ABSTRACT

Purpose: To determine the association between sport specialization and self-reported knee injury history in soccer athletes.

Methods: A total of 761 soccer athletes (431 females; mean age: 14.7 ± 1.8 years) between 12 and 18 years of age completed an online questionnaire. Sex- and age-adjusted odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated to investigate associations of specialization and volume of participation with knee injury history (P ≤ .05).

Results: Highly specialized athletes were more likely to report a history of an overuse (OR = 2.05 [95% CI: 1.07 to 3.90]) and acute (OR = 1.68 [95% CI: 1.01 to 2.78]) knee injury compared to low specialization athletes. Highly specialized athletes were 5.49 times more likely to report an overuse knee injury (OR: 5.49 [95% CI: = 2.23 to 13.50]) when injuries were limited to only those attributed to soccer. Playing one sport more than 8 months per year was associated with overuse knee injuries (OR = 1.97 [95% CI: 1.01 to 3.86]).

Conclusions: Specialization in soccer is associated with the increased risk of acute and overuse knee injuries.


An estimated 30 to 45 million children between 5 and 17 years of age participate in organized sports annually, with the number continuing to grow each year. With this rise in participation, rates of both acute and overuse injuries are also increasing. High school sports account for an estimated 2 million injuries, 500,000 physician visits, and 30,000 hospitalizations per year. More than 3.5 million children younger than 14 years receive medical treatment for sport injuries annually.

Soccer is one of the most popular sports in the United States, with approximately 17.6 to 24.5 million individuals participating each year. Children begin playing as young as 3 years of age and elite travel programs start as early as 7 to 8 years of age. Soccer is also one of the most popular high school team sports. Recent data from the National Federation of High School Associations revealed that more than 800,000 high school students participated in soccer, which ranked as the fourth and fifth most popular sports among boys and girls, respectively, in high school programs. The potential to earn a scholarship and play in college and the recent growth of professional leagues for both men and women in the United States drive young athletes to achieve elite status because they see an opportunity to extend their soccer careers past their teen years.

Although there are some variations, sport specialization is defined as intense, year-round training in a single sport and may include the exclusion of other sports. Some consider specialization based on training volume, whereas others consider it as simply limiting participation to a single sport on a year-round basis, regardless of training volume. Regardless of the definition, several authors have identified negative consequences of sport specialization. In a clinical review, Myer et al. observed that quitting all sports to focus on one sport at a young age increased the risk of injury and burnout. Similarly, in a case-control study of male and female teenagers...
across multiple sports that controlled for hours of participation, sport specialization was an independent risk factor for serious overuse injury. Additionally, Hall et al. found early specialization increased the risk of overuse knee injury diagnoses in female soccer, volleyball, and basketball athletes.

Recently, attention to the topic of sport specialization has grown among health care providers, parents, and youth sports organizations. Many medical organizations questioned the benefits of early sport specialization in recent consensus and position statements. Sport specialization is theorized to be linked with the noted rise in the increased risk of musculoskeletal injuries among youth athletes, including overuse injuries, and injuries that require surgical intervention. The knee is the second most commonly injured body site in young athletes, so the economic impact of sport-related knee injuries is significant.

Most research in sport specialization has examined the effects of overuse injuries across a broad sample of sports, limiting our understanding of sport-specific implications. The primary purpose of this study was to determine the association between sport specialization and knee injury history in youth soccer athletes. Secondly, the study aimed to determine whether playing a single sport more than 8 months per year was associated with knee injury history in youth soccer athletes. We hypothesized that both high levels of specialization and exceeding volume recommendations (> 8 months per year) would be independently associated with overuse knee injuries but not acute knee injuries in this population.

**METHODS**

The study was approved by the institutional review board at the University of Wisconsin–Madison. Parents and athletes were recruited to complete a short, anonymous online survey. The inclusion criteria were athletes who were between 12 and 18 years of age and had participated in organized soccer in the previous 12 months.

