

User or abuser of isokinetics?: 5 simple steps for valid and reliable isokinetic measurements

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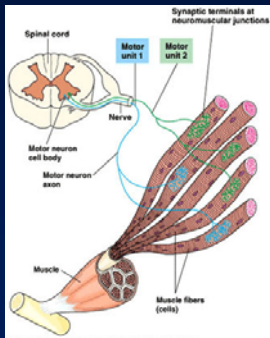
IPRS Isokinetic Event-Old Trafford
Tuesday 8 September 2009



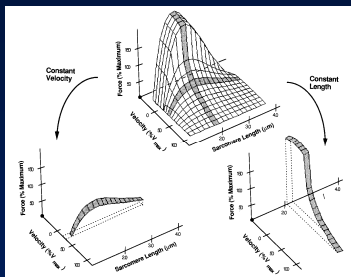
Measurement of Static and Dynamic Muscle Strength



Generation of muscle force



Force-Length-Velocity relationship



Lieber (1992)

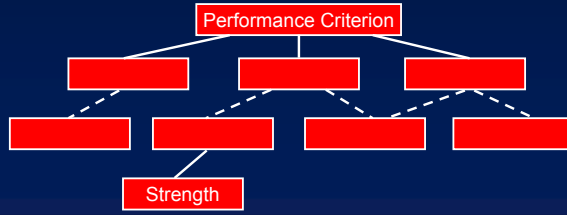
Strength requirements in different sports



Strength-limited sports
Strength-related sports
Strength-independent sports (Wrigley 2000)

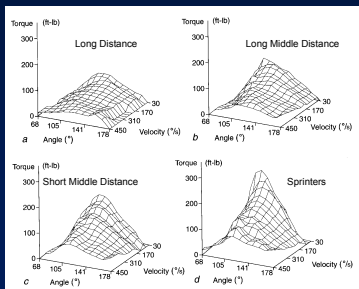


Strength requirements in different sports



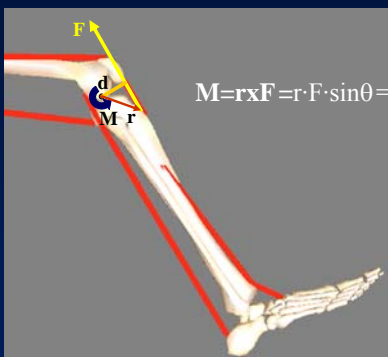
Isokinetic Dynamometry:

Very useful for measurement of sport-specific strength because of the ability to measure the strength-muscle length-velocity relationship



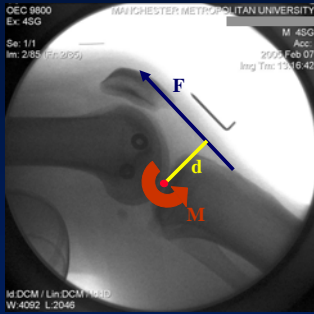
Signorile & Applegate (2000)

Joint Rotation: Muscle Moment (Nm)



$$M = r \times F = r \cdot F \cdot \sin\theta = d \cdot F$$

Joint Rotation: Muscle Moment (Nm)



$$M = F \cdot d$$

The Total Joint Moment is the Sum of All Muscle Moments

Isokinetic Dynamometry: A bit of history...



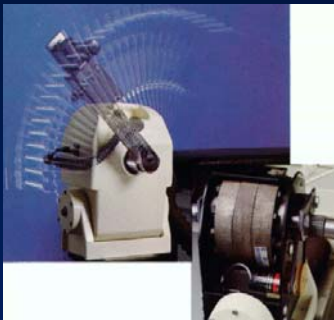
Thistle, H. G. et al. (1967). Isokinetic contractions: a new concept of resistive exercise, *Archives of Physical Medicine Rehabilitation*, 6, 279-282



