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MSK Injury Following Concussion

Alice Barnes, PT, DPT

Brittney Millett, MS, LAT, ATC

Sarah Reinking, PT, DPT, SCS

SPORTS MEDICINE
CENTER

 Children's Hospital Colorado

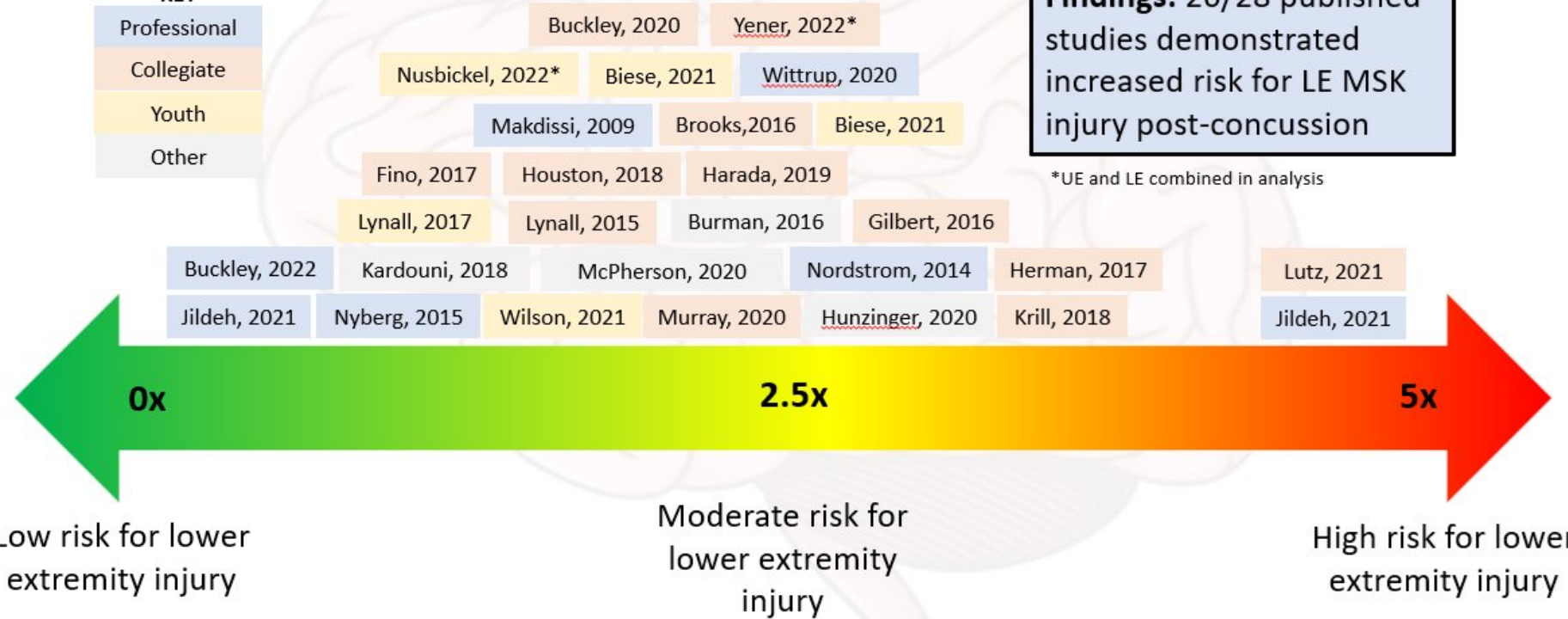
RELATIONSHIP BETWEEN CONCUSSION AND SUBSEQUENT LOWER EXTREMITY INJURY RISK

KEY

Professional
Collegiate
Youth
Other

Findings: 26/28 published studies demonstrated increased risk for LE MSK injury post-concussion

*UE and LE combined in analysis



WHY DOES THIS HAPPEN?

We don't exactly know why MSK injury increases after concussion.

