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Is Early Sport Specialization Harming Our Children?

Kendra Dunsford DPT, SCS, STC
University of the Pacific, k_dunsford@u.pacific.edu

Preeti Oza PT, PhD
University of the Pacific, poza@pacific.edu

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Abstract

Sports and physical activity in children are healthy and have numerous positive mental and physical health benefits. Recently, there has been a shift away from deliberate play and focusing on specializing in a single sport from a young age. Participating in rigorous training and competition schedules 8 months out of the year for prepubescent athletes has garnered attention from the medical community. It is assumed that this type of early specialization has the potential to cause negative effects, especially in terms of overuse injuries, nutritional deficiencies, poor sleep hygiene, and mental health concerns. While there appears to be a consensus among the sports medicine community regarding the potential for deleterious effects and anecdotal correlation between early sport specialization and a variety of injury risks, there is a current gap in the literature and a lack of useful data for evidence-based guidelines and recommendations. Youth sports is a multi-billion dollar industry and the pediatric sports medicine healthcare community needs to address the trend towards early sport specialization to protect the health of our children now and as they grow into adulthood.

Keywords

sport specialization, youth sport specialization, early sport specialization, prepubescent youth sports

Background

Youth sports are integral to growing up and establishing a healthy lifestyle; children should have fun doing activities they love. In 2019, the Aspen Play Project determined that 38% of children in the United States ranging from ages 6-12 years participated in regular sports activities, which is ~9 million American children per year participating in sports [1]. It has been estimated that anywhere between 10-30% of athletes ages 12-14 years specialize in a single sport in the United States [2]. Yet, today, we see a huge shift to sport specialization occurring at younger ages, specifically during the prepubescent phase, ages 9-12 years [3] where kids are being forced to pick one sport, without considering the consequences. Despite the push for kids to specialize at younger ages the common age threshold in literature for the physical and mental effects of early sport specialization is before the age of 12 years [1].

Defining Early Sport Specialization

The most current research defines sport specialization as performing a single sport, including intensive training and competition for more than 8 months out of the year [3]. In addition, this sport is played to the exclusion of participation in any other sport, as well as limits overall free play. More specifically, early sport specialization involves children in the prepubertal ages, considered 9-12 years [3,4]. There is concern in the sports medicine community that a shift toward encouraging early sport specialization can have deleterious effects on prepubescent athletes. However, appropriate training volumes or outcome measures have not been defined or identified [5]. Limited research surrounds the social and physical effects of specialization in the prepubescent age group. Specifically, there is a lack of data or validated outcome tools to consistently and accurately measure the effects that early sport specialization is having on this vulnerable group.

Pressure to Specialize

There is a push by governing bodies, coaches, parents, and the sports world, in general, to start early specialization to increase talent exposure for the purposes of college athletic scholarships or participation on elite-level travel teams [3]. Rather, prepubescent children should be participating in sports for fun, camaraderie with teammates, and specifically to promote a healthy relationship with physical activity. To fully understand the push towards early sport specialization, we must consider the impact and influence of the media and the public in general. Why is the media allowing athlete exposure in the form of promoted youth tournaments and competitive leagues, in addition to the NCAA allowing 14-15-year-olds to commit to colleges in hopes of earning a scholarship [3]? It was estimated in 2015 that families spent 10.5% of their gross income on youth sports [6]. There is an argument in the literature that youth sports are over-commercialized and professionalized, likening it to adult sports experiences and environments [7]. These factors must be considered in the discussion surrounding why there is a significant rise in early sport specialization, targeting prepubescent youth.

Current Research

A systematic literature review on early sport specialization was performed by the primary author, which only yielded one article, a consensus statement, pertaining to sport specialization in children ages 9-12 years. In 2016, a think tank was convened which put together this American Orthopaedic Society for Sports Medicine (AOSSM) Early Sport Specialization Consensus Statement [3] calling for more evidence-based research, rather than recommendations, however, there remains a research gap in this arena. There are very few studies that explicitly study the effects of early sport specialization. The potential implications of early sport specialization and increases in training and competition volume on a multitude of

factors in prepubescent youth include musculoskeletal injuries, sleep, nutrition, and ultimately mental health. The gap in primary research articles leaves the correlation of early sport specialization to the aforementioned conditions undetermined, ultimately risking the physical and mental health of our youth. We are not letting children develop or find their passion throughout their younger ages; to be considered for the travel team and eventually college, kids are being encouraged to specialize in single sports at very young ages, resulting in burnout before they even reach high school [8].

