

# Association of Competition Volume, Club Sports, and Sport Specialization With Sex and Lower Extremity Injury History in High School Athletes

Eric G. Post, MS, ATC,<sup>\*†‡</sup> David R. Bell, PhD, ATC,<sup>†‡§</sup> Stephanie M. Trigsted, MS, ATC,<sup>†‡</sup> Adam Y. Pfaller,<sup>§</sup> Scott J. Hetzel, MS,<sup>||</sup> M. Alison Brooks, MD, MPH,<sup>§</sup> and Timothy A. McGuine, PhD<sup>§</sup>

**Background:** High school athletes are increasingly encouraged to participate in 1 sport year-round to increase their sport skills. However, no study has examined the association of competition volume, club sport participation, and sport specialization with sex and lower extremity injury (LEI) in a large sample of high school athletes.

**Hypothesis:** Increased competition volume, participating on a club team outside of school sports, and high levels of specialization will all be associated with a history of LEI. Girls will be more likely to engage in higher competition volume, participate on a club team, and be classified as highly specialized.

**Study Design:** Cross-sectional study.

**Level of Evidence:** Level 3.

**Methods:** High school athletes completed a questionnaire prior to the start of their competitive season regarding their sport participation and previous injury history. Multivariable logistic regression analyses were used to investigate associations of competition volume, club sport participation, and sport specialization with history of LEI, adjusting for sex.

**Results:** A cohort of 1544 high school athletes (780 girls; grades 9-12) from 29 high schools completed the questionnaire. Girls were more likely to participate at high competition volume (23.2% vs 11.0%,  $\chi^2 = 84.7$ ,  $P < 0.001$ ), participate on a club team (61.2% vs 37.2%,  $\chi^2 = 88.3$ ,  $P < 0.001$ ), and be highly specialized (16.4% vs 10.4%,  $\chi^2 = 19.7$ ,  $P < 0.001$ ). Athletes with high competition volume, who participated in a club sport, or who were highly specialized had greater odds of reporting a previous LEI than those with low competition volume (odds ratio [OR], 2.08; 95% CI, 1.55-2.80;  $P < 0.001$ ), no club sport participation (OR, 1.50; 95% CI, 1.20-1.88;  $P < 0.001$ ), or low specialization (OR, 2.58; 95% CI, 1.88-3.54;  $P < 0.001$ ), even after adjusting for sex.

**Conclusion:** Participating in high sport volume, on a club team, or being highly specialized was associated with history of LEI. Girls were more likely to participate at high volumes, be active on club teams, or be highly specialized, potentially placing them at increased risk of injury.

**Clinical Relevance:** Youth athletes, parents, and clinicians should be aware of the potential risks of intense, year-round participation in organized sports.

**Keywords:** club sports; specialization; injury; youth sports; high school

From the <sup>†</sup>Department of Kinesiology, University of Wisconsin–Madison, Madison, Wisconsin, <sup>‡</sup>Wisconsin Injury in Sport Laboratory, University of Wisconsin–Madison, Madison, Wisconsin, <sup>§</sup>Department of Orthopedics and Rehabilitation, University of Wisconsin–Madison, Madison, Wisconsin, and <sup>||</sup>Department of Biostatistics and Medical Informatics, University of Wisconsin–Madison, Madison, Wisconsin

\*Address correspondence to Eric G. Post, MS, ATC, University of Wisconsin–Madison, 2000 Observatory Drive, 2224 Gymnasium-Natatorium, Madison, WI 53706 (email: egpost@wisc.edu).

The following authors declared potential conflicts of interest: David R. Bell, PhD, ATC, and M. Alison Brooks, MD, MPH, report an institutional grant from the American Medical Society for Sports Medicine and National Federation of High Schools. M. Alison Brooks also reports grants/grants pending from the NCAA–Department of Defense CARE Consortium, DJO Global Inc, and Anthrotronix Inc.

