

# Topic 6: Muscle Function Testing

Laboratory Manual Section 06

HPER 6720  
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## **W** *Introduction*

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- Why do we measure muscle strength and power?
  - Health-related component of physical fitness
  - Fundamental to athletic and human performance
  - Progress in response to training programs
  - Rehabilitation/clinical assessment

## **W** General Testing Considerations

- Planning
- Safety
- Warm-Up
  - Light intensity arm or leg ergometry
- Familiarization
  - Practice session followed by actual test after residual DOMS is over (2-3 days)
- Specificity

## **W** Types of Tests/Contractions

- **Isometric Testing**
- Isotonic Testing
  - Contractions in which an object of fixed mass is lifted against gravity
  - Example: 1-RM Testing
- Field Tests
  - Examples: Vertical jump, anaerobic power tests
- **Isokinetic Testing**

## **W** Terminology

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- Force
  - Strength or energy exerted or brought to bear
  - Units: pounds (lbs), kilograms (kg), Newtons (N)
    - SI Unit: Newtons (N)
      - The newton is that force which, when applied to a mass of 1 kg, gives it an acceleration of 1 meter per second squared.
    - Conversion Factors:
      - lbs x 4.4482 = N
      - kg x 9.807 = N

## **W** Terminology

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- Torque
  - The measure of the force applied to an object to produce rotational motion. Torque is determined by multiplying the applied force by the distance from the pivot point to the point where the force is applied.
  - Peak torque is a measure of an individual's maximal strength
  - Unit: Foot-pounds (ft-lb), Newton-meters (N·m)
    - SI Unit = Newton-meters (N·m)
    - Conversion Factors:
      - ft-lb x 1.3558 = N·m

## **W** Terminology

- **Work**

- The amount of energy transferred by a force acting through a distance ( $W = \text{force} \times \text{distance}$ )
- SI Unit: Joule (J)
  - 1 Joule = 1 N·m (but, torque and work are not the same)
  - Work = torque x angular displacement

- **Power**

- Rate at which work is performed or energy is converted ( $\text{Power} = \text{work}/\text{time}$ )
- SI Unit: Watt
  - 1 Watt = 1 Joule/sec

## **W** Terminology

**Peak torque:** Highest point of the torque curve. The most commonly used parameter during isokinetic testing. Corresponds to the area of maximal torque on a strength curve. Measured in newton meters (N·m). May also be expressed relative to body weight.

**Average peak torque (N·m):** The average of all peak torques for each repetition performed.

**Average torque (N·m):** The average of torque produced for the entire torque curve.

**Angle-specific torque (N·m):** Represents torque produced at a specific joint angle of the range of motion.

**Total work (J):** The total amount of work performed based on the number of repetitions. Total work is the product of average torque (N·m) and angular displacement (rad). May be expressed relative to body weight and as the average work performed per repetition.

**Peak power (W):** The maximum product of torque and velocity (highest power attained during the trial).

**Average power (W):** Total work divided by the time taken to perform the work. Average power may be expressed relative to body weight.

**Torque acceleration energy:** The amount of work performed in the first 1/8 of a second.

**Acceleration time:** The time to the variable of interest (i.e., peak torque or joint angle) has been determined.

**Average points variance:** A guideline determining consistency set forth to ensure that all repetitions performed are within 10% above and below the average.

**Rate of peak torque development:** Time it takes to reach peak torque during a trial.

**Endurance (fatigue) ratio and index:** Determined by endurance protocols in which either maximal number of repetitions is performed until a specific reduction (i.e., 50%) is observed, percent loss of torque is calculated over a test, or total work is measured for a specified number of repetitions and is compared with another specified group.

**Force decay rate:** Down slope of a torque curve.

**Torque-velocity relationship:** Useful tool for analysis of torque produced at a specified velocity.

**Reciprocal innervation time:** Time between agonist and antagonist muscle actions.

**Isomap:** Multiple dimension analyses.

Figure 8.3 Common parameters obtained from isokinetic testing.

