Faculty Disclosure

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Dr. Hansen has listed no financial interest/arrangement that would be considered a conflict of interest.

CLINICAL APPLICATION OF GAIT RETRAINING FOR RUNNERS

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CHI Health Sports Medicine at D1

I don’t run. And if you ever see me run, you should start running too. Because something is probably chasing me.
A Little Background

Running Injuries: By the Numbers

- 29.5 to 56% of runners experience one or more injuries per year and about 25% of runners are injured at any one time.
- Although incidence of injuries is relatively high for non-contact sports, it is still 2-6x lower than other sports.
- When injured runners will...
  - Reduce or stop training 30-90% of injuries
  - Seek medical care 20-70% of injuries
  - Miss work <5% of injuries

Injuries by Body Part:
- Knee: 25%
- Hip: 7%
- Upper Leg: 10%
- Ankle: 15%
- Lower Leg: 20%
- Foot: 16%
- Back: 7%
Top 14 Running Injuries

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patellofemoral Pain Syndrome</td>
<td>568</td>
<td>32.2</td>
</tr>
<tr>
<td>Tibial Stress Syndrome (Shin Splints)</td>
<td>306</td>
<td>17.3</td>
</tr>
<tr>
<td>Achilles Tendinitis</td>
<td>128</td>
<td>7.2</td>
</tr>
<tr>
<td>Stress Fractures</td>
<td>127</td>
<td>7.2</td>
</tr>
<tr>
<td>Plantar Fasciitis</td>
<td>119</td>
<td>6.7</td>
</tr>
<tr>
<td>Iliotibial Band Syndrome</td>
<td>111</td>
<td>6.3</td>
</tr>
<tr>
<td>Patellar Tendinitis</td>
<td>100</td>
<td>5.7</td>
</tr>
<tr>
<td>Metatarsal Stress Syndrome</td>
<td>58</td>
<td>3.3</td>
</tr>
<tr>
<td>Adductor Strain</td>
<td>52</td>
<td>3.0</td>
</tr>
<tr>
<td>Hamstring Strain</td>
<td>45</td>
<td>2.6</td>
</tr>
<tr>
<td>Posterior Tibial Tendinitis</td>
<td>45</td>
<td>2.6</td>
</tr>
<tr>
<td>Ankle Sprain</td>
<td>42</td>
<td>2.4</td>
</tr>
<tr>
<td>Peroneus Tendinitis</td>
<td>34</td>
<td>1.9</td>
</tr>
<tr>
<td>Iliac Apophysitis</td>
<td>29</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>1764</td>
<td>100</td>
</tr>
</tbody>
</table>

Risk Factors for Running Injuries

<table>
<thead>
<tr>
<th>IMPORTANT RISK FACTORS</th>
<th>EQUIVOCAL RISK FACTORS</th>
<th>UNRELATED RISK FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Miles Per Week (Increases at 19 and 40 mpw)</td>
<td>Hyper/Hypoflexibility</td>
<td>Sex</td>
</tr>
<tr>
<td>Previous Running Injury (Previous 12 months)</td>
<td>Stretching Exercises</td>
<td>Running Surface</td>
</tr>
<tr>
<td>Inexperienced Runner (&lt;3 years)</td>
<td>Running Shoes (Should be replaced after 250 miles)</td>
<td>Cross Training</td>
</tr>
<tr>
<td>Training Intensity (Duration and Frequency)</td>
<td>Shoe Orthotics</td>
<td>Time of Day</td>
</tr>
<tr>
<td>Cavus Feet</td>
<td>Roadside Running</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malalignment Problems (Leg length, Age, Body Morphology)</td>
<td></td>
</tr>
</tbody>
</table>
Running and Knee Arthritis


Abstract

OBJECTIVE: Regular physical activity, including running, is recommended based on known cardiovascular and mortality benefits. However, controversy exists regarding whether running can be harmful to knees. The purpose of this study is to evaluate the relationship of running with knee pain, radiographic osteoarthritis, and symptomatic osteoarthritis.

