# Correlation Between Muscle Power And Architecture Of Biceps Brachii In Children With Spastic Hemiplegic Cerebral Palsy

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## ABSTRACT

**Background:** Cerebral palsy (CP) refers to a collection of permanent mobility and postural impairments that are caused by non-progressive disruptions in the fetal or infant brain throughout development. Children with cerebral palsy have motor abnormalities that are commonly accompanied by sensory and cognition disorders as well as seizures and secondary musculoskeletal difficulties. **Purpose:** To check if there were any correlations between the ultrasonography pictures of muscle thickness and muscle pennation and the muscle strength in hemiplegic cerebral palsied children. **Materials and methods:** Only one group contained thirty children from both sexes diagnosed as CP in the form of spastic hemiplegia. Their age ranged from two to six years old. They were recruited and their parents signed consent forms to participate. Cases were selected according to modified Ashworth scale as grade 1 and +1 spasticity. Ultrasonography was used to measure the muscle architecture parameters while dynamometer was used to measure muscle strength. **Results:** Results showed that there was found a mild positive correlation between grip strength and muscle thickness ($r = 0.46$, $p = 0.01$), and a mild positive correlation between grip strength and angle of pennation ($r = 0.37$, $p = 0.03$) on the affected side. While the non-affected side, there was a moderate positive correlation between grip strength and muscle thickness ($r = 0.51$, $p= 0.004$), and a mild positive correlation between grip strength and angle of pennation ($r = 0.39$, $p = 0.03$). **Conclusion:** There is a significant correlation between grip strength and both; muscle thickness and pennation angle of the biceps brachii muscle in the affected and non-affected sides of the spastic hemiplegic cerebral palsy children.

**Keywords:** Muscle Power, Architecture, Biceps Brachii, Spastic Hemiplegic.

## I-INTRODUCTION

Cerebral palsy (CP) refers to a collection of permanent mobility and postural impairments that are caused by non-progressive disruptions in the fetal or infant brain throughout development. Children with CP have motor abnormalities that are commonly accompanied by sensory and cognition disorders as well as seizures and secondary musculoskeletal difficulties . Cerebral palsy can be broken down into four basic categories based on the degree of activity restriction: (1) motor abnormalities, (2) accompanying impairments, (3) anatomical and neuroimaging results (4) etiology and timing of motor problems [1].

Strength assessments are commonly used in medical practice and rehabilitation programs to assess the health status of patients and the effectiveness of training programs. Muscle strength in children with developmental disorders such as CP is assessed using dynamometer measures [2]. Although CP is primarily linked to movement abnormalities, impairments can also include sensory and perceptual issues, global or specific cognitive challenges, communication and behavioral problems as well as seizures [3].

Dynamometers are widely used because they are inexpensive, easy to use and don't require any special preparation of the subject. Dynamometer readings, on the other hand, can be impacted by an operator and patient placement problems [2, 4].

Muscle thickness and pennation angle can be quantified using ultrasound [5]. Researchers believe ultrasonic imaging is a reliable tool for measuring muscular strength and determining lean mass. It is true that the measurement of muscle cross sectional area (CSA) gives a way to quantify prospective alterations, but it does not demonstrate the exact dimensionality of the configurationally change. To put it another way: A total score doesn't take into account how much each dimension contributes, which could provide extra insight into functional limits due to pathology and allow for a closer look at the effects of strength training [6].

Ultrasound is a far less expensive and more portable imaging technology compared to CT and MRI. Quantitative and qualitative information regarding muscle aspects can be obtained using ultrasound technology, which may be related to measurements of muscular strength, myopathy and normal muscular cross-sectional diameters during contraction and relaxation, as well as how these changes relate to strength. This might help us to better understand the potential of ultrasound imaging in assessing the response to exercise and, conversely, the disuse of a particular muscle [7].

Motor unit in-activation causes muscle weakness in CP patients, and 50 percent of tiny muscles are thinner in CP patients compared to children with normal development [8]. Abnormal movement patterns, coupled with muscle atrophy and reorganization of the internal muscle architecture, could result in knee extensor weakness and secondary disuse [9].

