Correlation between Pennation Angle and Muscle Strength in Children with Hemiplegic Cerebral Palsy

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ABSTRACT

Background: Cerebral palsy describes a group of permanent disorders of movement and posture development, causing activity limitations attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. **Purpose:** This study was conducted to correlate between pennation angle and muscle strength in children with hemiplegic cerebral palsy. **Subjects and materials:** There was only one group that include 40 hemiplegic cerebral palsied children of both sexes. Their ages ranged from four to Nine years. Recruited from the outpatient clinics, National Institute of Neuromuscular Disorders and Cairo university hospitals. All parents of children signed a consent form. Ultrasonography was used to assess pennation angle while dynamometer used to assess quadriceps muscle strength. **Results:** Children aged 6.67 ± 1.58 years, there were strong direct correlations between affected and less affected sides (0.967and 0.953) regarding pennation angle and muscle strength respectively. Also, there were moderate direct correlations between strength and pennation angle (.367 and .434). Also, there is statistically significant difference between both sides regarding pennation angle and muscle strength (P>0.000). **Conclusion:** It could be concluded that there was difference in muscle strength and architecture between affected and less-affected side in hemiplegic cerebral palsied children. so, we can somehow predict muscle strength from pennation angle as there is moderate direct correlation between them.

Keywords: Hemiplegia; Cerebral Palsy; Muscle Strength; Muscle Pennation Angle.

INTRODUCTION

Cerebral palsy (CP) describes a group of permanent disorders of movement and posture development, causing activity limitations attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by

disturbances of sensation, perception, cognition, communication, and behavior, Epilepsy and secondary musculoskeletal problems represent the main factors hindering physical rehabilitation" Recognizing the extent of activity restriction is an important part of the CP evaluation, Cerebral Palsy can be classified into four major components: (1) motor abnormalities, (2) accompanying impairments, (3) anatomical and neuro- imaging findings, and (4) causation and timing (1).

Traditionally, hemiplegia or hemiparesis, was defined as a central "unilateral" palsy that only affects one side of the body, almost always of "spastic" type, While the word "hemidystonia" is more adequately used to define the dyskinesic form. With respect to cerebral palsy, a distinction is made between a congenital form of hemiplegia, when the lesion occurs before the end of the neonatal period (within the first four weeks of life), and an acquired form, when the lesion provoking hemiplegia occurs later, within the first three years of life (2).

Congenital forms of hemiplegia cerebral palsy children amount to 70-90% of childhood hemiplegia, while acquired forms only amount to 10-30% (3) .

In A review conducted by Surveillance of Cerebral Palsy in Europe (SCPE) working group, the prevalence of unilateral spastic hemiplegia accounted for about 0.6 per 1000 live births and it did not change significantly over time (4).

Hemiplegic CP forms the most common expression of CP; more than 38 % of cases are hemiplegic, In terms of frequency hemiplegic CP is considered the second (after diplegia), in premature infants as 20% of cases (5).

Very often, in the medical practice and in rehabilitation programs, strength measurements are performed to evaluate the health status of patients and effectiveness of training programs. The force measurements by Dynamometers were also used to assess muscle strength in children with developmental disabilities, such as cerebral palsy (6).

The use of dynamometer is very popular because the device is inexpensive, easy to use and does not require specific patient preparation; in fact, the patient has just to assume the position defined by the protocol, e.g.

sitting on a bench for knee flexion/extension trials, while the therapist applies the dynamometer on the leg and asks the patient to push against the dynamometer. At the end the therapist simply reads the force value on the display of the device, On the other side, dynamometer measures are affected by errors due to the operator and patient positioning, Studies

were already conducted on the intertester reliability of the method and concluded that the method is questionable since due to the low reproducibility among trial repetitions (6) (7).

Currently ultrasound is the most widespread method used to quantitively estimate the muscle architectural characteristics which are represented by the pennation angle (8).

Compared with CT and MRI, ultrasound is a considerably less expensive and relatively more portable imaging technique. Ultrasound technology provides quantitative and qualitative information about muscle features that may be linked to measures of muscle strength. Observations of how normal and myopathic muscles differ in cross-sectional diameters during contraction and relaxation and how these differences relate to strength may lead to a better appreciation of the potential of ultrasound imaging in quantifying response to exercise and, conversely, to disuse (9).

MATERIALS AND METHODS

Correlational study was used. A Group of 40 hemiplegic cerebral palsied children of both sexes. Their ages ranged from Four to Nine years. Selected from the Outpatient Clinic , National Institute of Neuromuscular Disorders and Cairo university hospitals. All parents of children signed a consent form. The following inclusion criteria were assured: grade I and II according to Gross Motor Function Classification (GMFCS) while spasticity was graded 1 and 1+ according to modified Ashwar's scale. Hemiplegic children who had knee joint deformity or lower limb surgery in more or less affected side were excluded from this study.