DOI: 10.1177/1941738117714160

© 2017 The Author(s)

High school athletes are increasingly encouraged to participate in 1 sport year-round to increase their sport skills.<sup>4,5,9,10</sup> This trend toward increasing specialization in a single sport often leads athletes to participate in club sport teams in addition to their high school sports and can result in increased competition volume throughout the year.<sup>4,5,9</sup> Many club sport teams participate in a larger number of competitions relative to practices to showcase the abilities of talented athletes to college coaches or scouts.<sup>10</sup> Previous research has demonstrated that there is an increased risk of injury during competitions compared with practice.<sup>14,15,17</sup> Therefore, dual participation in both club and high school sports is potentially problematic as it may lead to increased exposure and, particularly, a higher competition volume, which may increase the risk of sustaining lower extremity injuries (LEIs).

Specialization has been previously linked with injury in a broad sample of athletes as young as 7 years presenting to a sports medicine clinic and in a sample of female high school athletes.<sup>7,8</sup> Playing a single sport for more than 8 months out of the year and high levels of specialization are associated with increased odds of reporting a previous overuse knee injury in high school athletes.<sup>2</sup> Cuff et al<sup>6</sup> found that high school athletes who participated in organized sports for all 4 seasons of the year were more likely to report a previous overuse injury compared with athletes who took at least 1 sport-season off during the year.<sup>6</sup> However, total number of primary sport competitions may serve as a more accurate measure of sport participation volume than sport seasons because of the large differences in the total number of competitions during a season between various sports. Additionally, the impact of club sport participation in addition to high school sport participation on potential injury risk has not been examined. Previous studies examining specialization in high school athletes examined a limited number of sports from either 1 or 2 local high schools.<sup>2,7</sup>

The effects of sex on patterns of sport participation in youth athletes are also unknown. Female athletes are at greater risk for certain injuries, such as anterior cruciate ligament injuries or overuse injuries of the knee.<sup>1,3,7</sup> One theory for this increased risk among female athletes is the increasing trend toward intense, year-round sport participation and specialization. Only 1 recent retrospective study observed that single-sport female athletes were at greater risk of developing anterior knee pain and other chronic knee injuries compared with multisport athletes.<sup>7</sup> However, no study has examined whether female athletes participate in a greater volume of competitions throughout the year, are more likely to compete on a club team, or are more likely to be highly specialized than male athletes.

Therefore, the purposes of this study were to determine (1) the association of competition volume, club sport participation, and sport specialization with previous LEI in high school athletes and (2) the association of sex with competition volume, club sport participation, and sport specialization status. We hypothesized that increased competition volume, participating

on a club team outside of school sports, and high levels of specialization would all be associated with a previous history of LEI and that female athletes would be more likely than male athletes to engage in greater competition volume, participate on a club team, and be classified as highly specialized.

## METHODS

### Participants

This study was approved by the Institutional Review Board of the University of Wisconsin–Madison, and informed written assent/consent was obtained from the participant and parent or guardian prior to participation. High school athletes (grades 9–12) were recruited during preseason team meetings from 29 Wisconsin high schools during the 2015–2016 academic year as part of a larger ongoing study. Participants completed a paper-and-pencil questionnaire prior to the start of their competitive season regarding their sport participation and previous injury history. Participants completed the questionnaire independently but in a group setting with their teammates and coaches. High schools were classified as either large (enrollment, >1000 students), medium (enrollment, 500–1000 students), or small (enrollment, <500 students).

