




The Boston Sports Medicine and Performance Group Summer Seminar

FUNCTIONAL NEUROMUSCULAR ASSESSMENT IN ACLR ELITE SKI RACERS

IT'S NOT ALL DOWNHILL

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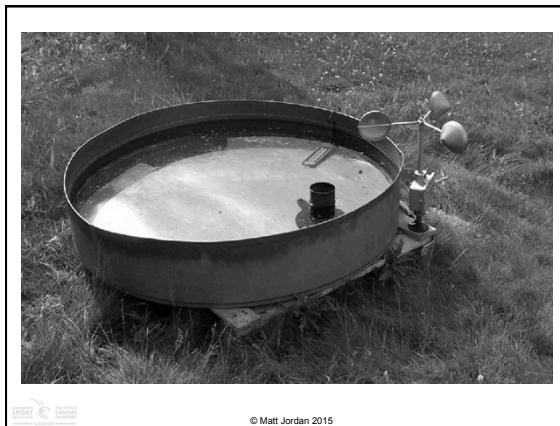





PRESENTATION OVERVIEW

- Why bother monitoring?
- ACL injury risk in elite alpine ski racing
- Functional neuromuscular assessments in elite alpine ski racers
- Next steps for ACL injury / re-injury prevention

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QUANTIFY IMPACT

FIND WHAT MATTERS, MEASURE WHAT MATTERS,
CHANGE WHAT MATTERS

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A SPLIT SECOND DECISION



(Gio Auletta, Pentaphoto)

→ Unpredictable environment

(Bere et al., 2011)

→ High speeds (Bere et al. 2011)

→ Tactical errors (Bere et al. 2011)

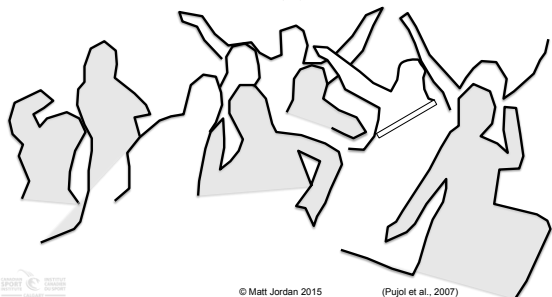
→ Short time frames for muscles to produce force to deal w/ extreme loads

(Barone et al., 1999)

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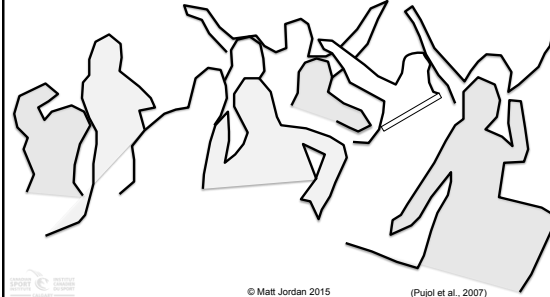
CANADIAN WOMEN'S SKI TEAM

- A database of ski racers with French Alpine Ski Team was analyzed
- Of 379 athletes registered, 28% suffered at least one ACL injury
- 50% of top ranked skiers suffered ACL injury

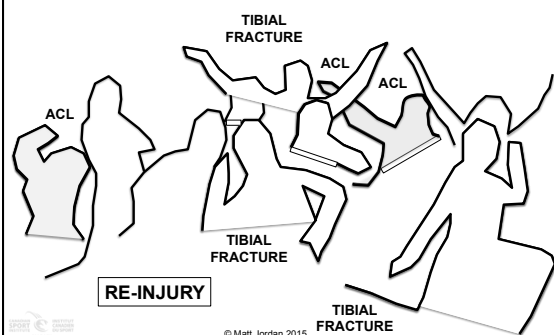


CANADIAN WOMEN'S SKI TEAM

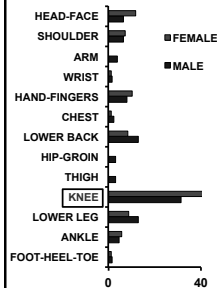
- More than 30% of top ranked skiers suffered ACL re-injury



CANADIAN WOMEN'S SKI TEAM



INCIDENCE OF ACL INJURY



→ Knee injuries most frequently injured body part (36%) and more than 50% result in > 28 days time-lost

→ ACL injury most frequent specific diagnosis

→ ~ 5 ACL injuries / 100 athletes / season (Bere et al., 2014)

→ No sex difference in knee injuries/ ACL injuries (Bere et al., 2014)

Men: 1.7 ACL injuries / 1000 runs

Women: 1.2 ACL injuries / 1000 runs

Figure 1 Distribution by body region of all reported injuries (n = 191) expressed as the percentage of the total number reported for males (n = 122; open bars) and females (n = 69; hatched bars).