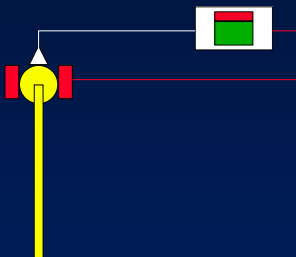
Isokinetic Dynamometry: Single Joint Testing



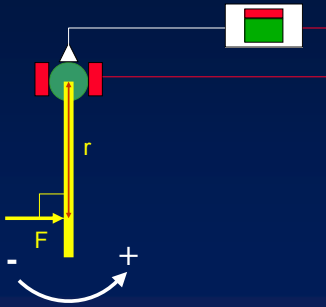
Isokinetic Dynamometry: Control of Angular Velocity



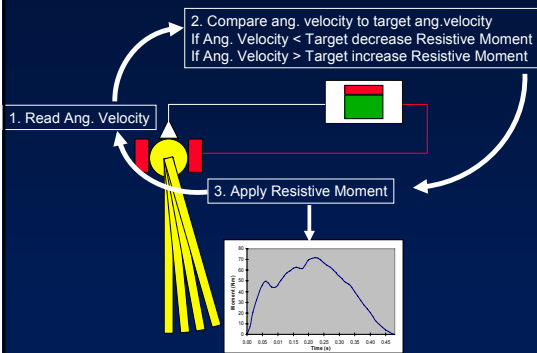
Feedback system to maintain the velocity constant and equal to the required test ang. velocity



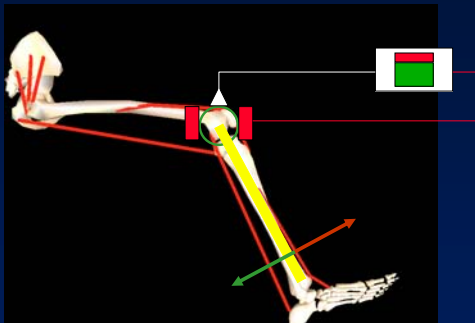
Moment of Force: $M=r \times F$



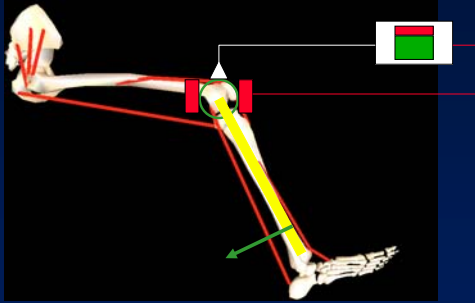
Feedback loop for control of angular velocity



Application of Resistive Moment

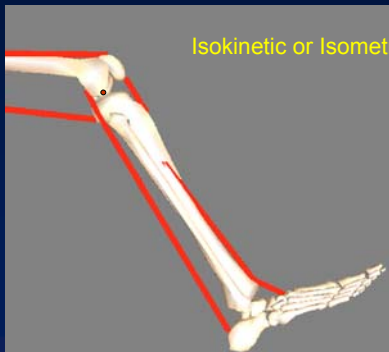


Isokinetic Dynamometry: Constant Joint Angular Velocity
(not constant muscle contraction linear velocity)



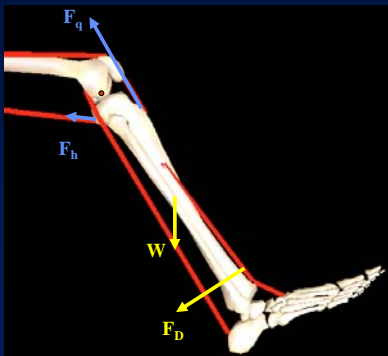
but how is the resistive moment related to the joint (sum of all muscle) moment?

