

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

- ii. Seaver's
    - 4. Epiphyseal injuries<sup>5,27</sup>
    - 5. tendinopathy
      - i. patellar tendon (PFPS)/ anterior knee pain
      - ii. Achilles' tendon
  - \*Puberty related injuries=gradual onset vs acute <sup>27</sup>
  - F. Is ESS beneficial to the athlete? <sup>3,5,8</sup>
    - 1. Early adolescence <sup>4,8</sup>
      - a. not recommended, per above reasons<sup>3,8</sup>
      - b. large potential for gains in early training due to untrained potential and growth factors<sup>12,34</sup>
    - 2. Late adolescence <sup>3,5,8</sup>
      - 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? <sup>3,5</sup>
  - G. Best Practice/Recommendations <sup>3,4,6,11</sup>
    - 1. Variable play in early youth (5 years-puberty) <sup>3,4,9,34,40</sup>
      - 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.<sup>11,12,14,34</sup>
      - d. prior exposure to complex movement patterns contribute to future success and gains in said movement pattern<sup>12,14</sup>
    - 2. Specialization later in adolescences (~16 years) <sup>3,5,8,11</sup>
    - 3. track volume and intensity of loads across leagues (school, travel, etc), sports—don't overload
      - a. especially important during puberty<sup>11</sup>
      - b. Modify as need, reduce and then progressively overload to build back up to pre-injury level <sup>12,27</sup>
    - 4. Adequate rest and recovery between seasons (2-3 successive months off from formal sports a year) <sup>11</sup>
    - 5. sleep (6 or fewer hours associated with increased risk for injury)<sup>6,53</sup>
    - 6. nutrition/ hydration<sup>6,53</sup>
- 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<sup>1,4,6,8,11</sup>
      - a. adjust frequency, volume, intensity, etc—modify training parameters
    - 2. maladaptive movement pattern predisposition<sup>1,4,6,13</sup>
      - 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<sup>35,38,42</sup>
  - a. corrective neuromuscular eversion potential<sup>38</sup>
  - b. initial contact vs weight acceptance injury<sup>38</sup>
2. Apophyseal and epiphyseal injuries<sup>5,27</sup>
  - a. rapid bone growth > muscle/tendon lengthening
3. Tendinopathy (Achilles', patellar)/ PFPS<sup>16,25</sup>
  - a. chronic overload > tissue capacity<sup>16,25</sup>
    - i. necessitates need to appropriately load pre-season
    - ii. modify activity, slowly progressive/ overload tissues over time
4. Musculotendinous Injuries<sup>18,41,52</sup>
  - a. Hamstring strain<sup>41</sup>
    - i. most prevalent field sport injury
    - ii. sprint type vs stretch type injuries<sup>41</sup>
    - iii. Trunk control and sensorimotor contributions<sup>41</sup>
  - b. adductor strain<sup>52</sup>
    - i. kicking sports
5. Knee Instability injuries: ACL, MCL tears<sup>14,15,17,18,20,25,26,28,29,30,31,32,33,34,35,37,43,44,45,50,53,54</sup>
  - a. biomechanical principles<sup>1,14,35,43,44,54</sup>
    - i. excessive anterior tibial shear, reduced posterior inhibitors<sup>14,15,54</sup>
    - ii. repetitive material fatigue<sup>15,18,20,25</sup>
      - aa. need for adequate recovery time
    - iii. deficits in quad strength<sup>43</sup>
    - iv. Rotation knee loading (lack of dynamic control)<sup>14,25,43,45</sup>
      - aa. proximal control (hip and core)<sup>17,31,45</sup>
    - v. Performance factors during change of direction/deceleration<sup>25,43</sup>
  - b. Neurological and sensorimotor contributions<sup>26,28,29,30,32,33,34,50</sup>
    - i. decreased visual-spatial attention, delayed reaction time/processing speed, reduced working memory<sup>26</sup>
    - ii. Perception-action mismatch with surrounding environment<sup>26</sup>
    - iii. Delayed anticipatory neuromuscular response<sup>26</sup>
    - iv. growth spurts decrease these in young adolescents<sup>14</sup>
    - v. fatigue is a factor<sup>14</sup>
    - vi. neurological impairments increase risk for secondary injury<sup>28</sup>

### D. Movement Principles and Important Considerations

1. Early adolescent Movement strategies<sup>19,21</sup>
  - a. Multiple movement strategies<sup>19,21,34</sup>
    - i. development of stabilizer muscles<sup>21</sup>
  - b. Make activities game-like and engaging<sup>19</sup>
  - c. Find ways to progress/ challenge the multiplanar movements<sup>19,34</sup>
  - d. Develop cardiovascular system and general fitness<sup>46</sup>
  - e. Require more external feedback for new motor tasks<sup>14</sup>

