Isokinetics

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Manager Innovatie AZ Alma
Projectmanager Mensana

Ways to Measure Strength

- **Isometric**

- **Isotonic – Isodynamic – iso inertia**

- **Isokinetic**

Ways to Measure Strength: isometric

Isometric:
- muscle action when tension is produced but there is no change in the length of the muscle
  - ie., hand grip dynamometer
  - Is work being done? (FxD)
  - no distance but physiological work is being done since we are using ATP
### Ways to Measure Strength: isometric

**Advantages**
- simple
- cheap
- saves time

**Disadvantages**
- specific to the joint angle (doesn't reflect the full ROM)
- Strength training – increase of strength at that point of ROM
- doesn't correlate with sports performance
- more likely to perform the Valsalva Maneuver

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### Ways to Measure Strength: isotonic

**Isotonic – Isodynamic – iso inertia**

muscle action in which a muscle shortens or lengthens with varying tension and velocity while overcoming a constant resistance throughout a ROM

**Advantages**
- correlates better with sports performance
- relatively inexpensive
- accessible
- psychologically seeing work done

**Disadvantage**
- measuring the weakest point in the ROM
- doesn't measure strength at different speeds

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### 12 steps in the muscle contraction

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initiation</td>
</tr>
<tr>
<td>2</td>
<td>Proprioception</td>
</tr>
<tr>
<td>3</td>
<td>Activation of motor units</td>
</tr>
<tr>
<td>4</td>
<td>Stretching of tendons</td>
</tr>
<tr>
<td>5</td>
<td>Cocontraction</td>
</tr>
<tr>
<td>6</td>
<td>Resistance to movement</td>
</tr>
<tr>
<td>7</td>
<td>Full contraction</td>
</tr>
<tr>
<td>8</td>
<td>Maximal effort</td>
</tr>
<tr>
<td>9</td>
<td>Return to resting state</td>
</tr>
<tr>
<td>10</td>
<td>Recovery phase</td>
</tr>
<tr>
<td>11</td>
<td>Fatigue</td>
</tr>
<tr>
<td>12</td>
<td>Complete fatigue</td>
</tr>
</tbody>
</table>

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Ways to Measure Strength: isokinetic

Isokinetic maximal tension is developed at all joint angles throughout the ROM with speed being constant (have accommodating resistance at a controlled speed of movement)

- **Advantages**
  - measure strongest point in ROM
  - measure strength at different speeds

- **Disadvantages**
  - expensive
  - not readily accessible
  - need someone knowledgeable to run the equipment

<table>
<thead>
<tr>
<th>Type of Contraction</th>
<th>Definition</th>
<th>Work</th>
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</thead>
<tbody>
<tr>
<td>Concentric</td>
<td>Force of muscle contraction &gt; resistance</td>
<td>Positive work; muscle moment and angular velocity of joint in same direction</td>
</tr>
<tr>
<td>Eccentric</td>
<td>Force of muscle contraction &lt; resistance</td>
<td>Negative work; muscle moment and angular velocity of joint in opposite direction</td>
</tr>
<tr>
<td>Isokinetic</td>
<td>Force of muscle contraction = resistance; constant angular velocity; special case is isometric contraction</td>
<td>Positive work; muscle moment and angular velocity of joint in same direction</td>
</tr>
<tr>
<td>Isometric</td>
<td>Force of muscle contraction &lt; resistance; series elastic component stretch = shortening of contractile element (two to 7% of resting length of muscle)</td>
<td>No mechanical work; physiological work</td>
</tr>
</tbody>
</table>

Isotonic vs. Isokinetic Exercise

[Diagram showing isotonic vs. isokinetic exercise]
Length-Tension Relationships

![Graph showing length-tension relationships](image)

Force Production – Load-Velocity Relationship

![Diagram of force-velocity relationship](image)
Length-Tension Relationships

![Length-Tension Curve of a Muscle]

Force Production – Load-Velocity Relationship

![Force-Velocity Relationship](image)

