

Revisiting Early Sport Specialization: What's the Problem?

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Context: The assumed risks of early specialization in sport are well known, with several international consensus statements advising against specialization in early athlete development. However, there have been recent calls for more focused research in this area.

Evidence Acquisition: Research evidence from several scientific disciplines (eg, sport psychology, sports medicine, human development) were synthesized to develop a framework for practitioners working with adolescent athletes.

Study Design: Narrative review.

Level of Evidence: Level 4.

Results: There appear to be risks associated with a highly specialized approach to athlete training, but the mechanisms driving these effects are largely unknown. Greater attention to understanding these mechanisms would help mitigate risk and develop stronger policy for athlete development. Recommendations for program modifications are provided.

Conclusion: Early specialization remains an important topic for researchers and practitioners working with youth and adolescent athletes. However, more work needs to be done to provide truly evidence-based recommendations for youth athlete training.

Keywords: adolescents; training; athlete development; specialization

It appears early specialization is increasing among athletes, presumably due largely to the changing nature of youth sport participation and the professionalization of youth sport.^{11,33} Interestingly, there is no consistent definition of sport specialization. One of the earliest posited definitions described sport specialization as year-round training in a single sport at the exclusion of other sport or nonsport activities.⁸⁰ While there is some variation, researchers have found that the average age of sports specialization for elite athletes is about 14 years^{10,13,70} and is therefore during a crucial stage in human development—early adolescence. According to the World Health Organization, adolescence occurs between 10 and 19 years of age and is the transition period from childhood to adulthood.⁸² Although the age at which this life stage occurs can vary by sex (ie, girls typically reach it earlier than boys), in sport, early adolescence is usually marked by an increase in the volume of sport (ie, training and competition), and an increased pressure to specialize to become an elite athlete.⁷⁸

The notion that earlier specialization increases the likelihood of eventually achieving elite sport performance mainly comes

from research using the “deliberate practice framework.”²² As the name suggests, this framework emphasizes the time spent in training and proposes a monotonic relationship between hours spent engaging in effortful, domain-specific (ie, sport-specific) “deliberate practice” and performance. Even more relevant to the concept of *early* specialization, Ericsson et al²² suggested (1) the sooner one began deliberate practice, the sooner one would reach a high level of performance and (2) those who started deliberate practice later would not be able to reach the same level of performance as their earlier starting peers.

Despite support for other elements of this framework (eg, the positive relationship between overall time spent in training and eventual level of attainment, and the importance of domain specificity, see Young et al,⁸³ for a recent review), there is a growing body of evidence suggesting early specialization is not a prerequisite for elite level attainment in sport.^{10,13,30,57} Furthermore, early specialization among youth athletes is linked to negative consequences.^{31,37,43} One of the main concerns of early specialization relates to injuries. Athletes who are highly specialized are at greater risk of serious overuse injuries³¹ and

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are more likely to report a previous overuse injury.⁶ In addition to these types of negative physical outcomes, there is also concern about negative effects on psychological outcomes. For example, early specialization is associated with psychological needs dissatisfaction⁴⁴ and emotional exhaustion.⁶⁸ Although there have been a number of consensus statements and recommendations about the dangers of early specialization,^{11,18,37} the relationship between early specialization as a behavior and these negative consequences is poorly understood.⁴

There are likely several reasons for this disconnect in understanding. First, there is a surprising lack of research on this topic of early specialization, given its prominence in discussions of youth sport and athlete development. A recent systematic review,⁴⁵ including both empirical and nonempirical peer-reviewed papers, found that much of the literature was recirculated information in the form of commentaries and editorials. While there is value in expert opinion and summaries of previous literature, in order for the field to advance, there is a clear need for more criticality and data driven research. Of the data-driven articles, only 48 were aimed at advancing understanding of specialization in sport, and of those, only 25 examined “early” specialization.

One of the main concerns of early specialization is the outcome of overuse injuries, yet 2 separate systematic reviews and meta-analyses^{5,14} specifically evaluating specialization and overuse injury included only 5 and 6 studies, respectively. In a broader review of several aspects of specialization (eg, number of sports, months per year and hours per week of involvement, multiple team participation) and injury, only 12 studies were included. In addition to the lack of research related to specialization and injury, some have suggested that there are “substantial gaps in the scientific literature regarding the effect of specialization on motor control development, sport performance, musculoskeletal injury risk, psychosocial outcomes, burnout, attrition, and optimal strategies for youth athletes’ training and development in specific sports.”³³ This lack of research across the field leads to a lack of understanding of specialization as a whole.

