The Effect of Severity on the Isokinetic Strength in Knee Osteo Arthritis (OA)

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Abstract

To determine the relationship of torque measures of knee flexors to extensor muscles developed as a result of dysfunction and disease in knee Osteoarthritis (OA) and does the maximum peak torque measures change in patients with knee OA compared to healthy normal subjects.

Keywords: Isokinetic strength, concentric contraction, maximum peak torque, isokinetic dynamometer.

Introduction

Knee osteoarthritis is the leading cause of chronic disability in older persons[1]. Osteoarthritis commonly affects hands, feet, spine and large weight bearing joints such as hip and knees. Osteoarthritis is the second most common rheumatic problem and is most frequent joint disease with prevalence of 22% to 39% in India [4]. Prevalence of osteoarthritis in all joints is strikingly correlated with age. For subjects over the age of 45 years most population surveys showed that presence of radiographically determined OA of the knee varies between 14 and 30% and increases steadily with age[6]. Osteoarthritis of knee joint is characterized by localized tenderness over the joint and pain on passive or active motion Pain is frequently the first symptom and is often associated with swelling. Crepitus can often be detected and muscle atrophy is seen secondary to disuse [7]. Knee flexor muscle gaps are subject to hypotrophy and loss of strength, as well as the knee extensors in osteoarthritis of the knee joint. It has been documented that dynamic stability of the Knee joint depends on the appropriate strength ratio of quadriceps and hamstrings [9]. Purpose of this study is to determine the relationship of torque and torque ratio of knee flexors to extensors muscles developed as a result of dysfunction and disuse in osteoarthritis.

Statement of the Question

1) Does the maximum peak torque measures and maximum peak torque hamstring/ quadriceps ratio change in patients with knee osteoarthritis compared with normal control subjects.
2) Are there any differences between 2 patient groups when maximum peak torque and maximum peak torque hamstring/ quadriceps ratios were compared with each other.

Materials and Methods

30 patients with the symptomatic osteoarthritic knees (age 40 – 60 yrs) were divided into 3 groups.

Group1 – 10 Subjects exhibiting symptomatology and radiologic findings of knee OA.

Group2 – 10 Subjects having knee joint pain without any radiologic evidence of knee OA.

Group3 – 10 Healthy subjects.

Subjects in all the 3 groups performed concentric contractions of knee flexors and extensors that include 4 repetitions at 60 deg/ sec, 10 reps at 120 deg/sec and 20 reps at 180 deg/sec. Values of maximum peak torque of flexors and extensors and maximum peak torque hamstring to quadriceps ratio were recorded after each session.

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Results

Significant difference was found in maximum peak torque of flexors and extensors among 3 groups of subjects but no significant difference for ratio was observed among 3 groups. Values of maximum peak torque measures decreased with increasing speed of shortening and the hamstring to quadriceps values increased with increasing speed of shortening.

Conclusion

There is equal strength loss of both the muscles in patients with

Knee osteoarthritis, so hamstring strengthening exercises should be incorporated along with quadriceps strengthening exercise in rehabilitation plan of knee OA.

Hypothesis

There is equal strength loss of knee flexors and extensors in patients with knee osteoarthritis.

Methodology

Sample: A sample of convenience of 30 subjects with an age range from 40-60 years were recruited from Department of Orthopedics (Physiotherapy) , All India Institute of Medical Sciences. Subjects were referred by the Orthopedician. The eligibility criteria were checked and a written consent was taken from the subjects.

Inclusion criteria

1) Age group: 40-60 years
2) Symptomatic Osteoarthritic knees
3) Minimum available range of 0-90 degrees knee flexion

Exclusion criteria

1) Symptoms or signs of synovitis
2) Acute or chronic ligamentous insufficiency
3) Any history of knee surgery
4) Any history of recent injury to knee joint
5) Low back or hip joint disorders
6) Any systemic illness
7) Any history of doing prescribed exercises for knee osteoarthriti

Design

A comparative design was used in this study. Subjects were randomly assigned into three groups and were named as Group 1 ,Group 2 and Group3 . Demographic data was collected from the subjects who met the inclusion and exclusion criteria of the study. This included age, height weight, etc. Data was collected in one 45 minutes test session.