### Questionnaire

Participants completed a nonvalidated sport participation and LEI history questionnaire prior to the start of their sport season. Athletes reported all interscholastic and club sports they participated in during the previous year and current school year. Additionally, athletes were asked to identify their primary sport and number of primary sport competitions within the past year. Primary sport competition volume was defined as high (>60 primary sport competitions), moderate (30–60 competitions), or low (<30 competitions). Sport specialization status was determined using a previously utilized 3-point specialization scale (score of 1 = low specialization, score of 2 = moderate specialization, score of 3 = high specialization).<sup>2,8</sup> This scale classifies athletes from low to high specialization based on the definition of sport specialization as “year-round, intensive training in a single sport at the exclusion of other sports.”<sup>2,8</sup> Finally, participants provided information regarding previous history of LEI. An LEI was defined as an injury that occurred during sports and that caused the athlete to seek medical care from his or her school athletic trainer or other medical provider. While the questionnaire used in this study has not been validated, components of the questionnaire such as the specialization scale have been utilized in a variety of settings.<sup>2,8,13</sup> Additionally, each questionnaire was reviewed individually with the participant by an athletic trainer to make sure injuries and sport participation were accurately recalled, correctly classified, and met the criteria above.

### Statistical Analysis

Data were summarized as frequencies and proportions (%), means  $\pm$  SDs, and odds ratios (ORs) with 95% CIs. Chi-square

tests were used to examine differences in competition volume, club sport participation, and specialization status by sex and school size. Multivariable logistic regression analyses were used to investigate associations of primary sport competition volume, club sport participation, and sport specialization status with previous history of LEI, adjusting for differences in sex. Statistical significance was set a priori at  $P < 0.05$ , and all analyses were performed using SPSS statistical software (v 22.0; IBM Corp).

## RESULTS

A total of 1544 athletes (female, 50.5%; mean age,  $16.1 \pm 1.1$  years) enrolled in the study and completed the questionnaire. Over half of participants reported taking part in a low volume of competition, while almost 1 in 5 participated in a high volume of competition (Table 1). Approximately half of athletes participated on a club team in addition to their interscholastic sport participation. Club sport participation was greatest for baseball/softball (83.2%), soccer (75.2%), and volleyball (67.3%) players. Among sports with at least 100 respondents, the proportion of highly specialized athletes was largest for soccer (21.5%), baseball/softball (19.1%), and volleyball (16.7%) players. The prevalence of specialization differed by school size, with athletes at large schools more likely to be highly specialized (27.5%) than athletes at medium (12.3%) or small (6.7%) schools ( $\chi^2 = 103.6$ ;  $P < 0.001$ ).

A total of 487 participants (31.5%) reported sustaining a total of 599 previous time-loss LEIs. The ankle (43.2%) was the most common site injured, followed by the knee (23.4%) and lower leg (9.5%). Common injuries included ligament sprains (50.5%), muscle strains (20.2%), and fractures (10.3%). Thirty-three (5.5%) of the reported previous injuries required surgical treatment. Sex-adjusted ORs for competition volume, club sport participation, and specialization are presented in Table 2. Athletes with high or moderate competition volume were more likely to report previous LEI. Similarly, athletes who participated in a club sport in addition to their school team had significantly greater odds of having a previous LEI than those who competed on their school team only. Finally, participants who were high or moderately specialized had significantly greater odds of reporting a previous LEI than low-specialization athletes.

Girls were more likely than boys to participate at a high competition volume (23.2% vs 11.0%,  $\chi^2 = 84.7$ ,  $P < 0.001$ ), participate on a club team (61.2% vs 37.2%,  $\chi^2 = 88.3$ ,  $P < 0.001$ ), and be highly specialized (16.4% vs 10.4%,  $\chi^2 = 19.7$ ,  $P < 0.001$ ). Girls were more likely to report a previous LEI than boys when considering all sports (36.5% vs 27.0%,  $\chi^2 = 15.9$ ,  $P < 0.001$ ) and when the sample was restricted to sex-equivalent sports (37.3% vs 28.2%,  $\chi^2 = 9.0$ ,  $P = 0.003$ ).

