Lower Extremity Screening

By: Michael Hauber, PT, DPT

https://us.123rf.com/450wm/spotpoint74/spotpoint741803/spotpoint74180300039/97555057-runner-explosive-start-in-running.jpg?ver=6

Objectives

1. Review injury risk factors associated with lower extremity.
2. Define the purpose of performing a screen versus an assessment.
3. Analyze commonly used lower extremity screening tests for youth athletes.
4. Identify the efficacy of lower extremity screening tests in predicting injuries.
5. Demonstrate an example of a lower extremity screen and breakout.

General Injury Risk Factors: Non-modifiable

- Age[25]
  - Highest incidence: ages 15-17
- Sex (females>males)[15]
- ****Previous injury****[2,6,15,22,23,28]
- Anthropometrics (height, weight)[7,22,28]
- Bad luck
- **Honorable mention**: *parents who think their son has a "million-dollar arm"*

https://i.dailymail.co.uk/1s/2023/12/26/01/79333537-12900397-image-a-1_1703555916901.jpg

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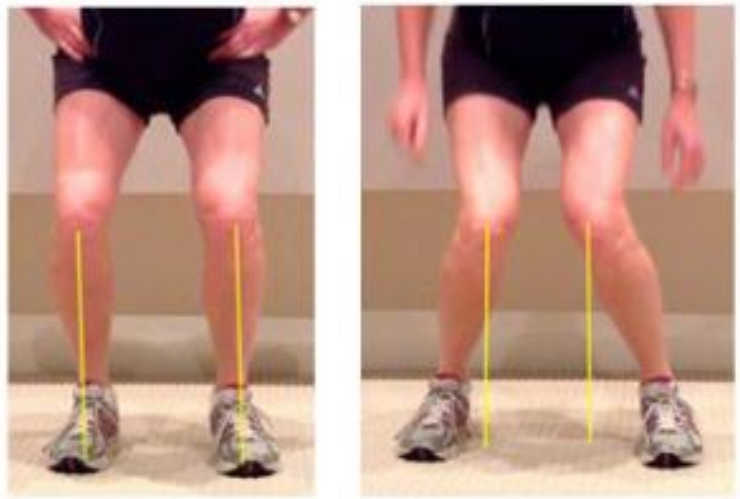
General Injury Risk Factors: Modifiable

- Pain with movement[6]
- Movement asymmetry[6,8]
- Perceived recovery from injury[7]
- Muscle flexibility – too much, too little[9]
- Aerobic fitness[7,20]
- Power – too much, too little[9]
- Speed – slower sprint speed[9]
- Training variables:
  - Technique[25]
  - Programming (intensity, duration): too much, too little[25]
- Sports equipment[25]

Lower Extremity Injury Risk Factors

- Hamstring flexibility: too much, too little[9]
- Mobility asymmetry: ankle DF, hip ext[9]
- Strength asymmetry: hip, knee, ankle[8, 23]
- Foot type: pronation vs supination[23]
- Balance[9]
- Jumping/landing mechanics[28]
- Core stability[28]

https://www.spineandbody.com.au/wp-content/uploads/2016/02/120-degree-leg-lift.jpg



https://aclstrong.com/wp-content/uploads/2018/07/valgus-landing-2-300x201.png

Unique to Adolescents

- Growth spurt (reduced musculotendinous flexibility)[25]
- Delayed physical maturation status: skeletal age versus chronological age[23]
- Growth cartilage: immature growth plate susceptible to stress injury[25]
- Bone structure:
  - Growing bone is inherently weaker[25]
  - Predisposition to tendon/ligamentous injury and avulsions[25]
- Psychological maturity: coping skills, ability to comply with recommendations[25]
- Key question: what is normal and what is relevant for age, gender, sport?

Screen vs Assessment

- Screen:
  - Risk stratification[26]
  - Early detection of disease before it manifests[2]
  - Global movement patterns
  - Low to high threshold
  - Informs whether further assessment is needed.
- Assessment:
  - Designed to dig deeper
  - Break down the pattern into parts
  - Structure vs motor control

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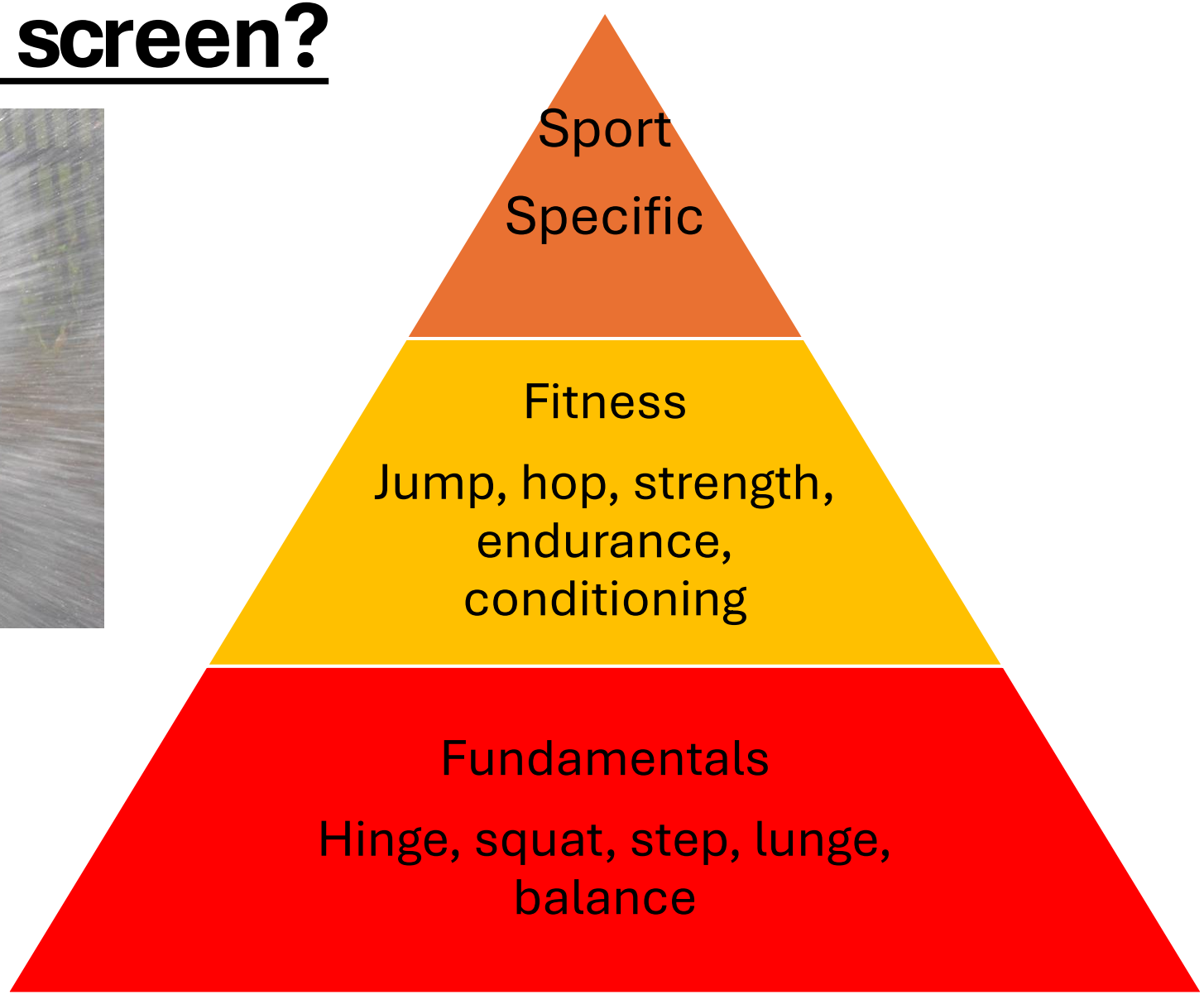
What should we screen?

https://www.action-strategies.com/wp-content/uploads/2016/12/fire-hose-spray-close-up.jpg

Where should we start?



