STARTING POSITION AND SPEED UPON KNEE TORQUE OF ATHLETES

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The function of the knee joint during the stresses of normal and athletic locomotion has been widely studied. The musculature surrounding the knee has been shown to play an important role in the prevention of knee injury as well as in the enhancement of knee function. Clinicians have suggested that preseason evaluation of the knee may identify those at risk for injury. Preseason baseline measures of knee function would also serve as individual goals for rehabilitation should injury occur (Heiser, Weber, Sullivan, Clare, & Jacobs, 1984; Slagle, 1979). Knee evaluations of athletes routinely include the assessment of peak torque of the knee flexors and extensors and the calculation of a hamstrings/quadriceps ratio (HQR). There is a range of ratios reported in the literature with HQR for football players being reported to be about .60 and higher goals recommended for rehabilitation (Campbell & Glenn, 1975; Davies et al., 1981; Stafford & Grana, 1984; Wyatt & Edards, 1981).

Discrepancies in the literature in reporting HQR have been due to several factors. It has been shown that HQR is affected by velocity of exercise. Stafford & Grana (1984) and others have shown that HQR increased as velocity increased from 90^o/sec to 300^o/sec on a Cybex II. Few investigators have corrected hamstrings and quadriceps peak torque values for gravity thus affecting the calculation of the HQR. Fillyaw, Bevins, and Fernandez (1986) reported gravity corrected HQR which decreased as velocity increased. Some investigators have reported a correlation between fiber type distribution and muscle torque at high velocities of contraction (Thorstenssen, Larsson, Tesch, & Karlsson, 1977; Yates & Kamon, 1981). Since different sports require specific skills involving specific angular motion, it would seem that athletes from different sports may generate peak torques which are specific to both velocity and angular range.

The purpose of this investigation was to compare the ability of two groups of highly trained athletes to generate peak hamstrings and quadriceps torque at three different velocities and through three different ranges of motion.

METHOD

Fifteen college varsity football linemen and 15 members of the varsity crew team served as subjects for this study. Subjects were screened to rule out any individual with a history of knee or thigh injury. Prior to participating in the study, each subject signed an informed consent. Height and weight were measured and recorded for each subject and leg dominance was determined by kicking preference. Subscapular and triceps skinfold measures were taken and percent body fat determined using a regression formula.

A Cybex II Isokinetic Dynamometer (Cybex, Division of Lumex, Inc., Ronkonkoma, NY) was used to measure the peak torque generated by the dominant quadriceps and hamstrings during knee extension and flexion. At the start of each testing session, the torque resulting from the weight of the leg and the machine accessories was determined and used to correct peak torque for the effect of gravity according to the methods described by Nelson and Duncan (1983).

Each subject was positioned on the Cybex II seat with the back supported and the hip between 90-100° of flexion. Velcro straps were used to stabilize the subject's chest, pelvis, and thigh. The tested leg was secured to the dynamometer arm with the shin pad just above the malleoli. The dynamometer shaft was aligned with the knee joint axis. The arms were folded across the chest during testing. Initially, subjects were permitted four practice trials through the full range of motion at 90°/sec. During the test session, each subject was allowed one practice trial at each velocity or angle change. Each subject was instructed to produce three maximal repetitions of alternating extension and flexion from initial starting positions of 120° (used in this study for the full range of motion on Cybex II), 90°, and 60° at speeds of 60, 180, and 300°/sec. The starting position of 120° was determined by having the subject place his heel against the pad of the chair. The starting positions of 60° and 90° was determined using an arthrodial goniometer. A specially designed wooden structure placed between the chair and the heel was used to assure return to the 60° and 90° position following each repetition. A latin square was used to randomize the order of testing the speed/angle conditions.

All torque values were corrected for the effect of gravity according to the method of Nelson and Duncan (1983). HQR were calculated for each subject and absolute peak torque values were normalized for lean body weight. A repeated measures analysis of variance was used to determine the effect of speed and starting angle upon peak torque and HQR generated by football linemen and rowers.

RESULTS

Means and standard deviations of absolute peak torque values and peak torque values normalized for lean body weight (relative) for quadriceps and hamstrings are displayed in Tables 1 and 2. Football linemen generated significantly greater ($p<.01$) absolute peak quadriceps torque than the rowers under all conditions tested. When torque values were expressed relative to lean body weight, football linemen demonstrated greater relative peak quadriceps torque values only from an initial starting position of 120° at a speed of 60°/sec. Football linemen also demonstrated significantly greater ($p<.05$) absolute peak hamstring torque than rowers in seven out of nine conditions tested. When torque values were expressed relative to lean body weight, however, it was shown that rowers were able to generate significantly greater ($p<.05$) peak hamstring torque per kilogram of lean body weight from starting positions of 90° at speeds of 60 and 180°/sec.