A second factor contributing to poor understanding of early specialization and potential negative consequences is the lack of a clear and consistent definition of specialization. A systematic review by Moshier et al⁴⁵ reported a range of inconsistencies in the definitions and components used for specialization. While time spent in deliberate practice has often been suggested to be the underpinning rationale for specialization, Moshier et al⁴⁵ found that only 9% of studies included elements of practice in their definition of specialization. Additionally, 17% of studies failed to define specialization altogether.⁴⁵ This corroborates a 2019 review that found only 32.5% of studies operationally defined specialization.¹⁹ *Early* sport specialization becomes even more difficult to define as the parameters for “early” are arbitrary and change depending on both the sport and researcher. In previous work, some of these parameters have included (1) 12 years of age or earlier,^{15,70} (2) before 15 years of age,⁶⁰ (3) before

high school,⁸¹ and (4) as old as 23 years of age (in a sample of marathon runners.⁴⁹ Recently, a group of researchers formed a Delphi panel and came to a consensus definition of specialization as intentional and focused participation in a single sport for the majority of the year that restricts opportunities for engagement in other sports and activities.⁸ While this is a more encompassing definition, whether it is accepted and widely used in the field remains to be seen. Until there is a concrete definition of the concept of specialization, researchers will continue to struggle to fully understand these relationships.⁷¹

Collectively, these first 2 factors lead to the third and arguably most substantial limitation to our understanding of the relationships between specialization and negative consequences, a lack of knowledge regarding the mechanisms underpinning these relationships. In a 2009 review of the literature, Baker et al³ attempted to explain the mechanisms behind specialization by suggesting a range of potential factors. Unfortunately, despite the authors’ recommendations for future research that would better explain this connection, current research has taken to using a blanket construct of “specialization” that is both inconsistently defined and unreliably measured. This has led to (1) an inability to draw cause-and-effect relationships between specialization and negative consequences and (2) an inability to design optimal training and development environments.

While these issues have clear implications for researchers, their relevance for practitioners is even more important. Practitioners are warned to advise parents and athletes against the practice of specialization without understanding *why* or *how* it should be avoided. In a multidisciplinary review that provided a broad picture of the empirical research performed on the topic of specialization, DiSanti et al¹⁹ summarized the work and conclusions in this area but did not provide possible explanations for these associations. As highlighted in a recent editorial by Baker et al,⁴ “We need greater attention to the mechanisms driving any negative effects. What is it about specialization that leads to negative outcomes?” Commentaries, editorials, and reviews are regularly added to the literature on specialization, but few extend our understanding of the mechanisms underpinning these negative specialization effects. Without this understanding of the processes by which these negative events occur, practitioners, parents, and other stakeholders cannot design healthy training environments to buffer against the mechanisms.

A FRAMEWORK FOR EXPLORING EARLY SPECIALIZATION IN SPORT

In an effort to move the discussion forward, in this section, we use the existing literature on specialization to provide a framework for future work exploring these mechanisms (Figure 1).

Antecedent Conditions

The model begins with establishing that early specialization does not happen in a vacuum. There are several antecedent

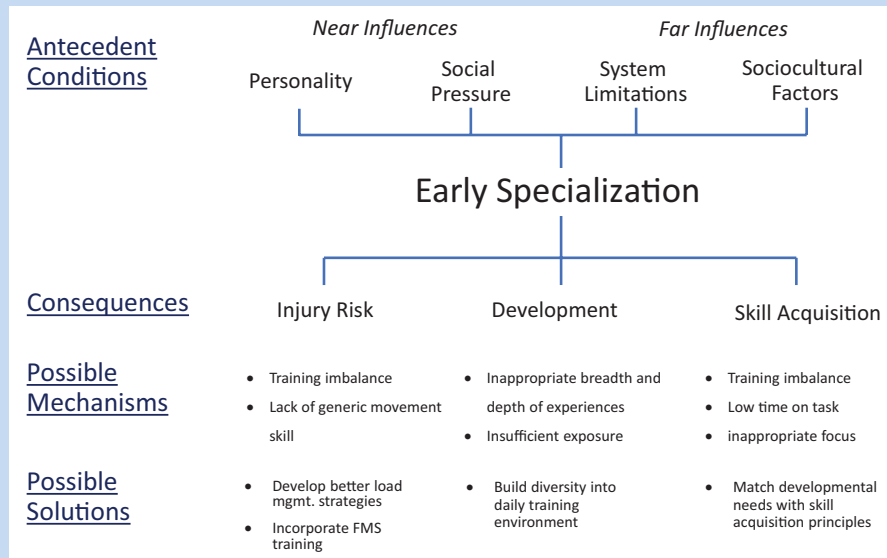


Figure 1. A framework for exploring early specialization in sport. Fundamental movement skills (FMS) are the basic building blocks of advanced movement that occurs later in athlete development.

conditions that promote its occurrence, which we have divided into those that have a close relationship with the athlete (*near influences*) and those occurring more distally (*far influences*). First, athlete-specific characteristics such as *personality* or motivation are near influences that may promote a more specialized focus during adolescence. For instance, athletes with high levels of passion⁷⁵ or commitment⁶³ may have a more focused engagement profile than those with lower scores on these measures. Moreover, *social pressure* from significant others such as peers, parents, or coaches could exert powerful influences on the decision to specialize in a single sport (eg, to be with key peers, to please valued coaches or parents).

