November 17, 2023

Return to sport strategies after sport-related concussion

Advanced Care of the Youth Athlete Symposium
Children's Hospital Colorado

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Introduction

Board-certified sports clinical specialist

CHCO PT Concussion Team Lead

Residency trained at Cincinnati Children's Hospital Sports Physical Therapy Residency

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Introduction

Certified Athletic Trainer

Associate Clinical Manager for Outreach Athletic Trainer

AT for 3d Lacrosse, Rattler's Lacrosse, and AYL Football

SPORTS MEDICINE CENTER
Children's Hospital Colorado

The Musculoskeletal Injury Problem

High school athletes: the risk of LE injury resulting in time-loss from sport increased by 34% for every previous SRC (Lynall, 2017)

Collegiate athletes:

- Basketball, soccer, and lacrosse athletes had 3.4x increased injury risk compared to non-concussed athletes within 90 days of SRC (Gilbert 2016)
- Athletes were significantly more likely to sustain a LE injury at 180 days (2.02 times) and 365 days (1.97 times) post-SRC compared to pre-concussive injury rates (Lynall et al 2015)
- Elevated LE MSK injury risk in male football athletes post-SRC have been demonstrated to extend beyond 365 days from initial concussive event (Krill 2018)

Professional athletes: National Football League athletes who reported one, two, or three or more concussions had up to 63%, 126%, and 165% greater odds of sustaining a LE musculoskeletal injury (Pietrosimone 2015)

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Specific to high school athletes…

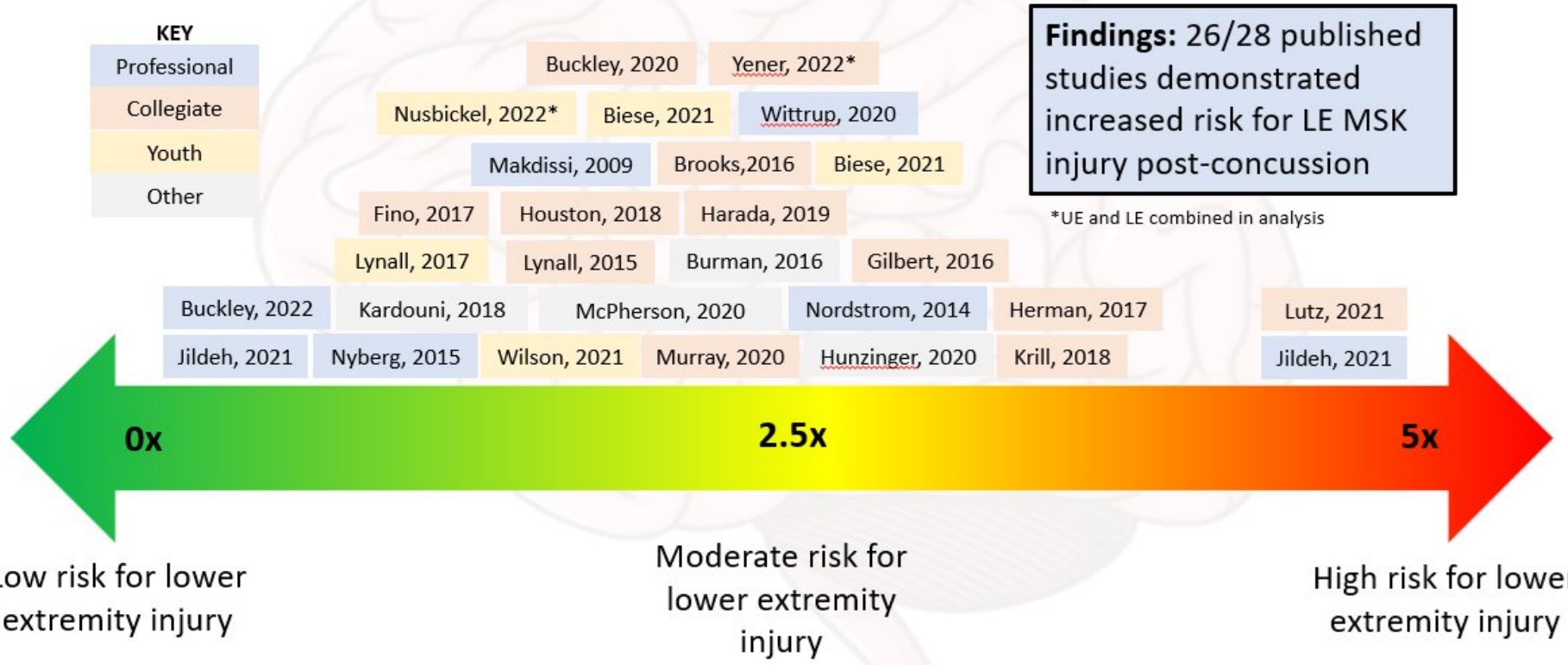
Previous hx of concussion = 34% increase in odds of sustaining a time-loss LE injury

