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original research

Epidemiology of Skin Infections in Men's Wrestling: Analysis of 2009–2010 Through 2013–2014 National Collegiate Athletic Association Surveillance Data

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Context: Our knowledge of the current epidemiology of skin infections among wrestlers is limited.

Objective: To analyze and report the epidemiology of skin infections among National Collegiate Athletic Association (NCAA) men's wrestling student-athletes during the 2009–2010 through 2013–2014 academic years.

Design: Descriptive epidemiology study.

Setting: Aggregate skin infection and exposure data collected by the NCAA Injury Surveillance Program.

Patients or Other Participants: Collegiate men's wrestling student-athletes.

Main Outcome Measure(s): All viral, bacterial, or fungal skin infections reported by athletic trainers at 17 NCAA programs were analyzed, providing 35 team-seasons of data. Skin infection rates per 10 000 athlete-exposures (AEs), rate ratios, skin infection proportions, and skin infection proportion ratios were calculated.

Results: The athletic trainers reported 112 skin infections contracted by 87 student-athletes across 78 720 AEs. The overall skin infection rate was 14.23/10 000 AEs (95% confidence interval [CI] = 11.59, 16.86). Of the skin infections identified, 22.3% (n = 25) were recurrent skin infections. Most skin infections (65.2%) were attributable to 5 team-seasons (range, 11–19 infections). Most skin infections occurred during the regular season (n = 76, 67.9%), were identified during practice (n = 100, 89.3%), and resulted in ≥24 hours' time loss (n = 83, 74.1%). The rate for viral skin infections was 1.72 times the rate for bacterial skin infections (95% CI = 1.09, 2.72) and 2.08 times the rate for fungal skin infections (95% CI = 1.28, 3.39). Fungal skin infections more often resulted in time loss <24 hours compared with all other skin infections (75.0% versus 12.5%; infection proportion ratio = 6.00; 95% CI = 3.30, 10.92).

Conclusions: Our findings highlight the contagiousness of skin infections and suggest that skin infection rates may be attributable to high incidences among particular teams.

Key Words: skin conditions, outbreaks, dermatology

Key Points

- Most infections were reported during the regular season and practices, yet they resulted in at least 24 hours of time loss.
- The majority of skin infections were attributable to 5 team-seasons.

Wrestling is a historic sport that has evolved to include many styles of combat. Across many cultures, the origin of the sport dates back to early civilization.[1–3] Currently, wrestling remains a popular sport among adolescents and young adults. In the 2013–2014 academic year, the reported numbers of US high school and collegiate wrestling participants were 279 418[4] and 6982,[5] respectively.

As does any physical activity, wrestling carries an inherent risk for injury. In fact, wrestling has one of the highest rates of injury among high school and collegiate athletes.[1,6–8] Unlike many other sports, wrestling also poses a serious risk for skin infection.[1] Previous investigators have highlighted the contagious nature of skin infections among wrestlers. Outbreaks of ringworm have also been linked to the sport.[9–15]

Nevertheless, the existing research has limitations. First, the literature on collegiate wrestling skin infections is often limited to case studies[9,16–19] or 1 category for skin infections within broader descriptive epidemiologic studies of wrestling injuries.[1,3,7,10,14] These studies limit our ability to analyze specific diagnoses and clustering of skin infections. Second, previous authors[1] also suggested that the overall skin infection rate in collegiate wrestlers was higher than that in high school wrestlers, yet recent descriptive epidemiologic studies of skin infections among collegiate wrestlers are lacking. Third, previous descriptive epidemiologic studies focused solely on skin infections resulting in time loss of at least 24 hours.[1,3] To understand the breadth of skin infections that may occur, regardless of time loss, non–time-loss infections should be included. Finally, the existing literature is often limited to studies of short duration (1 year) and does not feature recent data

from multiple teams. The purpose of our study was to analyze and report the epidemiology of skin infections among National Collegiate Athletic Association (NCAA) men's wrestling student-athletes during the 2009–2010 through 2013–2014 academic years using data from the NCAA Injury Surveillance Program (ISP).

