

Running Injuries: Assessment & Management

Live Interactive Webinar

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Course Overview

• “Running Injuries” is a live (real-time) interactive webinar for rehabilitation professionals that examines orthopedic injuries related to running. This course includes a review of current literature relating to gait kinematics, common clinical presentations, and treatment considerations for running injuries.

Course Rationale

• The purpose of this course is to provide participants with current evidenced-based information on orthopedic running injuries with comparative analysis of kinematics and clinical presentation to understand rehabilitation considerations and maximize outcomes based on current research.

Goals & Objectives

Upon completion of this course, participants will be able to:

1. List and identify the phases of the running gait cycle.
2. Distinguish the risk factors commonly associated with running injuries.
3. Identify tests and measures with clinical utility for evaluation of the injured runner.
4. Outline the process of conducting a running gait analysis including normal kinematics and common deviations.
5. Recognize and define common running injuries of the lower extremity.
6. Identify running specific rehabilitation strategies to target common running injuries.
7. Detail return to running programs for the injured runner who is progressing back to activity.
8. Recognize the psychological considerations of running injury.
9. Compare and contrast running shoe features as they relate to running kinematics.
10. List patient reported outcome measures with greatest utility for the injured runner.

Disclaimer

- Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations
- No conflict of interest exists for the presenter or provider of this course

Course Schedule: 3 Hr Live Webinar

Topic	Time
Phases of running gait cycle	0:00-0:05
Running injury risk factors	0:06-0:20
Weight bearing tests and measures for runner evaluation	0:21-0:25
Functional movement tests and measures for runner evaluation	0:26-0:30
Non weight bearing tests and measures for runner evaluation	0:31-0:35
Gait analysis	0:36-0:50
Interactive Discussion of Clinical Applications	0:51-1:00
Tendinopathy	1:01-1:15
Medial tibial stress syndrome	1:16-1:30
Patellofemoral pain syndrome	1:31-1:40
Plantar fasciitis	1:41-1:50
Interactive Discussion of Clinical Applications	1:51-2:00
Running specific rehabilitation strategies	2:01-2:10
Return to running programs	2:11-2:25
Psychological considerations	2:26-2:30
Running shoes	2:36-2:45
Outcome measures for the injured runner	2:46-2:50
Interactive Discussion of Clinical Applications	2:51-3:00

Course Post-Test

- Slides with “Consider This” icon in bottom right corner will be helpful in completing the post-test



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Running: Why Talk About It?

- 60 million Americans run each year (2017)
- >600 million people run worldwide
- Average age of runners is increasing
 - 5k: 32 y/o → 40 y/o
 - 10k: 33 y/o → 39 y/o
 - Half marathon: 37.5 y/o → 39 y/o
 - Marathon: 38 y/o → 40 y/o

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Running: Why Talk About It?

- Runners get hurt...**A LOT**
 - Impact forces ~1.5 to 5x body weight
 - Up to 70% of runners sustain an overuse injury each year
 - Running injury costs an estimated \$4 billion each year

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Running Key Terms

Step length	Stride length	Gait cycle	Cadence/step rate
• Distance between successive foot strikes of different feet	• Distance from one foot contact to the next contact of the same foot	• Interval of time to complete one stride	• Number of steps taken per unit time (steps/min)

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Running Key Terms

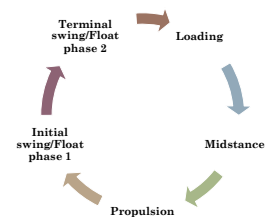
Initial contact	Midstance	Heel off	Toe off
• Point in gait cycle when foot first contacts the ground	• Point in gait cycle when the stance leg and swing leg cross paths	• Point in gait cycle when stance leg first elevates heel above the ground	• Point in the gait cycle when stance leg no longer has contact with the ground

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Running Gait Cycle

- Phases



DuJong, P., Hatamiya, N. S., & Barkley, L. C. (2022). Running Gait Analysis and Biomechanics. Current Sports Medicine Reports, 21(4), 107-108.

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Running Gait Cycle

- Loading
 - Begins with initial contact
 - Ends with foot flat

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Running Gait Cycle

- Midstance
 - Begins at forefoot contact with the ground
 - Transition between loading and propulsion

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Running Gait Cycle

- Propulsion
 - Begins with heel off as rearfoot starts to invert

Consider This

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Running Gait Cycle

- Initial swing/Float phase 1
 - Begins at toe off

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Running Gait Cycle

- Terminal swing/Float phase 2
 - Begins at the completion of contralateral limb toe-off

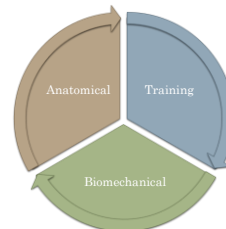
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Risk Factors for Running Injury

- Categories



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Risk Factors for Running Injury

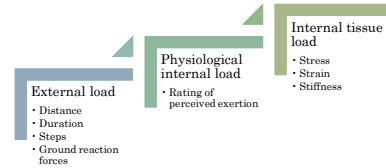
- Training: overuse
 - Positive adaptation to load
 - Force is less than the tensile limit of structure
 - Adequate recovery time between loads
 - Overuse occurs if these metrics are exceeded

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Risk Factors for Running Injury

- Training: overuse
 - Determinants of training load
 - Need to consider all categories of load, not just mileage!



