



Early sport specialization in the adolescent female athlete

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Abstract: A growing trend in sports is early sport specialization which involves training in a single sport on a year-round basis. Factors that contribute to an athlete specializing in a sport include: enjoyment of the sport, obtaining a scholarship, professional aspirations, gaining a competitive advantage, lack of enjoyment in other sports, injury risk, lack of time to participate in other sports, and parent/coach pressure. With the growing hyper competitiveness and professionalization of sports and lucrative financial gains that proceed them, more and more young athletes, coaches and parents are looking to gain a competitive edge. Sport specialization may contribute to increased risk of injury and burnout in athletes. Male athletes have garnered most of the attention regarding early sport specialization, particularly in baseball. Female athletes have their own set of risk factors as they tend to specialize earlier in their athletic career and have been shown to accumulate primarily overuse injuries. In addition to contributing to this paper, Dr. James R. Andrews has been one of the leaders in injury prevention and an advocate in cautioning against early sport specialization in all young athletes. The focus of this paper is to highlight the specific risks associated with sport specialization for adolescent female athletes in hopes of developing successful athletes while avoiding injury or burnout along their path. Over the years there has been a trend of increased youth sports participation by female athletes. As female athlete participation continues to increase, we concomitantly have an increase in injury rates. Additionally, the iconic female influences of superstars like Nadia Comaneci and Lindsey Vonn has popularized the notion of sports specialization in young female athletes. Thus, with both the increase in participation as well as the heightened popularity of sport specialization, greater focus needs to be devoted to injury recognition and prevention in youth female athletes. Identifying the at-risk female athlete is prudent for the health and well-being of our youth athletes.

Keywords: Early sports specialization; youth sports; adolescent athletes; female athlete; overuse injuries; burnout; specializer; non-specializer; female sports injury research; recommended guidelines

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History of sports specialization

A growing trend in sports is early sport specialization which involves training in a single sport on a year-round basis. Factors that contribute to an athlete specializing in a sport include: enjoyment of the sport, obtaining a scholarship, professional aspirations, gaining a competitive advantage, lack of enjoyment in other sports, injury risk,

lack of time to participate in other sports, and parent/coach pressure (1). With the growing hyper competitiveness and professionalization of sports and lucrative financial gains that proceed them, more and more young athletes, coaches and parents are looking to gain a competitive edge. Sport specialization may contribute to increased risk of injury and burnout in athletes. Male athletes have garnered most of the attention regarding early sport specialization, particularly in

baseball. Female athletes have their own set of risk factors as they tend to specialize earlier in their athletic career and have been shown to accumulate primarily overuse injuries (2). In addition to contributing to this paper, Dr. James R. Andrews, has been one of the leaders in injury prevention and an advocate in cautioning against early sport specialization in all young athletes. The focus of this paper is to highlight the specific risks associated with sport specialization for adolescent female athletes in hopes of developing successful athletes while avoiding injury or burnout along their path.

Over the years there has been a trend of increased youth sports participation by female athletes. As female athlete participation continues to increase, we concomitantly have an increase in injury rates. Additionally, the iconic female influences of superstars like Nadia Comaneci and Lindsey Vonn has popularized the notion of sports specialization in young female athletes. Thus, with both the increase in participation as well as the heightened popularity of sport specialization, greater focus needs to be devoted to injury recognition and prevention in youth female athletes. Identifying the at-risk female athlete is prudent for the health and well-being of our youth athletes.

Growing trend

From a historical perspective, the 1950s–1960s offered limited opportunities for females to compete in sport. Thus, females focused solely on one individual sport, such as swimming, gymnastics, or track & field versus multiple team sports like male athletes. Trends of technical individual sports specialization (gymnastics, swimming, figure skating etc.) began to demonstrate distinct advantages in performance for younger, smaller body frames. In 1977, Staffo *et al.* (3) first alluded to the notion of sport specialization, and the term was later coined in 1988 by Hill when discussing the potential pros and cons of the issue (4). The idea of early sport specialization gained popularity with the dose-dependent “10,000-hour rule” discussed in 1993 by Ericsson *et al.* (5). Even more attention was gained with the highly acclaimed book, *Outliers* (6) by Malcolm Gladwell, and although the evidence was later debunked by Sagas [2013] (7), the trend of early sport specialization continues to spike in youth athletes.

Identifying the at-risk female athlete

A greater amount of attention to youth sport is currently focused on the association of sports specialization and injury.

Many sports medicine organizations such as the American Medical Society for Sports Medicine (AMSSM), American Orthopedic Society for Sports Medicine (AOSSM), American Academy of Pediatrics (AAP) and National Athletic Trainer’s Association (NATA) have expressed concern over early sports specialization and the increased risks of injury and burnout (8-11). Malina (12) advocated that early sport specialization did not have correlation to future success or achieving elite athletic status. Suggesting that limiting to a single sport year-round may not be the best path to elite status. To the authors knowledge there are no data available that favors early sports specialization, yet the trend of sports specialization continues to be apparent.