METHODS

The NCAA-ISP is a prospective surveillance program that is managed by the Datalys Center for Sports Injury Research and Prevention, Inc (hereafter known as the Datalys Center), an independent, nonprofit research organization. The Research Review Board of the NCAA approved the study, which used data from men's wrestling during the 2009–2010 through 2013–2014 academic years. A convenience sample of 17 NCAA varsity wrestling teams provided 35 team-seasons of data; a *team-season* is defined as 1 season of 1 team. The included team-seasons for wrestling represented 3.2% of all 1096 wrestling team-seasons that occurred during the 2009–2010 through 2013–2014 academic years. Five wrestling teams participated in 2009–2010, followed by 9 in 2010–2011, 8 in 2011–2012, 6 in 2012–2013, and 7 in 2013–2014. The median number of seasons in which each team participated was 2 (range, 1–5 seasons). The methods of the ISP during the 2009–2010 through 2013–2014 academic years have been previously described[20] but are summarized here.

Data Collection

Athletic trainers (ATs) working with participating men's wrestling programs attended school-sanctioned practices and competitions and reported exposure and injury data (including infections).[20] The ATs provided the number of student-athletes participating in each practice, conditioning session, and competition. Only varsity-level practices, competition events, and team conditioning sessions were included in the ISP datasets. Individual weight-lifting and conditioning sessions were excluded.

When injuries, illnesses, or infections occurred, the ATs reported them through the electronic health record application used by the team medical staff. For each injury, illness, or infection event, the AT completed a detailed event report on the injury or condition, including the body site, diagnosis, assessment, activity, injury mechanism, event type (ie, competition or practice), time in season (ie, preseason, regular season, or postseason), and whether the injury was recurrent (ie, from an injury within the same or previous academic year).[20] For wrestling, ATs also entered the injured student-athlete's weight class. Previously submitted information could be viewed and updated as needed during the course of a season, including when the student-athlete returned to full sport participation. The difference between the event date and the return date yielded the number of days in which the athlete was restricted from participation.

Exported data passed through an automated verification process that involved a series of consistency checks. Data were reviewed and flagged for invalid values. The AT and data–quality-assurance staff were notified and worked together to resolve the concern. Data that passed the verification process were then placed into the final dataset.

Definitions

A reportable *skin infection* in the ISP was a contagious or noncontagious skin infection that occurred as a result of participation in an organized intercollegiate conditioning session, practice, or competition and required attention from an AT, physician, or other medical professional. Multiple skin infections could be included as the result of 1 skin infection event. In detecting and diagnosing skin infections, we relied on the experience and knowledge of the ATs and the team medical staff with whom they worked to accurately monitor the incidence of skin infection; however, the NCAA provides guidance for medical providers regarding diagnosis and management of skin infections.[21]

Non–time-loss skin infections were those skin infections resulting in less than 24 hours of time loss. *Severe skin infections*[22] were those skin infections resulting in time loss of more than 3 weeks or those that resulted in the student-athlete prematurely ending the season (ie, *season-ending skin infection*).

A reportable *athlete-exposure* (AE) was defined as 1 student-athlete participating in 1 NCAA-sanctioned practice or competition in which he or she was exposed to the possibility of skin infection, regardless of the time associated with that participation. Only athletes with actual playing time in a competition were included in competition exposures.

Statistical Analysis

Skin infection rates were calculated as the ratio of skin infections per 10 000 AEs. Given the rarity of skin infection cases in the ISP, we used 10 000 AEs as the denominator instead of the typical 1000 AEs. We also explored the distribution of skin infections within a team-season across time. We calculated rate ratios and infection proportion ratios. A *rate ratio* (RR) is defined as the relative difference between 2 groups and, in this study, compared the incidences of viral, bacterial, and fungal skin infections. The RR provides information on which specific type of skin infection had the highest incidence across the dataset. The following is an example of an RR comparing viral and bacterial skin infection rates:

$$\mathrm{RR} = \frac{\left(\frac{\sum \text{viral infections}}{\sum \text{athlete-exposures}}\right)}{\left(\frac{\sum \text{bacterial infections}}{\sum \text{athlete-exposures}}\right)}$$