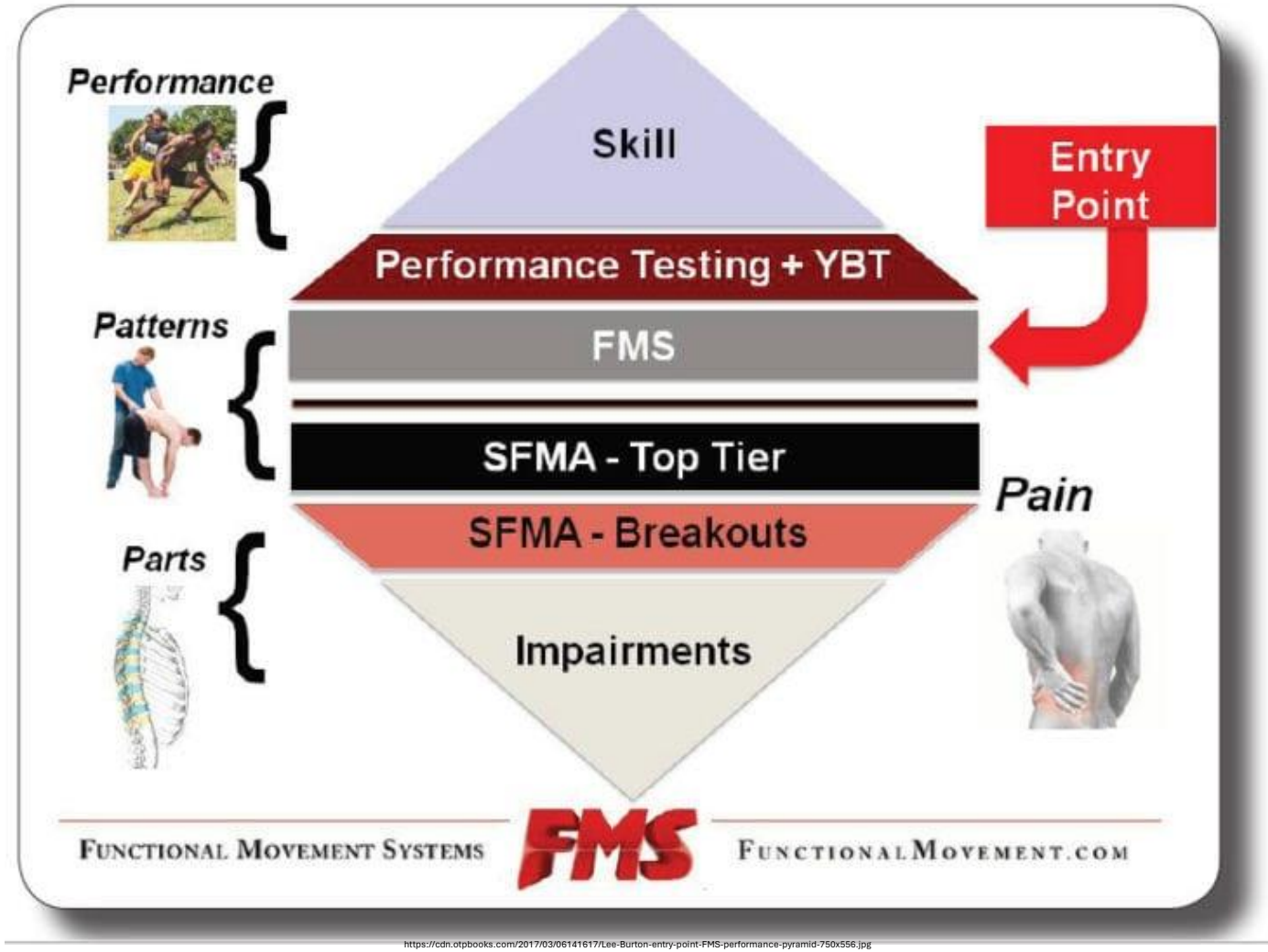
Starting Point: Functional Movement Screen

- Movement fundamentals
- Low threshold
- Decision-making
  - Catch pain
  - Qualify movement dysfunction and/or asymmetry
  - Risk analysis
- **Key principles:** Protect, correct, develop[12]