A common thread in the literature in support of early sport specialization surrounds the 10,000-hour rule, stating that in order to acquire skill and high-level performance, an athlete must devote at least 10,000 hours to that specific skill [9]. However, it has been noted that this research has not been validated as a way to garner athletic success [3]. In contrast, there has been more recent research into athlete development and ways to ensure long-term participation in sports from childhood into adulthood. One widely accepted framework is the Developmental Model of Sport Participation (DMSP) [10]. This model suggests the importance of early diversification and deliberate free play. Of significance, the DMSP suggests that athletes are not physically or mentally developed enough to specialize in a specific sport until the age of 16 years [10]. In agreement is research out of Germany [11], declaring that athletes who participate in multiple sports have increased athletic success at elite levels of sports participation. These postulates have strong implications for youth sports policies and need to be considered as the sports medicine world navigates the continued phenomenon of early sport specialization.

Clinical Applications

With the push towards early sport specialization, the question arises as to whether or not prepubescent athletes might be at an increased risk of harmful physical implications and mental

health illnesses if they specialize in a single sport, as compared to their older counterparts who specialize at later ages. A 2015 statement by the International Olympic Committee (IOC) [11] recommends avoiding specialization until at least puberty, rather encouraging diversification of physical activities and deliberate free play for children.

Early sport specialization can negatively affect mental and social factors, including academic performance, social isolation, inadequate sleep, as well as increased anxiety and depression [8]. These negative effects may also contribute to burnout, thus causing athletes to withdraw from sports at a young age. To consider the whole of the athlete, physical and mental health considerations must be made to determine if there are any deleterious effects of early sport specialization in terms of musculoskeletal injuries, mental health illness, nutritional deficiencies, and poor sleep hygiene.

Musculoskeletal

A large concern in athletes who engage in early sport specialization is an increased risk of musculoskeletal injuries. Adverse effects of early sport specialization on the musculoskeletal system have been recognized, specifically negative effects on motor development thus leading to an increase in injury risk [2]. Additional recent data notes improved neuromuscular control and landing patterns in youth who sampled many sports, as compared to their counterparts who specialized during the prepubescent period [13], indicating that athletes who participate in sports diversification may have decreased risk for musculoskeletal and ligamentous injuries. Of note, there is an increased injury rate of 200% for organized play versus deliberate free play, as well as a specific increase in injury for athletes who specialize in a single sport before the age of 12 years [14].

Ligaments

One way to reduce injury risk in early sport specialization is to implement neuromuscular control training to prepare youth athletes for the demands of competitive sports [15]. In addition, the importance of free play in youth shows that there are some suggestions that these specific types of loading can provide ligamentous protection in elite athletes [16]. This research is also important in future implications of reducing the risk of ACL injury in prepubescent children, especially those who engage in deliberate free play, which has been shown to have protective benefits. Using this knowledge to determine the kind of play and the amount of beneficial free play would be crucial in setting standardized guidelines for practice and play hours in early sport specialization.

Bone

Another unique concern surrounding musculoskeletal injuries in prepubescent athletes is in regard to epiphyseal plates. It has been found that mechanical loading of growth plates is a necessary biomechanical feature, but that overexertion or increases in load bearing can cause injury to epiphyseal growth plates [17]. The mean age for skeletal maturity is roughly 15 years [18]. Skeletally immature athletes who participate in extreme loading, which arguably occurs with early sport specialization, can sustain repetitive trauma to their growth plates and into the bone shaft. Training and competition programs and schedules must take into account the physiology of a skeletally immature athlete to ensure optimal bone health and protection. The American Academy of Pediatrics issued a position statement recommending delaying sport specialization until ages 15-16 years [19]. The increased risk of injury suspected during early sport specialization is likely a contributing factor to growth plate injuries or other bony trauma in prepubescent athletes.