An *infection proportion ratio* (IPR) is defined as the proportion of skin infections among 1 group compared with another group and, in this study, we compared the proportion of skin infections by time loss. The IPR helps us understand which type of skin infection the athlete presents to a sports medicine professional may be more likely to result in a more severe outcome (or less severe in the case of a non–time-loss infection). The following is an example of an IPR comparing the proportion of fungal skin infections that were non-time loss with that of all other skin infections:

$$\mathrm{IPR} = \frac{\left(\frac{\sum \text{fungal infections resulting in non-time loss}}{\sum \text{fungal infections}}\right)}{\left(\frac{\sum \text{all other infections resulting in non-time loss}}{\sum \text{all other infections}}\right)}$$

Table 1. Skin Infection Rates in National Collegiate Athletic Association Wrestlers by Time in Season, 2009–2010 Through 2013–2014 Academic Years

Time in Season	No. of Infections in Sample	Athlete-Exposures	Infection Rate per 10 000 Athlete-Exposures (95% Confidence Interval)
Preseason	33	22 946	14.38 (9.47, 19.29)
Regular season	76	50 873	14.94 (12.10, 18.30)
Postseason	3	4900	6.12 (0.00, 13.05)
Total	112	78 720	14.23 (11.59, 16.86)

All 95% confidence intervals (CIs) not containing 1.00 were considered statistically significant. Data were analyzed using SAS-Enterprise Guide software (version 4.3; SAS Institute Inc, Cary, NC).

RESULTS

Skin Infection Frequencies and Rates

During the 2009–2010 through 2013–2014 academic years, ATs participating in the ISP reported 112 skin infections contracted by 87 unique student-athletes across 78 720 AEs. The resulting skin infection rate was 14.23/10 000 AEs (95% CI = 11.59, 16.86; Table 1). Twenty student-athletes (23.0%) contracted multiple skin infections: 16 sustained 2 skin infections, 3 sustained 3 skin infections, and 1 sustained 4 skin infections. Of the skin infections identified, 22.3% (n = 25) were recurrent. The majority of skin infections occurred during the regular season (n = 76, 67.9%) and were identified during practice (n = 100, 89.3%; Table 1).

Type of Skin Infections

The most common skin infections reported were viral (n = 50, 44.6%), particularly herpes simplex I (n = 46, 41.1%; Table 2). Bacterial skin infections and fungal skin infections comprised 25.9% (n = 29) and 21.4% (n = 24), respectively, of the total skin infections. The rate for viral skin infections (6.35/10 000 AEs) was larger than those for bacterial skin infections (3.68/10 000 AEs; RR = 1.72; 95% CI = 1.09, 2.72) and fungal skin infections (3.05/10 000 AEs; RR = 2.08; 95% CI = 1.28, 3.39). The most commonly reported bacterial skin infection was impetigo (n = 12, 10.7%), and the most commonly reported fungal skin infection was tinea versicolor (n = 15, 13.4%). Impetigo constituted the largest proportion of recurrent cases (41.7% of all impetigo cases), followed by ringworm (33.3% of all ringworm cases) and herpes simplex I (37.0% of all herpes simplex I cases).

Time Loss

Eighty-three skin infections resulted in ≥24 hours of time loss (74.1%), whereas 29 skin infections were classified as non-time loss (25.9%). Of the skin infections that resulted in ≥24 hours of time loss, 4 (4.8%) were considered severe (time loss >3 weeks). These severe skin infections consisted of 1 case of non–methicillin-resistant *Staphylococcus aureus* infection, 1 case of cellulitis, and 1 case of boil, abscess, furuncle, or carbuncle. The fourth most frequent severe skin infection was *not specified*. Fungal

Table 2. Types of Skin Infections Reported in National Collegiate Athletic Association Wrestlers, 2009–2010 Through 2013–2014 Academic Years[a]

