Eccentric/Concentric Torque Deficits in the Quadriceps Muscle

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The purpose of the present investigation was to estimate the percentage of asymptomatic subjects who demonstrate an eccentric/concentric torque deficit in leg extension. One hundred and five subjects with a mean age of 23.51 were tested on the KIN-COM® dynamometer for maximum eccentric and concentric torque during leg extension using an 80° range of motion at 50°/sec velocity. The subjects were categorized as demonstrating a deficit if at any point in the range of motion the eccentric torque was 85% or less of the corresponding concentric torque. The results revealed that 35–54% of the subjects, depending upon sex or leg tested, demonstrated a deficit. These results suggest that many asymptomatic individuals possess an eccentric/concentric torque deficit. These findings question the validity of previous clinical research indicating that patients with anterior knee pain tend to possess an eccentric/concentric torque deficit and that correction of the deficit alleviates the pain.

Over the past decade, a great deal of progress has been made in the area of evaluation and treatment of knee problems. Effective treatment of anterior knee pain, however, remains a problem for physicians and physical therapists who treat orthopaedic and sports related injuries. Although symptoms are frequently related to activity, complaints of anterior knee pain are prevalent in sedentary individuals as well as active, well trained athletes.

The most frequently made diagnosis for complaint of anterior knee pain continues to be "chondromalacia patella" (1, 6, 8). Arthroscopic examination reveals that only 51% of patients with patellar pain actually have pathology of the patellar articular cartilage (5). Another commonly made diagnosis for anterior knee pain is extensor mechanism malalignment due primarily to weakness of the vastus medialis oblique muscle (1). With the recent developments in strength testing devices, we have a greater ability to investigate the possible contribution of strength deficits to patellofemoral pain and dysfunction. Not only can quadriceps strength be accurately assessed, but comparisons of strength between quadriceps and hamstrings or eccentric versus concentric torque production are possible. Recently, Bennett and Stauber (2) investigated eccentric to concentric quadriceps torque ratios in patients with anterior knee pain. Subjects who demonstrated a 15% deficit of eccentric to concentric torque, in absence of quadriceps strength deficit when compared to the uninvolved leg, were included in the study. Bennett and Stauber (2) reported pain relief in 39 of 41 of these symptomatic patients with participation in an eccentric training program, often after only 2–4 weeks.

Bennett and Stauber consequently suggested that this eccentric to concentric torque pattern might be used as a predictor of anterior knee pain. That study's design, however, included no formal placebo control condition or adequate comparison group. Therefore, their findings could have been due to a placebo type effect. The purpose of the present study was to estimate the percentage of individuals in an asymptomatic population who might demonstrate the eccentric to concentric torque pattern previously described.

METHODS

Subjects

The sample for the study included 105 males (N=49) and females (N=56) without any history of knee or leg abnormality. The subjects ranged

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in age from 15 to 34 years, with a mean of 23.51 ± 5.61. All subjects were volunteers who signed an informed consent. Minors also had signed permission from a parent or guardian in order to participate in the study. Subjects completed a medical history concerning knee and leg injury or surgery. Although most of the subjects were involved in various forms of physical activity at the time of data collection, this was not a criterion used in selection of the sample population.

Procedures

Prior to testing, all subjects participated in a standard warm-up. The first phase consisted of a 5-minute ride on a cycle ergometer at a self-selected pace described to the subject to be of moderate intensity. Following the ride the subject performed two 10-sec static stretches of the quadricep and hamstring muscles. The last phase of the warm-up included five submaximal repetitions on the KIN-COM[1] dynamometer (Chattecx Corp., 101 Memorial Drive, P.O. Box 42887, Chattanooga, TN 37405). The KIN-COM is a computer controlled, hydraulically powered device capable of measuring eccentric and concentric torque (2, 4). These repetitions were leg extensions using an 80° range of motion at 50°/sec and included a concentric quadriceps contraction followed by an eccentric quadriceps contraction. In these warm-up repetitions, the subject was instructed to give an approximated 50% effort. The purpose of this warm-up phase was to further prepare the subject for maximal contractions and to familiarize the subject with the resistance provided by the KIN-COM.