- 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

Lynall et al, 2017

SPORTS MEDICINE CENTER
Children's Hospital Colorado

RELATIONSHIP BETWEEN CONCUSSION AND SUBSEQUENT LOWER EXTREMITY INJURY RISK



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

*UE and LE combined in analysis

@JasonAvedesian

So, why are athletes getting hurt?

“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)

"It has been demonstrated through numerous studies that following a concussive event, the majority of athletes are able to return to baseline values relating to symptom reporting, NP performance, and balance/sway within a relatively short time period. However, subtle cognitive and physical deficiencies may still persist, only to be revealed during a dynamic sporting environment that tasks performers with completing highly complex maneuvers.” (Avedesian 2020)

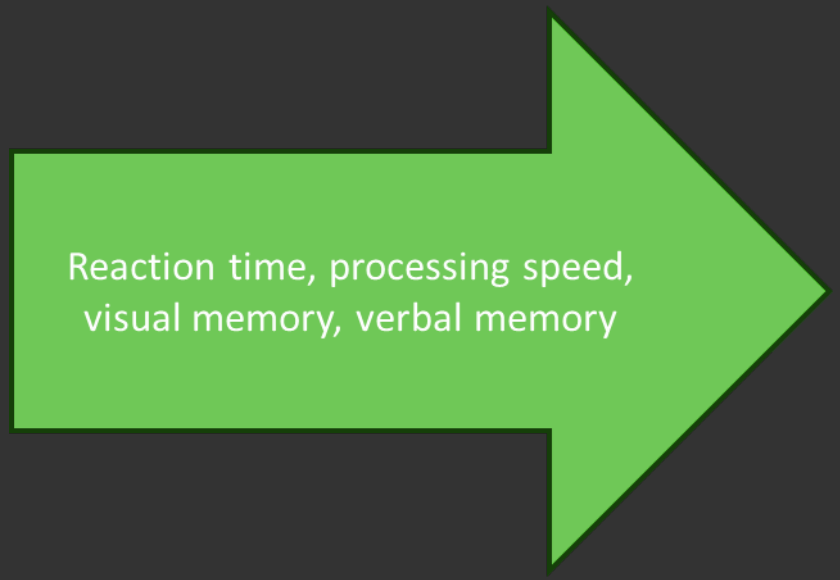
SPORTS MEDICINE CENTER
Children's Hospital Colorado

What is “motor control”?

- Definition: "How the nervous system interacts with the rest of the body and the environment to produce purposeful, coordinated movements." (Low 2018)
- Processing of sensory information  coordinating motor output
- Key aspects:
  - Motor learning
  - Motor planning

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Impaired motor control



Increased musculoskeletal injury risk

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Motor Control Research in Athletes Post-SRC

Athletes who went on to sustain a LE injury within 1 year after SRC demonstrated:

- Greater gait speed differential at 21 days post RTS clearance (Howell 2018)
- Slower speed and greater double-limb support time (Oldham 2020)

"At this time, motor control is neither explicitly assessed nor targeted in interventions."