FMS™
FUNCTIONAL MOVEMENT SCREEN

https://mattdrilias.com/wp-content/uploads/2021/01/Pic-FMS-7-Screens.jpg

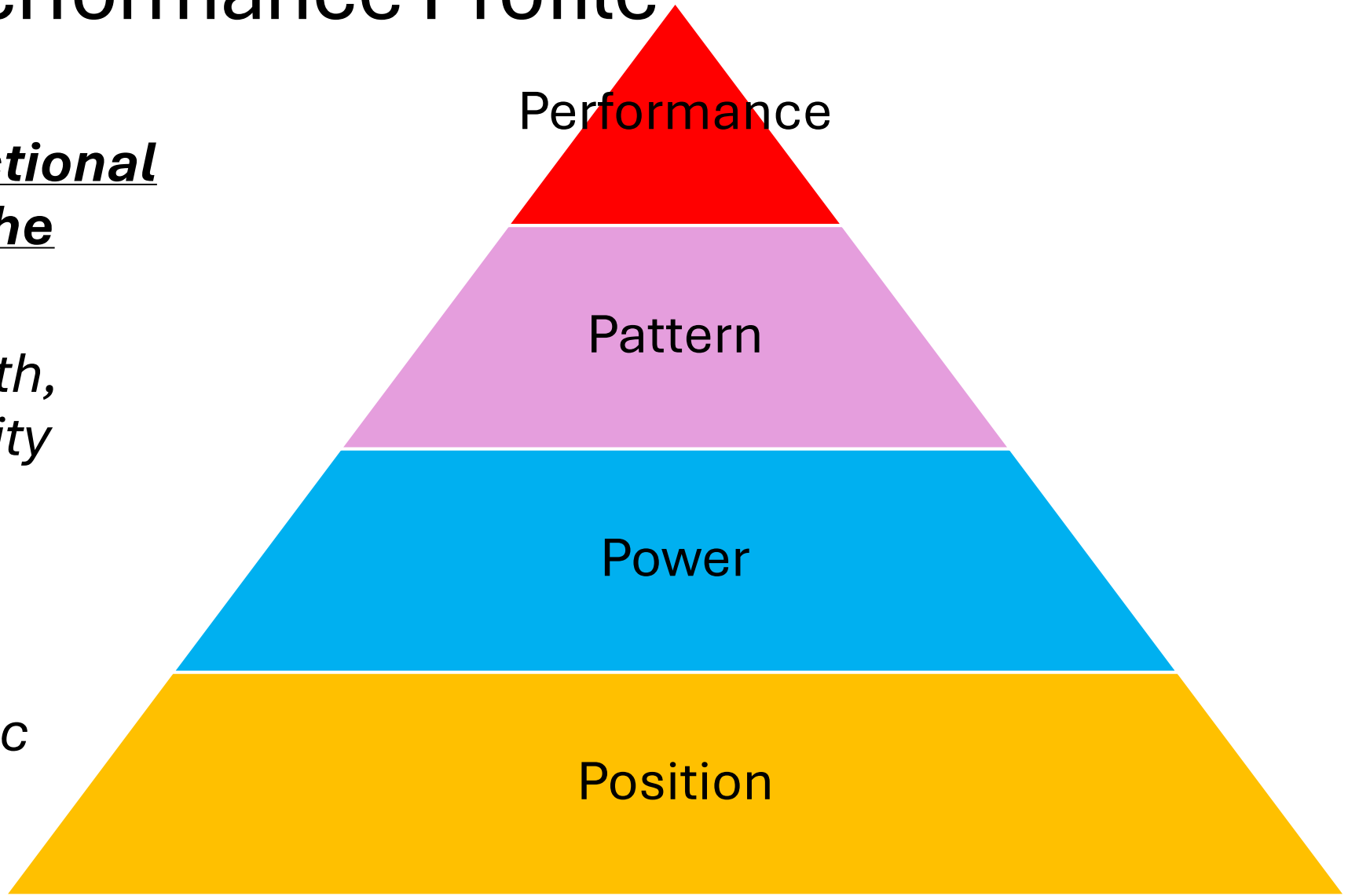
Functional Movement Systems

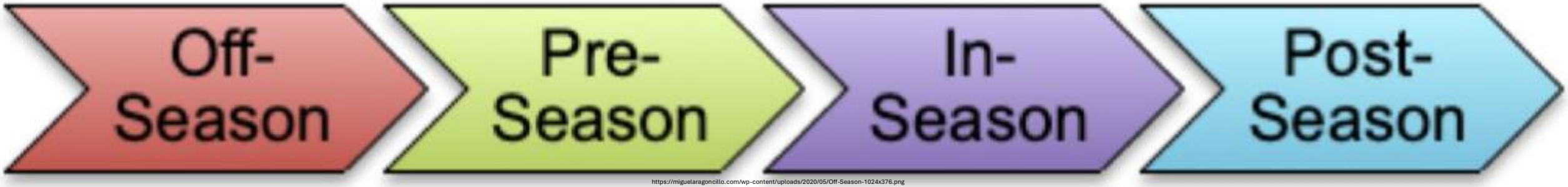


https://cdn.otpbooks.com/2017/03/06141617/Lee-Burton-entry-point-FMS-performance-pyramid-750x556.jpg

EXOS 3D Performance Profile

1. Position: ***<u>functional mobility for the movement</u>***
2. Power: *strength, power, capacity*
3. Pattern: *coordination*
4. Performance: *sports-specific production*



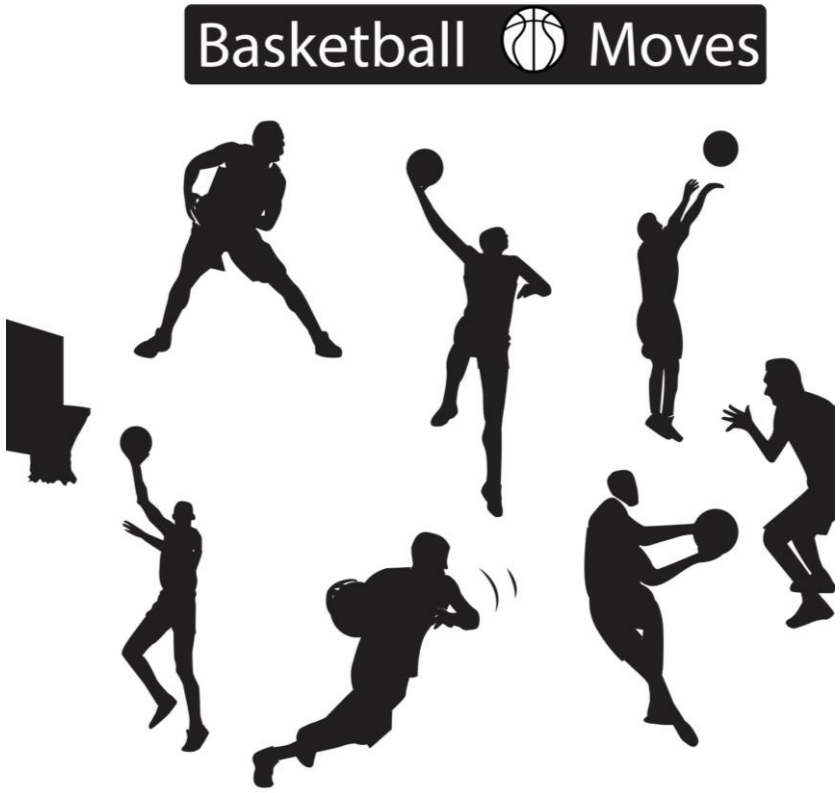


When should we screen?

- Offseason: more time to address
- Preseason: less time to address
- During rehab
  - Progression to higher level movements (run, jump, agility)
  - Return to sport testing
- 1-6 month follow-up post-discharge
- Regular 6-month check-up

Sport-Specific Demands

- Australian National Basketball League game
- Average[3]:
  - 46 jumps per player
  - 105 sprints (1 every 21 seconds)
  - 1000 movement pattern changes (1 every 2 seconds)
  - Lateral shuffling: 31%
  - Sprints: 10%
- Is the athlete prepared for their sport?



https://static.vecteezy.com/system/resources/previews/006/781/058/original/a-set-of-basketball-move-silhouette-icons-free-vector.jpg

