USING MUSCLE ARCHITECTURE TO PREDICT MAXIMUM STRENGTH AND ITS RELATION TO ACTIVITY LEVELS IN CEREBRAL PALSY PATIENTS

- **استخدام البناء العضلي للتنبؤ بالقوة العضلية العظمي و علاقته بمستويات النشاط في مرضي الشلل المخي**

- Cerebral palsy (CP) is a group of motor disorders of movement and posture, often characterized by impairments such as muscle weakness, spasticity , stiffness, and excessive co-contraction **(Bax et al., 2005).**

- In patients with CP, the strength (force-generating capacity) of the knee extensor muscles alone is significantly correlated with the standing, walking, running, and jumping components of the Gross Motor Function Measure and with the total Gross Motor Function Measure score (Goh 2006).

- Muscle architecture is defined as the internal arrangement of muscle fibers within a muscle and has been described as the primary determinant of muscle function **(Lieber et al., 2000).**

- Children and adolescents with CP have lower activity levels than their peers with TD. Whether primary weakness is the cause of decreased activity levels or whether decreased activity levels result in secondary weakness is unknown. Over time, the interaction of these 2 properties, in conjunction with abnormal movement patterns, may perpetuate a continuous cycle of inactivity and weakness, accompanied by disuse atrophy and alterations in muscle architecture **(Damiano 2006).**

- information in the literature about how muscle architecture predicts muscle function in CP is scarce. Even more scarce are studies reporting on how muscle architecture predicts other impairments or activity levels in CP, which are important for informing clinical practice. Children and adolescents with CP have lower activity levels than their peers with TD **(Moreau, 2010).**

- **<u>Statement of problem:</u>**
- Is there a relation between muscle architecture, muscle strength and activity level?

- **<u>The purpose of the study:</u>**

To propose a surrogate measure of strength (based on ultrasound imaging)

For better interpret how a change in muscle architecture would affect activity and participation in daily life.

- **Limitation:**

This study will be limited by:

- Psychological state of the subjects during test
- Cooperation of the subjects.
- Small sample size.
- Personal and individual difference between subjects

- **<u>Delimitation:</u>**

This study will be delimited by:

- Forty subjects.
- Age between 8 and 12 chronologically.
- Diagnosed with cerebral palsy diaplegia with mild spasticity

- **Basic assumption:**
- All patients will follow instructions faithfully and correctly.
- All patients will exert their maximum efforts during isokienetic test
- The calibrations of equipments used in this study were precise and insured to minimize any source of error.
- The results obtained from the study will be of value in physical therapy.

- **<u>Null hypothesis:</u>**
- There is no relationship between muscle architecture, muscle strength and activity level

- **Subjects:**

Forty subjects aged eight to twelve years included two groups:

- Group A: included twenty child with normal development
- And group B: included twenty spastic diplegic cerebral palsy children.
- Inclusion criteria for group B with cerebral palsy all, of them were:

1- Ambulant

2- Having mild spasticity

3-Were at Gross Motor Function Classification System (GMFCS) levels I through IV

- Exclusion criteria for group B:

1-Have no orthopedic or neurological surgery within 6 months before testing

2-Have no botulium toxin injections to the quadriceps muscle within 3 months before testing.

3-Have no cognitive or other behavioral impairments that interfered with the ability to understand and follow directions.

- NB: parental written informed consent was obtained for each participant.

- **<u>Instrumentation:</u> A)for evaluation**
  1-Ultrasonography machine: a 6- to 12-MHz linear-array transducer in2D B-mode.

2- Isokinetic dynamometer (System 3 Pro).

3- Plastic manual Goniometer.

