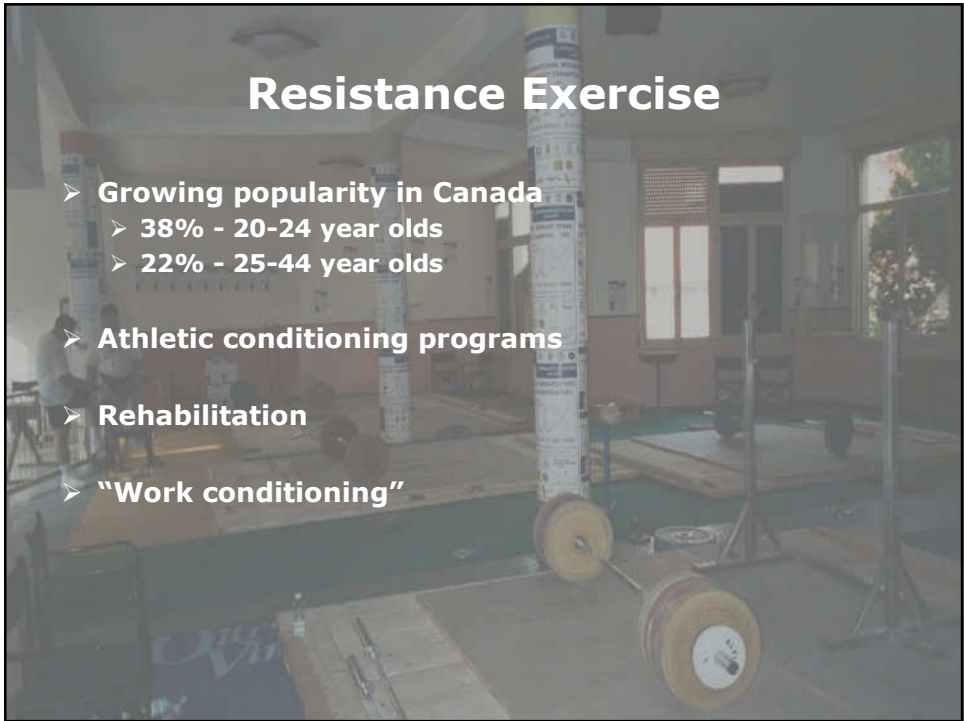




Analyzing the Squat: Performance, Rehabilitation & Health

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www.ualberta.ca/~loren1/nmrp.htm



Resistance Exercise

- **Growing popularity in Canada**
 - 38% - 20-24 year olds
 - 22% - 25-44 year olds
- **Athletic conditioning programs**
- **Rehabilitation**
- **"Work conditioning"**

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Coach Development

- Education
 - General
 - Specific
- Experience

Outline

- Resistance exercise basics
- The squat – biomechanics
 - Factors affecting mechanics
- The squat – teaching progressions