Developmental Versus Chronological Age

Moreover, due to findings that overuse injuries can occur irrespective of age, rather than using age or skeletal maturity as a predictive factor in sports participation, some argue that we should be considering developmental levels and the functional capacity of each individual athlete, as it has been found that "the rate at which body cells mature is an individual process that is only remotely related to chronological age" [20]. When discussing early sport specialization and injury rates, it is essential to acknowledge that developmental age is not equal to chronological age. Coaches and providers need to place athletes on teams with peers of similar developmental skill levels. This can help to reduce the risk of underdeveloped athletes sustaining injuries by trying to keep up with the playing and competition level of teammates or opponents who have increased skill acquisition.

Cost of Musculoskeletal Injuries

There also exists an economic burden of sports-related injuries, which is not well understood in the literature. It is estimated anywhere from $0.8 billion to $5.2 billion is spent in the United States each year on injuries sustained by youth sport specialization [21]. It is also noted that this number is likely higher, due to an increase in overuse injuries in early sport specialization, which cost more in both time and resources than acute injuries [21]. Due to these factors, sports medicine providers must be aware of the economic and financial implications related to early sport specialization.

Mental Health

The International Olympic Committee (IOC) consensus statement from 2015 states that mental health and physical health cannot be considered independent of each other in elite athletes [12]. Thus, increased risks for musculoskeletal injuries must be considered as a potential cause of anxiety and depression in prepubescent athletes. Early sport specialization is thought to be a

contributing factor to burnout and youth dropping out of sports and ultimately losing all interest in physical activity [2].

If training loads are managed properly, sports have a positive effect on wellbeing [22]. When youth of prepubescent and adolescent ages participate in sports, they are protecting their mental health, so long as their sport is enjoyable and developmentally appropriate [8]. Both recreational and elite-level sports are positively associated with mental health in prepubescent youth, which continues into later adolescence [23]. So, it is no surprise that research shows that sports improve mental health in youth. What is concerning is the potential for missing what the limit might be, ultimately setting prepubescent athletes up for an increase in mental health disease by increasing the number of hours they are engaged in sports each week. It has been noted that limited attention has been given to the psychosocial effects of early sport specialization on prepubescent athletes [8].

Screening Tools

There is a lack of clear information regarding the correlation between prepubescent sports participation and psychosocial components, as well as a need to standardize the best way to screen for mental health conditions in elite and competitive athletes in this age population [24]. There is a need for validated scales to truly assess mental health conditions, as well as the need for longitudinal, prospective designs to determine the effect of highly competitive prepubescent sports participation on clinical mental health symptoms [25]. The PHQ-9 (Patient Health Questionnaire with Depression Module) is widely used across medicine, however, it comes with limitations. It is a good screening tool but it does not assist with diagnosis, nor is it specific to prepubescent athletes and its use in the general population setting limits its utility with this population. Rather, the use of more focused questionnaires to specifically assess the factors of psychological distress in prepubescent athletes could better determine the actual incidence of

depression and anxiety in this population, as well as other factors, such as burnout. Practically, it is not enough just to screen prepubescent athletes, we need to detect clinical symptoms and determine interventions on an individual basis. It is also important to reduce the stigma behind mental health conditions in prepubescent athletes, which could help with screening and detection [25]. For future research, creating an outcome tool and testing it on focus groups to develop a standardized and validated measure to screen and detect the incidence of mental health diagnoses in athletes ages 9-12 years is critical. The American Medical Society for Sports Medicine (AMSSM) research priorities from the Youth Early Sport Specialization Summit [2], which supports the immediate need for validated outcome tools, state that the medical community needs to "conduct methodological studies to develop consistent, valid and reliable measures and definitions of youth sport specialization and health outcomes…" (pg. 108). These outcome tools should be used by pediatricians, sports medicine physicians, physical therapists, athletic trainers, social workers, and psychologists, to name a few, to assess the mental health status of prepubescent athletes accurately.

