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THE IMPACT OF ABDOMINAL CORE STABILITY EXERCISE THERAPY ON ENHANCING SITTING BALANCE AND HAND FUNCTION IN CEREBRAL PALSY PATIENTS

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ABSTRACT
Cerebral palsy (CP) is a disorder of posture and movement control in children during growth and development. One of the problems in children with CP is impaired sitting balance which results in weakness of hand function such as holding and manipulating objects. Objective: to determine the effect of abdominal core stability exercise therapy on improving sitting balance and functional hand abilities of children with CP at YPCP Surabaya. Method: an experimental study with one treatment group, the study's population consisted of 20 children with cerebral palsy (CP) who were in the sitting training phase at YPCP Surabaya. Using purposive sampling with specific inclusion and exclusion criteria, 18 participants were selected from the group. The treatment was abdominal core stability exercise therapy consisting of myofascial release of back muscles, trunk mobilization, sitting upright on a bench with feet on the floor, and moving toys with both hands in an upright sitting position. Exercise therapy was carried out for 30 minutes 3x per week for 12 weeks. The measuring instrument for sitting balance was TCMS (trunk control measurement scale) and the hand function was Melbourne Assessment 2. Result: 18 children with CP in the sitting exercise phase (12 boys and 6 girls) with an average age of 4.1 ± 1 years. The mean static sitting balance increased from 2.7 to 14.1 (p=0.000), the mean dynamic sitting balance rose from 0.00 to 3.3 (p=0.000), the mean reactive balance increased from 0.0 to 0.5 (p=0.3) and the mean functional hand ability increased from 6 to 7.4 (p=0.001). Conclusion: Abdominal core stability exercise therapy improves static, dynamic sitting balance and functional hand ability in children with CP at YPCP Surabaya, but not reactive balance.

Keywords: abdominal core stability; cerebral palsy; hand function; sitting balance

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INTRODUCTION

Cerebral Palsy (CP) is a disorder that affects brain development and is characterized by permanent and non-progressive disabilities in movement and posture during a child's growth (Upadhyay, 2020). Children with CP typically experience various movement challenges, including difficulty with posture stability, muscle stiffness, and impaired coordination (Carlberg, 2005). These issues can hinder their ability to perform daily activities such as sitting, standing, walking, playing with both hands, and writing (Carlberg, 2005). A significant factor contributing to these challenges is the reduced control over movement and diminished signals from the brain to the body's muscles, which results in decreased functional movement (Hallman-Cooper JL, 2024). One specific area that often faces stiffness and control challenges in children with CP is the middle region of the body, which includes the connection between the head, neck, and the entire body (Davids, 2018). In these children, this central body area may exhibit weakness, often manifested in poor posture, such as a hunched sitting position, and they may struggle to sit for extended periods (Matusiak-Wieczorek, 2020). From a kinesiology perspective, children with CP tend to adopt hunched sitting postures due to inadequate functioning of the core abdominal and multifidus muscles, which results from a lack of coordination between the brain and the body (Ali, 2019). The core

abdominal muscles are essential for supporting the front of the body, while the multifidus muscles provide support to the spine (Ali, 2019). It is challenging for a child with CP when their body-supporting muscles do not function optimally.

Poor sitting balance can significantly hinder children with cerebral palsy (CP) from performing daily functional activities (Sahinoğlu, 2017). This includes tasks related to sitting, as well as eye-hand coordination activities such as picking up and manipulating objects, holding items, eating, and drinking from a glass (Sahinoğlu, 2017). Academic activities, like writing, may also be affected (Sahinoğlu, 2017). If left untreated, these issues can lead to greater difficulty in performing functional activities with the hands and feet, resulting in an increased dependence on others (Zulkapli, 2016). This occurs because the hands and feet act as "passengers" attached to the core of the body (Zulkapli, 2016). Consequently, problems with sitting posture, such as hunching over, can impact the functionality of the hands and feet (Zulkapli, 2016). Additionally, poor posture can lead to further complications, including postural disorders like scoliosis and issues with respiratory and digestive functions (Sato, 2020). Respiratory problems may include infections and shortness of breath, while digestive issues may manifest as constipation and impaired food absorption (Dias, 2021). Children with CP who have poor sitting balance often adopt a hunched posture, which restricts the ability of their abdominal muscles to contract effectively and straighten their bodies (Iftikhar, 2024). Regarding hand function, a hunched-over position can lock the shoulders and scapula, making it difficult for children to move their arms and hands (Abd-Elfattah, 2021). This limitation can further increase disability in children with CP as they grow (Abd-Elfattah, 2021).

