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Original Research Article

COMPARISON BETWEEN MUSCULAR TORQUE AND H/Q RATIO IN NORMAL CHILDREN AND CHILDREN WITH GENERALIZED JOINT HYPERMOBILITY

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ABSTRACT

Purpose: the current study intended to investigate the effect of hypermobility on the hamstring's muscular torque, quadriceps' muscular torque and H/Q ratio.

Materials and Methods: thirty normal male children aged from seven to eleven years and thirty age-matched male children with GJH were tested using isokinetic dynamometer. Eccentric-concentric and concentric eccentric moods were used for hamstring and quadriceps respectively at angular velocity of 60°/s.

Results: the results exposed that there was significant decrease in both peak muscular torques and H/Q ratio in children with GJH when they were compared with normal children [$P < .05$].

Conclusion: it can be concluded that joint hypermobility decreases muscular torque and H/Q ratio. This may be due to proprioceptive deficits associated with hypermobility and abnormal muscular activation pattern. Further studies are needed to verify the definite cause of decreased muscular torque and H/Q ratio.

KEY WORDS: Muscular Torque, H/Q Ratio, Hypermobility.

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INTRODUCTION

Many strength trainees, bodybuilders, and exercisers are told that there should be a certain ratio between the strength of their hamstring and quadriceps muscles. It is called the H/Q ratio .It is ranged from .50 to .75 with a normative value of .60, this strength ratio is considered essential to the stability of the knee joint and to prevent ACL and other injuries. It is also sometimes thought to be predictive of those at risk for hamstring strain [1].

Some strength and conditioning experts actually test the maximal strength of the quadriceps and hamstring muscles of their clients, using leg extensions and leg curls, respectively, believing that, this relationship will tell them whether their clients are at risk for a knee injury. To calculate the hamstring-quadriceps strength ratio, the maximal knee extensor moment and the maximal knee flexor moment is tested at identical velocities [isokinetic], and the flexion result is divided by the extension result [1].

In reality there is not one value for concentric hamstring and quadriceps torque ratio but a range of ratios depending on joint angle and speed of movement. These have been well studied, producing averages anywhere from 0.5 to 0.75. The mechanical advantage of a muscle tends to change with the joint angle which changes the angle of pull of the muscle. As the mechanical advantage of one muscle increases the mechanical advantage of the other muscle may decrease. Also, the speed of the movement changes the angle at which peak torque occurs. [2] Another problem is that conventional testing, as described above, involves testing the maximal strength of the quadriceps and hamstrings using the same concentric action. This may make no sense because these muscles do not function in terms of concentric-concentric actions but concentric-eccentric actions [2].

H/Q strength ratio depends on the type of sport [3], age, pubertal status and gender [4].It has been reported that, the H/Q strength ratio might be higher in children compared to adults. In a study done by Armstrong et al.[4] on 8–10 years old children, they found that those children had significantly higher H/Q results compared to adults; however, the reasons for the difference were not clear. The authors concluded that smaller body size and different anatomy of children might be related to the reported differences. In addition, they reported that, puberty-related growth might cause strength changes and a decrease in the H/Q ratio. Therefore, puberty-related growth may be considered as one factor for changes in the H/Q ratio from childhood to adult.

With regard to gender, significant differences have been reported in the H/Q strength ratio between genders in children aged 8–12 years, as boys seem to have better muscle balance in thigh muscles. According to, Holm and Vøllestad 2008, [5] boys may have approximately 10 % higher H/Q strength ratios than girls of the same age may. They reported that, gender differences exist even before biomechanical maturational effects alter the children's biomechanics and anatomy. However, they observed only small differences in the H/Q ratios for each age group within prepubescent children.

Generalized Joint Hypermobility [GJH] is described as a condition with ligamentous or capsular looseness, either congenitally or genetically based [6], or a tissue adaptation due to repetitive movements to end range [7]. The increased range of movement in GJH is most frequently examined with the Beighton scoring system, a scoring system from 0 to 9 points [8].

Generalized joint laxity is a clinically well-recognized feature of genetic syndromes, such as osteogenesis imperfecta, Ehlers-Danlos syndrome and Marfan syndrome [9]. Beside laxity of joints and skin, pathologic phenomena in other organ systems are found such as in blood vessels, resulting in decreased blood pressure levels, and in bone, resulting in lower bone mass and abnormal bone structure [10].

The prevalence of generalized joint hypermobility in children varies between 10% and 25% and is related to age, gender, and race [11]. In addition, Gedalia et al., [12] reported that, Children possess an inherently greater range of motion in their joints than adults, with a gradual reduction in this range observed with age.

