High Prevalence of Nontraumatic Shoulder Pain in a Regional Sample of Female High School Volleyball Athletes

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Background: Shoulder pain is becoming increasingly problematic in young players as volleyball gains popularity. Associations between repetitive motion and pain and overuse injury have been observed in other overhand sports (most notably baseball). Studies of adult athletes suggest that there is a shoulder pain and overuse problem present in volleyball players, but minimal research has been done to establish rates and causes in juvenile participants.

Purpose: To establish rates of shoulder pain, regardless of whether it resulted in a loss of playing time, in female high school volleyball players. A secondary goal was to determine whether high repetition volumes correlated with an increased likelihood of experiencing pain.

Study Design: Descriptive epidemiology study.

Methods: A self-report survey focusing on the prevalence of pain not associated with a traumatic event in female high school youth volleyball players was developed. Survey questions were formulated by certified athletic trainers, experienced volleyball coaches, and biomechanics experts. Surveys were received from 175 healthy, active high school volleyball players in Iowa, South Dakota, and Minnesota.

Results: Forty percent (70/175) of active high school volleyball players remembered experiencing shoulder pain not related to traumatic injury, but only 33% (23/70) reported taking time off to recover from the pain. Based on these self-reported data, activities associated with significantly increased risk of nontraumatic shoulder pain included number of years playing competitive volleyball ($P = .01$) and lifting weights out of season ($P = .001$). Players who reported multiple risk factors were more likely to experience nontraumatic shoulder pain.

Conclusion: When using time off for recovery as the primary injury criterion, we found that the incidence of shoulder pain is more than twice as high as the incidence of injury reported by previous studies. Findings also indicated that the incidence of shoulder pain may be correlated with volume of previous volleyball experience.

Keywords: volleyball; cumulative trauma disorders; shoulder pain; adolescent female athlete; survey

The number of girls playing high school volleyball in the United States has increased by 60% over the past 30 years, such that it is now similar to the number of boys playing high school baseball.[12] Due to the historically high number of baseball players with shoulder pain and/or injury, the mechanics and prevention of shoulder overuse injury in youth and adolescent baseball players has been a topic of study for many years.[9] Despite using a biomechanically similar repeated overhand motion, the prevalence and prevention of overuse shoulder injuries in female volleyball players has received considerably less attention.

Studies report that more than 20% of youth baseball pitchers experience reoccurring shoulder pain and use this as motivation for considering preventative practices such as pitch counts,[6,8-10] but volleyball lacks similar studies investigating the prevalence of reoccurring shoulder pain and overuse injuries, particularly in youth. A number of

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studies have prospectively or retrospectively quantified the occurrence of shoulder injury in volleyball players as being somewhere between 8% and 20% of total injuries sustained in the sport.[1-4,11,13,14,17-19] These studies have speculated that many of these shoulder injuries were due to overuse. However, many of these studies tend to count injury only if playing time is lost, which will likely lead to an artificially low number of injuries.[5,16] In particular, pain that is not associated with a particular traumatic event (nontraumatic shoulder pain [NTP]) may be underrepresented in these studies, since this type of pain is often characterized by low pain levels that may be present for long periods of time but may not prevent the player from participating in regular activities. There is also no clear understanding of what factors contribute to overuse pain, although several authors have suggested biomechanical and anatomic features, as well as high playing volume, as possible candidates.[5,15,16]

While a few epidemiological injury studies have focused on youth players, none of them have attempted to identify the prevalence of pain in youth volleyball players or to identify risk factors for injury. Thus, the primary goal of this study was to identify the baseline shoulder pain rates in a regional sample of female high school volleyball players. The secondary goal was to enable future prevention research and interventions by identifying possible risk factors that merit further investigation. We hypothesized that questioning players about their history of NTP as a surrogate measure for overuse injuries will lead to substantially greater overuse shoulder injury rates than previously reported in the literature. We also hypothesized that players reporting NTP are more likely to also report higher playing volumes, which previous authors have suggested may be associated with overuse injuries.

METHODS

Survey Design

A paper-based survey to assess the prevalence of NTP in high school volleyball players and to collect demographic information was created. The survey was designed with input from athletic trainers, coaches, players, statisticians, and kinesiologists. The Dordt College institutional review board approved this survey study with a waiver for parental or informed consent.