Theories –

- Attention deficit
- Movement deficit
- Deconditioning
- Neuomechanical muscular control

Concussion History and Neuomechanical Responsiveness Asymmetry

Gary B. Wilkerson, EdD, ATC, FNATA*; Dustin C. Nabhan, DC, DACBSP, CSCS†; Ryan T. Crane, MS, ATC‡

*University of Tennessee-Chattanooga; †United States Olympic Committee, Colorado Springs, CO; ‡Emory Healthcare, Atlanta, GA

Abstract: Univariable analyses identified 12 strong predictor-related concussion history, which we combined to a composite metric with maximum predictive value. We found lateral asymmetry for whole-body reactive movement persisting effects of previous musculoskeletal injury in a logistic regression model with exceptionally good calibration (area under the curve = 0.845) and calibration-observed probabilities within 7 subgroups: $r = 0.901$. Application of the derived model is

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CURRENT OPINION

Increased Risk of Musculoskeletal Injury Following Sport-Related Concussion: A Perception–Action Coupling Approach

Shawn R. Eagle¹ · Anthony P. Kontos² · Gert-Jan Pepping³ · Caleb D. Johnson⁴ · Aaron Sinnott¹ · Alice LaGoy¹ · Chris Connaboy¹

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REVIEW ARTICLE

Loss of Motor Stability After Sports-Related Concussion: Opportunities for Motor Learning Strategies to Reduce Musculoskeletal Injury Risk

Jason M. Avedesian^{1,2} · Harjiv Singh¹ · Jed A. Diekfuss^{2,3} · Gregory D. Myer^{2,3,4,5} · Dustin R. Grooms^{6,7,8}

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Abstract

Current best practices to direct recovery after sports-related concussion (SRC) typically require asymptomatic presentation, exercise progression, and cognitive performance resolution. However, this standard of care for musculoskeletal (MSK) injury after return-to-sport (RTS). The elevated risk of neurophysiological and dual-task motor stability deficits that remain despite RTS.

Gait Performance Is Associated with Subsequent Lower Extremity Injury following Concussion

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TECHNICAL REPORT 62

HER A. KNIGHT^{5,6}, JEREMY R. CRENSHAW^{5,6}

²Division of Sports Medicine, Department of Orthopedics, Children's Hospital Colorado, Aurora, CO; ³Department of Kinesiology and Applied Program in Biomechanics and Movement Science, University of Colorado Boulder, Boulder, CO

Postural Stability Under Dual-Task Conditions: Development of a Post-Concussion Assessment for Lower-Extremity Injury Risk

Caroline Westwood, Carolyn Killelea, Mallory Faherty, and Timothy Sell

Context: Concussions are consequence of sports participation. Recent reports indicate the athlete is ready for competition. The increased risk of injury may indicate the athlete is ready for competition. The increased risk of injury may indicate the athlete is ready for competition. The increased risk of injury may indicate the athlete is ready for competition. **Objective:** Assess the between-session reliability and the effects of additional postural stability testing in a healthy population. **Setting:** Clinical laboratory. **Participants:** 22.3 [2.9] y, height 174.4 [7.5] cm, weight 70.1 [12.7] kg participated in this study. **Design:** Dynamic postural stability testing with and without the addition of a cognitive task (Str

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<https://doi.org/10.1007/s40279-018-0871-y>

REVIEW ARTICLE

Neuromuscular Control Deficits and the Risk of Subsequent Injury after a Concussion: A Scoping Review

David R. Howell^{1,2} · Robert C. Lynall³ · Thomas A. Buckley^{4,5} · Daniel C. Herman⁶

Specific to high school athletes...

