Original Article

Hamstring To Quadriceps Muscle Torque Ratio In Adult Females With Anterior Knee Pain

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Abstract

Background: Isokinetic dynamometry offers great clinical and research advantages, in the evaluation and rehabilitation of muscle performance. **The aim** of this study was to assess the association between hamstring to quadriceps (H:Q) ratio, the quadriceps angle (Q angle) and the effect of anterior knee pain (AKP) on these ratios at different angular velocity. **Methods:** 30 adult females; mean age (20±2.6) years with AKP. Biodex isokinetic testing dynamometer was used to measure H:Q ratios at angular velocity of 60°and120°/sec. Q angle was measured by the universal goniometer and pain was measured by visual analogue scale. **Results:** The results revealed that there is significant positive correlation between Q angles and H:Q ratio at 60°/sec, (P=0.049) (r=0.397 P<0.05). There is a positive correlation between Q angles and H:Q ratios at 120°/sec, but it was not statistically significant (r=0.317, P>0.05). There is positive significant correlation between AKP and H to Q ratio at 60°/s (P=0.049)(r=-0.397 P<0.05) There is positive correlation between AKP and H to Q ratio at (120°/s) but not significant(P=0.597) (r=1.11 P>0.05).**Conclusion:** A higher Q angle is associated with increased H: Q ratio and decreased power of quadriceps muscle ,at low and intermediate speed torque angles 60°and120°/sec by isokinetic testing. High Q angle-related knee joint disorders and sports injuries can be avoided by quadriceps strength exercises to prevent malalignment of the patella.

Key words: Isokinetic , Hamstring to Quadriceps Ratio , Anterior Knee Pain.

INTRODUCTION

The term Anterior Knee Pain (AKP) is often used interchangeably with patellofemoral pain syndrome. Softening of the articular cartilage of patella, happens without other intraarticular and peripatellar pathology in AKP [1,2].

The changes mention above lead to chondromalcia with time in normal subjects, affecting their functional activities and performance. Activities like descending stairs, sitting for lengthy periods of time, and crouching might aggravate AKP. Patellar maltracking also malalignment generally are common causes of AKP at different angles [3].

Patellar tracking controls how the patella moves within the trochlea. This movement can be changed by imbalances in static and dynamic stabilizers, which change how forces are distributed along the patellofemoral articular surface, the patellar as well as quadriceps tendons, also the soft tissues around them. This is closely related to the Q-angle [4,5]. Due to their anatomy, women are more likely to get AKP than men. This is because women's pelvises are wider than men's, which puts too much pressure on the knee. Researchers have seen that estrogen affects the synthesis of connective tissue [6].

As such, the Q-angle is a commonly investigated parameter in AKP. Individuals with a high Q-angle (≥ 15°-20°) are thought to be more vulnerable to AKP because of their higher lateral patellar position or lateral subluxation [7,8]. Q-angle is valid and reliable measure for AKP [9,10]. In spite of the effect of Q angle on the AKP, we can't only depend on it to assess the function of knee joint which affected by AKP.

Isokinetic devices have been greatly used for muscle function assessment [11]. Isokinetic muscle strength is a valid and reliable for determining the joint's maximum dynamic muscle strength across the full range of motion [1,12]. It is often used to evaluate sports performance and the efficacy of exercise in sports medicine, and to evaluate the efficacy of surgical intervention, rheumatological diseases associated with functional disabilities and rehabilitation [2,13]. Isokinetic testing has many benefits, including a shorter testing time, lower costs, and more useful results for clinical analysis [14].

Patients who suffer from Patellofemoral Pain (PFP) frequently have weakened quadriceps, especially during eccentric knee extension, and this weakness is linked to the development of PFP [5,7,9,10]. Patients with PFP also tend to have an imbalance between their quadriceps and hamstring muscles [10,11]. This muscular imbalance typically resulted from normal hamstring strength and weak quadriceps, leading to change of hamstring: quadriceps (H: Q) ratio [11,13].