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Risk Factors for Running Injury

- Training: overuse
 - Compounding factors
 - Speed
 - Surface
 - Shoes
 - Terrain
 - Weather
 - Sleep
 - Nutrition
 - Prior injury history

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Risk Factors for Running Injury

- Anatomical: anthropometric characteristics
 - Research shows an increased risk of injury
 - Limited dorsiflexion
 - Pes cavus
 - Leg length discrepancy
 - High Q angle

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Risk Factors for Running Injury

- Anatomical: anthropometric characteristics
 - Research does NOT show an increased risk of injury
 - Limited dorsiflexion
 - Pes cavus
 - Leg length discrepancy
 - High Q angle
 - Partly explained by the interplay of anatomy and biomechanics

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https://commons.wikimedia.org/wiki/File:Bon_Francia_California%27s_most_famous_yerba_Matita_dell_and_Vicino_Brown_photographed_in_the_1890s_enjoy_afternoon_tea_LOS.jpg

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Risk Factors for Running Injury

- Anatomical: strength
 - Training program including strength exercise has been shown to reduce risk of overuse injury in athletes
 - Why?
 - Gradual tissue conditioning
 - Increase tissue failure threshold
 - Technique and psychological preparedness
 - Training variation

Lauersen, J. B., Andersen, T. E., & Andersen, L. B. (2016). Strength training as superior, dose-dependent and safe prevention of acute and overuse sports injuries: a systematic review, qualitative analysis and meta-analysis. *British journal of sports medicine*, 52(24), 1557-1563.

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Risk Factors for Running Injury

- Anatomical: strength, cont'd
 - Core strengthening alone has not been shown to predict overuse injury
 - When integrated into comprehensive program, strengthen training has been shown to improve running economy

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Risk Factors for Running Injury

Consider This

- Anatomical: flexibility
 - Hamstring tightness has not been shown to adversely affect pelvic positioning in runners
 - Despite a lack of research to support, stretching is the most commonly used strength and conditioning activity amongst runners

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Risk Factors for Running Injury

- Anatomical: gender
 - Overall injury risk is similar between men and women (other studies have shown women have higher rates of injury)
 - Women: higher risk of bone stress injury
 - Men: higher risk of Achilles tendon injury

Image: Microsoft stock photo
Hollander, K, Ruff, A. L., Wilke, J., Edler, C., Steh, S., Jung, A., & Zech, A. (2021). Sex-specific differences in running injuries: a systematic review with meta-analysis and meta-regression. *Sports Medicine*, 51, 1011-1028.

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Risk Factors for Running Injury

- Biomechanical
 - Evaluated with gait analysis
 - More to come!

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Risk Factors for Running Injury

Consider This

- One more important factor for lower extremity injury that is supported by current literature...

Prior injury history

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Clinical Evaluation of the Runner

- Subjective questions
 - Have there been any recent changes in training?
 - What does your typical running routine look like?
 - Do you do any exercise other than running (strength, cross training, yoga, etc)?
 - How long have you been a runner?
 - Have you had any prior injuries (running or otherwise)?
 - Are you currently training for a race/event?

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Clinical Evaluation of the Runner

- Weight bearing tests
 - Standing postural assessment
 - Shoulder height symmetry
 - Spinal curvature
 - Pelvic tilt
 - Relative leg length
 - Knee varus/valgus
 - Ankle inversion/eversion
 - Navicular drop
 - Toe out angle

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Clinical Evaluation of the Runner

- Functional movement screens
 - Double and single leg squats (without shoes)
 - Hurdle stepping
 - Lunges
 - Trunk rotary stability
 - Walking gait tests
 - Hop*
 - Single leg balance*

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Clinical Evaluation of the Runner

- Non weightbearing tests
 - Foot alignment/1st metatarsal mobility
 - Joint ROM (hip, knee, ankle)
 - Flexibility (hip flexors, hamstrings, plantarflexors)
 - Strength (hip abduction/extension, core, hamstrings)
 - Patellar tracking

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Running Gait Analysis

- Getting set up
 - Qualitative video analysis using treadmill
 - Recording speed 120 frames/sec
 - Method for measuring joint angle (i.e. motion capture app)
 - Form fit clothing/shirt tucked in
 - Self-selected mid run pace

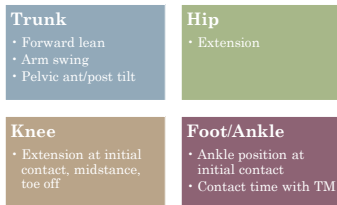
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Running Gait Analysis

- Lateral view



*Also vertical excursion

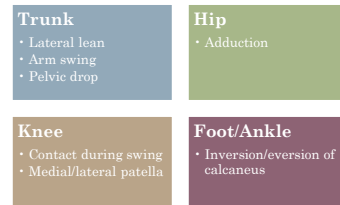
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Running Gait Analysis

- Posterior view



*Also, crossover

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Running Gait Analysis

- Transverse plane
 - Difficult to directly observe in clinical analysis
 - Can use symmetry of arm swing, pelvic rotation, and heel height to infer