Survey Content Summary

The survey (Table 1) had a demographic component, which provided information about the participant's year in school, volleyball playing history, current volleyball activities, and other activities not directly related to volleyball that might involve the shoulder, such as weight lifting and participation in other shoulder sports (tennis, softball, swimming). The component on volleyball-related shoulder pain history asked participants to report whether they had experienced pain, whether the pain was the result of a traumatic event, and how often the pain had reoccurred, as well as whether it had prevented them from participating in practices and/or games.

Survey Administration

Surveys were distributed via mail to 27 high schools known to have volleyball teams in northwestern Iowa, southwestern Minnesota, and southeastern South Dakota. Prior to receiving the mailed survey, coaches were alerted by email to the project and the survey's arrival. A cover letter instructed coaches to complete a coach survey and then have their players complete the survey using 15 minutes of practice time, and finally to return the surveys using the provided postage-paid envelope. Each school was given a random unique identifier to allow the coach survey and the player surveys to be paired, but all player responses were anonymous. As an incentive to complete the survey, teams were given the option to fill out and return a separate sheet to participate in a drawing for free admission to a varsity volleyball match at Dordt College. Before official survey administration, a pilot version of the study was given to players at a volleyball camp to ensure complete responsiveness.

Players who reported volleyball-related shoulder pain and who also indicated that the pain was not the result of a traumatic event (eg, collision or fall) were categorized as having NTP. Specific demographic variables were identified as having possible associations with NTP, including volume of contacts, number of years playing, and volleyball-specific weight training out of season. Sports involvement was derived from respondents indicating their participation in swimming, tennis, or softball. Volume of contacts described the self-reported number of times (in multiples of 100) that a player serves or spikes in practices during a typical week.

Statistical Analysis

Analyses of variables' effect on predicting pain was done in two steps with binary logistic regression using R software.[7] Initially, variables were tested individually to look for unadjusted significance ($P < .05$). Significant variables were then tested together to estimate adjusted effect sizes on NTP.

RESULTS

Sample Characteristics

A total of 191 survey responses were received from 19 high school teams at 9 different schools (a school response rate of 29.6%). Sixteen surveys that did not answer the pain questions properly were excluded from the data set, and the remaining 175 surveys were analyzed. The distribution of respondents was nearly equal among the 4 high school grade levels, and respondents playing at the varsity level accounted for half of the sample. Players who played a hitter position comprised 56% of the sample (Table 2).

Nontraumatic Pain

Out of a sample of 175 respondents, 40% indicated having experienced a volleyball-related shoulder pain not related to traumatic incidents (Table 3). Over a quarter of the total

TABLE 1
Survey Questions[a]

Background information
1. What is your dominant hitting arm? Check one. Right / Left / Ambidextrous
2. What is your primary position? Check one. LH / MH / RH / S / DS or Libero[b] / All
3. What is your secondary position? Check one. LH / MH / RH / S / DS or Libero[b] / None
4. What year are you in school? 7th / 8th / 9th / 10th / 11th / 12th[c]

Shoulder pain history
5. Have you ever experienced volleyball-related shoulder pain? Yes / No
   (If you answered no to question 5 please move directly to question 11)
   a. Was that pain due to a traumatic event (eg, collision or fall)? Yes / No
   b. Have you experienced more than one distinct type of shoulder pain? Yes / No
   (If yes, think about the most severe pain as you answer questions 6-10)
6. What was the earliest grade a pain like this happened?
7. About how often has this pain reoccurred? (Check one)
   Often / Sometimes / Rarely / Never (has occurred only once)
8. Have you used any of the following treatments for this pain? (Check all that apply)
   Rest / Ice / Medications / Modified Activity / Rehabilitation (PT/ATC/MD/PA) / Surgery
9. How many days has this pain prevented you from participating in
   a. Hitting (spiking) and/or Serving during practice b. All of practice c. Matches
10. Where in the shoulder is your volleyball-related shoulder pain located? (Check all that apply)
    Front / Side / Back / Cannot determine