Newton's Laws of Motion (2D)
Second Law (Rotational Movement):
 $\Sigma M = I\alpha$

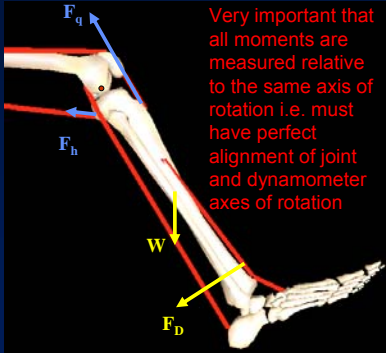


Isokinetic or Isometric: $\alpha = 0$

$$M_j = M_D + M_w$$



$$M_j = M_D + M_w$$

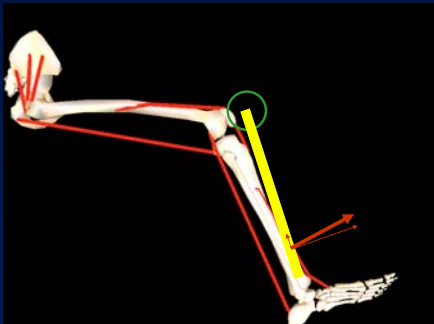


Very important that all moments are measured relative to the same axis of rotation i.e. must have perfect alignment of joint and dynamometer axes of rotation

Misalignment of joint and dynamometer axes of rotation due to compliance/deformation of soft tissue, seat, attachment & straps and shifting of the knee joint axis with knee motion

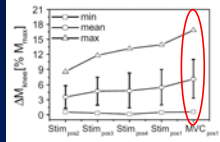
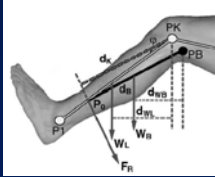


Effects of misalignment of axes of rotation



Errors between measured and resultant joint moments when using isokinetic dynamometers due to axes misalignment

- Herzog (1988): Single subject ~ 2%
- Kaufman et al. (1995): 10-13%
- Arampatzis et al (2004): Isometric 7.3% (range: 1-17%)



Arapatzis et al. (2004).

Errors between measured and resultant joint moments when using isokinetic dynamometers due to axes misalignment

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All previous studies used external cameras and skin markers to identify knee joint centre/axis of rotation

Measurement of knee joint kinematics during contraction using X-Ray video fluoroscopy

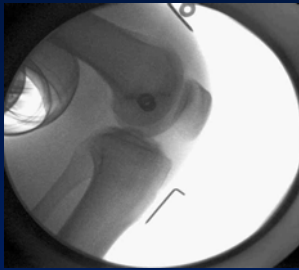


Measurement of knee joint kinematics during contraction using X-Ray video fluoroscopy



Isometric
Isokinetic Concentric 30 & 60 deg/s
Isokinetic Eccentric 60 deg/s

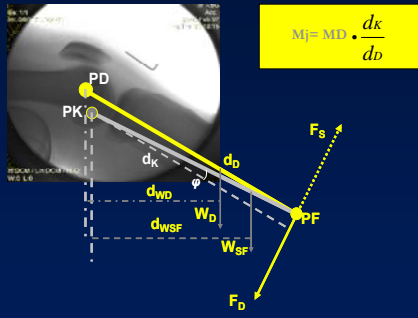
"Isometric" Knee Extension @ 90 deg knee flexion angle



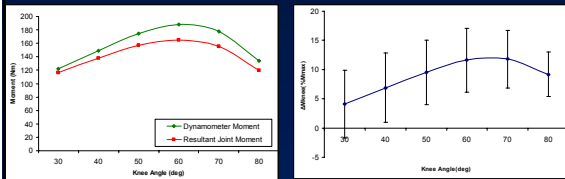
Isokinetic Concentric Knee Extension 30 °/sec