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Running Gait Analysis

- Factors that may influence gait mechanics
 - Age
 - Pre-puberty: may demonstrate increased variability
 - Older runners: may develop modifications
 - Fatigue
 - A runner may have different mechanics under fatigued conditions

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Running Gait Analysis

- Kinematics vs kinetics
 - Kinetic characteristics may be **predicted** from kinematic analysis
 - Kinematics at initial contact are related to loading



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Running Gait Analysis

- Relationship to injury
 - Abundance of studies investigating this
 - Limited conclusive evidence on the prospective role of mechanics in running related injury
 - Heterogeneous population with interplay of multiple factors
 - Hip adduction, internal rotation, pelvic drop → ITB syndrome, patellofemoral pain??
 - Eversion → lower limb tendinopathies??
 - Overstriding → bone stress??
 - Higher vertical impact forces associated with injury
 - Patellofemoral pain
 - Plantar fasciitis

Johnson, C. D., Terfende, A. S., Overkys, J., Reilly, J., & Davis, I. S. (2020). Impact-related ground reaction forces are more strongly associated with some running injuries than others. *The American journal of sports medicine*, 48(12), 3072-3080.
Mousavi, S. H., Hignett, J. M., Rajabi, R., Diercke, R., Zwaenier, J., & van der Worp, H. (2019). Kinematic risk factors for lower limb tendinopathy in distance runners: A systematic review and meta-analysis. *Gait & posture*, 69, 13-24.
Varma, C. N., Heinert, B. L., & Kenzle, T. W. (2020). Biomechanical risk factors for running-related injury differ by sample population: A systematic review and meta-analysis. *Clinical biomechanics*, 75, 104991.

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Running Injuries

- Common sites of injury
 - Knee
 - Lower leg
 - Foot
 - Upper leg
 - Ankle
 - Hip/pelvis

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Running Injuries

- A runner's not a runner
 - Most likely to sustain an injury
 - Sprinters
 - Ultra marathoners
 - Injury patterns differ due to propulsion activity
 - Sprinters have more proximal injuries than distance runners

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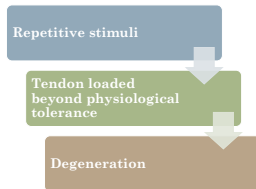
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Tendinopathy

- Pathogenesis of running related tendinopathy

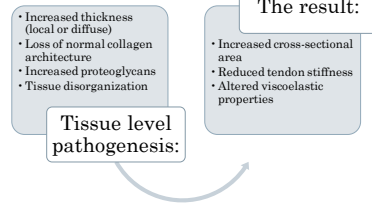


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Tendinopathy



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Tendinopathy

- General management strategies



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Tendinopathy

- Achilles
 - Etiology
 - Excessive gastrocnemius/soleus loading
 - Factors increasing risk
 - Sand
 - Races 1500 m to 5 km
 - For insertional tendinopathy
 - Compressive force on tendon and calcaneus
 - Footwear
 - Dorsiflexion (uphill running)
 - Anatomy (Haglund's)

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Tendinopathy

- Achilles
 - Evaluation
 - Subjective
 - Gradual onset
 - Stiffness in morning/after prolonged sitting
 - Pain with palpation
 - Pain with activity (early on, may subside within exercise)
 - Deficit in strength/performance

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Tendinopathy

- Achilles
 - Evaluation
 - Pain on palpation of the tendon
 - Subjective report of pain in the midportion (2–6 cm above the calcaneal insertion)
 - Special tests
 - Arc sign
 - Royal London Hospital test

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Tendinopathy

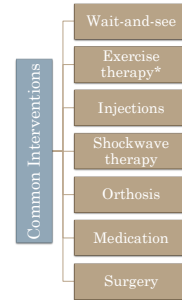
- Achilles
 - Evaluation
 - Additional impairments to consider
 - Deficits in hip neuromuscular control
 - Abnormal ankle dorsiflexion and subtalar-joint range of motion
 - Increased foot pronation
 - Increased body weight

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Tendinopathy

- Achilles
 - Management
 - Recovery prognosis
 - 3-12 months after beginning treatment
 - Chronic symptoms persist 10 yrs later in ~25% of patients



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Tendinopathy

- Achilles
 - Management
 - Comparison of different exercise paradigms does not reveal a single, best approach

Heavy eccentric calf training (Alfredson eccentric protocol)	Eccentric overload training (Silbernagel protocol)
Heavy slow resistance training	Modified heavy eccentric training (low-volume version)
'Stanish protocol'	Concentric training

- Any type of muscle contraction can be used to mechanically load the tendon!
 - Progressive
 - Based on patient response

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Tendinopathy

- Patellar tendon
 - Etiology
 - High, repetitive eccentric loading of the quadriceps femoris muscle

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Tendinopathy

- Patellar tendon
 - Evaluation
 - Pain at the attachment of the patellar tendon at the inferior pole of the patella
 - Often only symptomatic in high energy activities, not at rest
 - Contributing factors
 - Muscle weakness: quads, gastroc-soleus, hip abductors
 - Foot posture
 - Decreased motor control
 - Faulty running mechanics
 - Importance of good differential diagnosis
 - Infrapatellar fat pad, chondromalacia patella, plica

