Title
AOSSM Early Sport Specialization Consensus Statement

Journal
Orthopaedic Journal of Sports Medicine, 4(4)

ISSN
2325-9671

Authors
LaPrade, Robert F
Agel, Julie
Baker, Joseph
et al.

Publication Date
2016-04-01

DOI
10.1177/2325967116644241

Peer reviewed

AOSSM Early Sport Specialization Consensus Statement

Robert F. LaPrade,* MD, PhD, Julie Agel,[†‡] MA, ATC, Joseph Baker,[§] PhD, Joel S. Brenner,[‖¶] MD, MPH, Frank A. Cordasco,[#**] MD, MS, Jean Côté,[††] PhD, Lars Engebretsen,[‡‡§§‖‖‖] MD, PhD, Brian T. Feeley,[¶¶] MD, Daniel Gould,[##] PhD, Brian Hainline,[ab] MD, Timothy E. Hewett,[c] PhD, Neeru Jayanthi,[d] MD, Mininder S. Kocher,[ef] MD, MPH, Gregory D. Myer,[ghij] PhD, FACSM, CSCS*D, Carl W. Nissen,[klm] MD, Marc J. Philippon,[nopq] MD, and Matthew T. Provencher,[rstu] MD, CDR, MC, USNR

Background: Early sport specialization is not a requirement for success at the highest levels of competition and is believed to be unhealthy physically and mentally for young athletes. It also discourages unstructured free play, which has many benefits.

Purpose: To review the available evidence on early sports specialization and identify areas where scientific data are lacking.

Study Design: Think tank, roundtable discussion.

Results: The primary outcome of this think tank was that there is no evidence that young children will benefit from early sport specialization in the majority of sports. They are subject to overuse injury and burnout from concentrated activity. Early multisport participation will not deter young athletes from long-term competitive athletic success.

Conclusion: Youth advocates, parents, clinicians, and coaches need to work together with the sport governing bodies to ensure healthy environments for play and competition that do not create long-term health issues yet support athletic competition at the highest level desired.

Keywords: early sports specialization; consensus; youth sports

Despite mounting scientific evidence and professional athletes speaking out against its value, the trend of early sports specialization continues with tournaments and competitive leagues increasingly available as well as wider media exposure (eg, The Short Game [7- to 8-year-old golfers], Friday Night Tykes [Texas Youth Football]). Early sports specialization, or early single-sport specialization, is believed to be potentially damaging to the long-term physical and mental health of athletes and has not been validated as a requirement for competitive success in sport.[3] Early youth sport specialization has been associated with increased rates of overuse injury, burnout, decreased motivation for participation, and sports withdrawal,[19,33,34,43] while multisport participation is proposed to result in better long-term performance and an increase in lifetime enjoyment of physical activity and recreational sports participation.[2]

With these issues in mind, the American Orthopaedic Society for Sports Medicine (AOSSM) convened a think tank on the topic of early sports specialization on October 2, 2015, in Rosemont, Illinois. This report represents the consensus of the participants of this meeting; importantly, it identifies areas where more research is necessary to address the outstanding questions surrounding this topic (Appendix 1) and achieve the goal of healthy athletic participation through adulthood at the highest level of participation desired.

DEFINITION OF EARLY SPORTS SPECIALIZATION AND BACKGROUND INFORMATION

It was the consensus at this symposium that early sports specialization, or early single-sport specialization, be defined by the following 3 criteria:

1. Participation in intensive training and/or competition in organized sports greater than 8 months per year (essentially year round)[34]
2. Participation in 1 sport to the exclusion of participation in other sports (limited free play overall)[33]
3. Involving prepubertal (seventh grade or roughly age 12 years) children.

The Orthopaedic Journal of Sports Medicine, 4(4), 2325967116644241
DOI: 10.1177/2325967116644241

WHAT IS THE EVIDENCE THAT EARLY SPORTS SPECIALIZATION IS DETRIMENTAL?

A variety of researchers and organizations have investigated the impact of early sports specialization on long-term health and future sport success. The consensus statement of the American Medical Society for Sports Medicine[19] on overuse injuries and burnout in youth sports contends that a variety of physical and mental health concerns can be attributed to early sports specialization. In their position statement, they identify the concerns listed in Table 1.

Their recommendations for avoiding burnout and injury include the following:

- Avoiding overscheduling and excessive time commitments
- Consider using a valid and reliable tool to monitor burnout
- Emphasize skill development and fun
- Emphasize lifelong physical activity skills.