3-D Relationship of Force-Velocity-Length

![3-D Relationship of Force-Velocity-Length](image)
<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type IIA</th>
<th>Type IIB</th>
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</thead>
<tbody>
<tr>
<td>Speed of</td>
<td>Slow</td>
<td>Fast</td>
<td>Fast</td>
</tr>
<tr>
<td>contraction</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Primary source of ATP</td>
<td>Oxidative</td>
<td>Oxidative</td>
<td>Anaerobic</td>
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<tr>
<td>production</td>
<td>phosphorylation</td>
<td>phosphorylation</td>
<td>glycolysis</td>
</tr>
<tr>
<td>Glycolytic enzyme</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capillaries</td>
<td>Many</td>
<td>Many</td>
<td>Few</td>
</tr>
<tr>
<td>Myoglobin content</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Glycogen content</td>
<td>Low</td>
<td>Intermediate</td>
<td>High</td>
</tr>
<tr>
<td>Fiber diameter</td>
<td>Small</td>
<td>Intermediate</td>
<td>Large</td>
</tr>
<tr>
<td>Rate of fatigue</td>
<td>Slow</td>
<td>Intermediate</td>
<td>Fast</td>
</tr>
</tbody>
</table>

### History of Isokinetics

Has been available since the 50's

Hislop & Perrine (1967)

- movement that occurs at a constant angular velocity with accommodating resistance

- max muscle tension can be generated because resistance is variable to match the muscle tension produced at various points in the ROM!
Advantages

1) isolate weak muscle groups
2) work maximally throughout ROM
3) velocities simulate functional activity?
4) inherent safety mechanism

Disadvantages

1) cost
2) open-chain motions
3) cardinal planes !!!

Terminology

1) force
   when a stimulated muscle acts against a resistance force is produced
2) torque
   Force x Distance
3) work
   applied force times distance of rotation
4) power
   time required to perform work
Normal Torque Curve

1) Angle Specific Torque (AST) -

2) Peak Torque (PT) -

3) Average Torque (AT),
   torque over entire ROM
   lower than PT, higher reliability

Isokinetic Curves
Power Curves

Abnormal Torque Curve

- Predicting Injury from Curve?
  - can look at pt of pain, but not predict injury!
  - non-volitional reproduction of pain at the same pt in ROM
  - isokinetics will accommodate the pain by decreasing the dynamometer force

Types of Dynamometers

- Passive - primary function is the dissipation of energy
  - torque produced by the pt driving the dynamometer
  - old Cybex systems

- Active - "robotics", can either dissipate energy by the patient or supply energy to do work on the patient
  - Kin Com, Biodex, Cybex
Instrumentation

- **Mode of Muscle Action**
  - conv/ecc
  - isometric
  - Passive

- **Test Velocity**
  - 0°/s - 1000°/s
  - above 300°/s difficulty generating force (not isokinetics!!)

Gravity Correction

- Must be performed during any gravity dependent joint testing position
  - GC value + to force?
  - GC value (-) to force?
  - some dynamometers perform this either dynamically or stationary

- Failure to GC results in:
  - quads under predicted
  - hams over predicted

Interpreting an Isokinetic Evaluation

- Left – right ratio
- Agonist / antagonist ratio
- PT – PT/BW
- Work - Power
- Fatigue
- Acceleration – deceleration
- Time to
  - Pektorque
  - Isokinetic velocity
- Conv / Ecc
Interpreting an Isokinetic Evaluation

• Left – Right ratio

Strength:

In the case of testing only one side then the opposite side should be used as a reference (this is not the case in athletes who use one side preferentially over the other e.g. Javelin).

Imbalance of strength of up to 10% can be considered normal.

Imbalance between 10 and 20% is possibly abnormal (with injury this is considered probably abnormal).

Imbalance of 20% or greater is probably abnormal (injury, this is definitely abnormal).