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Tendinopathy

- Patellar tendon
 - Management
 - Strengthening progression
 - Isometrics → high rep, low weight → low rep, high weight
 - Manual therapy
 - During early phases
 - Tendon: crossfriction massage, instrument assisted mobilization
 - Muscle: soft tissue mobilization, dry needling to restore normal tone and extensibility
 - Assess technique for provocative activity prior to return to sport
 - Gait considerations include vertical displacement and overstriding (knee extension at initial contact)

Image: public domain Caltrap https://commons.wikimedia.org/wiki/File:Graston_tool.jpg
Mellingrath, S., & Neurohr, G. A. (2019). Evidence based treatment options for common knee injuries in runners. *Annals of translational medicine*, 7(Suppl. 7).

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Tendinopathy

- Patellar tendon
 - Management
 - Blood flow restriction training as option for patients with difficulty moving into heavier resistance
 - Modalities
 - Extracorporeal shockwave therapy may offer some benefit
 - No evidence for ultrasound, phonophoresis, iontophoresis
 - Infrapatellar straps for pain and proprioception

Dr. Sato

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Bone Stress Injury – Tibia

- Etiology
 - Loss of shock absorption due to muscle fatigue → load transferred to bone
 - Repetitive contraction of posterior tibial, soleus and/or flexor digitorum longus muscles generates excessive stress on tibia
 - Results in inflammation
 - Insufficient bone remodeling due to repetitive stress on the tibia
 - Muscle contraction
 - Vertical ground reaction force

Image: Creative Commons Attribution-Share Alike 3.0 Unported Smart Server website: Images related to bone remodeling: cycle (bone regeneration), Bone structure and bones https://commons.wikimedia.org/wiki/File:Bone_regeneration_-_Bone_remodeling_cycle_3_1_-_Osteoclasts_Monocytes_Pre-osteoblasts_aki_-_Smart_Server.png

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Bone Stress Injury – Tibia

- Evaluation: Medial tibial stress syndrome
 - Vague, diffuse pain along the middle-distal tibia
 - Area \geq 5-10 cm or more
 - Associated with exertion
 - Early on, pain is worse at beginning of run and gradually subsides
 - Pain subsides after run
 - As it progresses, may have pain at rest

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Bone Stress Injury – Tibia

- Evaluation : Tibial stress fracture
 - Localized pain and tenderness on the tibia
 - Radiograph may or may not show evidence of stress reaction
 - MRI as gold standard for diagnosis
 - Hop test

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Bone Stress Injury – Tibia

- Management
 - Manage load
 - Unloading with crutches/boot pm
 - Relative rest
 - Consider healing supplements
 - Low intensity pulsed ultrasound
 - Maintain fitness
 - Cross training
 - Address muscle function
 - Strength and flexibility of the lower leg
 - Address the kinetic chain and core

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Bone Stress Injury – Tibia

- Management
 - Recommence and progress running
 - After 5 consecutive days of pain free ADLs
 - Graduated loading
 - Reduce risk of subsequent injury
 - Address biomechanical abnormalities – cadence
 - Proprioceptive training
 - Footwear/orthoses

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Bone Stress Injury – Tibia

- Case Example
 - 20 year old female
 - Division I college cross country runner
 - Pain in right shin began 1.5 years ago
 - Evaluated by sports medicine physician through university and second opinion at home
 - Radiographs, MRI: confirmed initial tibial stress reaction
 - Bone density scan: normal results
 - Consulted with dietetics
 - Sat out the remainder of the season
 - Completed physical therapy including strength, flexibility, and balance
 - Switched shoes to more cushion
 - Pain improved over the off season

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Bone Stress Injury – Tibia

- Case Example, cont'd
 - Resumed training with the team the following season upon completion of a return to running program
 - Symptoms came back early in the season
 - Returned to physical therapy
 - Switched to cross training to avoid impact
 - Once symptoms resolved, initiated a very slow return to running program
 - Tibial pain returned
 - Decision made to red shirt the season
 - Referred to running specialist physical therapist

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Bone Stress Injury – Tibia

- Case Example, cont'd
 - Runner's clinic evaluation
 - Strength: 5/5 hip ABD and extension
 - Core: 5/5 lower abdominals
 - Postural alignment: neutral through hips, knees, ankle
 - Gait analysis: increased distance COM to IC, decreased knee ext at IC, increased DF at IC
 - Program recommendation
 - Gait retraining
 - Increased cadence by 10% with auditory cueing
 - Very gradual interval treadmill program
 - Desensitization
 - Resumed training with team for beginning of season
 - Successfully completed season without pain

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Bone Stress Injury – Other Sites

- Femoral stress reaction
 - Diagnosis often delayed
 - Symptom presentation

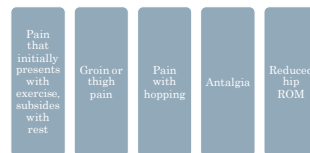


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Bone Stress Injury – Other Sites

- Metatarsal stress reaction
 - Most common in the 2nd and 3rd digit
 - Symptom presentation

