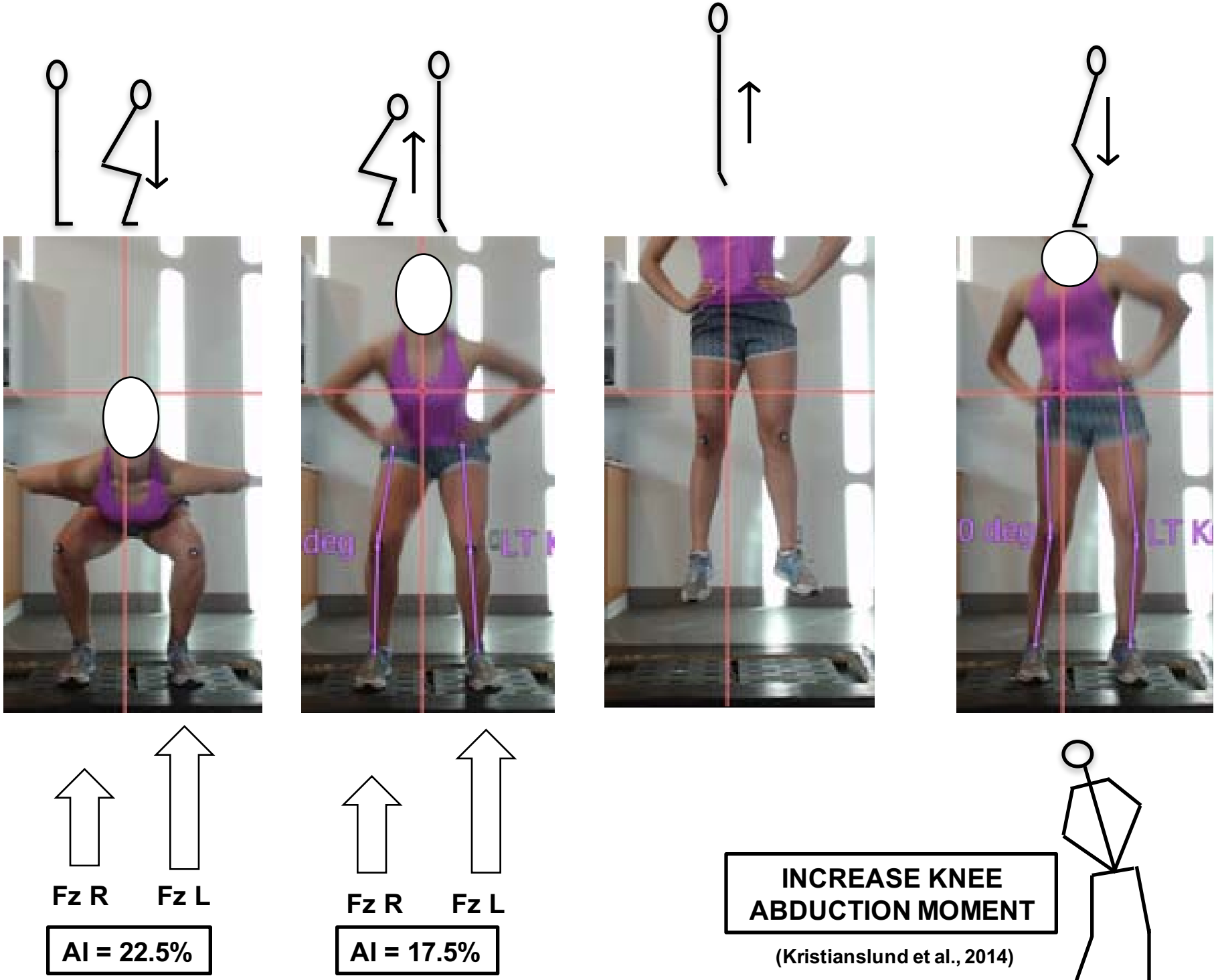
Assessing Functional Asymmetry and Eccentric Deceleration Ability

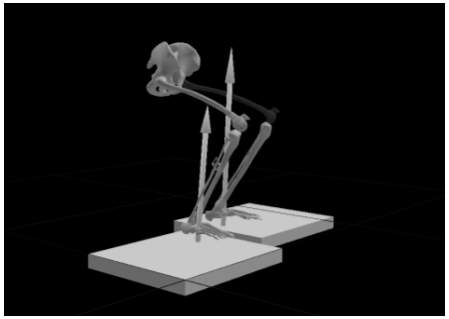
Matt Jordan

Advanced Asymmetry Assessment

How do we prevent injury/re-injury?

Determine what matters, measure what matters, change what matters





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Lower limb asymmetry in mechanical muscle function: A comparison between ski racers with and without ACL reconstruction

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Due to a high incidence of anterior cruciate ligament (ACL) re-injury in alpine ski racers, this study aims to assess functional asymmetry in the countermovement jump (CMJ), squat jump (SJ), and leg muscle mass in elite ski racers with and without anterior cruciate ligament reconstruction (ACL-R). Elite alpine skiers with ACL-R ($n = 9$; 26.2 ± 11.8 months post-op) and uninjured skiers ($n = 9$) participated in neuromuscular screening. Vertical ground reaction force during the CMJ and SJ was assessed using dual force plate methodology to obtain phase-specific bilateral asymmetry indices (AIs) for kinetic impulse (CMJ and SJ phase-specific kinetic impulse AI). Dual x-ray absorptiometry scanning was used to assess asymmetry in lower body muscle mass. Compared with controls, ACL-R skiers had increased AI in muscle mass ($P < 0.001$), kinetic impulse AI in the CMJ concentric phase ($P < 0.05$), and the final phase of the SJ ($P < 0.05$). Positive associations were observed between muscle mass and AI in the CMJ concentric phase ($r = 0.57$, $P < 0.01$) as well as in the late SJ phase ($r = 0.66$, $P < 0.01$). Future research is required to assess the role of the CMJ and SJ phase-specific kinetic impulse AI as a part of a multifaceted approach for improving outcome following ACL-R in elite ski racers.

