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# Improved hand muscle ability after 6 weeks of squeezing a tennis ball exercise in children with spastic cerebral palsy

*Poprawa zdolności mięśni ręki po 6 tygodniach ćwiczeń ściskania piłki tenisowej u dzieci z mózgowym porażeniem dziecięcym typu spastycznego*

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## Abstract

Children with cerebral palsy tend to be less physically fit compared to typically developing peers. This is mainly due to the lack of physical activity and exercise during their childhood. If adolescents and adults with cerebral palsy don't get enough exercise, it could result in reduced mobility and physical fitness. It is very important to start treatment for cerebral palsy when the child is young. The goal of this research was to investigate how children with spastic cerebral palsy might benefit from enhancing their hand muscle functioning by squeezing a sponge tennis ball during hand-strengthening exercises. The study implemented a true experimental design with a pre-and post-test control group. This methodology allowed for a rigorous and systematic investigation, ensuring reliable and valid results. Twelve boys between the ages of 15 and 17 who were all diagnosed with spastic cerebral palsy participated in sponge tennis ball gripping exercises as part of a program of intervention. A 30-minute workout of sponge tennis ball squeezing involves 4-6 sets of 15-20 repetitions with passive rests of 30 seconds. The prescribed regimen involves conducting the exercise four times per week for six weeks. Before and after the intervention, the Hand Grip Dynamometer was used to assess the hand muscle strength of children with spastic-type cerebral palsy. Data analysis techniques were applied using the independent samples t-test with a significant level of 5%. The results showed the average muscle strength of the right hand after the intervention between control vs. experiment ( $4.36 \pm 1.35$  kg vs.  $34.16 \pm 3.34$  kg ( $p = 0.000$ )), the average muscle strength of the left hand after the intervention between control vs. experiment ( $2.31 \pm 0.49$  kg vs.  $30.18 \pm 2.08$  kg ( $p = 0.000$ )). The findings of the research suggest that engaging in frequent tennis ball gripping exercises, conducted on a frequency of four sessions per week over a duration of six weeks, may yield notable improvements in the hand muscle functionality of children diagnosed with spastic-type cerebral palsy. The findings suggest that including these activities in treatment, procedures may provide significant value for persons with this particular illness.

## Keywords

cerebral palsy, children, spastic type, tennis ball exercise

## Streszczenie

Dzieci z mózgowym porażeniem dziecięcym (MPD) zazwyczaj charakteryzują się mniejszą sprawnością fizyczną w porównaniu do rówieśników o typowym rozwoju. Główną przyczyną jest brak aktywności fizycznej i ćwiczeń w okresie dzieciństwa. Jeśli młodzież i dorośli z MPD nie będą wystarczająco ćwiczyć, może to skutkować zmniejszoną mobilnością i sprawnością fizyczną. Bardzo ważne jest, aby rozpocząć leczenie mózgowego porażenia dziecięcego, gdy dziecko jest jeszcze młode. Celem tego badania było zbadanie, w jaki sposób dzieci z mózgowym porażeniem dziecięcym typu spastycznego mogą skorzystać na poprawie funkcjonowania mięśni ręki poprzez ćwiczenia ściskania gąbczastej piłki tenisowej w ramach ćwiczeń wzmacniających rękę. Badanie zastosowało prawdziwy projekt eksperymentalny z grupą kontrolną przed i po teście. Metodologia ta umożliwiła rygorystyczne i systematyczne badanie, zapewniając wiarygodne i ważne wyniki. W badaniu wzięło udział dwunastu chłopców w wieku od 15 do 17 lat, u których zdiagnozowano spastyczne mózgowie porażenie dziecięce, uczestniczących w ćwiczeniach ściskania gąbczastej piłki tenisowej jako części programu interwencyjnego. Trzydziestominutowy trening ściskania gąbczastej piłki tenisowej obejmował 4-6 serii po 15-20 powtórzeń z pasywnymi przerwami trwającymi 30 sekund. Zalecany reżim zakładał przeprowadzanie ćwiczeń cztery razy w tygodniu przez sześć tygodni. Przed i po interwencji użyto dynamometru ręcznego do oceny siły mięśni ręki dzieci z spastycznym typem mózgowego porażenia dziecięcego. Techniki analizy danych zastosowano, używając testu t dla niezależnych próbek przy istotności na poziomie 5%. Wyniki pokazały średnią siłę mięśni prawej ręki po interwencji między grupą kontrolną a eksperymentalną ( $4,36 \pm 1,35$  kg vs.  $34,16 \pm 3,34$  kg ( $p = 0,000$ )), średnią siłę mięśni lewej ręki po interwencji między grupą kontrolną a eksperymentalną ( $2,31 \pm 0,49$  kg vs.  $30,18 \pm 2,08$  kg ( $p = 0,000$ )). Wyniki badania sugerują, że regularne ćwiczenia ściskania piłki tenisowej, przeprowadzane z częstotliwością czterech sesji tygodniowo przez okres sześciu tygodni, mogą przynieść znaczące poprawy w funkcjonalności mięśni ręki u dzieci zdiagnozowanych z spastycznym typem mózgowego porażenia dziecięcego. Wyniki sugerują, że włączenie tych aktywności do procedur leczenia może dostarczyć znaczącej wartości dla osób z tą szczególną chorobą.