## **W** *Isometric Testing*

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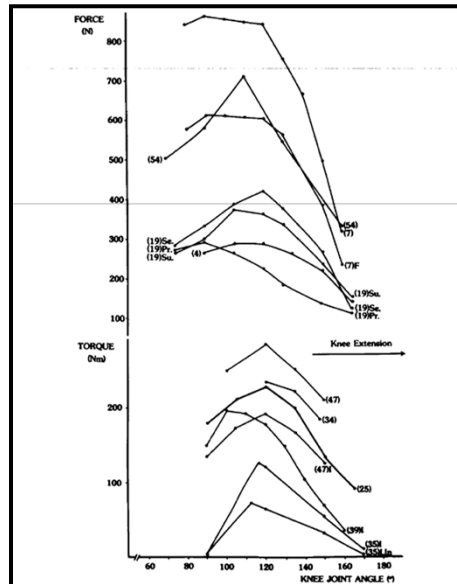
- **Isometric (Static) Contraction**
  - No change in muscle length
  - Muscle length depends on joint angle
  - Contraction is performed at an angular velocity of 0 degrees/sec.
  - Data is usually reported as:
    - Force (N)
    - Torque (N·m)

## **W** *Isometric Testing*

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- **Testing considerations**
  - Joint angle:
    - Defining strength at specific positions
  - Duration of contraction:
    - Debate: 3-6 seconds should be sufficient for the development of peak force
  - Rest intervals:
    - 1 minute between trials should be sufficient.
  - Number of repetitions:
    - Debate: 3 repetitions probably sufficient

## W Isometric Testing



### Joint Angle

FIGURE 12  
Knee extension strength curves. Numbers in parentheses identify the sources for data. Unless indicated by one or more of the following letters, curves were obtained under isometric conditions with male subjects: I = isokinetic torque; F = female subjects; I<sub>n</sub> = injured knee; Se., Su., or Pr. = force measured at seated, supine, or prone experimental positions.

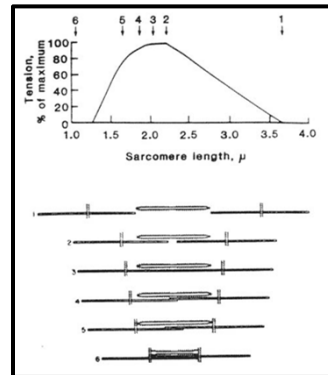
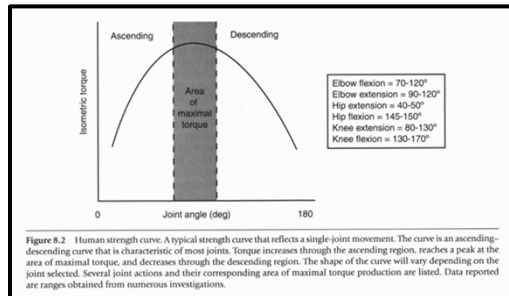
## W Isometric Testing

- Testing considerations (cont'd)
  - Averaging interval:
    - Probably around 1 second
  - Standardization of instructions
    - Non-emotional, objective, free of noise, spectators
  - Positioning and stabilization:
    - Body positioning can affect measurement of strength or torque.

# W Isometric Testing

- **Devices used to assess isometric strength**
  - Hip and back dynamometer
  - Cable tensiometers
  - Hand-grip dynamometers
  - Load cells
  - Isokinetic testing devices
  
- **Pre-test considerations**
  - Calibration
  - Warm-up

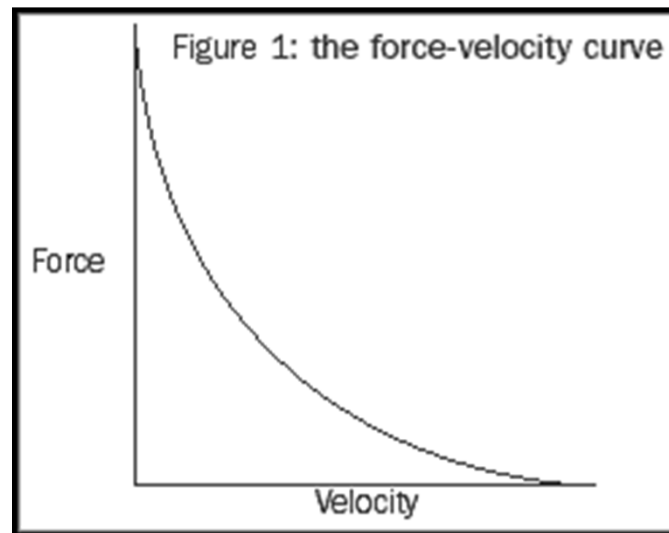
# W Isometric Testing



## **W** *Isokinetic Testing*

- **Isokinetic contractions**
  - Movement is performed at a constant speed (angular velocity) throughout the entire range of motion
  - Dynamic contraction
    - Concentric: Muscle shortening during contraction
    - Eccentric: Muscle lengthening during contraction
  - Data usually reported as:
    - Torque (N·m)
    - Torque = Force (N) x Lever Arm (m)