Volleyball history
11. How many years have you played volleyball for a school team?
12. What grade were you when you first practiced the overhand serve?
13. What grade were you when you first used your overhand serve regularly in competition?
14. What is your current level of play? 7th / 8th / 9th / JV / Varsity
15. How many years have you consistently practiced at the following levels?
    a. 9th 0 / 1 / 2 b. JV 0 / 1 / 2 / 3 / 4 c. Varsity 0 / 1 / 2 / 3 / 4
16. How many years have you had consistent playing time in matches at the following levels?
    a. 9th 0 / 1 / 2 b. JV 0 / 1 / 2 / 3 / 4 c. Varsity 0 / 1 / 2 / 3 / 4

In practice
17. During the regular season, in *how many practices* each week do you hit/serve the ball overhead?
18. Which of the following serving styles do you use regularly in serving practice? (Check all that apply) Underhand / Overhand / Jump serve
19. How many times do you hit (practice spiking) in a typical practice? Please answer in increments of 5 (ie, 5, 10, 15, etc)
20. How many overhand serves do you perform in a typical practice? Please answer in increments of 5 (ie, 5, 10, 15, etc)

In games
21. Which of the following serving styles do you use regularly in a game? (Check all that apply)
    Underhand / Overhand / Jump float / Jump spin / Side arm

Outside of games/practice
22. In addition to playing for your school, which of the following volleyball activities have you participated in at least once since 7th grade? (Check all that apply) Camps / Lessons / AAU / Club / Open Gym
23. How many hits (spikes) do you perform outside of team practices/games *each week*?
24. How many overhand serves do you perform outside of team practices/games *each week*?
25. Do you participate in weight lifting during the season? Yes / No
26. Do you participate in volleyball-specific weight lifting out of season? Yes / No
27. Do you competitively participate in any of the following sports during the school year and/or during summer club-sponsored activities? (Check all that apply) Swimming / Tennis / Softball
28. Do you plan to play volleyball at the college level? Yes / No

[a]AAU, Amateur Athletic Union; ATC, certified athletic trainer; DS, defensive specialist; JV, junior varsity; LH, left-side hitter; MD, medical doctor; MH, middle hitter; PA, physician assistant; PT, physical therapist; RH, right-side hitter; S, setter.
[b]The libero is the rearmost, roaming defensive player in volleyball or soccer.
[c]The survey was also sent to middle school teams, but the number of middle schools teams responding was insufficient for statistical analysis, so only data from the high school teams was analyzed.

sample (27%) described the shoulder pain as reoccurring more regularly ("sometimes" or "often"). Within those with NTP, 96% reported experiencing it more than once and 69% experiencing it more regularly ("sometimes," "often"). Players who reported playing club or AAU (Amateur Athletic Union) volleyball (ie, a season in addition to the school season) more frequently reported NTP than players who did not play an additional season (43.3% compared with 32.6%). Hitters also more frequently reported NTP than players who played setter and/or defensive specialist positions (43.8% vs 29.8%).

On average, players reported the earliest occurrence of NTP to be less than 2 years from present (Table 4). A total of 33% of the NTP group (13% of the total sample) reported taking time off from practice and/or play due to the pain.

TABLE 2
Grade Level, Playing Level, and Primary Position Demographic Information for All Survey Respondents[a]

	Overall (N = 175), n (%)
Grade	
9th	48 (27.4)
10th	48 (27.4)
11th	35 (20.0)
12th	41 (23.4)
No response	3 (1.7)
Playing level	
V	77 (44.0)
JV	44 (25.1)
9th	40 (22.9)
9th, JV	3 (1.7)
JV, V	8 (4.6)
9th, JV, V	3 (1.7)
Position	
Hitter: right side	21 (12.0)
Hitter: middle	38 (21.7)
Hitter: left side	39 (22.3)
Setter	22 (12.6)
DS/Libero[b]	45 (25.7)
All or multiple positions	10 (5.7)

[a]DS, defensive specialist; JV, junior varsity; V, varsity.
[b]The libero is the rearmost, roaming defensive player in volleyball or soccer.

TABLE 3
Characteristics of Pain Type, Reoccurrence of Pain, and Prevalence by Club/AAU Participation and Playing Position in the Surveyed Population

Pain Characteristics	Overall (N = 175), n (%)
NTP	70 (40)
Traumatic pain	7 (4)
No pain	98 (56)
Reoccurrence of NTP	Within NTP (n = 70)
Never	2 (2.9)
Rarely	19 (27.1)
Sometimes	31 (44.3)
Often	17 (24.3)
Not applicable	1 (1.4)
Pain prevalence by club/AAU participation	
Club/AAU, n = 132	56 (43.3)
No club/AAU, n = 43	14 (32.6)
Pain prevalence by playing position	
Hitter (R, M, L), n = 128	56 (43.8)
Setter/DS, n = 47	14 (29.8)

[a]AAU, Amateur Athletic Union; DS, defensive specialist; L, left; M, middle; NTP, nontraumatic shoulder pain; R, right.

