Incidence of injury based on sports participation in high school athletes

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ABSTRACT

Objectives: Youth participation in competitive athletics has significantly increased in the past two decades. There has also been a recent rise in the number of sports injuries that physicians are seeing in young athletes. The objective of this study was to assess the likelihood of sports injuries based on several risk factors in a general sample of athletes at a suburban-area high school.

Methods: This was a cross-sectional study. An online survey was distributed to 2,200 student-athletes at a local high school with a mean age of 15.9 years. Four hundred eighty-four (22%) complete responses were received. Data collected in the survey included demographics, frequency of sports participation, level of participation, types of sports played, participation in cross-training, injuries incurred, use of non-steroidal anti-inflammatory drugs, and treatment for sports injuries.

Results: Athletes played an average of 1.6 different sports. The average number of hours of participation in sports annually was 504.3 ± 371.6 hours. The average total number of sports injuries experienced by athletes in our study was 1.7 per participant. 80.8% of respondents reported having sustained at least one sports injury. A higher total number of hours per year of sports participation and playing a contact sport were significantly associated with more reported lifetime sports injuries. Older age, playing a contact sport, and playing on a travel/club team were associated with students using NSAIDs for sports injuries. Older age, playing a contact sport, and doing cross training are also associated with having had surgery for a sports injury.

Conclusions: Although more hours of participation and playing a contact sport may lead to an increased number of injuries, this risk must be weighed against the myriad of benefits that sports provide for young athletes.

Introduction

Youth participation in competitive athletics has significantly increased in the past two decades, with over 30 million American children participating in organized sports each year.[1–6] Approximately, 70% of male students and 53% of high-school students participate in organized athletic activities.[7] In general, participating in sports is thought to be beneficial for adolescents and is associated with improved overall physical and mental health.[7–9] Specifically, sports participation among high-school students is associated with positive character traits, such as sportsmanship, leadership, and work ethic, and is also protective against negative behaviors such as cigarette smoking and substance abuse.[7,10,11] Studies have also suggested that sports participation may have long-term benefits in the job market later in life.[11]

While competitive sports participation provides many benefits for young athletes, it also poses significant risk of bodily injury. The overall incidence of high-school sports injuries is estimated at 2.08 injuries per 1000 athlete exposures.[1] Expert panels have cited overuse as one of the most common etiologies of injuries in high-school athletes.[2] Furthermore, there has been an increasing trend toward sports specialization and intense training regimens for youth athletes in the United States.[12–15] These trends raise concerns about the possibility of overuse injuries, psychological stress, and long-term decreased enjoyment of sports in youth athletes who specialize at a young age and compete at highly intense levels.[13,14,16]

Several reports in the medical literature advocate against early sports specialization and intense training regimens in youth athletes due to the aforementioned factors, as well as burnout and potential for long-term growth disturbances as a result of certain types of injuries. However, many of these reports are based on expert opinion or small studies of athletes in a specific sport at elite levels.[2,12–14,16–18] The objective of this study was to assess the risk of sports injuries based on demographics, total hours of participation, and level of participation in sports among a general sample of athletes at a local high school. The primary outcome measure was total number of reported sports injuries. It was hypothesized that a greater number of hours of sports activity and participation in
only one sport, rather than playing multiple sports, would correlate with a higher number of reported injuries.

Materials and methods

Survey design and participant enrollment

A survey targeted to high-school student-athletes was devised to assess sport participation and injuries sustained during athletic activity (survey available as supplementary material online). This was based on examination of prior surveys related to youth athletic injuries.[19] The survey consisted of three components. The first was designed to gather basic demographic data including age, gender, and number of sports played. The next component assessed specific sport participation and at what level (school team, travel/club team, or recreational team). The final component of the survey assessed injury number, type, and severity. This was based on the extent of treatment for each injury and time missed from participation. Survey participants were then given the opportunity to document specific injuries and treatment for up to three injuries with additional space to list all other injuries, treatments, and surgeries beyond three. The survey was provided in an online format to aid with ease of delivery and data collection.

The survey was distributed to parents of student-athletes (grades 9–12) of a local high school with an active athletics program located in a suburb of a major metropolitan city in the United States. Parents were asked to complete the survey with their child. Completion of the survey was accepted as implied consent for participation. The study was approved by an Institutional Review Board and the research review board of the high school.

