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Sports Specialization is Associated with An Increased Risk of Developing Anterior Knee Pain in Adolescent Female Athletes

Randon Hall[1,2], **Kim Barber Foss**[1], **Timothy E. Hewett**[1,3,4,5], and **Gregory D. Myer**[1,3,4,5]

[1] Division of Sports Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

[2] Orthopedic Surgery and Sports Medicine, Phoenix Children's Hospital Medical Group, Phoenix, Arizona

[3] Departments of Pediatrics and Orthopaedic Surgery, University of Cincinnati, Cincinnati, Ohio

[4] The Micheli Center for Sports Injury Prevention, Waltham, Massachusetts

[5] The Sports Health and Performance Institute, OSU Sports Medicine, Ohio State University Medical Center, Columbus, OH

Abstract

Objectives—This study sought to determine if sport specialization increases the risk of anterior knee pain in adolescent female athletes.

Design—Retrospective cohort epidemiology study.

Methods—Female basketball, soccer and volleyball players (N=546) were recruited from a single county public school district in Kentucky consisting of five middle schools and four high schools. A total of 357 multi-sport, and 189 single sport (66 basketball, 57 soccer and 66 volleyball) athlete subjects were included due to their diagnosis of patellofemoral pain on physical exam. Testing consisted of completion of a standardized history and physician-administered physical examination to determine the presence of patellofemoral pain (PFP). This study compared self-reported multi-sport athletes with sport specialized athletes participating in only one sport. The sports participation data was normalized by sport season with each sport accounting for one season of exposure. Incidence rate ratios (IRR) and 95% confidence intervals (CI) were calculated and used to determine significant differences between athletes who specialized in sport in early youth and multi-sport athletes.

Results—Specialization in a single sport increased the relative risk of PFP incidence by 1.5 fold (95% CI 1.0 to 2.2; p=0.038) for cumulative PFP diagnoses. Specific diagnoses such as Sinding Larsen Johansson/patellar tendinopathy (95% CI 1.5 to 10.1; p=0.005) and Osgood Schlatter Disease (95% CI 1.5 to 10.1; p=0.005) demonstrated a four-fold greater relative risk in single sport compared to multiple sport athletes. Other specific PFP diagnoses such as Fat Pad, Plica, Trauma, Pes Anserine Bursitis and IT Band Tendonitis incidence were not different between single sport and multiple sport participants (p>0.05).

Correspondence Name: Gregory D. Myer, Address: Cincinnati Children's Hospital, 3333 Burnet Avenue; MLC 10001, Cincinnati, OH 45229, Telephone: 513-636-1243, Fax: 513-636-0516, greg.myer@cchmc.org.

Conclusion—Early sport specialization in female adolescents is associated with increased risk of anterior knee pain disorders including PFP, Osgood Schlatter, Sinding Larsen-Johansson compared to multi-sport athletes.

Keywords

sport specialization; knee injury; patellofemoral pain; adolescent athlete; sport injury

Introduction

In the United States, approximately 30 to 45 million youth age 6 to 18 participate in a form of organized or recreational athletics. [1, 2] However, youth sports specialization with intense year-round training in a single sport at the exclusion of other sports or activities, has been a steadily increasing trend in the U.S.[3] There are several reasons why a young athlete may specialize in a single sport, including the potential for scholarships or professional contracts, media reports or positive feedback from parents and coaches labeling them as exceptionally talented.[4] Currently, there is significant lack of consensus regarding sport specialization, including the appropriate age, as well as the risks and benefits of this type of athletic participation. The authors found only three consensus statements on youth sports specialization, each of which recommended that children should be encouraged to participate in a variety of sports in the level that is consistent with their abilities and interests in order to attain the physical, psychological and social benefits of sport.[5-7] A recently published evidenced based review concluded that, for most sports, intense training in a single sport to the exclusion of others should be delayed until late adolescence to optimize success and minimize risk for injury and psychological stress.[8] The small amount of published literature regarding sports specialization in youth is either extrapolated from psychological development studies or based on case reports and expert opinion.