A logistic regression evaluating the association of 4 potential risk factors for NTP (Table 5) showed significant (unadjusted) effects on NTP for self-reported volume of contacts per week, number of years playing, and out-of-season weight lifting, so these variables were considered in a combined regression model. In the adjusted model, players who lift weights out of season had an estimated odds of reporting NTP that was 3.2 times larger than those who do not lift weights out of season ($P = .001$).

TABLE 4
Key Pain and Volleyball History Characteristics of Players Reporting NTP[a]

	Mean ± SD
Grade of earliest occurrence of NTP	9.2 ± 1.6
Average number of grades after starting school team NTP first occurred	4.3 ± 1.8
Number of years from present initial NTP occurred	1.4 ± 1.2
Average time in days lost due to NTP	1.4 ± 2.6

[a]NTP, nontraumatic shoulder pain.

The average number of years playing was significantly greater ($P = .013$) for the players reporting NTP, such that the odds of reporting NTP increased by an estimated factor of 1.3 per year of playing experience. The chance of reporting NTP increased as the number of years of playing increased (Figure 1). For instance, those playing 4 to 6 years reported a 20% increase in NTP occurrences over those playing 1 to 3 years.

While contact volume per week was significantly associated with pain in the unadjusted model (2.79 hundreds per week among the NTP group vs 2.28 in the no-NTP group; $P = .022$), this result became only borderline significant after adjusting for weight lifting and years playing. In the adjusted model, the odds of reporting NTP increased by an estimated 1.33 per 100 contacts per week. Thus, a player who reported hitting or serving 250 times during a week of practices increases her odds of reporting NTP by 1.33 more than if she reported hitting or serving 150 times during a week. A substantial (greater than 20%) increase in number of players reporting NTP occurred when players reported 250 or more contacts per week (Figure 2).

To better assess the predictive capability of the significant variables, players were assigned risk factors. The inclusion criteria for each risk factor were weight lifting out of season, reporting more than 250 contacts per week (the upper tertile of reported contacts per week), and having played for a school team (during elementary, middle, or high school) for more than 5 years. Thirty-eight percent of players with 1 risk factor reported NTP, compared with only 15% of players with no risk factors, while 58% of players with 2 or more risk factors reported NTP (Figure 3). Due to a low number of players (n = 9) with all 3 risk factors, they were combined with players reporting 2 risk factors; however, it is worth noting that 8 of the 9 players in this group reported NTP.

DISCUSSION

Overuse injury has been shown to be prevalent and cause playing time loss for elite male and female volleyball players and also to a lesser extent for middle school and high school players.[1-3,14,16,18] However, the present study indicates that not only are high school players losing time due to NTP, but many more continue to play despite

TABLE 5
Logistic Regression Results for Predictors of NTP[a]

Risk Factor	NTP (n = 70)	No NTP (n = 105)	*P* Value	OR (95% CI)	Adjusted *P* Value	Adjusted OR (95% CI)
Volume,[b] mean (SD)	2.8 (1.4)	2.3 (1.2)	**.022**	1.3 (1.1-1.7)	.061	1.3 (0.9-1.7)
Years playing, mean (SD)	5.5 (1.5)	4.9 (1.6)	**.016**	1.2 (1.1-1.6)	**.013**	1.3 (1.1-1.7)
Participates in other sports, %	52.9	52.4	.951	1.0 (0.6-1.9)	N/A	N/A
Weight lifting out of season, %	47.8	30.8	**.024**	2.1 (1.1-3.9)	**.001**	3.2 (1.6-6.7)

[a]Boldfaced values indicate significance at $P < .05$. NTP, nontraumatic shoulder pain; N/A, not applicable; OR, odds ratio.
[b]Contacts per week, in hundreds.