To examine the relationship between muscular force and the image character of an individual muscle; muscle ultrasonography has been employed in biomechanical investigations [10]. Monitoring muscle contractions using ultrasonography can provide a good image of muscle function [11].

Muscle strength and re-education in physiotherapy can be improved by employing ultrasonography to measure muscle contractions, according to research [12]. Therefore, the goal of this study was to test the correlation between ultrasonographic readings (thickness and pennation angle) and dynamometer readings in children with hemiplegic CP, and to prove that ultrasound measurement of muscle thickness might be a reliable evaluation for muscle strength. We assumed that if this purpose was achieved, the architecture parameters can be used as an objective non-invasive method for evaluation of muscle strength in children with CP.

## II- MATERIALS & METHODS

- **Design of the study:** An experimental correlational research design was used.

The study involved only one group, which included 30 children with hemiplegic CP of both sexes. Their age ranged from two to six years old. Patients were selected from Minia government: Outpatient Clinics, Faculty of Physical Therapy Deraya University and Samalout general hospital, from January 2021 to October 2021. Written consent forms were signed by all parents of children.

- **Inclusion criteria:**

This research included patients who met the following criteria:

1. They were diagnosed as spastic hemiplegic CP.
2. They were from both sexes and their age ranged from two to six years.
3. According to the Gross Motor Function Classification Scale (GMFCS), they were grades I and II.
4. Spasticity was assessed as 1 or 1+ on the Modified Ashworth Scale .

- **Exclusion criteria:**

Children were excluded from the study if:

1. They were born with a permanent deformity of the elbow.

2. Children with a history of upper limb trauma or surgery on either the affected or the non-affected side.

3. Children who were unable to cooperate with the assessment owing to mental or psychological issues.

- **Instrumentation:**

**A) For Selection:**

*1. Gross motor function classification system (GMFCS):*

It was used for selection of children, The GMFCS was developed to describe gross motor function in children with CP and has its focus on self-initiated movements, in particular sitting and walking. It is an age-related five-level system in which level I represents the least limitation and level V the most. The GMFCS had been proved to be a valid and reliable tool and has been reported to remain relatively stable over time. The GMFCS has been internationally accepted and is widely used. According to the designers of the GMFCS, most children would be remain at the same level from age 2 to 6 years old, which makes it possible to try to predict gross motor development [13].

*Modified Ashworth scale:*

One of the most commonly used spasticity tests is the Modified Ashworth Scale, which requires minimum equipment and can be conducted quickly and comfortably in a day-care center. Using a manual technique, the test measures muscular resistance to passive stretching. As a result, it was originally thought to be a measure of spasticity. However, the test's speed has an impact. When walking, as explained below, the limb segments should be moved through their full range of motion [14], table (1).

**Table 1.** Modified Ashworth scale.

| Grading | Description |
|---|---|
| **0** | No increase in muscle tone. |
| **1** | Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the ROM. |
| **1+** | Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM. |
| **2** | More marked increase in muscle tone through most of the ROM but affected part(s) can be easily moved. |

**ROM=** Range of motion.

**B) For Measurements**

- **Ultrasonography:**

The architectural parameters of the biceps brachii muscle were measured using an ultrasound 2D device (Mindray Dp 10) with a 10 MHZ linear transducer probe, figure (1). Affected and unaffected arm would be compared. MRI and computerized tomography are expensive, bulky, and inaccessible compared to ultrasound, which is less expensive, more portable, and more accessible [9].

**Figure 1.** 2D Ultrasonography Mindary Dp 10.

- **Handheld Dynamometer:**

To measure the maximum muscular strength produced by the muscle, the Handheld Dynamometer (HHD) is an easy-to-use instrument with a wide range of applications and a quick and objective response [15, 16, and 17].

- **Procedures:**

*A) Measurement of muscle architectural parameters:*

By using ultrasonography to measure architectural parameters of the biceps brachii muscle of the affected and less affected limb in each subject from supine lying and sitting positions with elbow extension.

*1- Pennation angle*

Drawing two lines parallel to the fascicle and the deep bone, and measuring the pennation angle between those two lines [18].

*2- Measurement of muscle thickness:*

Ultrasonography device was used to measure the muscle thickness of the biceps brachii for the included children.