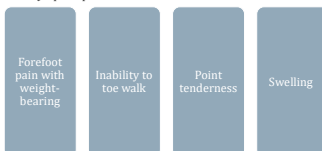


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Patellofemoral Pain Syndrome

- Etiology



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Patellofemoral Pain Syndrome

• Evaluation

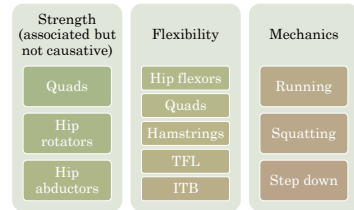
- Best diagnostic criteria
 - Retropatellar or peripatellar pain
 - Sx reproduced with squatting (sensitivity of 91%)
- Additional clinical tests (not useful in isolation)
 - Patellar compression
 - Patellar apprehension
 - Pain with palpation of lateral patellar facet
 - Pain with resisted quadriceps contraction in 30 of knee flexion
- Exclusion criteria
 - Patellar instability
 - Ligamentous injury
 - Meniscal injury

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Patellofemoral Pain Syndrome

- Evaluation
 - Associated impairments

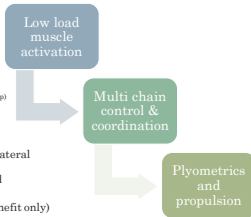


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Patellofemoral Pain Syndrome

• Management

- **Primary**
 - Strengthening
 - Quads
 - Hip rotation/abduction
 - Motor retraining
 - Gait mechanics (hip ADD/IR, pelvic drop)
 - Landing mechanics
- **Adjunct**
 - Manual therapy
 - Improve soft tissue mobility of lateral structures
 - Promote joint mobility if needed
 - Modalities
 - Taping/orthotics (short term benefit only)



Mellingert, S., & Neuhof, G. A. (2019). Evidence based treatment options for common knee injuries in runners. *Annals of translational medicine*, 7(Suppl 7).

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Plantar Fasciitis

• Etiology

- Degenerative process of the plantar fascia
- Failure of fascia to support the load applied to the body
 - During initial contact, the heel absorbs the impact of up to 3x body weight
 - Ability to absorb and transmit impact depends on foot structure resilience
 - Plantar fascia
 - Plantar fat pad
 - Intrinsic muscles of the foot
- Most common injury reported amongst master's runners
 - Age and prolonged repetitive overuse may decrease the absorability of plantar fascia and fat pad

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Plantar Fasciitis

• Evaluation

- Plantar medial heel pain
- Most notable with initial steps after a period of inactivity
- Worse following prolonged weightbearing
- Pain reproduced with palpation of proximal insertion of plantar fascia
- Positive windlass test
- Differential diagnosis
 - Peripheral nerve entrapment
 - Fat pad atrophy
 - Insertional tendinopathy of the lower leg

Image: public domain Kosi Gramatikoff <https://commons.wikimedia.org/wiki/File:PF-PlantarMove.jpg>

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Plantar Fasciitis

• Management

- Therapeutic exercise
 - Plantar fascia stretching
 - Gastroc-soleus stretching
- Manual therapy
 - Joint mobilization (especially for dorsiflexion)
 - Soft tissue mobilization for gastroc-soleus
- Taping (anti-pronation techniques)
- Education on load modification
- Footwear/orthoses for heel cushioning and arch support
- Night splints (1-3 months)
- Modalities
 - Iontophoresis, low-level laser, phonophoresis may be used

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Plantar Fasciitis

• Management

- Minimally invasive interventions
 - **Corticosteroid injection** (recommend ultrasound guidance)
 - Potential short-term benefit
 - Increases risk of plantar fascia rupture
 - **Platelet rich plasma injection**
 - Better long-term results than corticosteroid
 - **Extracorporeal shockwave therapy**
 - Better long-term results than corticosteroid

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Iliotibial Band Friction Syndrome

Etiology

- Inflammation, thickening of ITB, excess fluid
- Theory A: abnormal compression of distal ITB (abundant fat, blood vessels, nerves)
- Theory B: friction of the posterior ITB

Presentation

- Pain over the lateral aspect of the knee during lower extremity loading
- When knee extended from 90 → 30 deg flex

Treatment

- Very similar to patellofemoral pain syndrome
- Greater focus at hip during strength and mechanics retraining
- Gait considerations include hip ADD and IR

Melinger, S., & Neunohr, G. A. (2019). Evidence based treatment options for common knee injuries in runners. *Annals of translational medicine*, 7(Suppl 7).

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Exertional Compartment Syndrome

Etiology

- Reversible fascial compartment pressure increase
- Impaired tissue perfusion

Presentation

- Pain and/or neurologic symptoms
- Symptoms rapidly improve with rest
- Increased compartment pressure

Treatment

- Limit activity
- Modify gait mechanics
- Surgical intervention

Image: Microsoft stock photo

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Runner's Dystonia

Etiology

- Focal task-specific dystonia
- Associated with overflow activation

Presentation

- Regular participant in intense, repetitive exercise
- Involuntary, sustained muscle contraction causing abnormal postures or movements
- No report of pain

Treatment

- Botulinum toxin injections
- Physical therapy
- Pharmacological

Image: Creative Commons Attribution-Share Alike 2.0 Generic Roberto Ferrari [https://commons.wikimedia.org/wiki/File:Retro_Running_\(4008506566\).jpg](https://commons.wikimedia.org/wiki/File:Retro_Running_(4008506566).jpg)