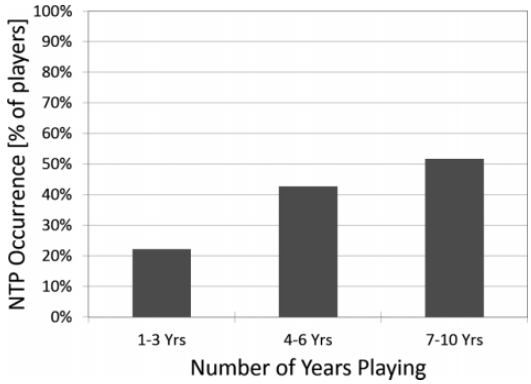

Figure 1. Percentage of players reporting nontraumatic shoulder pain (NTP) increased as a function of years playing.

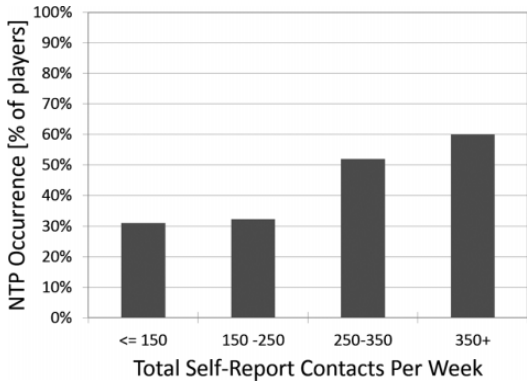

Figure 2. Percentage of players reporting nontraumatic shoulder pain (NTP) as a function of self-reported contacts per week (binned into groups of 100) increased as the number of contacts increased.

experiencing pain. The survey data demonstrate that self-reported NTP, characterized in the present study as pain in the shoulder region that reoccurs at least once and that was not originally caused by a traumatic event (collision, fall, etc), occurs in 40% of high school (grades 9-12) players in the geographic region under study here. Additionally, 13% of the players surveyed reported having taken time off as a result of the pain, which is consistent with literature reports using time off as a maker of shoulder overuse injury and reporting 8% to 20% of players taking time off for this

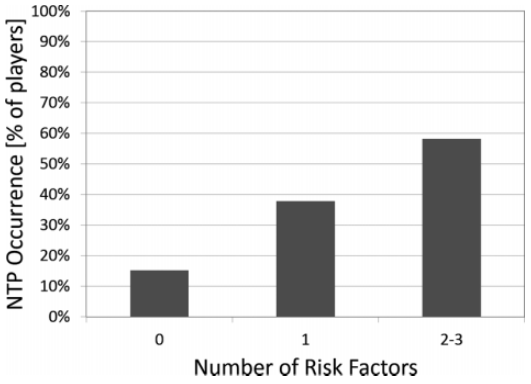

Figure 3. Percentage of players reporting nontraumatic shoulder pain (NTP) increased if the player had 1 or more risk factors (as identified in the regression analysis).

reason.[1-4,11,13,14,17-19] Within the players reporting NTP in our study, 96% reported experiencing the pain more than once, and 69% experienced it regularly ("sometimes" or "often"). This reoccurrence points toward a chronic problem. In addition, only one-third of these players reported taking time off due to the pain, meaning that the remaining two-thirds of players were not resting, indicating they may not be allowing their shoulders to recover from any related tissue damage or fatigue. The need for rest time is well known in other overhead arm-motion sports, particularly as it pertains to baseball pitchers.[6,8] It is worth noting that in this survey, athletes who played an additional season reported a greater prevalence of NTP, as did athletes who reported playing hitting (as opposed to setting or defensive specialist) positions. This suggests that rest-time guidelines and practices similar to those in baseball should be implemented in volleyball in order to reduce the prevalence of these chronic pains. Because volleyball has gained popularity as a youth sport over the past few decades, this problem is becoming more widespread and we need to understand causes in order to create possible prevention mechanisms.

