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original research

The Epidemiology of Overuse Conditions in Youth Football and High School Football Players

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Context: High-intensity sport training at the youth level has led to increased concern for overuse conditions. Few researchers have examined overuse conditions in youth sports.

Objective: To examine the rates, risks, and distributions of overuse conditions between youth and high school football players.

Design: Descriptive epidemiologic study.

Setting: Youth and high school football teams.

Patients or Other Participants: The Youth Football Safety Study (YFSS) investigated youth football athletes from age 5 to 14 years. The National Athletic Treatment, Injury and Outcomes Network (NATION) focused on high school football athletes 14 to 18 years old. The YFSS data consisted of 210 team-seasons, and the NATION data consisted of 138 team-seasons.

Main Outcome Measure(s): Athletic trainers collected football injury and exposure data during the 2012 and 2013 seasons. Injury rates, risks, and distributions were calculated, with injury rate ratios, risk ratios, and injury proportion ratios with 95% confidence intervals (CIs) comparing youth and high school football players.

Results: The YFSS reported 1488 injuries, of which 53 (3.6%) were overuse conditions. The NATION reported 12 013 injuries, of which 339 (2.8%) were overuse conditions. The overuse condition rate did not differ between high school and youth football (3.93 versus 3.72/10 000 athlete-exposures; injury rate ratio = 1.06; 95% CI = 0.79, 1.41). However, the 1-season risk of overuse condition was higher in high school than in youth football players (2.66% versus 1.05%; risk ratio = 2.53; 95% CI = 1.84, 3.47). Compared with high school football players, youth football players had greater proportions of overuse conditions that were nontime loss (ie, <24 hours participation-restriction time; 83.0% versus 67.0%; injury proportion ratio = 1.24; 95% CI = 1.07, 1.43) and affecting the lower extremity (92.5% versus 62.5%; injury proportion ratio = 1.48; 95% CI = 1.32, 1.65).

Conclusions: Overuse conditions may not present a primary concern in youth and high school football players. However, differences existed between the 2 levels of competition. Although additional research on the incidence of overuse conditions across all youth and high school sports is needed, these findings may highlight the need for programming that is specific to competition level.

Key Words: injury rate, injury risk, time-loss injuries, non–time-loss injuries, body part injuries, injury diagnosis, sports

Key Points

- A low incidence of overuse conditions was reported in youth football and high school football players.
- High school football athletes had a higher risk of overuse injury than youth football athletes but not a higher overuse injury rate.

In 2008, the National Council of Youth Sports documented that more than 60 million athletes aged 5 to 18 years participated in organized athletics.[1] Sports provide many valuable life skills, including social and leadership development, and they promote a healthier lifestyle through active exercise.[2] The trend in sports participation has evolved from recreational play to intense sport-specific skill development.[3] Overuse conditions are the result of repeated stresses to an area without adequate rest for structural adaptation to occur.[4] These injuries can be detrimental to youth and high school athletes, especially when the bony epiphysis is affected.[5]

In the literature, no consensus exists for the definition of overuse injury. The term *overuse* can refer to mechanism of injury, injury diagnosis, or both. As a mechanism of injury, overuse often refers to the cause of the injury, ie, the repetitive or collective activity that led to the injury.[6] As a diagnosis, overuse refers to a group of injuries classified by a gradual progression of inflammation, pain, or loss of function (or a combination of these).[7] Youth athletes may be more susceptible to overuse conditions than high school athletes because their tissues are less resistant to the tensile and compressive forces applied during physical activity.[5] Additionally, variations in skeletal maturity between youth and high school athletes may predispose youth athletes to overuse injuries. Some estimates suggest that more than 50% of youth sports injuries are overuse conditions, and half of these injuries are preventable.[5]

Overuse injuries represent nearly 20% of all US emergency department (ED) visits and cost approximately

$448 million per year.[8] Football-related injuries are a common reason for athletes presenting to EDs, particularly among youths. In 2012, athletes 19 years and under presented to EDs with approximately 394 000 football-related injuries.[9] More than 50% of all patients with pediatric injuries who reported to sports medicine clinics were deemed to have overuse conditions.[4,10]