It is possible to determine the H:Q ratio by varying the kind of contraction (concentric, eccentric, or isometric), the angular velocity, as well as the type of torque (peak or angle-specific torque). The Hamstring to quadriceps ratio (H:Q ratio) is considered a measure of balance of knee muscles and hence linked the susceptibility of the expected more stress and injury of the knee joint [14]. H:Q ratio is determined from peak isometric or concentric torque [15,16].

The relation between H:Q ratio and Q-angle with AKP which might reduce the risk of chondromalicia does not mentioned before in the literature review. So, the purpose of this study is to assess the association between hamstring to quadriceps (H:Q) ratio and the quadriceps angle (Q angle) and the effect of AKP on these ratios at different angular velocity.

SUBJECTS AND METHODS

This study was carried out in Physical therapy department, Cairo, Egypt's Modern University for Technology and Information to investigate the changes in the H:Q ratio among subjects with AKP in relation to Q-angle. The procedure was performed in the morning from 9:00 am till 1:30 pm for one month in the isokinetic lab located in the 2nd floor of faculty of physical therapy.

Thirty adult females with AKP, aged from (18 – 23) years with mean BMI (19.3±0.9). AKP was noticed during ascending stairs, rising up from squat, walking on ramp. AKP was not more than 6 months. Subjects with noticeable musculoskeletal defects, postural malalignment, severe neurological also cardiac problems, deformity in knee joint, leg length discrepancy, recent fracture around knee joint, pescavus and pesplanus were excluded.

Female students from the faculty of physical therapy at the Modern University for Technology and Information were asked to take part. All participants signed a written informed consent. Each subject informed on each step of the test so they would know what to expect and be comfortable with the testing protocol.

Ethical approval:

The ethical research committee at the faculty of physical therapy at the Modern University for Technology and Information gave their approval for this study**.**

Outcome measures:

1- H:Q ratio: measured by Biodex Isokinetic dynamometer

- Biodex Isokinetic dynamometer: (Made in USA with serial N 14083608). The Isokinetic system comes with a computer-compatible (IBM) device that collects displays, stores data, but also controls how the dynamometer moves.
2- Pain severity: assessed by Visual Analog Scale (VAS) in order to put a number on how bad the pain is. It has been shown that the 10-centimeter (VAS) is a valid and reliable outcome measure for AKP [17].
3- Q-angle: a method for detecting patellar malalignment using universal G.
The Q angle was measured with the individual lying supine, legs extended. The feet were positioned in a relaxed, neutral position. With a marker pen, important bone marks were marked; Anterior Superior Iliac Spine (ASIS), center of patella (CP) as well as centre of the tibial tubrosity (TT). After detecting the edges of the patella, a marker pen was used to draw its outline. Maximum patellar vertical and transverse diameters were used to determine the CP. The center of the TT was identified as the location of greatest prominence. An imaginary line was drawn using the straight edge of the measuring tape from the CP to the ASIS. The core of the TT and the CP were connected by a second line. The height of the second line was increased. The Q angle was determined by using a universal goniometer to measure the resulting angle between the above- mentioned lines [18]

Testing Procedure:

Preparation:

The greatest peak effort of the quadriceps and hamstrings was determined bytesting subjects at constant angular velo city (60 degree/sec and 120 degree/sec) for the knee extensors & flexors group undergoing isometric contraction.
The resistance pad is positioned slightly higher than the medial malleolus above the ankle joint. Hips reclined backwards 10–15 degrees while both knees flexed 90 degrees [15,16].

Subjects were well fixed during testing by straps of the machine. If the subjects have bilateral anterior knee pain, the most painful one was tested.

Before running any kind of test on the system, all of the equipment was properly adjusted and set up. The area of interest was stabilized appropriately, limiting any movement to that region. It was emphasized that participants should cross their arms over their chests to prevent unnecessary muscular activity in their shoulders and arms, which could lead to false positive results.

Knee test protocol:

A warm up for the tested muscles enhance and facilitate the muscles and prevents injury. Warm up exercises in the form of active free knee flexion and extension five repetition.