Total yearly hours of participation in sports was computed based on adding the total hours of participation that each student listed for each sport. Each sport reported in the survey was defined as contact, limited-contact, or noncontact based on the classification scheme used by the American Academy of Pediatrics Council on Sports Medicine and Fitness.[20] The number of total reported injuries was categorized as 0, 1, 2, 3, or 4 or more.

Statistical analysis

Survey data were analyzed with IBM SPSS version 22 (SPSS Inc., Chicago, IL). The number of total reported injuries was used as the primary outcome measure in an ordinal logistic regression model. Independent variables included in this model were age, gender, total hours per year of sports participation, number of days off per week with no sports activity, playing one sport versus multiple sports, contact level of primary sport, participation on a travel/club team, participation on a recreational team, and participation in cross-training. This model was assessed for goodness-of-fit using Pearson's Chi-square test ($P = 0.091$). Subsequently, binomial logistic regressions were conducted to look at the secondary outcomes of nonsteroidal anti-inflammatory drug (NSAID) use for a sports injury and having surgery for a sports injury. These models were assessed and deemed adequate using the Hosmer and Lemeshow test. The conventional power analysis for logistic regression requires 10 subjects per variable included in the equation.[21,22] Our model included 9 independent variables, thereby requiring 90 subjects. Given our sample size of 484 subjects, the model for the primary outcome was considered to be adequately powered. A $P$ value less than 0.05 was considered statistically significant.

Results

The survey was distributed to the parents of 2200 student-athletes. A total of 607 surveys were received, representing an overall response of 27.6%. One hundred and twenty-three respondents did not answer questions regarding sports injuries and were subsequently excluded. The remaining 484 surveys were included for analysis. This represented 22.0% of eligible participants.

Study sample

The mean age of participants was 15.9 years old (range, 13–21). There were 203 females (41.9%), 278 males (57.4%), and 3 students who did not report gender. Athletes reported current participation in an average of 1.6 ± 0.8 different sports. The most common primary sports included swimming, soccer, and football. The primary sports of athletes are reported in Table 1 and the levels of primary sport participation for each athlete are listed in Table 2. The mean age that athletes reported for starting their primary sport was 9.2 ± 3.5 years old. In athletes who only played one sport, the mean reported age of sport specialization was 13.2 ± 2.1 years old.

| Sport            | Number of athletes (%) | Sport            | Number of athletes (%) |
|------------------|------------------------|------------------|------------------------|
| Swimming         | 48 (9.9)               | Dance            | 8 (1.7)                |
| Soccer           | 47 (9.7)               | Figure skating   | 7 (1.4)                |
| Football         | 46 (9.5)               | Water polo       | 7 (1.4)                |
| Cross-country    | 43 (8.8)               | Gymnastics       | 6 (1.2)                |
| Lacrosse         | 33 (6.8)               | Softball         | 6 (1.2)                |
| Hockey           | 30 (6.2)               | Bowling          | 4 (0.8)                |
| Rowing           | 28 (5.8)               | Badminton        | 4 (0.8)                |
| Tennis           | 27 (5.6)               | Rugby            | 3 (0.6)                |
| Volleyball       | 22 (4.5)               | Sailing          | 2 (0.4)                |
| Basketball       | 21 (4.3)               | Weight lifting   | 2 (0.4)                |
| Track            | 21 (4.3)               | Snowboarding     | 1 (0.2)                |
| Baseball         | 18 (3.7)               | Canoe            | 1 (0.2)                |
| Wrestling        | 11 (2.3)               | Diving           | 1 (0.2)                |
| Field hockey     | 10 (2.1)               | Martial arts     | 1 (0.2)                |
| Fencing          | 10 (2.1)               | Ultimate frisbee | 1 (0.2)                |
| Golf             | 9 (1.9)                | Unspecified      | 6 (1.2)                |

Table 2. Reported level of participation in primary sport.

| Level                        | Number of students (%) |
|------------------------------|------------------------|
| School team only             | 206 (42.6)             |
| Recreational team only       | 10 (2.0)               |
| Travel/club team only        | 36 (7.4)               |
| School + travel/club team    | 172 (35.3)             |
| School + recreational team   | 21 (4.3)               |
| Travel/club team + recreational team | 5 (1.0) |
| School team + travel/club team + recreational team | 30 (6.2) |
| Unreported                   | 4 (0.8)                |
Injury outcomes

The mean total number of lifetime sports injuries sustained was 1.7 ± 1.3. Respondents reported a mean of 504.3 ± 371.6 total hours of participation in sports in the past year. Overall, 80.8% of survey participants reported sustaining at least one sports injury. Of those with a sports injury, 81.1% sought physician evaluation, and 6.8% underwent surgical treatment for their injuries.