B)For treatment :

1-Medical ball

2-ROLL

3-WEDGES

4-STEPER

5-BALANCE BOARD

Procedures:

Both groups A and B were evaluated at starting the study. while group B(cerebral palsy) only was evaluated after 6 months of physical therapy treatment for the change in muscle architectures of the quadriceps , their maximum strength and for group B only the activity level. **For evaluation:**

A- Ultrasound images of the rectus femoris (RF) and vastsus lateralis (VL) muscles was recorded in real time with a 6- to 12-MHz linear-array transducer in 2D B-mode. Imaging was performed prior to strength assessment, and the right lower extremity was chosen for measurement.

Participants must rest comfortably in the supine position with the knee joint near the natural resting position of 10 degrees flexion; a towel roll was placed under the knee as needed for positioning or to aid comfort and muscle relaxation. Participants were supine for approximately10 to 15 minutes prior to imaging. The resting angle of the knee was measured and recorded with a goniometer.

Participants were instructed to relax their muscles during scanning. Images was recorded only when the muscle is fully relaxed, as evidenced in real time.

Images of the rectus femoris RF muscle was taken at 50% of the distance between the anterior superior iliac spine and the superior border of the patella.

Images of the vastsus lateralis (VL) muscle was taken at the midpoint between the most prominent portion of the greater trochanter and the lateral femoral epicondyle.

NB: Three images was taken three times per muscle, and the average value from the 3 images for each measurement was used in the analyses.

B-Maximum voluntary knee extensor torque tested isometrically at a knee angle of 60 degrees of flexion with an isokinetic dynamometer (System 3 Pro). The 60-degree position was chosen because it approximates the optimal point on the length-tension curve for generating force. The peak isometric torque of the highest of 3 repetitions was used as the measure of strength, or maximum force-generating capacity.

C- The pediatric Outcomes Data Collection Instrument parent report and self-report administered as measures of activity and participation. The pediatric Outcomes Data Collection Instrument was designed to assess self-reported and parent reported physical function and psychosocial aspects of health status in children with mild to moderate musculoskeletal disability. The following scales, with scores ranging from 0 (worst) to 100 (best), will be used for analysis: Transfers and Basic Mobility Scale, Sports and Physical Functioning Scale, and Global Functioning Scale, which includes the preceding 2 scales in addition to an Upper- Extremity Scale and a Pain and Comfort Scale. The pediatric Outcomes Data Collection Instrument has been widely administered in children with CP; it has high internal consistency, moderate to good test-retest reliability, moderate to excellent concurrent validity with the Gross Motor Function Measure, and the ability to discriminate across motor groups for certain domains and is responsive to change after orthopedic surgery.

For treatment (only group B with cerebral palsy received 6 month of physical therapy program)which includes:

A-Strengthening of both lower extremities muscles with special emphasis on quadriceps muscle, exercise were conducted manually and mechanically.

B-Range of motion exercises.

C-Balancing exercises.

D- Neurodevelopmental technique.

E- Gait training.

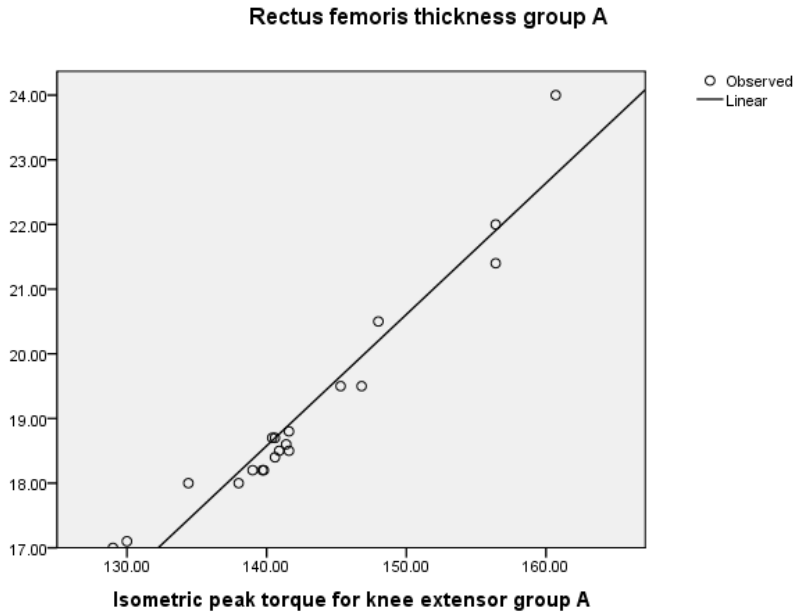
Statistical analysis:

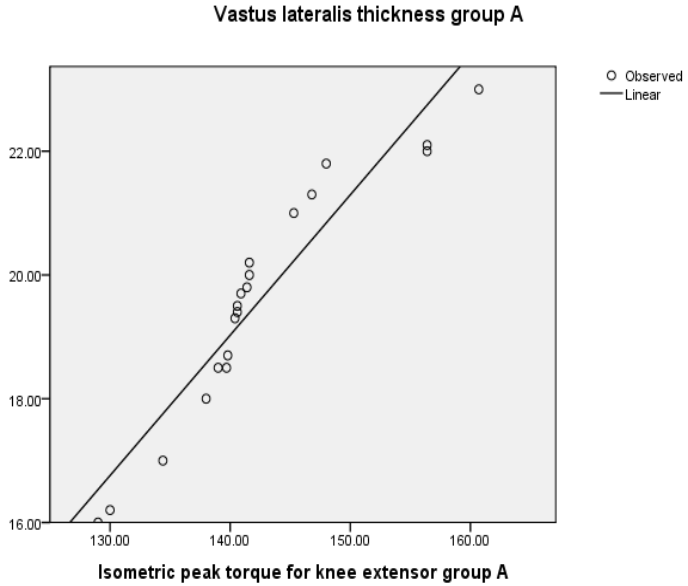
Data analysis was performed using:

Correlation-coeffecient test to detect relationship between variables

RESULTS

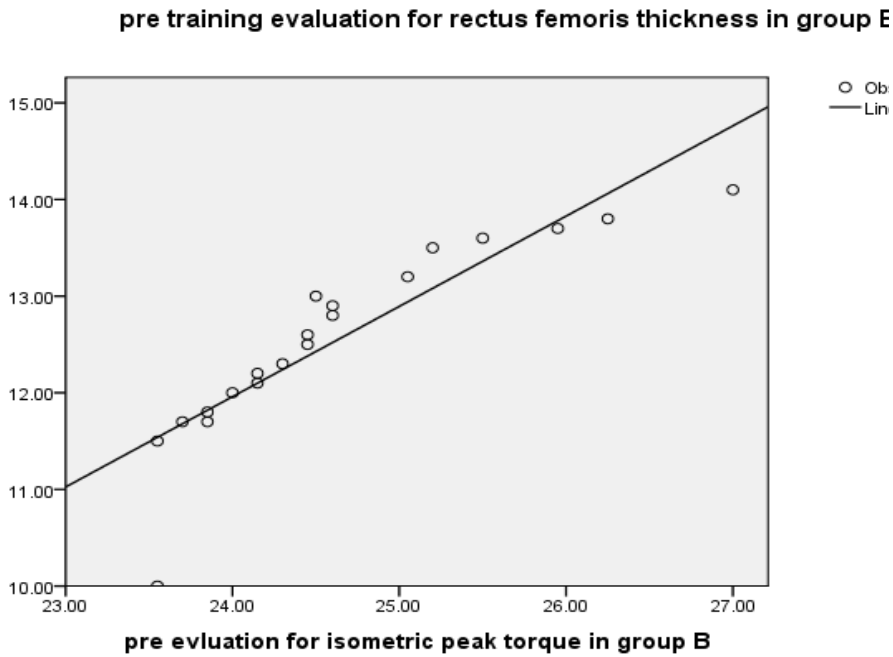
For group A results shows direct relationship between muscle thickness of rectus femoris and vastus lateralis and isometric peak torque of the quadriceps muscle