## DISCUSSION

Female athletes were more likely to specialize than male athletes, which is in agreement with previous findings among high school athletes that female athletes were more likely to

identify as single-sport athletes.<sup>2</sup> This result, in combination with the fact that female athletes were also more likely to participate in a high competition volume and be on a club team, indicates that female high school athletes may have a different sport participation profile than male athletes, which may increase their risk of injury. Female athletes in this study were more likely to report a previous LEI than male athletes in both the entire sample of sports and when only sex-equivalent sports were examined. The increased prevalence of high specialization, competition volume, and club sport participation among girls in this study may be 1 potential explanation for the increased risk of lower extremity injury that has been seen in female athletes.<sup>1,3,7</sup> Finally, athletes at large high schools were more likely to be highly specialized compared with athletes at small high schools. School size has been identified as a primary factor in the prevalence of specialization among high school athletes.<sup>2</sup> Athletes at larger high schools must compete for limited roster spots and thus may choose to specialize in a sport to try to gain an advantage in sport skills that will allow them to make a high school team.<sup>2</sup> Alternatively, not having as many students available for sport participation at smaller schools may result in pressure for athletically skilled students to participate in multiple sports.<sup>2</sup>

Overall, almost 1 in 5 high school athletes reported participating in greater than 60 primary sport competitions in the previous year, and roughly half reported participating on a club sports team in addition to their high school sport team. While the majority of high school athletes still participate in a low volume of sport competitions, it appears that club sport participation is now a common aspect of high school sport participation. Approximately 13% of high school athletes were classified as highly specialized, while other research has found the prevalence of high specialization to be upward of 28% to 36%, depending on the specific sample of youth athletes.<sup>2,8</sup> However, these studies did not include football athletes, and the inclusion of football may explain the lower prevalence of specialization in our sample. In fact, only 2 of 260 football athletes (0.8%) in this sample were classified as highly specialized. American high school football in our geographic region is mostly restricted to competition in the late summer and fall, with little to no off-season travel or club teams, which may explain the low prevalence of specialization among football athletes. Additionally, the large number of participants from small high schools may have contributed to the lower prevalence of high specialization seen in this study. Athletes at smaller high schools in both this study and others have been more likely to be less specialized.<sup>2</sup>

Athletes who competed in high (>60) or moderate (30-60) volumes of primary sport competition in the previous year were more likely to report a previous LEI than athletes who competed in fewer than 30 primary sport competitions. Injury rates are higher during competitions than during practices.<sup>14,15,17</sup> While football has one of the highest injury rates among high school sports,<sup>17</sup> a high school football player may only compete 8 to 10 times during the season. In contrast, a high school

Table 1. Participant demographics

Variable	n	%
Sex	1544	100.0
Female	780	50.5
Male	764	49.5
Grade		
N/A	13	0.9
9	419	27.1
10	419	27.1
11	382	24.7
12	311	20.1
School size (No. of students)		
Small (<500)	566	36.7
Medium (500-1000)	658	42.6
Large (>1000)	320	20.7
Competition volume (No. of competitions past year)		
Low (<30)	816	52.8
Moderate (30-60)	463	30.0
High (>60)	265	17.2
Club sport participation		
N/A	8	0.5
No	777	50.3
Yes	759	49.2
Specialization status		
Low	919	59.5
Moderate	418	27.1
High	207	13.4
Primary sport		
Baseball/softball	131	8.5
Basketball	330	21.4
Cheer/dance	23	1.5
Cross-country	16	1.0
Football	262	16.9

(continued)

Table 1. (continued)

Variable	n	%
Gymnastics	14	0.9
Ice hockey	22	1.4
Lacrosse	11	0.7
Soccer	312	20.2
Swimming	8	0.5
Tennis	67	4.3
Track	2	0.1
Volleyball	246	16.0
Wrestling	35	2.3
Other	13	0.8
None <sup>a</sup>	8	0.5

N/A, not available

<sup>a</sup>None indicates that an athlete reported playing multiple sports equally and was unable to identify a “primary sport.”

basketball player has the opportunity to also compete in his or her off-season with a club team and may therefore compete in a much larger number of competitions over the entire year. In this study, athletes who competed on a club sport team were more likely to report a previous LEI compared with athletes who participated on their high school team only. The opportunity to participate on club sport teams is sport specific but may play a large role in increasing the risk of injury among athletes in those sports due to increased exposure.