Type of Skin Infection	No. of Infections in Sample	Infection Rate per 10 000 AEs	Infections, %		
			Non-Time Loss[b]	Severe[c]	Recurrent
Bacterial	29	3.68	17.2	10.3	17.2
Impetigo	12	1.52	8.3	0.0	41.7
Folliculitis	8	1.02	37.5	0.0	0.0
Non–methicillin-resistant *Staphylococcus aureus* infection	6	0.76	0.0	16.7	0.0
Cellulitis	2	0.25	NA	NA	NA
Boil, abscess, furuncle, carbuncle	1	0.13	NA	NA	NA
Fungal	24	3.05	75.0	0.0	12.5
Tinea versicolor	15	1.91	100.0	0.0	0.0
Ringworm	9	1.14	33.3	0.0	33.3
Viral	50	6.35	6.0	0.0	34.0
Herpes simplex I[d]	46	5.84	6.5	0.0	37.0
Shingles (herpes azoster)	2	0.25	NA	NA	NA
Molluscum contagiosum	1	0.13	NA	NA	NA
Conjunctivitis	1	0.13	NA	NA	NA
Eczema	1	0.13	NA	NA	NA
Other	8	1.02	25.0	12.5	0.0
Total	112	14.23	25.9	3.6	22.3

Abbreviation: NA, not available.

[a] Percentages of non–time-loss, severe, and recurrent skin infections not calculated for counts under 5.

[b] Non–time-loss skin infections resulted in time loss <1 day.

[c] *Severe skin infections* were infections resulting in time loss >3 weeks or the season prematurely ending for the student-athlete.

[d] Includes herpes gladiatorum and fever blisters.

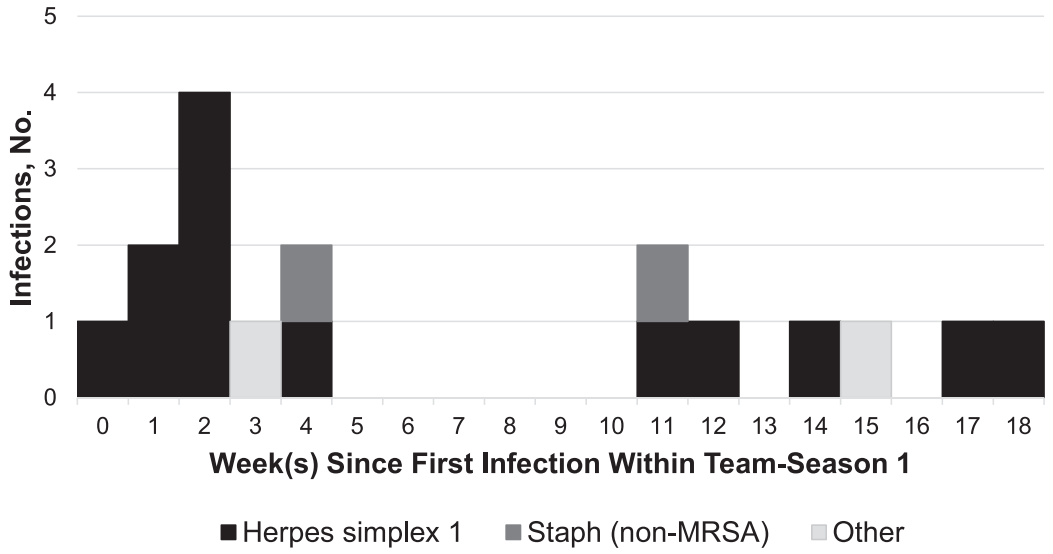

Figure 1. Example of grouping of infections among 1 team over season 1. Abbreviation: Staph (non-MRSA), non–methicillin-resistant *Staphylococcus aureus*.

skin infections more commonly resulted in no time loss compared with all other skin infections (75.0% versus 12.5%; IPR = 6.00; 95% CI = 3.30, 10.92). Bacterial infections were more likely to result in severe time loss compared with all other skin infections, although the difference was not statistically significant (10.3% versus 1.2%; IPR = 8.59; 95% CI = 0.93, 79.31).