Recently, in a comparison of youth athletes, 66% of the female athletes identified as specializing in a single sport while only 39% of the male athletes identified as specializing in a single sport (2). Additionally, it has also been reported in an examination of adolescent athletes specializing in a single sport, female athletes displayed a higher incidence of injury in comparison to their male counterpart (13). Specifically, female athletes demonstrated two times the injury prevalence. In a recent study of NCAA Division I athletes, athletes who specialized before the age of 14 years sustained more injuries in their youth, multiple injuries at the college level, a greater number of total injuries, and the injuries they did sustain required more missed playing time than those who did not specialize (1). Jayanthi *et al.* (14) created risk stratification criteria to classify the level of early sport specialization in athletes. The criteria included 3 components: (I) year-round training (>8 months/year); (II) main focus on a single main sport; and (III) quitting all other sports to pursue a single sport. Scoring 3 of 3 qualified an athlete as highly specialized, while 2 of 3 was deemed moderately specialized and 1 of 3 components was lowly specialized. The ability to classify the level of sports specialization allows for a better determination of injury risk in athletes. Moderate and highly specialized athletes are 2× as likely to develop a serious overuse injury compared to unspecialized athletes (14).

Furthermore, Stracciolini *et al.* (15) noted a gender bias towards increased overuse injuries among female adolescents; 63% of female athletes had reported an overuse injury compared with 37% of traumatic injuries reported. In Jayanthi’s study, nearly 25% of all overuse injuries were reported to be serious overuse injuries, which was described as a cessation of sport for at least 1 month. These serious overuse type of injuries included bone stress injuries, lumbar spine or extremities injuries, elbow ligament injuries, osteochondral injuries and high-risk physeal injuries. Similar to Stracciolini,

Jayanthi (2) demonstrated that female adolescents had fewer acute injuries, but significantly more overuse and serious overuse injuries when compared to male adolescents. The levels of overuse and serious overuse injuries significantly increased with increasing levels of sport specialization.

Burnout

There also exists belief that athlete burnout is associated with early sports specialization. It has been noted anecdotally but evidence has been inconclusive to this point. Larson *et al.* (16), studied this idea by looking at attrition rates of Canadian swimmers and possible risk factors (age of specialization, training intensity, emotional and physical exhaustion and sport devaluation/loss of autonomy) associated with early sport specialization. Contrary to expectation, they did not find a correlation between early sports specialization and increased burnout or dropout from sport. Other studies have previously suggested possible indicators for burnout/dropout with one study comparing retrospective data of athletes and another small study with hockey players suggesting that more focused activity led to increased rates of dropouts via loss of enjoyment and autonomy (17–20). Larson's study (16) was the first to look at potential indicators for early sport specialization. However, they speculated that psychological factors may have confounded results, thus advocating for future research to include for motivational factors, peer pressures and personal investment.

Russell *et al.* (21) demonstrated similar results concerning early sport specialization and burnout. Lack of motivation and sport devaluation may contribute to increased burnout which develop from focused early sport specialization, yet there was no direct correlation. However, this may have been due to confounding factors such as a similarity between specializers and non-specializers within the study. The specializers had a relatively short specialization period (<4 years) which could be explained as a prolonged sampling period prior to specialization thus confounding the results. Other extrinsic factors may also be influencing rates of burnout within early sport specialization such as social influences, peer pressures, parents and negatively perceived coaching. These factors may influence burnout greater than early sport specialization on its own.

Female sports-specific injury research

Maybe the most convincing evidence in female adolescent

athletes can be demonstrated between cross-country runners and level of sport specialization (22). One hundred and twenty-six runners were categorized as highly, moderately and lowly specialized (14). Highly and moderately specialized runners had 75% greater risk for musculoskeletal running-related injury. These athletes were also 4× more likely to have menstrual dysfunction which may contribute to Relative Energy Deficiency Syndrome (RED-S) formerly known as the Female Athlete Triad (23).

In 2018, Roetert *et al.* (24) studied the benefits of multi-sport participation for youth tennis players. Although they note that female athletes mature sooner than their male counterparts, he advocates for increased “sports sampling”, extended time trying different sports for motor and social development prior to specialization. Sports such as gymnastics, swimming and figure skating are the exception and should specialize sooner than other sports due to peak performance occurring before full maturation (25). Jayanthi *et al.* recommends that athletes should only specialize when they are mature physically, mentally and emotionally, typically by age 16.

