon test, X:Mean, SD: Standart Deviation

The data obtained in this study were analyzed using the SPSS statistical program (SPSS-22). Numbers, percentages, minimum and maximum values, mean and standard deviation were used in the evaluation of the data. In order to determine the normal distribution, the Kurtosis-skewness value was checked. According to the results of the kurtosis-skewness value, the normal distribution of the data (+1.5 -1.5) was determined (Tabachnick et al., 2007). The reliability of the measurement tools was evaluated with the Cronbach- α number. the difference in the mean scores of the individuals was evaluated by Independent samples T test and Wilcoxon test. In our study, p<0.05 was considered statistically significant.

Results

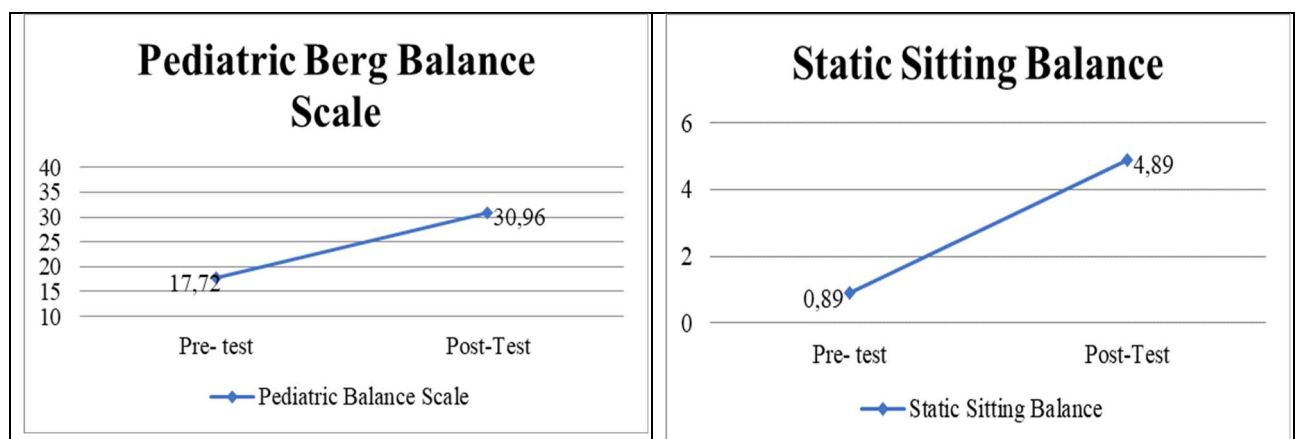
It was found that 51.7% of the individuals in our study were female, 51.7% were illiterate, and 89.7% had income equivalent to expenditure (Table 2).

Table 2. Demographic characteristics of individuals

Variables	(n: 29)		
	Number	%	
Gender	Female	14	48.3
	Male	15	51.7
Educational status	Illiterate	15	51.7
	Primary education	14	48.3
Income status (family)	Income less than expenses	1	3.4
	Income equal to expenses	26	89.7
	Income more than expenses	2	6.9
Average Age	X \pm SD 7.62 \pm 2.66(+12)		

X: Mean, SD: Standard Deviation

It was determined that the difference between the pre-test and post-test pediatric balance scale, static sitting balance mean scores, dynamic sitting balance score, coordination scores, body affect scale total scores of the individuals was statistically significant (p< 0.05) (see Table 3; Figure 1).



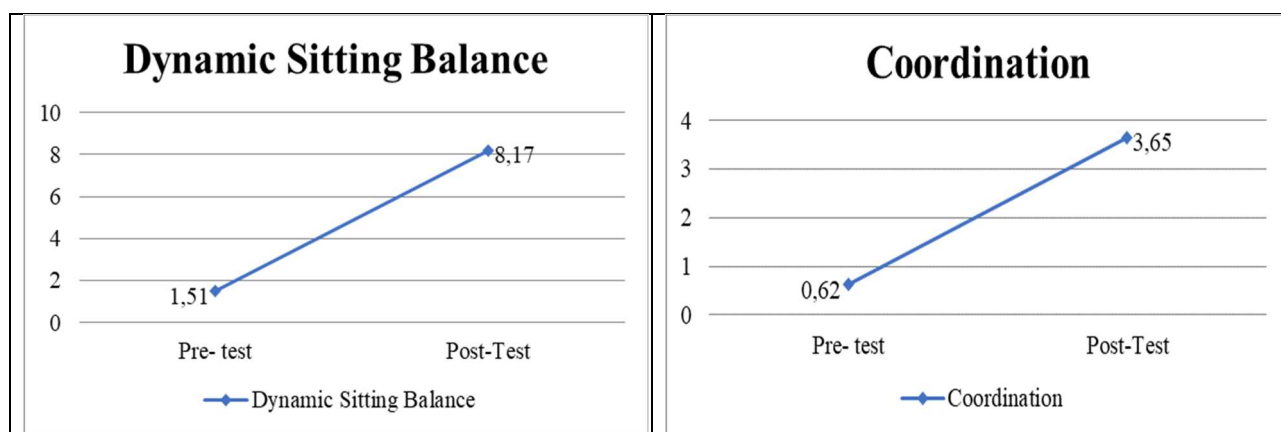


Figure 1. Comparison of the pre-test, post-test scales mean scores of the individuals