Procedure

Subjects were seated at the apparatus with their knees bent 90 degrees. At a predetermined speed and for a predetermined number of test repetitions, they were instructed to extend and their knees as far as possible against the accommodating resistance provided by the machine [17].

Knee test:

Five repetitions of extension and flexion at 60°/s, then thirty seconds rest.
Five repetitions of extension and flexion at 120°/s, then thirty seconds rest.

The maximum peak torque for the Quadriceps and Hamstring muscles was detected, H:Q ratio was measured. Isokinetic data were printed then analyzed.

Data collection

Each subject's body mass index was calculated, H:Q ratios at 60°/s and 120°/s., Q angle and pain was measured by visual analogue scale were collected.

-Statistical design and data analysis:

1. Descriptive statistics (mean and standard deviation) for general characteristics of participants age (years), Weight(kg), Height (Cm) and BMI.
2. Spearman correlation test to assess the relationship between agonist & antagonist ratio and Q angles at the determined angular velocities (60°/s and 120°/s).
3. Spearman correlation test to assess the relationship between H:Q ratios and pain at the determined angular velocities (60°/s and 120°/s).
4. All data statistically substantial differences were determined with confidence interval of 95% ($p<0.05$).
5. All data were analyzed by using graph SPSS version 11.

RESULTS

Thirty adult female, ages 18 to 23, participated in the study, with a mean value of (20.1±2.6), Weight (47±5.1), and Height (156±5.1) shown in table (1).

In table (1), Age, weight, and height were included as subjects' general characteristics.

Table (1) General characteristics of the subjects:

Variables	Value
Age (years) **Mean ±SD**	20±2.6
Weight(kg) **Mean ±SD**	47±5.1
Height(Cm) **Mean ±SD**	156±5.1
BMI **Mean ±SD**	19.3±0.9

Table (2) Mean ±SD of Q angles, agonist/ antagonist ratio (H:Q) ,r and p-value total at 60°/sec

Variables	Q angles	Agonist/antagonist	R	p-value
Mean	15.47	59.1	0.397	0.049
±SD	2.14	20.4		

Table (3) Mean ±SD of Q angles, agonist/ antagonist ratio (H:Q), r and p-value total at 120°/sec

Variables	Q angles	Agonist/antagonist	R	p-value

Mean	15.47	68.7	0.312	0.128
±SD	2.14	22.49		

Table (4) Mean ±SD of Pain scale, agonist/ antagonist ratio (H:Q), r and p-value total at 60°/sec

Variables	Pain scale	Agonist/antagonist	R	p-value
Mean	3.08	59.12	0.397	0.049
±SD	1.22	20.39		

Table (5) Mean ±SD of Pain scale, agonist/ antagonist ratio , r and p-value total at 120°/sec

Variables	Pain scale	Agonist/antagonist	R	p-value
Mean	7.04	68.71	1.11	0.597
±SD	1.9	22.4		

The mean for the Q angles was 15.5±2.1 degrees. H to Q ratio at (60°/s) was 59.1±20.4 as revealed in table (2). There is a substantial positive correlation between Q angles and H to Q ratio at 60°/s (P=0.049)(r= 0.397 P<0.05).

The mean for the Q angles was 15.5±2.1 degrees .H to Q ratio at (120°/s) was 68.7±22.5 as revealed in table (3). There is a positive correlation between Q angles and H to Q ratio at (120°/s) but it was not statistically significant (P=0.128) (r=0.317, P>0.05).

The mean for pain was 3.08±1.22 degrees .H to Q ratio at (60°/s) was 59.1±20.4 as revealed in table (4); There is positive substantial correlation between the effect of pain on anterior aspect of knee and H to Q ratio at 60°/s (P=0.049)(r=-0.397 P<0.05).

The mean for pain was 7.04±1.9 degrees .H to Q ratio at (120°/s) was 68.7±22. as revealed in table (5). There is positive correlation between the effect of pain on anterior aspect of knee and H to Q ratio at (120°/s) but not significant(P=0.597) (r=1.11 P>0.05).