Haider 2018, Avedesian 2020

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Relationship between cognitive function and LE injury

- Athletes classified as "low performers" on NP test battery displayed *biomechanical patterns suggesting a greater risk for ACL injury with dual-task drop landings* (Herman 2017)
  - Greater vertical ground reaction forces
  - Greater anterior shear forces
  - Greater knee abduction moments
  - Decreased trunk flexion angle
- Deficiencies in processing environmental stimuli and task constraints as well as in preplanning correct movement sequences may lead to inability to produce protective muscular forces, thus leading to high impact loads and subsequent injury (Swanik 2015)


So, now what?
SPORTS MEDICINE
CENTER
Children's Hospital Colorado

Step	Activity	Example	Goal	Date completed
1	Symptom-limited activity	Daily activities (walking, being with family/friends, attending school).	Gradual reintroduction of typical daily activity	
2A	Light aerobic exercise - intensity up to ~55% maxHR HR goal: ____	Stationary cycling or fast walking. Begin with 20 minutes and advance duration as tolerated.	Increase heart rate	
2B	Moderate aerobic exercise - intensity up to ~70% maxHR HR goal: ____	Stationary cycling or jogging. Begin with 30 minutes and advance duration as tolerated. May start light resistance training that does not result in more than mild and brief exacerbation of concussion symptoms.		
3	Individual sport-specific exercise	Sport-specific training away from the team environment (running, change of direction and/or individual training drills). No activities at risk of head impact.	Add movement, change of direction	

Note: If sport-specific training involves any risk of inadvertent head impact, medical clearance should occur prior to Step 3

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Return to Sport Progression After Concussion - Steps 4–6 should begin after the resolution of any symptoms, abnormalities in cognitive function and any other clinical findings related to the current concussion, including with and after physical exertion.

Step	Activity	Example	Goal	Date completed
4	Non-contact training drills	Exercise to high intensity including more challenging training drills (passing drills, multiplayer training) can integrate into a team environment.	Resume usual intensity of exercise, coordination and increased thinking	
5	Full contact practice	Participate in normal training activities.	Restore confidence and assess functional skills by coaching staff	
6	Return to sport	Normal game play		

NOTE: Athletes experiencing concussion-related symptoms during Steps 4–6 should return to Step 3 to establish full resolution of symptoms with exertion before engaging in at-risk activities.

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Traditional Assessment Tools

- Symptom reporting
- NP testing
- Balance assessment
- Vestibular/oculomotor screening
- Cervical spine assessment
- Aerobic capacity

"Based on the evidence of higher risk of MSK injuries after concussion, standard clinical assessments for athletes with concussion should include not only physical symptoms and cognitive function before return to sport but also neuromuscular risk factors associated with increased risk for MSK injuries." (McPherson 2019)

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Case Study

16 y/o female soccer player

Concussion sustained 3 weeks ago after hitting head with opponent going for header

Started PT 2 weeks

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Step 1: Symptom limited activities

- Walking, being with friends and family

Step 2A: Light aerobic exercise

- Stationary bike or fast walking x 20 min
- Dual task walking
- Tandem gait
    - Reverse numbers

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Step 2B: Moderate aerobic exercise (light resistance training)

- 20-30 minutes of light jogging
- Single leg balance
  - Ankle strength
  - Proprioception
- Squats
  - Valgus, anterior translation of the knee, trunk control

SPORTS MEDICINE CENTER
Children's Hospital Colorado

NEED MEDICAL CLEARANCE BEFORE STEP 3

Step 3: Individual sports-specific exercise

- Jogging
  - Progressively increase speed
  - Directional Changes
- Single leg hops exercises
  - Cross jumps
    - Control, strength
- Ball Drills
  - Inside/Outside
  - Top tapping the ball
  - Dribbling straight line
  - Dribbling around cones

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Step 4: Non-contact Practice

- Warm up/stretch with Team
- Line Drills and Ladder Drills
  - Speed, Coordination, Change of Direction
- Ball Drills
  - Chipping
  - Short passes
  - Volleys
  - Shooting

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Step 5: Full contact practice

- 1:1→ 2:2→3:3
- Controlled headers
  - Monitor
  - Check-in
  - Reaction to contact with other players
  - Body control