Several groups[11–14] have monitored injuries in youth and high school football players; however, few researchers have studied the overall incidence of overuse conditions in this population. Previous investigators[5,15,16] have studied only overuse conditions that accounted for time-loss (TL) injuries (ie, injuries resulting in participation-restriction time of at least 24 hours), potentially underestimating their prevalence. The purpose of our study was to compare the rates, risks, and distributions of overuse conditions between 2 levels of competition: youth football and high school football. We hypothesized that youth athletes would have higher rates and risks of overuse conditions compared with their high school counterparts. This information can be used to identify patterns or differences between the 2 levels of competition and associated age groups.

METHODS

Design

For this descriptive injury epidemiology study, we used data collected by the Datalys Center for Sports Injury Research and Prevention, Inc (Indianapolis, IN; hereafter known as *Datalys*) through 2 sports injury-surveillance programs: the Youth Football Safety Study (YFSS)[14] and the National Athletic Treatment, Injury and Outcomes Network (NATION).[17] Data originated from the 2012 and 2013 football seasons. The methods of the YFSS and NATION have been previously described[14,17] and are summarized in the next section; both used similar data-collection methods. The University's Institutional Review Board approved this study.

Participants

The YFSS enrolled more than 3000 athletes aged 5 to 14 years from 13 youth football leagues in 6 states, encompassing 210 team-seasons.[14] The NATION followed 11 957 football players aged 14 to 18 years from 96 secondary school football programs; during the 2012 and 2013 football seasons, NATION collected data from 138 team-seasons.[17]

Instruments

Athletic trainers (ATs) from each participating youth football league and high school football program reported injury and exposure data in real time via their electronic medical record applications throughout the academic year. Three software applications are certified to export injury data to the NATION: the Athletic Trainer System (ATS; Keffer Development Services, LLC, Grove City, PA), Injury Surveillance Tool (IST; Datalys), and Sports Injury Monitoring System (SIMS; FlanTech, Inc, Iowa City).[17] The YFSS used only the Injury Surveillance Tool.

For each competition and practice, ATs provided the number of participating football players. When an injury occurred, the AT completed a detailed event report on the injury or condition (eg, body part, diagnosis, whether the injury was chronic in nature) and the circumstances (eg, injury mechanism, event type [ie, competition or practice]). The ATs were able to view and update previously submitted information as needed.

Before data analysis, data were stripped of any personally identifiable information (eg, name, date of birth, insurance information), and only relevant variables and values were retained. Exported data passed through an automated verification process that conducted a series of range and consistency checks. Data were reviewed and flagged for invalid values. The automated verification process notified the AT and data quality-assurance staff who assisted the AT in resolving questionable values. Data that passed the verification process were then placed into the final datasets for analysis.

Definitions

Athlete-Exposures. An *athlete-exposure* (AE) was defined as 1 player's participation in 1 sanctioned practice or competition.

Injuries. All injuries that occurred during a sanctioned practice or competition and were evaluated or treated by an AT, physician, or other health care professional were included in this study.[14,17]

Overuse Conditions. As in previous studies,[15] overuse conditions were those injuries for which the mechanism was recorded as *overuse/gradual onset*. However, to capture overuse conditions that might have been missed due to this inclusion criterion, we also included those injuries recorded as being chronic in nature, as well as all conditions that were most likely to be classified as overuse: arthritis, avascular necrosis, bursitis, capsulitis, cartilage injury, chondromalacia, compartment syndrome, dislocation (chronic), effusion, entrapment/impingement, exostosis, stress fracture, inflammation, myositis ossificans, osteochrondritis, tear (strain, chronic), subluxation, synovitis, tendinosis, tendinitis, and tenosynovitis. All injuries that met these criteria were manually checked for inclusion by the primary investigator relative to the diagnosis and basic mechanism. Illnesses, general medical conditions, and concussions were excluded.