The International Olympic Committee[8] also published a consensus statement on youth athletic development. Their goal was to develop healthy, capable, and resilient young athletes while attaining widespread inclusive, sustainable, and enjoyable participation and success for all levels of athletic achievement. They identified several physical and mental health concerns associated with youth athletic

‡Address correspondence to Julie Agel, MA, ATC, Box 359798, 325 Ninth Avenue, Seattle, WA 98104, USA (email: bagel@uw.edu).
*Chief Medical Officer, The Steadman Philippon Research Institute, Vail, Colorado, USA.
†Harborview Medical Center, Seattle, Washington, USA.
§Professor and Director, School of Kinesiology and Health Science, York University Centre of Aging Research and Education, York University, Toronto, Ontario, Canada.
‖Medical Director, Sports Medicine Program, Children's Hospital of The King's Daughters, Norfolk, Virginia, USA.
¶Director, Division of Sports Medicine and Adolescent Medicine, and Associate Professor of Pediatrics, Eastern Virginia Medical School, Norfolk, Virginia, USA.
#Professor of Orthopaedic Surgery, Weill Cornell Medical College, Cornell University, New York, New York, USA.
**Attending Orthopaedic Surgeon, Sports Medicine and Shoulder Service; Co–medical Director, Leon Root Motion Analysis Laboratory, Hospital for Special Surgery, New York, New York, USA.
††Professor and Director, School of Kinesiology and Health Studies, Queen's University, Kingston, Ontario, Canada.
‡‡Medical & Scientific Department, International Olympic Committee, Lausanne, Switzerland.
§§Oslo Sports Trauma Research Center, Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway.
‖‖Department of Orthopedic Surgery, Oslo University Hospital, Oslo, Norway.
¶¶Associate Professor-in-Residence and Fellowship Director, Sports Medicine, Department of Orthopaedic Surgery, University of California, San Francisco, San Francisco, California, USA.
##Professor and Director, Institute for the Study of Youth Sports, College of Education/Department of Kinesiology, Michigan State University, East Lansing, Michigan, USA.
[a]NCAA Chief Medical Officer and Clinical Professor of Neurology, Indiana University School of Medicine, Indianapolis, Indiana, USA.
[b]New York University School of Medicine, New York, New York, USA.
[c]Consultant, Orthopaedic Surgery; Director, Biomechanics, Sports Medicine Research; Professor of Orthopaedic Surgery, Physical Medicine & Rehabilitation, Physiology & Biomedical Engineering, Mayo Clinic, Rochester, Minnesota, USA.
[d]Associate Professor, Orthopedics and Family Medicine; Director, Tennis Medicine; Associate Director, Primary Care Sports Medicine Fellowship, Emory Sports Medicine Center, Atlanta, Georgia, USA.
[e]Professor of Orthopaedic Surgery, Harvard Medical School, Boston, Massachusetts, USA.
[f]Associate Director, Division of Sports Medicine, Boston Children's Hospital, Boston, Massachusetts, USA.
[g]Director, Research and The Human Performance Laboratory, Division of Sports Medicine I, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA.
[h]Department of Pediatrics and Orthopaedic Surgery, University of Cincinnati, Cincinnati, Ohio, USA.
[i]The Micheli Center for Sports Injury Prevention, Waltham, Massachusetts, USA.
[j]Department of Orthopaedics, University of Pennsylvania, Philadelphia, Pennsylvania, USA.
[k]Elite Sports Medicine, Connecticut Children's Medical Center, Farmington, Connecticut, USA.
[l]Professor, Department of Orthopaedics, University of Connecticut, Storrs, Connecticut, USA.
[m]Team Physician, Trinity College, Hartford, Connecticut, USA.
[n]Managing Partner, Steadman Clinic, Vail, Colorado, USA.
[o]Co-chairman, Steadman Philippon Research Institute, Vail, Colorado, USA.
[p]Fellowship co-Director, Steadman Philippon Research Institute, Sports Medicine Program, Vail, Colorado, USA.
[q]Adjunct Clinical Associate Professor, Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania, USA.
[r]Chief of Sports Medicine and Surgery, Massachusetts General Hospital, Boston, Massachusetts, USA.
[s]Head Team Physician and Medical Director, New England Patriots, Boston, Massachusetts, USA.
[t]Professor of Surgery, Uniformed Services, University of the Health Sciences, Bethesda, Maryland, USA.
[u]Visiting Professor, Harvard University, Boston, Massachusetts, USA.
R.F.L. and J.A. are co-chairs.