Importance of Specialized Providers

There is growing concern and awareness surrounding the lack of specialized mental health care given to children and adolescents in the general population. This is also true in the sports world, where specialized mental health care providers are absent for prepubescent athletes [26]. There is an interdependence of mental well-being and physical performance, and the commonality of anxiety and depression seems to be interwoven into elite and competitive sports. The benefits of interventions via qualified mental health providers for prepubescent children in general have been shown to decrease depression and anxiety, as well as have a positive effect on well-being [27]. It should be assumed that mental health interventions via specialized sports

psychology providers can have a positive effect on the incidence of depression and anxiety in athletes engaged in early sport specialization.

Sex Differences

Lastly, there is inconsistent research showing the effects of sports participation and mental health and how it differs between the sexes. Future research should target the unique features of early sport specialization and how these features impact the mental health of girls, as compared to boys. Despite a study out of Norway [8] showing a higher incidence of psychological distress in non-athletes, as compared to athletes, they did find that female athletes had a 10% increase in mental distress over their male counterparts. In addition, female athletes experience anxiety and depression at a higher rate than male athletes [28]. This highlights the potential for significant differences in the mental health implications of male versus female prepubescent athletes.

It is recognized that physical activity and sports participation protect mental health. However, the medical community must proceed with caution, as there is a fine line between protective benefits and detrimental effects in prepubescent athletes specializing in a single sport. Determining what that line is will be beneficial in protecting athletes ages 9-12 years in both recreational and competitive settings, against anxiety, depression, and burnout. Because research shows mental health burdens occur in older elite athletes due to increased stress and pressure to perform [25], researchers and providers passionate about pediatric sports medicine must complete similar studies in the prepubescent population to determine if the societal push towards early specialization is detrimental to the mental health of youth athletes ages 9-12 years.

Nutrition

Children are not little adults and their nutritional and energy needs are unique and they change with each developmental phase. Most research in the area of sports nutrition has been

done on adults, despite the unique energy needs of prepubescent athletes [29]. Protein intake requirements are increased during childhood and adolescence [30]. Specifically, it is stated that the needs are higher in children ages 7-10 than in those 11-14, but there is little information on the adequate protein intake of prepubescent athletes or the energy expenditure of these athletes during specific sports [29,31].

Prepubescent athletes are metabolically less economical than adolescents and adults, mostly due to a lack of sufficient coordination of agonist and antagonist muscles during physical activity [32]. This phenomenon causes children ages 9-12 years to use 25-50% more energy than an adult while walking or running at the same speed [33]. It has been suggested that the energy cost of an activity decreases as proficiency increases, however, this same phenomenon has not been confirmed in prepubescent athletes [29], indicating that their energy needs remain unique as they grow and develop.

Another phenomenon to consider is in the field of anaerobic activities, such as sprinting and jumping, where children tend to be less successful, due to the need to use muscle glycogen for energy [34]. In sports where prepubescent youth are performing anaerobic activities utilizing mainly fast twitch muscle fibers, we should be concerned that they do not have adequate glycogen stores to safely support this type of sustained activity level. Given this information, youth who participate in early sport specialization should be focused on skill development and more aerobic activities, where fat is the main source of energy, which is more readily available in children [29].

Due to a lack of consistent research and evidence-based recommendations surrounding nutritional needs for prepubescent athletes, the sports medicine community needs to be aware of the energy requirements in athletes ages 9-12 years and the impact the increases in training

volumes, training activities, and overall participation hours have on nutritional status and formulate specific and evidence-based guidelines to avoid nutritional deficiencies during sports participation.

Sleep

Prepubescent athletes represent a unique population regarding sleep and how it can affect performance [35]. The obstacles prepubescent athletes face concerning lack of sleep include practice and competition schedules, travel, academic demands, social engagements, and overtraining [36]. The American Academy of Pediatrics and the American Academy of Sleep Medicine recommend that children ages 6-12 years old get 9-12 hours of sleep per 24-hour period. This is in contrast to the average 8 hours of sleep per night that younger athletes actually get [35]. This decrease in sleep can lead to decreases in performance and well-being. Of specific interest is that overtraining and lack of sleep lead to increased burnout in athletes specializing before the age of 12 years [37].