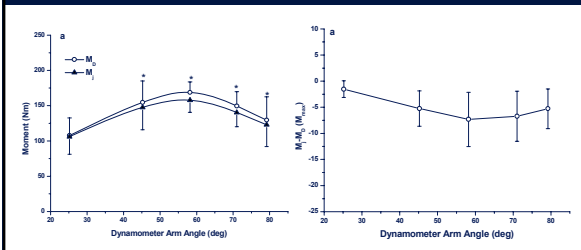
Calculation of the actual joint moment



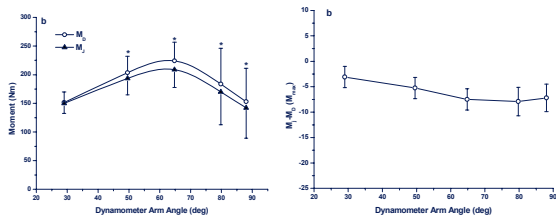
Errors between measured and resultant joint moments when using isokinetic dynamometers due to axes misalignment Isokinetic Concentric Knee extension @ 30 deg/s



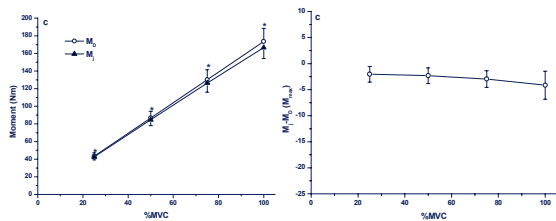
Errors between measured and resultant joint moments when using isokinetic dynamometers due to axes misalignment Isokinetic Concentric Knee extension @ 60 deg/s



Errors between measured and resultant joint moments when using isokinetic dynamometers due to axes misalignment
Isokinetic Eccentric Knee extension @ 60 deg/s



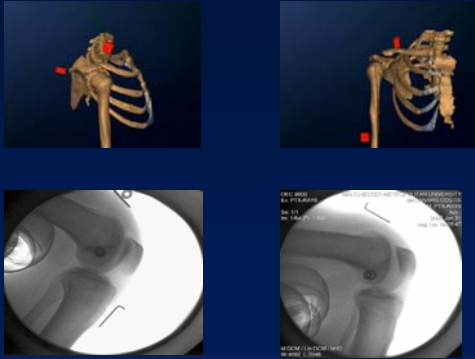
Errors between measured and resultant joint moments when using isokinetic dynamometers due to axes misalignment
Isometric Knee extension



Axes misalignment problems

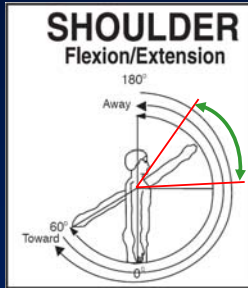
- The joint moment error due to axes misalignment cannot be neglected if the true joint moments need to be determined
- Implications for measurement of dynamic joint function for strength and rehabilitation assessment
- Align axes of rotation:
 - accurately
 - under contraction conditions
 - near the position of expected maximum joint moment

Axes of rotation alignment



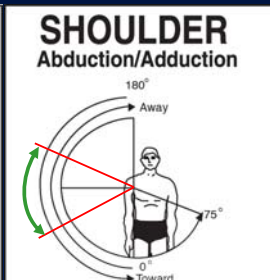
Axes of rotation alignment

Define ROM for **safe** axes of rotation alignment



Axes of rotation alignment

Define ROM for **safe** axes of rotation alignment



Accurate alignment of dynamometer & joint axes of rotation



User or abuser of isokinetics?: 5 simple steps for valid and reliable isokinetic measurements

Step No 1:

Align axes of rotation:

- accurately
- under contraction conditions
- near the position of expected maximum joint moment

Important Issues during Isokinetic Dynamometry



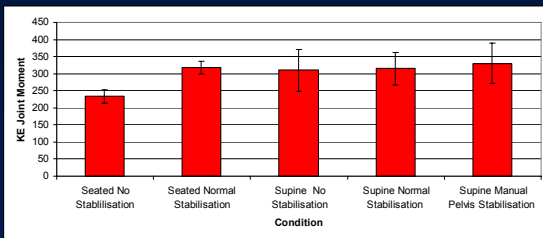
Stabilisation

Important Issues in Strength Measurement :

Stabilisation problems
&
Effects on Activation



Stabilisation problems:
Effects on Activation?