Outcome Variables

Participation-Restriction Time. Injuries were categorized by the number of missed days of participation from sport (ie, date of injury subtracted from the date of return to play). *Non–time-loss (NTL) injuries* were those injuries resulting in participation-restriction time of less than 24 hours. *Time-loss injuries* were those injuries resulting in participation-restriction time of at least 24 hours. Time-loss injuries were further categorized by the number of days missed: 1 to 6, 7 to 13, 14 to 29, or 30 or more.

Body Parts Injured. Injured body parts were separated into 4 regions: head/face/neck, upper extremity, trunk, and lower extremity.

Injury Type. Injury diagnoses, as defined by the AT and sports medical team staff, were grouped into 5 categories: inflammatory conditions (eg, tendinosis, tendinitis, and tenosynovitis), stress fracture, neuromuscular disorder (a fatigue-induced muscle disorder such as a tear [previously

Table 1. Injury Rates and 1-Season Risks in Youth and High School Football, 2012 and 2013 Seasons

Level	Injury Count	Injured Athletes, No.	Athletes, No.	Athlete-Exposures	1-Season Risk (95% CI)	Risk Ratio (95% CI)	Rate per 10 000 Athlete-Exposures (95% CI)	Rate Ratio: High School to Youth (95% CI)
Youth	53	43	4092	142 536	1.05 (0.74, 1.36)	1.00	3.72 (2.72, 4.72)	1.00
High school	339	318	11 957	862 503	2.66 (2.37, 2.95)	2.53 (1.84, 3.47)	3.93 (3.51, 4.35)	1.06 (0.79, 1.41)

Abbreviation: CI, confidence interval.

referred to as a *strain*] as described by the Munich Consensus Statement on the Terminology and Classification of Muscle Injury in Sport[18]), joint instability, and other.

Statistical Analysis

Injury rates (IRs) were calculated for overuse conditions in the 2 groups using the formula IR = (No. of injuries/No. of AEs × 10 000).[19] *Injury rate ratios* (IRRs) compared IRs between the groups using the formula IRR = $rate_a/rate_b$, where $rate_a$ was the IR for the first group and $rate_b$ was the IR for the second group.[11] *Injury proportion ratios* (IPRs) compared the relative proportions of categorical variables, including participation-restriction time, body part injured, and injury type.[20] *Injury risk* was the proportion of athletes who sustained at least 1 injury during a fixed period of time.[19] For this study, we examined pooled single-season injury risks.[21] The numbers of athletes in each season being monitored for the YFSS and NATION were summed and used as the risk denominator.[11] *Risk ratios* (RRs) compared risks between youth football and high school football.[19] All analyses were performed using SAS Enterprise Guide software (version 4.3; SAS Institute Inc, Cary, NC).

RESULTS

During the 2012 and 2013 seasons, 1488 injuries were reported to the YFSS, of which 53 (3.6%) were overuse conditions. The NATION reported 12 013 injuries, of which 339 (2.8%) were overuse conditions (Table 1).

Rates

Youth football players accumulated 142 536 AEs, leading to an overuse condition rate of 3.72 per 10 000 AEs (95% confidence interval [CI] = 2.72, 4.72). High school football athletes accumulated 862 503 AEs, leading to an overuse condition rate of 3.93 per 10 000 AEs (95% CI = 3.51, 4.35). The overuse condition rate did not differ between high school and youth football athletes (IRR = 1.06; 95% CI = 0.79, 1.41).

Risk

Among the 1994 youth athletes in 2012 and 2098 youth athletes in 2013, 43 athletes sustained overuse conditions in 1 season, leading to a 1-season risk of 1.05% (Table 1). Among the 4177 high school athletes in 2012 and 7780 high school athletes in 2013, 318 athletes sustained overuse conditions in 1 season (1-season risk = 2.66%). The 1-season risk of overuse conditions was higher in high school football than in youth football players (RR = 2.53; 95% CI = 1.84, 3.47).