**Instrumentation**

The questionnaire included participant demographics, sports participation, soccer participation history, recent self-reported injury history, and level of specialization. Data regarding sport-related injury history and sport participation were restricted to the previous 12 months to limit recall bias. Participants were asked to report any injury from a sport, not just limited to soccer. However, a follow-up question was used to determine what sport the athlete was playing when the injury occurred. This allowed us to focus on all injuries that occurred during the observation and those injuries that were attributed to soccer. Members of the Pediatric Research in Sports Medicine (PRiSM) Sport Specialization Research Interest Group developed the initial survey questions. Sport specialization was categorized using the 3-point specialization scale that has been previously described and prospectively linked with injury. Briefly, this scale consists of three questions with binary yes/no answers including: (1) “Have you quit other sports to focus on soccer?”; (2) “Do you consider soccer more important than your other sports?”; and (3) “Do you train more than 8 months a year in soccer?” One point is awarded for each “yes” response and specialization is classified along a continuum of low (scores of 0 to 1), moderate (score of 2), and high (score of 3). The survey was validated for face validity by another group of PRiSM Sport Specialization Interest Group members.

**Procedures**

Parents and athletes from across the United States were recruited to complete an online survey (Qualtrics, Provo, UT). The survey link was distributed by research interest group members via e-mail and through personal social media accounts (Twitter, Facebook). The survey link was also shared with youth sports advocates, sports medicine groups, youth soccer organizations, and high school coaches, who were asked to share the link on their own social media channels. The survey was available from May 2017 to March 2018. Only participants who completed the survey were included for analysis.

**Statistical Analysis**

Data were summarized via means and standard deviations, frequencies, proportions, odds ratios, and 95% confidence intervals as appropriate. Chi-square tests and one-way analyses of variance were used to explore differences between demographics and levels of specialization. Fisher’s least significant difference test was used for post-hoc testing when appropriate. Multivariable logistic regression analyses were used to compare levels of specialization (low, moderate, and high) to injury history (overuse/chronic or acute). Binary logistic regressions were used to compare training more than 8 months per year to incidence of overuse and acute knee injuries. All
models were adjusted for sex and age. Statistical significance was set a priori at a $P$ value of less than .05. All analyses were performed using SPSS software (version 22.0; SPSS, Inc., Chicago, IL).

RESULTS

A total of 761 participants (431 females; mean age: 14.7 ± 1.8 years) completed the questionnaire, meaning that the survey software recognized their responses as complete. However, there were instances of missing data because we did not force respondents to answer questions. The number of missing cases is listed in Table 1 and cases were included in all analyses in which data were available. Descriptive statistics between levels of specialization (low: 28.6%; moderate: 35.6%; high: 35.7%) are reported in Table 1. During a typical competitive season, athletes self-reported participating in soccer 4.5 ± 1.0 days per week for approximately 10.7 ± 5.3 hours per week on average. For the entire sample, 72 (9.5%) participants reported a history of overuse knee injury in the previous 12 months that was attributed to soccer, whereas 115 (15.1%) participants reported a history of acute knee injury in the previous 12 months that was attributed to soccer. Age- and sex-adjusted odds ratios are presented in Table 2. Highly specialized athletes were more likely to report a history of an overuse knee injury but not an acute knee injury. For our secondary analysis, athletes who exceeded the recommendation of playing one sport more than 8 months per year were more likely to report a history of an overuse knee injury but not an acute knee injury.

DISCUSSION

The most important finding of this study was the association between sport specialization and overuse and acute knee injuries in adolescent soccer players. Specifically, highly specialized soccer athletes were more likely to report a history of overuse knee injury in our sample. This partially supports our hypothesis because we theorized that we would observe an increase in overuse but not acute knee injuries. Additionally, the odds increased significantly (odds ratio = 5.49) when in-

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low (n = 218)</th>
<th>Moderate (n = 271)</th>
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<th>$P$</th>
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<tbody>
<tr>
<td>Male sex</td>
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<td>Age (y)</td>
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<td>18</td>
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<tr>
<td>Grade</td>
<td>8.7 ± 2.0</td>
<td>8.8 ± 1.8</td>
<td>9.2 ± 1.8</td>
<td>.01</td>
<td>18</td>
</tr>
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<td>Months/year playing soccer</td>
<td>6.5 ± 3.3</td>
<td>9.7 ± 2.8</td>
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<td>&lt;.001</td>
<td>–</td>
</tr>
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<td>Hours/week playing soccer</td>
<td>10.1 ± 5.6</td>
<td>10.3 ± 5.1</td>
<td>11.5 ± 5.2</td>
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<td>Frequency of athletes who train &gt; 8 months/year in soccer</td>
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</tr>
</tbody>
</table>

$^a$ Values are presented as means ± standard deviation or frequency (%).