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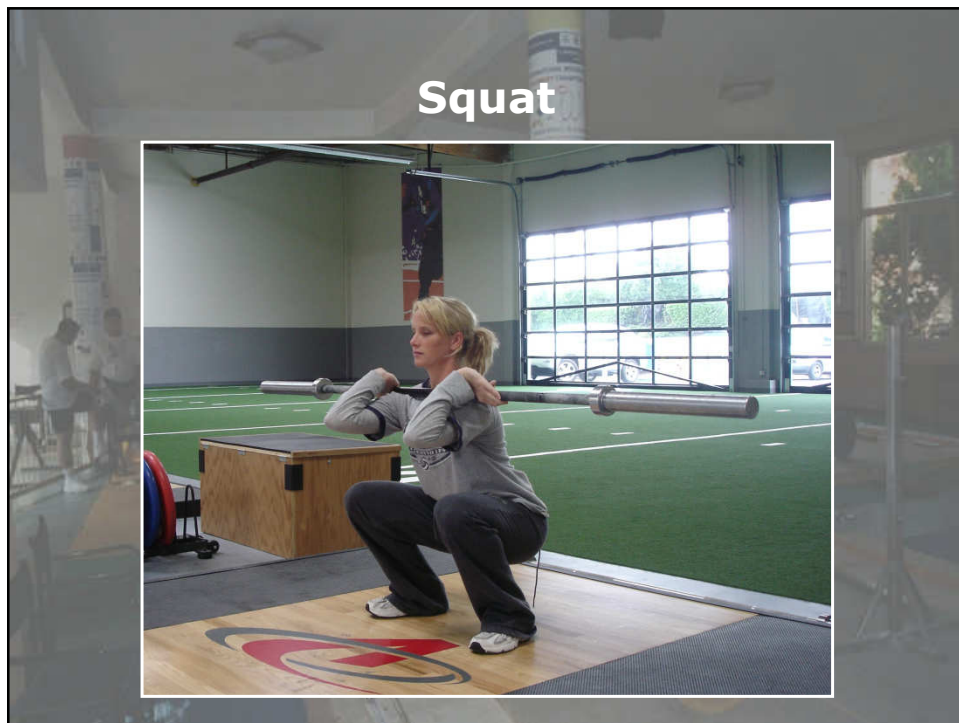
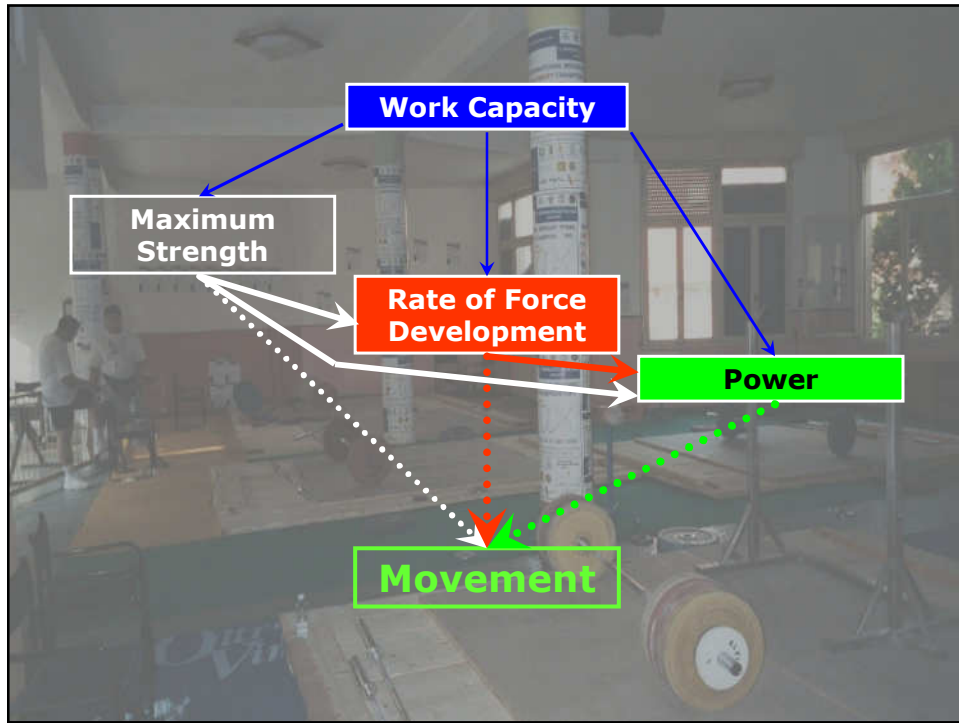
Resistance Exercise

- Physiologic adaptations
- Performance
- Rehabilitation
- Health

Physics of Strength

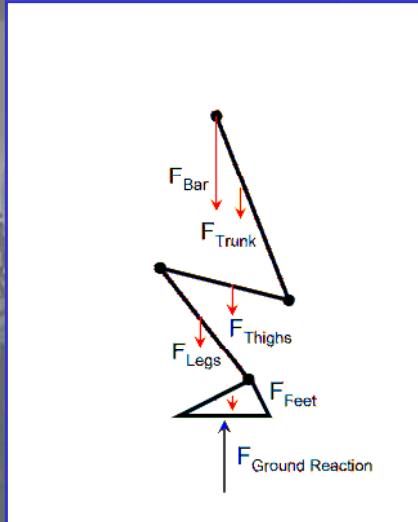
$$\int F \cdot dt = m \cdot dv$$

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Segment Biomechanics



- Segment kinematics
- Net joint moments
- Muscle activity

Net Joint Moments

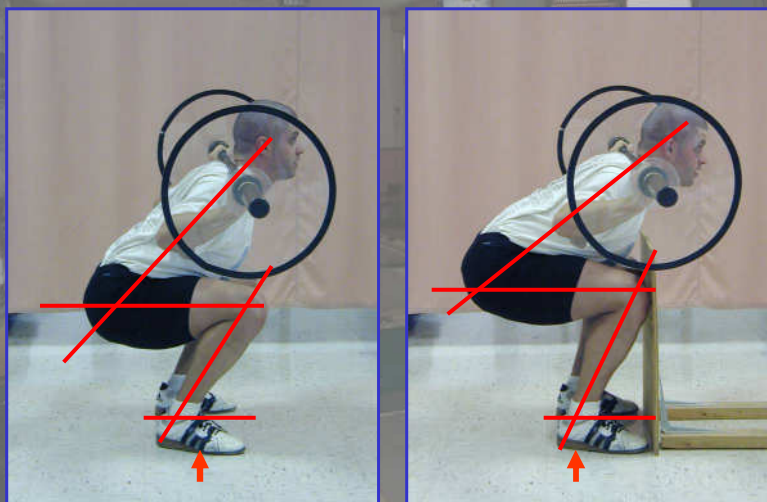
	Hip Extensor (N•m)	Knee Extensor (N•m)	Ankle Plantar-Flexor (N•m)
Hay et al. 1983	320	400	200
Escamilla et al. 2001	547	573	51
Wretenberg et al. 1996	230	190	
Nisell & Ekholm 1986	400	220	150

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Considerations

- Effect of stance width
- Effect of squat depth
- Effect of external load
- Single- vs. double-limb