One or more of the authors has declared the following potential conflict of interest or source of funding: This study was not sponsored. The think tank was sponsored by the AOSSM, who paid for staff travel and lunch. R.F.L. receives consulting fees and royalties from Arthrex, Ossur, and Smith & Nephew. M.S.K. is a consultant for Smith & Nephew Endoscopy, Ossur, OrthoPediatrics, and Best Doctors; receives royalties from OrthoPediatrics; has stock/stock options in Pivot Medical and Fixes-4-Kids; and receives publishing royalties from WB Saunders and Elsevier. G.S.M. receives book royalties from Human Kinetics. M.J.P. receives royalties from Smith & Nephew, Bledsoe, Donjoy, Arthrosurface, and ConMed Linvatec; is a paid consultant for Smith & Nephew and MIS; has stock/stock options in Arthrosurface, Hipco, and MIS; receives research support from Ossur, Siemens, Smith & Nephew, and Vail Valley Medical Center; receives publishing royalties from SLACK Inc and Elsevier; and receives other financial/material support from Smith & Nephew and Vail Valley Surgical Center. N.J. receives research support from the AOSSM foundation and is a consultant to AAP COSMF and WATA tennis for travel. D.G. receives book royalties from Human Kinetics.

TABLE 1
Categorization of Risk Factors for Overuse Injury[a]

Growth-related factors
Susceptibility of growth cartilage to repetitive stress
Adolescent growth spurt
Other intrinsic factors
Previous injury
Previous level of conditioning
Anatomic factors
Menstrual dysfunction
Psychological and developmental factors (athlete-specific)
Extrinsic factors
Training progression
Equipment/footwear
Sport technique
Psychologic factors (adult and peer influences)

[a]Adapted from DiFiori et al.[19] Reprinted with permission.

talent development, including insufficient sleep, increased overuse injury rates, overtraining, burnout, and eating disorders. They recommended that children be encouraged to participate in a variety of different activities and develop a wide range of skills and avoid specialization until at least puberty. They recommended focusing on the integration of strength and neuromuscular fitness in conjunction with the development of the entire athlete in terms of competence, confidence, connection, and character.

Researchers have suggested that early specialization isolates the young athlete from their peers (interferes with normal identity development) and increases the potential for burnout or withdrawal from sport as a result of chronic stress.[11,43] Athletes who experience burnout are characterized by a loss of motivation and especially have decreased intrinsic motivation, a lack of enjoyment, high perceived stress and anxiety, ineffective or limited stress coping strategies, and mood disturbances.[23,24]

Several types of burnout have been identified.[25,26] One of these is social psychological in nature and is driven by factors such as perfectionism in the young athlete or excessive coach and/or parental pressure to perform. The other type is driven by physical factors, such as overtraining and lack of sleep. Research suggests, then, that while high training loads are certainly involved in athlete burnout, other personal and situational factors of a social psychological nature also play a very important role.[20,25,26] Recent evidence also suggests that monitoring the balance between intensive sports participation/specialization and other childhood commitments such as friends, school, and extracurricular activities is important to consider in determining the health and wellness status of young athletes.[20]

Studies directly linking youth sports specialization to psychosocial outcomes are lacking. However, the available evidence suggests youth specialization before the age of 12 years is associated with increased burnout and dropout rates and decreased athletic development over time.[22] Importantly, there is a lack of evidence that early specialization is necessary for adult elite performance. In a German study, 88% of Olympians reported participating in more than 1 sport as a child.[28] Work by Güllich and Emrich[27] evaluated 1558 German national squad athletes in Olympic sports and reported that a great training volume in other sports beyond the individual's current main sport was associated with great long-term success in an elite sport (unpublished data, 2006). In addition, 97% of professional athletes believed being a multisport athlete was beneficial to their success in another study.[39]

One factor driving the emphasis on early specialization is the increasingly common practice of early talent identification/selection. Researchers in this area note that talent identification is difficult at all phases of development, but particularly difficult to identify before puberty. The available evidence reviewed at this meeting does not support the belief that early sports specialization is a requirement (gymnastics and figure skating may be examples of exceptions because the top tiers of competition tend to occur during the teenage years to the early 20s). Diversification of sports during childhood results in increased long-term participation, increased adult performance, and increased personal development.[17] Moreover, early diversification does not seem to hinder elite-level participation in sports where peak performance occurs after maturation.[4] A transition period seems to occur around the end of primary school (at age approximately 13 years). Playing sport without the consistent intervention of coaches (youth-led activities like play) has also been identified as necessary to develop good skill levels prior to this age.