## Słowa kluczowe

mózgowe porażenie dziecięce, dzieci, typ spastyczny, ćwiczenia z piłką tenisową

## Background

Depending on the location of the initial brain lesion, spastic, dyskinetic, and ataxic forms of cerebral palsy are prevalent in neonates. The condition merits our attention and consideration, particularly in the medical field, where a comprehensive understanding of the types and causes of cerebral palsy can contribute to the development of effective treatments [1, 2]. Motor dysfunction that does not worsen with time is a hallmark of cerebral palsy, a neurological disorder caused by problems during brain development. This disorder has a significant impact on an individual's lifelong capacity to engage in various activities [3]. The etiology of permanent muscular contractures in persons diagnosed with spastic cerebral palsy has conventionally been ascribed mostly to muscle atrophy and stretch hyperreflexia, as shown by Kruse et al. [4] and Lieber and Fridén [5]. According to Hanssen et al. [6], spastic cerebral palsy is the most prevalent subclass based on its neuromuscular presentation. Additionally, the topographical categorization further differentiates spastic cerebral palsy into two categories: unilateral involvement and bilateral involvement. Spastic cerebral palsy is classified in children with special needs quadriplegics directly or indirectly affect communication, coordination, mobility, and impaired personal needs [7]. Children in Paradise encounter atypical physiological circumstances, including skeletal problems and irregularities in muscles and joints, resulting in impaired mobility and limitations in doing routine tasks [8]. Both cerebral palsy and children with special needs who have additional impairments are recognized as individuals who encounter disruptions in their physical, mental, cognitive, emotional, and social functioning [9]. In certain instances, irregularities or abnormalities may arise in an individual's developmental process, which may require the provision of special education services [10]. Cerebral palsy is a condition that manifests itself via abnormalities in movement, posture, and tone. According to the dominant motor syndrome, it may be clinically characterized as spastic hemiplegia, spastic diplegia, spastic quadriplegia, or extrapyramidal or dyskinetic syndromes [11]. According to Hu et al. [12], the most common kind of cerebral palsy that may be detected in the population is spastic. In cerebral palsy, muscular paralysis results in a lack of muscle control, deformities, and movement limitations [13]. Not only the motor limbs but also the speech organs will experience disturbances [14]. In normal humans when carrying out a movement, there will be an agreement between the two muscle groups, that is, if one muscle group performs a movement, the other muscle group will automatically relax. When these two groups of muscles contract at the same time, it makes it hard and stiff for people with spastic cerebral palsy to move [15]. Children with cerebral palsy tend to be less physically fit compared to typically developing peers. This is mainly due to the lack of physical activity and exercise during their childhood. If adolescents and adults with cerebral palsy don't get enough exercise, it could result in reduced mobility and physical fitness. It is very important to start treatment for cerebral palsy when the child is young. Maltais et al. [16] say that treating this problem early can help the patient live a better life and have better results. In general, the type of spastic cerebral palsy is a type of abnormality located in the motor cortex [17]. The causes are so varied namely, some are relatively mild so that the effect is only a few movements, while causes

that are classified as more severe can affect the entire body [3]. As a result of the disorder suffered, a quadriplegic is at risk of experiencing various emotional, social, and work barriers [18, 19]. Disturbed physical and mental conditions can risk hampering the learning process [20, 21].

Realizing comprehensive education is a significant challenge for the education community, which includes promoting physical education [22]. The objective of managing cerebral palsy is to enhance functionality, mobility, and autonomy using customized physical activity [23]. Verschuren et al. [24] say that it is of the greatest importance to encourage physical activity and prevent idle behavior in children with spastic cerebral palsy. This is because physical exercise plays a key role in improving general health and lowering the risk of diseases linked to lifestyle. Merino-Andrés et al. [25] said that strength training has been shown to help children with spastic cerebral palsy improve their muscle function and movement. It must be used in the right amount and according to certain rules. For people with spastic cerebral palsy in their hands, practicing holding a tennis ball can be the right choice. However, not many studies have addressed this issue. The goal of this research was to investigate how children with spastic cerebral palsy might benefit from enhancing their hand muscle functioning by squeezing a sponge tennis ball during hand-strengthening exercises.