While it is not entirely clear what causes this relatively high incidence of NTP in female high school volleyball players, the present survey results provide some possible explanations. Two of these possibilities relate to volume of play: self-reported contacts per week and number of years playing. The self-reported number of hitting and serving ball contacts per week correlated significantly with

increasing incidence of NTP (Figure 2); in fact, for each increase of 100 contacts per week, the odds of being in the NTP group increased by a factor of about 1.3 (Table 5). These data suggest that even though self-reported volume of contacts is not an exact measure from player to player, there is likely a significant relationship between volume and repetitive motion shoulder injury, a finding that would be in keeping with observations that baseball pitchers should have limited numbers of repetitions.[6,8] The number of years playing also correlated significantly with the incidence of NTP (Figure 1), with the likelihood of being in the NTP group increasing by a factor of 1.3 (Table 5) for each year of playing experience. From the current data, it is difficult to tell whether the odds ratio for increase in the years playing was due simply to the fact that more years of playing means more opportunity for injury, since it is difficult to obtain a true "baseline" measurement of NTP, or if playing at higher levels means higher swing volume or harder swings. However, because both contacts per week and years playing correlated with an increase in self-reported incidence of repeated shoulder pain, a relationship between volume and pain is probable.

A third possible predictor of NTP was performing self-reported volleyball-specific weight-lifting activities out of season (the survey did not specify particular lifting activities). Players reporting out-of-season weight lifting had 3.2 times higher odds of reporting NTP (Table 5). While substantial overlap might be expected between players who lift weights out of season and players who experience particularly high contact volume in season (the highly motivated group of players), this odds ratio is surprisingly high (in spite of its adjustment for years and volume). The high ratio may suggest that either the out-of-season weight-lifting activities are not appropriate for the type of shoulder motions (eg, do not focus on rotator cuff and/or scapular rotator muscle groups) or that the athletes are not taking time off to recover from existing minor aggravations, which eventually may lead to more significant problems. One notably nonsignificant possible factor for increased risk of NTP was playing other sports, which may suggest that training the body differently when playing other sports has a protective effect against NTP.

Based on these survey data, we identified 3 possible risk factors for the occurrence of NTP: contact volume, years playing, and out-of-season volleyball-specific weight lifting. Approximately 15% of players who reported none of the risk factors (fewer than 250 weekly repetitions, fewer than 6 years playing, and no out-of-season lifting) reported NTP, suggesting that this is the baseline risk level. A player reporting just 1 risk factor was twice as likely to report NTP (Figure 3) and this risk increased with 2 or more factors. Overall, these risk factors appear to point toward overuse and/or underrest as significantly contributing to the widespread prevalence of NTP in female high school volleyball players.

There are several limitations to the present study. First, the survey provides an asynchronous snapshot in time, asking about volleyball history (playing level, repetitions, etc) this year, but about shoulder pain over the player's entire volleyball career. While this discrepancy, which may lead to recall bias, should be noted when considering implications of these data, it is worth taking into account that 75% of respondents reported the initial pain occurring within the past 2 years, affirming the relevance of the pain-related questions to the current history questions. It is also worth noting that the amount of time off reported is consistent with other literature reports, which suggests that the important point to consider is that there are likely more low-level problems than the time-off metric reports.[1-4,11,13,14,17-19] Second, pain and volume were both self-reported, and the current set of pain-related questions did not differentiate for possible causes of NTP. While these results suggest a correlation between pain and chronic overuse, they do not establish a causal link; further investigation of these questions through prospective longitudinal studies and medical evaluations by a trainer or a physician need to be performed to establish a causal relationship. Third, the response rate to this survey was relatively low, which may introduce a bias either toward or away from teams with practices that make them susceptible to injury. It may also introduce a bias toward teams at particular levels of competition, although it is worth noting that two-thirds of the responding schools had all 3 levels of teams (9th grade, junior varsity, and varsity) evenly represented in their responses. Finally, this was a regional sample of volleyball teams in a particular tri-state area of the United States, and thus it is not clear whether these regional statistics are representative of the national picture. However, given the popularity of volleyball in this region, we expect that other regions of the country will show similar trends and that this may be a significant problem in youth volleyball on a national scale. Future work should address these limitations by replicating this study in other geographic regions and also in younger players (particularly middle school) to determine whether these effects are systemic. Additionally, repeating this study with a larger sample size would allow further elucidation of possible risk factors. Furthermore, it would be worthwhile to create a more objective assessment of NTP to determine causes and identify interventions that might reduce its prevalence. In the meantime, coaches, players, and parents should be aware that more repetitions may present risks to the long-term shoulder health of high school volleyball players.

In conclusion, 40% of female high school players in the region of northwestern Iowa, southwestern Minnesota, and southeastern South Dakota recalled experiencing NTP that appears to correlate with several different risk factors related to high contact volumes.

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