Fact or Fiction: Are Female Runners at Greater Risk of Injury than Male Runners: Introduction/Epidemiology of Running-Related Injuries from Adolescence to Middle Age

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1. Participation
   - Middle School
   - High School
   - Collegiate
   - Adults

2. Injury Incidence & Body Location Injured/Injury Type
   - Middle School
   - High School
   - Collegiate
   - Adults

3. Risk factors for Running Injury
   - Prior Injury
   - Static Measures
   - Muscle Strength Measures
   - Dynamic/Functional Measures
   - Training Error measures
   - Female Athlete Triad

4. Take Home Messages

5. Future Research
   The Effect of Gender and Maturation on Neuromuscular Control and Performance on Functional Movement Screening Tools
Middle School to Middle Age...
- Middle School to Adolescence
  - Puberty: changes in height, weight, hormones, body composition
- High School and College
  - Potential changes in competitiveness
  - Changes in training schedule, sleep schedule, lifestyle
- Young Adult to Middle Age
  - Changes in work or school schedule
  - Training plans, distances run
  - Potential changes with pregnancy

Within the subjective assessment, there are important questions to ask your athlete specific to their age, gender, experience, and background
- Running History
  - When did you start running?
  - How many miles a week are you currently running?
  - Any recent changes in training?
- Nutritional History: Any dietary restrictions?

Screening Questions Specific to Females
- Menstrual history
  - Have you started your period? If so, when did you start? How often do you have it?
  - Do you notice any change in menstrual regularity between seasons or between the season and off-season? (Tenforde 2013)
- Pregnancy
  - Were you able to run throughout your pregnancy? Any changes in your running habits during or after pregnancy?
  - Any problems (back pain, hip pain, plantar fasciitis, incontinence) since pregnancy? (Thein-Nissenbaum 2012)

Objective Assessment
- Cardiovascular Screen
  - Heart rate, blood pressure (Aagaard 2013)
- Anthropometric Measures
  - Height
  - Weight
  - BMI (Tenforde 2013)
- Postural Alignment
  - Standing Posture
Functional Assessment Testing

- So now that I have evaluated my runner’s strength, ROM, flexibility, posture, and have done my special testing, what next?
- Whittaker 2016: Predicting LE injury risk
  - Systematic Review
  - “Overall there is inconsistent level 4 evidence that poor movement quality is a risk factor of lower extremity injury”
  - “It is highly unlikely that a lower extremity injury is a result of a single factor or aberrant movement pattern, but rather the consequence of complex interactions between multiple risk factors and inciting events”

What about the FMS?

- Agresta & Loudon 2014: FMS Normative Values
  - Mean FMS scores were 13.1±1.8 and 15.4±2.4
  - No significant difference between novice/experienced, history of injury/no history of injury, or male/female runners
  - Significant difference in age (under 40 and over 40)
  - Sex differences found in active SLR for both studies
    - Deep squat, trunk stability push-up, and shoulder mobility?
- Hotta 2015
  - 84 competitive track & field males 18-24 yo
  - FMS pre-season with follow-up surveys during 6-month season
    - Injury defined as a result of practice/race and prevented 4-weeks of participation
  - No significant difference in overall FMS score, but difference in deep squat and active SLR

What about the YBT?

- There is no research evidence indicating using the y-balance test or star excursion balance test will assist in the identification of injury risks or rehabilitation prognosis for runners

Gluteal Weakness

- Systematic Review: hip abductor strength may be associated with ITBS, unclear if it is associated with PFPS (Mucha 2016, van der Worp 2012)
  - Decreased hip abductor strength correlated with M/F runners with ITBS (Fredericson 2000)
  - Decreased hip abduction strength associated with PFP in females (Dierks 2008)
- Decreased gluteus maximus activation associated with dynamic valgus during single leg squat (Nguyen 2011)

Single Leg Squat?

- Increased frontal plane projection angle in females (Zeller 2003, Willson 2006)
  - Females had greater muscle activation (Zeller 2003)
  - Females had decreased trunk extensor, flexor, and lateral flexor, hip ER*, and knee flexor, extensor strength (Willson 2006)
Willy 2011 found increased knee adduction in males with PFP and increased hip adduction in females with PFP

Single Leg Squat Predicts Running Mechanics?

- Sort-of... (Willy 2011)
- 20 uninjured females with increased hip adduction, hip IR, and knee IR while running and squatting underwent a 6-week hip strengthening protocol
- Single leg squat mechanics and strength improved, but no significant change in running mechanics

Jump/Hop Tests?

- There is no research evidence indicating the use of jump or hop testing to assist in the identification of injury risks or rehabilitation prognosis for runners

So What do We Know?