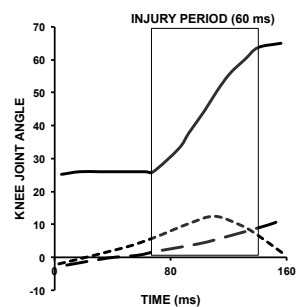
Flaenens et al. *British Journal of Sports Medicine* 43.13 (2009): 973-978.

MECHANISMS OF INJURY



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SLIP AND CATCH MECHANISM

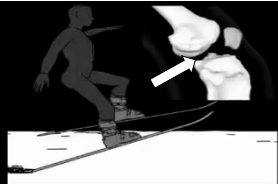


— Knee Flexion
— Valgus
— Internal Rotation

- Rapid increase in knee flexion 26° to 63°

Barone et al. *Skiing Trauma and Safety*, 12th Edition (1999): 63-81.
Bere et al. *The American Journal of Sports Medicine* 41.5 (2013): 1067-1073.

LANDING BACK WEIGHTED



- backward in flight
- Lands on ski tails
- Boot and knee extensor torque cause anterior translation of tibia

Bere et al., 2011

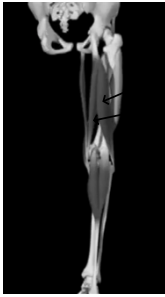
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LANDING BACK WEIGHTED



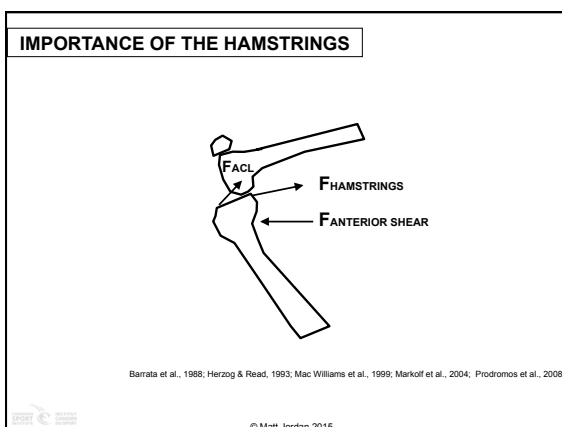
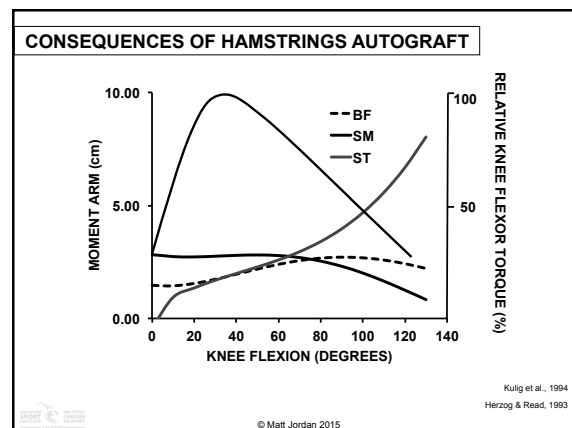
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HAMSTRINGS – AN ACL AGONIST

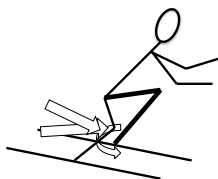


- Hamstrings important ACL agonist (decreases ACL loading) (1999; Markolf et al., 2004)
- Assists by preventing anterior translation of tibia b/w 30-90° flexion but not in extension (Mac Williams et al., 1999; Markolf et al., 2004)
- Medial hamstrings / medial quadriceps (VM) important for ACL unloading and medial joint compression (anti-valgus) (Zebis et al., 2009)
- H/Q co-contraction increases valgus/varus stiffness (Mac Williams et al., 1999)

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SUMMARY OF MECHANISMS



- Range of knee flexion
- Skier out of balance
- Lateral to medial knee joint loading (valgus loading)
- Twisting load (internal rotation of tibia)
- Back to front load on tibia (anterior displacement of tibia)
- Time frame of injury (< 60 ms)



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RISKS FACTORS FOR ACL INJURY

- Equipment
- Speed
- Changing snow conditions
- Course setting
- **Physical factors (e.g. fitness, strength)**