Previous hx of concussion = **34%** increase in odds of sustaining a time-loss LE injury

- Football (boys) and soccer (girls) had the highest risk
- Injuries sustained included:
 - Sprains (50%)
 - Strains (17%)
 - Contusions (12%)
 - Fractures (5%)
- Ankle (40%), knee (25%), and thigh (14%)
- Girls had 1.5x the proportion of season-ending injuries
- Up to a 1.34x elevated risk of LEMSK exists within the year after a concussion and is consistent across a variety of sports.*



Concussion specific consideration: Alterations in landing mechanics

“When paired with a cognitive task, deficits in locomotor abilities may persist weeks beyond symptom resolution and baseline scores.” (Avedesian 2020)

“Individuals with prior concussive history displayed greater knee valgus and knee internal rotation during a jump-cut maneuver, along with changes in LE stiffness during a jump landing task.” (Avedesian 2020)

- ❖ Research demonstrates that jump-landings and jump-cutting should be analyzed and trained with external stimuli (dual-task training) most similar to the sport-specific environment. (Avedesian 2020, Dubose 2017)
- ❖ Alterations in hip and knee stiffness with landing demonstrate decreased motor planning and neuromuscular control leading to increased LE injury risk. (Dubose 2017)

In summary:

Motor control impairments after SRC could increase risk for musculoskeletal injury.



Athletes with sport-related concussion (SRC) resume sport participation when they are symptom-free and pass clinical tests of function.

Neuroanatomical and neurophysiological changes relevant to motor control may persist in athletes with SRC after they return to sport participation.

Athletes with SRC may also show altered motor function, such as gait disturbances that worsen when a cognitive task is performed at the same time.

SRC clinical management does not explicitly address motor control impairments during evaluation or rehabilitation, allowing the impairments to persist.

Risk for lower extremity musculoskeletal injury is higher in athletes with SRC after they resume sport participation compared to their uninjured counterparts.



Therefore, injury prevention principles may be important to include in the rehabilitation of these athletes!

Addressing motor control impairments in SRC clinical management might mitigate musculoskeletal injury risk.

Prevention Programs

Primary goal: To influence the neuromuscular system via a multicomponent exercise program to prevent injury

Secondary goal: Enhance athletic performance through improved strength, power, and coordination

Effectiveness: Overall 50% reduction in ACL injury in all athletes, 67% reduction for non-contact injuries in females (Webster, Hewett 2018)

Use: Only 13%–20% of female high school teams use NMT prevention programs nationally; only 4% in rural areas (Petushek 2019)

- ❖ Demonstrates need to educate athletes, coaches, parents, and administrators!

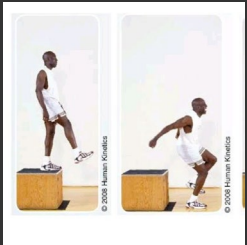
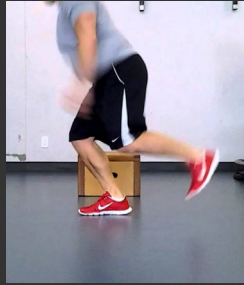
Six Principles of Prevention

1. Age
2. Biomechanics
3. Compliance
4. Dosage
5. Feedback
6. Exercise Variety



Types of Exercise: Plyometrics

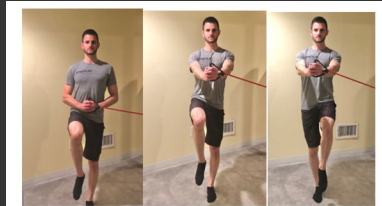
Goal: focus on proper technique and mechanics while improving power generation and force attenuation



Types of Exercise: Neuromuscular Training

Goals:

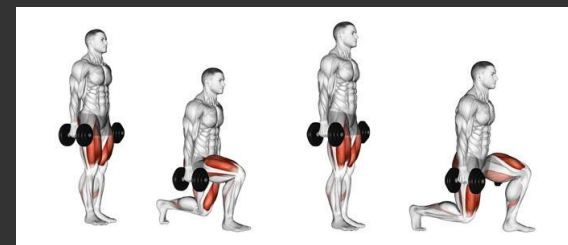
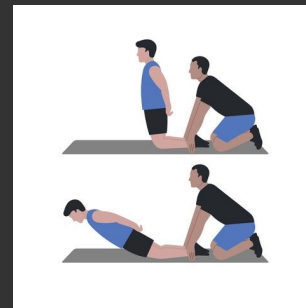
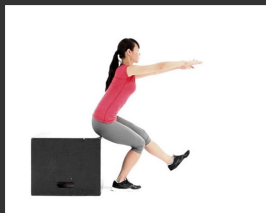
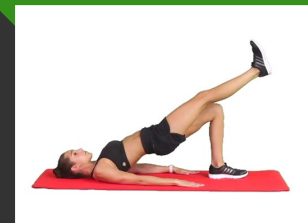
- Improve the ability to generate optimal muscle firing patterns
- Increase dynamic joint stability
- Safely perform movement patterns and skills necessary during sport