TABLE 1

MEAN PEAK TORQUE VALUES OF KNEE EXTENSORS

Velocity	60°/s			180°/s			300°/s		
Angle	60°	90°	120°	60°	90°	120°	60°	90°	120°
Crew									
Absolute (ft-lb)	154.3	187.9	177.0	106.6	137.2	128.5	81.3	104.8	97.1
SD	19.9	24.2	23.8	17.1	19.6	14.6	16.5	12.9	12.3
Relative (ft-lb/kg)	2.2	2.7	2.5	1.5	1.9	1.8	1.2	1.5	1.4
SD	.3	.3	.3	.2	.3	.2	.2	.2	.2
Football									
Absolute (ft-lb)	196.3	248.2	247.9	141.7	173.8	167.3	113.9	139.5	126.7
SD	21.2	31.8	30.4	16.0	24.2	22.9	15.6	18.0	13.3
Relative (ft-lb/kg)	2.2	2.8	2.8	1.6	1.9	1.9	1.3	1.6	1.4
SD	.2	.3	.2	.1	.2	.2	.1	.1	.1

TABLE 2

MEAN PEAK TORQUE VALUES OF KNEE FLEXORS

Velocity	60°/sec			180°/sec			300°/sec		
Angle	60°	90°	120°	60°	90°	120°	60°	90°	120°
Crew									
Absolute (ft-lb)	104.2	107.7	112.1	79.3	86.1	91.3	61.8	65.5	73.4
SD	17.7	18.1	14.9	18.7	16.6	14.9	18.5	14.2	14.7
Relative (ft-lb/kg)	1.5	1.5	1.6	1.1	1.2	1.3	.9	.9	1.0
SD	.2	.2	.2	.2	.2	.2	.3	.2	.2
Football									
Absolute (ft-lb)	128.7	123.2	135.7	95.5	97.6	110.4	69.0	78.8	87.9
SD	21.6	20.4	19.2	19.8	17.9	21.0	20.6	17.4	19.7
Relative (ft-lb/kg)	1.4	1.4	1.5	1.1	1.1	1.2	.8	.9	1.0
SD	.2	.2	.2	.2	.2	.2	.2	.2	.2

Both groups of athletes generated significantly greater peak quadriceps torque at the 60°/sec speed. There was a significant decrease in torque as speed increased in both groups (Figure 1 & 2). The greatest mean peak value for quadriceps torque in both groups was generated from the 90° starting position at 60°/sec, although in the football group this value was not significantly different from the torque generated from the 120° position at the same speed. The effect of initial starting position within each velocity appeared to be sport specific. The rowers

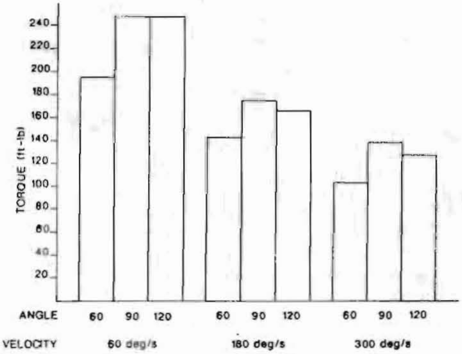

Figure 1. Football: Mean peak quadriceps torque.

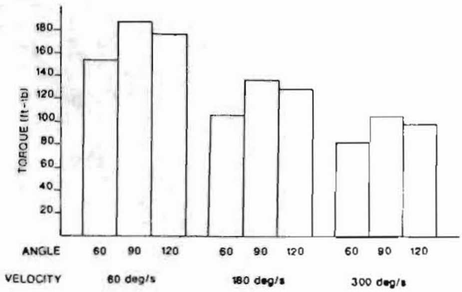

Figure 2. Crew: Mean peak quadriceps torque.

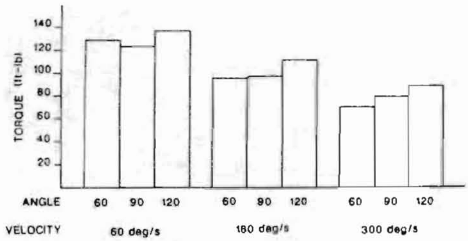

Figure 3. Football: Mean peak hamstrings torque.

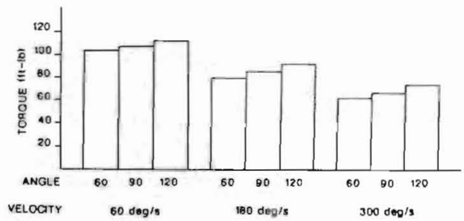

Figure 4. Crew: Mean peak hamstrings torque.

demonstrated significant differences ($p<.05$) between torques produced from each starting position at speeds of 60 and 180°/sec whereas football linemen had similar significant differences at speeds of 180 and 300°/sec.

Peak torque values generated by the hamstrings decreased as velocity increased in both groups (Figure 3 & 4). Rowers demonstrated a pattern of significant increases in peak hamstring torque as the starting angle increased at all velocities. Peak hamstring torque values of the football linemen were not affected by starting angle in the same consistent manner.

Rowers demonstrated significantly greater ($p<.05$) HQR values (Table 3) when calculated from peak torque values generated from starting angles of 60° and 120° at a speed of 60°/sec. HQR values increased in both groups with increases in the speed of contraction.

MEAN HAMSTRINGS/QUADRICEPS RATIOS

TABLE 3

Velocity	60°/s			180°/s			300°/s		
Angle	60°	90°	120°	60°	90°	120°	60°	90°	120°
Crew	.67	.57	.64	.75	.63	.71	.78	.63	.76
Football	.66	.50	.55	.68	.56	.66	.61	.56	.69

The results of this investigation indicate that there may be some important sport specific differences in quadriceps and hamstrings torque values related to both velocity of contraction and range of motion. The data also suggests that HQR may be sport specific and that velocity of contraction and range of motion should be considered before attempting to develop target HQR for conditioning and rehabilitation. Further study on this topic should include a variety of types of athletes as well as an investigation of the effect of hip angle on peak torques.

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