At first, the child was positioned in supine position with extended elbow. A longitudinal section image was taken by ultrasonography for the affected biceps muscle for hemiplegic child while the researcher was seated beside the patient to support the upper limb as needed as shown in, figure (2).


**Figure 2.** Ultrasonography for biceps muscle.

After capturing the images by ultrasonography, the researcher measured muscle thickness by measuring a distance by drawing a vertical line between the superficial aponeurosis and the deep aponeurosis or bone as shown in, figure (3).

**Figure 3.** Measurement of muscle thickness of biceps muscle by ultrasonography (A) normal limb, (B) affected limb.

*B) Measurement of muscle strength:*

Muscle strength was measured with the use of a handheld dynamometer (HHD), a tool that is easy to use and has a wide range of applications, as well as providing a quick and objective answer [15, 16, and 17].

- **Procedures of muscle strength measurement**

1- A standard posture (supine and sitting) was used to measure each child's abilities.

2- Hand-held techniques were used.

3- As part of a make test, which holds the muscle at a constant length to reduce reflexes, maximal isometric contractions are carried out. In order to acquaint the youngster with the procedure, a practice trial was conducted before beginning the session.

4-There were three trials administered for each muscle group, with strong verbal encouragement utilized to reach maximum effort during the trials [19].

5- A total of three maximal voluntary isometric contractions lasting five seconds were required of the participants, with a 10-second rest interval between trials. The peak torque of three trials for a particular muscle group was recorded.

6- As the subjects were supine, their elbows were extended, figure (4). During each test, the dynamometer was kept as still as possible.

7- The Examiner sits next to the patient's extended arm, supporting the elbow joint of the subject as he or she was being examined.

8- The examiner applied resistance to prevent the limb from moving. In the case of two consecutive trials, there was a one-minute rest interval in between.

9- As a result of the three trials, the best reading was taken and recorded.

**Figure 4.** Positioning of the examiner and the subject during the procedure:(assessment of muscle strength).

- **Statistical analysis:**

Descriptive statistics was utilized in presenting the subjects demographic and clinical data. Pearson Correlation Coefficient was conducted to investigate the correlation between grip strength, muscle thickness and pennation angle. The level of significance for statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

## III- RESULTS

- **Subject Characteristics:**

Thirty children with spastic hemiparesis participated in this study. Their mean ± SD age was 4.5 ± 1.3 years respectively, table (2).

- **Grip strength, muscle thickness and pennation angle of the study group**

The mean ± SD grip strength of the affected and non-affected sides of the study group were 0.68 ± 0.37 and 1.05 ± 0.64 kg respectively. The mean ± SD muscle thickness of the affected and non-affected sides of the study group were 0.74 ± 0.21 and 0.92 ± 0.18 cm respectively. The mean ± SD angle of pennation of the affected and non-affected sides of the study group were 8.66 ± 1.72 and 10.33 ± 2.07 degrees respectively, table (3).

**Table 2.** Participant characteristics.

| | Mean ± SD | Maximum | Minimum |
|---|---|---|---|
| **Age (years)** | 4.5 ± 1.3 | 6 | 2 |
| | **N** | **%** | |
| **Sex distribution, n (%)** | | | |
| **Girls** | 18 | 60 | |
| **Boys** | 12 | 40 | |
| **Affected side, n (%)** | | | |
| **Right** | 16 | 53 | |
| **Left** | 14 | 47 | |

**SD,** Standard deviation

**Table 3.** Descriptive statistics of grip strength, muscle thickness and pennation angle of the study group.

| | Mean ± SD | Minimum | Maximum |
|---|---|---|---|
| **Grip strength (kg)** | | | |
| Affected side | 0.68 ± 0.37 | 0.2 | 1.5 |
| Non affected side | 1.05 ± 0.64 | 0.5 | 2.1 |
| **Muscle thickness (cm)** | | | |
| Affected side | 0.74 ± 0.21 | 0.33 | 1.1 |
| Non affected side | 0.92 ± 0.18 | 0.5 | 1.18 |
| **Angle of pennation (degrees)** | | | |
| Affected side | 8.66 ± 1.72 | 6 | 12 |

| | | | |
|---|---|---|---|
| Non affected side | 10.33 ± 2.07 | 9 | 15 |

**SD,** Standard deviation

- **Correlation between grip strength, muscle thickness and pennation angle of the study group**

The correlation between grip strength of the affected side and muscle thickness was moderate positive significant correlation (r = 0.46, p = 0.01) and was moderate positive significant correlation with angle of pennation (r = 0.37, p = 0.03), table (4).

