Fatigue and the Risk for Non-Contact ACL Injury: A Five Year Experience

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BIOMECHANICS RESEARCH GROUP

Conflict of Interest

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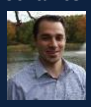
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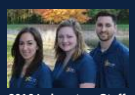
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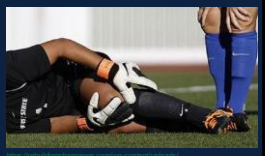
BACKGROUND

Epidemiology

1. ACL injuries are a frequent event.[1]
1. Approximately 70% per cent are classified as non-contact.[1]
1. Females are 2 and 10 times more likely to sustain a non contact injury than males.[2]
1. Non contact injuries occur during deceleration, landing maneuvers, change of direction maneuvers.[3]



https://rebuildingchampions.com/wp-content/uploads/2014/09/Knee-Injury-and-Soccer.jpg

1. Griffin LY, et al. *Am J Sports Med*. 2006;34(9):1512-1532.
2. Alentorn-Geli E, et. *Knee Surg Sports Traumatol Arthrosc*. 2009;17(7):705–29.
3. Hewett TE. *Sports Med*. 2000;;29(5):313-327.

BACKGROUND

'At Risk' Biomechanics

1. 'Position of no return'[4]:
   - Hip
     - Adduction
     - Internal Rotation
     - Decreased Flexion
   - Knee
     - Valgus
     - External Rotation
     - Decreased Flexion
1. Laterally displaced Center of Mass.[5]

4. Ireland ML. *J Athl Train*. 1999;34(2):150-154.
5. Jamison ST, et al. *J Biomech*. 2012;45:1881-1885.

BACKGROUND

'At Risk' Biomechanics

1. Muscular Control:[6]
   - Increased quadriceps activation
   - Decreased hamstring activation
2. Fatigue:
   - Majority of ACL injuries occur towards the end of half or game.[7]

https://www.followyoursport.com/admin/plugins/ckeditor/lcfinder/uploadImages

6. Huston LJ, Wojtys EM. *Med Sci Exer Sport*. 1996;24:427-436.
7. Hawkins RD, Fuller CW. *Br J Sports Med*. 1998;33(3):196-203.

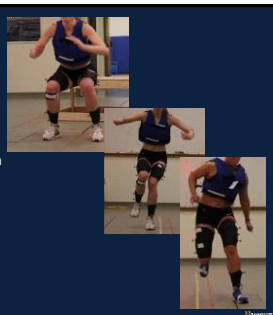
BACKGROUND

Prevention

1. ACL prevention programs have been proven to be effective at reducing the risk for sustaining a non contact injury.
   - The injury rate remains high.
1. Potential explanations are the programs are:
   - Too time consuming
   - Very complex
   - Not implemented correctly

BACKGROUND

1. The effectiveness of the programs are assessed using non 'game-like' paradigms.
1. The amount of training and its impact on the ACL is not fully known.



Aim of Project

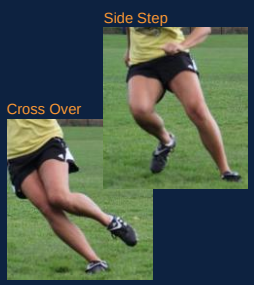
1. To determine how "at-risk" biomechanics are affected by fatigue utilizing a 'game-like' testing paradigm.
1. To determine the impact of training on the osseous structures and anterior cruciate ligament of the knee.

POTTER, REDINGER SZYMALOWICZ, ET AL.[4] MCGOVERN, DUBE, MUNKELEY, ET AL.[3]

- What effect does fatigue have on lower extremity and trunk kinematics?
  - Subjects: 19 female and 10 male D1 soccer players.
  - Each player completed a T test until they were unable run the course within 1 s.d. of the mean of four baseline (non-fatigue) trials.
  - Marker displacement histories were recorded using a 10 camera motion analysis system recording at 240 Hz.