KINETIC IMPULSE ASYMMETRY INDEX

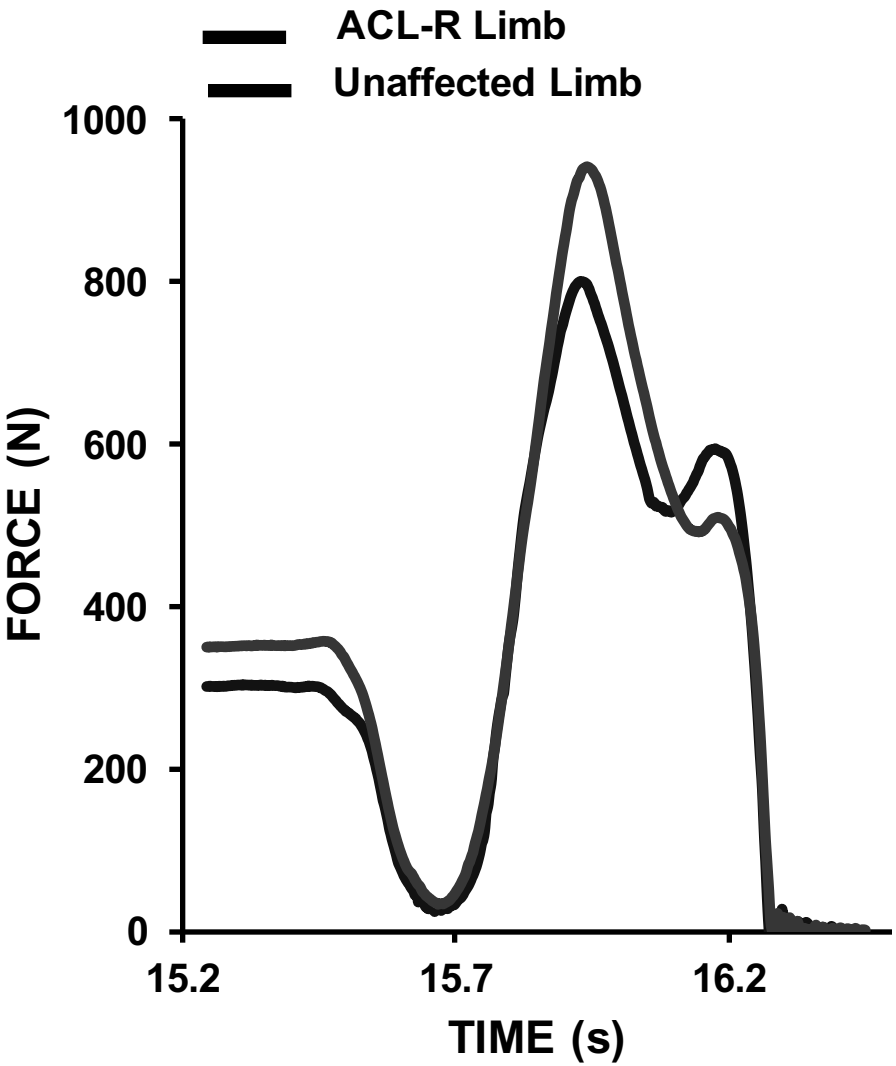
$$\text{KINETIC IMPULSE ASYMMETRY INDEX} = \left[\frac{(\text{LEFT LIMB} - \text{RIGHT LIMB})}{\text{MAX OF LEFT AND RIGHT}}\right] \times 100 \quad + \qquad 0 \qquad \text{SYMMETRY}$$

$$\left[\frac{(\text{UNINVOLVED LIMB} - \text{INVOLVED LIMB})}{\text{MAX OF LEFT AND RIGHT}}\right] \times 100 \quad -$$

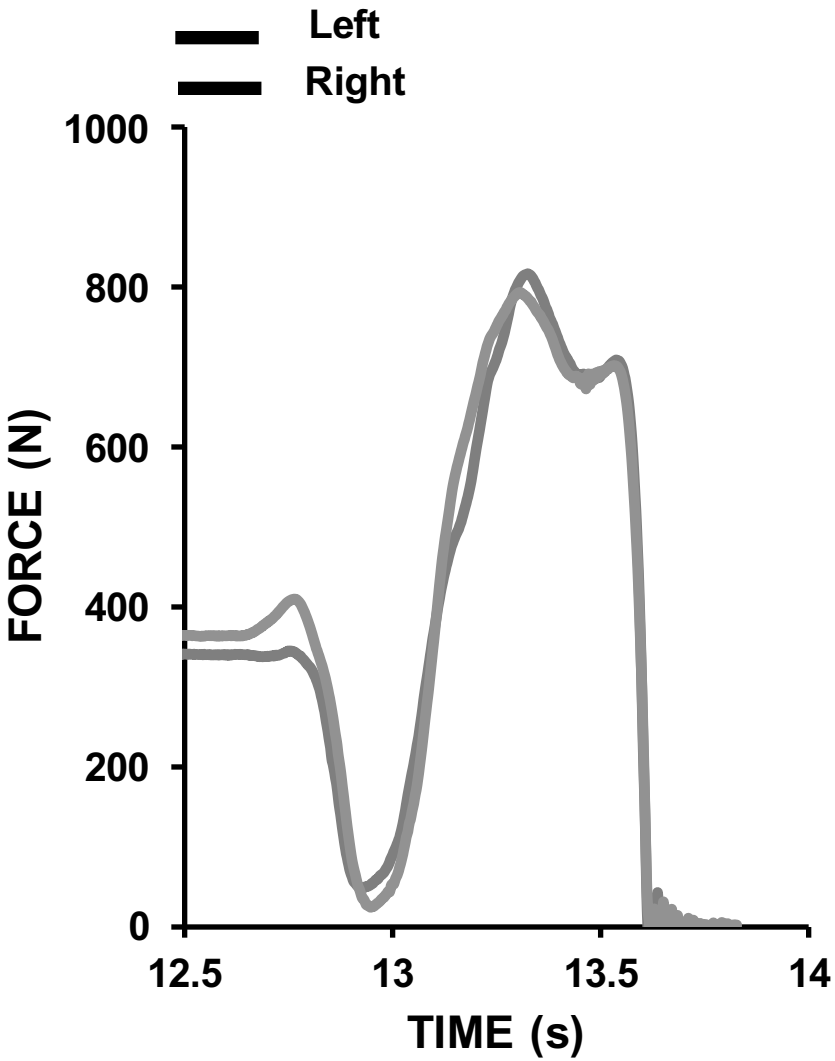
Jordan et al., *Scan J Med Sci Sports*: 2015