DISCUSSION

No studies have been conducted to our knowledge that examine the relationship between the H:Q ratio and the Q angle in AKP patients. This research set out to determine how AKP affected the H:Q ratio and the Q angle. The importance of the present study's findings will be beneficial for sports medicine, exercise, physical therapy and rehabilitation.

Understanding the neuromuscular functional limits in different clinical situations may be aided by the capacity to measure the effect of peak torque on the degree of performance in activities of daily living [4,15]. High isokinetic H:Q strength ratios can be caused by either hamstring muscles or weak quadriceps, or both occurred.

The results of this study show there is a significant positive correlation between Q angles and H to Q ratio at 60°/s and120°/s tables (2,3). There is positive significant correlation between the effect of pain on anterior aspect of knee and H to Q ratio at 60°/s tables (4,5).

During Isokinetic contraction, muscle activity demonstrates the torque velocity relationship at different angular velocity provided the rule is the force velocity relationship is indicated [16]. Even at the same joint angles, the muscle fiber lengths will vary, provided the muscle forces are different. This could be the reason why the force velocity as well as torque velocity relationships don't always line up. Maximum isokinetic effort of the quadriceps is a good example of this, so it has been the point of research [16,19].

Differences in body mass index have to be considered when measuring muscular strength to have comparison. So, in this study the body mass index for the study sample was determined [11].

Functional testing and isokinetic dynamometry must be performed independently [16,18]. In this study the outcome measure only detected by isokinetic data and VAS and no functional tests were done.

Analysis of peak torque independent of joint angle has been suggested as a means to draw important conclusions about muscle function. This is because at faster speeds, the acceleration is greater, and the limb may go past the optimal angle before the resistive mechanism is activated [14] In the current investigation, H:Q ratios were measured using a Biodex isokinetic testing dynamometer at 60°/s (a slight speed test) and 120°/s (an intermediate speed test) but not at higher velocities.

It's possible that the tension that builds up throughout the range of motion isn't reflected in the peak torque responses. However, measures like total work as well as mean power generated highly relevant measure [19]. The outcome measure in this study is peak torque and its relation to the Q angle and AKP. Prior studies have investigated the relation between peak torque and the workload and power generated by the muscles surrounding the knee, reporting correlation values ranging from 67 to 99 [6,16].

It has been argued that the H:Q ratio is more relevant in assessing muscle function than peak torque, which has been the reference for all isokinetic investigations. Increased stress and injury risk have been both associated with high H:Q ratios, which have been utilized as a measure of muscle balance in the knees [5,11,20]**.**

Because of methodological limitations and issues with the experimental protocol, great care was taken to consider the torque ratio measurement issues as a calculation method [21,22].

There are a variety of angular velocities that can be utilized for the test; all studies except only 2 used a low angular velocity (60°/s), seven studies used a test at 180°/s, four studies used a test at 240°/s, and one study used a test at 300°/s [21,23]. In the current study slow and intermediate angular velocity 60°/s and120°/s were used.

Lack of studies assessed the H:Q ratios and found its relation to AKP or injury for lower limb but one study done by Kellis et al (2019) who evaluated H:Q ratios in female athletes following hamstring injury but rather ACL reconstruction surgery and found no evidence of long-term deficits in agonist-antagonist muscle strength balance in relation to H:Q ratio. This was observed for all H:Q types, including the traditional, the functional, and the mixed. Significant impairments in the knee extensor and flexor isokinetic strength were observed between athletes with a previous history ACL surgery or hamstring injury and those without such a history; these results might be difficult to be compared with the current study because of the different sample. Weakness of both quad and hamstring by any cause will affect the H:Q ratios should be considered [24].

Conclusion:

Having a larger Q angle is related to increased H: Q ratio and decreased power of quadriceps muscle, at low and intermediate speed torque angles 60°and120°/sec by isokinetic. High Q angle-related knee joint disorders as well as sports injuries can be prevented by quadriceps strength exercises to prevent malalignment of the patella.

Limitation

Small sample was used and no functional scale were done.

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