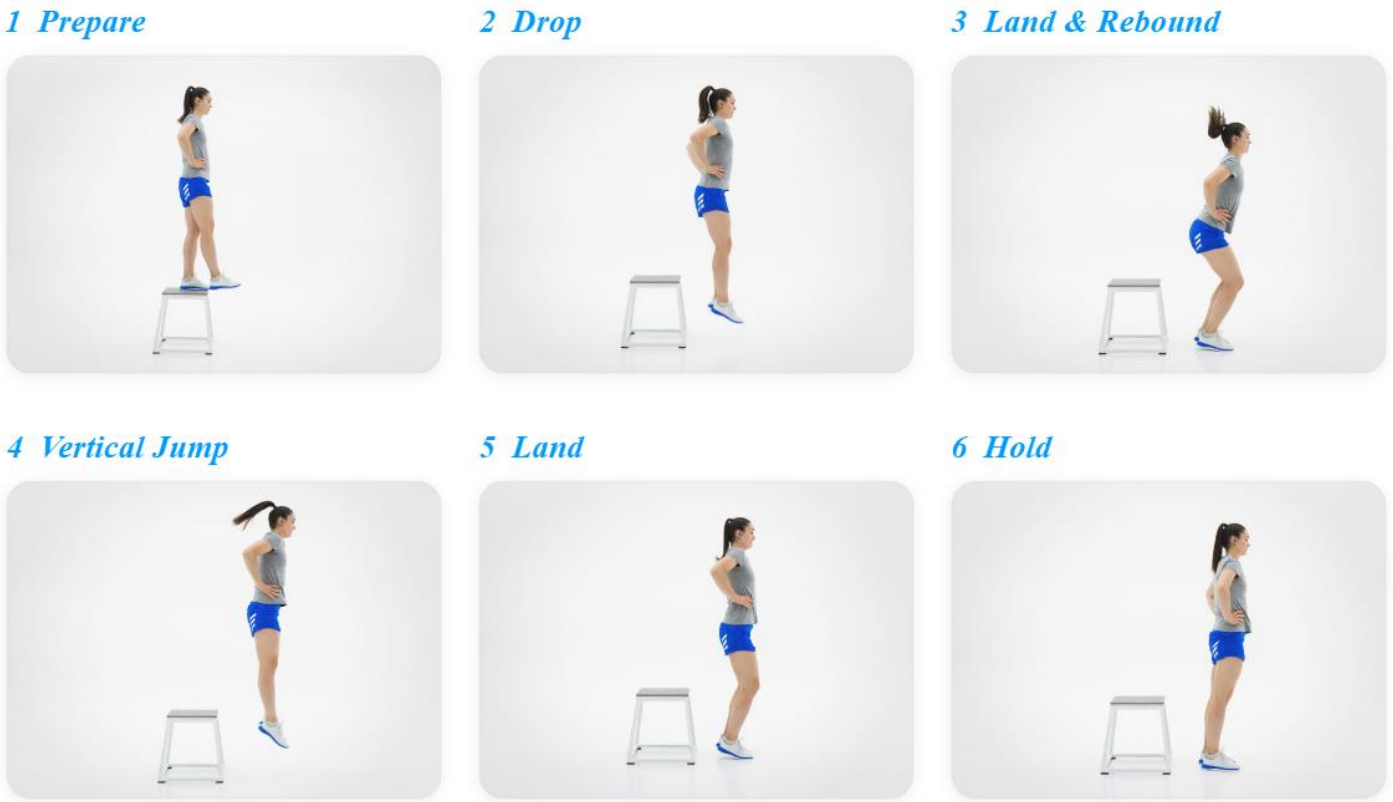
NCAA Basketball

- Higher injury rates pre-season versus in-season[3]
  - Men: 3X higher in practices
  - Women: 2X higher in practices
- Offseason deconditioning and preseason training demands[3]
  - Increased raining intensity
  - Increased fatigue
  - Decreased recovery
  - Increased pressure to become starter

https://www.ncaa.com/_flysystem/public-s3/styles/original/public-s3/images/2022/03/08/GettyImages-1311019527_0.jpg?itok=1WDY-6aW

Drop Jump Test[6]

- Reliable
- Validity needs more testing
- Significant dynamic knee valgus: <60% normalized knee separation[6]
- Takeaway: record jump/landing mechanics



https://moticon.com/wp-content/uploads/2022/09/img-1-blog-drop-jump-sequence.svg

Landing Error Scoring System

Broad jump from box

Distance 50% of height

Vertical Jump

https://www.physio-pedia.com/images/thumb/5/5c/Jumping_technique.jpg/390px-Jumping_technique.jpg

- Frontal and sagittal planes[6]
- Short version: i-LESS

Landing Error Scoring System

Frontal-Plane Motion

1. Stance width

- ☐ Normal (0)
- ☐ Wide (1)
- ☐ Narrow (1)

2. Maximum foot-rotation position

- ☐ Normal (0)
- ☐ Externally rotated (1)
- ☐ Internally rotated (1)

3. Initial foot contact

- ☐ Symmetric (0)
- ☐ Not symmetric (1)

4. Maximum knee-valgus angle

- ☐ None (0)
- ☐ Small (1)
- ☐ Large (2)

5. Amount of lateral trunk flexion

- ☐ None (0)
- ☐ Small to moderate (1)

Sagittal-Plane Motion

6. Initial landing of feet

- ☐ Toe to heel (0)
- ☐ Heel to toe (1)
- ☐ Flat (1)

7. Amount of knee-flexion displacement

- ☐ Large (0)
- ☐ Average (1)
- ☐ Small (2)

8. Amount of trunk-flexion displacement

- ☐ Large (0)
- ☐ Average (1)
- ☐ Small (2)

9. Total joint displacement in the sagittal plane

- ☐ Soft (0)
- ☐ Average (1)
- ☐ Stiff (2)

10. Overall impression

- ☐ Excellent (0)
- ☐ Average (1)
- ☐ Poor (2)

https://www.researchgate.net/publication/51131028/figure/fig2/AS:276983490596866@1443049418228/Scoring-sheet-for-the-Landing-Error-Scoring-System-Real-Time-LESS-RT-assessment-tool.png

Landing Error Scoring System

- Post-fatigue ACL reconstruction:
  - Higher percentage of errors compared to healthy controls[6]
- 829 elite youth soccer players[24]:
  - Higher LESS associated with ACL injury
  - Cutoff: score > /= 5

Single leg hop (SLH)[4]

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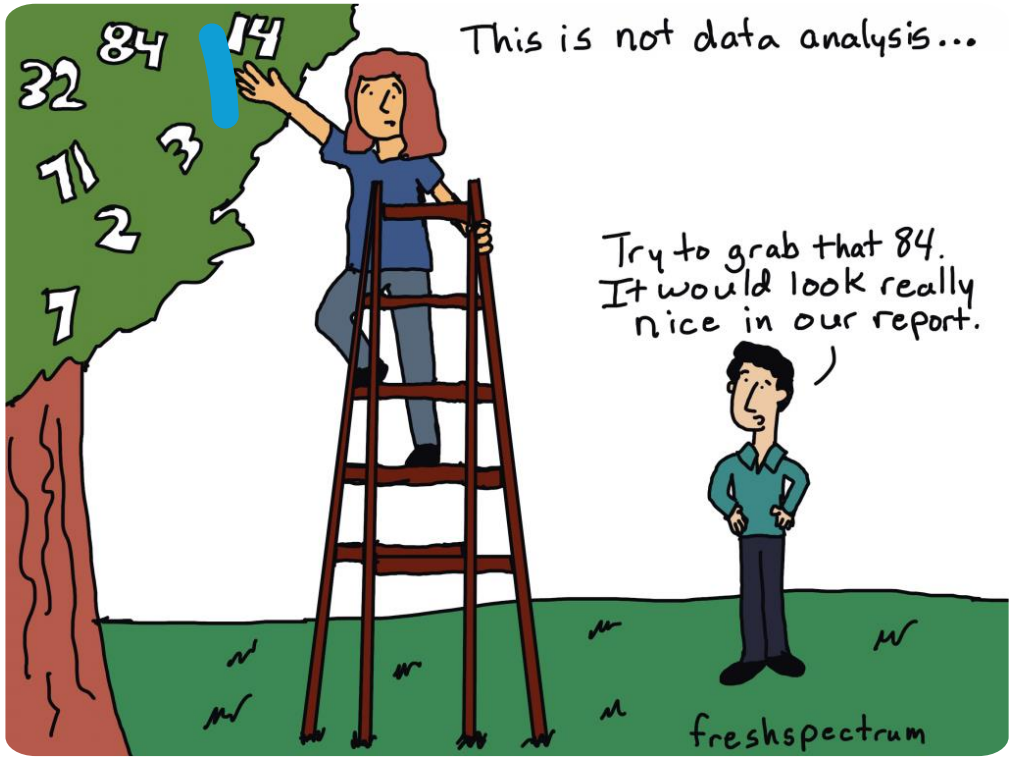
- 193 Division III student athletes (10 sports)
- Preseason screening
- Females:
  - > 10% R-L asymmetry
  - Foot/ankle injury: 4X more likely
- Males:
  - Distance >/= 75% of their height
  - Low back/LE injury: 3X more likely
  - What??