After accounting for all other variables, a higher total number of hours per year of sports participation was associated with more reported lifetime injuries (P = 0.03, OR 1.001 for each increased hour of sports participation; 95% CI 1.00–1.001) (Table 3). In addition, compared to primarily playing a noncontact sport, playing a limited contact sport (P < 0.001, OR 3.14; 95% CI 1.81–5.45) and playing a contact sport (P < 0.001, OR 4.32; 95% CI 2.85–6.55) were both associated with a higher number of reported sports injuries. Older age was also associated with an increased number of total reported sports injuries (P < 0.001, OR 1.25; 95% CI 1.10–1.41). Number of days off per week from sports activity, gender, playing on a travel/club or recreational team, participating in cross-training, and playing versus multiple sports had no significant correlation with number of reported sports injuries (P > 0.05).

Among survey respondents, 304/484 (62.8%) reported taking anti-inflammatory medication for sports-related pain or injuries. Factors that were associated with using anti-inflammatory medication included older age (P = 0.001, OR 1.32; 95% CI 1.12–1.55), playing a contact sport (P = 0.03, OR 1.68; 95% CI 1.05–2.67), and playing sports at the travel/club level (P = 0.02, OR 1.69; 95% CI 1.09–2.62).

Thirty-three students (6.8%) reported that they had undergone a surgery for a sports-related injury. Older age (P = 0.007, OR 1.40; 95% CI 1.10–1.79), playing a contact sport (P = 0.002, OR 4.79; 95% CI 1.76–13.03), and participating in cross-training (P = 0.047, OR 2.31; 95% CI 1.01–5.25) were all associated with having had surgery for a sports-related injury.

A number of the 237 respondents (49.0%) reported the age at which they had dropped all other sports in order to focus on their primary sport. The mean age was 13.2. There was no significant correlation between age of sport specialization and number of reported sports injuries (P = 0.608).

Discussion

This study demonstrates that athletes who reported more total hours of participation in athletics per year also reported more sports injuries. This finding was consistent with the initial hypothesis and was not surprising, given that each time an athlete participates in sports activity, there is a chance of sustaining an acute injury. In an effort to specifically prevent overuse injuries, the American Academy of Pediatrics Council on Sports Medicine and Fitness has recommended limiting one sports activity to a maximum of 5 days per week, with at least 1 day off from organized physical activity each week and 2–3 months off from the main sport each year to allow injuries to heal.[2,12] In the current study, there was no significant association between number of days off per week from sports activity and incidence of injury. However, further studies are needed to determine if rest and mandated time off for athletes from their primary sport could help to decrease the number of injuries that they may otherwise sustain.

Participation in contact sports and limited-contact sports, in comparison to noncontact sports, also significantly correlated with a higher number of reported injuries in the present study sample. Prior studies of concussion epidemiology have found that contact sports including football, ice hockey, lacrosse, and soccer have the highest incidence of concussion-type injuries.[23] Although noncontact sports such as swimming[24] and tennis[25] have been implicated in leading to overuse injuries, results of the present study demonstrate that contact sport athletes are at greater risk of injury.

Contrary to the initial hypothesis, there was no significant difference in number of sports injuries reported in athletes specializing in one sport versus those who participate in multiple sports. Cuff et al. also found no difference in risk of injury among athletes who played the same sport all year versus athletes who played different sports throughout the year.[19] These findings do not support the conventional wisdom and other reports in the literature that cite the physical harm of sports specialization in young athletes.[26–28] Cuff et al. found that participation in all four seasons of sports throughout the entire year was the greatest modifiable risk factor for overuse injury among high-school athletes.[19] Similarly, the present study results support the idea that total hours of exposures to sports, rather than specialization in one sport versus playing many sports, is the key factor in predicting risk of injuries.