Participation-Restriction Time

Most overuse conditions were NTL injuries in both youth football (n = 44, 83.0%) and high school (n = 227, 67.0%; Table 2) football players. The proportion of overuse condition injuries that were NTL was significantly lower in high school than in youth football players (IPR = 0.81; 95% CI = 0.70, 0.93). No other differences were noted in participation-restriction time between youth and high school football athletes.

Body Part

A lower proportion of overuse condition injuries were to the lower extremity in high school (n = 212, 62.5%) than in youth (n = 49, 92.5%; IPR = 0.68; 95% CI = 0.60, 0.76; Table 3) football players. The proportion of overuse conditions to the upper extremity was higher in high school (n = 74, 21.8%) than in youth (n = 2, 3.8%; IPR = 5.78; 95% CI = 1.46, 22.86) football athletes.

Injury Type

The distributions of injury type varied between youth and high school football players (Table 4). Inflammation was the most common type of overuse condition reported in youth football (n = 41, 77.4%), with a higher proportion reported than that in high school (n = 83, 24.5%; IPR = 3.16; 95% CI = 2.49, 4.00) athletes. In high school players, neuromuscular overuse conditions were the predominant type reported (n = 196, 57.8%), with a higher proportion

Table 2. Injury Participation-Restriction Time in Youth Football and High School Football Players, 2012 and 2013 Seasons

Participation-Restriction Time	Count (%)		Injury Proportion Ratio (95% Confidence Interval)	
	Youth	High School	Youth Versus High School	High School Versus Youth
<24 h (non-time loss)[a]	44 (83.0)	227 (67.0)	1.24 (1.07, 1.43)	0.81 (0.70, 0.93)
1 to 6 d	6 (11.3)	38 (11.2)	1.01 (0.45, 2.27)	0.99 (0.44, 2.23)
7 to 13 d	1 (1.9)	25 (7.4)	0.26 (0.04, 1.85)	3.91 (0.54, 28.24)
14 to 29 d	1 (1.9)	12 (3.5)	0.53 (0.07, 4.02)	1.88 (0.25, 4.02)
30+ d	1 (1.9)	34 (10.0)	0.19 (0.03, 1.35)	5.32 (0.74, 38.02)
Missing	0	3 (0.9)	—	—
Total	53 (100.0)	339 (100.0)	—	—

[a] Injury proportion ratio is statistically significant (95% confidence interval does not include 1.00).

Table 3. Body Part Injured in Youth Football and High School Football Players, 2012 and 2013 Seasons

Body Part	Count (%)		Injury Proportion Ratio (95% Confidence Interval)	
	Youth	High School	Youth Versus High School	High School Versus Youth
Head/face/neck	0	13 (3.8)	—	—
Head/face	0	1 (0.3)	—	—
Neck	0	12 (3.5)	—	—
Upper extremity[a]	2 (3.8)	74 (21.8)	0.17 (0.04, 0.68)	5.78 (1.46, 22.86)
Shoulder	0	51 (15.0)	—	—
Arm/elbow	1 (1.9)	11 (3.2)	0.58 (0.08, 4.41)	1.72 (0.23, 13.05)
Hand/wrist	1 (1.9)	12 (3.5)	0.53 (0.07, 4.02)	1.88 (0.25, 14.13)
Trunk	2 (3.8)	40 (11.8)	0.32 (0.08, 1.28)	3.13 (0.78, 12.56)
Vertebral/paraspinal	2 (3.8)	3 (0.9)	4.26 (0.73, 24.93)	0.23 (0.04, 1.37)
Abdominothoracic	0	37 (10.9)	—	—
Lower extremity[a]	49 (92.5)	212 (62.5)	1.48 (1.32, 1.65)	0.68 (0.60, 0.76)
Hip/pelvis[a]	1 (1.9)	76 (22.4)	0.08 (0.01, 0.59)	11.88 (1.69, 83.64)
Thigh/upper leg	1 (1.9)	16 (4.7)	0.40 (0.05, 2.95)	2.50 (0.34, 18.47)
Knee[a]	21 (39.6)	54 (15.9)	2.49 (1.65, 3.76)	0.40 (0.27, 0.61)
Lower leg/Achilles[a]	16 (30.2)	43 (12.7)	2.38 (1.45, 3.91)	0.42 (0.26, 0.69)
Ankle	0	5 (1.5)	—	—
Foot/toes	10 (18.9)	0	—	—
Total	53 (100.0)	339 (100.0)	—	—