The importance of sleep cannot be overlooked, as it has been reported that roughly 30% of children do not get the right amount of sleep and that sleep does improve performance in elite athletes of all ages [35,38]. Adequate sleep has also been shown to have an impact on both mental and physical development. More specifically, prepubescent athletes who do not get enough sleep have an increase in bone stress injuries [35].

Scientific research on the effect early sport specialization has on sleep hygiene in the prepubescent population is needed to ensure that parents and coaches are aware of the implications of a healthy and consistent sleep schedule that meets the needs of the child to enhance performance and health, not detract from it. Sleep schedules must also be considered when scheduling practice and competitions.

Future Implications

In this era where youth sports are exploding, many unanswered questions and concerns exist surrounding the push for prepubescent athletes to specialize in a single sport to further their future success. Why don't we have current evidence-based guidelines and prospective studies on injury risk and mental health concerns in athletes who are specializing during their prepubescent years? Why is the information regarding nutritional and sleep needs focused on adults or older childhood athletes? The answer: the youth sports movement is accelerating faster than the medical community and governing bodies can keep up with, putting millions of prepubescent youth at risk for many negative implications. It is no secret that this research topic has huge implications for not just the medical community, but for business stakeholders as well, as youth sports is a greater than $15 billion industry in the United States [2]. The medical community agrees that there are likely physical and mental health concerns of sport specialization in the prepubescent population. Still, there continues to be a lack of prospective studies to determine to what extent or severity this is or is not happening. Perhaps there is a fear of a loss of revenue for a variety of business stakeholders pushing back on scientific research in this realm. Members of the sports medicine community cannot continue to let vague guidelines and recommendations set the tone for the health of our youth. Invested partners in pediatric sports medicine must set standard guidelines for sports hours, mandate integration of cross-training and neuromuscular training, discuss the importance of encouraging free play, engage in nutrition counseling, implement mental health screenings, and develop validated tools to properly and accurately assess these athletes' health as the push for being elite at younger ages increases.

While we must encourage children of all ages to become and remain active, we need to be vigilant about screening for physical and mental health concerns, as well as advance research

in this growing field. We must remember that sports are supposed to be enjoyable. It teaches discipline, teamwork, and dedication. We need to be at the forefront of evidence to protect our kids. Sports are not bad; they have so many positive benefits. But, let's not let the appeal of money or fame or the promise of an elite future drive our decision-making. As these young athletes start to mature and grow into adults, we have the potential to see an increase in chronic injuries and a decrease in physical activity from burnout which can cause a whole host of problems, not limited to obesity, cardiovascular concerns, diabetes, depression, and anxiety [8, 39]. In a world where only 3-6% of high school athletes play college sports and an even smaller percentage make it to the professional level [40], we need to protect the health of those individuals who want to live their lives and benefit society, not as athletes, but as healthy individuals. Let's harness the benefits of sports and athletics and use it for good; for all ages.

References

[1] Mosher A, Fraser-Thomas J, & Baker J. What defines early specialization: A systematic review of literature. Front Sports Act Living 2020. https://doi.org/10.3389/fspor.2020.596229

[2] Kliethermes S, Marshall SW, LaBella, CR, Watson A, Brenner JS, Nagle K, et al. Defining a research agenda for youth sport specialization in the United States: The AMSSM Youth Early Sport Specialization Summit. Clin J Sport Med 2021;31(2):103–112. https://doi.org/10.1097/jsm.0000000000000900

[3] LaPrade RF, Agel J, Baker J, Brenner JS, Cordasco FA, Côté J, et al. AOSSM early sport specialization consensus statement. Orthop J Sports Med 2016;4(4). https://doi.org/10.1177/2325967116644241

[4] Hainline B. Early sport specialization: Shifting societal norms. J Athl Train 209;54(10):1011-1012. https://doi.org/10.4085/1062-6050-251-18

[5] Popkin CA, Bayomy AF, & Ahmad CS. Early sport specialization. J Am Acad Orthop Surg 2019;27(22):e995–e1000. https://doi.org/10.5435/jaaos-d-18-00187

[6] Sullivan P. The rising costs of youth sports, in money and emotion. The New York Times website. January 16, 2015. The Rising Costs of Youth Sports, in Money and Emotion - The New York Times (nytimes.com). Accessed September 20, 2023.