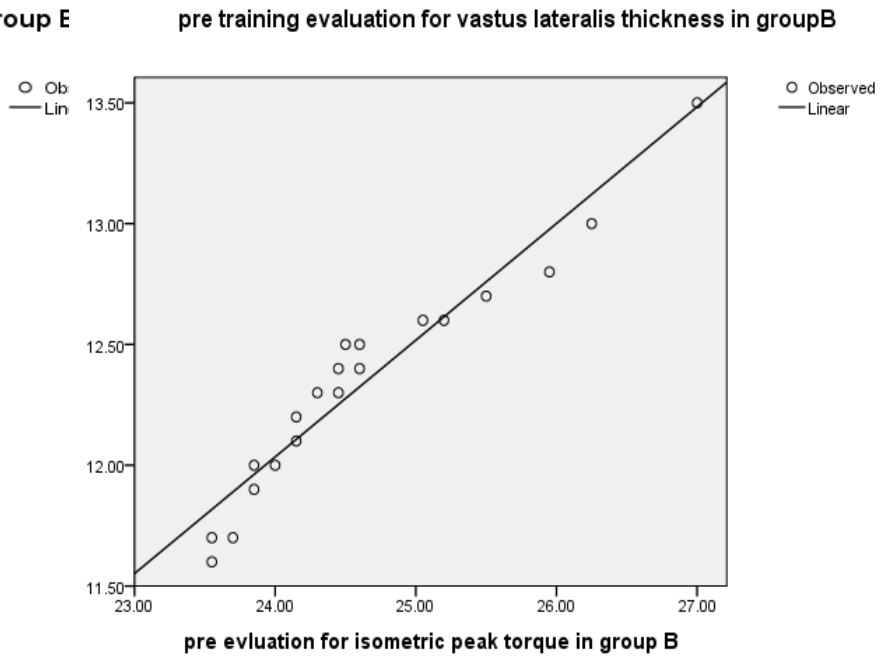




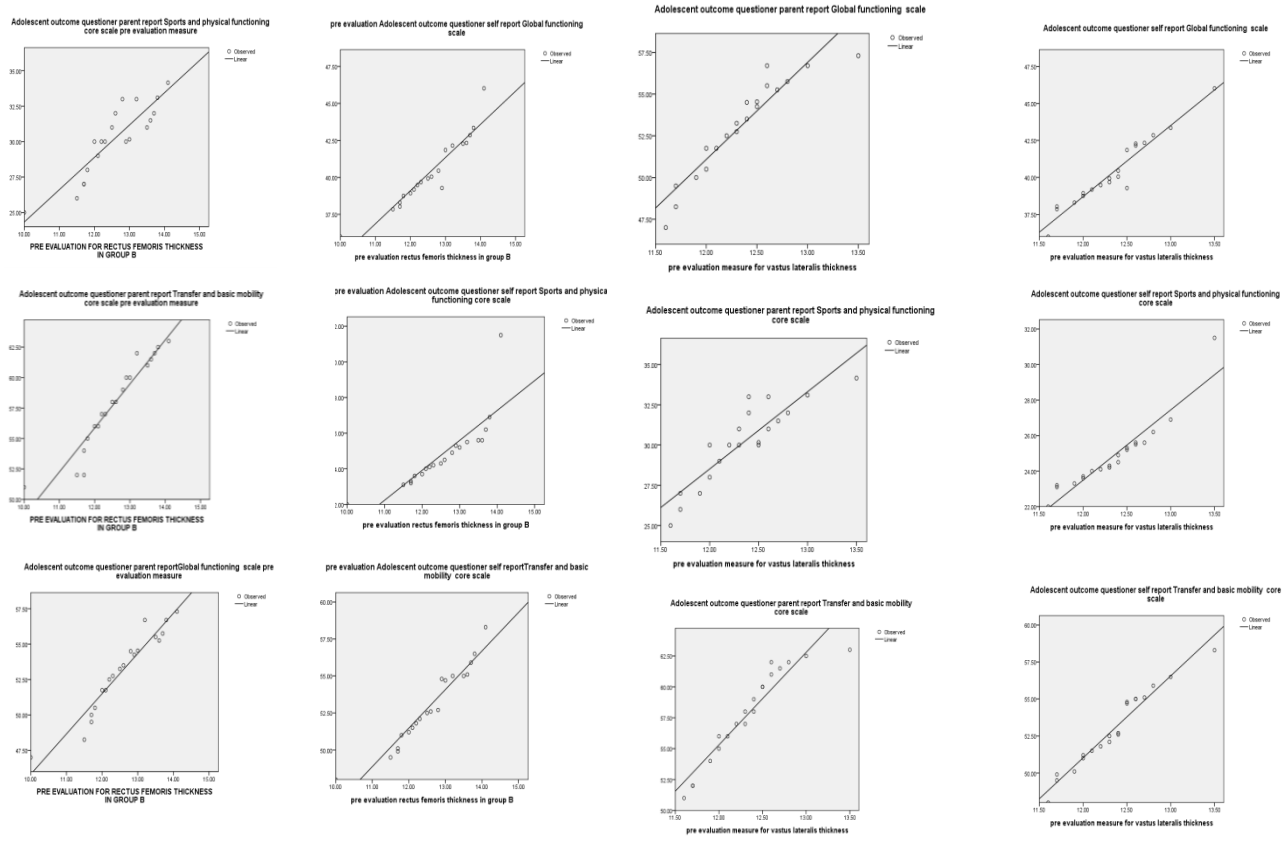
Group (B) pre training evaluation

Shows 1-direct relationship between muscle thickness (rectus femoris and vastus lateralis muscles) and isometric peak torque of the quadriceps muscle



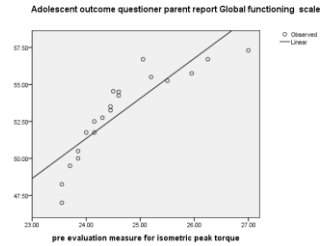


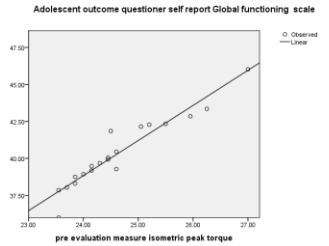
2- direct relationship between muscle thickness (rectus femoris and vastus lateralis muscles) and pediatric outcome data collection instrument (PODCI)measure instrumentation (parent report and self report)

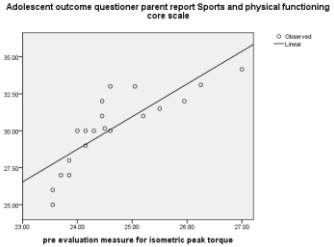


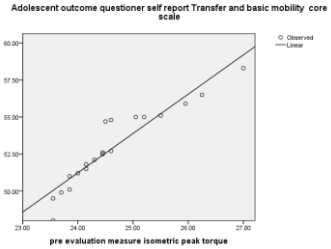
Muscle thickness and PODCI

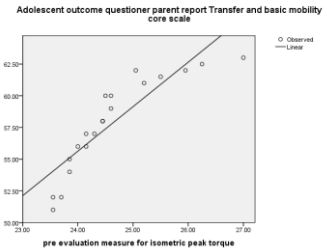
3-direct relationship between isometric peak torque of the quadriceps muscle and pediatric outcome data collection instrument (PODCI)measure (parent report and self report)