FUNCTIONAL ASYMMETRY

ACL-RECONSTRUCTED SKIER



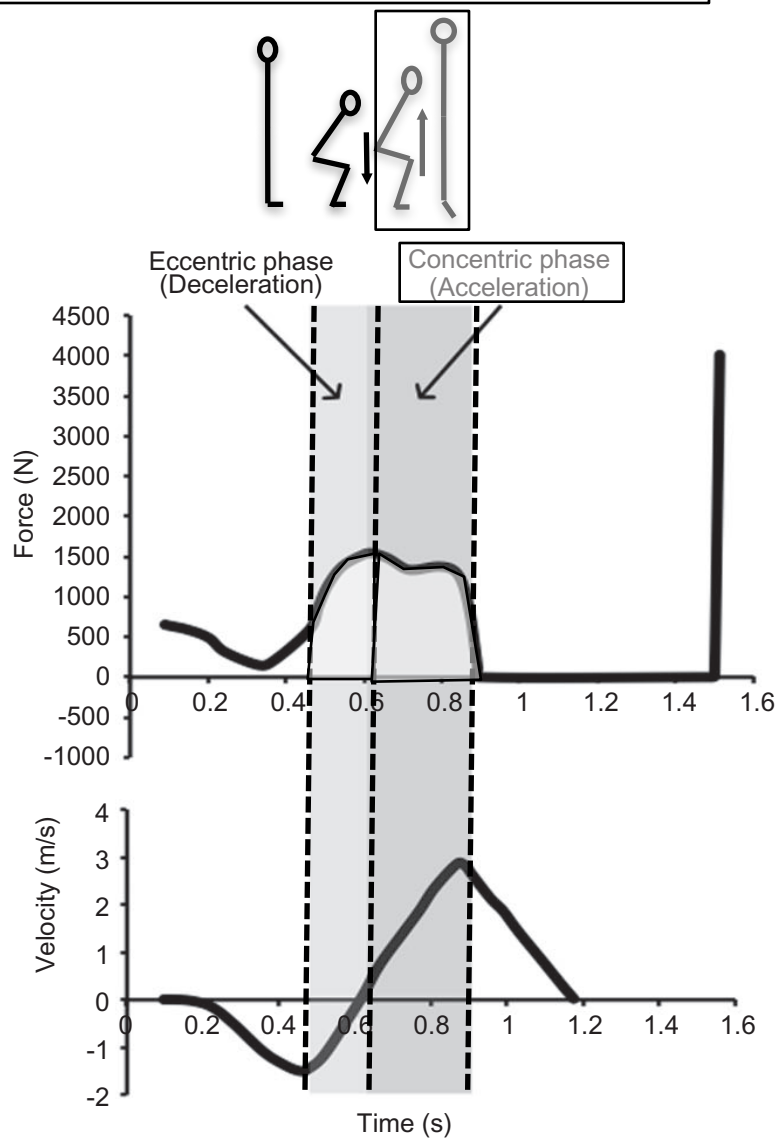
UNINJURED SKIER



Jordan et al., *Scan J Med Sci Sports*: 2015

KINETIC IMPULSE ASYMMETRY INDEX

COUNTERMOVEMENT JUMP



SQUAT JUMP

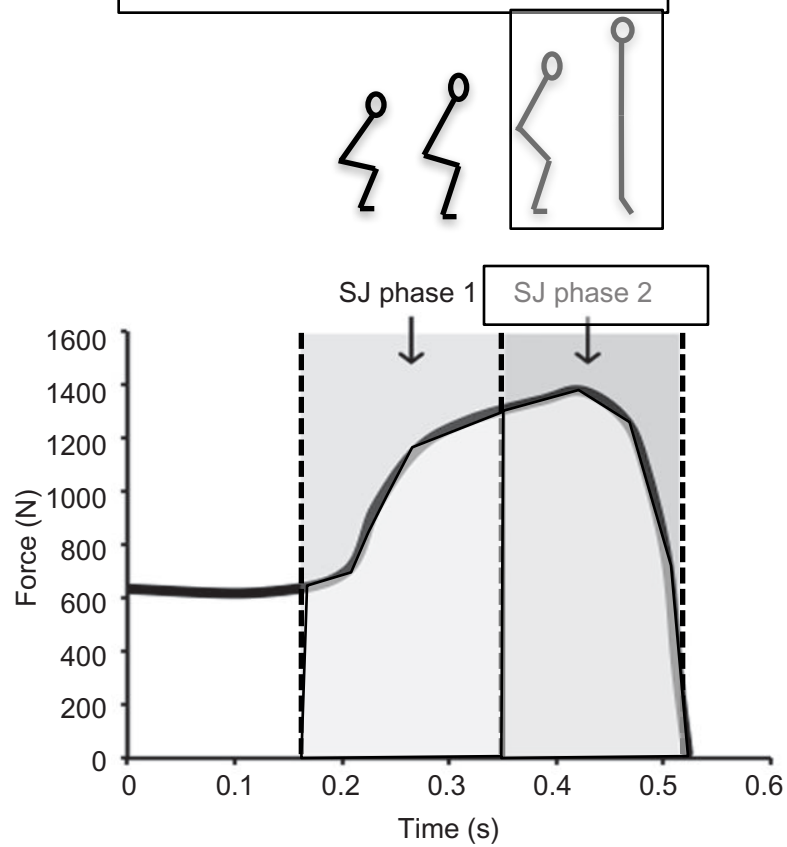


Fig. 1. Plots on the left identify the countermovement jump (CMJ) eccentric deceleration phase and concentric phase using the velocity of the body center of mass. Plot on the right side identifies squat jump (SJ) phase 1 (time = 0 to time = ½ of total jump time) and phase 2 (time = ½ of total jump time to takeoff).

Jordan et al., *Scan J Med Sci Sports*: 2015

KINETIC IMPULSE ASYMMETRY INDEX

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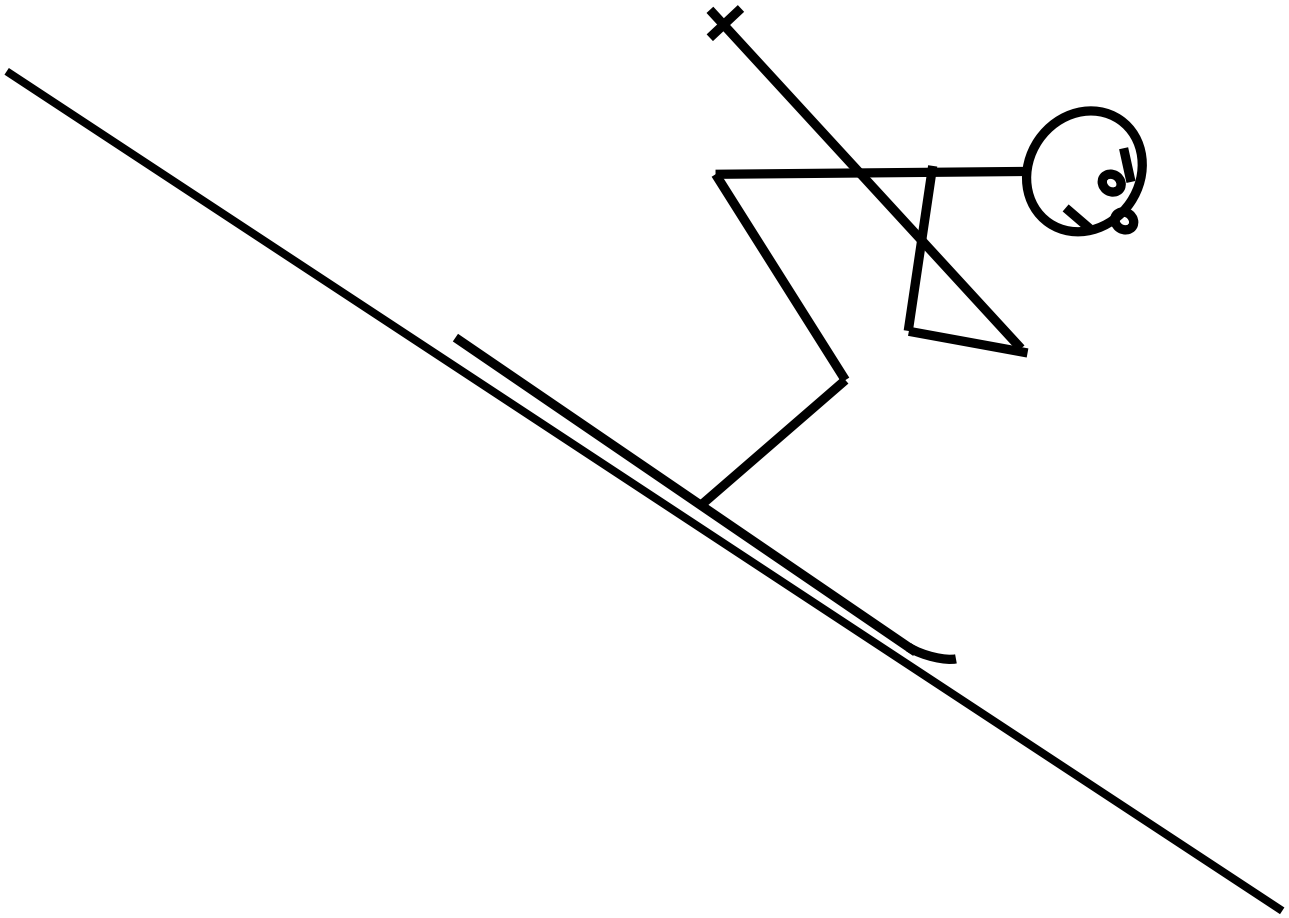
$$\left[\frac{(\text{UNINVOLVED LIMB} - \text{INVOLVED LIMB})}{\text{MAX OF LEFT AND RIGHT}}\right] \times 100 \quad -$$

Jordan et al., *Scan J Med Sci Sports*: 2015

Can the kinetic impulse asymmetry index predict injury in elite athletes?