## **W** *Isokinetic Testing*



## **W** *Isokinetic Testing*

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- Testing considerations
  - Isolation and stabilization
  - Axis of motion:
    - Critical that axis of rotation of the machine and the joint being tested are aligned.
  - Gravity compensation:
    - Knee flexion example
      - Gravity assists the motion
  - Range of motion:
    - Total ROM vs. physiological ROM

## **W** *Isokinetic Testing*

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- Testing considerations (cont'd)
  - Standardization of instructions
  - Practice
  - Repetitions:
    - Determined by what you are assessing
      - Strength = 5 reps
      - Endurance: up to 50 or beyond
  - Angular velocity:
    - 30 to 360 deg/sec
  - Velocity order:
    - Debated: order vs. random

## W Isokinetic Testing

- Testing considerations (cont'd)
  - Velocity overshoot:

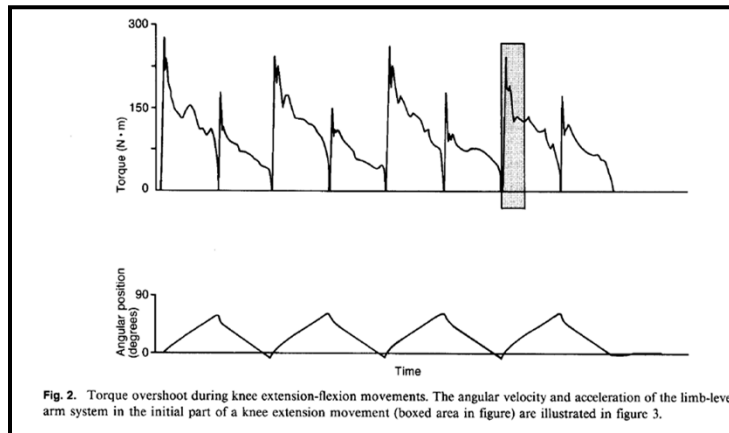


Fig. 2. Torque overshoot during knee extension-flexion movements. The angular velocity and acceleration of the limb-lever arm system in the initial part of a knee extension movement (boxed area in figure) are illustrated in figure 3.

## W Isokinetic Testing

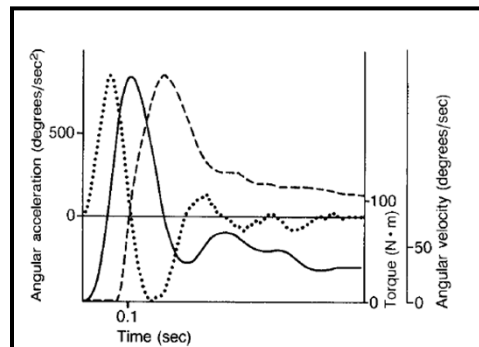


Fig. 3. Torque (---), angular velocity (—) and angular acceleration (···) of the limb-lever arm system during knee extension. The angular velocity of the dynamometer was preset at 30 °/sec. Notice that the preset velocity is exceeded by the velocity of movement during the free acceleration period and the torque overshoot is the torque required to decelerate the limb. The velocity of movement becomes constant and equal to the preset velocity after a series of acceleration and deceleration periods.

## **W** *Isokinetic Testing*

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- Rest Interval
  - 30 to 90 seconds between sets

## **W** *Class Laboratory Exercise*

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- We are going to attempt to recreate two different “physiological” curves that you always see in textbooks:
  - Joint Angle/Muscle Length vs. Force/Torque Production
  - Force-Velocity Curve
- All students will complete the following tests:
  - Isometric Knee Extension
    - 90, 100, 120, 140, 160 degrees
  - Isokinetic Knee Extension
    - 30, 60, 120, 180, 250 deg/sec