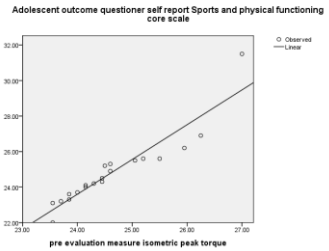






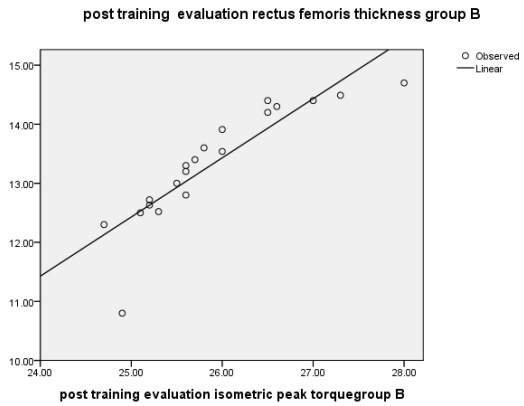


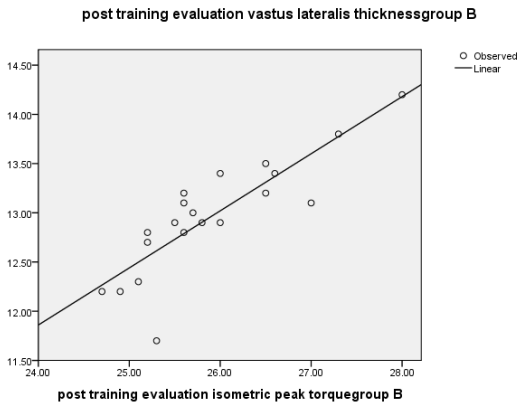




Group B post training results shows

1-direct relationship between muscle thickness (rectus femoris and vastus lateralis muscles) and isometric peak torque of quadriceps muscle





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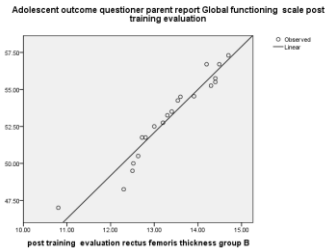
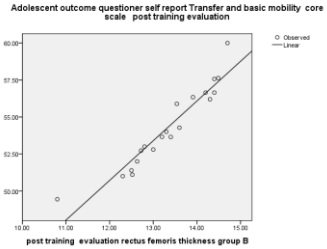
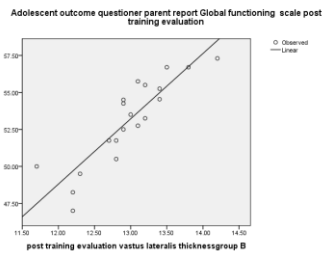
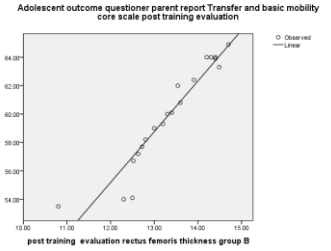
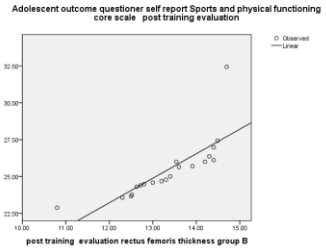
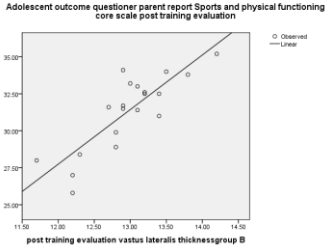