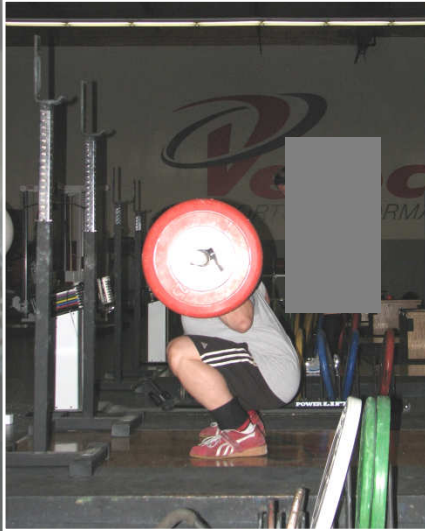
Different Techniques



Fry et al., JSCR 2007

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Back Squat



- COP – mid-foot
- Shank – 30-40°
- Thigh – 90-110°
- Trunk – 30-45°

Front Squat



- COP – mid-foot
- Shank – 30-40°
- Thigh – 100-120°
- Trunk – 20-30°

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Wide Stance Back Squat



- COP – rear-foot
- Shank – 20-30°
- Thigh – 90-100°
- Trunk – 50-60°

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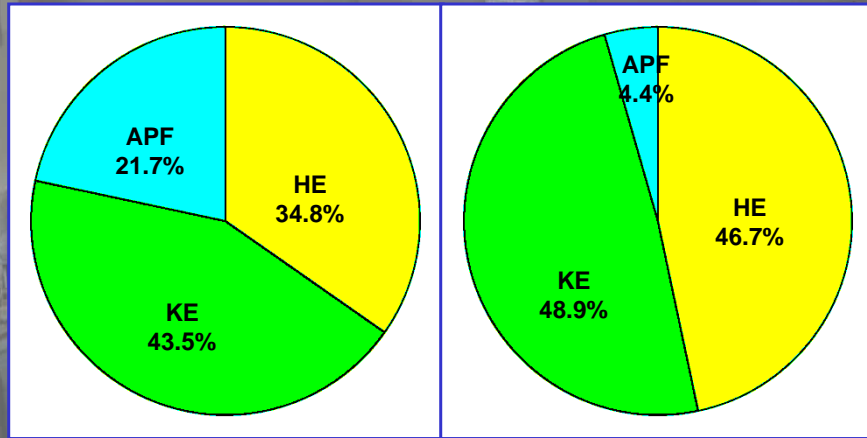


Narrow vs. Wide Stance

<u>Narrow</u>	<u>Wide</u>
<ul style="list-style-type: none"> ➤ Moderate ankle PF NJM ➤ Moderate knee extensor NJM ➤ Moderate hip extensor NJM ➤ Moderate lumbar extensor NJM 	<ul style="list-style-type: none"> ➤ Low ankle PF NJM ➤ Moderate – High knee extensor NJM ➤ High hip extensor NJM ➤ High lumbar extensor NJM

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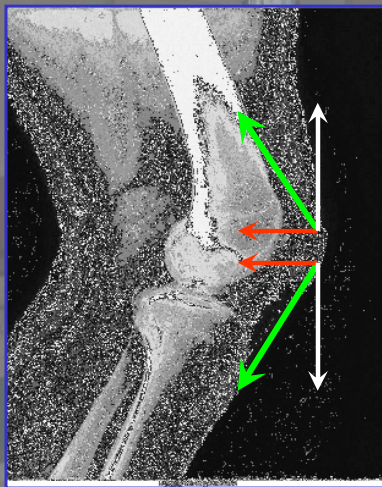
Distribution of Effort