[7] Whatman C, Van Den Berg C, Black AM, West S, Hagel B, & Emery C. High sport specialization is associated with more musculoskeletal injuries in Canadian high school students. Clin J Sport Med 2022;33(3):233–238. https://doi.org/10.1097/jsm.0000000000001100

[8] Brenner J, LaBotz M, Sugimato D, & Stracciolini A. The psychosocial implications of sport specialization in pediatric athletes. J Athl Train 2019;54(10):1021-1029.

[9] Ericsson KA, Krampe RT, Tesch-Romer C. The role of deliberate practice in the acquisition of expert performance. Psychol Rev 1993;100:363-406.

[10] Côté J, Lidor R, & Hackfort D. ISSP position stand: To sample or to specialize? Seven postulates about youth sport activities that lead to continued participation and elite performance. Int J Spor Exerc Psychol 2009;*7*(1):7–17. https://doi.org/10.1080/1612197x.2009.9671889

[11] Fullich 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.

[12] 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.

[13] DiStefano LJ, Beltz EM, Root HJ, Martinez JC, Houghton AR, Taranto N, et al. Sport sampling is associated with improved landing technique in youth athletes. Sports Health 2017;10(2):160–168. https://doi.org/10.1177/1941738117736056

[14] Jayanthi N, LaBella CR, Fischer DA, Pasulka J, & Dugas LR. Sports-Specialized intensive training and the risk of injury in young athletes. Am J Sports Med 2015;43(4):794–801. https://doi.org/10.1177/0363546514567298

[15] 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(23):1510–1516. https://doi.org/10.1136/bjsports-2014-093661

[16] Beaulieu ML, Declercq M, Rietberg N, Li S, Harker EC, Weber AE, et al. The ACL can hypertrophy in response to mechanical loading: an MRI study in elite athletes (157). Orthop J Sports Med 2021;9(10_suppl5). https://doi.org/10.1177/2325967121s00283

[17] Mirtz TA, Chandler JP, & Eyers CM. The effects of physical activity on the epiphyseal growth plates: A review of the literature on normal physiology and clinical implications. J Clin Med Res 2011. https://doi.org/10.4021/jocmr477w

[18] Calfee RP, Sutter M, Steffen JA, & Goldfarb CA. Skeletal and chronological ages in American adolescents: Current findings in skeletal maturation. J Pediatr Orthop 2010;*4*(5): 467–470. https://doi.org/10.1007/s11832-010-0289-z

[19] Brenner JS. Sports specialization and intensive training in young athletes. Pediatrics 2016;138(3). https://doi.org/10.1542/peds.2016-2148

[20] Seefeldt V, & Gould D. Physical and psychological effects of athletic competition on children and youth. ERIC Clearinghouse on Teacher Education 1980. http://files.eric.ed.gov/fulltext/ED180997.pdf

[21] Bell DR, DiStefano LJ, Pandya NK, & McGuine TA. The public health consequences of sport specialization. J Athl Train 2019;54(10):1013–1020. https://doi.org/10.4085/1062-6050-521-18

[22] McKay C, Hoch JM, Hoch MC, & Dlugonski D. Sports specialization, physical literacy, and physical activity levels in young adults. J Sport Rehabil 2023;*32*(2):190–195. https://doi.org/10.1123/jsr.2022-0057

[23] Doré I, Sabiston CM, Sylvestre M, Brunet J, O'Loughlin J, Nader PA, et al. Years participating in sports during childhood predicts mental health in adolescence: a 5-Year longitudinal study. J Adolesc Health 2019;64(6):790–796. https://doi.org/10.1016/j.jadohealth.2018.11.024