Step 6: Return to Sport

- Check in and monitor

Beyond Step 6: Weekly Check-Ins

- Check on strength, proprioception, control
- Adjust HEP

SPORTS MEDICINE CENTER
Children's Hospital Colorado

New(er) Assessment/Progression Suggestions

1. Complex gait
2.
3.

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Complex Gait

- "Walking on uneven surfaces or in crowded environments requiring obstacle avoidance and navigation"
- Dual task comparison
  - Greater motor and cognitive demands
- Limited research findings
- Motor performance recovery is not associated with cognitive function
- Impaired dynamic stability and obstacle avoidance may suggest deficits in:
  - Executive functioning
  - Spatial awareness
  - Rapid information processing

SPORTS MEDICINE CENTER
Children's Hospital Colorado

New(er) Assessment/Progression Suggestions

1. Complex gait
2. Sports-specific biomechanics
3.

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Sports-specific biomechanics

- Alterations in hip, leg, and knee stiffness with unilateral landing tasks (DuBose 2017)
- Greater knee valgus and internal rotation on cutting limb (Quatman 2009)
- Consider using objective movement analysis in RTP progression
  - Tuck jump
  - Jump-landings
  - Jump-cutting
  - Single leg squat
  - Y-balance
  - Motion capture/force platforms (in an ideal world!)
- Add in external stimuli (visual, auditory, tactile) and **COMPARE PERFORMANCE**
- Incorporate into RTP protocols and monitor once athlete has fully RTS in an effort to reduce risk of LE injury

Step	Activity	Example	Goal	Date completed
1	Symptom-limited activity	Daily activities (walking, being with family/friends, attending school).	Gradual reintroduction of typical daily activity	
2A	Light aerobic exercise - intensity up to ~55% maxHR HR goal: ____	Stationary cycling or fast walking. Begin with 20 minutes and advance duration as tolerated.	Increase heart rate	
2B	Moderate aerobic exercise - intensity up to ~70% maxHR HR goal: ____	Stationary cycling or jogging. Begin with 30 minutes and advance duration as tolerated. May start light resistance training that does not result in more than mild and brief exacerbation of concussion symptoms.		
3	Individual sport-specific exercise	Sport-specific training away from the team environment (running, change of direction and/or individual training drills). No activities at risk of head impact.	Add movement, change of direction	

Note: If sport-specific training involves any risk of inadvertent head impact, medical clearance should occur prior to Step 3