Throwing sports such as baseball have been the main focus of youth sports for Dr. Andrews and many others. However, there has been less research on the female throwing athlete. Thought to be a “natural” throwing motion, the windmill pitching mechanics display increased torque within the elbow from internal rotation into maximal external rotation as the elbow acts to resist elbow flexion. Softball pitchers have compressive forces on the shoulder and elbow that are 70–98% of body weight during the delivery phase of the pitch (26). Similar increasing compressive forces on the shoulder and elbow at ball release have been reported Plummer *et al.* (27). In effort to provide stability during the pitching motion, the biceps brachii and flexor/pronator muscle groups function to eccentrically decelerate elbow extension and prevent further distraction in the shoulder at ball release. It is suggested that the pitching motion could lead to a greater risk of biceps-labral overuse injuries, noting that it is not uncommon to see female pitchers pitch in multiple games on the same day and over a short period of time, such as weekend tournament play. Janes *et al.* (28), also discusses increased risk for overuse injuries in softball pitchers due to fatigue. Kinematics were studied over the course of a simulated game and found that female pitchers can maintain similar pitch speeds over time, but biomechanical compensations often set in as the pitcher noted self-reported fatigue. Decreased elbow flexion and altered pelvic mechanics occurred in effort to generate the

same force onto the ball. Janes argued against the notion that softball pitchers experienced fewer overuse injuries than baseball pitchers, especially when performing past the point of fatigue.

In terms of pitch count limitations, Oliver *et al.* (29) have begun to look closer into limiting pitches specifically for softball pitchers. Their study demonstrated that collegiate softball pitchers on average had higher pitch counts per outing (179±45) compared to recommendations for male pitchers who are recommended to throw less than 120 pitches per outing with a required 5 days rest in between outings. Skillington *et al.* (30) also noted that softball pitchers would throw on average 1.5 games per day at 82 pitches per day, which totaled an average of 166 pitches per tournament. Yang *et al.* (31) demonstrated that within a 6-week season time frame, softball pitchers averaged 12±5.7 games pitched, throwing 89±25 pitches per game, had decreased shoulder strength and reported increased pain and fatigue. Lastly, when developing such pitch count restrictions, one must also factor in warmup throws pregame and between innings which can accumulate up to 30–40% of unaccounted pitches in a game (32). This evidence may provide a framework to develop a safe and effective pitch count to help prevent overuse injuries in our softball pitchers.

Summary/recommended guidelines

In summary, we would like to make recommendations based on the above data to help prevent injury and burnout in adolescent female athletes. These are generalized recommendations for all youth athletes which have evolved from prior beliefs in sport, newly found evidence and an understanding that there needs to be continued efforts for research specific to female athletes. We advocate for continued research in all aspects of early sport specialization and for more focus on our female athletes as they comprise of almost ~50% of our youth athletes today.

We advocate for use of the risk stratification criteria proposed by Jayanthi's study to help identify at-risk female athletes (14). This is described by 3 main components: (I) year-round training (>8 months/year); (II) main focus on a single main sport; and (III) quitting all other sports to pursue a single sport. Scoring 3 of 3 qualified an athlete as highly specialized, moderately specialized was deemed 2 of 3 and lowly specialized was 1 of 3 components. There is evidence already demonstrating this association for identifying at-risk female athletes as previously discussed

on female cross-country runners (22). Identifying at-risk female athletes will improve our ability to prevent increased risks for injury and keep our athletes on the field.

Despite the growing trend for early sport specialization, evidence continues to argue against early sports specialization as it may lead to increased risk for overuse injury in the female athlete. However, early sport specialization may not be solely linked to increased rates of burnout/dropout. Instead, there may be extrinsic factors such as social influences, peer-pressure and negatively perceived coaching which may have stronger association with burnout when athletes specialize early in their careers. Early sports specialization has not proven to help develop success in the future as seen from studies discussed within this article (12). In the book *The Sports Gene* by David Epstein (33), there is suggestion that early sport specialization may aid the athlete at that point in time, but in actuality may not benefit them or may even become detrimental to their long-term success. The theory from Ericsson *et al.* (5), on the 10,000-hour rule may help an athlete learn hard work and perseverance but may not provide the expertise in sport that athletes desire. Their practice should be distinguished between deliberate versus recreational practice. Deliberate practice hours may have association to increased rates of burnout while recreational practice provides potential benefits through diversification of movement in a relaxed, enjoyable environment (21,33). Diversification of movement within the sport may help maintain the athlete's enjoyment and autonomy for sport leading to prevention of overuse injury or burnout.