But …

Functional testing in a rested state under optimal conditions



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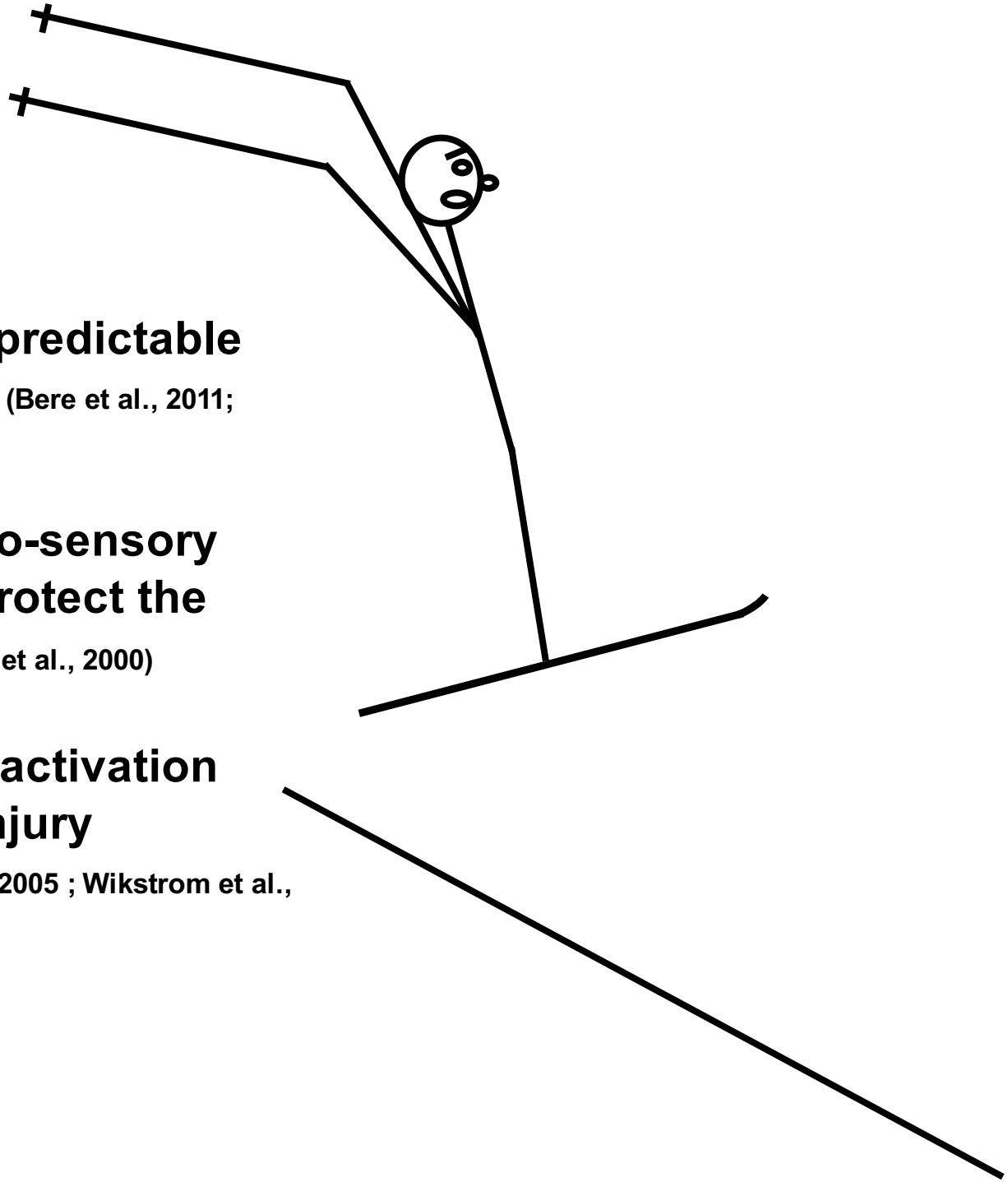


Injury events are unpredictable and happen quickly (Bere et al., 2011; Krosshaug et al., 2007)

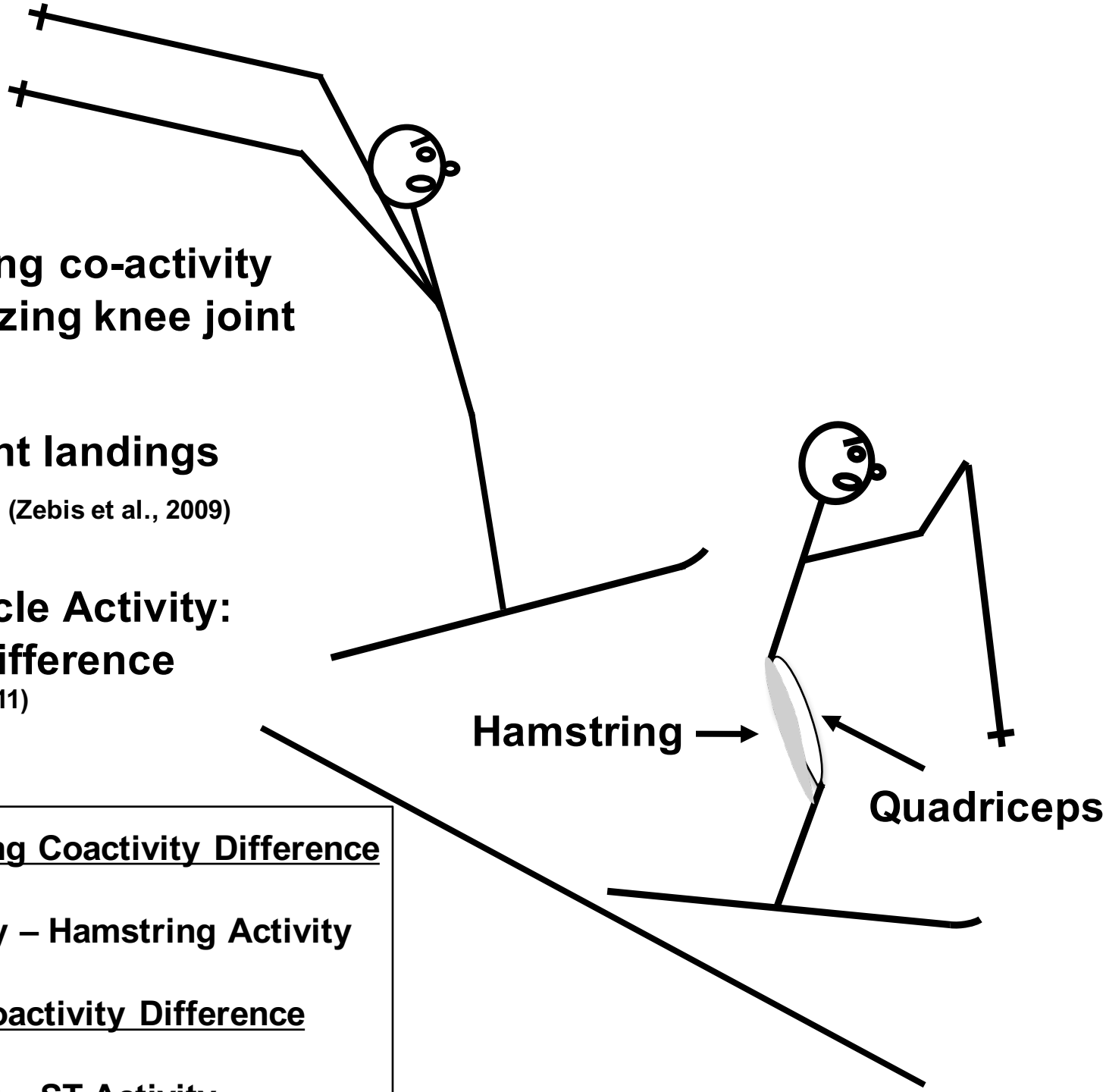
Too fast for mechano-sensory feedback loops to protect the knee joint (Dyhre-Poulsen et al., 2000)

Preparatory muscle activation important for ACL injury prevention (Hewett et al., 2005 ; Wikstrom et al., 2006; Zebis et al., 2009)