High levels of sport specialization were associated with previous LEI history, independent of sex. The 3-point specialization scale is associated with injury in various youth athlete populations.<sup>2,8</sup> Jayanthi et al<sup>8</sup> developed the 3-point specialization scale and reported an association between sport specialization and previous injury in a sample of youth athletes between the ages of 7 and 18 years reporting to a sports medicine clinic. Additionally, Bell et al<sup>2</sup> found an association between high levels of specialization and history of overuse knee injuries in a 2–high school sample of athletes from a limited number of sports. Sustaining an injury during sports participation is associated with dropout from sports, and sport dropout is associated with decreased physical activity throughout the athlete’s life span.<sup>11,12,16,18</sup> Therefore, youth athletes and parents should weigh the potential gain in sport-specific skills against the potential risk of injury and long-term health consequences of specializing in 1 sport.

This study has several limitations. Participants were asked to recall any previous sports-related injuries and the number of

**Table 2.** Odds ratios (ORs) for competition volume, club sport participation, sport specialization status, and previous lower extremity injury<sup>a</sup>

	Previous Lower Extremity Injury	
	OR (95%CI)	P Value
Low competition volume <sup>b</sup>	—	
Moderate competition volume <sup>c</sup>	1.68 (1.31-2.16)	<0.001
High competition volume <sup>d</sup>	2.08 (1.55-2.80)	<0.001
Club sport participation—No	—	
Club sport participation—Yes	1.50 (1.20-1.88)	<0.001
Low specialization	—	
Moderate specialization	2.38 (1.86-3.05)	<0.001
High specialization	2.58 (1.88-3.54)	<0.001

<sup>a</sup>Models adjusted for sex.

<sup>b</sup>Low competition volume: <30 competitions in past year.

<sup>c</sup>Moderate competition volume: 30-60 competitions in past year.

<sup>d</sup>High competition volume: >60 competitions in past year.

competitions in the previous year that they participated in, creating the opportunity for recall bias. Particularly, athletes who had a previous overuse injury may have received consultation from a physician regarding the impact of volume on overuse injuries, and thus, these participants may have been more aware of their competition volume and more accurate with their reporting. Also, as mentioned previously, the validity and reliability of the nonvalidated questionnaire in this study has not been established. However, components of the questionnaire such as the specialization scale have been widely utilized in a variety of settings.<sup>2,8,13</sup> We attempted to limit the effect of recall bias and maximize the accuracy of the questionnaire responses by having an athletic trainer review each questionnaire individually with the participant. Additionally, we did not determine whether previous injuries were acute or chronic in nature or whether those injuries occurred during practice or competition. Previous research has examined the association between specialization and overuse injury in particular,<sup>2,8</sup> so the use of all previous LEIs in this study should be considered when comparing results between studies. Also, because of the use of previous LEIs and the cross-sectional nature of this study, it is not possible to determine causality between our participation variables and injury. It may be that increased competition volume, club sport participation, and specialization increase injury risk, but it is also possible that an athlete would modify these sport participation patterns after sustaining an injury. Finally, all data were collected from high schools in 1 state and thus are limited to only the sports offered by the schools in that state. However, by enrolling athletes from a large, diverse sample of high schools, we attempted to

provide an accurate representation of high school athletes in this state.

## CONCLUSION

High school athletes who participated in more than 60 primary sport competitions in a year, participated on a club team in addition to their high school team, or were highly specialized had significantly greater odds of reporting a previous lower extremity injury. Female high school athletes were more likely to participate in high competition volume and on club teams and to be highly specialized, potentially placing them at greater risk for injury. Youth athletes, parents, and clinicians should be aware of the potential risks of intense, year-round participation in organized sports.