Spörri et al., 2012



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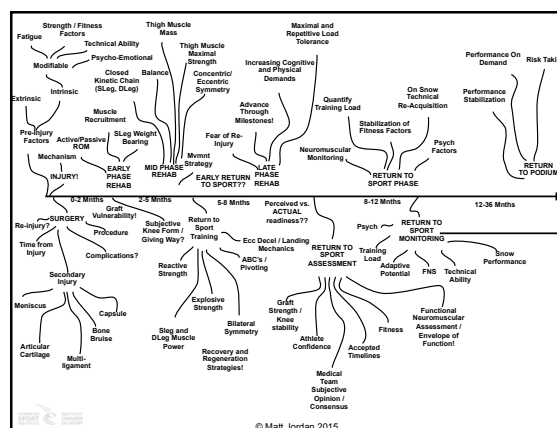
THE INJURY / RE-INJURY CYCLE



Bere et al., 2011; Bere et al., 2011; Ferguson, 2009; McConkey, 1996; Natri et al., 1999; Pujol et al., 2007



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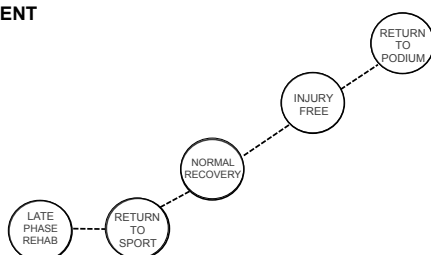