IS EARLY SPECIALIZATION NECESSARY FOR ELITE PERFORMANCE?

Support for early specialization comes from the assumption that early training experiences distinguish those who become experts/elites from those who do not. Much of the recent rhetoric regarding early sports specialization can be traced to studies of "deliberate practice," a specific form of training proposed by Ericsson and colleagues[21] more than 2 decades ago. Deliberate practice is highly effortful and relevant to performance improvement, and Ericsson et al[21] proposed that anyone beginning deliberate practice early would have a benefit over peers starting later. Despite the consistent evidence for the value of deliberate practice for athlete development in general,[6] there is very little support for the necessity of high amount of deliberate practice during childhood for the development of adults' elite performance. Comparisons of experts and nonexperts in field hockey,[29] soccer,[29] and triathlon[5] found that differences in training profiles did not occur until age 13, 15, and 20 years, respectively. Although there may be specific sports where early specialization is required due to early ages of peak performance (eg, gymnastics, figure skating, diving), the overall evidence supporting early specialization, as a general requirement for elite performance in sport where peak performance is achieved in adulthood, is not convincing. It is felt that some, but not all, athletes in early entry sports such as women's gymnastics, figure skating, and dance may benefit from specialization because their peak competitive levels generally occur before full maturity. These sports may lend themselves to be at the

TABLE 2
Seven Postulates Associated With the Different Pathways of the Development Model of Sport Participation[a]

Postulate 1: Early diversification does not hinder elite sport participation in sports where peak performance is reached after maturation.
Postulate 2: Early diversification is linked to a longer sport career and has positive implications for long-term sport involvement.
Postulate 3: Early diversification allows participation in a range of contexts that most favorably affects positive youth development.
Postulate 4: High amounts of deliberate play during the sampling years build a solid foundation of intrinsic motivation through involvement in activities that are enjoyable and promote intrinsic regulation.
Postulate 5: A high amount of deliberate play during the sampling years establishes a range of motor and cognitive experiences that children can ultimately bring to their principal sport of interest.
Postulate 6: Around the end of primary school (about age 13 years), children should have the opportunity to choose to either specialize in their favorite sport or continue in sport at a recreational level.
Postulate 7: Late adolescents (around age 16 years) have developed the physical, cognitive, social, emotional, and motor skills needed to invest their effort into highly specialized training in one sport.

[a]Adapted from Côté et al.[16] Reprinted with permission.

forefront of the effort to reset competitive expectations so that early specialization would not be necessary to meet the expectations of the sport.

WHAT RESEARCH HAS BEEN DONE TO DATE?

Several models of athlete development in sport have been proposed in the literature to explain long-term participation and performance in sport.[1,12,41,44] Systematic review studies of athletes' development models[9,10] have reported that the Developmental Model of Sport Participation (DMSP)[12,14] is the most prominent conceptualization of athletes' development within the sports literature. The DMSP is a conceptual framework that integrates the developing athlete in its environment with processes that focus on early diversification and play.

The different stages of the DMSP are based on changes in the type and amount of involvement in different sports, deliberate play, and deliberate practice throughout an athlete's career.[16] It is composed of a series of 7 postulates associated with the different pathways and outcomes of the DMSP. The postulates highlight the efficiency of sport programs to develop adult elite performance, continued participation, and personal development based on early sampling (postulates 1, 2, and 3), deliberate play (postulates 4 and 5), and key transitions throughout development (postulates 6 and 7). The DMSP and its postulates (Table 2) integrate the various outcomes of sport—performance, participation, and personal development—by focusing on key proximal processes (deliberate play, deliberate practice, and early sampling) and the environment in which the processes are occurring (role of coaches, peers, and parents).