Instrumentation

1) Biodex System3 Pro Isokinetic Dynamometer
2) Weighing Scale
3) Stadiometer

Protocol

1) Subjects were diagnosed by the Orthopedician with the diagnosis of knee Osteoarthritis.Diagnosis was based on the Clinical criteria by Altman et al. Severity of osteoarthritis was measured by Kellgren and Lawrence criteria for radiological assessment.
2) The subjects diagnosed with knee osteoarthritis were invited to participate in the study. Those who fulfilled the inclusion criteria were asked to sign an informed consent form.
3) A Subjects were assigned into three groups as :

   Group1: 10 subjects exhibiting symptomatology and radiologic findings of knee osteoarthritis.

   Group 2: 10 subjects having knee joint pain without any radiologic evidence of knee osteoarthritis.

   Group 3: 10 healthy subjects.

Procedure

All the testing was completed on Biodex System 3 Pro computer controlled isokinetic dynamometer, which was caliberated every 2 weekly by caliberation verification procedure as described in the operation manual of Biodex.

1) All the subjects were explained about the purpose, procedure and nature of the result.

2) Subjects were seated on the biodex chair and secured using upper crossing torso, pelvic, distal thigh stabilization straps.

3) An adjustable lever arm was attached to subject's leg by a resistance pad was put 1 inch proximal to the medial malleolus.

4) Subjects gripped the sides of chair and leaned back against the backrest, which was inclined posteriorly to an angle of 90 degrees above the horizontal.

5) The axis of rotation of dynamometer arm was positioned lateral to lateral femoral condyle.

6) Subject's anatomical position was caliberated by placing the joint in anatomical reference angle(0 degrees extension position was used as reference position in all subjects).

7) A range of motion of o degrees extension to 90 degrees flexion was targeted in all subjects.

8) With the limb positioned at 45 degrees of knee flexion, caliberation of limb weight was done to negate the gravity effect by the biodex software.

9) Subjects completed the warm up phase prior to actual testing. Warm up consisted of 3 consecutive trials for each speed of testing, one of which ws a maximal contraction.

10) Subjects performed concentric contraction of knee flexors and extensors at 3 preset speeds with 20 sec rest period between the sets.

11) Subjects performed 3 sets that included 4 repetitions at 60 degrees per second, 10 repetitions at 120 degrees per second and 20 repetitions at 180 degrees per second. The order of testing was from slower to faster speeds

12) Subjects were verbally encouraged to exert maximal efforts.

13) Data were collected for the maximum peak torque of flexors and extensors relative to body weight.

Data Analysis

Statistically the characteristics of the groups and the results were compared using One way ANOVA and Paired t tests.

Data were managed on an excel spreadsheet. SPSS (Statistical package for social science) software was used for data analysis.

One way ANOVA (Duncan's Mean Test) was used to analyze the difference in maximum peak torque of flexors and extensors and maximum peak torque hamstring to quadriceps ratio among 3 groups of respondents.

Paired t test was used to analyze the difference in maximum peak torque of flexors, extensors and maximum peak torque hamstring to quadriceps ratio among 3 speeds within the groups of respondents.

Result

In the present study, there was significant difference in Maximum peak torque of Flexors and Extensors among 3 Groups of respondents. No significant difference for Maximum peak torque (Hamstring / Quadriceps) Ratio was found among 3 Groups.When within group analysis was performed it was found that the value of maximum peak torque measures decreased with increasing speed of shortening and the Hamstring to Quadriceps sratio values increased with increasing speed of shortening.

Intergroup Analysis

Maximum peak torque / body weight of Extensors and Flexors and maximum peak torque hamstring to quadriceps ratio were compared among 3 groups of respondents using One way anova test.

Comparison of Maximum peak torque / body weight of Extensors among 3 Groups of respondents

At 60 deg/sec Maximum peak torque of extensors was significantly different between the groups. (F value = 56.99, P<0.01) Significant difference was found between groups 1 & 2, 2 & 3 and 1 & 3.

At 120 deg/sec Maximum peak torque of extensors was significantly different between the groups. (F value = 41.04, P < 0.01) Significant difference was found between groups 1 & 2, 2

& 3 and 1 & 3.

At 180 deg/sec Maximum peak torque of extensors was significantly different between the groups. (F value = 23.45, P < 0.01) Significant difference was found between groups 1 & 2, 2 & 3 and 1 & 3.

Comparison of Maximum peak torque / body weight of Flexors among 3 Groups of respondents

At 60 deg/sec Maximum peak torque of flexors was significantly different between the groups. (F value = 27.57, P<0.01) Significant difference was found between groups 1 & 3, 2 & 3 but not between 1 & 2.

At 120 deg/sec Maximum peak torque of flexors was significantly different between the groups. (F value = 16.14, P < 0.01) Significant difference was found between groups 1 & 3, 2 & 3 but not between 1 & 2.