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RETURN TO SPORT

RETURN TO PODIUM

SPORT-SPECIFIC FUNCTIONAL NEUROMUSCULAR ASSESSMENT



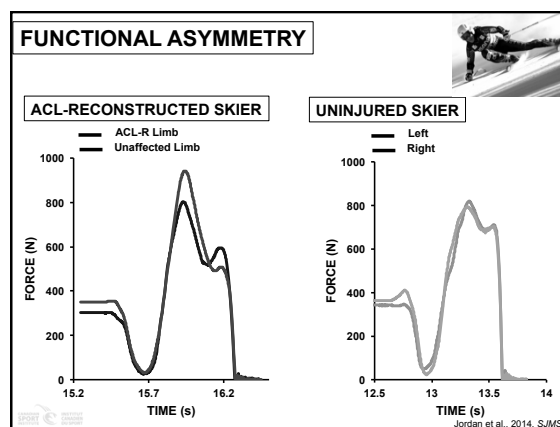
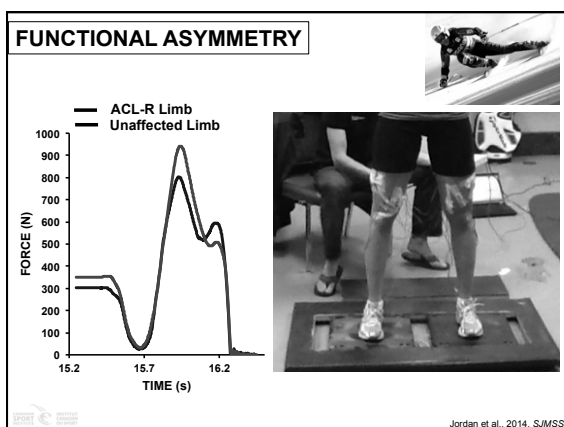
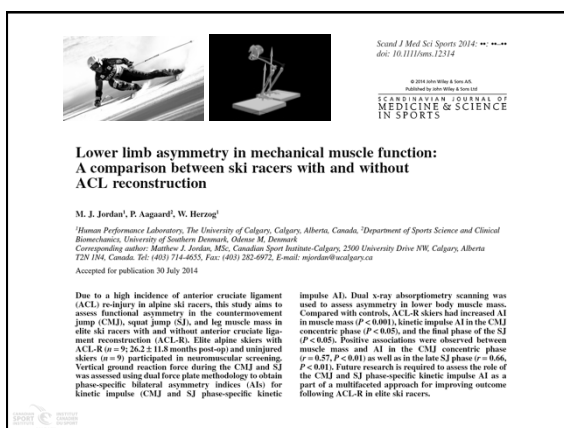
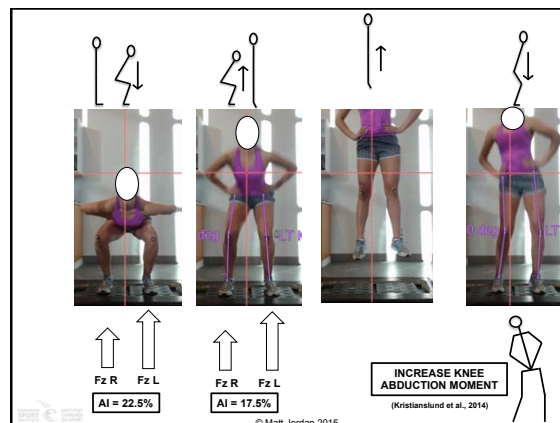
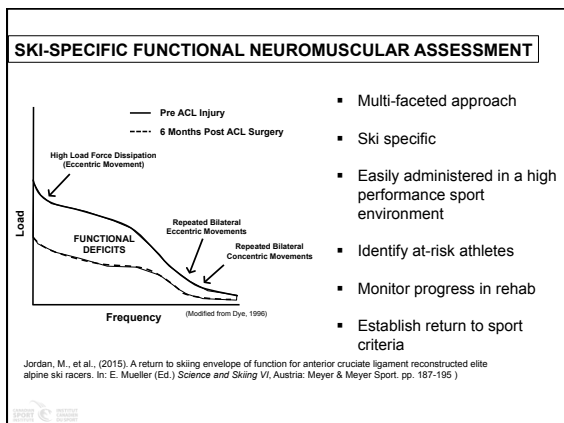
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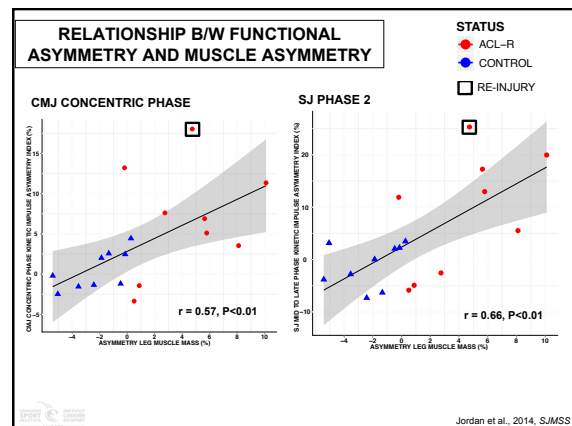
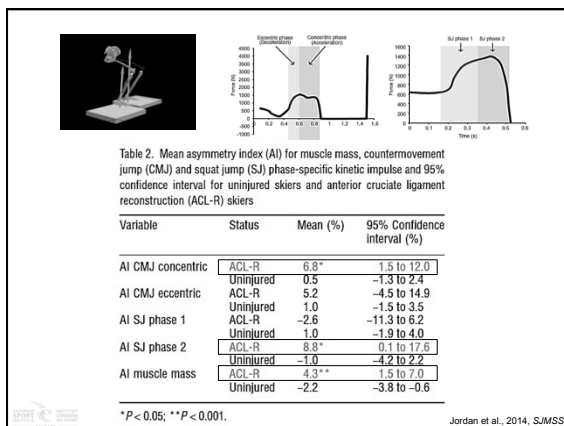
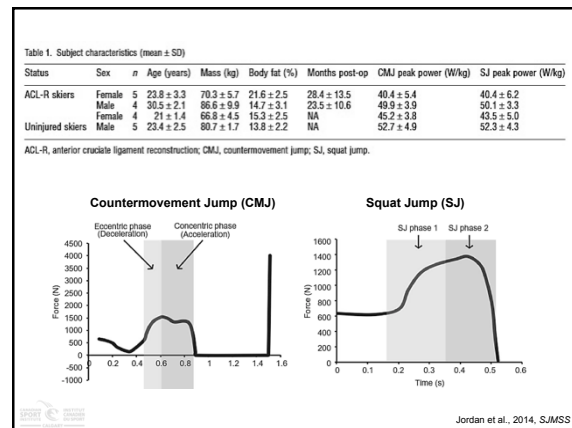
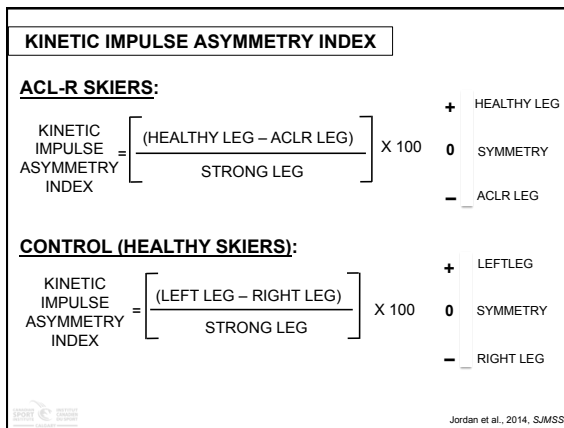
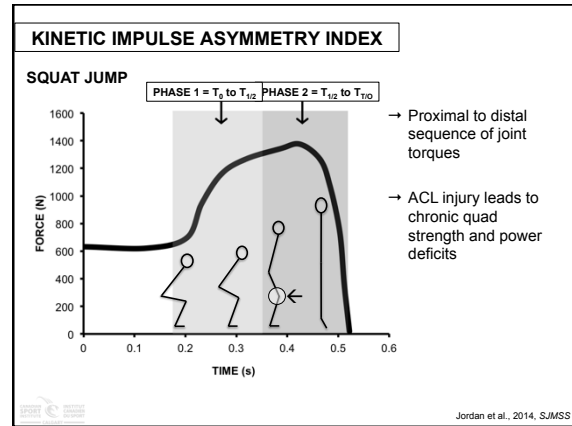
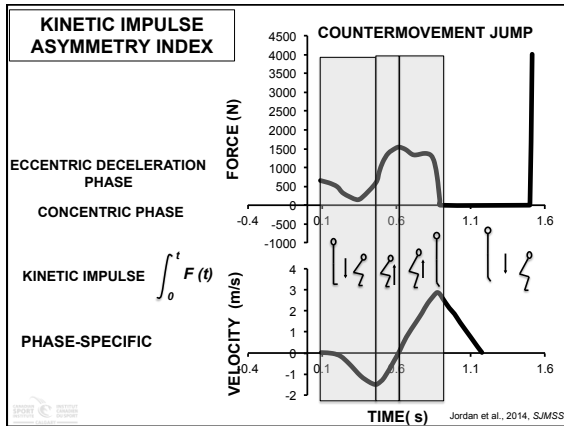
RETURN TO SPORT SCREENING