The correlation between grip strength of the non-affected side and muscle thickness was a moderate positive significant correlation (r = 0.51, p = 0.004) and was a moderate positive significant correlation with angle of pennation (r = 0.39, p = 0.03), table (4).

**Table 4.** Correlation between grip strength, muscle thickness and pennation angle of the study group.

| | Grip strength (kg) | | | |
|---|---|---|---|---|
| | Affected side | | Non affected side | |
| | r - value | P- value | r - value | P- value |
| Muscle thickness (kg) | 0.46 | 0.01 | 0.51 | 0.004 |
| Angle of pennation (degrees) | 0.37 | 0.03 | 0.39 | 0.03 |

***r value,** Pearson correlation coefficient; **p value,** Probability value.

## IV- DISCUSSION

The goal of this study was to explore the correlation between muscle power and architecture of biceps brachii in children with spastic hemiplegic CP.

Children aged 4.5 ± 1.3 years old, results showed there were a strong relationship between affected and less affected sides regarding pennation angle, muscle thickness and muscle strength.

Also, the correlation between grip strength and muscle thickness of the affected side was a moderate positive significant correlation and the correlation between grip strength and angle of pennation of the affected side was a moderate positive significant correlation.

When it comes to measuring muscle thickness, a wide range of people with CP can benefit from it, as it correlates with GMFM-88 activities. Children who are unable to conduct strength or functional tests can benefit from this measurement since it provides vital information about their muscles. After a muscular strengthening intervention, it may be eligible for quantitative measurement [20].

According to Moreau et al., [21], children and adolescents with and without CP could benefit from ultrasound evaluations of muscle thickness that were adjusted for age and GMFCS level (CP).

Muscle thickness is an indicator of muscle mass which reflect the level of daily activity (ADL), as a reduction in physical activity due to various impairments results in a drop in muscle mass in children. In case of Children with severe CP we can't evaluate muscle strength by the traditional way [20].

With Dynamometry, you may evaluate your volitional strength in a way that is not as subjective as the Medical Research Council scale for manual muscle tests, especially at grades 4 and 5. Baldwin et al., [22] investigated the reliability, least detectable change, and time to peak muscle force, measured with portable dynamometry, in critically sick patients as the key objectives of their research. Portable dynamometers were used to test isometric handgrip, elbow flexion, and knee extension.

The use of dynamometry during acute recovery could offer trustworthy readings in critically ill individuals. Impaired neuromuscular control may be seen in a lack of force timing [22]. Ultrasound has been employed in the majority of research to quantify muscle architecture parameters. In contrast to ultrasonic imaging, which is highly specialized and difficult to do, MRI is used less frequently because it is expensive and difficult to perform, as it demands extended relaxation, which is difficult to obtain in a predominantly pediatric patient base. When specific conditions are satisfied, such as joint relaxation and static position, ultrasonic imaging can be used to accurately measure the architectural elements of human skeletal muscles in vivo [23].

In our study There was a sonographer with over ten years of muscle scanning experience who did all of the ultrasounds, demonstrating strong reliability and validity [24].

In hemiplegic CP children muscle weakness occur due to reduced central drive, insufficient and interrupted motor recruitment, loss of voluntary control, loss of reciprocal inhibition, altered muscle spindles and reinforcement of abnormal neural circuits, changes in length of fibers and cross-sectional areas and reduced elasticity of muscles [24].

Leunkeu et al. [26] came in agreement with our study who found that children with CP with hemiplegia had reduced maximal isometric quadriceps strength in both the affected and non-affected leg compared to age-matched control children. As a result of these factors, there could be increased stiffness around the joints, spasticity or muscle weakness, or a combination of these. Moreover, children with CP could neither recruit higher threshold motor units or drive lower threshold ones towards higher firing rates, according to surface EMG findings. Children with CP had lower mean median frequency values in both affected and unaffected legs, indicating a higher level of muscular exhaustion.