[24] Graupensperger S, Sutcliffe J, & Vella SA. Prospective Associations between Sport Participation and Indices of Mental Health across Adolescence. J Youth Adolesc 2021;*50*(7):1450–1463. https://doi.org/10.1007/s10964-021-01416-0

[25] Gouttebarge V, Castaldelli-Maia JM, Gorczynski P, Hainline B, Hitchcock ME., Kerkhoffs GM, et al. Occurrence of mental health symptoms and disorders in current and former elite athletes: A systematic review and meta-analysis. B J Sports Med 2019;53(11):700-706.

[26] Christian I, Christian CM, Markus G, et al. SSSPP Position paper: Physical activity and mental health. Sport Exerc Med 2020. https://doi.org/10.34045/sems/2020/21

[27] García-Carrión R, Villarejo-Carballido B, & Villardón-Gallego L. Children and Adolescents Mental Health: A systematic review of interaction-based interventions in schools and communities. Front Psychol 2019;*10*. https://doi.org/10.3389/fpsyg.2019.00918

[28] Weber S, Puta C, Lesinski M, Brunhild G, Steidten T, Bar, KJ, et al. Symptoms of anxiety and depression in young athletes using the hospital anxiety and depression scale. Front Psychol 2018;9:182.

[29] Bar-Or O. Nutrition for child and adolescent athletes. SSE 2000;13(2).

[30] Hudson J, Baum JD, Diaz E C, & Børsheim E. Dietary protein requirements in children: Methods for consideration. Nutrients 2021;13(5):1554. https://doi.org/10.3390/nu13051554

[31] Ziegler PJ, Khoo CS, Kris-Etherton PM, Jonnalagadda SS, Sherr B & Nelson JA. Nutritional status of nationally ranked junior US figure skaters. J Am Diet Assoc. 1998;98: 809-811.

[32] Frost G, Dowling, Dyson K, Bar-Or O. Cocontraction in three age groups of children during treadmill locomotion. J Electromyog Kinesiol 1997;7:179-186.

[33] Åstrand PO. Experimental studies of physical working capacity in relation to sex and age. 1952. Copenhagen: Munksgaard.

[34] Hebestreit H, Meyer F, Htay-Htay, GJ, Heigenhauser F, Bar-Or, O. Plasma metabolites, volume and electrolytes following 30-s high-intensity exercise in boys and men. Eur J Appl Physiol 1996;72:563-569.

[35] Riederer M. How sleep impacts performance in youth athletes. Curr Sports Med Rep 2020;19(11):463–467. https://doi.org/10.1249/jsr.0000000000000771

[36] Watson A. (2017). Sleep and athletic performance. Curr Sports Med Rep 2017;16(6): 413–418. https://doi.org/10.1249/jsr.0000000000000418

[37] Gerber M, Best SR, Meerstetter F, Isoard-Gautheur S, Gustafsson H, Bianchi R, et al. Cross-Sectional and longitudinal associations between athlete burnout, insomnia, and polysomnographic indices in young elite athletes. J Sport Exerc Psychol 2018;40(6):312–324. https://doi.org/10.1123/jsep.2018-0083

[38] Gander, K. (2019, October 25). American kids aren't getting enough sleep and it's affecting their success at school, scientists warn. *Newsweek*. https://www.newsweek.com/american-kids-arent-getting-enough-sleep-its-affecting-their-success-school-scientists-warn-1466882

[39] Simmonds M, Llewellyn A, Owen CG, Woolacott N. Predicting adult obesity from childhood obesity: A systematic review and meta-analysis. Obes Rev 2016 Feb;17(2):95-107. doi: 10.1111/obr.12334. Epub 2015 Dec 23. PMID: 26696565.

[40] Swindell HW, Marcille ML, Trofa DP, Paulino FE, Desai N, Lynch TS, et al. An analysis of sports specialization in NCAA Division I Collegiate Athletics. Orthop J Sports Med 2019;*7*(1). https://doi.org/10.1177/2325967118821179