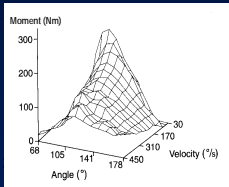


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valid and reliable isokinetic measurements

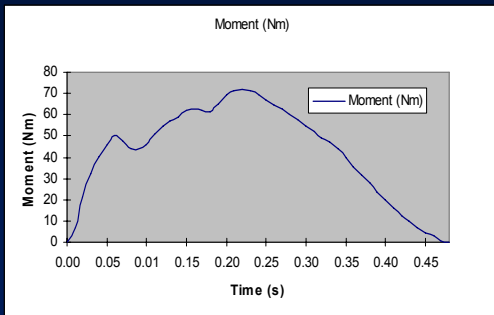
Step No 2:

Stabilise properly all segments involved in the production
of joint movement

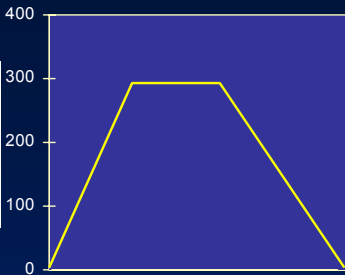
Joint moment at different joint positions and angular velocities measured with Isokinetic dynamometers



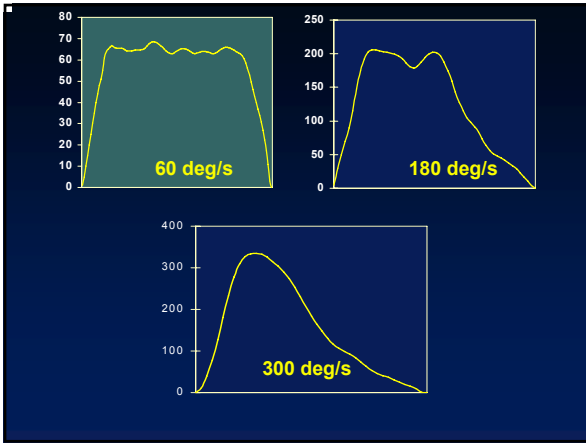
Joint moment during concentric knee extension @ 300 deg/s

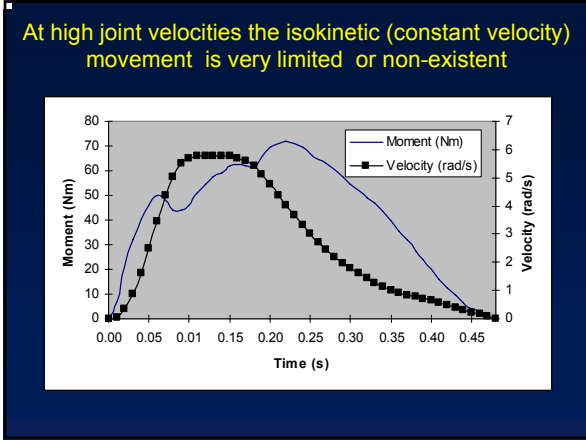


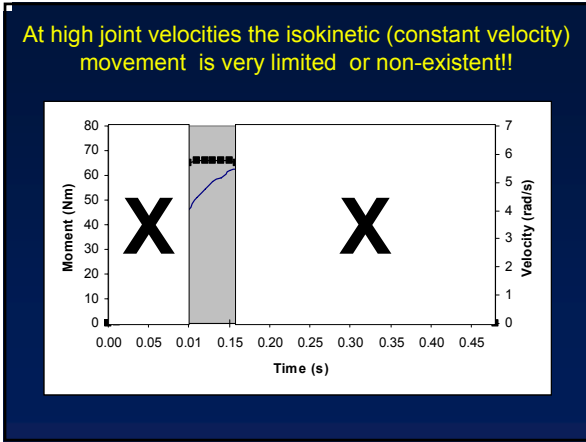
What is the maximum knee extension moment @ 300 deg/s?