## REFERENCES

1. Arendt EA, Agel J, Dick R. Anterior cruciate ligament injury patterns among collegiate men and women. *J Athl Train.* 1999;34:86-92.
2. Bell DR, Post EG, Triggsted SM, Hetzel S, McGuine TA, Brooks MA. Prevalence of sport specialization in high school athletics: a 1-year observational study. *Am J Sports Med.* 2016;44:1469-1474.
3. Beynon BD, Vacek PM, Newell MK, et al. The effects of level of competition, sport, and sex on the incidence of first-time noncontact anterior cruciate ligament injury. *Am J Sports Med.* 2014;42:1806-1812.
4. Brenner JS. Overuse injuries, overtraining, and burnout in child and adolescent athletes. *Pediatrics.* 2007;119:1242-1245.
5. Brenner JS; Council on Sports Medicine and Fitness. Sports specialization and intensive training in young athletes. *Pediatrics.* 2016;138:154-157.
6. Cuff S, Loud K, O'Riordan MA. Overuse injuries in high school athletes. *Clin Pediatr (Phila).* 2010;49:731-736.
7. Hall R, Barber Foss K, Hewett TE, Myer GD. Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. *J Sport Rehabil.* 2015;24:31-35.

8. Jayanthi NA, LaBella CR, Fischer D, Pasulka J, Dugas LR. Sports-specialized intensive training and the risk of injury in young athletes: a clinical case-control study. *Am J Sports Med.* 2015;43:794-801.
9. LaPrade RF, Agel J, Baker J, et al. AOSSM early sport specialization consensus statement. *Orthop J Sports Med.* 2016;4:2325967116644241.
10. Myer GD, Jayanthi N, Difiori JP, et al. Sport specialization, part I: does early sports specialization increase negative outcomes and reduce the opportunity for success in young athletes? *Sports Health.* 2015;7:437-442.
11. Myer GD, Jayanthi N, DiFiori JP, et al. Sports specialization, part II: alternative solutions to early sport specialization in youth athletes. *Sports Health.* 2015;8:65-73.
12. Perkins DF, Jacobs JE, Barber BL, Eccles JS. Childhood and adolescent sports participation as predictors of participation in sports and physical fitness activities during young adulthood. *Youth Soc.* 2004;35:495-520.
13. Post EG, Thein-Nissenbaum JM, Stiffler MR, et al. High school sport specialization patterns of current Division I athletes. *Sports Health.* 2017;9:148-153.
14. Roos KG, Kerr ZY, Mauntel TC, Djoko A, Dompier TP, Wickstrom EA. The epidemiology of lateral ligament complex ankle sprains in National Collegiate Athletic Association sports. *Am J Sports Med.* 2017;45:201-209.
15. Roos KG, Wasserman EB, Dalton SL, et al. Epidemiology of 3825 injuries sustained in six seasons of National Collegiate Athletic Association men's and women's soccer (2009/2010-2014/2015) [published online May 17, 2016]. *Br J Sports Med.* doi:10.1136/bjsports-2015-095718.
16. Telama R, Yang X, Viikari J, Välimäki I, Wanne O, Raitakari O. Physical activity from childhood to adulthood: a 21-year tracking study. *Am J Prev Med.* 2005;28:267-273.
17. Tirabassi J, Brou L, Khodae M, Lefort R, Fields SK, Comstock RD. Epidemiology of high school sports-related injuries resulting in medical disqualification: 2005-2006 through 2013-2014 academic years. *Am J Sports Med.* 2016;44:2925-2932.
18. Vella SA, Cliff DP, Okely AD, Scully ML, Morley BC. Associations between sports participation, adiposity and obesity-related health behaviors in Australian adolescents. *Int J Behav Nutr Phys Act.* 2013;10:113.

For reprints and permission queries, please visit SAGE's Web site at <http://www.sagepub.com/journalsPermissions.nav>.