METHODS: This was a retrospective cross-sectional study of Osteoarthritis Initiative participants (2004 – 2014) with knee x-ray readings, symptom assessments, and completed lifetime physical activity surveys. Using logistic regression, we evaluated the association of history of leisure running with the outcomes of frequent knee pain, radiographic osteoarthritis, and symptomatic osteoarthritis. Symptomatic osteoarthritis required at least one knee with both radiographic osteoarthritis and pain.

RESULTS: Of 3,362 participants, 55.6% were female; mean age was 64.3 (SD 8.9) years; body mass index was 28.5 (SD 4.9) kg/m2; 29.5% ran at some time in their lives. Unadjusted odds ratios of pain, radiographic osteoarthritis, and symptomatic osteoarthritis for those who never ran were 0.97 (95% CI 0.93-1.00), 1.02 (95% CI 0.98-1.06), and 0.98 (95% CI 0.88-1.09), p for trend = 0.01, and 0.81 and 0.64, respectively. Adjusted models were similar except radiographic osteoarthritis results were attenuated.

CONCLUSIONS AND RELEVANCE: There is no increased risk of symptomatic knee osteoarthritis among self-selected runners (compared to non-runners) in a cohort recruited from the community. In those without osteoarthritis, running does not appear detrimental to the knees. This study is protected by copyright. All rights reserved.

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Running and Knee Arthritis


Abstract

Study Design Systematic review and meta-analysis. Background Running is a healthy and popular activity worldwide, but data regarding its association with osteoarthritis (OA) is conflicting. Objectives To evaluate the association of hip and knee OA with running and to explore the influence of running intensity on this association. Methods PubMed, Embase, and Cochrane Library databases were used to identify studies investigating the occurrence of OA of the hip and/or knee among runners. A meta-analysis of studies comparing this occurrence between runners and controls (sedentary, nonrunning individuals) was conducted. Runners were regarded as “competitive” if they were reported as professional/elite athletes or participated in international competitions. Recreational runners were individuals running in a nonprofessional (amateur) context. The prevalence rate and odds ratio (with 95% confidence intervals [CI]) for OA between runners (at competitive and recreational levels) and controls were calculated. Subgroup analyses were conducted for OA location (hip or knee), sex, and years of exposure to running (less or more than 15 years). Results Twenty-five studies (n = 128610 individuals) were included and 17 (n = 114320 individuals) were meta-analyzed. The overall prevalence of hip and knee OA was 13.3% (95% CI 11.6%, 15.2%) in competitive runners, 3.5% (95% CI 3.4%, 3.6%) in recreational runners, and 10.2% (95% CI 9.0%, 10.6%) in controls. The odds ratio for hip and knee OA in competitive runners was higher than that in recreational runners (1.34; 95% CI 1.07, 1.66; 95% CI 0.69, 1.07, respectively; controls as reference group, for differences, I²=0%). Exposure to running of less than 15 years was associated with a lower association with hip and knee OA compared with controls (OR = 0.6; 95% CI 0.49, 0.73). Conclusions Recreational runners had a lower occurrence of OA compared with competitive runners and controls. These results indicate that a more sedentary lifestyle or long exposure to high-volume and/or high-intensity running are both associated with hip and knee OA. However, it was not possible to determine whether these associations were causative or confounded by other risk factors, such as previous injury. Level of Evidence Evidence synthesis, level 2A. J Orthop Sports Phys Ther 2017;47(6):373-300. doi:10.2519/jospt.2017.7137.

KEYWORDS: hip, knee; osteoarthritis; runners

PMID: 28700956 DOI: 10.2519/jospt.2017.7137
Injured Runners vs. Non-Injured – What’s the Difference?

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Iliotibial Band Syndrome

Competitive female runners with a history of iliotibial band syndrome demonstrate atypical hip and knee kinematics.