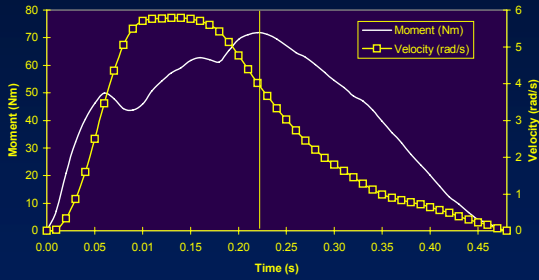
Test Velocity 300 deg/s



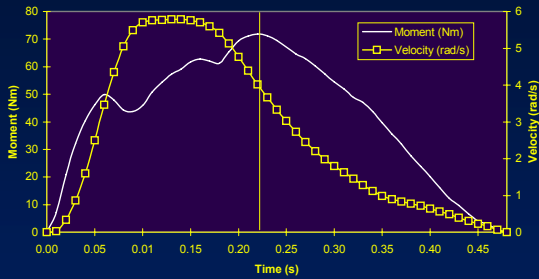




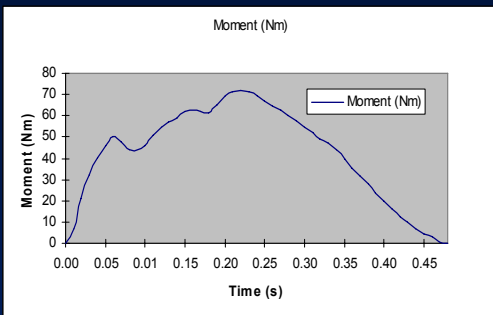
The peak dynamometer moment may not be recorded in isokinetic conditions and at the preset or target velocity



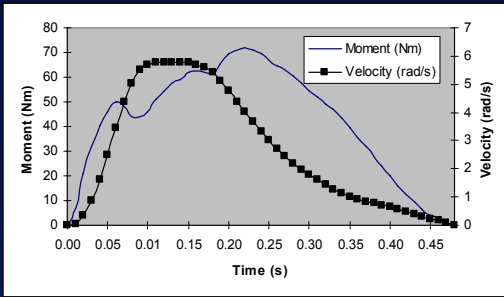
The dynamometer moment is not equal to the joint moment during non-isokinetic conditions



Joint moment during concentric knee extension @ 5.24 rad/s

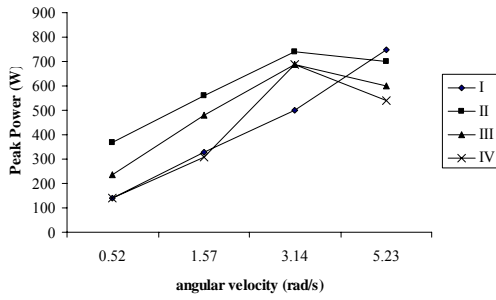


Knee Joint Power ?
Power=Moment X Angular Velocity



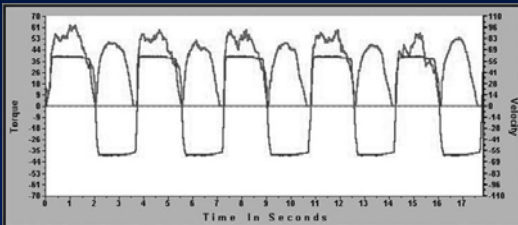
Knee Joint Power ?
 $\text{Power} = \text{Moment} \times \text{Angular Velocity}$

Knee Joint Power-Velocity Relationship

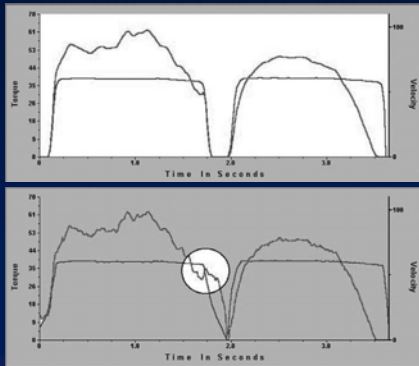


Iossifidou, Baltzopoulos & Giakas. (2003), JSS

System 4: Windowing function to exclude non-isokinetic conditions



System 4:
Windowing function to exclude non-isokinetic conditions



User or abuser of isokinetics?: 5 simple steps for valid and reliable isokinetic measurements