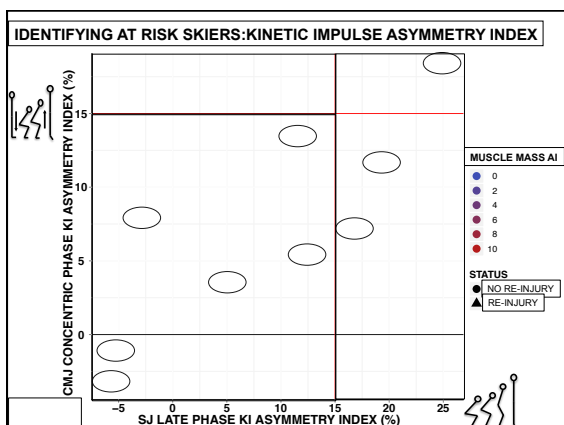
- Quad/hamstring strength symmetry (Myer et al., 2009)
- ACLR alter jump technique (i.e. achieve performance symmetry but still have knee extensor deficits) (Ernst et al., 2000)
- Assessments of functional symmetry in eccentric and concentric movements (Hewett et al., 2011; Myer et al., 2006; Paterno et al., 2011)
- Multiple test increase sensitivity (Gustavsson et al., 2006)



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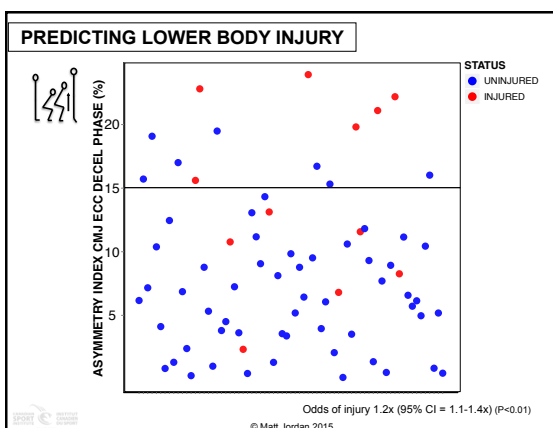
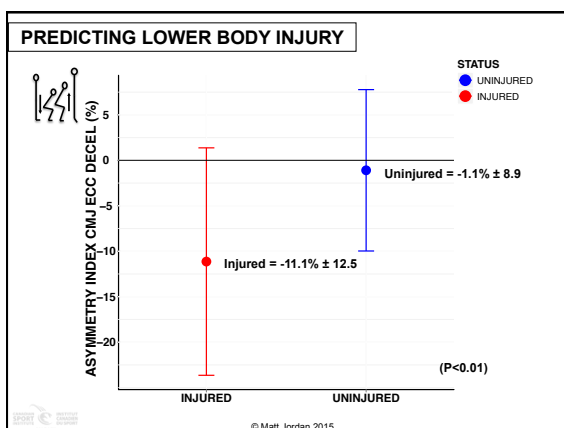