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Injured Runners vs. Non-Injured – What’s the Difference?
Shin Injuries

There are three major causes of running injuries:

1. **STRUCTURE**
   - The runner’s body type (usually non-modifiable)
   - Example: Low arched runners are prone to soft tissue injuries (such as plantar fasciopathy), whereas high arched runners are prone to bony injuries (such as stress fractures)

2. **DOSAGE**
   - Duration, intensity, and frequency of running (modifiable)
   - Example: Increasing weekly running mileage by >10% from week to week increases your risk of injury

3. **MECHANICS**
   - How a runner runs (modifiable)
   - Example: Runners with a cadence below 166 steps/minute have been shown to have higher incidence of shin injuries
Clinical Evaluation of Runners

Includes:
- Subjective History
- Functional Testing
- Site Specific Objective Exam
- Shoe Wear Assessment
- Ancillary Testing (if needed)

Gait Analysis

Combine all findings to identify the painful structure and cause of the dysfunction.

Clinical Gait Analysis

- Equipment Needs
  - Treadmill
  - Video system (optional)
- Lateral and Posterior Views
- Camera Frames Per Second – Higher the Better
- Use Tripod for Best Results
- Software Programs
  - Dartfish
  - Hudl
  - Others
Treadmill Basics\textsuperscript{1,9}

- Treadmill Type
  - Minimal Frame
  - Below-Belt Motor
  - Top Speed Depends on Type of Runners Treated
  - Clinic Space
- Warmup
  - No Consensus Yet
  - Depends on Runner’s Familiarity with Treadmill
- Speed Selection
  - May Video Race Pace or Easy Pace

Lateral (Sagittal Plane) View\textsuperscript{1,9,10}

- Moments of Importance
  - Initial Contact
  - Maximal and Minimal Vertical Height
  - Terminal Stance
  - Knee Flexion Angle (15-20 degrees at initial contact)
  - Foot Contact Position
  - Vertical Excursion (5-7cm)
  - Peak Swing Phase Knee Flexion (>90 degrees)
  - Trunk Lean (10-12 degrees forward)
  - Hip Extension (18-20 degrees)
Posterior (Frontal Plane) View\textsuperscript{1,9,10}

- Moments of Importance
  - Initial Contact
  - Mid Stance
  - Terminal Stance
- Pelvic Lateral Tilt
- Proximity of Knee Joints
- Medial-lateral Foot Placement (Crossover)
- Toe Out
- Trunk Sway/lean
- Arm Symmetry
- Landing and Terminal Stance Positions
- Heel Whip

Cadence

https://vimeo.com/18627138
How Do We Fix Mechanics?

• The first step in fixing mechanics is to understand which mechanics need to be fixed (the cause)

Example:

• A growing body of evidence has been showing the impact of impaired muscular control of the hip, pelvis, and trunk can affect tibiofemoral and patellofemoral joint kinematics and may underlie injuries such as ACL tears, IT band syndrome, and PFPS.3,4

How Do We Fix Mechanics?

Strengthening


The effect of a hip-strengthening program on mechanics during running and during a single-leg squat.

Abstract

STUDY DESIGN: Block randomized controlled trial

OBJECTIVES: To investigate whether a strengthening and movement education program, targeting the hip abductors and hip external rotators, alters hip mechanics during running and during a single-leg squat.

BACKGROUND: Abnormal movement patterns during running and single-leg squating have been associated with a number of running-related injuries in females. Therapeutic interventions for these aberrant movement patterns typically include hip strengthening. While these strengthening programs have been shown to improve symptoms, it is unknown if the underlying mechanics during functional movements is altered.

METHODS: Twenty healthy females with excessive hip abduction during running, as determined by instrumented gait analysis, were recruited. The runners were matched by age and running distance and randomized to either a training group or a control group. The training group completed a 10-week strengthening and movement education program, 3 times a week for 6 weeks, in addition to single-leg squat training with neuromuscular education, consisting of mirror and verbal feedback on proper mechanics. The control group did not receive an intervention but maintained the current running distance. Using a handheld dynamometer and standard motion capture procedures, hip strength and running and single-leg squat mechanics were compared before and after the strengthening and movement education program.
So Strengthening Alone is Not Enough to Change the Way a Runner Runs!

- Hip abductor and external rotator strength increased
- Single leg squat form improved significantly
- **No change in running mechanics**

**RESULTS:** Hip abductor and external rotation strength increased significantly ($P < 0.005$) in the training group, and there were no significant changes in hip or knee mechanics during running. However, during the single-leg squat, hip adduction, hip internal rotation, and contralateral patellar drop did decrease significantly ($P = 0.05$, $P = 0.05$, and $P = 0.02$, respectively). The control group exhibited no changes in hip strength, nor in the single-leg squat or running mechanics at the conclusion of the 6-week study.