- Impaired hip strength in female runners is associated with running-related injuries such as PFP and ITBS
- There is a potential link between single leg squat and running gait impairments
  - However, strength and squat training may not improve running gait mechanics
- Adolescents
  - Neuromuscular control with jumping, cutting, and squatting changes during puberty with females showing greater movement impairments including hip drop, femoral adduction, and dynamic valgus (Mendigucia 2011, Quatman 2006)
- Pregnancy
  - Pelvic/trunk control are critical during and after pregnancy (Wesnes 2013)

Conclusions

- We are still very reliant on our subjective assessment coupled with strength, balance, ROM, flexibility, and special tests
- There is unsubstantiated evidence that functional screenings can assist in the assessment of neuromuscular control while running
- Future research should continue to investigate the use of functional assessments in injury prevention and prognosis of rehabilitating from running injuries

References


21. WILLY R, DAVIS I. The Effect of a Hip-Strengthening Program on Mechanics During Running and During a Single-Leg Squat. *JOSPT.* 2011;41:


**The Effect of Gender & Maturation on Running Biomechanics: Apply 3D Gait Findings to the Clinic**

D. S. Blaise Williams III, Ph.D., MPT

Disclosure

I have nothing to disclose.
By the end of this presentation the learner should be able to:
1. Understand the effects of gender and maturation on running injury incidence and running gait mechanics.
2. Identify the root causes of common gait abnormalities as well as evidence-based treatment techniques

**The Pronated Lower Extremity**

**Anterior Pelvic Tilt**
- Imbalance between muscles surrounding and controlling the pelvis
- Weak abdominals and hamstrings
- Tight hip flexors and low back
- Risk factor for hamstring strains (Opar et al, 2012)
- Questionable whether static hip flexibility relates to dynamic hip extension/pelvic tilt (Franz et al, 2009; Schache et al, 2000)
- Tight hip flexors create an ER bias at the hip
- Weak abductors and ER result in IR under load
- This places increased stress on the tight hip flexors

**Hip Internal Rotation**
- Women demonstrate greater static hip internal rotation than men (Nguyen & Schultz, 2007)
- Does not seem to be related to gluteus medius and maximus activity during a single leg squat (Nguyen et al, 2011)
- Activation may need to be similar or increased in order to maintain similar hip position at midstance
- Anteversion is a predictor of hip impingement and pain (Miguel et al, 2012)
- Women more likely to be anteverted
- Hip Adduction
- May be related to wider hips in females
- Injuries not likely to occur at the lateral hip in younger runners (trochanteric bursitis)
- Changes the position and movement of the knee
- Patients with increased hip adduction are more likely to develop patellofemoral pain (Noehren et al, 2012)

**Knee Valgus**
- Strong relationship to patellofemoral pain (Salsich & Long-Rossi, 2010)
- Difference between Q angle and F-Tangle
- Tibial Internal Rotation
- Relationship between tibial position and rearfoot eversion
- Top-down or bottom-up cause of tibial rotation?
- Both seem to be related in PFP patients (Barton et al, 2012; Noehren et al, 2012)
- Increased tibial IR may be present in order to decrease knee ER due to hip IR
- Rearfoot Pronation
- No evidence to suggest difference in pronation between males and females
As females age (10-18 yrs), the foot becomes more supinated (Shultz et al, 2008)
Younger athletes may need orthotics but not need later
Evidence supports pronated foot posture related to ERLLP and MTSS (Willems et al, 2007; Tweed et al, 2008)
Medial Longitudinal Arch
Males have a lower medial longitudinal arch than females (Pauk et al, 2012)
However, increased activity levels are related to lower arches in both males and females (Pauk et al, 2012)
EXTREMES of arch position AND mobility are likely more important than slight deviations for injury (Williams et al, 2001)

Hamstring Length
Increased length decreases knee stability (Boden et al, 2000)
After puberty, females remain very flexible compared to males (Hewett et al 1996)
Increased hamstring flexibility may lead to increased external tibial rotation (Nyland et al, 1999)
Ligament Laxity
Females have greater ligament laxity than males (Boden et al, 2000)
Must rely on muscle stabilization
May cause a decrease in proprioception (Rozzi et al, 1999)

Running Mechanics
Running is a series of single leg landings
Important to understand the difference in landing mechanics between men and women
Most of these data come from the ACL literature
Consider treating all adolescent female athletes with training programs focused on ACL injury
Single Leg Landing
Landing Mechanics
Restrictions proximally & distally may predict increased valgus knee motion in female soccer players
< hip external rotation explained 16% of variance
< ankle dorsiflexion explained 10% of variance (Sigward et al, 2008)
Landing Mechanics
Excessive knee valgus discriminates between men and women when landing from a jump (Hewett et al, 2005; Ford et al, 2005)
Controlled by hip and exercises focused on jumping and landing
Landing Mechanics
Femoral IR may compensate for increased tibial IR as the demands of the task increase (Tillman et al, 2005)
Bottom up or top down?
Women appear to have less transverse plane control (Wojtys et al, 2003)
Landing Mechanics
Women utilize greater rectus femoris and less gluteus maximus muscle activity during landing (Sell et al, 2004; White et al, 2003)
Men utilize their hips and land softer (Hewett et al, 2005)
Women have more rigid movement patterns than men (Pollard et al, 2005)