Physiotherapy as a profession that works in the field of human body movement and function, plays a very important role in the above conditions (Chughani, 2021). Physiotherapy can help provide exercise therapy aimed at increasing abdominal and multifidus muscle activity to improve children's upright reactions, as well as teaching correct posture positioning, with the hope of improving sitting balance and functional activity of the arms and hands (Yilmaz, 2023). Abdominal core stability model exercise therapy consists of several components such as ergonomic sitting positioning, trunk mobilization, trunk extensor muscle relaxation, stimulation of the uprighting/intrinsic muscles, abdominal muscle stimulation, and activities reaching for toys on the upper or side of the patient (Elshafey, 2022). This type of exercise therapy is a concept of balanced agonist and antagonist muscle performance in the abdomen and back (Sanad, 2021). When the performance of the abdominal/abdominal and back muscles is in harmony, the movement function of the arms and hands will increase, so that the functional ability of the hands of children with CP can be improved for basic functions such as reaching and picking up objects (Elshafey, 2022). Previous studies, only focused on assessing the function of the upright body when sitting (Ali, 2019), (Anwar, 2023), there has been no additional measurement of functional hand ability after being given this type of exercise, even though the final result of therapy is the functional ability that must be evaluated because in the end the functional ability of the hand greatly influences the quality of life of children with CP (Sahinoğlu, 2017), (Elshafey, 2022).

Yayasan Peduli Cerebral Palsy (YPCP) Surabaya is a foundation composed of parents of children with cerebral palsy (CP) from Surabaya and its surrounding areas. This foundation offers physiotherapy services specifically for children with CP. A preliminary survey revealed that 20 children were experiencing movement disorders characterized by hunched sitting and poor sitting balance. As a result, these children struggle to engage in activities while seated, which affects their ability to perform tasks that require the use of their hands, such as picking up toys or writing. Given this situation, it is essential to conduct research on the effectiveness of abdominal core stability exercise therapy. The goal is to improve sitting balance and enhance functional hand abilities in children with cerebral palsy at YPCP Surabaya. The

objective of this study was to evaluate the impact of abdominal core stability exercise therapy on enhancing sitting balance and functional hand abilities in children with cerebral palsy at YPCP Surabaya

METHOD

This study used a field experimental method, with 18 samples of CP patients who experienced impaired sitting balance and functional hand (starting from 20 samples, 2 samples withdrew). Samples were taken using the purposive sampling method. The inclusion criteria in this study were: 1) CP children aged 1-7 years, 2) experiencing hunched sitting and functional hand disorders, and 3) in the sitting to standing exercise phase. While the inclusion criteria: 1) there are complications of serious diseases such as epilepsy, 2) children do not understand two-way communication. Dropout criteria: patients do not come according to the predetermined schedule. The research design is a group pre and post-test design. The independent variable in this study is abdominal core stability exercise therapy, the dependent variables are sitting balance and hand functional ability. Sitting balance is measured by TCMS (trunk control measurement scale), while hand function uses the Melbourne Assessment 2 measuring instrument. Both measuring instruments use numbers/numerics, the closer to 100 the better. The study was conducted at YPCP Surabaya which is located at Jl Jojoran Surabaya. 18 samples were present according to the predetermined schedule. The treatment was carried out for 3 months, with a dose of 30 minutes per session, 3 times per week, for 12 weeks in the period from January to April 2025. Descriptive data were collected through interviews with parents. Sitting balance data and functional hand abilities were directly measured using the TCSM and the Melbourne Assessment 2 instruments by observing children's capabilities. Abdominal core stability exercise therapy involves a series of movements, including back muscle relaxation, trunk mobilization with right and left rotation, and maintaining an upright sitting position on a bench with feet on the ground. The therapy also includes activities such as reaching for and touching toys while seated upright and moving toys from one corner of the area to another while in an upright position (Elshafey, 2022), (Hong, 2014). The intervention was conducted by two professional physiotherapists who have worked with cerebral palsy patients at the foundation for 10 years. The statistical analysis in this study utilized descriptive statistics, one-group difference tests, and a statistical data processing program, with a significance level set at $p < 0.05$ and a 95% confidence interval.