The subject was then given a brief rest before performing the maximal effort contractions. Once the subject indicated readiness, three leg extensions were performed at maximal voluntary effort through both eccentric and concentric phases in the range and speed stated above.

The reliability and validity of the KIN-COM as a test device has previously been reported (4). However, in a pilot study (N=20) using the procedures indicated above, test-retest reliabilities exceeded 0.94 for both maximal concentric and eccentric torque. The testing was done on both the right and left legs.

The KIN-COM's software samples force production at a rate of 100 times/sec and calculates the subject's performance by computing the average torque in newton/meters for each 8° of motion throughout the 80° range across the three test repetitions.

Data Analysis

Eccentric/concentric torque ratios were formulated by dividing the reported eccentric torque by the concentric torque for each 8° range of motion from 24–64°. This was done to correspond as closely as possible to a 30–60° range used previously (2) for determining a meaningful deficit. In addition, the average concentric and eccentric torques across the entire range of motion were computed. The eccentric/concentric ratio was formed with these average torque values and a meaningful deficit was indicated if the ratio was 0.85 or below. Percentages of males and females demonstrating these deficits were calculated and the chi-square test was used to determine if significant differences existed between males and females and between legs tested.

RESULTS

The average concentric and eccentric torque expressed in newton/meters for males and females are provided in Figures 1 and 2.

Upon examination of the mean torque values over the tested range of motion, the data indicated that asymptomatic individuals in general do not demonstrate a concentric/eccentric deficit. While females demonstrated less eccentric torque than concentric torque between the 24 and 40° range of motion, it was not at the critical deficit level of 15%.

When individual subject's torque values were analyzed, however, the data from our study population demonstrated that a substantial percent-

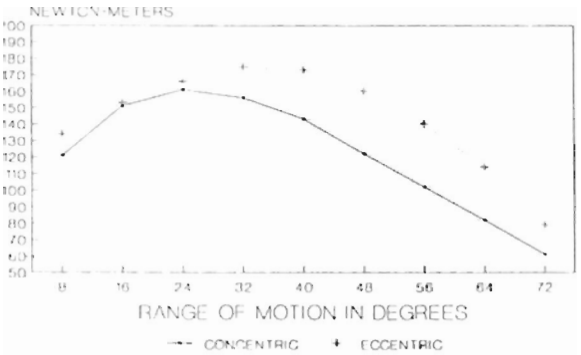

Figure 1. Average eccentric and concentric torques in males.

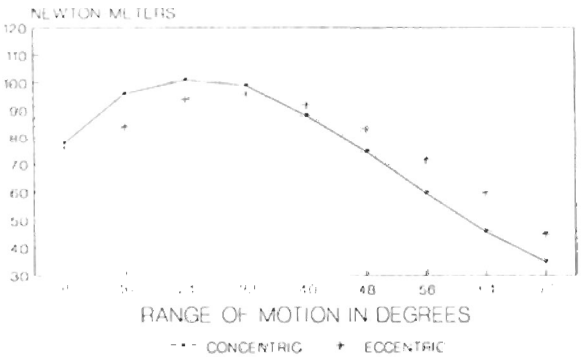

Figure 2. Average eccentric and concentric torques in females.

TABLE 1

Percentage of subjects demonstrating eccentric/concentric deficit

Leg	Males	Females
Right	35.6	42.2
Left	44.9	54.2

TABLE 2

Percentage of subjects demonstrating eccentric/concentric deficit for specific ranges of motion

Range of Motion in Degrees	Right Leg		Left Leg	
	Male	Female	Male	Female
24–32*	10.3	24.8	5.6	23.3
32–40*	11.5	28.1	6.7	26.7
40–48*	14.9	34.7	14.6	30.0
48–56	26.4	35.5	27.0	36.7
56–64	31.0	38.8	41.6	48.3

* $p < 0.05$, chi-square test, percentage of females significantly greater than males.