## Methodology

The study implemented a true experimental design with a pre- and post-test control group. The research recruited a cohort of twelve male individuals, ranging in age from 15 to 17 years, all of whom had received a diagnosis of spastic-type cerebral palsy. The participants received interventions through a physical exercise regimen that required them to squeeze a sponge tennis ball. Before the commencement of the research, all participants were furnished with both oral and written information about the study. They then provided their informed consent by signing a consent form. The procedures conducted in this study were granted approval by the Health Research Ethics Committee at the Faculty of Medicine, University of Brawijaya, under the reference number 260/EC/KEPK-S1/09/2019. Furthermore, this study adheres to the ethical guidelines outlined in the Helsinki World Medical Association Declaration concerning the ethical conduct of research involving human subjects.

The activity of applying pressure to a sponge tennis ball was carried out in the presence of knowledgeable staff from the Department of Sports Science in the Faculty of Sports Science at the State University of Malang. The participants were allocated randomly into two distinct groups, namely Control ( $n = 6$ ) and Experiment ( $n = 6$ ). The sponge tennis ball squeezing exercise is performed for a duration of 30 minutes every session, divided into 4-6 sets consisting of 15-20 repetitions each. Passive rest periods of 30 seconds are used between sets. The exercises were carried out 4x/week for 6 weeks and Grip Dynamometer measures the grip strength in spastic cerebral palsy children [26] which was carried out before and after the intervention with three measurements and then the value of the measurements event results. The data underwent analysis to assess its conformity to a normal distribution using the Shapiro-Wilk test. Paired and independent sample t-tests were conducted at a level of significance of 5%. Data are shown with Mean  $\pm$  SD.



## Results

Based on the study results, it has been observed that there was a notable augmentation in the mean muscular strength of both the dominant and non-dominant hands before to and subsequ-

ent to a six-week intervention including the utilization of a sponge tennis ball for squeezing. The augmentation of muscle strength is depicted in Figures 1 and 2.

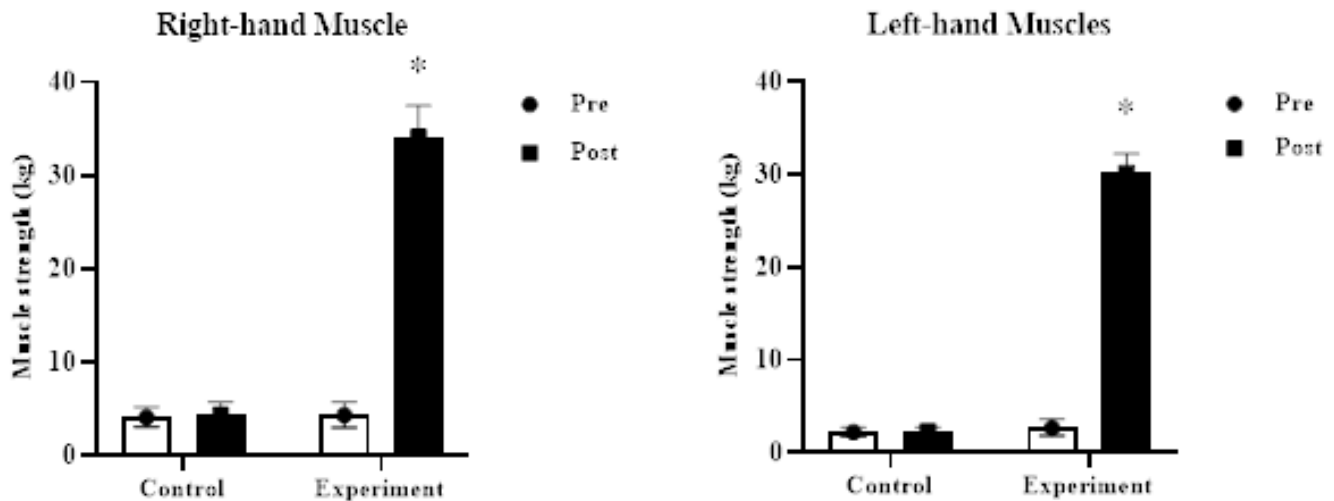


Figure 1. Average muscle strength of the right and left hands before and after the intervention in each group. (\*) significantly different from the pretest ( $p \leq 0.001$ ). Data are shown with Mean  $\pm$  SD. A paired Sample t-test was applied to find out the p-value