POTTER, REDINGER SZYMALOWICZ, ET AL.[4] MCGOVERN, DUBE, MUNKELEY, ET AL.[3]

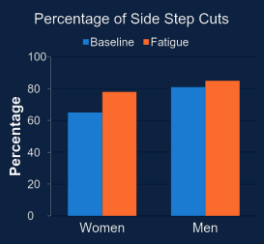
- The cuts performed at the center cone were classified.
- Trunk and lower limb kinematics at 33ms post initial contact were analyzed.



RESULTS

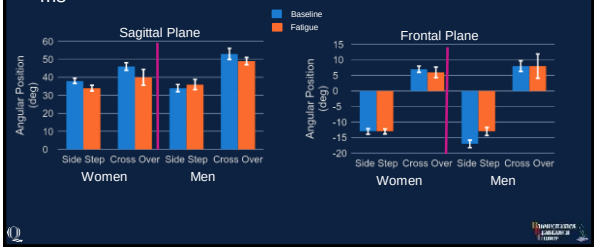
Type of Cut

- Preferred cut was a side step
  - Non significant increase in side step cuts with fatigue
  - The discrepancy was greater for women



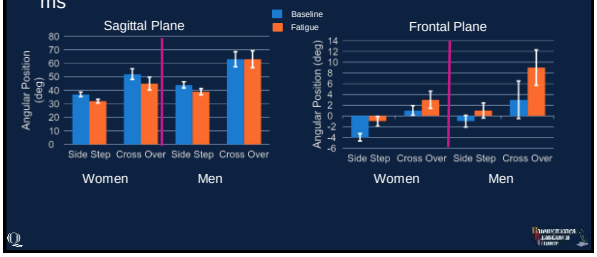
RESULTS

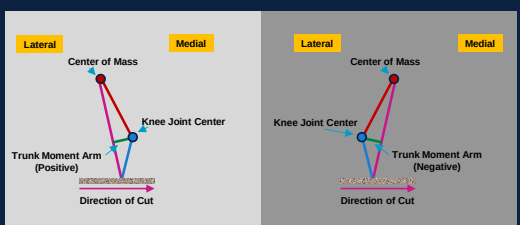
Hip Joint Kinematics at 33 ms



RESULTS

Knee Joint Kinematics at 33 ms



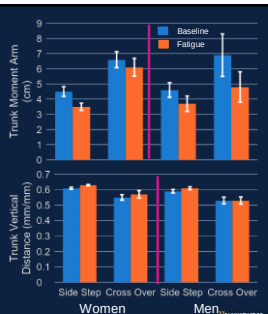


DERIVATION OF TRUNK MOMENT ARM/POSITION OF CENTER OF MASSS

RESULTS

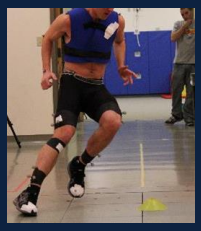
Position of the Center of Mass at 33 ms

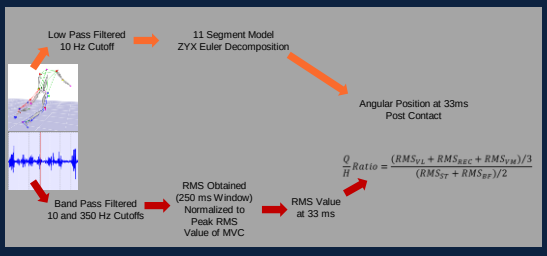
- Medial-Lateral Position
  - Trunk was more medially displaced with respect to knee with fatigue and during cross over cuts.
- Vertical Position
  - Women's trunk was more vertically displaced.
  - With fatigue men's and women's trunk was more vertically displaced.
  - During side step cuts the trunk was more vertically displaced than during cross over cuts.