FMS

- Walbright[30]
  - Preseason screening: FMS, YBT, SLH
  - 35 female collegiate volleyball and basketball players
  - Tests were NOT predictive of injury
- Zarei[34]
  - Preseason screening: FMS
  - 131 volleyball players (13.83-16.5 yo)
  - Monitored for 6 months
  - Composite score </=14: significant predictor of injury



https://freshspectrum.com/wp-content/uploads/2012/02/Cherry-Picking-Data-1024x768.png

Functional Movement Screen

Letafatkar[19]	Siupsinskas[27]
100 college students: 18-25 y.o.	169 elite female basketball players
Sports: soccer, handball, basketball	Sport: basketball
Preseason screening: FMS	Preseason screening: FMS, YBT-LQ, LESS **Performed each preseason for 4 years
FMS composite score < 17 • Lower extremity injury: 4.7X more likely during competitive season	FMS composite score: • Significant difference between injured vs. uninjured groups • Injured = 14.1 • Uninjured = 15.4

Functional Performance Tests[28]

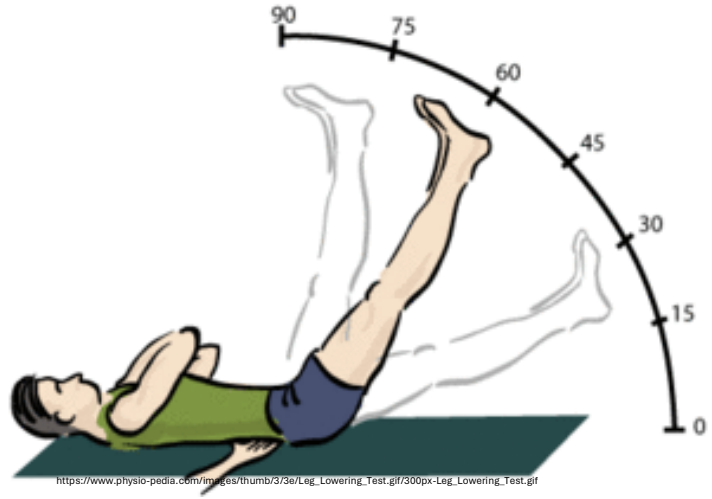
100 adolescents: 14.4 +/- 1.6 y.o.

Sports: volleyball, basketball, soccer

Preseason screening, then monitored for 6 months

Functional Performance Tests:

- Triple hop for distance: R-L single leg power, landing mechanics
- Star excursion balance test: dynamic balance
- Double leg lowering maneuver: core stability
- Drop jump video test: jump/landing mechanics
- Multi-stage fitness test: cardiorespiratory fitness



https://www.physio-pedia.com/images/thumb/3/3e/Leg_Lowering_Test.gif/300px-Leg_Lowering_Test.gif

https://www.researchgate.net/publication/342209608/figure/fig1/AS:1143128112495150 8@1678173558959/Multi-stage-Fitness-Test.jpg

Functional Performance Tests[28]

- Calculated composite score for functional performance tests
- Significant positive correlation between functional performance tests and multi-stage fitness test in males
- Significant difference between injured and uninjured groups
  - Drop jump video test
  - Double leg-lowering maneuver
- Significant differences between injured and uninjured groups in males
  - Anterior reach on Star Excursion Balance Test
- Takeaways: capturing aerobic fitness, dynamic balance, jump-landing mechanics, and core endurance are relevant

Single leg squat

- Ugalde[29]
  - 142 middle school and high school athletes
  - SLS 30 deg and 2D drop jump
  - SLS captured similar information as the 2D drop jump test
- Takeaways:
  - SLS and 2D drop jump test interrelated
  - If you don’t squat well, then you don’t jump well.

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Prone Plank[14]

Boys	Girls
Age 12 • 5th percentile: 10.09 sec • 50th percentile: 55.96 sec • 80th percentile: 112.9 sec	**Age 12** • 5th percentile: 9.49 sec • 50th percentile: 43.76 sec • 80th percentile: 68.76 sec
Age 16 • 5th percentile: 15.94 sec • 50th percentile: 57.50 sec • 80th percentile: 132.2 sec	**Age 16** • 5th percentile: 20.30 sec • 50th percentile: 65.98 sec • 80th percentile: 133.8 sec

- *Normative data for adolescents: 2,970 healthy Pakistani students*

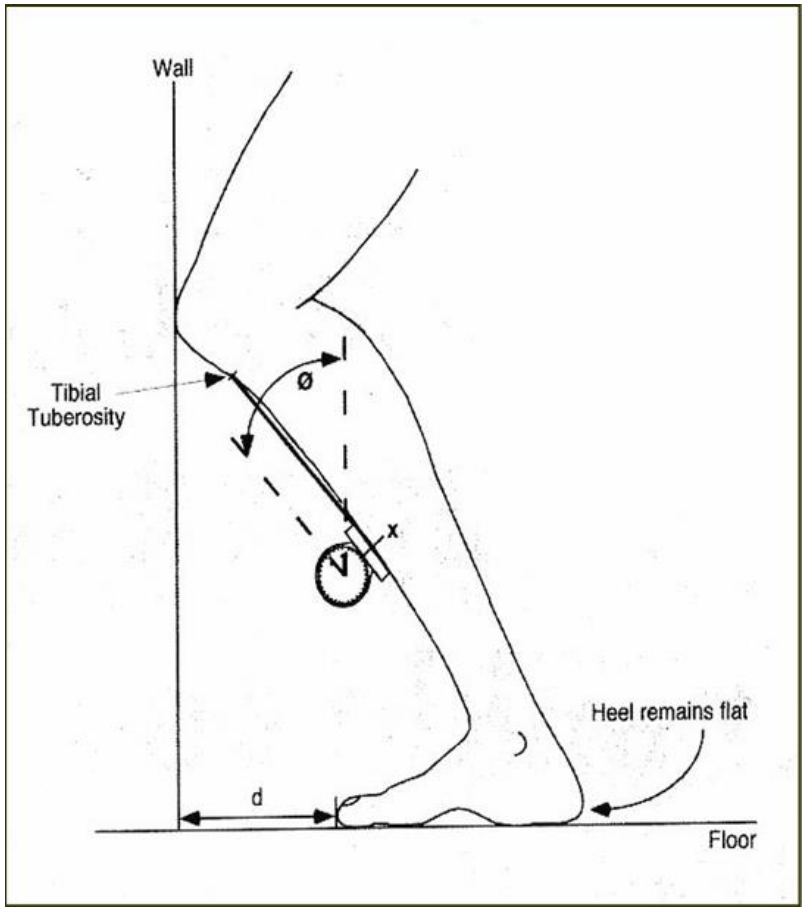
Single leg stance (SLS)[9]

- Male/female collegiate athletes
- SLS < 10 sec
- 2.5X more likely to experience ankle sprain
- Moderate evidence

https://www.indiewire.com/wp-content/uploads/2018/05/shutterstock_5882324a-copy.jpg?w=780

Ankle flexibility[9]

Asymmetry	Increased DF	Decreased DF
U.S. Army Rangers	Belgian Army basic trainees	Elite junior basketball players
Asymmetry >/= 6.5 deg • Any MSK injury: 4.0X more likely • Overuse MSK injury: 5.1X more likely	Injury: 1.2X more likely	Ankle DF < 36.5 deg • More likely to develop patellar tendinopathy
*Systematic review: rated study as excellent methodology	*Systematic review: questioned significant difference between groups	

