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Infectious Disease Outbreaks in Competitive Sports

A Review of the Literature

Sean D. Turbeville,*† PhD, Linda D. Cowan,† PhD, and Ronald A. Greenfield,‡ MD
From the †Department of Biostatistics and Epidemiology, College of Public Health, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, and ‡Infectious Disease Section, Department of Medicine, College of Medicine, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma

Recent outbreaks of infectious diseases in athletes in competitive sports have stimulated considerable interest. The environments in which these athletes compete, practice, receive therapy for injuries, and travel, both domestically and internationally, provide varied opportunities for the transmission of infectious organisms. The purpose of this medical literature review is to identify the agents most commonly reported in the medical literature as responsible for infectious disease outbreaks in specific sports and their modes of transmission and to guide targeted prevention efforts. A literature review of English-language articles in medical publications that reported outbreaks of infectious diseases in competitive athletes was conducted in PubMed MEDLINE from 1966 through May 2005. Outbreaks that were solely food borne were excluded. Fifty-nine reports of infectious disease outbreaks in competitive sports were identified in the published medical literature. Herpes simplex virus infections appear to be common among wrestlers and rugby players, with no single strain responsible for the outbreaks. Methicillin-resistant *Staphylococcus aureus* was responsible for several recent outbreaks of soft tissue and skin infections among collegiate and professional athletes. The most common mode of transmission in outbreaks was direct, person-to-person (primarily skin-to-skin) contact. Blood-borne exposure was implicated in 2 confirmed outbreaks of hepatitis. Airborne and vector transmissions were rarely reported. This review provides an overview of infectious disease outbreaks thought to be either serious enough or unusual enough to report. Appropriate surveillance of the frequency of infections will allow sports medicine staff to identify outbreaks quickly and take necessary measures to contain further transmission and prevent future outbreaks.

Keywords: infectious diseases; outbreaks; competitive sports; epidemiology

More than 7 million athletes at the high school and collegiate levels participate annually in competitive sports in the United States.[56,58] Because of this, there is a growing interest in the incidence of infectious disease outbreaks among persons engaging in competitive sports. The environments in which these athletes compete, practice, receive therapy for injuries, and travel, both domestically and internationally, provide varied opportunities for the transmission of infectious organisms via airborne, person-to-person, or common-source exposures.

Disease outbreaks in competitive sports are not new. In 1922, Patton[63] published a report of an outbreak of *Chlamydia trachomatis* in professional wrestlers. Since then, many outbreaks representing a variety of infectious diseases have been reported. These outbreaks affect not only athletes but also the coaching and support staff and spectators in sports such as football, wrestling, rugby, gymnastics, soccer, swimming, fencing, triathlons, and, more recently, Eco-challenges. In most cases, the morbidity associated with these outbreaks is mild. In others, significant morbidity can occur, and in some cases, albeit rarely, outbreaks result in life-threatening conditions. Not only do outbreaks present a public health concern, they can also disrupt or potentially eliminate a team's chance to compete at the highest level. Furthermore, infectious disease outbreaks can spread to social contacts, propagating the outbreak into the community.

An earlier review of infectious diseases in competitive sports, including case reports, was published in 1994.[34] The purpose of this review is to update that review and to consolidate the medical literature on infectious disease outbreaks among participants in competitive sports, to describe the epidemiology of these outbreaks, and to provide a basis for development of evidence-based strategies for infectious disease prevention and control among athletes in competitive sports.

*Address correspondence to Sean D. Turbeville, PhD, 801 Northeast 13th Street, Oklahoma City, OK 73190 (e-mail: sean-turbeville@ouhsc.edu).
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METHODS

A search of English-language articles published in the medical literature was conducted in PubMed MEDLINE from 1966 (the oldest year available) to May 2005. Search terms included the following keywords: *disease outbreaks*, *infectious diseases*, and *sports*. Additional studies were identified from the reference lists of articles. All reports of infectious disease outbreaks that met the search terms and that occurred in competitive sports were included in the review, regardless of the quality of methodology. Case reports, outbreaks in competitive sports reported in newspapers or magazines, and outbreaks that were solely food borne were not included. Outbreaks reported from state health departments were included if available.