RAGO, EUSEBIO, MARTIN, ET AL.[20]

- What effect does fatigue have on the muscular control of the lower extremity?
  - Subjects: 16 female and 13 male D1 soccer players
  - Each player completed a T test until a 5% decrement in performance was observed.
  - sEMG from the quadriceps and hamstring muscles and marker displacement histories were obtained



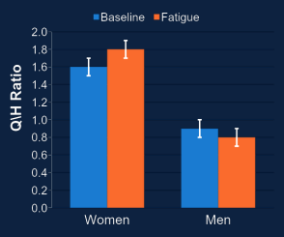


QUADRICEPS / HAMSTRING RATIO AT 33 MS

RESULTS

Quadriceps/Hamstring Ratio at 33ms

- Kinematics:
  - With fatigue athletes were in a more:
    - Extended hip and knee position
    - Less abducted knee position
- Muscle Activity:
  - Females, regardless of fatigue status, had a significantly greater Q/H ratio than males
  - With fatigue Q/H ratio significantly increased in females



Summary

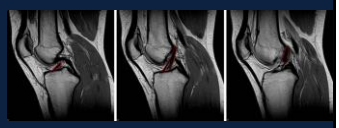
1. Hip and Knee
   - Hip and knees become more extended with fatigue
1. Center of Mass
   - Fatigue decreases the lateral displacement of the center of mass
1. Muscular Control
   - Women use a more 'quad dominant' strategy
   - In women fatigue exacerbates the use of a 'quad dominant strategy

Aim of Project

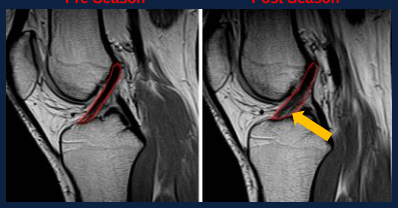
1. To determine how "at-risk" biomechanics are affected by fatigue utilizing a 'game-like' testing paradigm.
1. To determine the impact of training on the anterior cruciate ligament of the knee.

KIM, MYRICK, MELE, ET AL.[11]

- What effect does training have on the ACL?
  - Subjects: 16 female D1 soccer players
  - Each subject had two MRI examinations of their knees bilaterally:
    - Pre-season
    - Within 2 weeks of completion of season (Post-Season
  - T2 weighted sagittal images taken
    - Images graded for absence-presence of edema.
    - Contours of ACL were delineated by one investigator and used to obtain volume of ACL



Pre Season Post Season

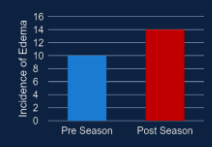


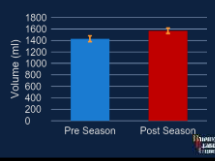
PRE- POST SEASON SCANS OF ACL

RESULTS: KIM, MYRICK, MELE, ET AL.[11]

ACL Volume

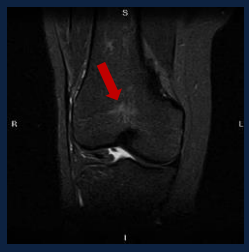
- Training appears to have an effect on the ACL.
  - Over the course of a competitive season:
    - Incidence of edema increases
    - Increase in the volume of ACL is seen





MYRICK, MELE, MARTIN, ET AL.[12]

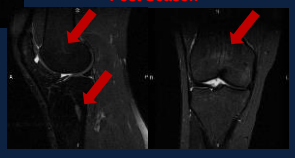
- What effect does training have on the osseous structures of the knee?
  - Subjects: 19 female D1 soccer players
  - Each subject had three MRI examinations of their knees bilaterally:
    - Pre-season
    - Within 2 weeks of completion of season (Post-Season
    - Within 6 weeks of completion of season (Recovery)
  - Images were classified and then scored using Knee Osteoarthritis Scoring System (KOSS) by board certified radiologist.[13]



13. Kornaat Pret al. *Skeletal Radiology*. 2005; 34(2):95-102.

Pre Season

Post Season

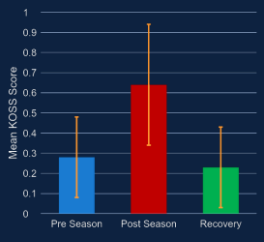


PRE- POST SEASON SCANS OF KNEE OF ATHLETE WITH BME

RESULTS: MYRICK, MELE, MARTIN, ET AL.[12]

KOSS Ratings of BME

- Training has an effect on osseous structures of the knee.
  - The severity of BME increases over the span of a season.
  - With rest will return to preseason levels



Summary

1. Training – Competition:
   - Causes changes in the ACL
   - Impacts osseous structures

Contact

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