RESULT

Table 1.
Mean changes in sitting balance variables and hand functional ability

Number	Variable	Pre-test	Post-test	Wilcoxon test
1	Static sitting balance	2,7	14,1	0,000*
2	Dynamic sitting balance	0,0	3,3	0,000*
3	Reactive sitting balance	0,0	0,5	0,3
4	Hand function	6,0	7,4	0,001*

*p Value is significant

A total of 18 samples of children with Cerebral Palsy (CP) in the sitting phase were evaluated, comprising 12 males (67%) and 6 females (33%). The average age of the participants was 4.1 ± 1 year, all diagnosed with spastic diplegia type of Cerebral Palsy. For numerical assessments, static, dynamic, and reactive sitting balance were measured using the Trunk Control Measurement Scale (TCMS), while hand functional ability was assessed using the Melbourne Assessment 2. The average score for static balance increased from 2.7 in the pre-test to 14.1 in the post-test. For dynamic balance, the pre-test average was 0, while the post-test average rose to 3.3. Reactive balance showed a pre-test average of 0, with a post-test average of 0.5. In terms of hand functional ability, participants scored an average of 6 in the pre-test and 7.4 in the post-test. The data distribution for all pre- and post-test variables was not normal (as shown in Table 1), leading to the use of the Wilcoxon test for hypothesis

testing, with a significance level set at $p<0.05$. Below are the average values from the pre- and post-tests, along with the data from the normality tests. The results from the Wilcoxon test indicated significant improvements in static, dynamic, and functional hand balance values. However, the reactive sitting balance value did not show significant improvement. Figures 1, 2, and 3 illustrate an increase in the average values for both static and dynamic balance, as well as an enhancement in average functional hand ability. Based on these findings, we can conclude that abdominal core stability exercise therapy positively impacts static and dynamic sitting balance, as well as functional hand ability in children with cerebral palsy at YPCP Surabaya. Conversely, this exercise therapy does not affect reactive balance values.