A review of the evidence that supports these postulates can be found in recent publications.[13,17] In sum, the DMSP and its 7 postulates are based on a developmental approach that features the interaction of variables at the activity (eg, deliberate play, diversification) and the environment levels (eg, sport setting, coaching) that have strong implications for youth sport policies.[15]

The current evidence supports the contention that children should be encouraged to take part in a variety of sports at levels consistent with their abilities and interests to best attain the physical, psychological, and social benefits of sport.[36] Children who specialize early (eg, prior to maturation) in a single sport may execute less age-appropriate sports skills, especially when they do not participate in as many youth-led activities (eg, deliberate play) as their peers. Without opportunities to experience sport diversification, children may not fully develop neuromuscular patterns that may be protective of injury. Based on the cumulative evidence, sport specialization was concluded to be a real issue that will very likely continue to occur in many sports. The authors recommend the inclusion of diverse opportunities for motor skill development during the growing years, combined with planned integrative neuromuscular training to help optimize the potential for success and reduced injury risk in young athletes (Figure 1).[37]

It is well accepted that youth-driven play has shifted greatly toward parent- and coach-driven activities recently at the expense of free play (N. Jayanthi, personal communication, October 15, 2015). Athletes who come from high median incomes (>US$70,000 per year) and who have private insurance have an increased risk of early sports specialization (N. Jayanthi, personal communication, October 15, 2015). Moreover, athletes who utilize private facilities are often encouraged to participate year round because those facilities are businesses that require income.

It is also important to recognize that chronological age is not equal to developmental age (Figure 2). For increased organized play over free play, there has also been reported to be a greater than 2 to 1 increased injury rate.[34] Athletes who specialize before the age of 12 years also may have a trend toward greater risks of being injured (N. Jayanthi, personal communication, October 15, 2015). Increased athlete exposure has a linear relationship to adjusted injury rate in high school athletes. For ice hockey, there is an increased dropout rate for those who participate in off-ice training at younger ages.

An increased risk of hip injury has been shown in hockey players as they move through the ranks of organized hockey. As hockey players reached the midget level, with increased age and increased participation in hockey, the prevalence of factors associated with labral tears in the hip increased. When matched with skiers of the same age, hockey players had significantly higher prevalence of factors associated with labral tears in the hip. This study showed that risk factors may not only include years of play but may also include sports that put the hip at risk in young athletes.[38] Increased years of play was also a factor in young tennis players. A total of 148 youth tennis players

Figure 1. Qualified education and instruction support the complex programming components for effective implementation of integrative neuromuscular training. Reprinted with permission from Myer et al.[35]

were screened. Players were defined at risk of femoroacetabular impingement (FAI) if they had a positive anterior impingement test, a positive FABER (flexion, abduction, external rotation) distance test, or decreased internal rotation. Those players who had hips at risk played tennis longer compared with those without hips at risk (9.5 years compared with 8.6 years).[18]

Biomechanical Issues

Practitioners, trainers, parents, coaches, and athletes should be aware of the nonmodifiable risk factors that may predispose some athletes to a greater risk of injury. In the knee, anatomic factors include genu recurvatum, valgus alignment, increased lateral tibial slope greater than 4 degrees, and increased Beighton score.[7] These factors have been reported to be associated with a greater risk of knee injury. For elbow injuries associated with throwing sports, poor throwing mechanics such as increased trunk lean, improper stride, and "opening up early" are risk factors for elbow injury.[40] However, it is important to recognize that high throwing velocity increases elbow valgus moment, and younger pitchers may put greater forces on the medial elbow and be at a greater risk for injury.

DISCUSSION

The topic of early sport specialization is receiving significant attention in the media.[42] There is a false or overstated importance of sports as it relates to individual roles in

Figure 2. Ten-year-old female basketball players.

society; sports may be a financial bonanza for a very few but not the masses. The historical context of the need for large amounts of sport-specific practice may stem from the 10,000-hour rule,[21] but research has not substantiated this as a requirement for athletic success. One potential cause of this early sport specialization is that in North America particularly there is a competitive varsity school sports program and "select" teams which, while allowing for multisport participation, are often combined with nonschool sport teams. There is an expectation for better athletes to participate in school teams as well as community (eg, regional, state) teams, which may set up these athletes to over-train. There is also a push for college scholarships where 14- and 15-year-olds are now committing to colleges based on their early teenage sports performance.