Discussion

The current study reveals a number of novel and interesting findings. It was determined that the difference between the Pre-Test and Post-Test Pediatric Balance Scale Score Averages of the individuals was statistically significant ($p < 0.05$). HCP patients have various problems that directly and indirectly affect postural balance (Macedo et al., 2022). Postural control defects have long been recognized as a significant limitation of the motor development of children with HCP. The notable differences observed both before and after the treatment, which clearly favored the study group, can be attributed to the impactful effects of core stability. These effects contribute to the activation of the ideal alignment of the lumbar and pelvic regions. By incorporating core stability exercises, the muscles surrounding the core and pelvic areas are strengthened. This reinforcement, in turn, enhances the stabilization of the body and head during various limb movements. The process involves the intentional engagement of tonic or postural muscles throughout the entirety of full-body exercises, as elaborated in reference (Reyes-Ferrada et al., 2021).

The enhancement in endurance within the trunk muscles of the study group can be attributed to the strategic approach employed in core stability training. This approach integrates numerous low-load isometric contractions executed within a restricted range of motion (da Silva Sartori et al., 2022). Such a training modality induces tonic activation of deep multifidus muscles, as well as other trunk muscles characterized by a higher proportion of type I (slow twitch) muscle fibers (Plotkin et al., 2021).

The integration of repetitive, less demanding exercises contributes to the augmentation of local muscular endurance and strength. Consequently, the endurance time of lateral flexor muscles displayed improvement exclusively within the core stability group. This outcome can be linked to the comprehensive nature of the core stability rehabilitation strategy, which encompasses all core muscles and amplifies the endurance capacity of these muscular structures. Furthermore, the dedicated abdominal and back exercises target muscle force and initiate neuroadaptive

mechanisms, thereby promoting early advancements in stability and proprioceptive activities (Škundrić et al., 2021).

Postural balance is essential for all motor abilities, so improving standing balance and postural stability is critical. It is controlled by highly complex neuromuscular mechanisms and is automatically maintained by proprioceptive, vestibular and visual feedback. In order to ensure postural stability, the center of gravity must be kept on the support surface, that is, the balance mechanism must work properly (Anker et al., 2008). Balance is the ability to achieve stabilization of the body in static and dynamic situations (Anker et al., 2008). Balance, which occurs as an automatic reaction in healthy people, is actually a complex process that requires many systems to work in an organized manner. They stated that balance problems are frequently encountered in children with CP due to the inability of the systems that ensure the functioning of the balance mechanism to perform its task or secondary problems related to CP (Hsue et al., 2009). A large part of the studies focusing on the balance problem in children with CP agree that the balance of children with CP is affected (Cemil et al., 2023; Krishnaprasad et al., 2022; Saxena et al., 2014). In a study by Ali et al., 30 children aged 6-8 diagnosed with hemiplegic CP were treated with core exercises in addition to traditional treatment, and it was found that the group in which the exercise plan was applied had higher balance score averages compared to the control group ($p < 0.05$) (Ali et al., 2016).

In our study, it was determined that the difference between the Pre-Test-Post-Test Static and Dynamic Sitting Balance Scores of the individuals was statistically significant ($p < 0.05$). In a study by El-Basatiny and Abdel-aziem, 30 children aged 10-14 diagnosed with CP had core exercises applied for 30 minutes in addition to traditional treatment, and significant positive improvements were achieved in sitting balance ability, coordination and dynamic walking balance ($p < 0.05$) (El-Basatiny & Abdel-Aziem, 2015).

In our study, it was determined that the disparity between the Pre-Test and Post-Test Coordination Scores of the participants exhibited statistical significance ($p < 0.05$). A separate study conducted by Son et al. demonstrated that

the application of 30 minutes (6/14 days) of core exercises among a group of 15 children aged 10-18, all diagnosed with diplegic CP, resulted in a substantial enhancement of postural control, diaphragm kinetics, and abdominal engagement. In a study by El Shemy et al., they performed an intervention in which they applied core exercises to 30 children diagnosed with hemiplegic CP aged 10-12 years, and as a result of the study, significant improvements were observed in endurance and gait pattern ($p < 0.05$) (Son et al., 2017).

It was determined that the difference between the Pre-Test-Post-Test Body Affect Scale Total Scores of the individuals was statistically significant ($p < 0.05$). In a study by Ahmed et al., it was determined that 1-hour (6/7 days) core exercise application to 26 children diagnosed with diplegic CP, aged 1 to 4 years, increased postural control and shoulder stability (Ahmed et al., 2014). In the study of Kim et al. with a 13-year-old hemiparetic CP patient, the effect of applying core exercises on balance and gait patterns was investigated. Walking speed and balance test performance were positively correlated with exercise intensity (Kim et al., 2017).

The investigation by Allen et al. [25] delved into the impact of a core stability intervention on the endurance of trunk muscles among school-aged children. Their findings indicated that the enhancements observed in muscular endurance test performance could be ascribed to the training effect and the adequate provision of practice opportunities, rather than being solely contingent upon the replication of identical movements between the intervention and assessment phases.

Conclusion

The results of our study showed that core exercises can be used alongside other treatment options in the treatment of this patient group. Postural control improves significantly after core exercises. More research is needed to investigate how the positive effects of core stability exercise will be sustained over time and to determine the key characteristics (intensity, frequency, and duration) of core stability exercise.

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