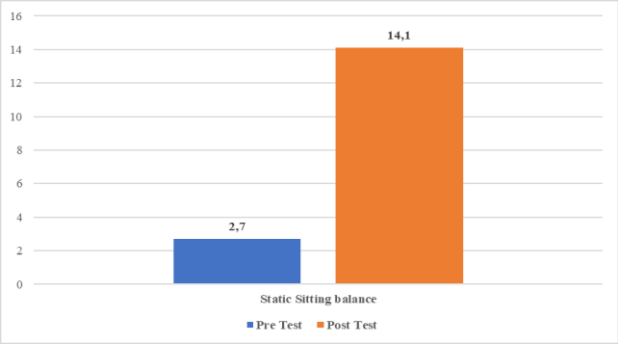

Figure 1. Average changes in static sitting balance

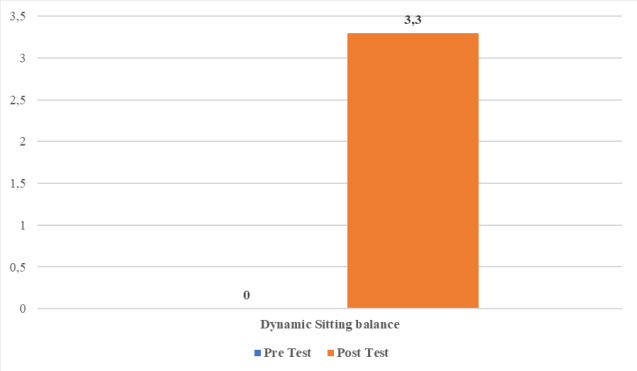

Figure 2. Averages changes in dynamic sitting balance

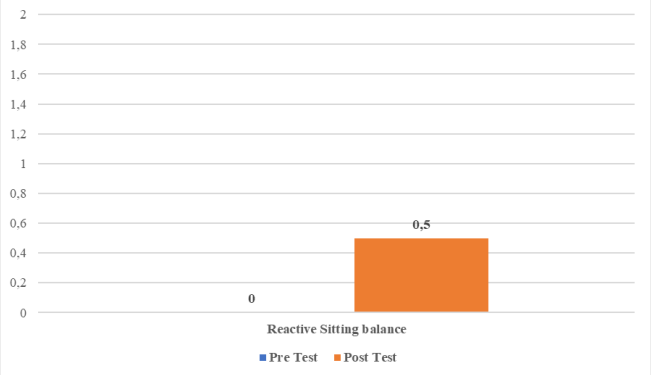

Figure 3. Averages changes in reactive sitting balance

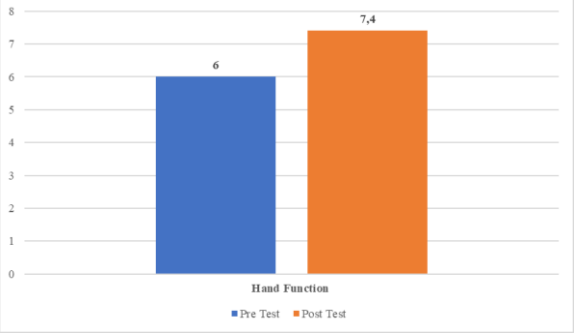

Figure 4. Average Changes in Hand Function

DISCUSSION

This study was conducted to provide abdominal core stability exercise therapy to 18 children with cerebral palsy at YPCP Surabaya from January to April 2025. The intervention consisted of 30-minute therapy sessions, three times a week for 12 weeks (Ali, 2019), (Anwar, 2023). The results showed improvements in both static and dynamic sitting balance, as well as enhanced hand function. However, there was no change observed in the reactive sitting balance variable. Cerebral palsy is a condition characterized by movement and posture disorders resulting from damage to brain cells during a child's growth and development (Chen A, 2020). This condition can significantly reduce a child's ability to maintain proper body posture (Liang WR, 2018). When postural control is not optimal, it can negatively impact the ability to move the legs and hands (Iftikhar, 2024). Specifically, regarding hand function, inadequate movement coordination from the scapula to the fingers can lead to impaired abilities (Metwaly, 2022) . This manifests in difficulties with actions such as holding toys, gripping writing instruments, and performing various tasks that require the use of both hands (Metwaly, 2022).

This study focused on exercises designed to improve sitting balance through abdominal core stability exercise therapy. This type of therapy aims to enhance the activation of key abdominal core muscles, specifically the transversus abdominis and multifidus, which contribute to the patient's ability to maintain an upright position (Sanad, 2021), (Elshafey, 2022). Additionally, relaxation techniques were employed for the hypertonic trunk extensor muscles associated with cerebral palsy (Topcu & Tomaç, 2020). This approach aims to promote a more functional and physiological upright reaction without excessive compensation through trunk extension. In the final session, we introduced cortical-level exercises. These involved teaching the child to recognize and maintain the physiological upright sitting position while engaging in play and manipulating toys with both hands (Hong, 2014). This exercise is important because it integrates postural training with hand movement coordination. The results after 12 weeks of exercise therapy indicated a significant improvement in the body’s ability to maintain an upright position, as well as enhanced functional ability in hand use.

The average value of sitting balance, as measured by the Trunk Control Measurement Scale (TCMS), shows an increase in both static and dynamic sitting balance. Static sitting balance refers to a child's ability, particularly those with cerebral palsy (CP), to maintain a fixed sitting position without shifting their body posture (Kazon, 2012) . In children with CP, this ability is often hindered by inadequate coordination of the core abdominal muscles (Faiqa Mehmood Rana, 2022). The optimal contraction between the transversus abdominis and multifidus muscles, which play a role in supporting an upright posture, does not occur effectively (Yilmaz, 2023). Therefore, exercises focusing on proper positioning to maintain a sitting posture are essential (Yilmaz, 2023). These exercises engage the postural abdominal muscles, working them statically and through small movements (Yilmaz, 2023). For children to activate their core abdominal muscles more effectively, it is important to relax the trunk extensor muscles, which often dominate trunk movement (Ali, 2019). Children tend to rely on excessive trunk extension to sit upright, making relaxation techniques, such as myofascial release and trunk mobilization, crucial for this study (Sahinoğlu, 2017). Static sitting balance is fundamental for enhancing sitting balance skills at advanced levels (Muehlbauer, 2024). Achieving proper posture in a static position is essential for developing the next stages of posture, namely dynamic and reactive balance (Liu, 2024). When static balance is effectively established and optimized, it naturally facilitates the development of dynamic and reactive balance (Jonathan Pierret, 2021).