In addition to these proximal variables, there are a number of more distal social and sport-related factors that can influence the likelihood of specialization. For example, one *system limitation* might be when sport funding comes from the number of enrollments in a program, resulting in programs being cautious of athletes participating in other sports. In many national sporting systems, sports are largely “siloes” and losing athletes (ie, to another sport) has significant repercussions for the short- and long-term success of the program. As a result, these sports may create additional training programs to complete in the off season to maintain athletes’ engagement within this one sport. Finally, the *sociocultural factors* associated with specific sports can promote more specialized engagement as the norm, seen most obviously in sports commonly referred to as “early specialization sports” such as gymnastics, figure skating, and diving. Surprisingly, there has been relatively little exploration of how these antecedents (and others) promote early specialization. As we note later in the paper, understanding the conditions from which a specialized athlete

emerges could be valuable for understanding the most appropriate response. It is to this understanding of mechanisms and responses that we turn next.

Consequences and Mechanisms

Based on prior work, we have noted 3 main categories of consequences associated with early sport specialization, although it is possible others will emerge after more research attention to the mechanisms driving these effects. The first category deals with the increased *injury risk* that is regularly noted as a negative outcome of specialization.^{7,31} Presumably, these increased risks are associated with inappropriate training loads leading to overuse injuries.²¹ Some have also noted that increased injury risk could come from the lack of foundational, or so-called “fundamental” movement skills. The implication here is that specialized involvement does not provide athletes with the same broad exposure to movement opportunities, which ultimately limits their experiential foundation and increases injury risk.

In addition to the obvious ill effects of chronic injuries on athletes’ physical development, other areas of *development* have been negatively associated with early specialization. For instance, early studies have suggested participation in intensive training with limited engagement with peers during early development can limit the acquisition of social skills (see Baker et al³ for a review). Importantly, much of this work needs to be replicated in contemporary samples. There are also links between negative psychological indicators such as eating disorders and early specialization sports,^{35,69} although this relationship may reflect elements related to the aesthetic component of these sports, rather than being a direct

consequence of specialization per se. Additionally, it has been suggested that patterns of specialization are associated with burnout and/or dropout from one's primary sport.^{25,68} However, more recent research has refuted this claim, finding no direct link between indicators of early specialization and burnout or dropout, suggesting instead mediating effects of enjoyment, competency, and autonomy.³⁸ The hypothesized mechanisms driving these negative developmental effects seem to be related to the lack of opportunities to develop "normal" skills for social, emotional, and psychological coping.

The final category of consequences, and the one that has had the greatest degree of discourse, relates to *skill acquisition*. On one hand, in the past, some researchers¹⁶ have argued that specialized forms of engagement compromise long-term skill acquisition by undermining intrinsic forms of motivation and enjoyment. On the other hand, others (eg, Ericsson et al²²) have noted the specificity of training-related adaptations and the relationship between deliberate practice and attainment, which seemingly justifies the need for starting focused, specific training, as early as possible. The relationship between time spent in practice and improvement/attainment is well established in other domains (eg, chess; see Ericsson et al²² and Newell and Rosenbloom⁴⁸), although the requirement of an early start age in sport seems questionable.^{12,42} From a skill acquisition perspective, the impacts from early specialization have the potential to be both positive (more time on task, promoting specific performance-related adaptations) and negative (imbalance between the developmental needs of the athlete leading to injury). Much of the debate about the value of early specialization as it relates to skill acquisition comes from the inability to reconcile these potentialities.

In the next section, we propose a range of solutions for practitioners working with young athletes to try to accommodate the risks and mechanisms that may be related to negative effects from early specialization. However, it is important to emphasize some of the limitations of this evidence base as a way of stimulating further work. For instance, most of these studies are done with small samples, some quite dated, that have never been replicated or extended beyond the original study design. This is a significant issue in sport—particularly elite sport, where the developmental context is critical. Discourse in this area seems to have accepted these study findings at face value, without the normal pushing and prodding that the scientific method uses to both stabilize robust findings and eliminate elements that do not stand up to scrutiny. In the framework we have presented, there is a need for considerable additional work in all elements of the model.

PROGRAMS TO MANAGE THE RISKS

As we suggest above, the negative consequences may not lie with early sport specialization alone but rather the design, implementation, and management of an early specialization program, similar to what has been proposed within talent identification and development systems.⁵⁵ From this perspective,

managing and minimizing the negative consequences associated with early specialization involves developing practices to avoid triggering potential driving mechanisms. We propose 5 strategies for practitioners to consider to manage risks.