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Runner's Dystonia

• Case Example

- 60 y/o female runner with c/c of left foot drop
- 20 year running hx
- Self referred to ortho spine after outside PT evaluation
 - Ortho spine felt it was not related to her back and referred to sports medicine
- Sports medicine evaluation
 - Differential diagnosis
 - Peroneal neuropathy (at fibular head vs above the knee)
 - Lumbar radiculopathy at L5 – lumbosacral plexopathy
 - Motor neuron disease
 - Ordered EMG
 - Came back normal
 - Referred to PT for gait analysis, dx of "left foot drop"

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Runner's Dystonia

• Case Example, cont'd

- Subjective
 - C/c: L foot "scuffs" when running
 - Feels the leg "hiccup and stop"
 - Has caused her to trip
 - Now has to "think about running" part of the way through her run
 - No pain
 - Worst at beginning of run and with slower pace
- Going on about 3 years
- Running ~30 mile/week on pavement
- Sx progressing
 - Lately feels like she has to be cautious when walking on carpet

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Runner's Dystonia

• Case Example, cont'd

Objective

Standing posture: normal
No atrophy or TTP
ROM and strength: normal
Neuro: PF clonus and spasticity NEG B

Functional testing

Hops: x5 B WFL
Heel/toe walking: in tact
Walking: no foot drop

Gait analysis (At 6 & 35 min)

Cadence 149
R: 1C heel strike, L: 1C foot flat
R: 0 deg DF mid swing, L: PF mid swing

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Runner's Dystonia

• Case Example, cont'd

Intervention

- Gait characteristics support diagnosis of runner's dystonia
 - Antagonist overactivity vs. agonist weakness
- Discussed PT options to address: sensory tricks
 - Increasing cadence and auditory cueing
 - Consider altering kickback
 - Surface change
 - Foot strike

Outcomes

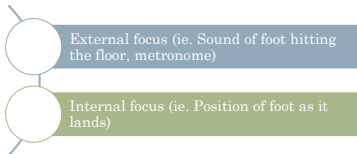
- No objective change in mechanics with cadence or footstrike
- Pt reports small improvement in sx on trails



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Running Specific Rehab Strategies

- Gait retraining
 - Target metric: cadence, mechanics, muscle activation, foot strike
 - Treadmill vs overground
 - Progressive program
 - Feedback



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Running Specific Rehab Strategies

Consider This

- Gait retraining: cadence
 - Increasing cadence by 10% can improve abhorrent gait mechanics
 - Pelvic drop, femoral adduction, knee flex angle
- Changes the muscle activation patterns
 - Increase in gastrocnemius and gluteal pre-activation/activation
- Reduces average vertical loading rate

Image: public domain Winston https://commons.wikimedia.org/wiki/File:Barney_Rubbia_and_Fred_Flintstone.png
Bramah, C., Preese, S. J., Gil, N., & Hemington, L. (2019). A 10% increase in step rate improves running kinematics and clinical outcomes in runners with patellofemoral pain at 4 weeks and 3 months. *The American journal of sports medicine*, 47(14), 3405-3413.

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Running Specific Rehab Strategies

- Gait retraining
 - Cadence and foot strike retraining not shown to impact running performance or economy

Image: Microsoft stock photo

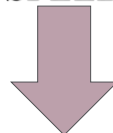
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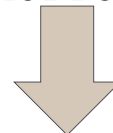
Running Specific Rehab Strategies

- Monitoring speed
 - Decrease training speed to decrease impact forces

SPEED



IMPACT FORCES



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Running Specific Rehab Strategies

- Scheduling recovery
 - Utilize longer rest periods between training runs
 - Allow for positive remodeling to occur between training sessions

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Running Specific Rehab Strategies

- Cross training
 - Active recovery days
 - Non-impact aerobic exercise or strength training
 - Biking may offer performance benefits for running

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Return to Running Programs

- When to initiate the return to running process
 - No pain with activities of daily living
 - If using reduced body weight treadmill running, after progressing to 85-90% BW
 - Be aware of cumulative footstrikes/day
 - Trial two 30 sec bouts of running and monitor post-activity response for 24 hours

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Return to Running Programs

- Interval program vs continuous graduated distance
 - Starting volume
 - Running accounts for <5-25% of total exercise duration
 - Progression
 - Either number of intervals OR duration of intervals
 - Work towards greater total volume until continuous running is reached
 - Then may re-integrate running workouts (speedwork, etc)

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Return to Running Programs

- The 10% rule
 - Limit weekly mileage increase by no more than 10%
 - Not strongly supported by research
 - Similar injury rates shown with increases ~10% and ~20%

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Return to Running Programs

- Technology
 - GPS system
 - Temporospatial metrics (distance, speed, cadence)
 - Accelerometer or IMU (inertial measurement unit)
 - Kinematics
 - Peak positive acceleration (shock)
 - Insoles
 - Kinetics (plantar pressure)

Image: Microsoft stock photo

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Return to Running Programs

- Technology: more is more?
 - More data on training load than distance alone
 - Decreases reliance on clinician
 - Allows for native environment
 - Assess adherence with gait retraining
- However, only use valid metrics that directly relate to injury!