The current study found no significant difference in the incidence of injury between male and female high-school athletes. There is disagreement in the literature, with Knowles et al. reporting a higher incidence of athletic injuries in high-school males, while Cuff et al. reported a higher incidence of overuse types of injuries in females.[1,19] Future large-scale studies are needed to determine the specific role of gender in determining the incidence of athletic injury at the high-school level.

A secondary objective in this study was to examine risk factors for use of NSAIDs for sports-related injuries among survey respondents. Older age, playing a contact sport, and playing on a travel/club team were all significantly associated with reported use of NSAIDs for sports-related pain or injuries. Older age is an unsurprising risk factor given that older high-school students may have more knowledge of and access to anti-inflammatory medications. Playing a contact sport is also an intuitive risk factor for NSAID use, since athletes involved in these sports likely have a higher frequency of collisions which can lead to bruising, aches, and
other more serious painful injuries which may prompt the athlete to seek medication. Finally, it is possible that participation on a high-level team such as a travel or club team may prompt the athlete to feel compelled to continue playing even in the face of pain from a sports-related injury. A previous study of high-school football players found that 75% of athletes had used NSAIDs in the prior 3 months and 15% used NSAIDs daily. Forty-one percent reported that they perceived improved performance when they used NSAIDs.[21] Teenagers are often unaware of the potential toxicities of NSAIDs and often use these drugs without consulting an adult or medical professional.[21,29] In addition to increased rest to allow healing of sports injuries, it is important for high-school athletes to be educated about the risks and benefits of NSAID use.

There was no correlation in the present study between self-reported participation in any type of cross-training and number of reported injuries. Although cross-training has been touted by sports medicine experts as an important component in sports injury prevention for all ages,[2,30] no studies have demonstrated that variations in exercise play a role in injury prevention.[31] It is possible that the benefit of cross-training could be confounded by the decreased amount of rest time that it allows for high-school athletes. Interestingly, cross-training was significantly correlated with having had a surgery for a sports-related injury ($P = 0.047$). Although the precise reason for this association is unclear, it is possible that athletes who have undergone surgery are subsequently more conscientious about the importance of injury prevention and therefore incorporate cross-training into their athletic routine. More research is needed to substantiate this hypothesis. The precise benefits of cross-training, as well as the ideal amount of cross-training needed to protect against injury, have not yet been established.

There are several limitations to the present study. Survey design was retrospective in nature and therefore subject to recall bias. In addition, the response rate was 27.6% which was a lower yield compared with similar prior studies who administered surveys within the classroom.[8,19] However, as the survey was administered via parents of student-athletes, this was felt to provide more reliable data as parents may have a better recollection of their child’s athletic pursuits and injuries. Due to the nature of the survey, the number of injuries is represented as a lifetime incidence of injury in a particular athlete and is not able to be calculated to represent a precise rate of injury. However, total lifetime injuries is felt to represent an important and reasonable primary outcome measure as study participants had similar ages and small variance in total years of athlete exposure. The survey tool that was used in this study was developed by the authors and has not been validated in the literature. We chose to develop this new survey, because no previously validated survey tool was available to use to answer the questions that we wanted to examine in this study. Future studies with validated survey tools will be useful to substantiate or refute the preliminary results that we have provided here. A power calculation was performed for the primary outcome variables in this study but was not performed for secondary outcomes, and thus, the secondary outcomes results may be underpowered. Finally, this study did not distinguish between acute versus overuse injuries and therefore was not able to evaluate the different factors leading to each.

**Conclusion**

With the rise in youth participation in organized sports in the past few decades, the risk of injuries in young athletes has become a topic of frequent discussion. This study found that a higher total number of hours per year of sports participation and playing a contact sport were associated with a higher number of reported sports injuries. Sports specialization was not significantly associated with reported injuries. Older age, playing a contact sport, and playing on a travel/club team were associated with using NSAIDs for sports-related pain and injuries. Older age, playing a contact sport, and participating in cross-training were all associated with having had surgery for a sports-related injury. Although more hours of participation and playing a contact sport might lead to an increased number of injuries, this risk must be weighed against the myriad of benefits that sports provide for young athletes. Health-care providers should encourage sports participation in interested patients, while still bearing in mind the risks of injury in this patient population.

**Financial & competing interests disclosure**

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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