Establish an "Appropriate" Environment

Practitioners need to understand the potential risks and negative consequences associated with specialization during early adolescence. Alongside, understanding the risks and negative consequences, taking responsibility for the design and implementation of their program and establishing an appropriate environment focused on promoting positive and reducing negative health consequences is key.⁷¹ To establish this, it is recommended the environment has clear values, expectations and day-to-day routines within the organization, which is the responsibility of all staff working with early specialization athletes.

To prevent negative *physical* consequences, practitioners must understand, place importance on and communicate the risks of early specialization to align day-to-day practices with minimizing such risks. For example, while athletes may specialize in sports, the environment can still support the development of a broad range of skills and experiences delivered in-house such as an integrative neuromuscular program (see below) and implementation of other activities (eg, within warm-ups). This can provide opportunities for the growth of fundamental movement skills while preventing overuse injuries.⁴⁷ To prevent negative *psychosocial* consequences, implementing an integrated approach focused on the personal, social, and physical youth development rather than sporting success alone would be beneficial.²⁶ Practitioners can do this by demonstrating a safe and caring environment where the person is the focus^{17,74} rather than their athletic achievements. As mentioned previously, the process of *skill acquisition* is significantly affected by a loss of motivation and enjoyment. To prevent these negative consequences, creating autonomy-supportive, mastery-oriented, and positive climates can result in less stress, greater enjoyment and more intrinsic motivation.^{77,79}

Perhaps most important, avoiding the negative consequences associated with early specialization can be done by practitioners creating an environment that values the holistic development of their athletes (ie, technical, tactical, physical, psychological, social health, and performance).⁷³ This places greater importance on understanding developmental principles as they relate to children and young people, the influence of growth and maturity as well as the processes of emotional and social development. The key factor here is that development is individual focused. It is the practitioner's responsibility to establish positive training and competitive environments, and to create relationships that focus on individual athletes' needs in addition to the long-term objectives of performance, participation, and personal development.⁷⁶ In early adolescence especially, coaches should strive to create a challenging and enjoyable climate that focuses on development over competition and results. Moreover, other stakeholders are also important.

The inclusion of parents, guardians, and supportive others can be a further strategy, acknowledging that implementation can be a challenge.³⁴ Sport organizations can develop interdisciplinary support teams with specific expertise across the sport sciences, including athletic development, injury, medical, psychological, and lifestyle factors (eg, nutrition). Finally, education of all stakeholders and athletes is vital for preventing negative consequence associated with early specialization, as well as other potential negative elements associated with youth sport participation.

Monitor and Evaluate Athletes

Having a clear approach to monitoring and evaluation can serve several purposes with adolescent athletes, including informing needs analysis and talent identification as well as evaluating the effectiveness of training programs. Furthermore, monitoring and evaluation tools could have additional value for managing athlete health during early adolescence, thereby minimizing risks of early specialization and/or the mechanisms associated with these effects over the short and longer term.⁷¹ Several areas have been highlighted for establishing a monitoring and evaluation tool in adolescent athletes, including athlete wellness,^{61,62} growth and maturation for measuring when the relative risk of injury may be increased or performance may be decreased,^{32,41} training load and practices, including training diaries, to establish what the athlete is doing,^{51,64} physical development,⁴⁶ recovery,²⁷ injury prevalence and mechanisms,⁵³ psychosocial factors, including burnout,⁵² perfectionistic tendencies,² athletic identity,¹ and educational attainment.^{54,56} The aforementioned list alone provides a large number of areas to monitor effectively, making this a challenge for all stakeholders. Therefore, an area for future work is the establishment of valid, reliable, and practically applicable tools that can be applied in such settings without becoming additional burdens.

Implement Integrative Neuromuscular Programs

Participation in organized sport alone does not ensure appropriate development of strength and other biomotor abilities. Therefore, the implementation of integrative neuromuscular training (see Fort-Vanmeerhaeghe et al²⁴ and Lloyd et al³⁹) is a strategy to manage the *physical* risks associated with early specialization. Integrative neuromuscular training is supplemental training incorporating general (eg, fundamental movements) and specific (eg, exercises targeted to motor control deficits) strength and conditioning activities (eg, resistance, dynamic stability, core focused strength, plyometric, and agility) that are designed to enhance health and skill-related components of physical fitness.^{23,47} Integrative neuromuscular training programs allow the development of concepts of athleticism (ie, “the ability to repeatedly perform a range of movements with precision and confidence in a variety of environments, which require competent levels of motor skills, strength, power, speed, agility, balance, coordination, and endurance”⁴⁰) and are associated with enhanced athletic qualities and reductions in negative consequences, especially injury. Standardized integrative

neuromuscular programs have been designed and implemented through specific warm-up protocols within some sports (eg, soccer, FIFA 11+,^{58,59} rugby union, Activate program^{28,29}), which have seen injury reductions of up to 80%. However, successful implementation and compliance toward such programs requires coach, athlete and parent education and behavior to be successful, which can be difficult because of the rigidity and repetitive nature of these programs.^{20,50} Instead, other coach education and practice frameworks have been presented (eg, RAMPAGE⁷²) to provide coaches with a greater degree of freedom in choosing activities within an overall framework while still emphasizing the importance of neuromuscular development. Overall, the implementation of integrative neuromuscular training is important for early specialization athletes during early adolescence to develop biomotor abilities and reduce injury risk.