Narrow Stance Squat

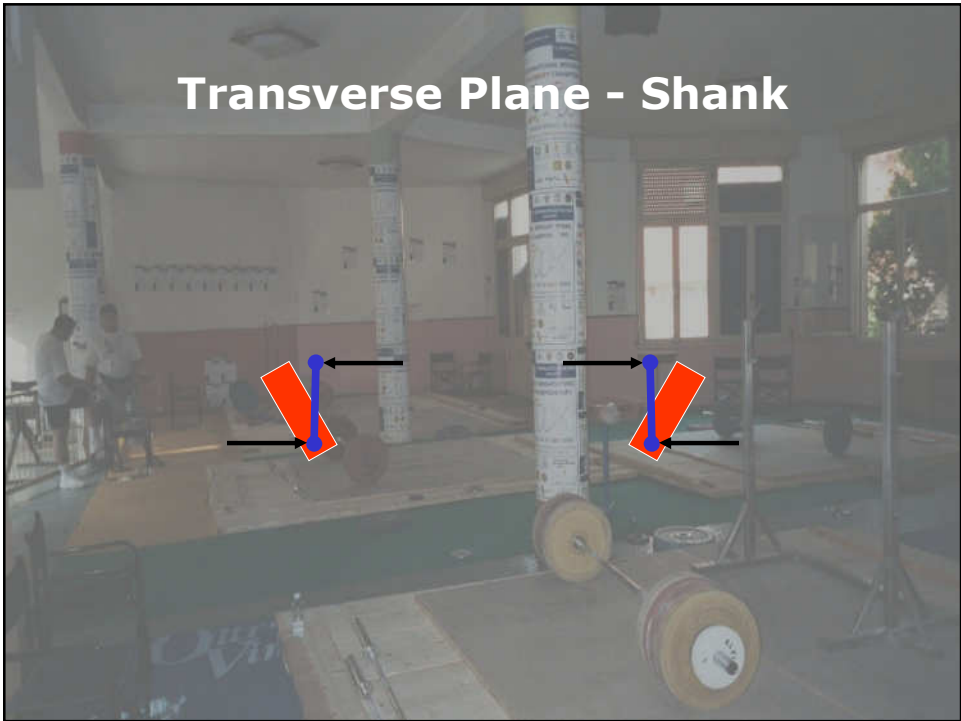
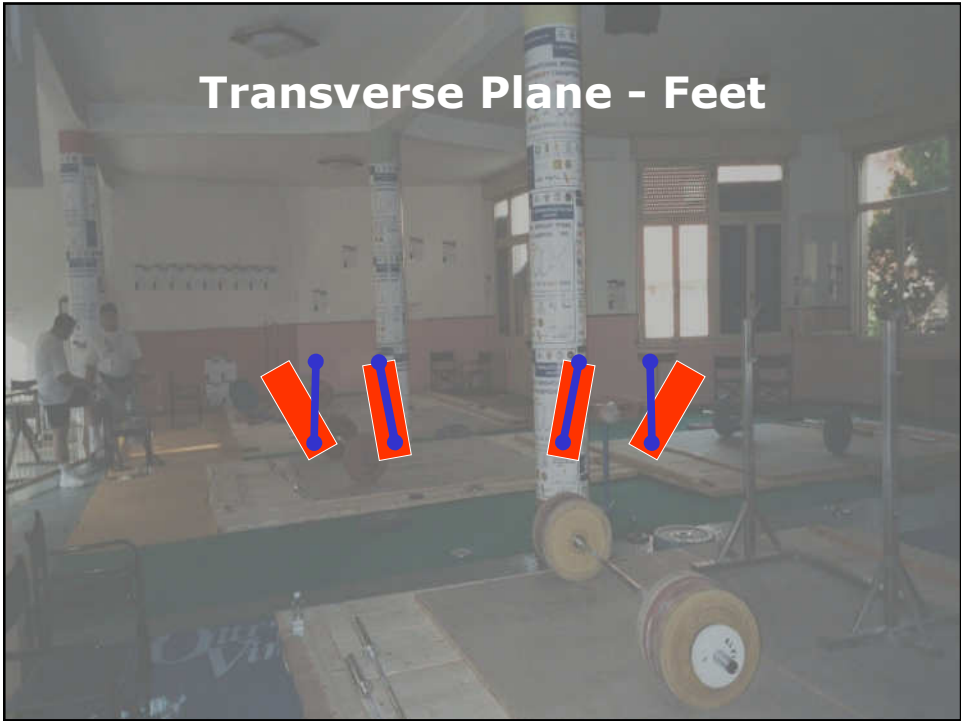
Wide Stance Squat

Patellofemoral Force



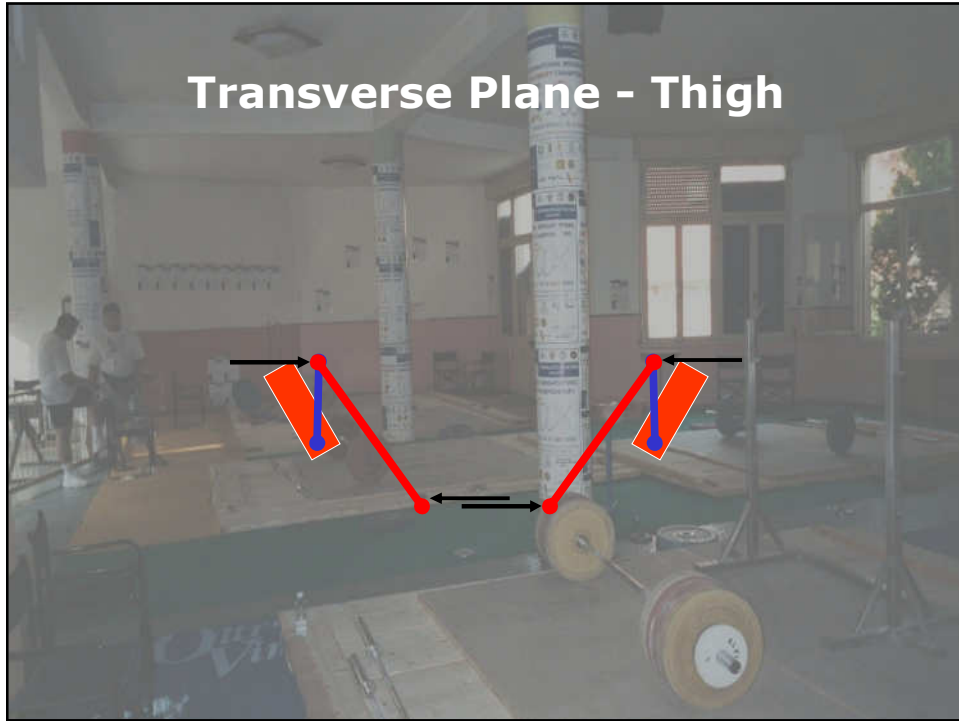
Atlas of Clinical Gross Anatomy. Elsevier