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Return to Running Programs

- Warm-up/cool down
 - Static vs dynamic
 - Ideal program is comprehensive
 - Aerobic activity, dynamic stretching, sport specific activity
 - Static stretching >60 sec may impair strength and power
 - Negative effects may be trivial if static stretch is <60 sec

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Chastane, H., Behm, D. G., Negra, Y., & Granacher, U. (2019). Acute effects of static stretching on muscle strength and power: an attempt to clarify previous caveats. *Frontiers in physiology*, 10, 1468.

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Return to Running Programs

- Warm-up/cool down
 - Static vs dynamic
 - Recreational athletes: include short duration static stretching for flexibility and musculotendinous injury prevention
 - High level athletes: may prioritize the small performance impact and avoid static

Image: Microsoft stock photo
Chastane, H., Behm, D. G., Negra, Y., & Granacher, U. (2019). Acute effects of static stretching on muscle strength and power: an attempt to clarify previous caveats. *Frontiers in physiology*, 10, 1468.

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Return to Running Programs

- Warm-up/cool down
 - Active cool down
 - Accelerates recovery of lactic acid in blood
 - Partially prevents immune system depression
 - Promotes faster recovery of cardiovascular and respiratory system
 - However...
 - Lactic acid in blood ≠ lactic acid in muscle tissue
 - Unknown whether there is any difference in post-exercise illness, syncope or cardiovascular complications
 - Not shown to improve muscle soreness or damage, range of motion, hormone concentrations, or psychological recovery

Image: Microsoft stock photo
Van Hoorren, B., & Peake, J. M. (2018). Do we need a cool-down after exercise? A narrative review of the psychophysiological effects and the effects on performance, injuries and the long-term adaptive response. *Sports Medicine*, 48(7), 1575-1595.

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Psychological Considerations

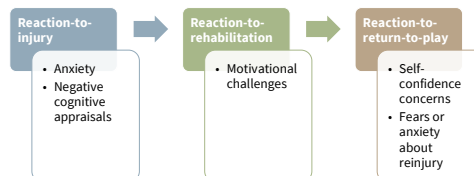
- When a runner can't run
 - Signs of distress present at higher rates
 - Depression
 - Anxiety
 - Confusion
 - Over-all mood disturbance
 - Lower self esteem
 - Many rely on running as a coping strategy
 - Loss of socialization

Consider This

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Psychological Considerations



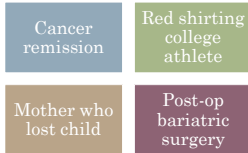
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Psychological Considerations

- Case examples
 - Running is more than just cardio



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Nutritional Considerations

- Goals for endurance running nutrition
 - Optimize storage and utilization of energy
 - Prevent fatigue due to nutrient depletion
 - Minimize gastrointestinal distress
 - Hydration

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Spurlock, B. (2016). Marathon running: physiology, psychology, nutrition and training aspects. Physiological aspects of marathon running, 1-12.

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Nutritional Considerations

- Nutritional needs
 - Overall energy
 - Macronutrients (carbohydrates, proteins, etc)
 - Iron
 - Vitamin C
 - Dietary antioxidants
 - Nutrients that modulate immune function

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Nutritional Considerations

- Race day nutrition
 - Maximize pre-race muscle glycogen storage capacity
 - Consume carbohydrates, fluid, sodium
 - Caffeine supplementation for performance
- Nutrition is complex
 - Performance level
 - Environmental conditions
 - Running pace
 - Gastrointestinal discomfort
 - Aid stations availability during the race

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Nutritional Considerations

- Energy and body composition
 - Caloric cost of running:
 - 1.6 kcal/kg/mile
 - Low body weight/low % body fat benefits
 - Assist fast, efficient running
 - Facilitate heat dissipation
 - Chronic energy deficiency risks
 - Reproductive function
 - Bone strength and quality
 - Cardiovascular health
 - Performance



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Running Shoes

- Anatomy of a running shoe

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Running Shoes

- How to select the right one
 - According to foot morphology??
 - “Shoe shop theory”
 - High arch, rigid feet, reduced pronation → cushion shoe
 - Neutral anatomy → stability shoe
 - Excessive pronation, LE malalignment → motion control shoe
 - No evidence that matching morphology to shoe design reduces injury risk

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https://commons.wikimedia.org/wiki/File:Foot_Analysis_Clinic_helpe_improve_running_prevent_injuries_130109_F_O2655-011.jpg

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Running Shoes

- How to select the right one
 - More cushion, less injury??
 - The research says maybe
 - Unclear for which population (lighter runners?)
 - How much is optimal?