Provide Psychological Skills Training

Because of some of the suggested negative *psychological* consequences associated with early specialization, providing psychological skills training to assist adolescent athletes in acquiring psychological strategies for coping, goal setting and managing multiple demands is important.^{36,66} In alignment with other elements noted in the sections above, this recommendation positions athletes as key agents in navigating their sport experience. Providing them with coping skills, for example, may mitigate the negative effects of performance pressure, a characteristic often seen as being associated with early specialization.

Commitment to the psychological development of resilient and adaptable athletes characterized by mental capability and robustness, high self-regulation, and enduring personal excellence qualities, is critical. Furthermore, practitioners should encourage early specialization athletes to communicate honestly about how they are feeling and utilize other monitoring tools (see the Monitor and Evaluate Athletes section). Together, this information can be used to better understand the demands and stresses on athletes and potentially change training cultures in early specialization sports. Moreover, adopting this approach, where athletes feel more supported to share their feelings and concerns with coaches, parents, and peers, could be important for managing other emerging issues in high-performance sport (eg, mental health concerns⁶⁷).

Manage Training Practices

Programs, particularly during early adolescence, should focus on an appropriate sport-life balance.⁹ The appropriate management of training practices, including frequency, volume, and intensity of training, alongside adequate rest and recovery, could be vital for minimizing the negative consequences of early specialization. This is important not only from both a physiological and psychological perspective to balance workload and recovery to maximize training adaptations and learning but also for providing opportunities for other priorities, including social time with family and friends, academic work, and enjoying other activities. Therefore, the careful planning of training (including a balance of technical, tactical, physical, and

psychological development), competition, rest, and recovery, and the promotion of other key activities of youth development (eg, social activities) is vital to maximize positive and reduce negative consequences. However, research on key stakeholders (eg, parents) has shown limited understanding of these concepts.⁷ Importantly, managing training volumes may be easier in early specialization athletes with fewer stakeholders (eg, coaches) than multisport athletes, a group that has been described as “organized chaos” because of the multiple stakeholders across multisports, -clubs, and -coaches.⁶⁵

CONCLUSION

In developing the above framework and recommendations, we wish to be very clear—we have many more questions than we do answers about the relationships between early specialization (and its varied definitions) and negative health and developmental outcomes. However, based on the limited existing empirical work, the various systematic and narrative reviews, as well as the editorials and position statements, we believe the framework provides a useful roadmap for future work. Furthermore, we believe the recommendations are useful guidelines given that they have general relevance for athlete development, training load management, and positive youth development generally, and happen to focus on what researchers and policy makers believe are the key factors associated with early specialization more specifically. Continued work in this area will help us refine these recommendations as causal links between behavior and effect emerge.

The consistent interest in this area provides good momentum for future work. However, we need to move beyond the simplistic correlational studies used in prior work to prospective and longitudinal designs that can track participation patterns and developmental effects in multivariate models. Moreover, having adequate comparison groups across the spectrum of participation (eg, including those with an extreme multisport participation) would extend our understanding of the optimal forms of participation for athlete skill acquisition as well as for positive and healthy development.