• Force/Torque ratios Relative to BW:
  - Nm torque / kg BW
  - mainly involving the lower extremity

• Reciprocal Muscle Group Comparisons
  - Knee flex/ext (H:Q) = .67 ratio
  - Shoulder ER/IR = .70 -.90 (.65 & .80 }

• Trunk muscles
  - 60 – 66% Flex/Ext

Interpreting an Isokinetic Evaluation

Fatigue index:

Combining the above two measures this is the percentage that peak torque declined during the endurance test. It uses a simple Chi-Sq test by subtracting initial peak torque from final peak torque then dividing that by the initial peak torque again this is then multiplied by 100 to give a percentage out of 100.
Interpreting an Isokinetic Evaluation

- Left – right ratio
- Agonist / antagonist ratio
- PT – P/T/BW
- Work - Power
- Fatigue
- Acceleration – deceleration
- Time to
  - Peaktorque
  - Isokinetic velocity
- Con / Ecc: Quadriceps / hamstrings

An innovative and state of the art high-technological 3 dimensional biomechanical and (sport) medical low back evaluation – rehabilitation and training tool
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- added value in the (sport) medical diagnosis
- left – right ratio
- agonist – antagonist ratio
- compensatory movements !!!

- parameters measured
- muscular strength - torque (back and abdominal)
- range of motion
- velocity of movement
- acceleration and deceleration

**simultaneous 3D**

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- DIFFERENT CONTRACTION MODES
- STANDING AND SITTING IN THE SAME DEVICE
- SIMULTANEOUS 3D MEASUREMENT ALL AXES - PARAMETERS
- EASY TO USE SOFTWARE
- FULL FEATURED MENU DRIVEN SOFTWARE
- USER CENTRED SYSTEM
- ERGONOMIC DESIGNED

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Different contraction modes

**Isometric**
- no movement
- maximal torque

**Isodynamic**
- constant resistance (% of the isometric values)
- variable velocity

**Isokinetic** (Hislop & Perrine (1967))
- constant velocity (wide range of °/s)
- variable resistance
Joint forces related to the type of contraction

**HIGHEST**
- Isodynamic eccentric
- Isokinetic eccentric
- Isometric
- Isodynamic concentric
- Isokinetic concentric

**LOWEST**

Strength increase related to the type of contraction

**HIGHEST**
- Isokinetic eccentric
- Isodynamic eccentric
- Isokinetic concentric
- Isodynamic concentric
- Isometric

**LOWEST**

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**Presentatie en films**

[bionix\Videos\NINIX MONITOR YT.mp4](#)
Isometric evaluation

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<td>N.m</td>
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<td>2.5</td>
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<tr>
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</table>
Pre - post
Pre - post

- Geen informatie
  - Morfologie van de curve
  - Proprioceptie – stabiliteit
  - Acceleratie – deceleratie
  - Arbeid geleverd
  - Dynamische activiteit
  - Compensatoire bewegingen
  - Functionele beweging

- Enkel isometrische bepaling
  - op meest optimale punt (1 punt in de ROM)

Dank voor uw aandacht
**Isokinetic contraction**

- The speed of the motion is constant during the range of motion
- Maximal muscle tension can be generated because resistance is variable to match the muscle tension produced at various points in the ROM!
  - Always optimal resistance according to the physiological tension – force diagram

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**Isokinetic contraction - Advantages**

- Maximal loading throughout whole range of motion
- Work maximally throughout ROM
- Objective, reproducible and easily quantifiable

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**Isokinetic contraction - Advantages**

- Velocities relatively simulate functional activity
- Morphology change indicates presence of a pathology
  - Not diagnostic – no linear relation between pathology and morphology
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Standing and Sitting
Biomechanical and medical differentiating

SIMULTANEOUS 3D MEASUREMENT ALL AXES - PARAMETERS
rotation

SIMULTANEOUS 3D MEASUREMENT ALL AXES - PARAMETERS
flexion extension
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SIMULTANEOUS 3D MEASUREMENT ALL AXES - PARAMETERS

lateroflexion

Isokinetic evaluation: Rotation 30°/s

Data analysis

Compensatory torques at peak torque repetition

Graphs showing data analysis.