This study involved exercises focused on activating the multifidus muscle while sitting upright. The multifidus muscle is an intrinsic muscle that connects the vertebrae segments (Kuan Wang, 2023). When this muscle is activated, it helps optimize balance in the body's core (Kuan Wang, 2023). The exercises included activities such as picking up and manipulating toys while in a seated position (Indira Brundavanam, 2017). There was an increase in dynamic sitting balance, in this study because the exercise involved the child's ability to shift body weight while sitting, by practicing taking toys and placing them on several sides, then there was a change in the center of mass of the body to the outermost point (Akyüz, 2022). As a result of the shift in the center of mass of the body far from the center of motion, the patient will inevitably try to return the body position to its original point (Ketaki Inamdar, 2020). If this activity is done repeatedly or repetitively, then there is a change in dynamic balance that we see in this study (Akyüz, 2022). Dynamic balance when sitting is an advanced stage of the child's ability to do body awareness during static balance exercises (Aqeel Ahmed, 2022). The results of this study are by the studies of (Faiqa Mehmood Rana, 2022) and (Indira Brundavanam, 2017) which link increased sitting balance with functional hand abilities in children with cerebral palsy.

For reactive balance in the sitting position, there is not much change, because this type of balance is the highest level of balance, namely the child must be able to maintain balance far from the center of gravity (Carlberg, 2005). The child's efforts to return to the center of gravity that is too far away are not balanced with the ability of muscle strength and endurance (Faiqa Mehmood Rana, 2022).So this requires a longer repetition effort. Most likely the duration and frequency of exercise limited to 3 months is the cause of the absence of changes in reactive balance which is the highest level of sitting balance in the human body movement system including in children with CP.In the change in the average functional ability of the hand, there was also an increase in the average functional ability between before and after the intervention. Returning to the concept that good, upright posture will facilitate the functionality of the hands and feet, this is very clear in several previous studies (Zulkapli, 2016), (Abd-Elfattah, 2021), (Indira Brundavanam, 2017). The hands and feet as executors of functional movements such as manipulating objects or toys and the feet are used for walking. Both are attached to the pelvic girdle and shoulder girdle. These two girdles are part of the posture or middle of the human body. A stable middle body will make it easier for these executors to work well and vice versa (Carlyne Arnould, 2014), (Chu-Fen Chang, 2011).

In the change in the average functional ability of the hand, there was also an increase in the average functional ability between before and after the intervention. Returning to the concept that good, upright posture will facilitate the function of the hands and feet, this is very clear in several previous studies (Zulkapli, 2016), (Abd-Elfattah, 2021), (Indira Brundavanam, 2017). The hands and feet as executors of functional movements such as manipulating objects or toys and the feet are used for walking. Both are attached to the pelvic girdle and shoulder girdle. These two girdles are part of the posture or center of the human body. A stable center of the body will make it easier for these executors to work well and vice versa (Carlyne Arnould, 2014), (Chu-Fen Chang, 2011). The increase in functional hand ability occurs due to increased stabilization of posture and center of the body in patients as evidenced by increased static balance in a sitting position (Zulkapli, 2016). This is the basis for increasing the ease with which patients can perform active movements with both hands, such as lifting their arms or playing by picking up and manipulating toys (Luzia Lara Pfeifer, 2014).

The application of exercise therapy was carried out for 3 months to improve changes in motor memory in the brain according to (Mohn-Johnsen, 2017) although it was still in the stage of forming short-term memory. Exercise therapy carried out with intense repetition, as in this study, will increase axonal transport so that short-term potentiation will occur (Samsir, 2020). The key to the success of exercise therapy in changing brain function is in intensive repetition

(Samsir, 2020). In this study, the repetition of exercise therapy was 3x per week for 12 weeks, meaning that it is possible that there has been short-term potentiation, or short memory. Indeed, in theory, long-term memory occurs within 6 months of exercise (Samsir, 2020), but due to time constraints in conducting the study, this study could only be carried out for 3 months.

CONCLUSION

Abdominal core stability exercise therapy improves static and dynamic sitting balance, functional hand ability but not improve reactive balance in children with cerebral palsy in YPCP Surabaya.

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