**CONCLUSION:** A training program that included hip strengthening and movement training specific to single-leg squats did not alter running mechanics but did improve single-leg squat mechanics. These results suggest that hip strengthening and movement training, when not specific to hip training, do not alter abnormal running mechanics.

**LEVEL OF EVIDENCE:** Therapy, level 2b.

PMID: 27166220 (PubMed - indexed for MEDLINE)
How Else Do We Fix Mechanics?
Gait Retraining

Mirror gait retraining for the treatment of patellofemoral pain in female runners.  

Background: Abnormal hip mechanics are often implicated in female runners with patellofemoral pain. We sought to evaluate a simple gait retraining technique, using a full-length mirror, in female runners with patellofemoral pain and abnormal hip mechanics. Transfer of the near motor skill to the untrained task of single leg squat and step descent was also evaluated.

Methods: Ten female runners with patellofemoral pain completed 8 sessions of mirror and verbal feedback to pass lower extremity alignment during treadmill running. During the last 4 sessions, mirror and verbal feedback were progressively reduced. Hip mechanics were assessed during running gait, single leg squat and a step descent, both pre and post retraining. Subjects returned to their normal running routines and analyses were repeated at 1-month and 3-month post-retraining. Data were analyzed via repeated measures analysis of variance.

Findings: Subjects reduced peaks of hip adduction, contralateral pelvic drop, and hip abduction moment during running (P<0.05, effect size=-0.79 to -2.91). Skill transfer to single leg squatting and step descent was noted (P<0.05, effect size=0.91 to 1.05). At 1 and 3 months post-retraining, most mechanics were maintained in the absence of constraint feedback. Subjects reported improvements in pain and function (P<0.05, effect size=3.81 to 7.01) and maintained through 3 months post-retraining.

Interpretation: Mirror gait retraining was effective in improving mechanics and measures of pain and function. Skill transfer to the untrained task of squatting and step descent indicated that a higher level of motor learning had occurred. Extended follow-up is needed to determine the long-term efficacy of this treatment.

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Hip adduction, contralateral pelvic drop, and hip abduction moment during running improved:
- Single leg squat and step up form also improved
- Improvements in mechanics, pain, and function were maintained at 3 month follow-up
Gait Retraining in the Clinic

Gait Retraining – A Word of Caution

• Gait retraining moves stresses from one area of the body to another
  → Changing a runner’s form without a skilled, thorough assessment of the runner may result in loss of performance or new/further injury

• Injured vs. Non-Injured Runners

• Inexperienced providers should refer to a provider who specializes in running mechanics and treatment for appropriate assessment

https://youtu.be/BCdF84OZdOs
• Real-time feedback is the most effective (mirror, audio, or video) in modifying running form.
• Use faded feedback to improve motor learning.
  - No consensus on number of treatments/sessions needed yet
    – 1000 steps per mile
  - Try to keep cues as simple and focused as possible
• A single cue can change multiple aspects of a runner’s gait
  – Only give one cue at a time until the runner’s form has normalized to the new form
• The provider must prescribe the correct amount of intensity and duration to prevent relapse or new injury.

Gait Retraining in the Clinic²,³

• Audio feedback can help decrease impact loading rates
• Increasing stride rate (cadence) has been shown to:
  – Decrease vertical mass excursion, ground reaction forces, shock attenuation, and energy absorbed at the hip, knee, and ankle
  – Increasing step rate to 110% of the preferred reduced peak patellofemoral joint force by 14%
• Metronome/Music Training
Gait Retraining – Before and After

• 39 year old female with 1 year history of right anterior hip pain

Clinical Application of Gait Retraining for Runners: Summary

• Successful treatment of running injuries requires a correct assessment of the painful structure and the cause of the dysfunction
• Running injuries are caused by either structural, dosage, or mechanical problems
• Clinical gait retraining from a knowledgeable provider can help correct many mechanical running injuries
• Running is not bad for you – but running incorrectly can be!
Contact Information

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References