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Transverse Plane - Thigh



Narrow vs. Wide Stance

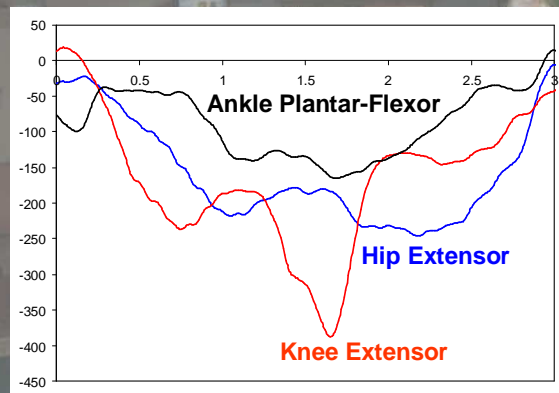


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Optimal Squat Stance



Effect of Depth



Data from: Chiu & Salem, JSCR 2007

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Knee Extensor NJM

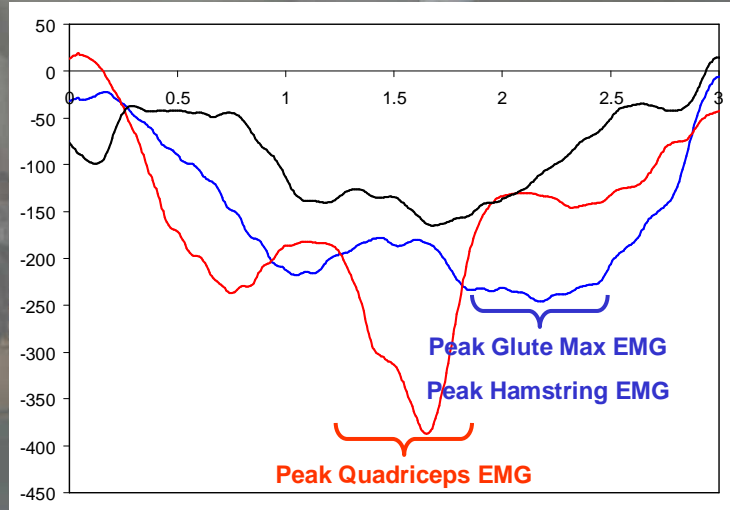
- Full squat @ 85% 1 RM
 - NJM = 1.3-1.5x > parallel squat
- Assuming the same kinematics for the parallel squat...
- Would require 100% increase in barbell load to equal NJM for full squat