On the other hand GJH is an advantage in selection of individuals in sports which require a large degree of flexibility and a greater range of movement, such as ballet dance, and elite gymnastics. In contrast, it seems to be associated with musculoskeletal complaints, such as soft tissue rheumatism, osteoarthritis [OA], arthralgia and subluxations [13].

Knee strength and strength balance [ratio between the strength of the hamstring and quadriceps muscle groups, the H/Q ratio], in children with GJH classified by Beighton scores need further investigations. Since this implies an increased risk of ligament and muscle injuries. [14].

Certain studies showed that, adults with GJH have impaired H/Q ratio. So the aim of this study was to investigate the effect of GJH [including knee joint hypermobility], on the hamstring's muscular torque, quadriceps' muscular torque and H/Q ratio to clarify whether specific attention to this ratio may be required in children with GJH that is to guard against hamstring strain and other knee joint injuries.

Beighton score which is a simple system to quantify joint laxity and hypermobility. It is more commonly used in diagnosing hypermobility in childhood. It uses a simple nine point system where the higher score, the higher the laxity. The threshold for joint laxity in a young adult is ranging from 4-6, thus the score above six indicate hypermobility [15].

MATERIALS AND METHODS

Subjects: Sixty male children aged from 7 to 11 years participated in this study. They were recruited from the public primary schools at Taif. They were assigned into two groups, [GI] and [GII], the control group and the study group respectively. Group I contained 30 normal children and group II contained 30 children with GJH. The sample didn't include females because the society's customs and traditions limited us.

Inclusion criteria for children with GJH: Beighton score was $\geq$ 5/9. They had hypermobile knees and no knee pain complain during the last week. The Body mass index [BMI] should not be more than 25. They should not participated in strength training programs.

Exclusion criteria: The children were excluded if they had a previous injury to the lower limb, which indicated medical attention, or had other impenetrable conditions such as lower limb's deformities, surgeries, or a neuromuscular condition. Patients also were excluded if they had genetic, metabolic, or rheumatologic diseases. The study conducted at the isokinetic lab of the College of Applied and Medical Sciences, Taif university, KSA. The practical part of the study last for approximately three months from May 15 to august 20, 2016. The assessment was done between 11 am and 1 pm.

The study was approved from the ethical committee at the College of Applied and Medical Sciences and from the schools which chosen. The informed consents were collected from the parents before the beginning of the study. Concerning the confidentiality and anonymity, we considered the privacy of all data that were collected from the participants. In addition, the participants had the right to withdraw from the study at any time they want.

Methods:

1- BMI was calculated by the following steps; 1] obtain accurate height and weight measurements for each child, 2] calculate the BMI by the following formula: BMI is weight [in kilograms] divided by the square of the height [in meters].

2- GJH: it was assessed by using the Beighton score [appendix I].Children wore light clothes, and were pare foot. Before the assessment, the movement was illustrated by the examiner, associated with verbal instructions. Children were instructed to relax their muscles as much as possible, and the maneuver was performed without inducing pain if the child could do the required motion with the required range grade [1] is given, if not grade[0] is given. The following joints were assessed:

- Left and right little [fifth] finger: the child did passive dorsiflexion beyond 90°. Left and right thumb: the child did passive dorsiflexion to the flexor aspect of the forearm.

- Left and right elbow: if the child did hyperextension beyond 10°. Left and right knee: the child did hyperextension beyond 10°.

- Forward flexion of trunk with knees full extended: he can rest palms and hands flat on the floor.

- The sum of the grades of the previous joints indicated if the subject had hypermobility or not. Score above six indicated hypermobility [15].

3- H/Q ratio and peak torque for hamstring and quadriceps:

- Muscular torque was evaluated with an isokinetic dynamometer: two Multi-Joint System [Biodex Medical System, New York, NY, USA]. An expert with practice in these evaluations was responsible for the evaluation procedures. Initially, warm-up in cycle ergometer was performed. five minutes of pedaling a cycle ergometer at 65-85% of age-predicted max heart rate as recommended by Kelly et al, 2010 [16].

- The subject was supported on the equipment using two straps crossing his chest, one pelvic strap, and a thigh strap support the proximal thigh. The knee was placed at 90° flexion with the center of the equipment's axis lined up with the lateral epicondyle of the femur . The hip was kept at 90 flexion by support of the pelvis. The isokinetic lever was sited parallel to the leg of the individual and engaged at height of 5cm superior to the lateral malleolus.

