Overuse Lower Extremity Injuries in the Runner: Gait Analysis and Retraining

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RUNNING STATISTICS

- 300% growth from 1990 - 2013
- 2014 - 18,750,000 finishers in US running events
- 2014 - 28,000 US running events
- Marathoner Ave Age - 38.8
RUNNING AND INJURIES

79% of runners that run more than 12 miles per week will get injured at some point within a 12 month span.

Van Gent et al 2007
EACH FOOT STRIKES THE GROUND APPROXIMATELY 1,000 STEPS PER MILE

Musculoskeletal tissues of the lower extremity become susceptible to cumulative overload, leading to overuse injuries.

Davis & Futrell 2016
COMMON OVERUSE INJURIES IN RUNNERS…. 

- Stress Fractures
- Shin Splints
- Plantar Fascitis
- Patellofemoral Pain
- ITB Syndrome
- Compartment Syndrome
- Achilles Tendonopathy

Pujalte et al 2014
INTRINSIC RISK FACTORS ASSOCIATED WITH OVERUSE INJURIES IN RUNNERS….

- Previous Injury (#1 predictor)
- Age
- Sex
- BMI
- Physical Fitness
- Anatomical Alignment
- Running Mechanics

Buist et al 2010, Saragiotto et al 2014
EXTRINSIC RISK FACTORS ASSOCIATED WITH OVERUSE INJURIES IN RUNNERS….

- Running Distance Per Week
- Frequency Per Week
- Running Surface
- Running Shoe Age
- Running Shoe Type

Buist et al 2010
FACTORS ASSOCIATED WITH RUNNING INJURIES......

Every runner has threshold for injury and it depends on several factors....

Davis & Futrell 2016
A CLOSER LOOK:

1. Dosage – modifiable risk factors
2. Structure – need to be considered, but effectively non-modifiable
3. Mechanics – forces (kinetics) and movement patterns (kinematics)
   - Can we modify this???
HOW DO WE TYPICALLY TREAT THESE RUNNING INJURIES?

• Rest
• Modalities
• Stretch
• Strengthen
• Manual Treatments

– Why this may not be enough for this population?
THE EFFECT OF A HIP STRENGTHENING PROGRAM ON MECHANICS DURING RUNNING AND DURING A SINGLE-LEG SQUAT

WILLY ET AL. 2011

- 20 healthy females with excessive hip ADD while running
- Exercised 3x/wk for 6 weeks targeting hip ER and ABD
- First 2 weeks NWB and last 4 weeks WB exercises
- Final 3 weeks – single-leg squats added
RESULTS - WILLY ET AL. 2001

- Significant gains of strength in hip ER and ABD
- Reduction of hip ADD and CPD seen in single-leg squats
- No changes seen in abnormal hip mechanics during running
GAIT RETRAINING

• Increasing evidence that individuals can alter gait mechanics with real-time feedback

• Ultimate goal is to learn new patterns

• Feedback must be given and gradually removed

• Indications of learning include the retention of new motor skills as well as their transfer to another unpracticed activity

Sherwood and Lee 2003
TREADMILL SET-UP AND WARM-UP

• Run at a pace that matches a “long run” or the pace when they experience pain.

• Video a minimum of 2 views.

• A 6-10 minute warm-up is recommended if possible.

Souza 2016
WHAT TO LOOK FOR IN THE SAGITTAL PLANE....

1. Foot Strike Pattern
2. Foot Inclination Angle at Initial Contact
3. Tibia Angle at Loading Response
4. Knee Flexion During Stance
5. Hip Extension During Late Stance
6. Trunk Lean
7. Overstriding
8. Vertical Displacement of the Center of Mass
FOOT STRIKE PATTERN

• Easily seen on slow motion video

• A study showed that runners with a rear foot strike pattern developed more repetitive overuse injuries than those with a FFS pattern (Daoud et al 2012)

• More research needs to be done before broad conclusions on foot strike can be made (Souza 2016)
FOOT INCLINATION ANGLE AT INITIAL CONTACT (HEEL STRIKERS)

Angle created by the sole of the shoe and the treadmill belt at initial contact

INCREASED FOOT INCLINATION ANGLE DURING RUNNING:

• higher peak knee extensor moments
• increased knee energy absorbed
• higher peak vertical ground reaction force
• greater breaking impulse

Souza 2016, Wille et al 2014
**TIBIA ANGLE AT LOADING RESPONSE**

Use freeze frames at loading response - right as shoe starts to deform

1. **EXTENDED TIBIA** – lateral knee is posterior to lateral malleolus
2. **FLEXED TIBIA** – lateral knee is anterior to lateral malleolus
3. **VERTICAL TIBIA** – lateral knee is directly over the lateral malleolus

For runners that suffer from impact related injuries an extended tibia is not ideal

Souza 2016

[Diagram showing initial contact and loading response]
KNEE FLEXION DURING STANCE

Scroll through stance frames to identify max knee flexion

Normal peak flexion approaches 45 degrees at midstance

• <45 degrees of peak knee flexion may suggest <shock absorption

• < 40 degrees may be associated with certain subgroups of patients with patellofemoral pain (Dierks et al 2011)

• Knee stiffness – reduced knee flexion or increased knee flexion may be associated with tibial stress fractures (Milner et al 2006)
HIP EXTENSION DURING LATE STANCE

Reduced hip extension during late stance is a common in the recreational runner

- Believed that a lack of hip extension = reduced flexibility of the iliopsoas
- Optimal amount of hip extension is elusive.