Centre of Pressure

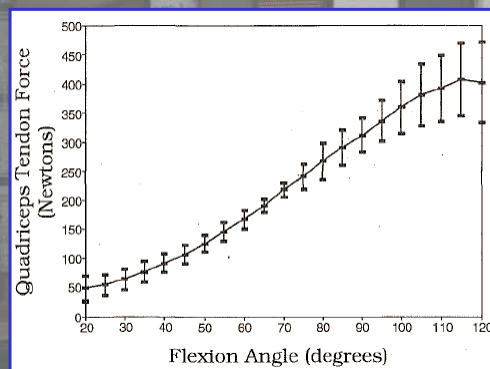


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Muscle Activation



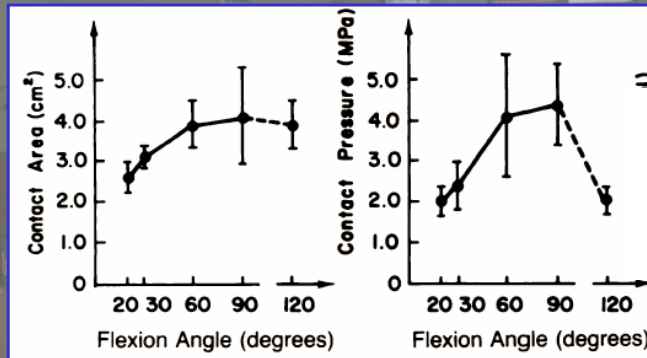
Patellafemoral Force



From: Singerman et al., J. Biomech. Eng. 1999

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Patellofemoral Pressure



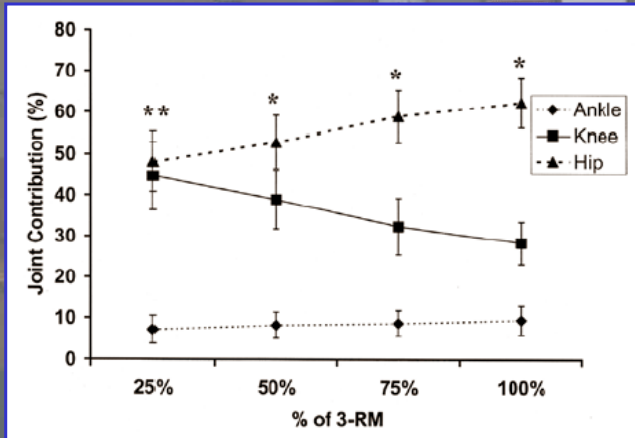
From: Huberti & Hayes, JBJS 1984

Optimal Squat Depth



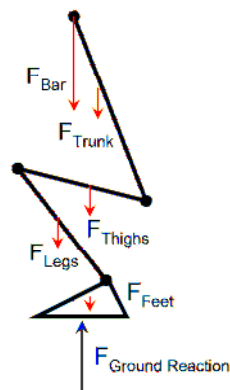
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Effect of Load



From: Flanagan & Salem, JAB 2008

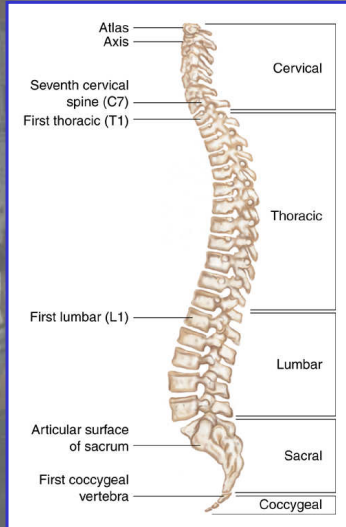
Effect of Load



- ↑ bar mass
- ↑ forward lean
- COP shifts forward

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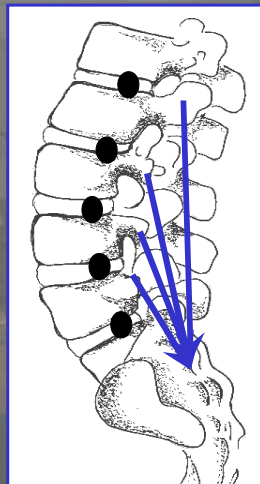
Spine Curvature



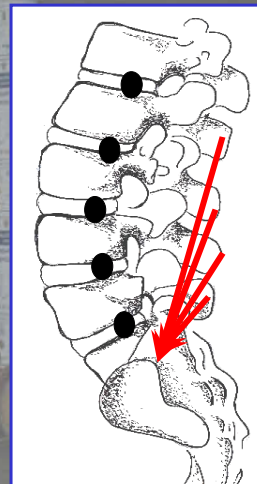
- Maintain "neutral" curvature
 - Prevent forward lean
- Extensor mechanism
- Intra-abdominal & intra-thoracic pressure

Essentials of Strength Training and Conditioning. Human Kinetics.

Extensor Mechanism



Erector Spinae

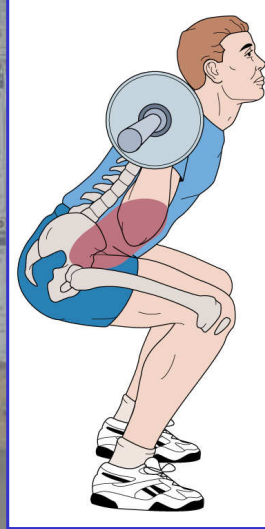


Multifidus

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IAP & ITP

- Passive resistance to spine flexion
- Reduces torque required by extensor mechanism
- Valsalva maneuver



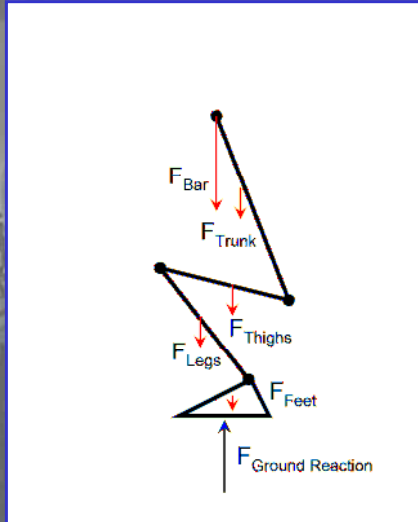
Essentials of Strength Training and Conditioning. Human Kinetics

Single-Limb Squats?

- More appropriate for beginners?
- Utilize more stabilizing muscles?
- Emphasize hip abductors?
- More specific to running, change-of-direction tasks?