PREDICTING INJURIES USING THE KIAI

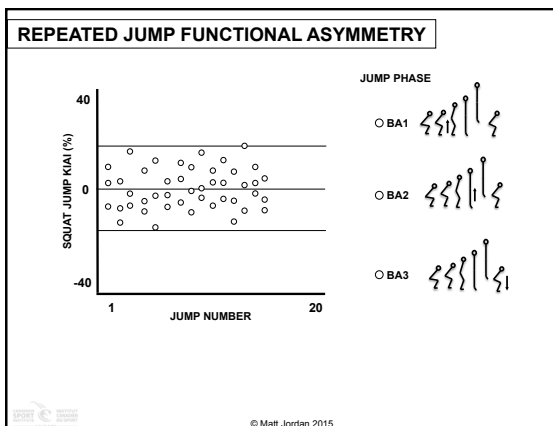
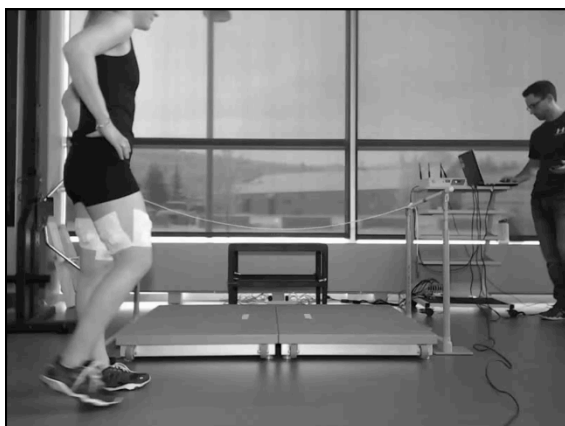
- N = 71 athletes
- Females: n=51, Age=20.6±2.3 years, Body Mass = 67.8±11.5 kg
- Males: n=20, Age=20.1±1.7 years, Body Mass = 78.7±16.5 kg)
- Alpine skiing, luge, soccer, rugby, wrestling
- Assessed at the start of the off-season preparatory period and throughout training (1x/week)