Types of Exercise: Strength Training

Muscle groups to include:

- Hamstrings
- Quadriceps
- Hip
- Core
- Calf



Concussion specific consideration: Dual- task training

“Deterioration in gait performance during dual-task testing is present among people with concussion.” (Kleiner et al., 2018)

“Dual-task neuromuscular control deficits may continue to exist after patient report of resolution of concussion symptoms or perform normally on other clinical concussion tests.” (Howell et al., 2018, 2022)

- ❖ Impaired perception-action coupling?

Outline of Program

1. Warm up
2. Combination of plyometrics, neuromuscular control, and strengthening exercises
3. Sports specific agility, running, cutting

Individual vs. team-based considerations

FIFA 11+

- Injury prevention program specifically designed to prevent soccer injuries
 - Significantly prevents non-contact injuries in soccer in males and females
 - Decreased rate of injury in male elite basketball players (Longo 2012)
- 20 minutes to complete, 3 components
 - Part 1: running exercises at a slow speed combined with active stretching and controlled partner drills - 8 minutes
 - Part 2: strength, plyometrics, and balance exercises with 3 levels of increasing difficulty - 10 minutes
 - Part 3: running exercises at moderate/high speed combined with planting/cutting- 2 minutes
- Designed to be done at least 2x/week as a warm up
- No specific equipment needed
- 11+ Kids (<14 years old)

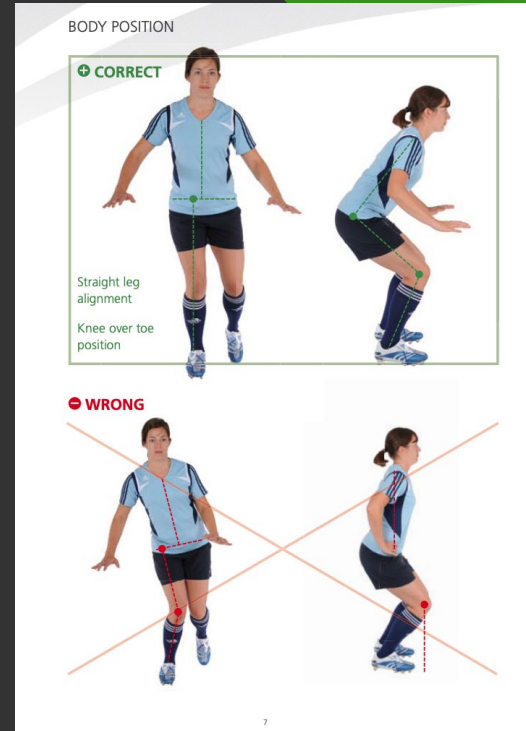
FIFA 11+

Performance Benefits

- Improved neuromuscular control (Impellizzeri 2013)
- Improved functional balance (Steffen 2013)
- Enhanced knee hamstring/quadriceps strength ratios and superior static and dynamic balance and agility (Daneshjoo 2012, 2013)
- Improved jumping and agility skills (Brito 2010, Reis 2013)

Implementation

- Coach is key, must motivate players to learn and perform exercises regularly (compliance is key factor in efficacy)
- RCT evaluation different delivery methods: Preseason coaching workshop > unsupervised delivery



Taken from The 11+ Manual

Barriers to Implementation

1. Motivation
2. Time requirements
3. Facilitator skill requirements
4. Compliance
5. Cost



Small Group Discussion

Please break into small groups with people who share your same profession (ie AT, PT, MD)!