Appendix 5

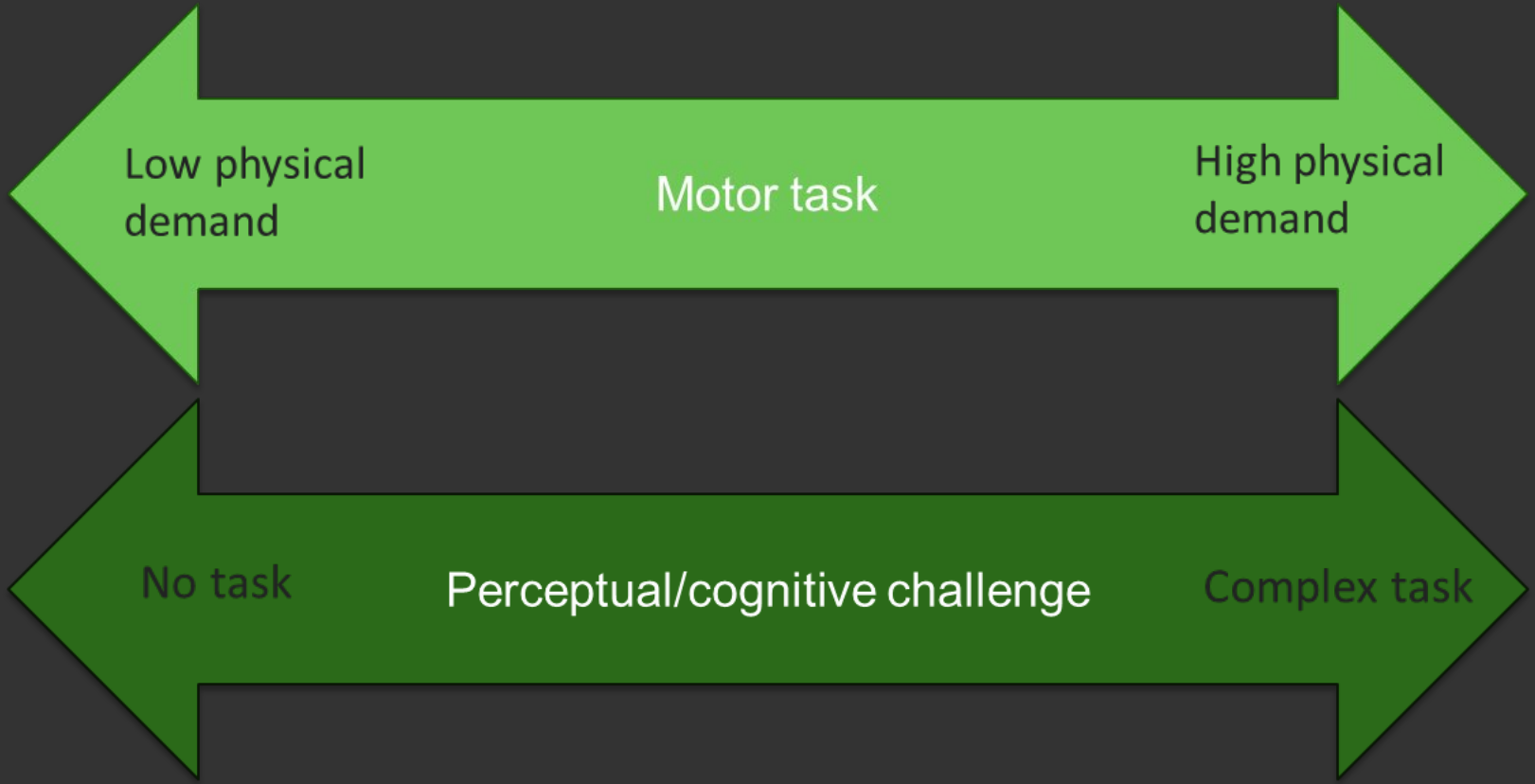
Return to Physical Activity Following Concussion

Soccer

Stage	Activity	Soccer Specific Exercise	Objective of the Stage
1	No physical activity; Complete physical and cognitive rest	• No activity	• Recovery and elimination of symptoms
2	Light aerobic activity	• 10-15 min of walking at home or at field, or stationary bike	• Add light aerobic activity and monitor for symptom return
3	Moderate aerobic activity Light resistance training	• 20-30 min jogging • Resistance training -body weight squats and push-ups 1 set of 10 reps each	• Increase aerobic activity and monitor for symptom return
4	Non-contact soccer specific drills	• Inside/inside, top tapping the ball, dribbling in a straight line, dribbling around cones, chipping, goal- keeper punts, goal-keeper catches, long and short passing (inside foot and instep), shooting, volleys	• Maximize aerobic activity • Accelerate to full speed with change of directions (cuts) • Introduce rotational head movements • Monitor for symptoms
5	Limited contact soccer drills	• Ball tossed headers from knees (progress to standing then jumping) • goal-keeper dives from knees (progress to standing), 1 on 1 (progress to 2 on 2, 3 on 3 etc.)	• Maximize aerobic activity • Add deceleration/rotational forces in controlled setting • Monitor for symptoms
6	Full practice (after medical clearance)	• Normal training activities	• Reassess for symptoms every 30 minutes throughout the practice • Monitor for symptoms
7	Return to play	• Normal game play	• Assess frequently • Monitor for symptoms

- Progress to the next stage may occur every 24 hours as long as symptoms do not return.
- It is recommended that you seek further medial attention if you fail more than 3 attempts to pass a stage