At 180 deg/sec Maximum peak torque of flexors was significantly different between the groups. (F value = 6.86, P < 0.01) Significant difference was found between groups 1 & 3, 2 & 3 but not between 1 & 2.

Comparison of Maximum peak Torque (Hamstring / Quadriceps) Ratio among 3 Groups of respondents.

At 60 deg/sec Maximum peak torque (Hamstring / Quadriceps) Ratio values were not significantly different between the groups. (F value = 2.45, P = 0.10)

At 120 deg/sec Maximum peak torque (Hamstring / Quadriceps) Ratio values were not significantly different between the groups. (F value = 2.10, P = 0.14)

At 180 deg/sec Maximum peak torque (Hamstring / Quadriceps) Ratio values were not significantly different between the groups. (F value = 2.22, P = 0.12)

Within Group Analysis

Maximum Peak Torque / Body weight of extensors and flexors were compared among 3 speeds of testing within each group using paired-t test

Comparison of Maximum peak torque / body weight of extensors among 60 deg/sec, 120 deg/ sec and 180 deg/sec in Group 1

Significant difference in maximum peak torque of extensors was found between 60 deg/ sec and 120 deg/sec (t value = 2.87, P < 0.01).

Significant difference in maximum peak torque of extensors was found between 60 deg/ sec and 180 deg/sec (t value = 5.66, P < 0.01).

Significant difference in maximum peak torque of extensors was found between 120 deg/ sec and 180 deg/sec (t value = 4.39, P < 0.01).

Comparison of Maximum peak torque / body weight of flexors among 60 deg/sec, 120 deg/ sec and 180 deg/sec in Group 1

Significant difference in maximum peak torque of flexors was found between 60 deg/ sec and 120 deg/sec (t value = 2.32, P < 0.05).

Significant difference in maximum peak torque of flexors was found between 60 deg/ sec and 180 deg/sec (t value = 3.64, P < 0.01).

Significant difference in maximum peak torque of flexors was found between 120 deg/ sec and 180 deg/sec (t value = 2.93, P < 0.01).

Comparison of Maximum peak torque (Hamstring / Quadriceps) Ratio among 60 deg/ sec, 120 deg/sec and 180 deg/sec in Group 1

No significant difference was found in Maximum peak torque (Hamstring/ Quadriceps) Ratio between 60 deg/sec and 120 deg/sec (t value = 0.75, P = 0.47).

Significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 60 deg/sec and 180 deg/sec (t value = 2.17, P < 0.05).

Significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 120 deg/sec and 180 deg/sec (t value = 2.17, P < 0.05).

Comparison of Maximum peak torque / body weight of extensors among 60 deg/sec, 120 deg/ sec and 180 deg/sec in Group 2

Significant difference in maximum peak torque of extensors was found between 60 deg/ sec and 120 deg/sec (t value = 3.87, P < 0.01).

Significant difference in maximum peak torque of extensors was found between 60 deg/ sec and 180 deg/sec (t value = 6.78, P < 0.01).

Significant difference in maximum peak torque of extensors was found between 120 deg/

sec and 180 deg/sec (t value = 8.97, P < 0.01).

Comparison of Maximum peak torque / body weight of flexors among 60 deg/sec, 120 deg/sec and 180 deg/sec in Group 2

No significant difference in maximum peak torque of flexors was found between 60 deg/sec and 120 deg/sec (t value = 0.98, P = 0.35).

Significant difference in maximum peak torque of flexors was found between 60 deg/sec and 180 deg/sec (t value = 2.97, P < 0.01).

Significant difference in maximum peak torque of flexors was found between 120 deg/sec and 180 deg/sec (t value = 2.60, P < 0.05).

Comparison of Maximum peak torque (Hamstring / Quadriceps) Ratio among 60 deg/sec, 120 deg/sec and 180 deg/sec in Group 2

Significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 60 deg/sec and 120 deg/sec (t value = 1.96, P < 0.05).

No significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 60 deg/sec and 180 deg/sec (t value = 1.63, P = 0.13).

No significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 120 deg/sec and 180 deg/sec (t value = 0.54, P = 0.60).

Comparison of Maximum peak torque / body weight of extensors among 60 deg/sec, 120 deg/sec and 180 deg/sec in Group 3

Significant difference in maximum peak torque of extensors was found between 60 deg/sec and 120 deg/sec (t value = 5.30, P < 0.01).