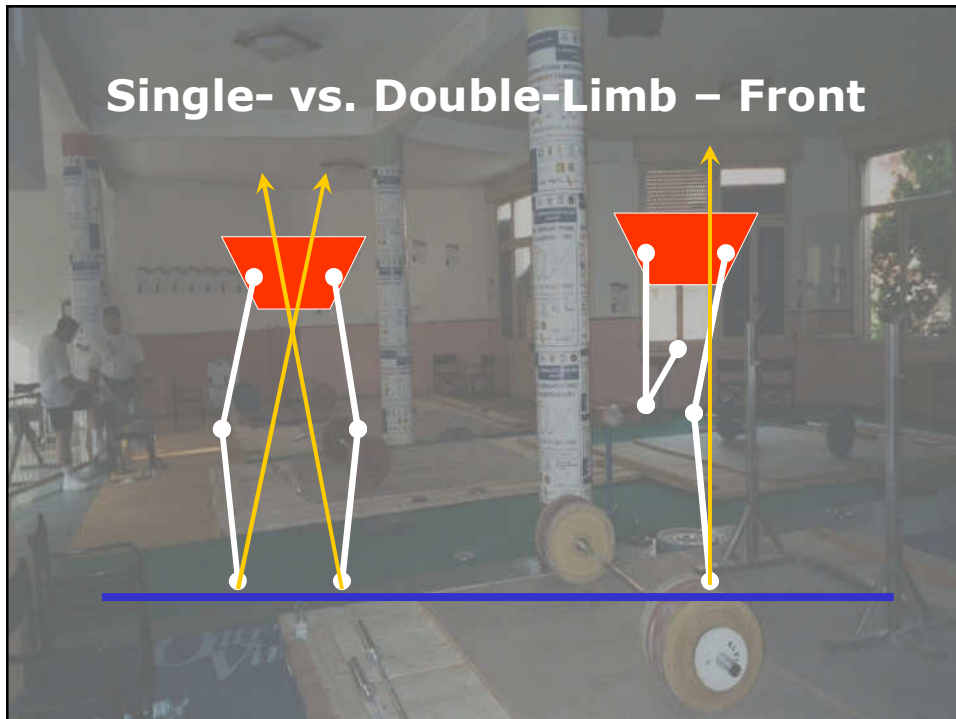
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Joint Kinetics



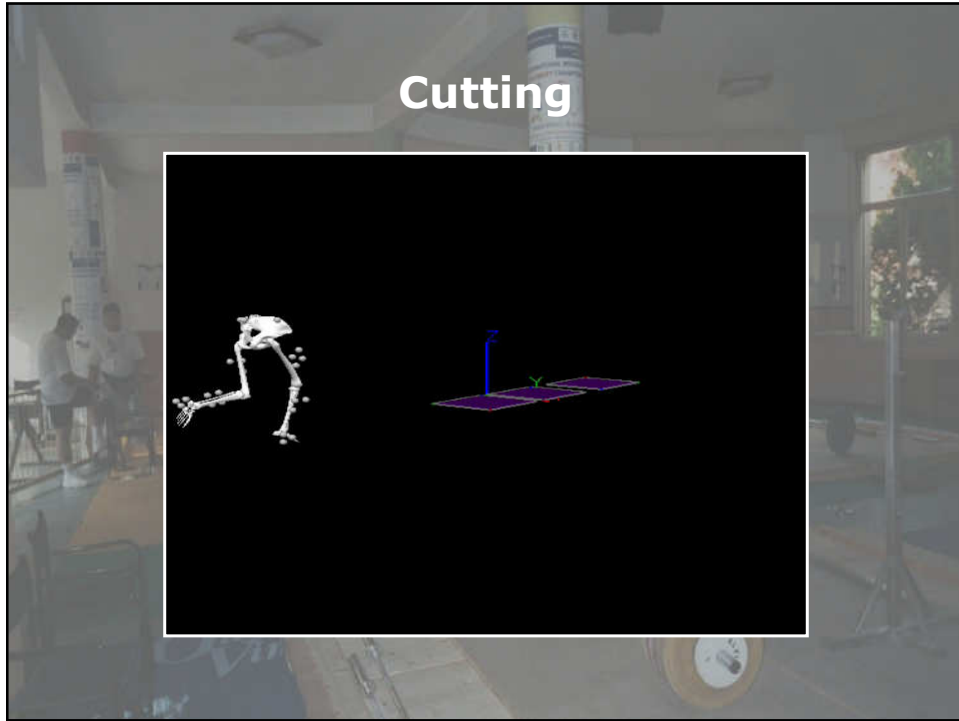
- Free-body diagram
- Assuming the same kinetics
 - GRF acts through 1 limb only (i.e. doubles)
 - Hip extensor, knee extensor and ankle plantar-flexor NJM doubles
- For 80kg individual, SLS = Back squat with 80kg (176lb)