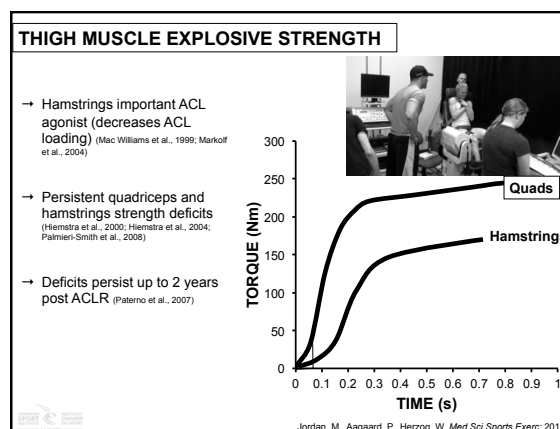
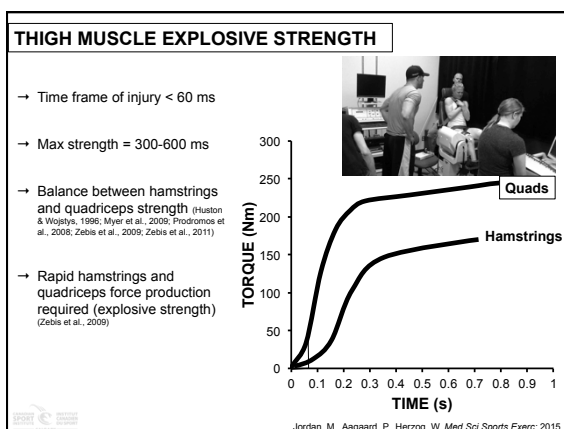
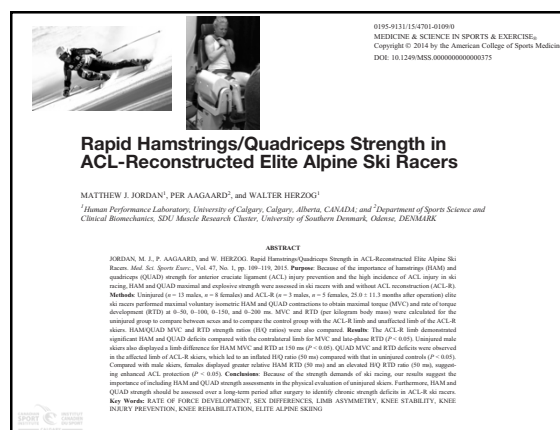
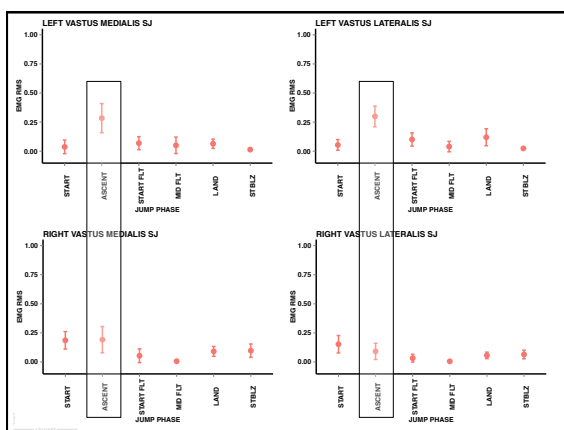
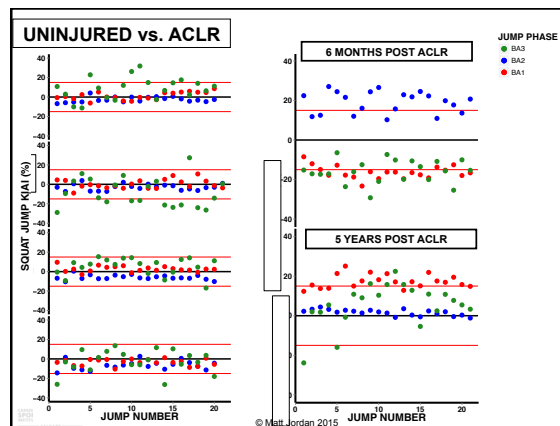
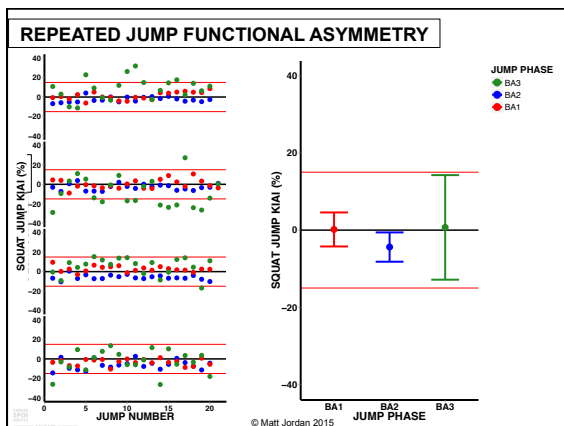
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Rapid Hamstrings/Quadriceps Strength in ACL-Reconstructed Elite Alpine Ski Racers

MATTHEW J. JORDAN¹, PER AAGAARD², and WALTER HERZOG¹



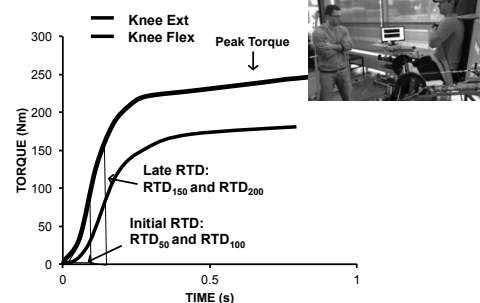
TABLE 1. Subject characteristics.

Characteristics	ACL-R Subjects				Control Subjects			
	Female		Male		Female		Male	
n	5	3	3	3	8	2	13	3
Age (yr)	24.2	±3.2	28.3	±8.8	20.9	±2.4	21.6	±3.4
Mass (kg)	69.4	±4.1	89.0	±9.3	64.8	±6.2	84.1	±7.3
Left limb mass (g)	9273.8	±772.4	12,806.9	±1555.4	9043.2	±1048.1	12,191.5	±1322.3
Right limb mass (g)	8626.4	±1168.8	12,477.1	±1222.5	8527.2	±1014.5	12,475.6	±1301.6
% body fat	20.5	±3.3	13.9	±3.0	16.4	±1.7	12.7	±2.2
Postoperation (months)	28.4	±13.5	19.3	±1.2	NA		NA	

NA, not applicable.