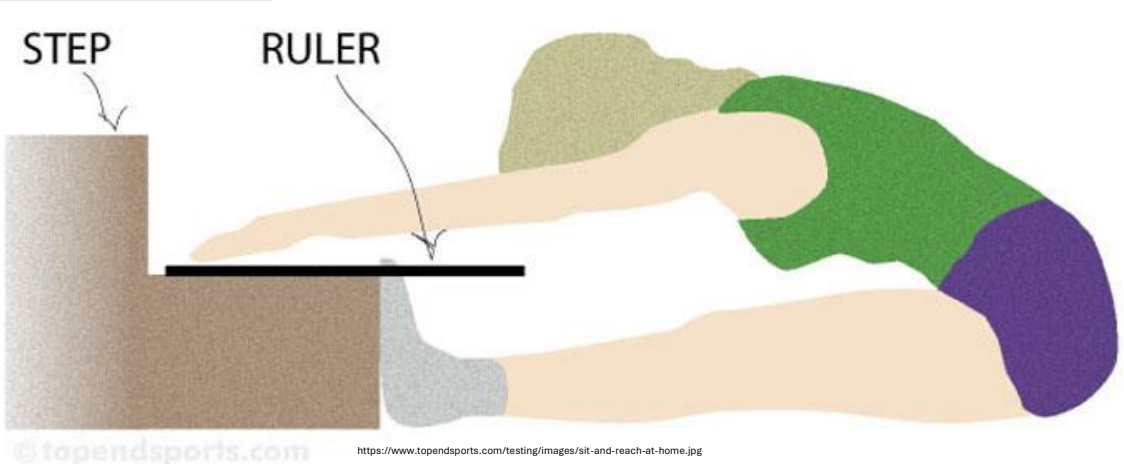


https://sportspodiatryinfo.files.wordpress.com/2010/02/lunge-test4.png

Hamstring* flexibility[9]

Male U.S. Army basic trainees	English professional soccer players
Test: Sit and reach	Straight leg raise
Highest flexibility: • Hamstring injury: 2.9X more likely **Lowest flexibility** • Hamstring injury: 3.3X more likely	**Decreased flexibility** • 30% MORE likely to experience injury compared to those with more flexibility

Takeaway: too much versus too little



https://www.topendsports.com/testing/images/sit-and-reach-at-home.jpg

Lower leg strength[8]

Asymmetry	Overall Strength
Isokinetic eccentric PF:DF strength	Decreased versus increased PF strength
Asymmetry >15% • Increased risk of ankle sprain in male professional soccer players	Decreased PF strength • Predictive of Achilles tendon overuse injury in Belgian Army basic trainees Increased PF strength • Independent risk factor for injury in male volleyball players

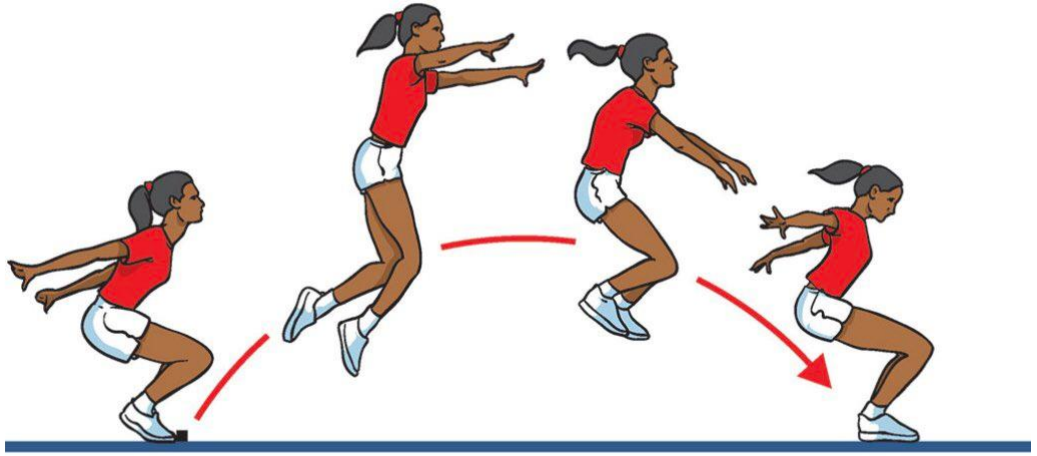
One Leg Heel Raise

https://upload.wikimedia.org/wikipedia/commons/5/52/Exercise_Heel_Raise_One_Leg.png

Takeaways: significant asymmetry, too much, too little

Power

Finnish military subjects	Professional soccer players
Decreased broad jump distance • Severe acute injury: 2.8X more likely • Overuse injury: 1.8X more likely **Moderate evidence	Highest percentage vertical jump • Hamstring injury: 1.5X more likely



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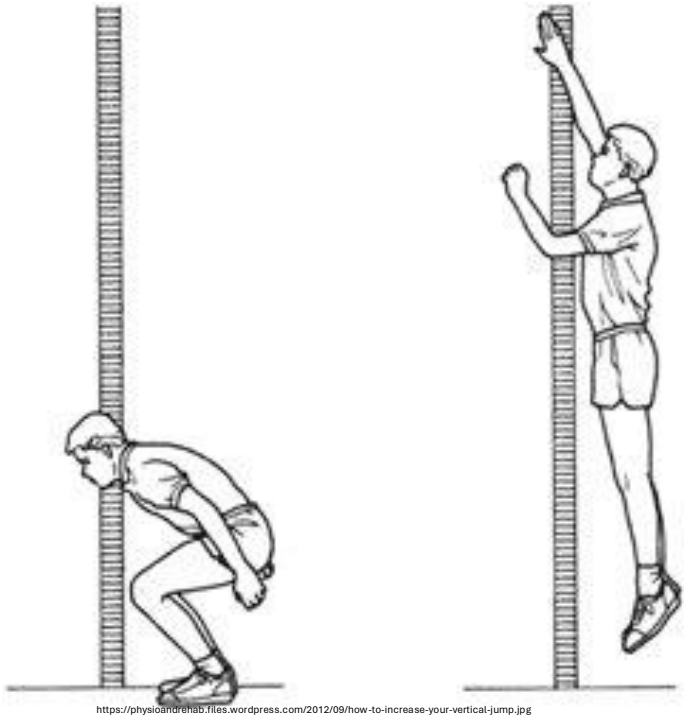