Season-Specific Infection Occurrences

Most skin infections (65.2%) occurred within 5 team-seasons (range, 11–19 infections). Within these 5 team-seasons, several groups of skin infections were identified. For example, 1 team-season had an occurrence of 8 herpes infections throughout 5 weeks of the season (Figure 1). Another program had occurrences of 14 skin infections, of varying types, throughout 8 weeks of the season (Figure 2). These skin infections included herpes, tinea versicolor, and shingles, among others.

DISCUSSION

To our knowledge, this is the first study to present the epidemiology of skin infections among collegiate men's wrestling student-athletes. Previous literature on collegiate wrestlers' skin infections has been limited to case studies[9,16–19] or broader descriptive studies in which skin infections represented 1 combined injury category.[1,3,7,10,14] Therefore, these data provide the largest in-depth examination of recent skin infection data from multiple collegiate wrestling teams, which can help inform skin infection-prevention protocols. According to the National Athletic Trainers' Association position statement[23] on skin diseases, infection-control policies are recommended for all collegiate institutions, including cleaning and disinfecting of all facilities, encouraging hand hygiene, and ensuring the practice of athlete hygiene. Currently, the National Wrestling Coaches Association[24] offers a Webinar on skin infections and the National Federation of State High School Associations[25] emphasizes proper care for and prevention

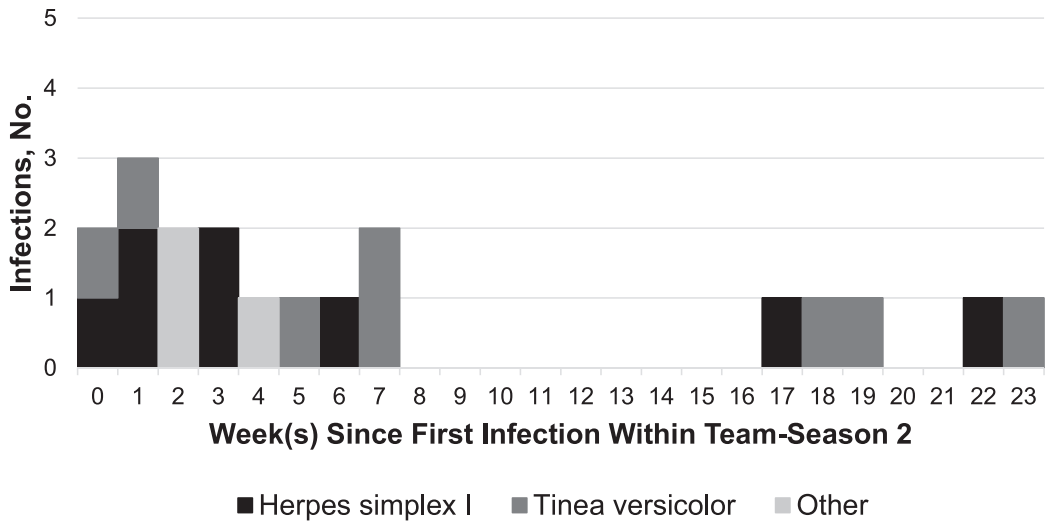

Figure 2. Example of grouping of infections among 1 team over season 2.

of communicable skin conditions. The National Federation of State High School Associations emphasizes the importance of becoming educated regarding skin conditions, cleaning wrestling mats daily using a solution of 1 part bleach to 100 parts water, maintaining proper ventilation, cleaning all wrestling gear after use, using body wipes or taking a shower using individual soap following each practice or competition, performing daily skin checks, and not sharing personal hygiene supplies.[25] In addition, education regarding the importance of controlling skin infections should be a priority for all collegiate wrestling stakeholders.[23]

A majority of the reported skin infections occurred within 5 of the 35 team-seasons examined, highlighting the contagious nature of skin infections. However, given the limitations of these surveillance data, we were unable to determine whether the skin infections were causally related. When analyzing causal links in a group of skin infections, future researchers should consider the mechanisms of transmission and the incubation periods for each specific type of skin infection. In addition, our data did not include information on hygiene practices within each participating program. We suspect that environmental hygiene may exacerbate student-athletes' susceptibility to skin infection. Ensuring proper student-athlete hygiene and daily mat cleaning with disinfectant solutions may help to decrease athlete-to-athlete and mat-to-athlete transmission. Therefore, routine cleaning of facilities and equipment is strongly encouraged. Mat cleaning should be undertaken daily using a solution of 1 part bleach to 100 parts water to mitigate the risk for skin infection transmission.[25] Additionally, maintaining proper body hygiene; not sharing personal equipment, towels, or razors; and taking proper care of skin lesions are important for preventing skin infections.[21]