Single- vs. Double-Limb – Front

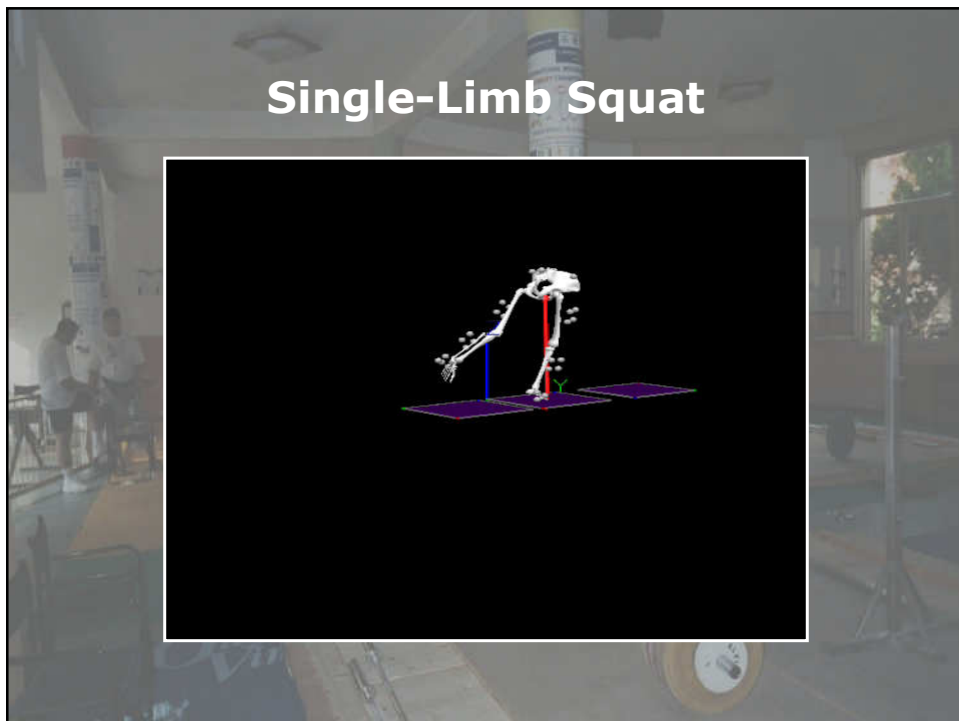


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Cutting

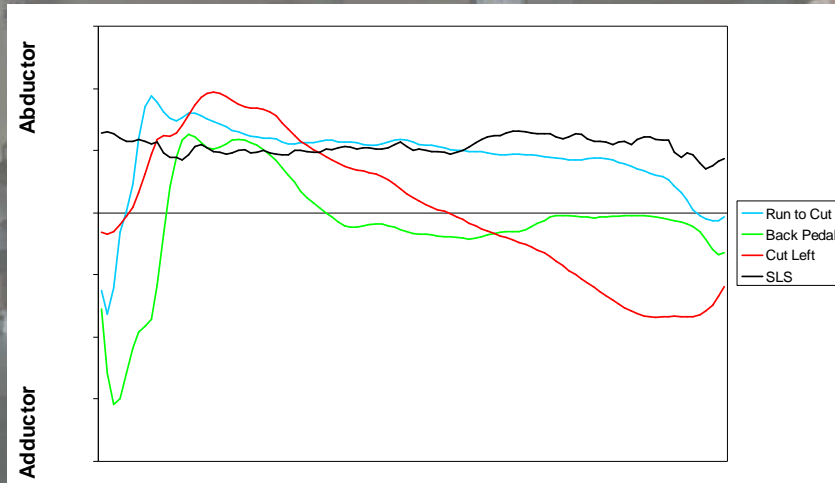


Single-Limb Squat

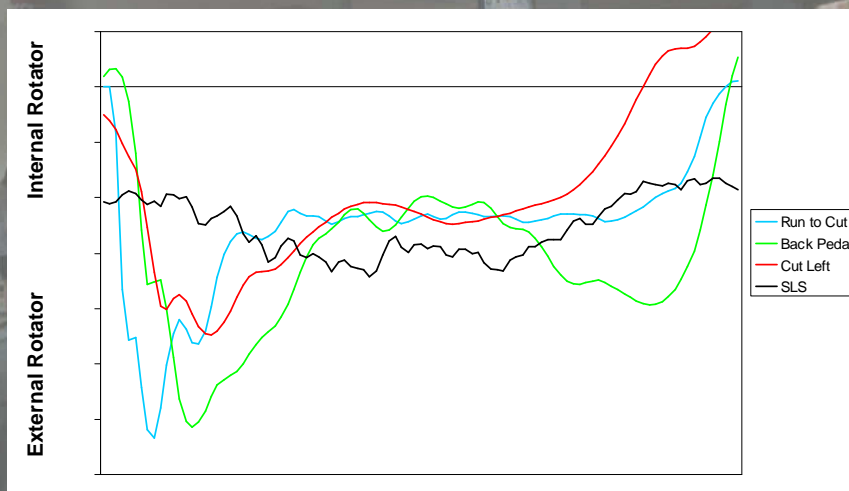


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Hip Frontal Plane



Hip Transverse Plane



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Optimal Squat Technique

- **Narrow stance**
- **Full depth**
- **Utilize Valsalva maneuver**
- **Maintain upright posture**

Teaching Progression

1. **Squat posture**
2. **Plate squat**
3. **Front squat**
4. **Back squat**

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Squat Posture

- Feet pelvis width
- Deep breath
- Push knees forward
- Hips move straight down
- Tempo



Plate Squat

- Hold 10kg plate parallel to ground
- Maintains appropriate posture



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Front Squat



Back Squat



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