It is recognized that sports participation, including sports specialization, has many benefits, including living a healthy lifestyle, having a positive self-image and building social relationships.[9] However, sports specialization has been speculated to be associated with overuse injuries, burn-out and social isolation.[1, 9] In particular, patellofemoral pain (PFP), also known as anterior knee pain, makes up the significant portion of the over-use injuries observed in adolescent athletes.[10] The incidence of PFP is substantial in adolescence at approximately 15 – 20%, and is therefore becoming more important for researchers and clinicians to be aware of the predictors, etiology and ultimate prevention of this condition.[11, 12] The purpose of the current study was to determine if sport specialization is associated with an increased risk of development of PFP in adolescent compared to those that participate in multiple sports.

Methods

Female basketball, soccer and volleyball players (N=546) were recruited from a single county public school district in Kentucky consisting of five middle schools and 4 high schools. A total of 357 multiple sport, and 189 single sport (66 basketball, 57 soccer and 66 volleyball) female athletes were included in this study. This study was derived as part of a

larger study investigating the mechanisms underlying increased risk for knee injuries. The designation of multi-sport athletes and sport specialized athletes was based on self-reported sports participation. Each participant was asked to report their current sport participation, any additional sports participation and how many years they participated in each sport for both scholastic and recreational sports. There was no minimum number of years that an athlete had to participate to be included in the study but all athletes participated for at least one year. Athletes that reported participation in only one sport were assigned to the sport specialized group and those that reported participation in more than one sport were assigned to the multi-sport group.

The investigators followed the ethical guidelines set forth by the institutional review board committee at Cincinnati Children's Hospital Medical Center and the protocol was approved for human investigation. The Institutional Review Board approved the data collection procedures and consent forms. Parental consent and athlete assent were obtained before data collection. Subjects were tested prior to the start of their competitive season. Testing consisted of completing of the Anterior Knee Pain Scale (AKPS), International Knee Documentation Committee (IKDC) form, standardized history and physician-administered physical examination, medical history, maturational estimates (self-reported questionnaire on menses status, breast development, and hair growth) and anthropometrics (height, weight, fat%, and BMI). The maturational and anthropometric measures were secondary to determine if any between group differences existed.

Testing initially consisted of completion of the Anterior Knee Pain Scale (AKPS). The AKPS has a minimum score of 0 and a maximum score of 100 points, with 100 representing no pain. The AKPS has demonstrated high test-retest reliability and appears to be responsive to clinical changes in patients with PFP.[13, 14] Secondarily, the International Knee Documentation Committee (IKDC) form was completed. The IKDC is a reliable and valid instrument for use in a broad patient population concerning subjects' pain, symptoms, function, and sports activity.[15, 16] Lastly, each participant was evaluated by a physician, on site at the biodynamics center, where a standardized history and musculoskeletal physical examination was performed to determine the presence of PFP. The exam included palpation for tenderness at: medial patellofemoral ligament (MPFL), medial and lateral patellofemoral joint, medial and lateral femoral-tibia joint line, medial or lateral plica within patellofemoral joint, Gerdy's tubercle and iliotibial band, pes anserine bursa, distal pole of patella, tibial tubercle, Hoffa's fat pad, quadriceps and patella tendon. Standard evaluation and examination criteria were used for the diagnosis of the components of anterior knee pain. Height was measured with a stadiometer with the participant in bare feet. Body mass was measured on a calibrated medical-grade scale.

This study compared self-reported multi-sport athletes with sport specialized athletes participating in only one sport. In order to normalize the data based on each athlete's estimated cumulative amount of activity, the decision was made to give each sport equal weight in normalization. Thus each sport was given the designation of a year's sports participation and data was normalized by sport season with each sport accounting for one season of exposure. If a subject reported that they played one sport they were considered to have one season of exposure. If they played two sports they were considered to have two

seasons of exposure. The multi-sport athletes had the amount of reported diagnosis divided by the amount of exposures in order to normalize exposure between groups (single and multi-sport) We did understand that the exact exposure could not be calculated and that this was our best estimate knowing that some subjects would have more than a season's worth of exposure and some would have less. We defined season as a year's worth of exposure for the average athlete for that sport.

Statistical analyses were conducted in SPSS (IBM SPSS Statistics, Version 21.0, Chicago; IL) and statistical significance was established *a priori* at $p<0.05$. A one-way ANOVA was used to evaluate potential group differences in height, mass, and age. Incidence rate ratios (IRR) and 95% confidence intervals (CI) were calculated to determine significant differences between athletes who specialized in sport in early youth and multi-sport athletes. Significant differences in incidence rate were determined by the 95% confidence intervals that did not contain zero.