$^b$ High > low and moderate.

$^c$ High > moderate > low.

$^d$ Overall sample is 742 for subanalysis due to missing data.

TABLE 1
Comparisons Between Levels of Specialization$^a$

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juries only attributed to soccer were analyzed, which was driven by a reduced number of injuries in the low and moderate specialization groups. The second important finding of this study was that we were able to identify associations between exceeding safe sport recommendations and overuse knee injuries. Specifically, exceeding playing or training in soccer more than 8 months per year was associated with a history of overuse knee injuries, supporting our hypothesis. To our knowledge, this is the first study to demonstrate these relationships between specialization and exceeding safe sport recommendations and knee injuries in youth soccer athletes.

Previous research has demonstrated associations between highly specialized athletes and risk of injury.\textsuperscript{11,13,15} In a prospective study of sport specialization and injury, McGuine et al.\textsuperscript{13} reported an increase in lower extremity injuries associated with moderate and high levels of sport specialization in 1,544 high school athletes. This large prospective study supported findings of an early case–control study of 12- to 18-year-old athletes that demonstrated sport-specialized training as an independent risk factor for injury, including serious overuse injury.\textsuperscript{16} Finally, a recent systematic review corroborated these results and included three studies demonstrating that levels of sport specialization were associated with an increased risk of overuse injury.\textsuperscript{23} One limitation of these studies was the wide variety of sports included in their sample, which limited generalizability of the findings to a specific sport, such as soccer. The current study adds to the body of knowledge in this area but is unique in that it focused exclusively on soccer, a sport with 17.6 to 24.5 million participants and one in which year-round participation is common.\textsuperscript{7}

Unlike prior studies linking sport specialization to overuse injury,\textsuperscript{13} the current study also demonstrated an association between acute knee injury and soccer specialization. This finding is concerning because soccer participation has been implicated for a high rate of acute knee injuries, including anterior cruciate ligament tears.\textsuperscript{24} Although we did not focus on specific acute injuries or mechanisms for those injuries (contact vs noncontact), there is abundant literature regarding the mechanisms and risk factors for acute knee injuries among youth athletes, resulting in a push toward the implementation of injury prevention programs.\textsuperscript{25,26} Although the effectiveness of these prevention programs has been demonstrated,\textsuperscript{27} our findings might suggest that reducing the single-sport training load and participating in a variety of sports may also serve as a risk reduction strategy.

Early specialization in sports is becoming more common among children and adolescents in the hopes that they will make their high school team and eventually play in college.\textsuperscript{9,10} Early sport specialization was once believed to be a hallmark of individualized sports (ie, tennis and gymnastics) rather than team sports.\textsuperscript{28} However, approximately 21% to 38% of soccer athletes are now classified as highly specialized, which is higher than the prevalence of specialization reported in other high school sports.\textsuperscript{12,13} Because of the year-round component associated with sport specialization, training

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overuse Knee Injury</th>
<th>Acute Knee Injury</th>
<th>Overuse Knee Injury Attributed to Soccer</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Specialization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>1.18 (0.60, 2.35)</td>
<td>1.38 (0.82, 2.31)</td>
<td>2.37 (0.91, 6.15)</td>
<td>1.55 (0.88, 2.74)</td>
</tr>
<tr>
<td>High</td>
<td>2.05 (1.07, 3.90)(b)</td>
<td>1.68 (1.01, 2.78)(c)</td>
<td>5.49 (2.23, 13.50)(d)</td>
<td>2.21 (1.28, 3.81)(e)</td>
</tr>
<tr>
<td>Volume recommendations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training for &gt; 8 months</td>
<td>1.97 (1.01, 3.86)(f)</td>
<td>1.40 (0.87, 2.26) (g)</td>
<td>4.90 (1.74, 13.82)(h)</td>
<td>1.46 (0.88, 2.42)</td>
</tr>
</tbody>
</table>