REFERENCES

- Anderson CB, Måsse LC, Hergenroeder AC. Factorial and construct validity of the athletic identity questionnaire for adolescents. *Med Sci Sports Exerc.* 2007;39:59-69.
- Appleton PR, Hill AP. Perfectionism and athlete burnout in junior elite athletes: the mediating role of motivation regulations. *J Clin Sport Psychol.* 2012;6:129-145.
- Baker J, Cobley S, Fraser-Thomas J. What do we know about early sport specialization? Not much! *High Abil Stud.* 2009;20:77-89.
- Baker J, Moshier A, Fraser-Thomas J. Is it too early to condemn early sport specialisation? *Br J Sports Med.* 2021;55:179-180.
- Bell DR, Post EG, Biese K, Bay C, Valovich McLeod T. Sport specialization and risk of overuse injuries: a systematic review with meta-analysis. *Pediatrics.* 2018;142:e20180657.
- Bell DR, Post EG, Trigsted SM, Hetzel S, McGuine TA, Brooks MA. Prevalence of sport specialization in high school athletics: a 1-year observational study. *Am J Sports Med.* 2016;44:1469-1474.
- Bell DR, Post EG, Trigsted SM, Schaefer DA, McGuine TA, Brooks MA. Parents' awareness and perceptions of sport specialization and injury prevention recommendations. *Clin J Sport Med.* 2020;30:539-543.
- Bell DR, Snedden T, Biese K, et al. Consensus definition of sport specialization in youth athletes using a Delphi approach. *J Athl Train.* Published online March 31, 2021. doi:10.4085/1062-6050-0725.20
- 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.
- Black S, Black K, Dhawan A, Onks C, Seidenberg P, Silvius M. Pediatric sports specialization in elite ice hockey players. *Sports Health.* 2019;11:64-68.
- Brenner JS, Council on Sports Medicine and Fitness. Sports specialization and intensive training in young athletes. *Pediatrics.* 2016;138:e20162148.
- Bridge MW, Toms MR. The specialising or sampling debate: a retrospective analysis of adolescent sports participation in the UK. *J Sports Sci.* 2013;31:87-96.
- Buckley PS, Bishop M, Kane P, et al. Early single-sport specialization: a survey of 3090 high school, collegiate, and professional athletes. *Orthop J Sports Med.* 2017;5:2325967117703944.
- Carder SL, Giusti NE, Vopat LM, et al. The concept of sport sampling versus sport specialization: preventing youth athlete injury: a systematic review and meta-analysis. *Am J Sports Med.* 2020;48:2850-2857.
- Côté J, Fraser-Thomas J. Youth involvement and positive development in sport. In Crocker PRE, ed. *Sport and Exercise Psychology: A Canadian Perspective.* 3rd ed. Pearson Prentice Hall; 2016:256-287.
- Côté J, Fraser-Thomas J. Youth involvement in sport. In Crocker PRE, ed. *Introduction to Sport Psychology: A Canadian Perspective.* Pearson; 2007:270-298.
- Cronin C, Armour K, eds. *Care in Sport Coaching: Pedagogical Cases.* Routledge; 2018.
- DiFiori JP, Brenner JS, Comstock D, et al. Debunking early single sport specialisation and reshaping the youth sport experience: an NBA perspective. *Br J Sports Med.* 2017;51:142-143.
- DiSanti JS, Erickson K. Youth sport specialization: a multidisciplinary scoping systematic review. *J Sports Sci.* 2019;37:2094-2105.
- Donaldson A, Lloyd DG, Gabbe BJ, Cook J, Finch CF. We have the programme, what next? Planning the implementation of an injury prevention programme. *Inj Prev.* 2017;23:273-280.
- Drew MK, Finch CF. The relationship between training load and injury, illness and soreness: a systematic and literature review. *Sports Med.* 2016;46:861-883.
- Ericsson KA, Krampe RT, Tesch-Römer C. The role of deliberate practice in the acquisition of expert performance. *Psychol Rev.* 1993;100:363-406.
- Faigenbaum AD, Farrell A, Fabiano M, et al. Effects of integrative neuromuscular training on fitness performance in children. *Pediatr Exerc Sci.* 2011;23:573-584.
- Fort-Vanmeerhaeghe A, Romero-Rodriguez D, Lloyd RS, Kushner A, Myer GD. Integrative neuromuscular training in youth athletes. Part II: strategies to prevent injuries and improve performance. *Strength Cond J.* 2016;38:9-27.
- 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.
- Gulbin JP, Croser MJ, Morley EJ, Weissensteiner JR. An integrated framework for the optimisation of sport and athlete development: a practitioner approach. *J Sports Sci.* 2013;31:1319-1331.
- Harrison CB, McGuigan M. Monitoring and assessment of young athletes. In: Lloyd RS, Oliver JL, eds. *Strength and Conditioning for Young Athletes: Science and Application.* Routledge; 2019:62-76.
- Hislop MD, Stokes KA, Williams S, et al. Reducing musculoskeletal injury and concussion risk in schoolboy rugby players with a pre-activity movement control exercise programme: a cluster randomised controlled trial. *Br J Sports Med.* 2017;51:1140-1146.
- Hislop MD, Stokes KA, Williams S, et al. The efficacy of a movement control exercise programme to reduce injuries in youth rugby: a cluster randomised controlled trial. *BMJ Open Sport Exerc Med.* 2016;2:e000043.
- Huxley DJ, O'Connor D, Larkin P. The pathway to the top: key factors and influences in the development of Australian Olympic and World Championship Track and Field athletes. *Int J Sports Sci Coach.* 2017;12:264-275.
- 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.
- Johnson DM, Williams S, Bradley B, Sayer S, Murray Fisher J, Cumming S. Growing pains: maturity associated variation in injury risk in academy football. *Eur J Sport Sci.* 2020;20:544-552.
- Kliethermes SA, Marshall SW, LaBella CR, et al. Defining a research agenda for youth sport specialisation in the USA: the AMSSM Youth Early Sport Specialization Summit. *Br J Sports Med.* 2021;55:135-143.
- Knight CJ, Holt NL. Strategies used and assistance required to facilitate children's involvement in tennis: parents' perspectives. *Sport Psychol.* 2013;27:281-291.