- The tested range was 80°, from 90° flexion to 10° extension. According to Selistre et al, 2012 [17]

- full extension was avoided to prevent discomfort during the test.

After supporting the individual, all the steps of the evaluation were explained. The used verbal command was "perform the movements [knee flexion-extension] using maximum effort and as fast as possible, throughout concentric contraction and use controlled release throughout eccentric contraction".

- After good stabilization of the participant and before the actual isokinetic testing procedures, the participant performed one practice series of three sub-maximal repetitions for each action of the isokinetic tests. This allowed the participant to accommodate to the specificity of the Biodex's speed of movement and ROM. Thus, the participant became familiar with the testing condition while minimized any practice or learning effect during the actual test.

- The testing procedures were started with verbal command of "be ready and use your maximum effort just after go" they should start making effort only after go. The individuals also get verbal motivation "keep it strong as much as you can" on the other hand the individuals received visual feedback from the equipment at any moment of the evaluation. The isokinetic evaluation was completed using eccentric-concentric mood and concentric-concentric mood for testing knee flexors and extensors respectively. The velocity [60°/s] was used for being near to the maximal strength of the athlete.

4- The normalized extensor and flexor peak torque [Nm] in the dominant limb were picked up from the isokinetic evaluation [Nm/kg], in addition the functional H/Q ratio [eccentric hamstring concentric quadriceps ratio] was also obtained

Study design and statistical analysis: Case control study was used, which is relatively inexpensive and frequently used type of epidemiological study that can be carried out by small teams or individual researchers. They have pointed the way to a number of important discoveries and advances Levin KA 2005 [18]. Statistical analysis was done through the Statistical Package for Social Studies [SPSS] version 20 for windows. Unpaired t-test was used to clarify if there was any significant difference in the mean values of age and anthropometric parameters. ANOVA was used to determine the statistical difference in peak torque and the H/Q ratio between both groups. The alpha level was seated at p value of 0.05.

RESULTS

with regard to the age, weight, height and body mass index of the two groups, no significant difference was detected between the two groups [P >0.05]. On the other hand, there was a significant increase in Beighton score in GII when it was compared with GI [P < 0.05] these results were illustrated in table [1].

Table 1: General characteristics of both groups.

	Control group [I] Mean ± SD	Study group [II] Mean ± SD	P-value
Age [years]	9.30 ±1.2	8.8 ±1.4	> 0.05
Height [cm]	150.00 ±5.26	153.00 ±3.46	> 0.05
Weight [kg]	41.80 ±2.24	43.01 ±1.90	>0.05
BMI [kg/m2]	19.00 ±0.70	18.50 ±0.50	> 0.05
Beighton score	1.7±0.3	7.2±.8	<.05

SD: standard deviation cm: centimeter
Kg: kilogram, kg/m2: kilogram/ meter square.

According to the peak extensors and flexors torque, there was significant decrease in both peak extensors and flexors torque in children with generalized hypermobility when compared with normal children P < .05. With regard to the H/Q ratio, there was also a significant decrease in the H/Q in children with generalized joint hypermobility when compared with normal children [P < 0.05] as illustrated in table [2].

Table 2: the peak flexors, extensors torque, and H/Q ratio in both groups.

	Control group [I] Mean ± SD	Study group [II] Mean ± SD	P-value
Peak eccentric flexors torque [Nm/kg]	0.9 ±0.2	0. 5±.05	< 0.05
Peak concentric flexors torque [Nm/kg]	0.89±0.2	0.49±.08	< 0.05
Peak eccentric extensors torque [Nm/kg]	1.83±0.4	1.53±.3	< 0.05
Peak concentric extensor torque (Nm/kg)	1.58 ±0.09	1.3±.07	< 0.05
H [ecc.] /Quad.[con.]	57±1.3	0.38±1.6	< 0.05

H [ecc.]/Quad. [con.]: Hamstring eccentric/Quadriceps concentric.

DISCUSSION

Concerning the muscular torque, there is a significant decrease in the peak flexors and extensors torque in children with generalized joint Hypermobility when compared with peer normal children. The reduced muscular torque may be due to decrease the control over the knee joint which is associated with proprioceptive and joint kinesthesia deficits that characterizes the hypermobility syndrome. This is concluded by Fatoye et al., 2009 [19] who said that, children with hypermobility syndrome (HMS) had sensorimotor deficits compared with the controls.

These sensory receptors that present in the skin, muscles, joints, ligaments and tendons give neural input, which is integrated by the CNS to generate motor response [20]. Therefore, deficits of proprioception associated with hypermobility could decrease the muscular torque.

