

- I. Early Sports Specialization in Youth Athletes
 - A. Target Audience: Youth Athletes, parents, sports coaches
 - B. Athletes age range
 1. Lower Limit: ~8 years old
 2. Upper Limit: 16-18 years old
 - C. Definition of ESS^{3,4,13}
 1. Early sports specialization
 2. Year-round sports participation (single sport or multiple)
 3. Multiple teams same sport (travel, AAU, etc.)
 - a. Increased prevalence^{3,5}
 - D. Factors associated with ESS
 1. Psychosocial Considerations^{3,4,7,22}
 - a. Socialization and positive peer relationships, leadership, teamwork, improved self esteem³
 - b. Cognitive benefits and increased motivation^{4,7}
 - c. Parental influence
 - d. Coaching influence
 - i. Both stressors which can decrease above positive
 - ii. Both increase perfectionism mentality in athletes-- increased self-pressure⁷
 - iii. Leads to excessive training, pushing through injuries⁷
 - iv. Risk of harmful culture around youth sports⁷
 - e. Why?
 - i. chance for college scholarship/ professional sport aspirations^{8,10}
 - f. Burnout rates for Youth athletes^{4,5,8,11,13}
 2. Repetitive loading in similar planes of motion^{1,6,8,53}
 - a. Overuse/overload potential^{4,6,11}
 - i. volume, intensity, lack of recovery^{4,6,11}
 - ii. relates to MSK and physiologic immaturity in youth athletes⁵
 - b. Decreased potential for development of other movement patterns^{1,4,13,14}
 - i. Increase chance of training error^{1,6}
 - ii. Contributes to further problems in late adolescence due to maladaptive loading patterns^{1,6,13,14}
 - c. Fatigue with decreased rest time (over scheduling)^{4,6,8,11}
 3. Key factors in early adolescences: puberty, significant changes in height (peak velocity height), decreased coordination with new body parameters, increased force capacity^{1,8,27}
 - E. Common repetitive/ overuse injuries seen in early adolescence: ^{2,6,8}
 1. Stress fracture
 2. Strain/ sprains
 - i. muscular
 - ii. lateral ankle
 3. Apophyseal injuries^{27,53}
 - i. Osgood-Schlatter's

- ii. Seaver's
 - 4. Epiphyseal injuries^{5,27}
 - 5. tendinopathy
 - i. patellar tendon (PFPS)/ anterior knee pain
 - ii. Achilles' tendon
 - *Puberty related injuries=gradual onset vs acute ²⁷
 - F. Is ESS beneficial to the athlete? ^{3,5,8}
 - 1. Early adolescence ^{4,8}
 - a. not recommended, per above reasons^{3,8}
 - b. large potential for gains in early training due to untrained potential and growth factors^{12,34}
 - 2. Late adolescence ^{3,5,8}
 - a. not harmful
 - b. may not be beneficial towards collegiate athletic/ professional sport participation
 - 3. Is Sports specialization necessary for best performance/ chance towards collegiate/professional goals? ^{3,5}
 - G. Best Practice/Recommendations ^{3,4,6,11}
 - 1. Variable play in early youth (5 years-puberty) ^{3,4,9,34,40}
 - a. make activities fun to increase buy-in
 - b. structured (sports) and unstructured play
 - c. improves acquisition of fundamental movement patterns and techniques to improve overall neuromuscular development.^{11,12,14,34}
 - d. prior exposure to complex movement patterns contribute to future success and gains in said movement pattern^{12,14}
 - 2. Specialization later in adolescences (~16 years) ^{3,5,8,11}
 - 3. track volume and intensity of loads across leagues (school, travel, etc), sports— don't overload
 - a. especially important during puberty¹¹
 - b. Modify as need, reduce and then progressively overload to build back up to pre-injury level ^{12,27}
 - 4. Adequate rest and recovery between seasons (2-3 successive months off from formal sports a year) ¹¹
 - 5. sleep (6 or fewer hours associated with increased risk for injury)^{6,53}
 - 6. nutrition/ hydration^{6,53}
- II. Repetitive/ sub-acute Lower Extremity Injury Modifiable Risk Reduction
- A. Target Audience: sports coaches, Strength and conditioning professionals
 - B. Repetitive vs chronic/sub-acute injury
 - 1. Repetitive overload injuries^{1,4,6,8,11}
 - a. adjust frequency, volume, intensity, etc—modify training parameters
 - 2. maladaptive movement pattern predisposition^{1,4,6,13}
 - a. need for variable movement strategy exposure in multiplanar and various joint positions

C. Mechanisms of Common LE injuries seen in youth sports

1. Lateral ankle sprain^{35,38,42}
 - a. corrective neuromuscular eversion potential³⁸
 - b. initial contact vs weight acceptance injury³⁸
2. Apophyseal and epiphyseal injuries^{5,27}
 - a. rapid bone growth > muscle/tendon lengthening
3. Tendinopathy (Achilles', patellar)/ PFPS^{16,25}
 - a. chronic overload > tissue capacity^{16,25}
 - i. necessitates need to appropriately load pre-season
 - ii. modify activity, slowly progressive/ overload tissues over time
4. Musculotendinous Injuries^{18,41,52}
 - a. Hamstring strain⁴¹
 - i. most prevalent field sport injury
 - ii. sprint type vs stretch type injuries⁴¹
 - iii. Trunk control and sensorimotor contributions⁴¹
 - b. adductor strain⁵²
 - i. kicking sports
5. Knee Instability injuries: ACL, MCL tears^{14,15,17,18,20,25,26,28,29,30,31,32,33,34,35,37,43,44,45,50,53,54}
 - a. biomechanical principles^{1,14,35,43,44,54}
 - i. excessive anterior tibial shear, reduced posterior inhibitors^{14,15,54}
 - ii. repetitive material fatigue^{15,18,20,25}
 - aa. need for adequate recovery time
 - iii. deficits in quad strength⁴³
 - iv. Rotation knee loading (lack of dynamic control)^{14,25,43,45}
 - aa. proximal control (hip and core)^{17,31,45}
 - v. Performance factors during change of direction/deceleration^{25,43}
 - b. Neurological and sensorimotor contributions^{26,28,29,30,32,33,34,50}
 - i. decreased visual-spatial attention, delayed reaction time/processing speed, reduced working memory²⁶
 - ii. Perception-action mismatch with surrounding environment²⁶
 - iii. Delayed anticipatory neuromuscular response²⁶
 - iv. growth spurts decrease these in young adolescents¹⁴
 - v. fatigue is a factor¹⁴
 - vi. neurological impairments increase risk for secondary injury²⁸