TABLE 3

Percentage of subjects demonstrating average eccentric/concentric torque deficit over entire range of motion

Leg	Males	Females
Right*	13.8	31.4
Left*	11.2	29.2

* $p < 0.05$, percentage of females significantly greater than males.

age, 35–54%, of the subjects exhibited the critical deficit defined by Bennett and Stauber (2) (Table I). A subject was considered to have demonstrated a deficit if, in any range of motion between 24 and 64°, the eccentric torque/concentric torque ratio was below 0.85. The chi-square test revealed no significant differences between gender or leg tested.

A breakdown of the percentage of subjects demonstrating the critical deficit by specific range of motion is provided in Table 2. The chi-square test revealed that the percentage of females demonstrating the eccentric/concentric torque deficit in the three 8° ranges between 24–48° was significantly greater than the percentage of males ($p < 0.05$).

Table 3 gives the percentage of individuals who exhibited the deficit when average eccentric torque was compared to average concentric torque over the entire range of motion.

DISCUSSION

This study indicated that a substantial percentage of individuals not currently experiencing anterior knee pain demonstrate the 85% eccentric/concentric torque deficit suggested by Bennett and Stauber (2) as critical in a conservative treatment program of symptomatic patients. This study, however, did not exactly replicate the Bennett and Stauber (2) procedures in terms of speed and range of motion since the data were collected from a database appropriate for a clinical situation. The database from which this data was obtained was one previously used to establish KIN-COM normative data. This data was collected prior to publication of Bennett and Stauber's study and was not collected for the purpose of replicating their experimental conditions. The velocity of 50°/sec was selected because at the time of the study, many clinicians were utilizing this velocity to increase strength in patients.

Bennett and Stauber (2) used a strength training program to produce an improvement in eccentric torque production in the patients they identified as having a critical deficit. They reported great success in alleviating the nonspecific anterior knee pain when the deficit was corrected and reasoned that a motor-learning factor must have been present in the correction of the deficit since the deficit was corrected in such a short period of time. This would seem consistent with Moritani and DeVries' study (7) indicating that a large proportion of initial strength gains are due to improved neural activation rather than actual muscle hypertrophy. If Bennett and Stauber's conclusions were valid, then the data in the present study would seem to indicate that a large percentage of asymptomatic subjects also have a motor control problem in expressing the potential eccentric quadriceps torque. This would be particularly meaningful in patients who have knee pain during athletic activities since eccentric contractions are so vital to most types of athletics (3, 9).

The results of this study further demonstrate that females may have a greater frequency of the eccentric/concentric torque deficit than males. If the deficit, as Bennett and Stauber (2) suggested, is a predictor of an individual who is at greater risk of developing anterior knee pain, then women would be at greater risk.

CONCLUSION

In conclusion, a large percentage of individuals without anterior knee pain nor a history of knee abnormality demonstrated a critical eccentric torque deficit as suggested by Bennett and Stauber (2). Although this is consistent with previous literature indicating a motor control problem which can be corrected by eccentric training, the significance of having an eccentric torque deficit should be questioned. Further research is needed to verify or disprove that an eccentric/concentric torque deficit is indicative of an individual who may be at greater risk of developing anterior knee pain.

At the time of data collection, none of the subjects in the study were reporting any knee discomfort or had any history of knee problems. A longitudinal study examining the percentage of

asymptomatic subjects who possess this torque deficit and subsequently develop anterior knee pain of unspecific nature is presently being conducted. A second phase of the study may be to use an eccentric exercise program to determine if symptoms can be alleviated as Bennett and Stauber reported (2). ❑

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