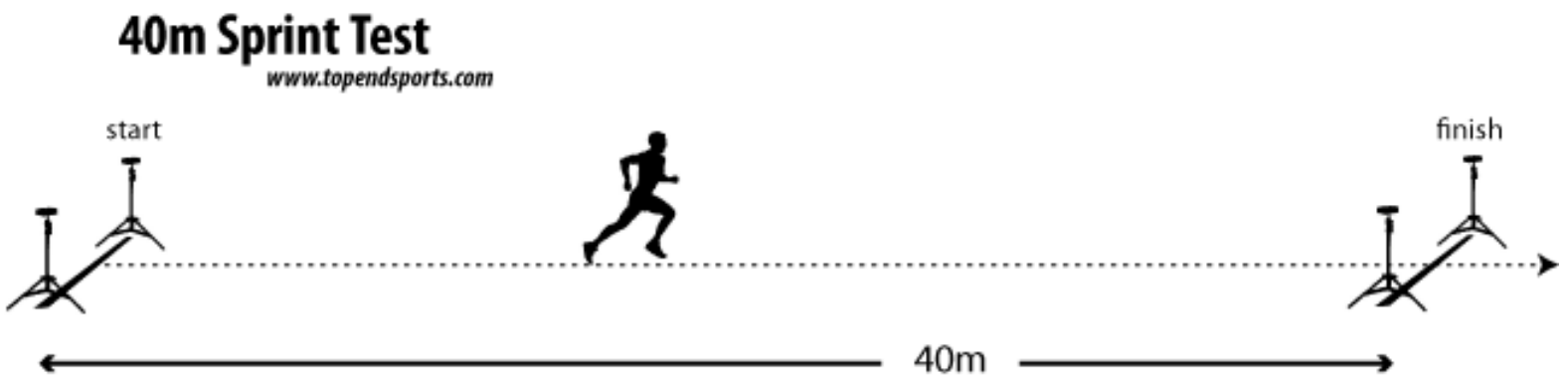
https://physioandrehab.files.wordpress.com/2012/09/how-to-increase-your-vertical-jump.jpg

Takeaway: too much, too little

Speed[9]

Australian rugby players	FBI trainees
Slower speeds • 10m sprint: injury 10.3X more likely • 40m sprint: injury 9.9X more likely	Slower speeds: • 300m sprint: higher injury incidence

Speed is an independent injury risk factor



https://www.topendsports.com/testing/images/sprint-40m.gif

Cardiorespiratory endurance[20]

Set distance for time (0.75-2 mi)	Timed shuttle run
Marine corps and FBI trainees	Rugby players and basic trainees
Poor performance: • Predicts MSK injury for both genders • Strong evidence	Poor performance: • Predicts MSK injury in males • Strong evidence

*Poor aerobic fitness is an injury risk factor

https://media.istockphoto.com/id/1225549108/vector/run-sport-exercise-vector-icon-illustration.jpg?s=612x612&w=0&k=20&c=RKFqwoj4U4mw076yakzLoxFxz5MLm1gQI_mU4RVpzp4=

Running-related injuries[15]

Strongest predictors	Step rate	YBT
• **Sex: female>male** • **History of previous running-related injury**	High school runners • <170/minute: • Shin injury: 7X more likely College runners • Bone shin injury risk • 5% increase for each step/minute dropoff	Anterior reach asymmetry > 2.5 cm • Running-related injury: 6X more likely Posteromedial asymmetry >/= 5.2 cm • Running-related injury: 5X more likely

Takeaways: check step rate, YBT

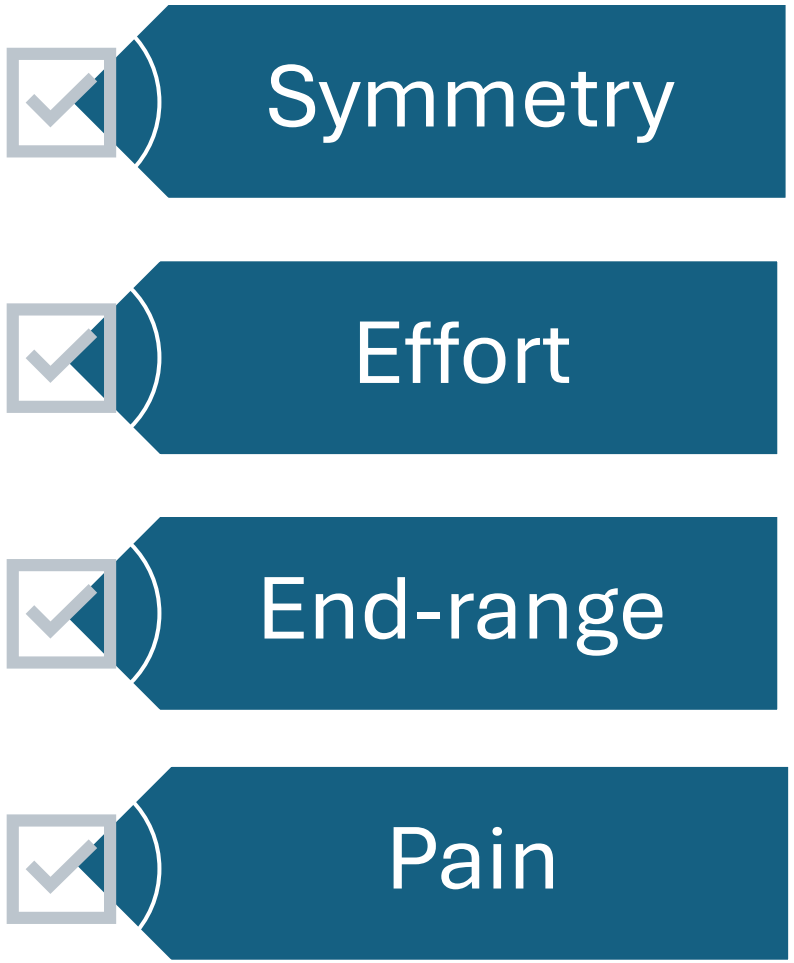
Single leg wall sit and questionnaire[32]

- Preseason screen: NCAA collegiate football players
  - Single leg wall sit (about 90 deg knee flexion): average hold = 28 sec
  - Oswestry Disability Index >/= 4
  - Starting 1 or more games
- >/= 2 factors: significant increased risk for core or lower extremity injury

Unique: combined physical measures, games played, and **self-perception of preparticipation functional tatus

Base Level Screen example

- Beighton Score
- Multisegmental flexion (SFMA)
- Multisegmental rotation (SFMA)
- Single leg stance: EO, EC
- Single leg stance: UE, LE reaches
- Standing knee lift
- Unilateral heel raise
- Bodyweight squat: arms crossed
- Single leg squat or split squat
- Closed chain ankle DF
  - Tandem stance or weight bearing lunge test (limited DF: <10cm^3)



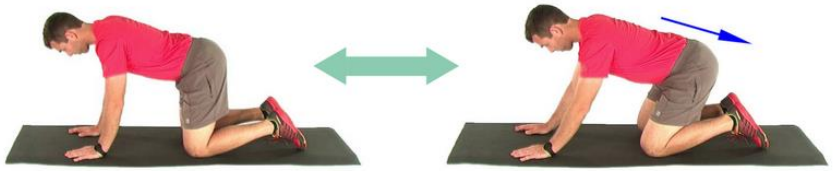
Higher Level Screen

- YBT-LQ
- Vertical jump / Single leg hop
  - Drop squat: fast versus slow
  - Drop squat: heel(s) elevated vs flat
- Sport-specific performance testing
- Introduce cardiorespiratory demand, then redo screen

https://experiencelife.lifetime.life/wp-content/uploads/2021/02/Squat-Jump-1.jpg

Example: Squat Dysfunction Breakout

- Change arm angle: air squat
- Change foot position / hip width
- Change ankle DF and anterior core demand
  - Elevate heels on half foam roll
- Ankle mobility: weight bearing lunge test
- Remove balance demands:
  - Quadruped rock back to heels
  - Happy baby pose (grab shins)
- Break down hip, knee, ankle, T-spine mobility
- Anterior chain trunk endurance: prone plank



https://myrehabconnection.com/wp-content/uploads/2017/02/quad-rock-with-APT-1.png