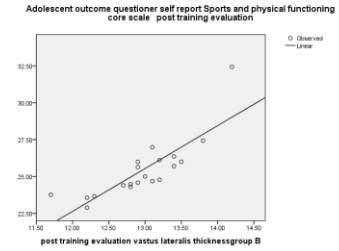


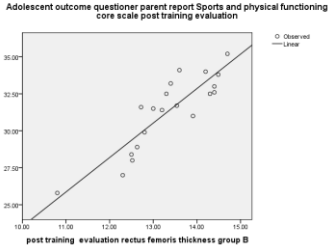


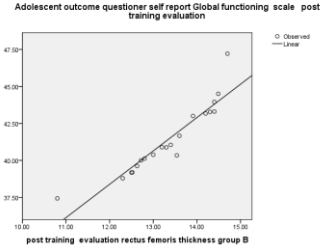


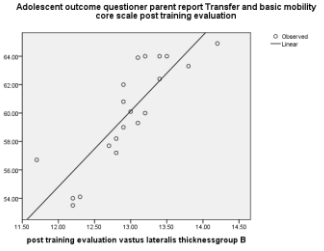


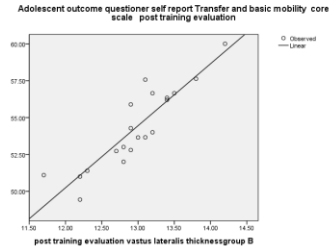




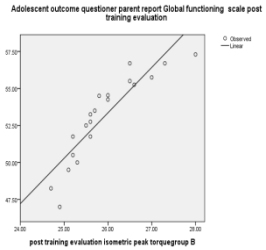


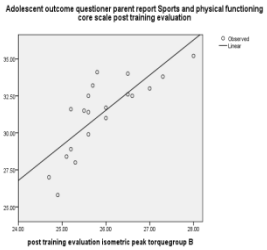


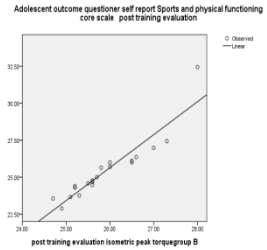


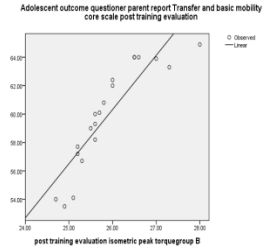


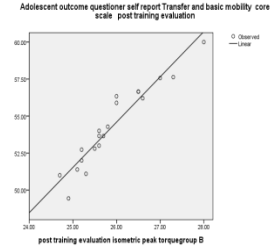
3-direct relationship between isometric peak torque of the quadriceps muscle and pediatric outcome data collection instrument (PODCI)measure (parent report and self report)











Discussion

Our results added further support to those of **Moreau et al (2010)** who examined 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. Found 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 an alternative measures of voluntary strength (force-generating capacity) in children and adolescents with and without CP.

Additionally, our results are in agreement with that reported by **Abe et al (2000)** who stated that although people with severe CP usually show muscle atrophy caused by palsy and limited activity, it is still possible that muscle thickness (MTH) measured by ultrasound imaging reflects muscle strength, at least to some extent. It has been proposed that quantitative ultrasonography is a potentially useful tool for studying skeletal muscle.

Our results also added further support to those of **Elder et al (2003) and Mohagheghi et al (2007) who** reported decreased anatomical cross-sectional area and thickness of the gastrocnemius muscles, respectively, on the paretic compared to non-paretic sides in children with hemiplegic CP.

Our results disagree with **Shortland et al (2002)** who used ultrasound imaging to evaluate muscle architecture in a small group of children with CP and a control group with TD. They observed no differences in fascicle angles and fascicle lengths between the groups.

Conclusion:

Ultrasound measures of rectus femoris and vastus lateralis muscles thickness were highly predictive of isometric peak torque of the quadriceps muscle and activity level and have the potential to serve as surrogate measures of voluntary strength and activity level in children and adolescents .

RECOMMENDATIONS

In the light of obtained results in the present study the following recommendations may be considered:

1-investigate other muscle other than quadriceps muscles.

2-investigation to the other components of muscle architectures and their relation to muscle strength and activity level.

3-investigate the relationship between muscle thicknesses, muscle strength and activity level for other age groups (including younger children and adult cerebral palsy).

4-evaluation of muscle thickness for different muscles and for different age groups to set standard value for normal thickness.

5-effect of strengthening on muscle thickness must be studied on normal individuals

Thank you