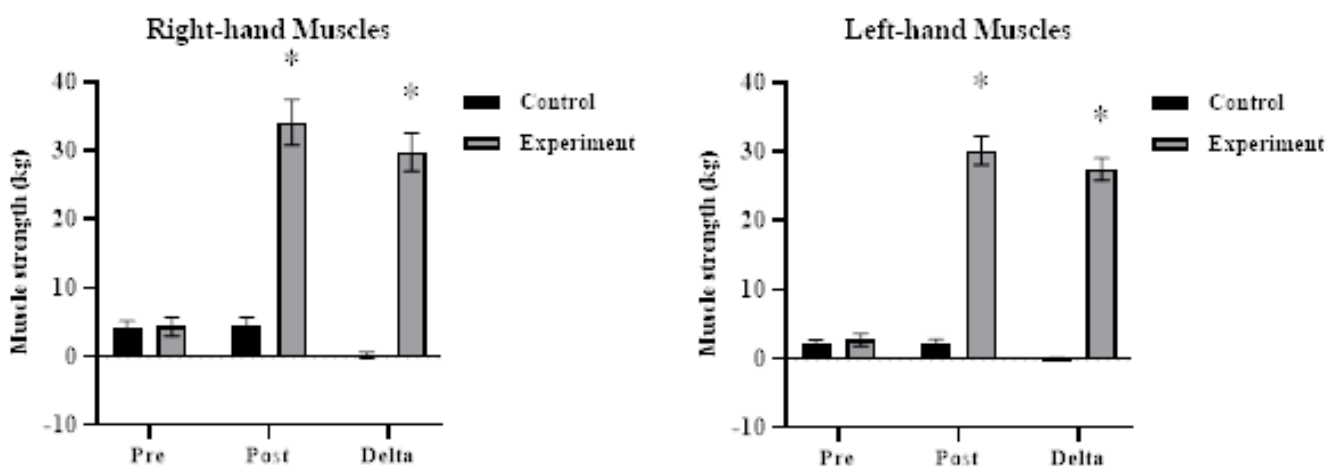


Figure 2. Average muscle strength of the right and left hands between control vs. experiment. (\*) significantly different from the control ( $p \leq 0.001$ ). Data are shown with Mean  $\pm$  SD. Independent Samples t-test was applied to find out the p-value

## Discussion

The goal of this research is to assess the impact of a tennis ball-squeezing training program on the enhancement of manual muscle strength in pediatric individuals diagnosed with spastic-type cerebral palsy. The present investigation has yielded noteworthy findings indicating a substantial enhancement in the muscular strength of both the right and left hand after 6 weeks including the repetitive action of squeezing a tennis ball. We are delighted to present this significant discovery to

our respected readership. This finding aligns with the findings reported by Merino-Andrés et al. [25], who asserted that strength training has a functional impact and beneficial influence on muscular activity. The primary objective in the care of cerebral palsy is to maximize the functional abilities, mobility, and independence of those afflicted by this disease [23]. Patients diagnosed with spastic hemiplegic cerebral palsy may present with many manifestations in the afflicted hand, including stiffness, paralysis, and dystonia, as reported by Hamed

et al. [27]. Regular physical exercise is anticipated to facilitate the restoration of normal muscle function, hence enhancing the ability to perform everyday physical tasks more effectively. According to a study conducted by Damiano and Abel [28], it was shown that enhancing muscular strength may lead to an improvement in motor function among patients diagnosed with spastic-type cerebral palsy.

Skeletal muscles are motors that produce movement and maintain posture by exerting force [29]. According to Chen et al. [30], there is an increased likelihood for children diagnosed with spastic cerebral palsy to experience the development of motor disorders, comorbidities, and subsequent concerns stemming from these motor disorders. These complications have the potential to impede their physical growth, overall development, and overall well-being. Prolonged contraction of spastic muscles can lead to the formation of contractures and the development of skeletal abnormalities. Consequently, this can result in heightened stiffness of joints and muscles, as well as a restricted range of motion for both passive and active joints [29, 31–40]. The literature suggests that exercise has been found to have a positive impact on functional and neural recovery. Specifically, it has been shown to enhance motor function by increasing synaptic plasticity, promoting myelin regeneration, supporting neuronal survival, and facilitating ce-

rebral angiogenesis [41–44]. Additionally, exercise has been found to increase the range of motion of joints [45]. Existing research suggests that exercise has the potential to significantly improve muscular strength in children diagnosed with spastic cerebral palsy.

The present investigation was constrained by the restricted sample size of participants who had comparable characteristics, namely, those with spastic cerebral palsy. Hence, it is recommended for future studies to increase the sample size by enrolling more participants who meet the same inclusion criteria.

## Conclusion

The research findings indicate that implementing a regimen of tennis ball gripping exercises, administered four times per week over a duration of six weeks, had positive outcomes in enhancing hand muscular capabilities among children diagnosed with spastic cerebral palsy.

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