ATHLETIC TRAINERS

- How do you determine your athlete post-concussion is ready to return to sport?
- What specific observations do you include while guiding an athlete through the return-to-play process?
- List some strategies for educating pre-teen/teens about injury prevention post-concussion.



PHYSICAL THERAPISTS

- How do you determine your athlete post-concussion is ready to return to sport?
- Do you include anything in your concussion evaluation that might identify an increased risk of lower extremity injury upon returning to sport? If so, what? If no, why not?
- Do you include injury prevention principles when rehabbing your athletes post-concussion?



PHYSICIANS

- How do you determine your athlete post-concussion is ready to return to sport?
- Do you screen in clinic to see if an athlete is at an increased risk of lower extremity injury upon returning to sport?
- Discuss strategies used to educate pre-teen/teens and their families about injury risk and prevention post-concussion.



Small Group Discussion Questions

AT

1

How do you determine your athlete post-concussion is ready to return to sport?

What specific observations do you include while guiding an athlete through the return-to-play process?

List some strategies for educating pre-teen/teens about injury prevention post-concussion.

PT

2

How do you determine your athlete post-concussion is ready to return to sport?

Do you include anything in your concussion evaluation that might identify an increased risk of lower extremity injury upon returning to sport? If so, what?

Do you include injury prevention principles when rehabbing your athletes post-concussion?

MD

3

How do you determine your athlete post-concussion is ready to return to sport?

Do you screen in clinic to see if an athlete is at an increased risk of lower extremity injury upon returning to sport?

Discuss strategies used to educate pre-teen/teens and their families about injury risk and prevention post-concussion.

Large Group Discussion

FIFA 11+ - Part 1

The 11+

PART 1 RUNNING EXERCISES • 8 MINUTES



1 RUNNING STRAIGHT AHEAD

The course is made up of 6 to 10 pairs of parallel cones, approx. 5-6 m apart. Two players start at the same time from the first pair of cones. Jog together all the way to the last pair of cones. On the way back, you can increase your speed progressively as you warm up. 2 sets



2 RUNNING HIP OUT

Walk or jog easily, stepping at each pair of cones to lift your knee and rotate your hip outwards. Alternate between left and right legs at successive cones. 2 sets



3 RUNNING HIP IN

Walk or jog easily, stepping at each pair of cones to lift your knee and rotate your hip inwards. Alternate between left and right legs at successive cones. 2 sets



4 RUNNING CIRCLING PARTNER

Run forwards as a pair to the first set of cones. Shuffle sideways by 90 degrees to meet in the middle. Shuffle an entire circle around one another and then return back to the cones. Repeat for each pair of cones. Remember to stay on your toes and keep your centre of gravity low by bending your hips and knees. 2 sets



5 RUNNING SHOULDER CONTACT

Run forwards in pairs to the first pair of cones. Shuffle sideways by 90 degrees to meet in the middle then jump sideways towards each other to make shoulder-to-shoulder contact.
Note: Make sure you land on both feet with your hips and knees bent. Do not let your knees buckle inwards. Make it a full jump and synchronize your timing with your team-mate as you jump and land. 2 sets



6 RUNNING QUICK FORWARDS & BACKWARDS

As a pair, run quickly to the second set of cones then run backwards quickly to the first pair of cones keeping your hips and knees slightly bent. Repeat repeating the drill, running half-cones forwards and one cone backwards. Remember to take small, quick steps. 2 sets



11 SQUATS WITH TOE RAISE

Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. **Exercise:** Imagine that you are about to sit down on a chair. Perform squats by bending your hips and knees to 90 degrees. Do not let your knees buckle inward. Descend slowly then straighten up more quickly. When your legs are completely straight, stand up on your toes then slowly lower down again. Repeat the exercise for 30 sec. 2 sets



11 SQUATS WALKING LUNGES

Starting position: Stand with your feet at hip-width apart. Place your hands on your hips if you like. **Exercise:** Lunge forward slowly at an even pace. As you lunge, bend your leading leg until your hip and knee are flexed to 90 degrees. Do not let your knee buckle inward. Try to keep your upper body and hips steady. Lunge your way across the pitch (approx. 10 times on each leg) and then jog back. 2 sets