Significant difference in maximum peak torque of extensors was found between 60 deg/sec and 180 deg/sec (t value = 8.27, P < 0.01).

Significant difference in maximum peak torque of extensors was found between 120 deg/sec and 180 deg/sec (t value = 5.82, P < 0.01).

Comparison of Maximum peak torque / body weight of flexors among 60 deg/sec, 120 deg/sec and 180 deg/sec in Group 3

Significant difference in maximum peak torque of flexors was found between 60 deg/sec and 120 deg/sec (t value = 4.68, P < 0.01).

Significant difference in maximum peak torque of flexors was found between 60 deg/sec and 180 deg/sec (t value = 7.28, P < 0.01).

Significant difference in maximum peak torque of flexors was found between 120 deg/sec and 180 deg/sec (t value = 5.16, P < 0.05).

Comparison of Maximum peak torque (Hamstring / Quadriceps) Ratio among 60 deg/sec, 120 deg/sec and 180 deg/sec in Group 3

No significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 60 deg/sec and 120 deg/sec (t value = 1.64, P = 0.13).

Significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 60 deg/sec and 180 deg/sec (t value = 1.96, P < 0.05).

No significant difference was found in Maximum peak torque (Hamstring / Quadriceps) Ratio between 120 deg/sec and 180 deg/sec (t value = 0.97, P = 0.91).

For the Maximum peak torque measures, as the velocity of shortening increased, the value of concentric peak torque reduced. With the increase in the velocity of shortening an increase in value of maximum peak torque (Hamstring / Quadriceps) Ratio was observed.

Discussion

Knee stability is accomplished through three components osseous structures, ligamentous structures and the neuromuscular dynamic control system. The dynamic stabilizers of the knee are the muscles surrounding the joint. Muscle functions to provide movement dynamic joint stability and to control and absorb joint stress.

The quadriceps muscle is an important stabilizer of the knee joint and often exercise is designed to strengthen the quadriceps muscle.[7]

However, pain and swelling of the knee joint leads to restriction of range of motion and contractures of joint capsule and hamstrings. [54] Therefore, knee flexor muscle groups are subject to hypotrophy as well as knee extensors in knee osteoarthritis.

In this study investigation was done to determine the relationship of torque developed

by knee flexors and extensors in the presence and absence of radiologic evidence of knee osteoarthritis. Measures of patients were also compared with healthy subjects to investigate muscle wasting in knee osteoarthritis.

To see the effect of severity on the Isokinetic strength in knee osteoarthritis. 3 groups of subjects were included in the study. Group 1 comprised of subjects with symptomatology and radiologic findings of knee osteoarthritis., more advanced cases of knee osteoarthritis. were included. Group 2 included subjects having knee joint pain without the radiologic evidence of knee osteoarthritis.. Group 3 comprised of healthy subjects of the same age group (40 – 60 years).

Lack of association between symptomatology and radiologic eveidence of OA was previously described by Cobbs et al in a study of Jaletan and Balci et al.[55]

The radiologic appearance may be normal if pathologic changes leading to clinical symptoms are sufficiently mild [56] and radiographic findings may lag behind patient's symptoms.

Stauff et al [49] cited in the study of Messier et al reported differences in Isometric strength of 55% to 70% in osteoarthritis. subjects compared to group of healthy adults.

Messier et al [49], in their studies confirmed that adults with osteoarthritis of knee have significantly less strength in both the dominant and non-dominant legs compared to age and gender matched adults without arthritis.

Chang, Pai et al [58], reported reduction in knee extension torques in knee osteoarthritis.. Lankhorst et al [50] reported that dynamic torque measurements had very little advantage over static tests.

Isokinetic exercise is an effective, safe and reliable alternative for knee osteoarthritis rehabilitation in elderly.

Concentric strength measures of knee flexors and extensors were used in accordance with the study by David et al[58], they reported test retest reliability of concentric mode of biodex.

Hamstring/quadriceps strength ratio was used based on the finding by Campbell et al (1982) who found that this ratio is better measure of knee function than peak torque. [36]

Klopffer et al[60] (1998) suggested the use of peak torque relative to body weight in establishing goals for rehabilitation of individuals with knee pathology.

Sitting position[48, 61] was chosen to measure maximum peak torque as supported by studies.

Slow to fast speed testing order was used in accordance with the study of Wilhite [48] et al (1992).

Tredinnick and Duncan[62] (1988) reported excellent reliability of concentric peak torque at 60 degrees/sec, 120 degrees/sec and 180 degrees/sec.