Ultrasound 2D device (Mindray Dp 10) with 10 MHZ linear transducer probe will be used to measure the architectural parameters of the quadriceps muscles. (Figure 1) By using ultrasonography to measure pennation angle of the quadriceps muscles of the affected and less affected limb in each subject from supine lying position with knee extension and hip in mid position. Pennation angle: Is the angle between muscle fiber and bone .

Figure (1): 2D ultrasound device (Mindray Dp 10) with 10 MHZ linear transducer probe

The Chatillon dynamometer is used to obtain an isometric measure of quadriceps muscle performance of both lower limb extremities, has been shown to have good reliability in the assessment of isometric strength of children with Cerebral Palsy .(10)

Maximum voluntary isometric contraction

The maximum force a muscle can generate can be measured by MVIC. This was done with the patient stabilized in a standard position pressing as hard as possible against a relatively stationary strap or pad with a force transducer connected to a frame. The examiner's role is to properly set up the equipment, position the patient to isolate the muscle in question, and encourage the patient to exert maximum effort. This was not a manual test. The recorded force depended entirely on the patient's voluntary action (11).

RESULTS

Age was distributed as follows: 12 patients of age 5, 12 patients of age 6, 2 patients of age 7, 5 patients of age 8 and 9 patients of age 9 with mean ± SD of 6.67 ± 1.58 as shown in **(figure 2).** Also when looking to gender we can found that 15 child were female while 25 child were male as shown in **(figure 3).** The results were summarized and represented in **tables (1) and (2).**

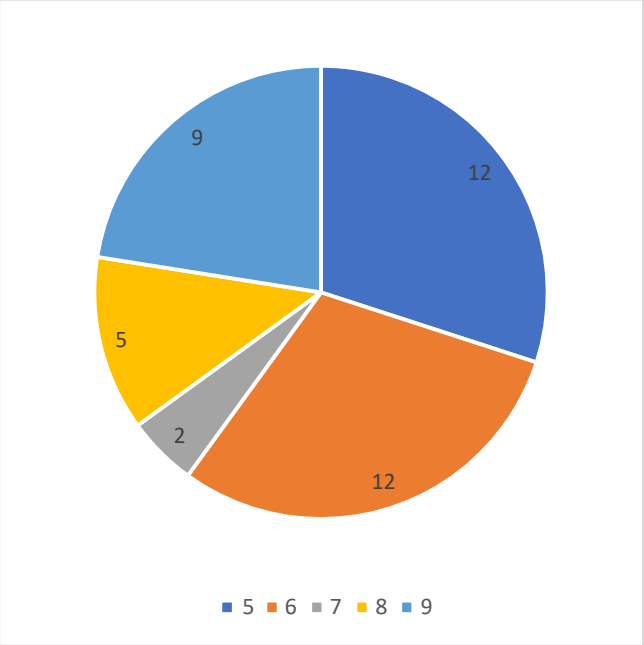

Figure (2): Age distribution among the group.

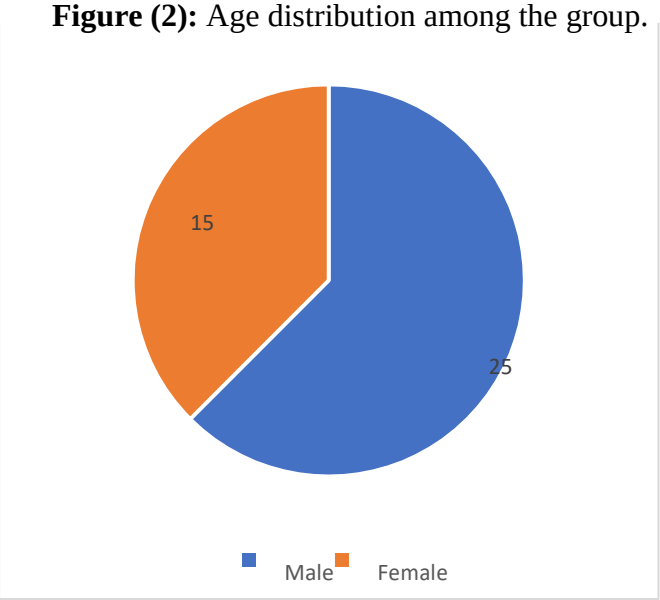

Figure (3): Gender distribution among the group

Table (1): Paired t test statistics between affected and non-affected side.