Quadriceps-hamstring co-activity important for stabilizing knee joint
(Baratta et al., 1988)

Quadriceps dominant landings linked to ACL injury (Zebis et al., 2009)

Valgus Related Muscle Activity: VL-ST Co-Activity Difference
(Zebis et al., 2009; Zebis et al., 2011)



Quadriceps Hamstring Coactivity Difference

Quadriceps Activity – Hamstring Activity

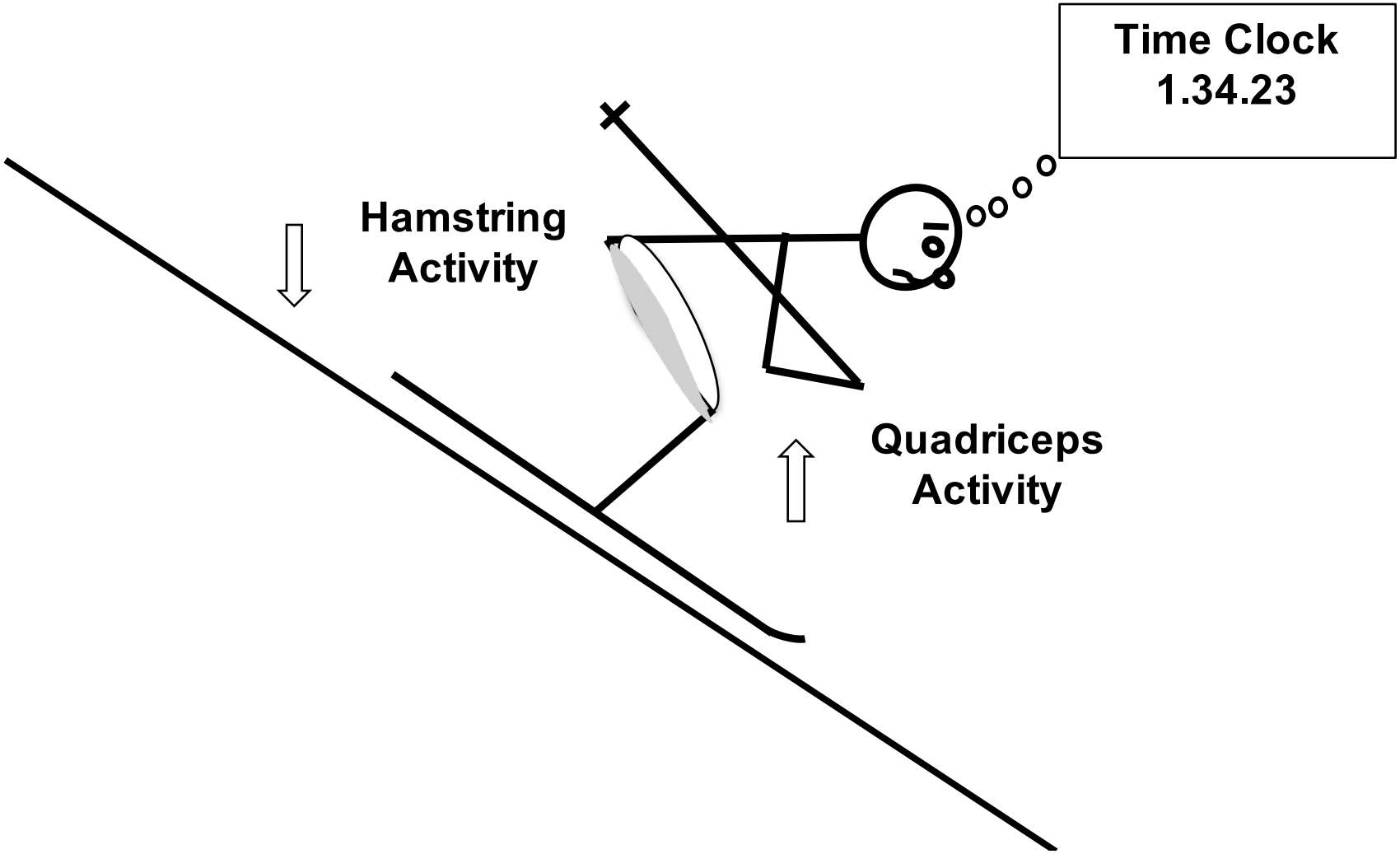
Valgus VL-ST Coactivity Difference

VL Activity – ST Activity

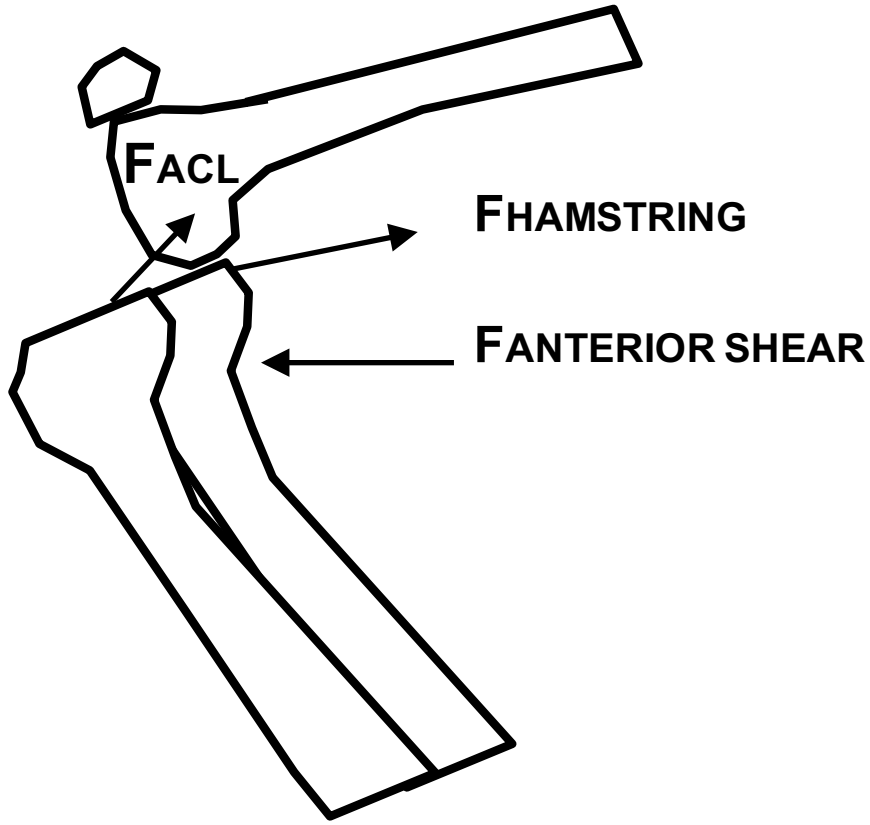
Don’t forget …

Injuries happen when fatigue factors are present (Bere et al., 2014)