**Landing Mechanics**
- Women have more quadriceps activity and higher quad to hamstring ratios than men (Hewett et al, 1996)
- With increased quad activity and poor alignment of the knee in the frontal plane, compressive forces at the PFJ greatly increase

**Intervention**
- **General approach**
- Hip ER ROM and DF ROM
- Strengthen muscles around core and hips
- Strengthen hamstrings
- Balance muscles around the knee
- Ankle stability and strength
- Functional training for landing and running
- Intervention
- **ROM**
- Important to have both static and dynamic stretches (Sekir et al, 2010)
- **Strength**
- Functional activities for runners
- Single leg stance
- Compliance
- Gait
- Knee flexion/extension
- Intervention
- **Hip Range of motion**
- Static=Pigeon pose
- Static=High kneel stretch
- Dynamic=Diagonal leg swings
- Dynamic=Sagittal leg swings
- Intervention
- **DF Range of motion**
- Static=Gastroc, soleus and joint
- Dynamic=Plank alternating steps
- Intervention
- **Core strength**
- Alternating lower extremity with abdominal activities
- Intervention
- **Hip strength**
- Side steps with knees flexed and extended
- Clam shells
Beyond Reps & Sets: The Role of Neuromuscular Control & Gait Retraining in Rehabilitation of Common Running Injuries

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Disclosures:
I have nothing to disclose.

Presentation Outline:

Objectives:
1. Define and integrate the following concepts into your clinical practice:
   - Motor Control
   - Motor Learning
2. Identify muscle activation thresholds necessary for inducing muscle strengthening
3. Determine the effects of strengthening & movement retraining on running mechanics
4. Implement evidence-based running retraining strategies utilizing motor learning theory

A Brief Review of Differences B/W Male & Female Running Mechanics:
1. Differing Kinematics
2. Differing Kinetics
3. Differing Muscle Activation

Treatment Paradigms: Strength vs. Neuromuscular Control
1. Neuromuscular Control Defined

Gluteal Anatomy & Running – Specific Function

Exercise Prescription using principles of Neuromuscular Control
1. Neuromuscular Activation
2. Sub-Strengthening Threshold Exercises: Gluteus Medius & Gluteus Maximus
3. Above-Strengthening Threshold Exercises: Gluteus Medius & Gluteus Maximus
4. Motor Control
   a. Definition
   b. Treatment Principles
   c. Motor Learning
      i. Cognitive phase
      ii. Associative phase
      iii. Automatic phase
5. Gait Retraining & different application utilizing motor learning theory
   a. Step Rate Manipulation
   b. Visual Gait Retraining
   c. Other types of gait retraining:
      i. Step Width
      ii. Trunk Lean

Gait Retraining: Main Error vs. Secondary Error
1. Main Error Definition
2. Secondary Error Definition

4 steps for Optimal Running Retraining
1. Identify the Proper Performance Criteria
2. Break the Skill into Parts: Gait Analysis
3. Determine the Main Errors affecting Performance
   i. Controversy of what constitutes the main error
      1. Step rate
      2. Heel vs. Forefoot strike
      3. Medial collapse
      4. Trunk lean
      5. Step Width
4. (Effective) Communication
   i. Implicit learning
   ii. External focus
   iii. Faded feedback design
   iv. Knowledge of results

References
6. Ekstrom et. al. 2007. JOSPT. 37(12): 754-762
17. Willy et al. 2011. JOSPT. 41(9):625-632
- Intervention
  - Hamstring strength
    - Single leg forward bends
    - Without rotation
    - With rotation
    - Single leg knee flexion at end range
    - Single leg bridges with weight through heels
    - Butts kicks
    - Switch lunges
  - Intervention
    - Balance
      - Single leg stance
        - Eyes open
        - Eyes closed
        - Head back
        - Single leg stance with reciprocal leg motion
      - Single leg stance on unstable surface
      - Single leg stance with rebounder
    - Intervention
      - Perturbation-enhanced neuromuscular training (Hurd et al, 2006)
  - Intervention
    - Neuromuscular training
      - Jump training
      - (Myer et al, 2008)
  - Sportsmetrics
    - FIFA 11+ (sport-specific)
  - Intervention
    - Ankle stability and strength
      - Posterior tibialis (Kulig et al, 2006)
    - Two up one down
    - Jump rope
    - Y balance
    - Alternate jumps onto Bosu ball
  - Summary
    - Adolescent female runners have different structural limitations than male runners
    - Flexible and weak hamstrings
    - Anterior pelvic tilt and weak core
    - Adolescent female runners have different running mechanics than male runners
    - Hip adduction and knee valgus
    - Quad dominant and weak hip extensors
Exercises and training should match the needs of the female runner and focus on mechanics related to single leg landing.