This comes in agreement also with Fatoye et al, 2009 [19] who used digital myometer [MIE, Medical Research Ltd, Leeds, UK] to assess Maximum isometric knee extensor and flexor muscle torque and found that children with HMS had weaker knee extensor and flexor muscles than healthy controls.

Our results agree also with Engelbert et al., 2003 [21], when he said that, Children with generalized joint hypermobility without musculoskeletal complaints had significantly higher total range of joint motion, and lower total muscle strength as compared with the reference group when they use hand-held myometer in the assessment. However, some of their findings may point towards another explanation, that these children are less active than normal children which also concluded by Dolan AL, 1998 [22].

Jensen et al., 2013 [23], contradict these findings when they used strain-gauge force transducer [PMH Electronic, Denmark] connected to a strap surrounding the ankle just proximal to the lateral malleolus to measure the isometric knee flexors and extensors maximum voluntary contraction (MVC). They concluded that children and adults with GJH did not differ from the control groups with respect to MVC values. But they used less advanced instrument than the isokinetic system and only assess the isometric force.

The results of muscular torque also contradict Juul et al., 2012 [24], who studied a large number of independent variables [age, gender, pain, activity level, beside GJH] and its effect on also a large number of dependent variables. They only found that, girls with non-symptomatic GJH had reduced isokinetic normalized PT knee extension [eccentrically].

But it is difficult to experiment with more than two factors, or many levels [if there's an error in one of the levels within, it can jeopardize great amount of work] also this study used the covariate adding a covariate into ANOVA reduces the degrees of freedom. Accordingly, adding a covariate which accounts for very little variance in the dependent variable might actually reduce power. In addition to that the covariate was differ with regard to the groups which affect its validity [25].

Concerning the H/Q ratio, in the present study, we assessed the hamstring [eccentric]/quadriceps [concentric] at angular velocity of [60°/s] what is called functional H/Q ratio, which is an important concept to provide applicable information. This is according to Aagard et al, [1998] who stated that, functional H:Q ratios are more effective to describe strength relationships, meaning concentric quadriceps should be compared to eccentric hamstrings to simulate muscle activation during normal activities. To consider the peak torques of H [ecc]: Q [con.] is much more functional than H [con.]: Q [con.] or H [ecc.]: Q [ecc.]. This makes sense when one considers that these are reciprocal muscle groups, and that the shortening of one results in the lengthening of the other. These functional ratios, then, are more accurate in simulating knee flexion and extension than the traditional ratios.

The results of this study revealed that, there was a significant decrease in H/Q ratio in children with GJH compared with normal children. This may attributed to increased flexibility of the hamstring in the children with GJH as they have hyperextension of the knee joint. This come in agreement with Costa et al., 2009 [26], who stated that, acute stretching for hamstrings-only, without stretching the antagonist muscles, may decrease strength ratio of these muscles.

In addition, the decrease in the H/Q ratio may be a result of the abnormal co-activation pattern during knee flexion. This appears as decreased agonist drive to the hamstring muscles rather than increased antagonist activity. This may be explained by a demand for stabilization of the hypermobile knee in the anterior/posterior direction. However, during knee extension, no difference in coactivation ratio was found between the hypermobile groups and the healthy controls. Thus, the coactivation strategy seems to be task-dependent as Jensen et al. 2013, [27], said. On the other hand, Juul-Kristensen, 2012 [24], disagree with us when he did his study about Knee function in 10-year-old children with generalized joint Hypermobility, as he said that, there is no significant difference in H/Q ratio between normal children and children with generalized joint hypermobility.

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Conflicts of interest: None

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Appendix I:

Beighton score:

Joint	Finding	Points
left little [fifth] finger	passive dorsiflexion beyond 90°	1
	passive dorsiflexion <= 90°	0
right little [fifth] finger	passive dorsiflexion beyond 90°	1
	passive dorsiflexion <= 90°	0
left thumb	passive dorsiflexion to the flexor aspect of the forearm	1
	cannot passively dorsiflex thumb to flexor aspect of the forearm	0
right thumb	passive dorsiflexion to the flexor aspect of the forearm	1
	cannot passively dorsiflex thumb to flexor aspect of the forearm	0
left elbow	hyperextends beyond 10°	1
	extends <= 10	0
right elbow	hyperextends beyond 10°	1
	extends <= 10	0
left knee	hyperextends beyond 10°	1
	extends <= 10	0
right knee	hyperextends beyond 10°	1
	extends <= 10	0
forward flexion of trunk with knees full extended	palms and hands can rest flat on the floor	1
	palms and hands cannot rest flat on the floor	0

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