The biggest roadblock to making this culture shift may be the acknowledgement of coaches and parents that children are participating too early in sports, but "this doesn't apply to 'my' sport or 'my' child." This consensus meeting emphasized that we need to reset expectations of when competitive events occur and the level of difficulty or skill expected at each age level. Sports that have taken on this task with varying degrees of success are ice hockey in Canada and tennis in the United States.[30] In the United States, an ideal training program for safe development in a high-level junior tennis player has been recommended as follows[32]:

- Minimum 12-year-old junior tournament player
- Play less than 12 hours a week of organized tennis
- Participate in less than 12 tournaments a year
- Possibly consider another sport (soccer) with an off-season for tennis
- Participate in 2+ hours a week of injury prevention training

However, within the current ranking system for athletes that tennis uses, this program will not allow an athlete to maintain a high ranking, highlighting a built-in contradiction.

Current recommendations for athletes who are involved in early sports specialization are as follows[37]:

- Children who participate in more hours per week than their age, for more than 16 hours per week in intense training, and who are specialized in sport activities should be closely monitored for indicators of burnout, overuse injury, or potential decrements in performance due to overtraining.[31]
- All youth (including inactive youth) can benefit from periodized strength and conditioning (eg, Integrative Neuromuscular Training [INT]) to help them prepare for the demands of competitive sport participation.
- Youth who specialize in a single sport should plan periods of isolated and focused INT to enhance diverse motor skill development and reduce injury risk factors.

Early sports specialization has been identified as damaging for the future physical and mental health of the athlete. Future recommendations should include the following points:

- A public health message that multisport participation will not diminish the athletic capabilities of athletes; we need better and more effective messaging with improved data.
- A focused effort toward the importance of physical education as an opportunity for noncompetitive play and put it back into school curriculums.
- Increased emphasis on the economic impact of a lack of physical fitness to health care costs as presented in obesity and various medical comorbidities.
- Recognition that each sport has its own distinct loading pattern and a distinct overuse injury to go with it.
- Identification of the optimal level of exposure to maximize training effect with minimal risk of injury needs to be identified.
- Early sport specialization has not been shown to be beneficial for high-caliber athletic performance at the national team/Olympic/professional levels, and in fact may be detrimental.

ACKNOWLEDGMENT

The authors acknowledge Barton J. Mann, PhD, of the American Orthopaedic Society for Sports Medicine (deceased).