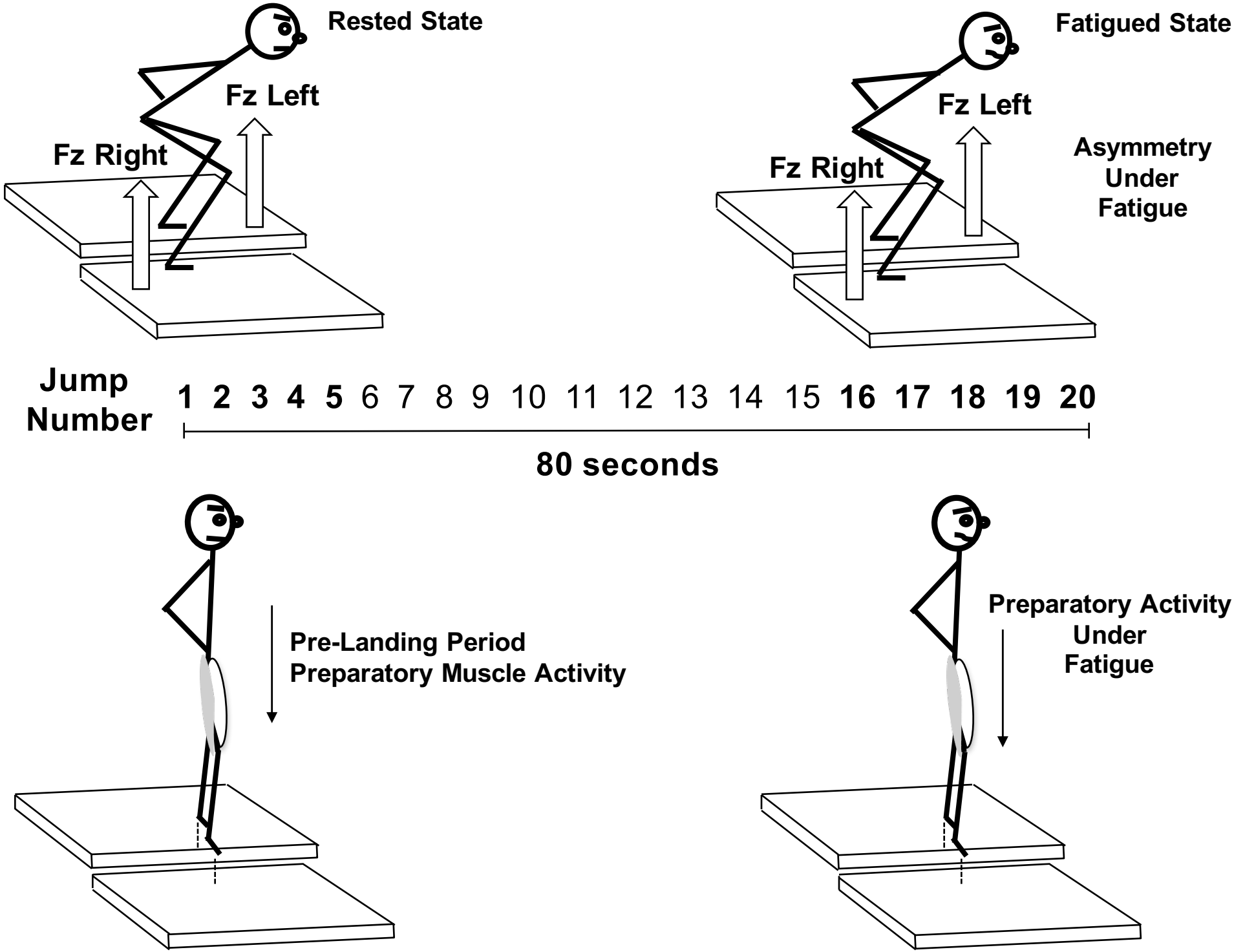
Fatigue impairs preparatory quadriceps-hamstring co-activity
(Zebis et al., 2011)

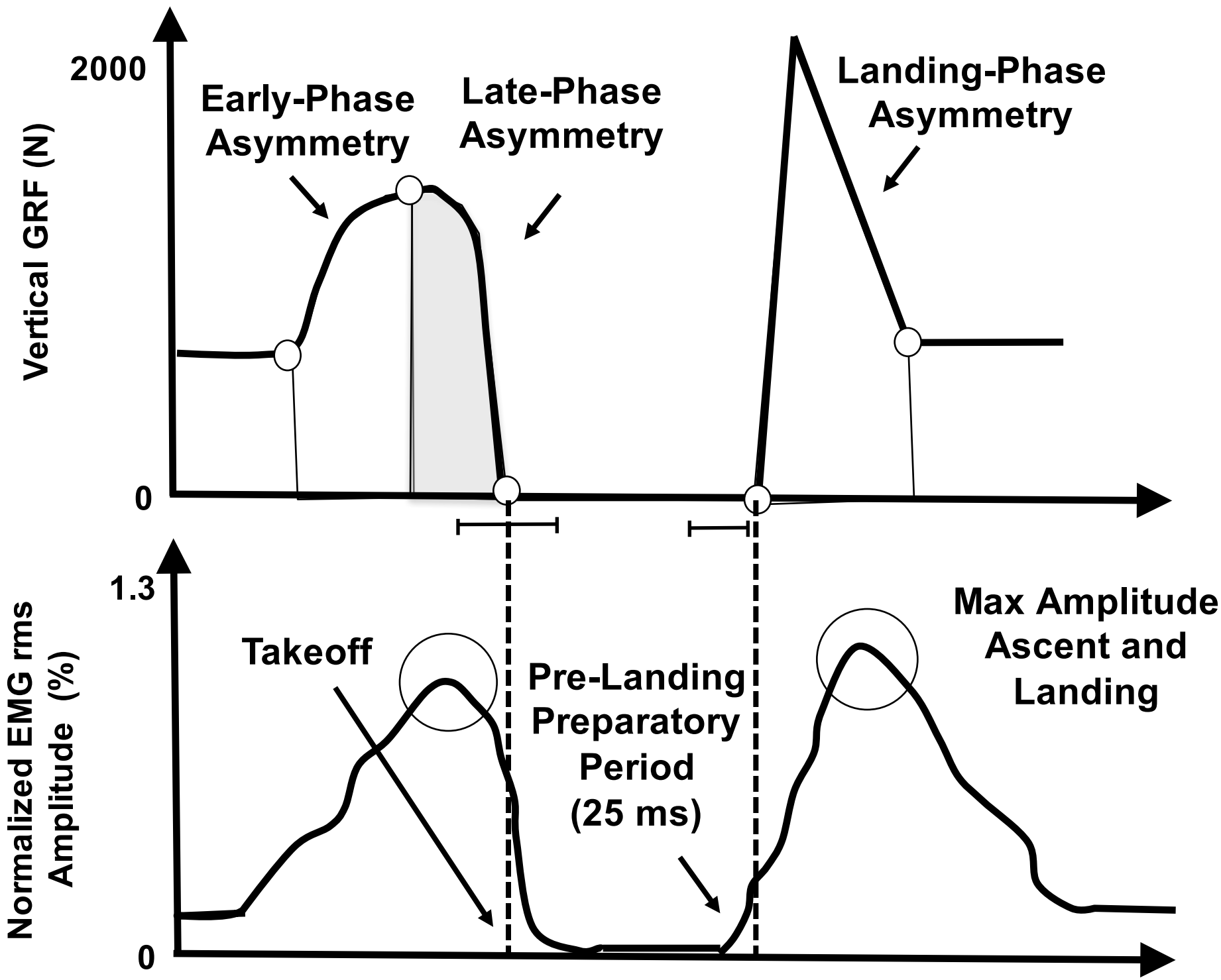


IMPORTANCE OF THE HAMSTRING MUSCLES



(Barrata et al., 1988; Herzog & Read, 1993; Mac Williams et al., 1999; Markolf et al., 2004; Prodromos et al., 2008)


Rested State
Fz Left
Fz Right
Fatigued State
Fz Left
Fz Right
Asymmetry
Under
Fatigue
Jump
Number
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
80 seconds
Pre-Landing Period
Preparatory Muscle Activity
Preparatory Activity
Under
Fatigue


2000
Vertical GRF (N)
0
Early-Phase
Asymmetry
Late-Phase
Asymmetry
Landing-Phase
Asymmetry
1.3
Normalized EMG rms
Amplitude (%)
0
Takeoff
Pre-Landing
Preparatory
Period
(25 ms)
Max Amplitude
Ascent and
Landing