Chen et al., [24] found that children with spastic CP and typically developing peers were compared for muscle thickness, fascicle length, and pennation angle. This cross-sectional study included 72 children with hemiplegic CP (n = 24), diplegic CP (n = 24), and their TD counterparts (n = 24). In order to determine the muscle architecture during rest, ultrasound was used. In the clinical setting, gross motor function and a Modified Ashworth Scale were used. Tibialis anterior and gastrocnemius muscles in children with CP were significantly weaker than those in their TD counterparts ($p< 0.05$). There were statistically significant changes between affected and unaffected sides in terms of muscle thickness and muscle strength ($p< 0.05$), according to our research.

The results of the current study agreed with [27] who claimed that spastic threshold velocity, using electromyography during isokinetic testing, for the quadriceps and hamstrings correlated with the Gross Motor Function Measure (GMFM), indicating the milder the spasticity the higher the function.

Mohagheghi et al., [28] found that the changes in gastrocnemius muscle architecture between the paretic and non-paretic legs in children with hemiplegic CP. Their findings were in agreement with our study in several outcomes and characteristics. Eight children with CP had their gastrocnemius muscle architecture assessed in vivo using ultrasonography using paretic and non-paretic legs. This resulted in a reduction of 18% and 20% in fascicle length and muscle thickness in the paretic legs compared to the non-paretic legs, respectively ($p< 0.05$) When it comes to other outcomes or parameters. Mohagheghi et al., [28] disagreed with our study There were no significant differences ($P>0.05$) in the pennation angles between the two types of leg: paretic and non-paretic

This study came in agreement with Reid, et al. [29] who found that children with spastic CP had larger and stronger knee flexor muscles than typically developing youngsters (TD). A total of 18 children with spastic diplegia, Gross Motor Function Classification System I-III, and 19 children with TD took part in this study. They measured muscle volume (MV) and cross-sectional area (ACSA) by using MRI. The peak torque (PT) and the knee's With the Biodex dynamometer, flexors and extenders were measured isometrically, isokinetically, and then normalized to body mass (BM). Across all torque variables, children with CP were weaker than their TD classmates, according to the results. Compared to TD children, children with CP had a poorer link between muscle size and strength. As for children with Down syndrome and CP, the strongest link was found between the two types of exercise: maximal voluntary contraction (MVC) and isometric (PT/BM). They found that children with CP have smaller, weaker muscles.

There were statistically significant changes between affected and unaffected sides for pennation angle, muscle thickness, and muscular strength ($P< 0.05$) in our investigation. A moderate direct association existed between muscle strength and pennation angle on the less affected side and on the more affected side (0.367and 0.434 respectively) . There was no link between muscle thickness and muscle strength in the less affected and affected side respectively [29].

According to Moreau et al. [9], there was no correlation between the maximum voluntary knee extensor torque in children and adolescents with or without CP and activity levels. Eighteen CP patients (GMFCS levels I through IV) and twelve age-matched peers with normal development were evaluated in the study. Rectus femoris (RF) and Vastus lateralis (VL) muscles were measured using 2-dimensional B-mode ultrasound imaging. Activities

Scale for Kids, Performance Version and Pediatric Outcomes Data Collection Instrument (PODCD) were used to measure activity and participation in patients with CP. Using ultrasound measurements of VL muscle thickness as a surrogate for voluntary strength, this study found that it was strongly predictive of maximum torque after adjusting for age and GMFCS level (force-generating capacity).

Our study don't agree with Lori et al., [30] who found an increase in muscle width with age, which was in clear agreement with the use of age- related normal parameters.

Also this conflict with Nelson et al ., [31] who stated that average fascicle lengths for both biceps brachii (long head) was significantly shorter in the paretic arm across all elbow positions in the relaxed condition.

## V- CONCLUSION

There is a significant correlation between grip strength and both; muscle thickness and pennation angle of the biceps brachii muscle in the affected and non-affected sides of the spastic hemiplegic CP children.

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