We agree with the other current recommendations outlined by both the NATA position statement and Jayanthi which include: (I) the 2:1 rule which encourages for recreational practice/play to be twice as many hours as deliberate practice/play, (II) hours of training per week should not exceed the current age of the athlete, (III) have at least 1 day off from all sport-related activities, (IV) take 3 months of from sport per year, including 1 month after a season is completed (11,14). We recommend limiting adolescent female throwing athletes with pitch count restrictions similar to their adolescent male counterparts. It should be understood that we do not have current evidence for an exact number of pitches but have evidence for biomechanical changes when fatigue sets in (26-28,31). Fatigue is highly variable between individuals thus it is difficult to use a one size fits all approach to monitoring the factors that contribute to fatigue. Exceeding pitch counts beyond fatigue can lead to increased risk for overuse injury.

Future research is needed to determine a safe and effective pitch count limit to avoid overuse injury. All clinicians should be aware of increased risk factors for RED-S in all female athletes as they have growth and developmental changes during their adolescence which coincide with typical age ranges of sport specialization. Lastly, we strongly advocate for continued research in all aspects of youth athletics and more specifically in our female athletes to help provide a safer playing environment for all individuals in all sports. Please find a supplemental Q&A between the authors and editors in Supplementary file ([Appendix 1](#)).

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Discussion

1. Dr. Sommer Hammoud: *In your opinion, what do you think it will take for the public at large to begin to adopt and implement the important messaging of the STOP Sports Injuries campaign? Do you think that we will begin to see a downturn in the numbers of youth athletes who specialize in sport?*

Response: The key to the campaign's success starts with a local, grassroots outreach movement. Our belief is to spread awareness through a comprehensive approach, involving everyone from clinicians, teachers, coaches and parents. We hope that our readers will implement these recommendations to help identify increased risks and prevent injuries from occurring. Discussing risks of early sport specialization begins before the athlete is putting themselves at risk. We encourage early discussion with our colleagues in primary care, physical therapy, and athletic training to help educate both athlete and parent before injuries occur.

As more awareness is created through early discussion on the risks of early sport specialization, we hope to see a push towards increased sport sampling periods which subsequently should decrease the number of athletes specializing early in sports. We are not against specialization in sport and anticipate that athletes will likely continue to specialize in sport as they mature. We advocate to begin specialization when you are physically, mentally and emotionally mature, typically around age 16.

You can find more resources on the STOP Sports Injuries campaign at: stopportsinjuries.org.

2. Dr. Sommer Hammoud: *What are the barriers to being able to develop pitch count restrictions in softball pitchers as we have in youth baseball?*

Response: The biggest barrier to developing a pitch count restriction in softball pitchers is that research is much more limited when compared to our male pitchers. The previous belief of a "natural throwing motion" which does not strain the throwing arm has evidence which clearly suggests that is false (26,27). Additionally, the injury rates in softball players tend to be low when examined prospectively compared to baseball player (34-36). Whereas the high elbow and shoulder injury rates in young baseball players helped to guide the development of pitch count and other competition regulations very few softball organizations have

acknowledged the potential risk for injury in their athletes. Little League Softball (37) developed pitch count regulations recommending a maximum of twelve innings in a day and one calendar day of mandatory rest after a day where a pitcher throws seven innings. However, USA Softball, the national governing body for the sport, and many other competitive organizations have not adopted similar guidelines. Although the data are limited, there are more and more researchers investigating number of pitches, fatigue, and strain on the upper extremity, particularly the shoulder and elbow (26-27,38-40). We have highlighted some studies within this paper that focus on developing upper limits for softball pitch counts (29-31). Although we do not have an exact limit of pitches, we offer evidence to help facilitate future discussion on the need to develop a safe and effective pitch count limit for softball pitchers to prevent overuse injuries.

3. Dr. Sommer Hammoud: *What is the best way to assess for "fatigue" in the adolescent female throwing athlete? Is it reliable for the athlete to self-report? Can we rely on coaches?*

Response: Currently there is no widely used metric to assess fatigue in the adolescent female athlete. Internal Training Load is a method that could be easily implemented by coaches to measure both acute and chronic workloads in adolescent female athletes. Internal Training Load is derived from assessing rating of perceived exertion (RPE), for the total body, on the Borg CR-10 scale and multiplying the value by the duration of performance. For softball pitchers this measure would need to be calculated for each inning pitched and should be monitored throughout the season. RPE is a subjective measure that relies on the athlete understanding how tired their body is and providing a truthful rating. Similarly, coaches must prioritize the health and well-being of the athlete over winning in order for Internal Training Load to be effectively utilized to reduce injury risk. The emergence of wearable technology is promising for the assessment of training load and fatigue. Fleisig (41) provided an editorial commentary regarding the growing use of wearable technology in baseball. The Motus Sleeve and the Whoop are two current devices that offer the potential to monitor workload in overhead athletes. While wearable technologies are used more frequently in collegiate and professional athletes, over time we expect more competitive adolescent athletes to begin to utilize this available technology.

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