CI = confidence interval
\(a\) Reference categories are low specialization and not training more than 8 months/year in soccer.
\(b\) \(P = .03, \text{Wald} = 4.5\).
\(c\) \(P = .046, \text{Wald} = 3.9\).
\(d\) \(P < .001, \text{Wald} = 13.7\).
\(e\) \(P = .005, \text{Wald} = 8.0\).
\(f\) \(P = .048, \text{Wald} = 3.9\).
\(g\) \(P = .003, \text{Wald} = 9.0\).
more than 8 months per year is common. Youth soccer players who reported playing soccer for more than 8 months of the year were more likely to have an overuse knee injury during the past year compared to those who played soccer for 8 or fewer months of the year. It is not clear whether this increase in injury is associated purely with the increased exposure or whether single-sport participation volume also contributes to injury in these athletes. Regardless, our results support the recommendation that soccer athletes should not play or train in organized soccer more than 8 months per year to reduce the risk of overuse knee injuries. This recommendation is in agreement with previous research that identified increased risk of injury using this training volume cut-off in a diverse sample of youth athletes.  

The injury prevalence in this study is similar to previous research. National representative samples report that knee injuries make up approximately 12% of injuries among high school and collegiate soccer athletes. The prevalence of knee injury in the current study was 9.5% for overuse injury and 16.8% for acute injury. The current study examined a younger population, including middle school athletes rather than only athletes in high school where reliable injury surveillance systems are more common. Although the overall injury prevalence seems to be in line with previous research, the overuse injury rate is low compared to other highly controlled epidemiological studies in similar age groups. In one prospective study, 85% of knee injuries were classified as overuse. However, other studies have also observed overuse knee injury estimates at a much lower proportion (47%) of all overuse injuries.  

Risk factors for knee injuries include female sex, previous knee injury, participation in soccer, and sport participation more than two times per week. Interestingly, O’Kane et al. found that soccer athletes playing for more than one soccer team reported a 2.5-fold increase in overuse knee injuries, whereas participating in other forms of physical activity besides soccer decreased the risk of overuse injuries by 61%.  

In addition to specialization, training volume is thought to increase the risk of injury among youth athletes. Previous research observed that athletes with high training loads who participated in club sports or were highly specialized reported more lower extremity injuries during the study period. Additionally, athletes who participated in a single sport for more than 8 months of the year or participated in a sport for more hours per week than their age were also more likely to report a history of overuse injury. Similarly, the current study found that youth soccer players who participated in soccer for more than 8 months of the year reported more overuse injuries in the prior year than those who participated in soccer 8 or fewer months of the year. Collectively, these findings suggest that it may be not only specializing in one sport, but the volume of that participation that contributes to overuse injury risk. Therefore, following previously published recommendations to allow 2 to 3 months, or a sports season, away from a specific sport for athletes who participate year-round may be advisable.  

This study is the first to examine the effects of sport specialization on injury risk in a national cohort of youth soccer players. However, there are several limitations to this study that should be noted. First, a generic sample of youth soccer players participated following e-mail and social media requests to soccer organizations and competitions with publicly available contact information. Although participants from multiple regions of the country responded, determining the number of potential participants was not feasible, thus limiting our ability to calculate a response rate. Additionally, there is response bias because those who chose to respond and complete the survey may have had more interest in how soccer participation may affect injury risk due to personal injury history. Sport specialization, training volume, and injury data were obtained from self-reported survey responses and therefore were subject to recall bias because participants were asked to report their training volume and injury history during the prior 12 months. However, these methods are frequently used in this area of research. We did not control for exposure in this analysis and it is possible that increases in injury risk are associated with increased playing time. Additionally, although we controlled for sex, future research should determine whether a specific sex is driving these differences. Finally, the internal validity of the survey used in this study was not evaluated, although the criteria used to measure specialization were consistent with prior studies.  

**IMPLICATIONS FOR CLINICAL PRACTICE**  
Individuals working with youth soccer athletes should be aware of the increased risk of both acute and overuse knee injury associated with soccer specialization during childhood and adolescence and with year-round soccer participation. Parents, coaches, and administra-
tors should encourage young soccer players to participate in a variety of sports and take one sports season off from soccer each year, ideally limiting soccer participation to 8 months per year as a way to minimize knee injury risk. Future studies collecting prospective data on training volume, training intensity, participation in other sports or fitness training, and incidence of acute and chronic injury that includes mechanism of acute injury may help determine specific factors that contribute most to injury risk in young athletes.

REFERENCES