35. Krentz EM, Warschburger P. Sports-related correlates of disordered eating in aesthetic sports. *Psychol Sport Exerc.* 2011;12:375-382.
36. Kuan G, Kueh Y-C. Psychological skills during training and competition on recovery-stress state among adolescent state athletes. *J Sports Res.* 2015;2:122-130.
37. LaPrade RF, Agel J, Baker J, et al. AOSSM early sport specialization consensus statement. *Orthop J Sports Med.* 2016;4:2325967116644241.
38. Larson HK, Young BW, McHugh T-LF, Rodgers WM. Markers of early specialization and their relationships with burnout and dropout in swimming. *J Sport Exerc Psychol.* 2019;41:46-54.
39. Lloyd RS, Cronin JB, Faigenbaum AD, et al. National Strength and Conditioning Association position statement on long-term athletic development. *J Strength Cond Res.* 2016;30:1491-1509.
40. Lloyd RS, Oliver JL, Faigenbaum AD, et al. Long-term athletic development—part 1: a pathway for all youth. *J Strength Cond Res.* 2015;29:1439-1450.
41. Lloyd RS, Oliver JL, Faigenbaum AD, Myer GD, De Ste Croix MBA. Chronological age vs. biological maturation: implications for exercise programming in youth. *J Strength Cond Res.* 2014;28:1454-1464.
42. Macnamara BN, Moreau D, Hambrick DZ. The relationship between deliberate practice and performance in sports: a meta-analysis. *Perspect Psychol Sci.* 2016;11:333-350.
43. Malina RM. Early sport specialization: roots, effectiveness, risks: roots, effectiveness, risks. *Curr Sports Med Rep.* 2010;9:364-371.
44. McPadden T, Bean C, Fortier M, Post C. Investigating the influence of youth hockey specialization on psychological needs (dis)satisfaction, mental health, and mental illness. *Cogent Psychol.* 2016;3:1157975.
45. Mosher A, Fraser-Thomas J, Baker J. What defines early specialization: a systematic review of literature. *Front Sports Act Living.* 2020;2:596229.
46. Murray A. Managing the training load in adolescent athletes. *Int J Sports Physiol Perform.* 2017;12(suppl 2):S242-S249.
47. Myer GD, Faigenbaum AD, Ford KR, Best TM, Bergeron MF, Hewett TE. When to initiate integrative neuromuscular training to reduce sports-related injuries and enhance health in youth? *Curr Sports Med Rep.* 2011;10:155-166.
48. Newell A, Rosenbloom PS. Mechanisms of skill acquisition and the law of practice. In: Anderson JR, ed. *Cognitive Skills and Their Acquisition.* Psychology Press; 2013:12-66.
49. Noble TJ, Chapman RF. Marathon specialization in elites: a head start for Africans. *Int J Sports Physiol Perform.* 2018;13:102-106.
50. Norcross MF, Johnson ST, Bovbjerg VE, Koester MC, Hoffman MA. Factors influencing high school coaches' adoption of injury prevention programs. *J Sci Med Sport.* 2016;19:299-304.
51. Phibbs PJ, Jones B, Roe G, et al. The organised chaos of English adolescent rugby union: influence of weekly match frequency on the variability of match and training loads. *Eur J Sport Sci.* 2018;18:341-348.
52. Raedeke TD, Smith AL. Development and preliminary validation of an athlete burnout measure. *J Sport Exerc Psychol.* 2001;23:281-306.
53. Read PJ, Oliver JL, De Ste Croix MBA, Myer GD, Lloyd RS. An audit of injuries in six english professional soccer academies. *J Sports Sci.* 2018;36:1542-1548.
54. Rongen F, McKenna J, Cogley S, Tee JC, Till K. Psychosocial outcomes associated with soccer academy involvement: longitudinal comparisons against aged matched school pupils. *J Sports Sci.* 2020;38:1387-1398.
55. Rongen F, McKenna J, Cogley S, Till K. Are youth sport talent identification and development systems necessary and healthy? *Sports Med Open.* 2018;4:18.
56. Rongen F, McKenna J, Cogley S, Till K. Do youth soccer academies provide developmental experiences that prepare players for life beyond soccer? A retrospective account in the United Kingdom. *Sport Exerc Perform Psychol.* 2021;10:359-380. doi:10.1037/spy0000259
57. Ross KA, Fried JW, Bloom DA, Gonzalez-Lomas G. The effect of specialization and level of competition on injury in elite male ice hockey players. *Phys Sportsmed.* Published online June 21, 2021. doi:10.1080/00913847.2021.1916786
58. Rössler R, Junge A, Bizzini M, et al. A multinational cluster randomised controlled trial to assess the efficacy of "11+ Kids": a warm-up programme to prevent injuries in children's football. *Sports Med.* 2018;48:1493-1504.