REFERENCES

1. Abbott A, Collins D. Eliminating the dichotomy between theory and practice in talent identification and development: considering the role of psychology. *J Sports Sci*. 2004;22:395-408.
2. Bahr R. Demise of the fittest: are we destroying our biggest talents? *Br J Sports Med*. 2014;48:1265-1267.
3. Baker J. Early specialization in youth sport: a requirement for adult expertise? *High Ability Stud*. 2003;14:85-94.
4. Baker J, Côté J, Abernethy B. Sport specific training, deliberate practice and the development of expertise in team ball sports. *J Appl Sport Psychol*. 2003;15:12-25.
5. Baker J, Deakin J, Côté J. Expertise in ultra-endurance triathletes: early sport involvement, training structure, and the theory of deliberate practice. *J Appl Sport Psychol*. 2005;17:64-78.
6. Baker J, Young B. 20 years later: deliberate practice and the development of expertise in sport. *Int Rev Sport Exerc Psychol*. 2014;7:135-157.
7. Beighton P, Solomon L, Soskolne C. Articular mobility in an African population. *Ann Rheum Dis*. 1973;32:413-418.
8. Bergeron MF, Mountjoy M, Armstrong N, et al. International Olympic Committee consensus statement on youth athletic development. *Br J Sports Med*. 2015;49:843-851.
9. Bruner MW, Erickson K, McFadden KK, Côté J. Tracing the origins of athlete development models in sport: a citation path network analysis. *Int Rev Sport Exerc Psychol*. 2009;2:23-37.
10. Bruner MW, Erickson K, Wilson B, Côté J. An appraisal of athlete development models through citation network analysis. *Psychol Sport Exerc*. 2010;11:133-139.
11. Coakley J. Burnout among adolescent athletes: a personal failure or social problem? *Sociol Sport J*. 1992;9:271-285.
12. Côté J. The influence of the family in the development of talent in sports. *Sport Psychol*. 1999;13:395-417.
13. Côté J, Abernethy B. A developmental approach to sport expertise. In: Murphy S, ed. *The Oxford Handbook of Sport and Performance Psychology*. New York, NY: Oxford University Press; 2012:435-447.
14. Côté J, Baker J, Abernethy B. Practice and play in the development of sport expertise. In: Eklund R, Tenenbaum G, eds. *Handbook of Sport Psychology*. 3rd ed. Hoboken, NJ: Wiley; 2007:184-202.
15. Côté J, Hancock D. Evidence-based policies for youth sport programs. *Int J Sport Policy*. 2014;8:1-15.
16. Côté J, Lidor R, Hackfort D. To sample or to specialize? Seven postulates about youth sport activities that lead to continued participation and elite performance. *Int J Sport Exerc Psychol*. 2009;9:7-17.
17. Côté J, Vierimaa M. The developmental model of sport participation: 15 years after its first conceptualization. *Sci Sport*. 2014;29(suppl):S63-S69.
18. Cotorro A, Philippon M, Briggs K, Boykin R, Dominguez D. Hip screening in elite youth tennis players. *Br J Sports Med*. 2014;48:582.
19. DiFiori JP, Benjamin HJ, Brenner J, et al. Overuse injuries and burnout in youth sports: a position statement from the American Medical Society for Sports Medicine. *Br J Sports Med*. 2014;48:287-288.
20. Dubuc NG, Schinke RJ, Eys MA, Battochio R, Zaichowsky L. Experiences of burnout among adolescent female gymnasts: three case studies. *J Clin Sport Psychol*. 2010;4:1-18.
21. Ericsson KA, Krampe RT, Tesch-Romer C. The role of deliberate practice in the acquisition of expert performance. *Psychol Rev*. 1993;100:363-406.
22. Fraser-Thomas J, Côté J, Deakin J. Examining adolescent sport dropout and prolonged engagement from a developmental perspective. *J Appl Sport Psychol*. 2008;20:318-333.
23. Goodger K, Gorely T, Lavallee D, Harwood C. Burnout in sport: a systematic review. *Sport Psychol*. 2007;21:127-151.
24. Goodger K, Wolfenden L, Lavallee D. Symptoms and consequences associated with three dimensions of burnout in junior tennis players. *Int J Sport Psychol*. 2007;38:342-364.
25. Gould D, Tuffey S, Udry E, Loehr J. Burnout in competitive junior tennis players, III. Individual differences in the burnout experience. *Sport Psychol*. 1997;11:257-276.
26. Gould D, Tuffey S, Udry E, Loehr J. Burnout in competitive junior tennis players. II: qualitative analysis. *Sport Psychol*. 1996;10:341-366.
27. Güllich A, Emrich E. Sport-spanning training variability augments individual success potential in elite sport. Paper presented at: 11th Annual Congress of the European College of Sports Science; July 5-8, 2006; Lausanne, Switzerland.
28. Güllich A. Selection, de-selection and progression in German football talent promotion. *Eur J Sport Sci*. 2014;14:530-537.
29. Helsen WF, Starkes JL, Hodges NJ. Team sports and the theory of deliberate practice. *J Sport Exerc Psychol*. 1998;20:12-34.

