ISOKINETIC EXERCISES

The term "isokinetic" was introduced in the late 1960s when the Cybex I dynamometer was developed (Hislop and Perrine, 1967):

...the concept of isokinetic exercise is control of the speed of muscular performance. In order to achieve this kind of performance, it is necessary to provide an external means of holding the speed of body movements to constant rates irrespective of the magnitude of forces generated by the participating muscles. (p. 116)

Although not explicitly stated, these authors used "isokinetic" to describe a type of muscular contraction characterized by the constant angular velocity of the body segment.

The resistance provided by the isokinetic dynamometer matches the force exerted on the attachment arm by the user throughout the range of motion of an exercise, making it theoretically possible for the muscles to exert a continual maximal force throughout the full range of motion (Fleck & Kraemer, 1997). In general, isokinetic exercises are very safe to perform and demand little coordination. As a result, isokinetic exercises and testings are commonly used in clinical settings for the strengthening of muscles and the evaluation of strength, respectively.

Despite the advantages of isokinetic exercises, several issues must be considered when using strength data collected from isokinetic dynamometers for research and diagnostic purposes.

! The duration of constant angular velocity decreases as the preset angular velocity increases (Chow et al., 1997; Herzog, 1988; Osternig et al., 1983). This phenomenon is primarily due to the fact that, under the same experimental condition, longer time (or angular distance) is needed to accelerate a body segment to a higher angular velocity.

! Errors in torque measurements occur when the gravitational and inertial effects are not considered (Chow et al., 1997; Herzog, 1988; Winter et al., 1981). The feature of gravity-correction is available in most modern isokinetic dynamometers.

! Mixed results on the within-day, inter-day, inter-machine reliability (or reproducibility) of strength data have been reported for different exercises (e.g., Madsen, 1996; Pincivero et al., 1997; Wyse et al., 1994).

Clinicians and researchers are all aware of the fact that there are limitations in isokinetic dynamometers. It should be emphasized that recognizing the limitations does not diminish the valuable contributions isokinetic dynamometers can make to our understanding of muscular function, but rather enhances the clarity of interpretation.

KNEE JOINT FORCES DURING ISOKINETIC KNEE EXTENSIONS

Isokinetic knee extensions are commonly used in knee rehabilitation after treatments and surgeries. Knee joint forces during isokinetic knee extensions have been reported in four studies.

In a study by Nisell et al. (1989), eight male subjects performed knee extensions at two speeds (30 and 180 °/s). Inertial effects
were neglected in the force analysis. The axial component (compressive force parallel to the longitudinal axis of the shank) of the tibiofemoral joint force was found to be the same magnitude as the patellar ligament force throughout the knee extension range of motion. The maximum tibiofemoral axial forces were nine times the body weight (9 BW) and 5 BW for 30 and 180 °/s, respectively. Peak tibiofemoral shear forces of 1.0 and 0.7 BW were recorded for 30 and 180 °/s, respectively.

Based on strength data collected from five male subjects at isokinetic speeds of 60 and 180 °/s and musculoskeletal parameters reported in the literature, Kaufman et al. (1991) predicted muscle forces using an optimization technique and also reported knee joint forces. The peak patellofemoral joint force, and peak tibiofemoral axial and shear forces were estimated to be 5.1, 4.0, 0.5 BW, respectively, during isokinetic knee extensions performed at 60°/s. They found minimum reductions in various knee joint forces when the speed increased from 60 to 180 °/s. This contradicts the findings of Nisell et al. (1989) unless most of the decrease in knee joint forces from 30 and 180 °/s observed by Nisell et al. occurred between 30 and 60 °/s.

Using a biomechanical model of the knee joint developed from direct radiographic measurements of the subjects, Baltzopoulos (1995) tested five males at four isokinetic knee extension speeds—30, 90, 150, and 210 °/s. The average peak tibiofemoral axial forces for these four speeds (from slow to fast) were found to be 7.4, 6.6, 5.8, and 5.7 BW, respectively. The corresponding tibiofemoral shear forces were 0.9, 0.8, 0.7, and 0.8 BW, respectively. The results supported the findings of Nisell et al. (1989) except that the tibiofemoral shear force seemed to be relatively insensitive to the isokinetic speed.

In a case study, Chow (1999) tested a female subject at preset angular speeds ranging from 25 to 400 °/s. Gravitational and inertial effects were included in determining the resultant knee torque. A combination of knee torque and geometry of the knee (obtained from knee radiographs) was used to determine the different knee joint forces. All knee joint forces were found to decrease with increasing isokinetic speed. The presence of tibiofemoral shear force indicated that the ACL was loaded throughout the range of motion.

It is apparent that there are inconsistencies in the findings of these four studies. The differences are probably due to the differences in technique for determining knee joint forces, geometric data of the knee joint, and isokinetic dynamometer used for strength tests, and small sample sizes. It is noteworthy that a total of 20 subjects were tested in these previous studies and only one female was involved. Clinicians and researchers should interpret all these results with caution. More studies are needed before any conclusion is made.

REFERENCES