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Running Shoes

- How to select the right one
 - How about heel-to-toe drop??
 - Low drop may be protective for occasional runners, but not for regular runners

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Running Shoes

- How to select the right one
 - More injuries in older shoes??
 - No definitive research on shoe age for preventing injuries
 - Some evidence that women are at higher risk when shoes 4-6 months old
 - Some evidence that men are at lower risk when shoes 4-6 months old

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Running Shoes

- How to select the right one
 - Expensive shoes are better, right??
 - Cushion performance has not been related to shoe cost
 - Low- and medium-cost shoes may provide equally good subjective comfort as more expensive models
 - No association between shoe brand or cost and injury risk has been established

Image: original photo

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Running Shoes

- How to select the right one
 - Should runners even wear shoes??
 - Barefoot/minimalist shoes
 - May improve running economy
 - Can build the cross-sectional area and stiffness of Achilles tendon
 - Greater loading of the ankle and metatarsophalangeal joint
 - Evidence does not currently support recommending them

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Sun, X., Lam, W. K., Zheng, X., Wang, J., & Fu, W. (2020). Systematic review of the role of footwear constructions in running biomechanics: implications for running-related injury and performance. *Journal of sports science & medicine*, 19(1), 20.

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Running Shoes

- Developing trends: maximal cushion shoes
 - Evidence does not show a reduction in impact loading
 - Biomechanics do not improve with change to maximalist shoe
 - Effect on pain and injury rates is unknown

Louton, J. K., & Swift, M. (2022). The Effect of Maximalist Running Shoes on Impact Loading: A Critically Appraised Topic. *International Journal of Athletic Therapy and Training*, 1(sup), 1-6.

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Running Shoes

- Developing trends: female specific shoes
 - Women ran in the male and female version of a running shoe
 - No significant difference in biomechanics or physiology of the run
 - Ground reaction force
 - Sagittal joint angles and moments
 - Oxygen consumption
 - Respiratory exchange ration
 - Perceived comfort

Image: Microsoft stock photo
Rasmussen, S., Wilkes, B., Poulton, L., Roser, M., Draper, S., Crear, A., & Standfield, T. (2022). Effect of Sex-Specific Running Shoes on Female Recreational Runners. *Applied Sciences*, 12(15), 7537.

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Running Shoes

- How to select the right one
 - Then what??
 - Runner's perceived feeling of comfort is best supported for injury prevention
 - Transition progressively into a new pair
 - Listen to your body when training
 - Research may support alternating between pairs of running shoes

Image: public domain Staff Sgt. Anthony Hyatt
https://commons.wikimedia.org/wiki/File:Gait_Analysis_Clinic_helps_improve_running_prevent_injuries_130108-F-GE255-011.jpg

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Outcome Tools for the Runner

- University of Wisconsin Running Injury and Recovery Index (UWRI)
 1. How does your running injury impact your ability to perform **daily activities**?
 2. How **frustrated** are you by your running injury?
 3. How much **recovery** have you made from your running injury?
 4. How much **pain** do you experience while running?
 5. How much pain do you experience during the **24 hours** following a run?
 6. How has your weekly **mileage** or weekly running time changed as a result of your injury?
 7. How has the distance of your longest weekly run changed as a result of your injury?
 8. How has your running **pace** or speed changed as a result of your injury?
 9. How does your injury affect your **confidence** to increase the duration or intensity of your running?

Nelson, E. O., Kikiermos, S., & Heiderschelt, B. (2020). Construct Validity and Responsiveness of the University of Wisconsin Running Injury and Recovery Index. *Journal of Orthopaedic & Sports Physical Therapy*, 50(12), 702-710.

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Conclusion

- Running is a widely utilized activity, both in the United States and globally. As runners often encounter frequent and recurring injury, it is critical that healthcare providers consider the unique biopsychosocial needs of this population across the continuum of care.

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Q1

Which phase of the running gait cycle begins with heel off as rearfoot starts to invert?

- A.Loading
- B.Midstance
- C.Propulsion
- D.Terminal swing

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Q2

When assessing a runner's threshold for overuse, which of the following determinants of training load should be used?

- A.External load
- B.Physiological internal load
- C.Internal tissue load
- D.All the above

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Q3

What is the most commonly employed strength and conditioning activity amongst runners?

- A.Strength training
- B.Plyometric training
- C.Stretching
- D.Altitude training

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Q4

Which of the following is a risk factor for lower extremity running injury based on current evidence?

- A.Training without a running coach
- B.Previous running injury
- C.Heel strike pattern at initial contact
- D.BMI >25

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Q5

Which of the following gait characteristics is best evaluated from the posterior view during video gait analysis?

- A.Pelvic drop
- B.Foot strike pattern
- C.Knee flexion angle
- D.All the above

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Q6

Which of the following is a gait mechanics retraining strategy that has been shown in the running literature to improve aberrant movement patterns?

- A.Increasing cadence
- B.Decreasing cadence
- C.Running backwards
- D.Overstriding

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Q7

What does IMU stand for related to gait analysis?

- A.Immediate medial utilization
- B.Insufficient myofascial unit
- C.Inertial measurement unit
- D.Interim muscular upswing

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Q8

Which of the following signs of psychological distress is demonstrated at increased rates in runners who are prevented from running?

- A. Depression
- B. Anxiety
- C. Confusion
- D. All the above

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Q9

Which running shoe characteristic is best supported in the literature as a means of injury prevention?

- A. Minimalist design
- B. Maximal cushion
- C. Motion control
- D. Runner's perceived comfort

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Q10

Which of the following patient reported outcomes tools was developed specifically for runners?

- A. UWRI
- B. FAAM
- C. LEFS
- D. DASH

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