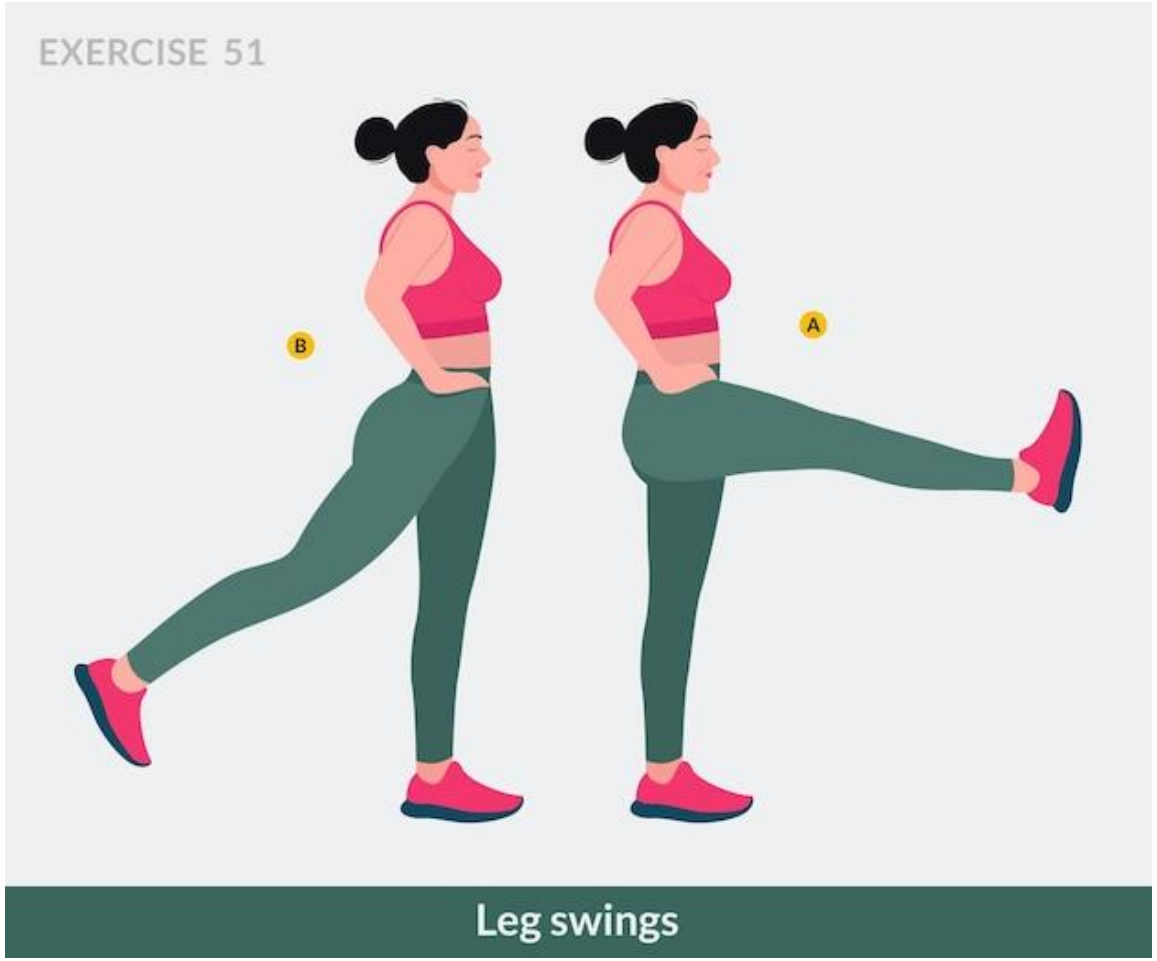
SFMA: Top Tier examples

Multisegmental flexion[26]

- Can they touch their toes?
- Posterior weight shift?
- Sacral angle >/= 70 deg?
- Purpose: posterior chain extensibility
- Archetype for hip hinge

Multisegmental rotation[26]

- Pelvic rotation >/= 50 deg?
- Torso rotation >/= 50 deg?
- Purpose: quick screen of global rotation
- Archetype for rotational sports (e.g., tennis, baseball)



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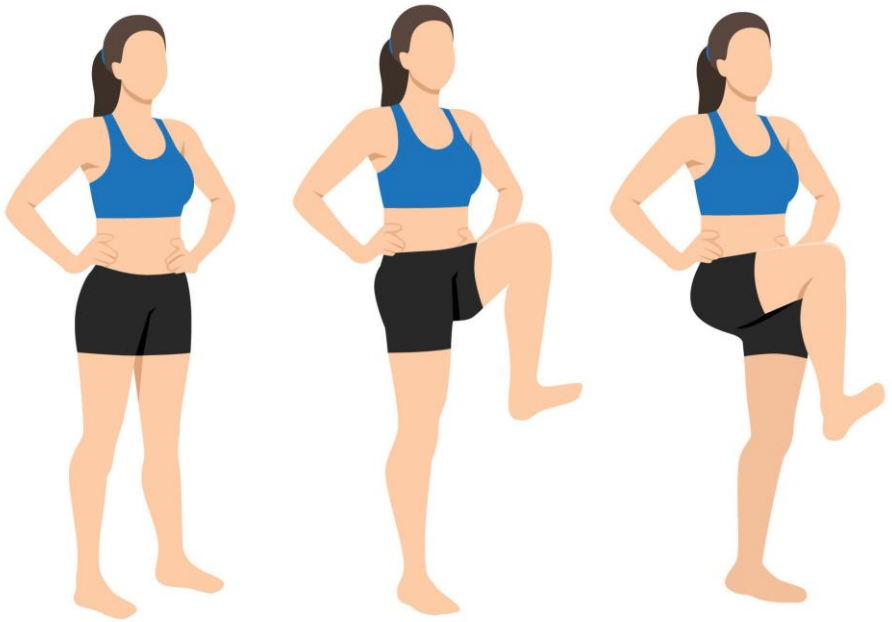
Balance Screen

- SLS: UE, torso, LE[11]
  - Arms overhead: move 1 arm to side
  - Arms in front: move 1 arm to side
  - Arms in 90/90: turn upper extremities/torso while keeping pelvis forward
  - Arms in T position: lower extremity reach (ant, post, lateral, posteromedial)
- Qualitative: amount of sway, loss of balance, excessive tension[11]

Standing Knee Lift



https://static.vecteezy.com/system/resources/previews/025/868/478/original/woman-doing-standing-knee-raises-abdominal-exercise-vector.jpg

- Arms can be in T position
- Balance, hip flexion control, lumbopelvic control
- Archetype: running, sprinting, kicking
- Breakouts:
  - Seated knee lift (arms in T position)
  - Supine hip flexion with contralateral hip/knee extension
  - Modified Thomas test

Takeaways

- In general, the more injury risk factors you have, the higher your risk of injury[7]
- Let data inform your decisions, but don’t ignore your clinical judgment or what has worked for you in the past.
- Apply common sense inferences: a bad squat leads to a bad jump, which leads to increased injury risk.
- Reference movement hierarchy to determine how to progress or regress athlete based on screening results.
- Research and normative data are difficult to infer for youth athletes due to multiple variables: age, gender, sport, position, etc.

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1. Alemany JA, Bushman TT, Grier T, et al. Functional Movement Screen: pain versus composite score and injury risk. *Journal of Science and Medicine in Sport*. 2017. doi:10.1016/j.jsams.2017.08.001
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