59. Rössler R, Verhagen E, Rommers N, et al. Comparison of the "11+ Kids" injury prevention programme and a regular warmup in children's football (soccer): a cost effectiveness analysis. *Br J Sports Med.* 2019;53:309-314.
60. Russell WD, Limle AN. The relationship between youth sport specialization and involvement in sport and physical activity in young adulthood. *J Sport Behav.* 2013;36: 82-98.
61. Saw AE, Main LC, Gastin PB. Monitoring athletes through self-report: factors influencing implementation. *J Sports Sci Med.* 2015;14:137-146.
62. Sawczuk T, Jones B, Scantlebury S, Till K. Relationships between training load, sleep duration, and daily well-being and recovery measures in youth athletes. *Pediatr Exerc Sci.* 2018;30:345-352.
63. Scanlan TK, Carpenter PJ, Simons JP, Schmidt GW, Keeler B. An introduction to the Sport Commitment Model. *J Sport Exerc Psychol.* 1993;15:1-15.
64. Scantlebury S, Till K, Sawczuk T, Phibbs P, Jones B. Navigating the complex pathway of youth athletic development: challenges and solutions to managing the training load of youth team sport athletes. *Strength Cond J.* 2020;42:100-108.
65. Scantlebury S, Till K, Sawczuk T, Phibbs P, Jones B. Validity of retrospective session rating of perceived exertion to quantify training load in youth athletes. *J Strength Cond Res.* 2018;32:1975-1980.
66. Sharp L-A, Woodcock C, Holland MJG, Cumming J, Duda JL. A qualitative evaluation of the effectiveness of a mental skills training program for youth athletes. *Sport Psychol.* 2013;27:219-232.
67. Snyder AR, Martinez JC, Bay RC, Parsons JT, Sauers EL, Valovich McLeod TC. Health-related quality of life differs between adolescent athletes and adolescent nonathletes. *J Sport Rehabil.* 2010;19:237-248.
68. Strachan L, Côté J, Deakin J. "specializers" versus "samplers" in youth sport: comparing experiences and outcomes. *Sport Psychol.* 2009;23:77-92.
69. Sundgot-Borgen J, Torstveit MK. Prevalence of eating disorders in elite athletes is higher than in the general population. *Clin J Sport Med.* 2004;14:25-32.
70. Swindell HW, Marcille ML, Trofa DP, et al. An analysis of sports specialization in NCAA Division I collegiate athletics. *Orthop J Sports Med.* 2019;7:2325967118821179.
71. Till K, Baker J. Challenges and [possible] solutions to optimizing talent identification and development in sport. *Front Psychol.* 2020;11:664.
72. Till K, Eisenmann J, Emmonds S, et al. A coaching session framework to facilitate long-term athletic development. *Strength Cond J.* 2021;43:43-55.
73. Till K, Weakley J, Read DB, et al. Applied sport science for male age-grade rugby union in England. *Sports Med Open.* 2020;6:14.
74. Turner G, Rudz T, Bertolacci L. Strength and conditioning coaching practice and positive youth athletic development: context-specific application of the developmental relationships framework. *Strength Cond J.* 2018;40:49-55.
75. Vallerand RJ, Blanchard C, Mageau GA, et al. Les passions de l'âme: on obsessive and harmonious passion. *J Pers Soc Psychol.* 2003;85:756-767.
76. Vierimaa M, Erickson K, Côté J, Gilbert W. Positive youth development: a measurement framework for sport. *Int J Sports Sci Coach.* 2012;7:601-614.
77. Warner S, Dixon MA. Understanding sense of community from the athlete's perspective. *J Sport Manage.* 2011;25:257-271.
78. Watchman T, Spencer-Cavaliere N. Times have changed: parent perspectives on children's free play and sport. *Psychol Sport Exerc.* 2017;32:102-112.
79. Watson JC 2nd, Connole I, Kadushin P. Developing young athletes: a sport psychology based approach to coaching youth sports. *J Sport Psychol Action.* 2011;2:113-122.
80. Wiersma LD. Risks and benefits of youth sport specialization: perspectives and recommendations. *Pediatr Exerc Sci.* 2000;12:13-22.
81. Wilhelm A, Choi C, Deitch J. Early sport specialization: effectiveness and risk of injury in professional baseball players. *Orthop J Sports Med.* 2017;5:2325967117728922.
82. World Health Organization. Adolescent health. Accessed May 13, 2021. <https://www.who.int/health-topics/adolescent-health/>
83. Young BW, Eccles D, Williams AM, Baker J. K. Anders Ericsson, deliberate practice and sport: contributions, collaborations and controversies. *J Expertise.* 2021;4:169-189.