Results

The point incidence of patellofemoral pain in our population was 28%. Specialization in a single sport increased the relative risk of PFP incidence by 1.5 fold (95% CI 1.0 to 2.2; $p=0.038$) for cumulative PFP diagnoses. Specific diagnoses such as SLJ/patellar tendinopathy (95% CI 1.5 to 10.1; $p=0.005$) and OSD (95% CI 1.5 to 10.1; $p=0.005$) demonstrated a four-fold greater relative risk in single sport compared to multiple sport athletes. Incidence of other specific anterior knee pain diagnoses such as Fat Pad, Plica, Trauma, Pes Anserine Bursitis and IT Band Tendonitis incidence were not different between single sport and multiple sport participants ($p>0.05$). Significant findings are displayed in Figure 1. The average per multi-sport athlete is 2.305 sport exposures.

Importantly, group differences were observed in anthropometric and demographic data in the sample population studied. Specifically, single sport had an average age of 14.5 (95% CI 14.3 to 14.7 years; $p<0.05$), which was older than the multi-sport athletes aged 13.8 (95% CI 13.6 to 14.0 years). Similarly, the single sport athletes were taller and heavier than their multi-sport peers ($p<0.05$). The single sport athletes were measured at 162.4 (95% CI 161.3 to 163.5 cm) and 57.6 (95% CI 55.9 to 59.2 kg), while the multi-sport were measured at 160.2 (95% CI 159.4 to 161.1 cm) and 54.3 (95% CI 53.0 to 55.6 kg) for height and mass respectively. While these group differences represent relatively small effect sizes, the variation between groups may indicate potential insight to the sport selection process.

Discussion

Sports specialization is not a new concept and is believed to have been formally implemented into the training of young athletes during the mid to late 20th century in Eastern Europe.[4] There is convincing data to indicate that deliberate practice over a period of ten years is an essential factor in reaching elite status in a particular activity.[9, 17] These conclusions have been extrapolated to sport and it is hypothesized that the largest physiologic benefit of early specialization is a higher level of proficiency in motor skill for

that sport.[9] In addition, the prospects for attainment of a scholarship or professional status are a significant motivator for early sports specialization.

Critics of sports specialization have largely focused on the psychosocial aspects of this type of training regimen as specific injury data is lacking in the literature. Due to the time-intensity of training for one sport year-round, many athletes suffer from social isolation due to altered relationships with friends and family.[3, 4, 9] In addition, burnout due to overtraining has also been characterized as a principal component of the disadvantages that accompany sports specialization.[1, 3, 4, 9]. Moreover, several studies have shown that success in elite athletes in adolescence is not necessarily associated with greater success at the adult and international level.[18, 19] Overuse injuries have been reported in up to 50% of all pediatric sports related injuries, and may be a consequence of the time-intensiveness and physiological rigor of training programs of today's youth.[20] However, there is currently no published literature comparing the injury patterns of multi-sport athletes to those of sport specialized athletes.

Patellofemoral pain is one of the most common disorders among adolescent athletes and is multifactorial in nature.[11] The current findings show that sport specialization in female adolescents is associated with increased risk of PFP when compared to multi-sport athletes. Specifically, both multi-sport and sport specialized athletes may participate in rigorous training programs; however, those female adolescents dedicated to one sport seem to have a higher risk of PFP. In addition, apophyseal injuries of Osgood-Schlatter Disease and Sinding-Larsen-Johansson Syndrome were four times greater in sport-specialized athletes compared to multi-sport athletes.

Sports specialization may be related to a reduction in the acquisition of motor skill and proficiency. Reduced diversity of activity in young adolescents may undermine the development of a wide-range of comprehensive motor skills that are obtained through diversified participation in sports.[21] Well-rounded conditioning programs designed to reduce the neuromuscular deficits that increase the risk of patellofemoral pain appear effective in children and adolescents.[22] Thus, these types of training programs are more likely to be replicated by diversified sport participation rather than focused single sport training. In addition, an absence of variety associated with sports specialization can be associated with repetitive load stress on the growing skeleton which may lead patellofemoral pain.[20]