**Compensations for runners with reduced hip extension:**

- Bounding
- Increased lumbar extension
- Overstriding
- Increased cadence

Souza 2016
A forward trunk lean of approximately 7 degrees significantly lowered the stress across the patellofemoral joint without significantly increasing ankle demand. (Teng and Powers 2014)
OVERSTRIDING

Evaluate during the loading response

Important to differentiate stride length from overstriding

• Overstriding is a running pattern where the foot lands in front of the center of mass

• Draw a line straight up from the lateral malleolus—it should fall within the pelvis

• The distance from the heel at initial contact to the center of mass is a significant predictor of knee extensor moment and braking impulse during running. (Wille et al 2014)
VERTICAL DISPLACEMENT OF THE CENTER OF MASS

- Increased excursion of the center of mass is predictive of the peak knee extensor moment, the peak vertical ground reaction force and braking impulse during running. (Wille et al 2014)

- Look for this in “bounders” – runners who increase float time

- Increasing cadence by 10% during running can significantly reduce this. (Heiderscheit et al 2011)
WHAT TO LOOK FOR IN THE FRONTAL PLANE.....(POSTERIORLY)

1. Base of Support
2. Heel Eversion
3. Foot Progression Angle
4. Knee Window
5. Pelvic Drop
**BASE OF SUPPORT**

- Look at running step width............

- The feet should not overlap in their ground contact location.

- A narrow base of support linked to ITBS, tibial stress fractures, excessive hip add and overpronation

HEEL EVERSION

• Evaluate peak heel eversion and the rate of pronation.

• Several studies have linked excessive heel eversion to tibial stress fractures, patellofemoral pain and achilles tendonopathy. (Barton et al 2010, Milner et al 2010 & Silbernagel et al 2012)

• Could try orthotics, but the current evidence is inconclusive. (Yeung et al, 2011)
FOOT PROGRESSION ANGLE

Transverse plane position of the foot during stance phase

• Should see the lateral aspect of the shoe in stance.

• Equates to about 5-10 degrees of toe out.

• An abnormal toe in progression angle may be associated with hip IR, knee IR, ankle IR, or some combination of these.

• Can also see excessive toe out – may be associated with tight hip ER.

Souza 2016
KNEE WINDOW

- Should be a space between the knees during the running cycle.

- Tend to see an abnormal knee window in runners with excessive hip add, excessive hip IR and excessive knee valgus.

- A large window may suggest a varus deformity.

Souza 2016
• Pelvic drop during running has been reported to be significantly related to both hip abductor strength and hip extension strength. (Ford et al 2013)

• Looking at side to side differences.

• Excessive pelvic drop during running contributes to excessive hip ADD. (Noehren et al 2007)
CADENCE

• Count number of times the right heel strikes the treadmill in 1 minute = stride rate

• Multiply by 2 = step rate

• Increasing the cadence by 10% can reduce center of mass vertical excursion, braking impulse and mechanical energy absorbed at the knee. (Heiderscheit et al 2011)

• Some suggest that 180 steps per minute ideal.
THE EFFECT OF REAL-TIME GAIT RETRAINING ON HIP KINEMATICS, PAIN AND FUNCTION IN SUBJECTS WITH PATELLOFEMORAL PAIN SYNDROME
NOEHREN ET AL. 2011

- 10 female runners with PFPS
- Running & single-leg squat: looked at HADD, HIR, CPD
- 8 training sessions – run time progressed from 15-30 mins
- Visual feedback given continually the first 4 sessions
- Feedback removed over the last 4 sessions
- 1 month f/u
RESULTS - NOEHREN ET AL. 2011

- Significant reduction of HADD, CPD and Pain while running
- HIR decreased by 23% - (not statistically significant)
- 18% reduction in HADD during a SLS - (not statistically significant)
- Significant improvement in pain and function
- Unexpected benefit was 20% reduction in average vertical load rates
MIRROR GAIT RETRAINING FOR THE TREATMENT OF PATELLOFEMORAL PAIN IN FEMALE RUNNERS
WILLY ET AL. 2012

• Visual feedback provided by a mirror – 10 females

• Instrumented analysis pre and post training: running, SLS and step descent

• Mirror placed in front of treadmill – 8 sessions over 2 weeks

• Verbal cues given: “run with knees apart and with kneecaps pointing straight ahead” & “squeeze your buttocks”

• Feedback gradually removed in the last 4 sessions
RESULTS - WILLY ET AL. 2012

• Reduced peaks of HADD and CPD during running

• Skill transfer: SLS and step descent

• Improvements of pain and function through 3 months post retraining
OVERVIEW

• Look at all potential risk factors
• Talk with patient’s about their training
• Gait retraining is very important in this population
• Give visual and verbal cues to assist with gait retraining