Step No 3:

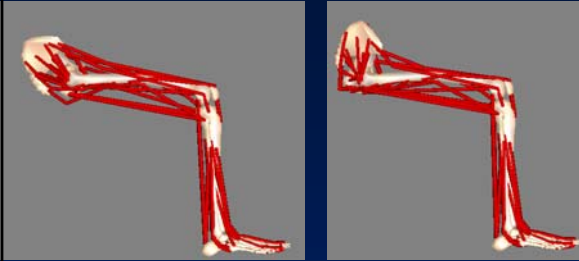
Monitor Angular Velocity throughout the ROM and exclude non-isokinetic data from the analysis

Important Issues during Isokinetic Dynamometry



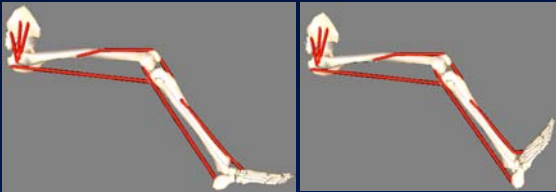
Adjacent joint position affects muscle length in two-joint muscles and therefore moment in the tested joint

Important Issues in Isokinetic Dynamometry



Adjacent joint position affects muscle length in two-joint muscles and therefore moment in the tested joint (knee extension or flexion in this example)

Important Issues in Isokinetic Dynamometry: Knee Flexion



Ankle joint position and gastrocnemius muscle length effects on knee flexion moment

Important Issues in Isokinetic Dynamometry: Knee Flexion



Miller et al. (1996)	T_h	<	T_h
Miller et al. (1997)	T_h	<	T_h
Croce et al. (2000)	T_h	<	T_h

User or abuser of isokinetics?: 5 simple steps for valid and reliable isokinetic measurements

Step No 4:

Plan positioning of adjacent segments and joints appropriately and control properly

User or abuser of isokinetics?: 5 simple steps for valid and reliable isokinetic measurements

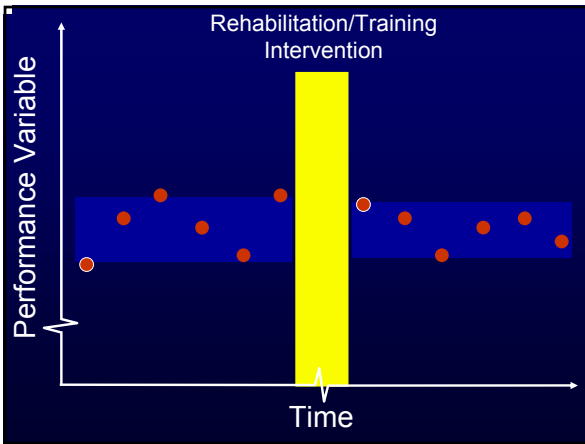
Step No 5:

Record all test settings, subject positioning and stabilisation accurately

User or abuser of isokinetics?: 5 simple steps for valid and reliable isokinetic measurements



- Axes of Rotation Alignment
- Isokinetic (constant ang. velocity) Phase
- Stabilisation
- Positioning
- Recording of Test Settings



Isokinetic dynamometers are excellent tools and very useful for measuring static & dynamic joint function...

...but users must ensure that some important principles are not violated by following some simple practical steps

Requirements for reduction of measurement variability in isokinetic dynamometry (Best Practice):

- Align axes of rotation:
 - accurately
 - under contraction conditions
 - near the position of expected maximum joint moment
- Calculate and monitor angular velocity independently and use isokinetic data only
- Stabilise segments and reduce extraneous movement
- Position and control second joint when biarticular muscles are involved
- Record all test settings and subject positioning

Thank you for your attention