Integrative training theory can further support the variety needed to prevent the development of risk factors to PFP. Integrative training is defined as a program that incorporates general and specific strength and conditioning activities, which enhance both health and skill related components of physical fitness.[23] A progressive and multi-disciplinary integrative training program demonstrates improvements in performance measures in children and adolescents.[24, 25] During early adolescent development performance gains may be largely from neuromuscular adaptation during a time when cognitive and motor capabilities are highly malleable and amenable to age-appropriate interventions.[26, 27] Sports specialization in youth may lead to a lack of diversity in training and thus reduced motor skill development in the young athlete. In 2010, Myer et al.[11] found that athletes who developed PFP demonstrated increased knee abduction moment at initial contact when landing compared

with uninjured controls.[28] It is likely that the pathomechanics related to PFP can explain at least a portion of the PFP that is reported in this study and is potentially associated with the higher risk seen in sport specialized athletes. We contend that varied sport participation and integrative training programs promote diversified neuromuscular adaptation and may counterbalance the risk of PFP associated with early sports specialization.

Interestingly, a statistical difference was observed between the ages and anthropometric data in the two groups that were compared in this study. In particular, on average the sport specialized athletes were about 8.4 months older, 2.2 cm taller and 3.3 kg heavier than the multi-sport athletes. This data may be consistent with recent findings that indicate that children who are several months older than classmates of the same numerical age, and are therefore slightly more physically developed, may be pushed to specialize early in childhood. [29] However, it has been shown that body mass index and body composition are not associated with propensity to develop PFP in young adolescent athletes, and therefore is unlikely to be a large role in the findings of our study.[30]

There are limitations to the current study. The first is that this study was limited to female adolescents participating in basketball, volleyball and soccer; therefore, inferences to athletes in other sports should be limited. This analysis does not differentiate between athletes who had unilateral or bilateral PFP. The final limitation concerns information about the PFP condition itself, including treatment that was undertaken, severity and outcome measures, with all positive cases of PFP being treated equally. Our determination of sport specialization was based on self-reported answers to a standardized questionnaire, which may have led to a response bias. Lastly, we attempted to standardize the sports participation exposure between groups by assigning equal weight to each sport as a distinct season. The authors acknowledge that normalization based on activity hours would be more accurate, but difficult to ascertain.

Conclusion

The current study results indicate that sport specialization in female adolescents is associated with increased risk of anterior knee pain compared to multi-sport athletes. Further research is needed and should be focused to understand the possible underlying relationships between sport specialization and anterior knee pain disorders including PFP, Osgood Schlatter, Sinding Larsen-Johansson and risk of other lower and upper extremity injuries. In particular, the differences in neuromuscular control between sport specialized athletes and multi-sport athletes.

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Practical Implications

- Single sport/sport specialized athletes are at greater risk (1.5 fold) of developing PFP
- Sport specialized athletes are 4 times more likely to develop SLJ/patella tendinopathy than multi-sport athletes.
- Sport specialized athletes are 4 times more likely to develop OSD than multi-sport athletes.

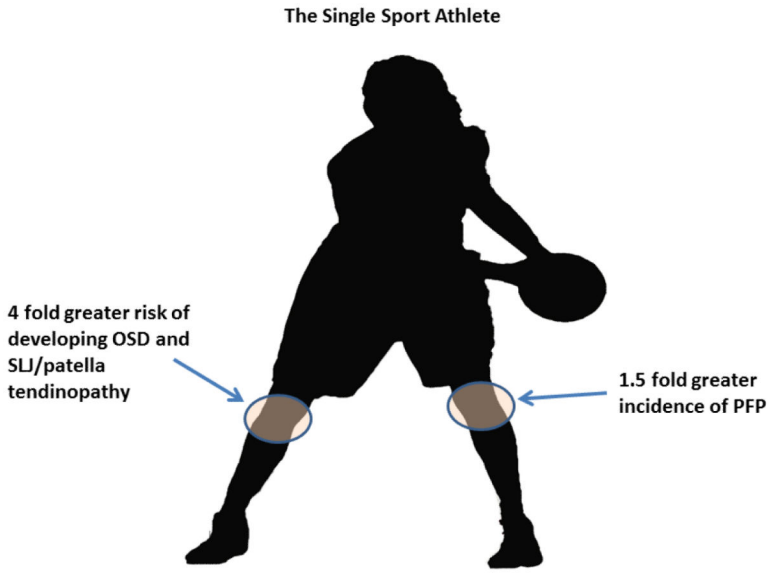

Figure 1.
Significant findings between single sport and multi-sport athletic participation.