11 SQUATS ONE-LEG SQUATS

Starting position: Stand on one leg, loosely holding onto your partner. **Exercise:** Slowly bend your knee as far as you can manage. Concentrate on preventing the knee from buckling inward. Bend your knee slowly then straighten it slightly more quickly, keeping your hips and upper body in line. Repeat the exercise 10 times on each leg. 2 sets



12 JUMPING VERTICAL JUMPS

Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. **Exercise:** Imagine that you are about to sit down on a chair. Bend your legs slowly until your knees are flexed to approx. 90 degrees, and hold for 2 sec. Do not let your knees buckle inward. From the squat position, jump up as high as you can. Land softly on the balls of your feet with your hips and knees slightly bent. Repeat the exercise for 30 sec. 2 sets



12 JUMPING LATERAL JUMPS

Starting position: Stand on one leg with your upper body bent slightly forwards from the waist, with knees and hips slightly bent. **Exercise:** Jump approx. 1 m sideways from the supporting leg on to the free leg. Land gently on the ball of your foot. Bend your hips and knees slightly as you land and do not let your knee buckle inward. Maintain your balance with each jump. Repeat the exercise for 30 sec. 2 sets



12 JUMPING BOX JUMPS

Starting position: Stand with your feet hip-width apart. Imagine that there is a cross marked on the ground and you are standing in the middle of it. **Exercise:** Alternate between jumping forwards and backwards, from side to side, and diagonally across the cross. Jump as quickly and explosively as possible. Your knees and hips should be slightly bent. Land softly on the balls of your feet. Do not let your knees buckle inward. Repeat the exercise for 30 sec. 2 sets

FIFA 11+ - Part 2

FIFA 11+ - Part 3

PART 3 RUNNING EXERCISES • 2 MINUTES



13 RUNNING ACROSS THE PITCH

Run across the pitch, from one side to the other, at 75-80% maximum pace.
2 sets



14 RUNNING BOUNDED

Run with high bounding steps with a high knee lift, landing gently on the ball of your foot. Use an exaggerated arm swing for each step (opposite arm and leg). Try not to let your leading leg cross the midline of your body or let your knees buckle inward. Repeat this exercise until you reach the other side of the pitch, then jog back to recover. 2 sets

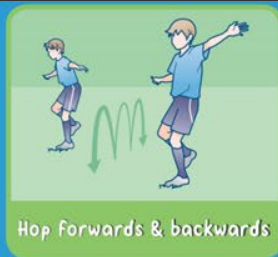


15 RUNNING PLANT & CUT

Jog 4-5 steps, then plant on the outside leg and cut to change direction. Accelerate and perform 5-7 steps at high speed (80-90% maximum pace) before you decelerate and do a new plant & cut. Do not let your knees buckle inward. Repeat the exercise until you reach the other side, then jog back. 2 sets

EXERCISE 5 ONE LEG HOPS

- 2x, 5 hops on right leg and 5 hops on left leg
- 2x, 5 hops on right leg and 5 hops on left leg
- 2x, 5 hops on right leg and 5 hops on left leg
- 2x, 5 hops on right leg and 5 hops on left leg
- 2x, 5 hops on right leg and 5 hops on left leg



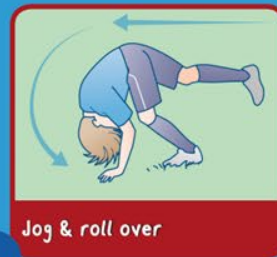
EXERCISE 6 SPIDERMAN

- 3x à 15 seconds
- 3x à 15 seconds
- 3x over 5-10 meters
- 3x over 5-10 meters
- 3x over 5-7 meters



EXERCISE 7 ROLL OVER

- 5-7x per side
- 5-7x per side
- 5-7x per side
- 5-7x per side
- 5-7x per side



The PEP Program

“Prevent injury and Enhance Performance”

Components

- Warm up
- Stretching
- Strengthening
- Plyometrics
- Sports-specific agility

15-20 minutes to complete



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