SPORTS MEDICINE CENTER
Children's Hospital Colorado



SPORTS MEDICINE CENTER
Children's Hospital Colorado

New(er) Assessment/Progression Suggestions

1. Complex gait
2. Sports-specific biomechanics
3. Injury prevention principles

SPORTS MEDICINE CENTER
Children's Hospital Colorado

C-Spine Strengthening

Smaller mean neck circumference, smaller mean neck to head circumference ratio, and weaker mean overall neck strength were significantly associated with concussion risk

(Collins et al 2014)

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Specific to soccer…

Biomechanics of head and neck movement = head acceleration with heading the ball

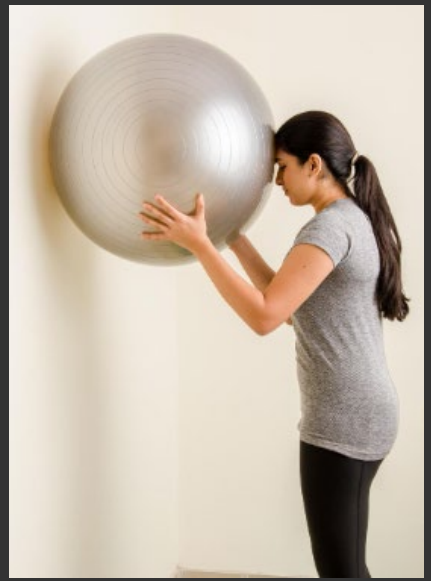
- Evidence suggests that brain injury is associated with head acceleration

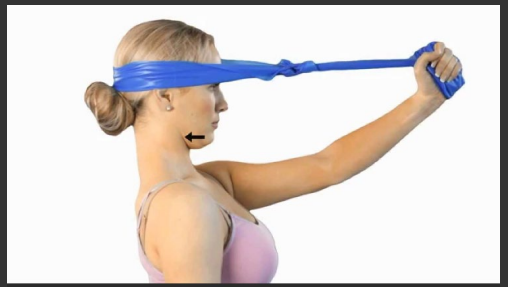
Symmetrical strength in neck flexors and extensors may reduce head acceleration of experienced collegiate players at low ball velocity

- Has not been studied in a younger population

A low flexion/extension ratio of <0.60 has been associated with a higher injury risk with a F/E closer to 1 being recommended for a number of contact sport athletes
(Gillies 2022)

SPORTS MEDICINE CENTER
Children's Hospital Colorado





SPORTS MEDICINE
CENTER
Children's Hospital Colorado


REMINDER!
Research in its infancy, there is so much room for growth!
Get creative with your athletes!
SPORTS MEDICINE
CENTER
Children's Hospital Colorado

Thank you!

Virginia Winn, MSc, LAT, ATC
Athletic Trainer
Children’s Hospital Colorado- Outreach Associate Clinical Manager
Virginia.Winn@Childrenscolorado.org

Sarah Reinking, PT, DPT
Board-certified sports physical therapist
Children's Hospital Colorado PT Concussion Team Lead
Sarah.reinking@childrenscolorado.org

SPORTS MEDICINE CENTER
Children's Hospital Colorado

References

Avedesian JM, Covassin T, Dufek JS. The Influence of Sport-Related Concussion on Lower Extremity Injury Risk: A Review of Current Return-to-Play Practices and Clinical Implications. Int J Exerc Sci. 2020 Aug 1;13(3):873-889. PMID: 32922630; PMCID: PMC7449327.

Chmielewski TL, Tatman J, Suzuki S, Horodyski M, Reisman DS, Bauer RM, Clugston JR, Herman DC. Impaired motor control after sport-related concussion could increase risk for musculoskeletal injury: Implications for clinical management and rehabilitation. J Sport Health Sci. 2021 Mar;10(2):154-161. doi: 10.1016/j.jshs.2020.11.005. Epub 2020 Nov 11. PMID: 33188963; PMCID: PMC7987572.

Brooks MA, Peterson K, Biese K, Sanfilippo J, Heiderscheit BC, Bell DR. Concussion increases odds of sustaining a lower extremity musculoskeletal injury after return to play among collegiate athletes. *Am J Sports Med.* 2017;44(3):742–747.