Quadriceps Hamstring Coactivity Difference

Quadriceps Activity – Hamstring Activity

Valgus VL-ST Coactivity Difference

VL Activity – ST Activity

Basic Asymmetry Assessments

Single Leg Drop Landing

Assessing Asymmetry in Locomotion

- Slow velocity movement – expand and contract solution space
- Sled pulls
- Water based movements

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doi: 10.1111/j.1600-0838.2009.00973.x

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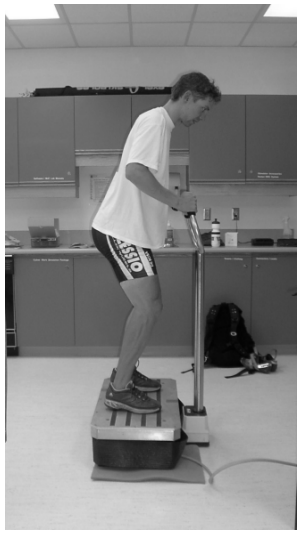

Acute effects of whole-body vibration on peak isometric torque, muscle twitch torque and voluntary muscle activation of the knee extensors

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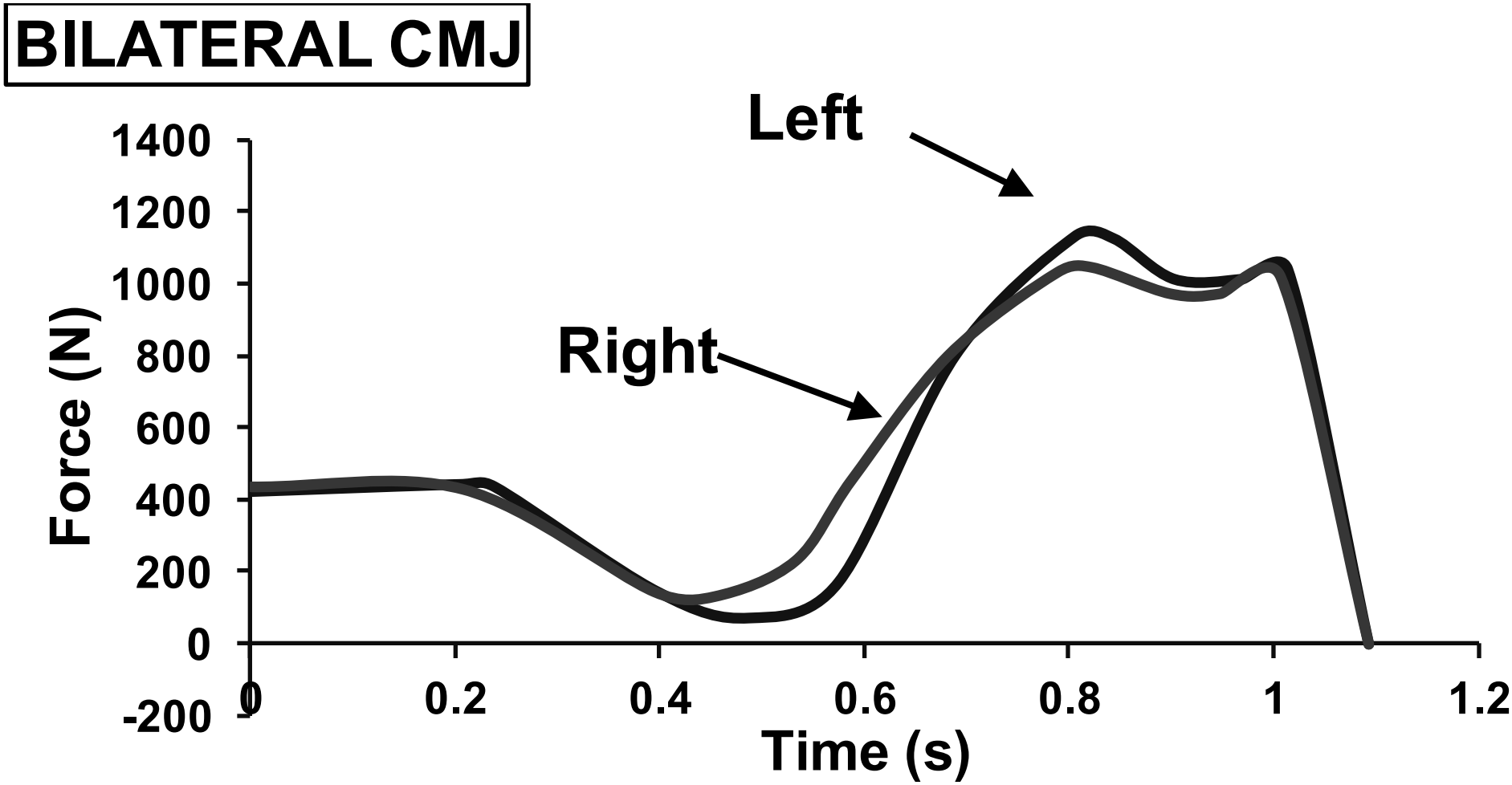
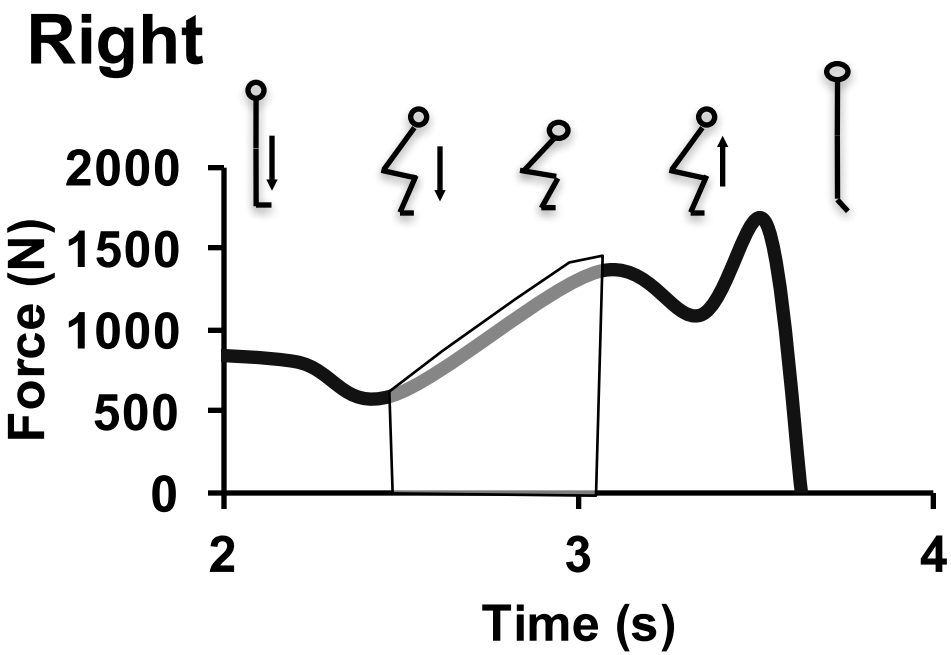
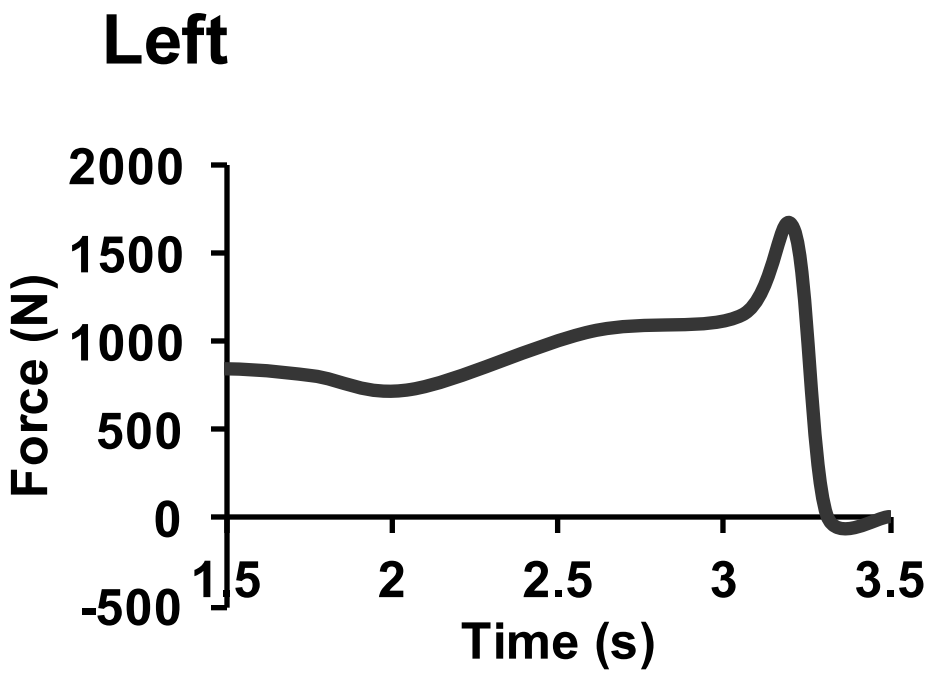
Accepted for publication 16 April 2009