We reported an overall rate of 14.23 skin infections per 10 000 AEs among collegiate wrestlers, which is similar to the rate reported in previously published literature. From previous ISP data from collegiate men's wrestling injuries in the 1988–1999 through 2003–2004 academic years, Agel et al[3] demonstrated an infection rate range of 0.72 to 0.98/1000 AEs (or 7.2 to 9.8/10 000 AEs). Another group[1] identified a slightly higher rate (1.9/1000AEs, or 19.1/10 000 AEs). The variation in reported skin infection rates may reflect differences in reporting or identifying conditions, or it could represent natural variations. In addition, previous investigators[1,3] considered only skin infections that resulted in time loss of at least 1 day, whereas 25.9% of infections in our study were non-time loss. Nevertheless, even when considering only the 83 skin infections in our study that resulted in time loss of at least 1 day, the infection rate estimate of 10.54/1000 AEs fell between prior estimates.[1,3] Previous authors[3] stated that skin infections increased annually by an average of 1.7% during the 1988–1989 through 2003–2004 academic years. Thus, despite infection-prevention initiatives, our findings may suggest persisting skin infections among collegiate wrestlers. Future researchers should directly assess the efficacy of skin infection-prevention initiatives in wrestling while identifying barriers to compliance with recommendations and standardization of detection and management. Weekly skin checks by ATs who work with collegiate male wrestlers throughout the season may allow for early identification and treatment to reduce outbreaks or clusters of these conditions. All athletes should be encouraged to immediately report any skin lesion, and appropriate referral for assessment and management should be pursued to prevent transmission. Continued surveillance of infections in wrestling will also help to identify areas of opportunity for infection prevention through recognition of clusters, which can lead to more focused studies of causation.

Among the skin infections we reported, few ($n = 4$) were considered severe (ie, time loss >3 weeks). This finding parallels the results of a previous 1-year study[1] of high school and collegiate wrestling programs in which no skin infections lasted >21 days but 8.8% of high school and 14.7% of collegiate skin infections resulted in 10 to 21 days of time loss. Of the severe cases reported in our study, 2 were identified as communicable (1 non–methicillin-resistant *Staphylococcus aureus* infection and 1 boil, abscess, furuncle, or carbuncle). However, the treatment time for these 2 skin infections often depends on the duration of the skin infection prior to the initiation of treatment and its severity. Although severe skin infections are relatively rare, ensuring appropriate and timely identification is essential. Skin infections located in crevices of the body, such as the buttocks, armpits, and groin, are difficult to keep dry and covered. Also, a skin infection may be difficult to identify until it accumulates to sufficient size with associated pain. A cursory skin check by a medical provider may not catch either of these skin infections until after they have formed a head and are raised and red or white. Thus, although many skin infections can be treated in less than a week, larger and more severe skin infections may require surgical drainage, wound packing, and longer-duration antibiotic treatments. It is important for each wrestler to perform routine self skin checks to expedite the treatment process for these painful and potentially contagious skin infections. Unfortunately, our data did not account for specific body location; thus, future investigators should examine how specific body locations of skin infections may be associated with transmission.