	Affected	less affected	t	P	Sig.
Pennation angle	15.35±3.26	18.05±3.71	-17.209	0.000	S
Muscle strength	14.08±4.13	16.95±4.94	-11.334	0.000	S

Regarding pennation angle values, the mean ± SD was 15.35±3.26 in affected side against

18.05±3.71 in less affected side with paired t value of -17.209 and correlation coefficient of 0.967 with P>0.000 in both tests. Regarding muscle strength values, the mean ± SD was 14.08±4.13 in affected side against 16.95±4.94 in less affected side with paired t value of -11.334 and correlation coefficient of 0.953 with P>0.000 in both tests.

Table (2): Correlation between strength and pennation angle in less affected and affected side.

	Pennation angle	
	R2	P
Strength less Affected	.367	0.020
Strength Affected	.434	0.005

Also the correlations showed moderate correlation between strength and pennation angle either in less affected or affected side (.367)

DISCUSSION

There were strong direct correlation between affected and less affected sides (0.967 and 0.953) regarding pennation angle and muscle strength respectively. Also there were moderate direct correlations between strength and pennation angle (.367 and .434). Also, there were statistically significant difference between both sides regarding pennation angle and muscle strength (P>0.000).

Leunkeu.,et al. 2010 came in agreement with our study who stated that Children with hemiplegic cerebral palsy exhibited a lower maximal isometric strength of the quadriceps muscle in both affected and non affected leg compared to their age-matched control children. Their results may be explained by the abnormalities of skeletal muscle function caused by spasticity, muscle weakness, excessive co activation of antagonist muscle, and increased stiffness around joints.

Moreover, the surface EMG data suggest that children with cerebral palsy were unable to recruit higher threshold motor units or to drive lower threshold motor units to higher firing rates. Furthermore, the mean median frequency values were lower in both affected and less affected legs of children with cerebral palsy in each muscle group examined, which suggests a higher level of muscular fatigue .(12)

Reid., et al. 2015 came in agreement with our study who conducted to investigate the muscle size–strength relationship of the knee flexors and extensors in children with spastic cerebral palsy (CP) in relation to typically developing children (TD). Eighteen children with spastic Diplegia, Gross Motor Function Classification System I–III and 19 TD children participated. Muscle volume (MV) and anatomical cross-sectional area (ACSA) were assessed using MRI. Measures of peak torque (PT) and work of the knee flexors and extensors were assessed isometrically and isokinetically using a Biodex dynamometer, and normalised to body mass (Bm). Results showed that Children with CP were weaker than their TD peers across all torque variables were smaller in children with CP. The relationship between muscle size and strength in children with CP was weaker than the TD children. The strongest relationship was between MV and isometric PT/Bm for TD children , and between MV and isokinetic work for children with CP. And from their results it could be concluded that Children with CP have smaller, weaker muscles than their TD peers (13). which was agreed with our study results which concluded that There were statistically significant differences between affected and less affected sides regarding pennation angle and muscle strength (p<0.05). Also, there were moderate direct correlations between muscle strength and pennation angle in less affected and affected sides (.367 and .434 respectively) .

Moreau ., et al. 2010 came in agreement with our study who conducted to determine whether the architecture of the rectus femoris (RF) and vastus lateralis (VL) muscles was predictive of maximum voluntary knee extensor torque in

children and adolescents with and without CP and whether these measures were related to activity and participation levels. Eighteen participants with CP at Gross Motor Function Classification System (GMFCS) levels I through IV and 12 age-matched peers with typical development were evaluated. Muscle thickness, fascicle length, and fascicle angle of the RF and VL muscles were measured with 2-dimensional, B-mode ultrasound imaging. The activity and participation measures used for participants with CP were the Pediatric Outcomes Data Collection Instrument (PODCI) and the Activities Scale for Kids, Performance Version (ASKp). They concluded that Ultrasound measures of VL muscle thickness,

adjusted for age and GMFCS level, were highly predictive of maximum torque and have the potential to serve as surrogate measures of voluntary strength (force-generating capacity) in children and adolescents with and without CP (14) and their results agreed with our study results in which we concluded that there were moderate direct correlations between muscle strength and muscle pennation angle in less and more affected side .

CONCLUSION

There were statistically significant differences between affected and less affected sides regarding pennation angle and muscle strength ($p<0.05$). Also, there were moderate direct correlations between muscle strength and pennation angle in less affected and affected sides (.367 and .434 respectively).

Depending on the findings of this study, it is recommended to predict muscle strength from pennation angle using ultrasonography especially with cerebral palsy children who cannot cooperate during assessment of muscle strength using traditional manual muscle testing methods .

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