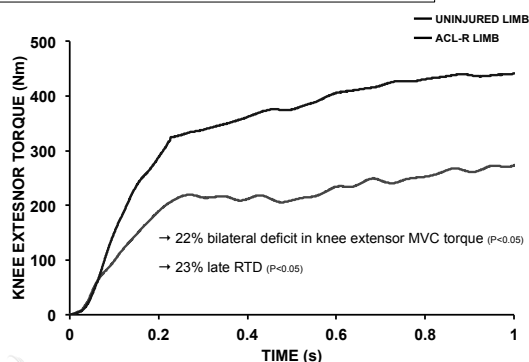
Jordan, M., Aagaard, P., Herzog, W. Med Sci Sports Exerc: 2015

THIGH MUSCLE EXPLOSIVE STRENGTH



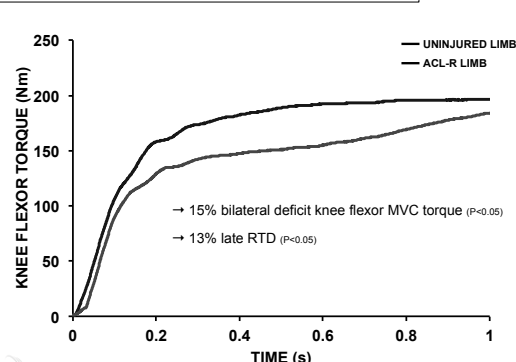
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BILATERAL KNEE EXTENSOR STRENGTH ACL-R SKIERS



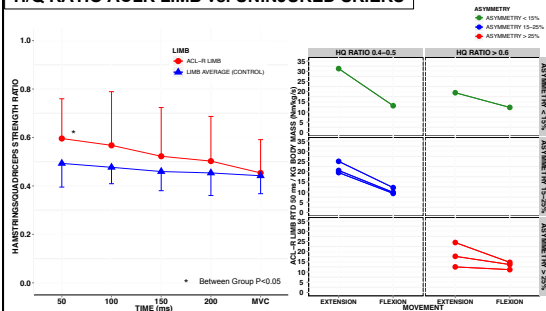
Jordan, M., Aagaard, P., Herzog, W. Med Sci Sports Exerc: 2015

BILATERAL KNEE FLEXOR STRENGTH ACL-R SKIERS



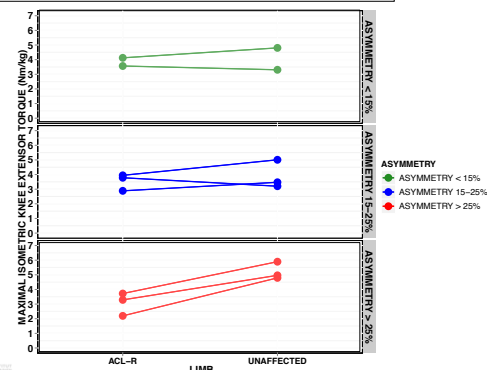
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H/Q RATIO ACLR LIMB vs. UNINJURED SKIERS



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IDENTIFYING AT RISK SKIERS: QUADRICEPS STRENGTH



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IS IT WORKING?



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ACL INJURIES 2010 – 2014 = NONE

ACL RE-INJURIES = NONE

LOWER BODY RE-INJURIES = 4



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SUMMARY

- ACL injury affects many ski racers
- Sport specific functional neuromuscular assessments required for long term efforts to reduce injury/re-injury risk
- Kinetic impulse asymmetry index (KIAI) effective assessment for identifying functional deficits
- Deficits persist in ACLR skiers despite return to sport



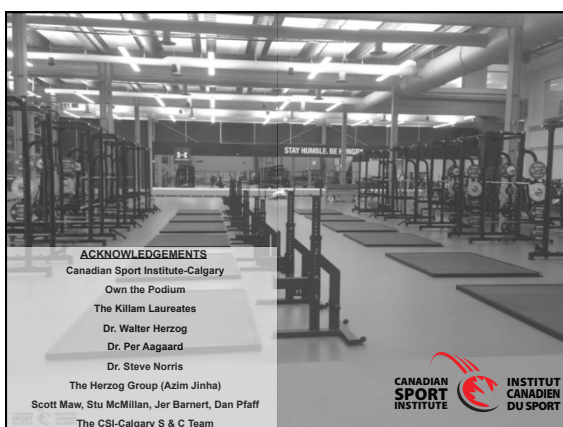
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FUTURE DIRECTIONS

- Develop a better understanding of the pattern of secondary injury associated with primary ACL injury
- Evaluate the effects of repeated mechanical loading on thigh muscle activity in uninjured and ACLR skiers
- Undertake prospectively designed research study to identify risk factors for ACL injury / re-injury
- Expand assessments to other populations at risk for ACL injury



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