Dubose DF, Herman DC, Jones DL, Tillman SM, Clugston JR, Pass A, Hernandez JA, Vasilopoulos T, Horodyski M, Chmielewski TL. Lower Extremity Stiffness Changes after Concussion in Collegiate Football Players. Med Sci Sports Exerc. 2017 Jan;49(1):167-172. doi: 10.1249/MSS.0000000000001067. PMID: 27501359; PMCID: PMC5161586.

Herman DC, Jones D, Harrison A, Moser M, Tillman S, Farmer K, Chmielewski TL. Concussion may increase the risk of subsequent lower extremity musculoskeletal injury in collegiate athletes. *Sports Med.* 2017;47(5):1003–1010.

Howell DR, Kirkwood MW, Provance A, Iverson GL, Meehan WP 3rd. Using concurrent gait and cognitive assessments to identify impairments after concussion: a narrative review. Concussion. 2018 Jan 19;3(1):CNC54. doi: 10.2217/cnc-2017-0014. PMID: 30202596; PMCID: PMC6094155.

Low M. A time to reflect on motor control in musculoskeletal physical therapy. *J Orthop Sports Phys Ther.* 2018;48:833–836.

Lynall RC, Mauntel TC, Pohlig RT, Kerr ZY, Dompier TP, Hall EE, Buckley TA. Lower extremity musculoskeletal injury risk after concussion recovery in high school athletes. *J Athl Train.* 2017;52(11):1028–1034.

May KH, Marshall DL, Burns TG, Popoli DM, Polikandriotis JA. Pediatric sports specific return to play guidelines following concussion. Int J Sports Phys Ther. 2014 Apr;9(2):242-55. PMID: 24790785; PMCID: PMC4004129.

McLeod TC, Lewis JH, Whelihan K, Bacon CE. Rest and Return to Activity After Sport-Related Concussion: A Systematic Review of the Literature. J Athl Train. 2017 Mar;52(3):262-287. doi: 10.4085/1052-6050-51.6.06. PMID: 28387547; PMCID: PMC5384824.

McPherson AL, Nagai T, Webster KE, Hewett TE. Musculoskeletal Injury Risk After Sport-Related Concussion: A Systematic Review and Meta-analysis. Am J Sports Med. 2019 Jun;47(7):1754-1762. doi: 10.1177/0363546518785901. Epub 2018 Aug 3. PMID: 30074832.

Oldham JR, Howell DR, Knight CA, Crenshaw JR, Buckley TA. Single-Task and Dual-Task Tandem Gait Performance Across Clinical Concussion Milestones in Collegiate Student-Athletes. Clin J Sport Med. 2021 Nov 1;31(6):e392-e397. doi: 10.1097/JSM.0000000000000836. PMID: 32852299; PMCID: PMC7887129.

Quatman-Yates CC, Hunter-Giordano A, Shimamura KK, Landel R, Alsalaheen BA, Hanke TA, McCulloch KL. Physical Therapy Evaluation and Treatment After Concussion/Mild Traumatic Brain Injury. J Orthop Sports Phys Ther. 2020 Apr;50(4):CPG1-CPG73. doi: 10.2519/jospt.2020.0301. PMID: 32241234.

Quatman CE, Hewett TE. The anterior cruciate ligament injury controversy: is "valgus collapse" a sex-specific mechanism? Br J Sports Med. 2009;43(5):328–335

Swanik CB. Brains and sprains: The brain's role in noncontact anterior cruciate ligament injuries. *J Athl Train.* 2015;50(10):1100–1102.

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Additional References

Patricios JS, Schneider KJ, Dvorak J*, et al* Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022 *British Journal of Sports Medicine* 2023;**57:**695-711.

SPORTS MEDICINE CENTER
Children's Hospital Colorado

Let’s Move: Practical Time

- Complex gait assessment: obstacle course
- SCAT6 dual task
- Single leg Exercises
  - Squats 2 sets of 5 reps
  - Balance without ball
  - Balance with ball (color or number)
- Advanced cervical exercises
  - Plank rollout on balls

SPORTS MEDICINE CENTER
Children's Hospital Colorado