[a] Injury proportion ratio is statistically significant (95% confidence interval does not include 1.00).

reported than in youth (n = 6, 11.3%; IPR = 5.11; 95% CI = 2.39, 10.91) football athletes. No other differences were present in injury type between youth and high school football players.

DISCUSSION

To our knowledge, we are the first to compare the rates, risks, and distributions of overuse conditions between youth and high school football players. This is also the first study to include NTL injuries in the estimation of overuse conditions in football athletes. Previous authors[16,22] have focused on the diagnosis of overuse based on the mechanism of injury. We included overuse conditions based on the injury mechanism and specific injury diagnosis. Including both allows for a more sensitive measure of actual overuse conditions.

Rates and Risks

Our overuse rate in high school football players (3.93/10 000 AEs) was higher than that of Roos et al[15] (1.35/10 000 AEs) and Schroeder et al[23] (1.27/10 000 AEs). This is likely because we included NTL injuries. We found that 83% and 67% of overuse conditions were NTL for youth and high school athletes, respectively. Lastly, we included overuse conditions based on mechanism and specific injury diagnosis, allowing for a more expansive criterion.

Although the rates of overuse conditions did not differ between youth and high school football players, we found that the 1-season risk was higher in the latter. This difference could be due to greater proportions of youth players with multiple reports of overuse conditions. The proportion of athletes who sustained more than 1 overuse condition was higher in youth (10/53; 19%) than high school (21/339; 6%) athletes. Because IRs are driven by the number of injuries, differences based on the number of injured athletes could not be detected as they were with our risk estimate. Prior investigators[15,24] theorized that participating at a higher level of competition increases the risk of overuse conditions because the intensity of training is greater. Higher-level athletes typically have additional years of sport participation, resulting in more exposures to repetitive stresses as well as more diagnosed injuries.[7,15] Because of the repetitive nature of overuse conditions, it is imperative that the authors of future epidemiologic studies calculate rates and risks and document reinjury.

Table 4. Injury Types in Youth Football and High School Football Players, 2012 and 2013 Seasons

Injury Type	Count (%)		Injury Proportion Ratio (95% Confidence Interval)	
	Youth	High School	Youth Versus High School	High School Versus Youth
Inflammation[a]	41 (77.4)	83 (24.5)	3.16 (2.49, 4.00)	0.32 (0.25, 0.40)
Stress fracture	1 (1.9)	13 (3.8)	0.49 (0.07, 3.68)	2.03 (0.27, 15.22)
Neuromuscular[a]	6 (11.3)	196 (57.8)	0.20 (0.09, 0.42)	5.11 (2.39, 10.91)
Joint instability	1 (1.9)	36 (10.6)	0.18 (0.02, 1.27)	5.63 (0.79, 40.19)
Other	4 (7.5)	11 (3.2)	2.33 (0.77, 7.04)	0.43 (0.14, 1.30)
Total	53 (100.0)	339 (100.0)	—	—

[a] Injury proportion ratio is statistically significant (95% confidence interval does not include 1.00).