The purpose of this investigation was to compare the acute effects of whole-body vibration (WBV) with a static squat on resting muscle twitch torque, peak isometric torque and voluntary muscle activation of the knee extensors during an isometric maximal voluntary contraction (MVC). Twenty-four healthy, strength-trained males were recruited for this randomized, cross-over design investigation. The WBV treatment consisted of three sets of 60 s of vibration (30 Hz, ± 4 mm) while standing in a semi-squat position. Voluntary muscle activation, peak isometric torque during MVC and resting muscle twitch torque (RTT) through percutaneous femoral nerve stimulation were obtained before and following the treatment. Change in peak isometric torque, voluntary muscle activation and the RTT were calculated as the difference between pre- and post-treamtent values. There was no observable post-activation potentiation of muscle twitch torque or enhancement in voluntary muscle activation or peak isometric torque. However, decreases in the peak isometric torque ($P = 0.0094$) and voluntary muscle activation ($P = 0.0252$) were significantly smaller post WBV interventions compared with the control treatment. Based on the current data, it is unclear whether or not this was attributable to the effects of WBV but further research into this possibility is warranted.

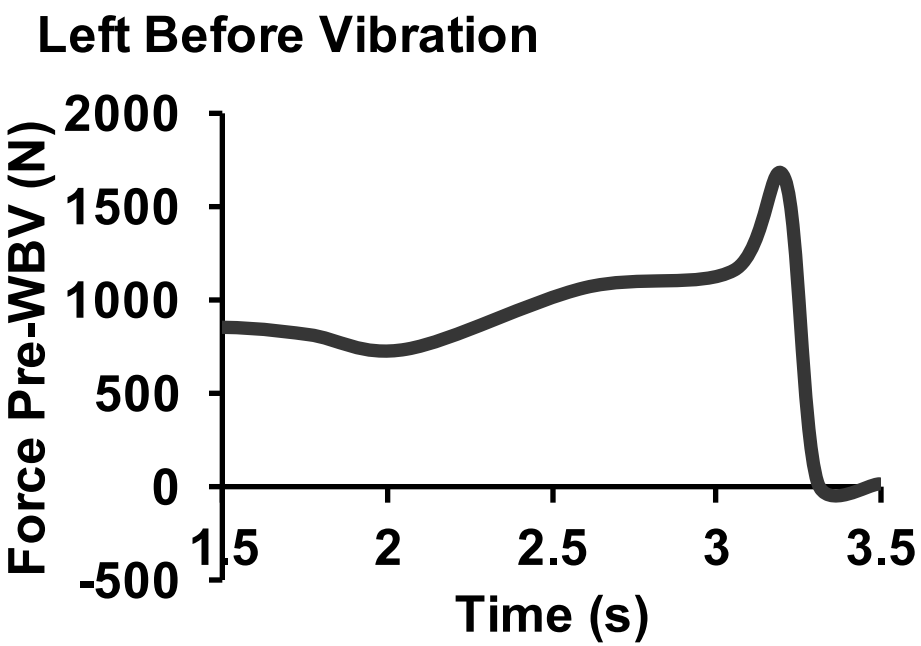


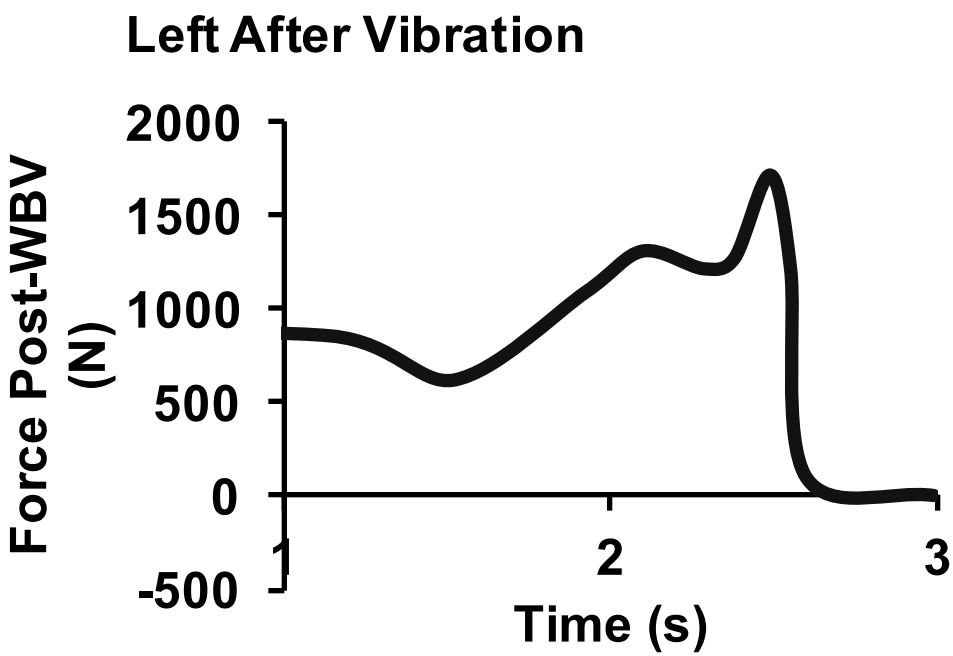
SINGLE LEG CMJ'S





SINGLE LEG CMJ LEFT SIDE POST-VIBRATION





What We Can Learn from Watching?

Reactive Strength – See, Hear, Don’t Judge

What is optimal?

Progressions for Eccentric Deceleration

Eccentric Deceleration Progressions

1. Proprioceptive drills
2. Low load / high velocity drills
3. Daily drills / assessment
4. Slow velocity high load
5. Accentuated eccentric training progressions
6. High velocity / high load

METHODS FOR ECCENTRIC STRENGTH DEV

1. **Negative repetitions**

Ex: 3RM + 4 Eccentric (4/0/1, 5E)

2. **Heavy load lifted with supra-maximal eccentric load**

Ex: Weight releasers (105-110% 1RM for eccentric phase, 1RM for concentric phase)

3. **Advanced Method I**

Ex: 4-6 sets of 4-6 repetitions with 110-120% of 1RM (6/0/A)

3. **Advanced Method II**

Ex: 3-6 sets of 1-3 repetitions with 120-140% of 1RM (3/0/A)

Case Study Examples of Asymmetry