2. Role of Closed Kinetic Chain on LE dynamics<sup>35,53</sup>
  - a. foot/ankle force attenuation impacts joints up the chain<sup>35,42</sup>
    - i. don't forget to train the calves<sup>35</sup>
  - b. core and truncal control for reduce AP and frontal plane control<sup>14,17,43,53</sup>
  - c. Use these principles to supplement LE/ core strength training<sup>43</sup>
  - d. role of soleus in limiting anterior TF shear forces with weight acceptance<sup>53</sup>
  - e. bilateral and unilateral approaches to strength train, difference in each<sup>39,43</sup>
3. Use of plyometrics, Eccentrics and isometrics<sup>23,24,38,40,43,44,46,48</sup>
  - a. Eccentrics<sup>38,40,42,46</sup>
    - i. Produce more force than other loading
    - ii. stretch-shortening cycle<sup>38,46,48</sup>
      - aa. foundation for plyometric training
    - iii. isometrics goal to increase tendon stiffness<sup>48</sup>
    - 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<sup>38,42</sup>
  - b. Plyometrics
    - i. goal to increase muscular stiffness<sup>48</sup>
    - ii. Intensive vs extensive plyos<sup>24</sup>
    - iii. Rhythm and coordination<sup>46</sup>
    - iv. lateral and rotational jumps for non-sagittal sports<sup>24</sup>
      - aa. linear and curvilinear approaches<sup>24</sup>
4. Deceleration training<sup>25,37,44,51</sup>
  - a. higher mechanical demands than accelerations<sup>25,37</sup>
  - b. Principles of proper cutting (COD) and deceleration mechanics<sup>20,25,44</sup>
    - i. role of the penultimate step<sup>25</sup>
  - c. rapid muscular contraction<sup>25,41</sup>
  - d. progressive overload<sup>37</sup>
5. Neuromuscular/ CNS development<sup>26,28,29,30,33,34,38,44,45,50</sup>
  - a. working memory and pattern recognition<sup>26,33</sup>
    - i. anticipatory responses<sup>33</sup>
  - b. dual task<sup>26,33</sup>
  - c. spatial recognition and multiple object tracking<sup>26,33</sup>
    - i. selective attention<sup>33</sup>
    - ii. prediction of deception<sup>33</sup>
  - d. reaction time and processing speed<sup>26,29</sup>
  - e. agility vs COD in regard to neuromuscular processing<sup>26</sup>
    - i. need for random practice and variable response training<sup>26,33</sup>
  - f. External focus/cueing<sup>28,30,45</sup>
6. Male vs Female considerations<sup>22,31,34,36,53</sup>

- a. need for adequate loading and movement development in female athletes<sup>31</sup>
  - b. both need adequate volume and intensity to elicit adaptations (too little vs too much principle)<sup>36</sup>
- 7. Demands of sports imposed
  - a. jump athletes<sup>29</sup>
  - b. sprint (needs deceleration)<sup>25,37</sup>
- 8. Screening for athletes at risk<sup>33</sup>
  - a. deficiencies in movement with variable tasks<sup>33</sup>
  - b. Assess where each athlete is deficient, prevention programs are individualized to athlete's needs—may not be feasible<sup>45</sup>
- 9. Return to Sport Criteria<sup>22,32,34,47,49,50</sup>
  - a. Assess, don't guess
  - b. ACL<sup>47,49</sup>
    - i. currently decreased likelihood to return preinjury levels (65%)<sup>32,47</sup>
    - ii. inability to meet RTS criteria before RTS leads to increased risk of secondary injury<sup>47,49</sup>
    - iii. strength testing<sup>32,47</sup>
      - aa. LSI and maximal HHD not enough as standalone measure<sup>47</sup>
    - iv. hop testing
    - v. quality of movement screening (COD, agility, blocked and randomized practice trials)<sup>20,32,34,47,49,50</sup>
      - aa. compensatory offloading strategy to protect involved limb during athletic performance task<sup>32,34,47</sup>
      - bb. asymmetries of unplanned COD tasks<sup>47</sup>
    - vi. psychological readiness<sup>32,47</sup>
    - vii. contralateral knee injury risk<sup>28,34,47,49</sup>
      - aa. neurological deficits<sup>28</sup>
- 10. Adjust for fact that some athletes not pre-disposed to variable movement patterns.
- 11. Barriers
  - a. unable to coach form/technique<sup>45</sup>
    - 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 adherence<sup>45</sup>
    - 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'<sup>45</sup>
  - c. COVID considerations<sup>45</sup>

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