Participation-Restriction Time

Our results demonstrated a higher proportion of NTL overuse conditions in youth (83%) than in high school (67%; IPR = 1.24 [95% CI = 1.07, 1.43]) football players. Youth football teams on average have fewer exposure events, such as practices per week and per season, than high school teams. The number of AEs per athlete-season was also lower in youth (34.8) compared with high school (72.1) athletes. Other researchers[11] have shown that youth football teams practice on average 1 to 2 times per week, whereas high school football teams participate up to 6 days per week. The increased time off between practices would affect the number of youth athletes reporting a TL injury of at least 24 hours. Our proportion of NTL overuse conditions in youth football players (83%) was higher than the proportion of overall NTL injuries reported by Dompier et al[25] (58.6%) and Beachy and Rauh[26] (61%). However, our proportion of NTL overuse conditions in high school athletes (67%) was considerably lower than the NATION's overall estimate of NTL injuries (82%).[17] It is important to note that *NTL* might not indicate injury severity, especially in youth football athletes who may be practicing only 1 or 2 times per week. Future researchers should consider other methods to detect and report injury severity.

Body Part

A greater proportion of overuse conditions affected the lower extremity in youth (92.5%) than in high school (62.5%) football athletes; in contrast, a greater proportion of overuse conditions affected the upper extremity in high school (21.8%) compared with youth (3.8%) football players. The proportion of overuse conditions to the lower extremity in high school football players was marginally less than lower extremity overuse conditions across all sports (70.4%).[15] More overuse lower extremity injuries occurred at both levels than previously documented proportions of lower extremity injuries in youth football (38.3%) and high school football (46.9%) athletes, which may indicate the need to further investigate and prevent overuse conditions.[24,25]

Injury Type

At the youth level, inflammatory conditions (77.4%) were the most common type of overuse condition reported; at the high school level, the most common type of overuse condition was neuromuscular (57.8%). The greater proportion of inflammatory conditions, especially tendinopathies, in youth football players may result from a higher risk for tendon-related growth plate injuries, such as Osgood-Schlatter and Sever diseases in youth athletes.[27] These conditions occur when the growth plate is open (up to age 15–16 years in males) and can be misdiagnosed as tendinopathy.[28]

Our results revealed that a large percentage of overuse conditions in high school athletes were chronic muscle injuries (51.3%). This percentage was larger than that reported by Roos et al[15] (33%) and Shankar et al[24] (16.5%). However, these authors examined all high school sports, whereas we studied only high school football. The higher proportion of muscle injuries in high school football athletes is theorized to be due to the higher-level sport training, leading to greater rates of muscle fatigue, which is a risk factor for this injury.[29]

LIMITATIONS

Currently, no standard clinical definition is available for overuse conditions. Investigators[16] have defined such injuries in terms of mechanism of injury, injury diagnosis, or both. The lack of a standard clinical definition may have allowed variations in reporting of overuse conditions to occur. Although we tried to make our methods more expansive by including additional criteria, it is possible that injuries were misclassified. Also, the level of experience of ATs may differ by team and level of competition, which could affect the reporting and quality of the data collected.

The frequency of overuse conditions across the 2 levels of competition may have been influenced by several factors. High school athletes may report more injuries to a medical professional because they are more familiar with ATs or team physicians. Practice frequency in youth football is much less than in high school football; this may have also influenced the number of TL injuries. In addition, although our dataset included a large number of youth and high school football players, the incidence of overuse injuries was low, possibly resulting in low statistical power for comparative analyses examining distributions by factors such as participation-restriction time, body part, and injury type.

Lastly, although the data were collected from high school and youth football programs at multiple sites across the United States, these data may not be generalizable to all youth football leagues and high school football programs. In addition, future researchers should examine overuse conditions in all youth and high school sports. These findings may allow for the development of injury-prevention strategies to target those sports and athletes with a high risk for overuse conditions. Investigators could also examine potential etiologic risk factors such as anatomic abnormalities, flexibility, and overscheduling (ie, participating in enrichment activities without appropriate rest periods).

CONCLUSIONS

Because of their relatively low incidence, overuse conditions may not be a primary concern in youth and high school football players; specifically, the 1-season risks were different between groups, but IRs were not. However, the risk for overuse conditions was greater in high school than in youth football athletes. In addition, differences related to risk as well as the distributions of participation-restriction time, body part injured, and injury type existed between the 2 levels of competition. Although additional research on the incidence of overuse conditions across all youth and high school sports is needed, these findings highlight the need for programming that may be specific to competition level.

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