30. Houghton K, Emery C. Bodychecking in youth ice hockey. Canadian Paediatric Society website. November 2, 2012. http://www.cps.ca/en/documents/position/bodychecking-ice-hockey. Accessed January 26, 2016.
31. Jayanthi N, Dechert A, Durazo R, Luke A. Training and specialization risks in junior elite tennis players. *J Med Sci Tennis*. 2011;16:14-20.
32. Jayanthi N, Feller E, Smith A. Junior competitive tennis: ideal training and tournament recommendations. *J Med Sci Tennis*. 2013;18:30-36.
33. Jayanthi N, Pinkham C, Dugas L, Patrick B, Labella C. Sports specialization in young athletes: evidence-based recommendations. *Sports Health*. 2013;5:251-257.
34. Jayanthi NA, LaBella CR, Fischer D, Pasulka J, Dugas LR. Sports-specialized intensive training and the risk of injury in young athletes: a clinical case-control study. *Am J Sports Med*. 2015;43:794-801.
35. Myer GD, Faigenbaum AD, Edwards NM, Clark JF, Best TM, Sallis RE. Sixty minutes of what? A developing brain perspective for activating children with an integrative exercise approach. *Br J Sports Med*. 2015;49:1510-1516.
36. Myer GD, Jayanthi N, Difiori JP, et al. Sport specialization, part I: does early sports specialization increase negative outcomes and reduce the opportunity for success in young athletes? *Sports Health*. 2015;7:437-442.
37. Myer GD, Jayanthi N, DiFiori JP, et al. Sports specialization, part II: alternative solutions to early sport specialization in youth athletes. *Sports Health*. 2016;8:65-73.
38. Philippon M, Ho C, Briggs K, Stull J, LaPrade R. Prevalence of increased alpha angles as a measure of cam-type femoroacetabular impingement in youth ice hockey players. *Am J Sports Med*. 2013;41:1357-1362.
39. Snyder C. *The Path to Excellence: A View on the Athletic Development of U.S. Olympians Who Competed From 2000-2012*. Colorado Springs, CO: Sport Performance and Coaching Education Division; 2014.
40. Solomito M, Garibay E, Woods J, Ounpuu S, Nissen C. Lateral trunk lean in pitchers affects both ball velocity and upper extremity joint moments. *Am J Sports Med*. 2015;43:1235-1240.
41. Stambulova NB. Developmental sports career investigations in Russia: a post-perestroika analysis. *Sport Psychol*. 1994;8:221-237.
42. Sullivan P.The rising costs of youth sports, in money and emotion. The New York Times website. January 16, 2015. http://www.nytimes.com/2015/01/17/your-money/rising-costs-of-youth-sports.html?_r=1. Accessed January 9, 2016.
43. Wiersma L. Risks and benefits of youth sport specialization: perspectives and recommendations. *Pediatr Exerc Sci*. 2000;12:13-22.
44. Wylleman P, Layalle D. A developmental perspective on transitions faced by athletes. In: Weiss M, ed. *Developmental Sport and Exercise Psychology: A Lifespan Perspective*. Morgantown, WV: Fitness Information Technology; 2004:507-527.

APPENDIX
Areas the Think Tank Identified Where Further Research Is Necessary

The following research suggestions were made during the meeting.

Short term

1. Retrospectively determine the fate of National Collegiate Athletic Association (NCAA) scholarship versus nonscholarship athletes (walk-on and DIII [Division III]). The primary endpoint would be years in sport, secondary would be injuries, time missed due to injury. Keep in mind that attrition happens more commonly between 10 to 15 years old.
2. Collect a cohort of athletes that stopped early and ask them why they stopped.

With these data, we could answer 2 important questions that would be relevant to the public: What happens to scholarship athletes when they get to college, and why do they burn out when they leave?

3. Which sports or injuries are highest risk? Focus on a single sport.
4. Develop a database that would allow for universal tracking of key variables across sports in a longitudinal fashion.

Long term

1. Develop an F-Marc program for all sports.
2. Make successful completion of skills a requirement for sport participation.
3. Is recovery (or inadequate recovery) a factor in staying healthy?
4. Small-scale interventional project with coaches.
5. One group with set hours of training and 1 group with no limit—5 years of follow-up.
6. Determine injury patterns in youth athletes and their long-term consequences.
7. Identify the age range at which sports specialization is clearly detrimental.
8. Identify the age range at which sports specialization becomes beneficial to the elite athlete being sure to define elite athlete.
9. Biomechanical studies: Determine the sport-specific risk of improper form on soft tissue or osseous overload.
10. Soft tissue laboratory: Understand the MSK (musculoskeletal) tissue changes during adolescence.

- How important is being “elite” early?
- What are the benefits of continued multisport activity?
- How much training is enough?
- How much recovery is needed?
- What is the influence of proper biomechanics on injury risk?

11. Prospective multicenter cohort study evaluating specific risks by sport and injury pathology.
12. Quantify the amount of specialized sport training that is not harmful to youth athletes.
13. Age at which specialization is appropriate.
14. Risks versus benefits of sports participation.

Could specialization be protective against acute injury through sport-specific neuromuscular control or adaptive changes?

Some of the more important think tank questions asked:

1. Conduct longitudinal studies that examine long-term participation patterns and attrition.
2. How much recovery is needed?
3. What are the benefits of multisport activity?
4. How much training is enough and too much at various ages?
5. What is the influence of proper biomechanics on injury risk?

Some think tank issues that need to be addressed:

1. We need data on the performance of athletes who specialize versus those that diversify as children.
2. Do some sports have multiple sports within them (eg, decathlon)?
3. Evidence-based versus general consensus recommendations.
4. There are 3.7 million injuries per year in high school sports. Overuse injuries are probably underestimated because many of them do not result in true time loss from sports.
5. Overscheduling is a huge issue with multiple events on the same day and consecutive days.