Trunk stabilization was used in accordance with a study by Hart et al.[35]

(1984) who found that adequate trunk stabilization leads to higher production of torque.

Michael et al[45] reported the importance of gravity correction of isokinetic peak torque during calculating knee flexor to extensor ratios.

Three submaximal including one maximal trials were selected in warm up on the basis of supporting literature. [63, 46]

Hard cushion end stop was used as suggested by Taylor et al[47] (1991).

Visual feed back of torque values was provided to subjects as supported by Broadie[63] et al (1991).

In this study significant difference was found in the maximum peak torque measures (Maximum peak torque/ body weight of flexors and extensors) of Group 1 ,2 and 3 .At all the speeds the extensor and flexor strength was reduced in subjects with advanced osteoarthritis as compared with healthy controls. In Group 1 subjects reduction of strength measures was more remarkable than subjects of Group 2.

There is significant isokinetic strength loss of both flexor and extensor muscle group progressing from Group 3 to Group 1, indicating that isokinetic strength loss progresses with disease progression, These findings are consistent with study by Jale tan et al (1995) they reported that there is isokinetic strength loss in patients with knee osteoarthritis.

Slemenda et al[59] (1998) reported reduced quadriceps strength relative to body weight in patients with knee osteoarthritis and contributed this to reflex inhibition of muscle contraction.

Dekkar et al cited in study of Giir et al[46] (2003) stated that muscle weakness is a mediating factor between negative affect and disability. They stated that negative affect enhances patient's tendency to avoid pain related activities, a low activity level induces muscle weakness and instability of joints.

Within group analysis in this study showed that as the speed of shortening increases the values of concentric torque decreases. Isokinetic muscle strength of knee flexors and extensors at 60 deg / sec was higher than the strength measures performed at 120 deg / sec and 180 deg / sec. These findings [55, 64, 66, 67, 69] are consistent with the findings reported in the literature.

Klofter and Grey [70] demonstrated increasing torque output by the hamstrings as the test velocities increased. They concluded that increasing velocity of knee extension may cause increased reaction of the stretch receptors in the hamstrings and facilitated torque production.

Thorstenson et al[71] (1977) stated that composition of fast twitch fibres and slow twitch fibres may effect torque output. If hamstring or quadriceps muscles contain a higher ratio of fast twitch fibres, increased torque production with increasing velocities may be expected.

The present study showed increased peak torque at decreasing velocity. Subjects (inactive, middle aged) in the study probably had a higher proportion of slow twitch fibres.

Kannus(1994)[72, 35] reported that for concentric contractions there is parallel decrease in maximal moment developed by muscles as speed increases. This is because of neuromuscular recruitment patterns that is both type I and type II fibres are activated together at lower speeds but as speed increases less number of type I fibres are recruited and eventually become inactive. At very high velocities smaller and smaller fiber populations are recruited.

The hamstring to quadriceps ratio is a measure of the relationship between strength of these two muscle groups.

In the present study , Within Group analysis showed that as the speed of shortening increases the value of torque increases.

These findings are in accordance with findings by Kannus et al [72], Nunne et al, indicating a possible decline in quadriceps activity.

Maximum peak torque hamstring to quadriceps ratio values were not significant between 3 groups of subjects at 60 deg / sec, 120 deg / sec and 180 deg / sec. The results indicate that there is hamstring as well as quadriceps weakness in subjects with knee osteoarthritis. These findings are consistent with findings by Brandt et al and Tan et al [55] (1995).

The findings of the present study are that i) as the disease progresses there is an increase in isokinetic strength loss of both flexors and extensors of the knee.ii) No significant difference in maximum peak torque hamstring to quadriceps ratio indicates strength loss of both muscle groups.

Clinical relevance

The results of this study showed that there is considerable loss of strength of flexors and extensors in patients with osteoarthritis as the severity of disease increases.There is no significant difference in maximum peak torque ratio indicating equal strength loss of both muscle groups.

So, hamstring muscle strengthening exercises are as important as quadriceps strengthening exercises and should be incorporated in the treatment plan of knee osteoarthritis.Isokinetic maximum peak torque loss of knee extensors and flexors was found in both patient groups, when measures were compared with healthy individuals.However, isokinetic strength ratios of hamstring to quadriceps muscles did not show a statistically significant difference between the groups.This may be related to equal strength loss of knee extensors and flexors sin patients with knee osteoarthritis rather than an ipsilateral muscle imbalance, which significantly proves the present hypothesis.

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