The skin diseases position statement released by the National Athletic Trainers' Association[23] in 2010 outlined the treatment and criteria for return to competition for various skin infections. The associated time loss varied by the specific type of skin infection, from no time loss for molluscum contagiosum to 2 weeks for systemic antifungal treatment of tinea capitis. In our study, nearly 26% of the reported skin infections did not result in time loss (<24 hours). Fungal infections were the most likely to be non-time loss (75%), and reported cases of impetigo (8.5%), folliculitis (37.5%), and herpes simplex I (6.5%) did not result in time loss. These skin infections are highly contagious: at least 72 hours are recommended before return to sport.[23] It is possible that these skin infections were discovered before a break in participation (eg, weekends, holidays), which would have allowed the student-athlete to complete the prescribed antibiotic course and return to sport once team activities resumed. Alternatively, the student-athlete may have self-treated or sought medical care from outside providers before reporting the skin infection to the institution's medical health providers. Team medical staff may have also used innovative skin infection-covering techniques to allow for quicker return to sport. We did not examine the use of such alternative

services and treatments and their association with non–time-loss skin infections; future research is warranted.

As did previous researchers,[3] we found that most skin infections were identified during practice. Currently, collegiate student-athletes undergo skin checks before competition. If an infectious skin condition is identified, the student-athlete is often barred from competing until it has resolved.[23] For this reason, student-athletes, coaches, and medical professionals may be more likely to identify and attempt to treat skin infections during practice in order to prevent a last-minute withdrawal from competition. Skin checks before both competition and practice and removal from participation after identification of contagious skin conditions are necessary to prevent the spread of these diseases. Athletes and coaches should be trained to recognize potential skin conditions and encouraged to seek immediate care from a medical professional.

Types of skin infections in our study were also similar to those identified previously,[1,3,10] with herpes simplex I (41.1%) and impetigo (10.7%) identified as common pathogens. Tinea versicolor was the most frequent fungal infection identified, which contrasts with previous NCAA-related research[3] in which ringworm occurred most often among wrestlers. This may be because previous authors included only skin infections resulting in time loss. In our sample, all cases of tinea versicolor were non–time-loss skin infections and, thus, would have been excluded using previous identification criteria. It is also possible that other investigators did not include tinea versicolor in their findings because it is not considered a contagious skin disease. Despite these variations, our findings, coupled with those of previous researchers, highlight the breadth of skin infections that may be reported in wrestling athletes.

Limitations

The ISP does not include information on skin infections that were not reported to ATs or other team medical staff. This should have a minimal effect on the analysis because skin infections often require medical treatment; however, it remains possible that athletes did not report skin infections that could be self-treated. In addition, although the NCAA Sports Medicine Handbook includes recommendations for the diagnosis and management of these conditions, we have no information on actual implementation of and compliance with these recommendations. All data were reported by ATs with medical training in identification of skin infections, which we believe reduces the potential for heterogeneity in reporting. Given the convenience sample of 17 varsity wrestling programs, selection bias may have occurred. It is possible that the results are not generalizable to all collegiate wrestlers, yet the ISP represents the most current, nationally representative data available on collegiate wrestlers. The ATs were provided with training on integrating the NCAA-ISP into their member institutions' electronic health record applications. Nevertheless, because identification of skin infections and their characteristics (eg, recurrence) is based on the expertise of the participating ATs, it is possible that variations in reporting and monitoring occurred within our sample. For example, the examination process for skin problems before practices and competitions may have differed; the ISP does not collect such specific data. Also, the definition of a skin infection as *recurrent* was based on expertise of the AT, as was the determination of how the skin infection was contracted. With recurrent skin infections in particular, there is some ambiguity as to whether a second occurrence of the same skin infection in a single athlete is a recurrent skin infection or an independent second occurrence, and these may have been identified and reported in different ways. Finally, some variables of interest may have been misclassified. For example, time loss due to a skin infection could result for a variety of reasons (ie, during participation breaks) and may not accurately reflect the severity of the condition; however, inclusion of all skin infections, regardless of time loss, improves our ability to understand the occurrence of skin infections among collegiate male wrestlers.

CONCLUSIONS

Our findings highlight the contagious nature of skin infections in NCAA wrestlers, with the most skin infections occurring among 4 teams over 5 team-seasons. Also, most skin infections were reported during practices. Interventions that reduce such clusters will help to dramatically reduce the rate of skin infections among collegiate wrestlers. This may include daily mat cleaning with bleach water, skin checks by ATs that exceed competition requirements, promotion of self skin checks, proper student-athlete hygiene, and other educational initiatives.

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