D. Movement Principles and Important Considerations

1. Early adolescent Movement strategies^{19,21}
 - a. Multiple movement strategies^{19,21,34}
 - i. development of stabilizer muscles²¹
 - b. Make activities game-like and engaging¹⁹
 - c. Find ways to progress/ challenge the multiplanar movements^{19,34}
 - d. Develop cardiovascular system and general fitness⁴⁶
 - e. Require more external feedback for new motor tasks¹⁴

2. Role of Closed Kinetic Chain on LE dynamics^{35,53}
 - a. foot/ankle force attenuation impacts joints up the chain^{35,42}
 - i. don't forget to train the calves³⁵
 - b. core and truncal control for reduce AP and frontal plane control^{14,17,43,53}
 - c. Use these principles to supplement LE/ core strength training⁴³
 - d. role of soleus in limiting anterior TF shear forces with weight acceptance⁵³
 - e. bilateral and unilateral approaches to strength train, difference in each^{39,43}
3. Use of plyometrics, Eccentrics and isometrics^{23,24,38,40,43,44,46,48}
 - a. Eccentrics^{38,40,42,46}
 - i. Produce more force than other loading
 - ii. stretch-shortening cycle^{38,46,48}
 - aa. foundation for plyometric training
 - iii. isometrics goal to increase tendon stiffness⁴⁸
 - iv. modify and progress via time under tension, changing variables
 - v. important to control foot pronation (post tib, TA, foot intrinsics, FHL) for LE mechanics and GRF attenuation^{38,42}
 - b. Plyometrics
 - i. goal to increase muscular stiffness⁴⁸
 - ii. Intensive vs extensive plyos²⁴
 - iii. Rhythm and coordination⁴⁶
 - iv. lateral and rotational jumps for non-sagittal sports²⁴
 - aa. linear and curvilinear approaches²⁴
4. Deceleration training^{25,37,44,51}
 - a. higher mechanical demands than accelerations^{25,37}
 - b. Principles of proper cutting (COD) and deceleration mechanics^{20,25,44}
 - i. role of the penultimate step²⁵
 - c. rapid muscular contraction^{25,41}
 - d. progressive overload³⁷
5. Neuromuscular/ CNS development^{26,28,29,30,33,34,38,44,45,50}
 - a. working memory and pattern recognition^{26,33}
 - i. anticipatory responses³³
 - b. dual task^{26,33}
 - c. spatial recognition and multiple object tracking^{26,33}
 - i. selective attention³³
 - ii. prediction of deception³³
 - d. reaction time and processing speed^{26,29}
 - e. agility vs COD in regard to neuromuscular processing²⁶
 - i. need for random practice and variable response training^{26,33}
 - f. External focus/cueing^{28,30,45}
6. Male vs Female considerations^{22,31,34,36,53}

- a. need for adequate loading and movement development in female athletes³¹
 - b. both need adequate volume and intensity to elicit adaptations (too little vs too much principle)³⁶
- 7. Demands of sports imposed
 - a. jump athletes²⁹
 - b. sprint (needs deceleration)^{25,37}
- 8. Screening for athletes at risk³³
 - a. deficiencies in movement with variable tasks³³
 - b. Assess where each athlete is deficient, prevention programs are individualized to athlete's needs—may not be feasible⁴⁵
- 9. Return to Sport Criteria^{22,32,34,47,49,50}
 - a. Assess, don't guess
 - b. ACL^{47,49}
 - i. currently decreased likelihood to return preinjury levels (65%)^{32,47}
 - ii. inability to meet RTS criteria before RTS leads to increased risk of secondary injury^{47,49}
 - iii. strength testing^{32,47}
 - aa. LSI and maximal HHD not enough as standalone measure⁴⁷
 - iv. hop testing
 - v. quality of movement screening (COD, agility, blocked and randomized practice trials)^{20,32,34,47,49,50}
 - aa. compensatory offloading strategy to protect involved limb during athletic performance task^{32,34,47}
 - bb. asymmetries of unplanned COD tasks⁴⁷
 - vi. psychological readiness^{32,47}
 - vii. contralateral knee injury risk^{28,34,47,49}
 - aa. neurological deficits²⁸
- 10. Adjust for fact that some athletes not pre-disposed to variable movement patterns.
- 11. Barriers
 - a. unable to coach form/technique⁴⁵
 - i. Find ways to challenge athletes in multiplanar movements that do not require high level coaching or technique
 - ii. know the demands imposed on the body with activities selected, and where faults may be seen in movement
 - b. compliance/athlete adherence⁴⁵
 - i. Make movements fun and engaging (especially in early adolescents—games> strict form-based exercises
 - ii. incorporate multiple movement patterns in dynamic warmup—more time effective than '10-minute foam roll and static stretch'⁴⁵
 - c. COVID considerations⁴⁵

i. slowly build-up movement patterns, volume, frequency, and intensities due to delayed and shortened seasons