To review published reports of infectious disease outbreaks in competitive sports, it is important to have an operational definition of an outbreak. An epidemic (or outbreak) is typically defined as any health-related event that occurs in excess of usual expectancy.[32] "Usual expectancy" is measured by collecting data for that event over time. On the other hand, a cluster is an aggregation of cases at the same place and time in numbers that are believed, or perceived, to be greater than one would expect by chance.[32] Because background incidence rates for teams are generally not collected by athletic personnel, it is sometimes difficult to distinguish true outbreaks from clusters of cases in these reports. Collecting systematic incidence data over many years can assist in distinguishing the two, but data are often lacking.

RESULTS OF LITERATURE SEARCH: CHARACTERISTICS OF THE OUTBREAKS

The literature search identified 59 reported infectious disease outbreaks in competitive sports from 1922 through May 2005. Details of these outbreaks, grouped by sport, are given in Table 1. The outbreaks reported in the literature will first be characterized by type of sport, infectious agent, mode of transmission, site of infection, and the ages and gender of the affected players.

The frequencies with which either outbreaks or clusters of infectious diseases were reported for specific sports are as follows: football (20 reports, 34% of all reports), wrestling (19, 32%), rugby (10, 17%), soccer (2, 3%), adventure races or Eco-challenges (2, 3%), followed by 1 each in swimming, triathlon, track and field, trekking, gymnastics, basketball, and fencing (Table 1). The range of ages of affected athletes was 14 to 80 years, although the majority of infected athletes were in their teens and early 20s. Athletes with infectious diseases were predominantly male, reflecting the preponderance of contact sports among the published reports and the predominance of males in competitive contact sports. Female volleyball players and cheerleaders were, however, involved in 1 reported infectious disease outbreak.[3]

The agents most often responsible for the reported outbreaks were herpes simplex virus (HSV; n = 13/59 outbreaks, 22%) and *Staphylococcus aureus* (n = 13, 22%). The HSV and *S aureus* outbreaks were reported primarily in wrestling, rugby, and football. This finding reflects the known mode of transmission for these agents (ie, direct person-to-person contact) and the opportunity for exposure (ie, skin-to-skin contact) (Table 1).

Other agents responsible for outbreaks in competitive sports include enteroviruses (n = 11/59, 19%), tinea (trichophytosis; n = 8/59, 14%), *Streptococcus pyogenes* (n = 4/59, 7%), hepatitis A and B viruses (n = 4/59, 7%), measles virus (n = 3/59, 5%), Leptospira species (n = 2/59, 3%), and *Neisseria meningitides* (n = 2/59, 3%). Infectious agents such as Norwalk virus, rickettsia, chlamydia, and pseudomonas were also implicated in outbreaks, although rarely.

In general, there are 3 modes of transmission of infectious diseases in sports: person to person (eg, direct contact such as skin to skin; indirect contact through respiratory route, blood borne, or fecal-oral exposure), common source (ie, athletic equipment or other source such as watercoolers), or vector transmission. When reported, the most common mode of transmission was direct person-to-person (primarily skin-to-skin) contact.[§] Transmission through common-source exposure was also implicated, although rarely quantitatively. Common sources of exposure included contaminated water or watercoolers,[6,36,39,54] water bottles, and drinking cups[3,52,80]; athletic equipment[19,25]; locker rooms[65]; fencing equipment[15]; soap and towels[60]; whirlpools[11]; swimming pools[68]; and contaminated lakes and rivers used for triathlons and Eco-challenges.[53,72] In some outbreaks, multiple modes of transmission were suspected.[39] In 3 confirmed outbreaks, blood-borne exposure was implicated.[40,70,81] Airborne transmission was rarely reported except for measles outbreaks.[14,21,26,71] Only 1 outbreak involved vector transmission: African ticks responsible for an outbreak of African tick-bite fever in participants of an Eco-challenge.[29] There were no reports of West-Nile virus infections among participants in competitive sports, including football, in which the sport's season occurs at the time mosquito populations are at their highest density. There were no reports of transmission of zoonoses among rodeo athletes.

The most common site of infection among athletes was the skin (56%), reflecting the frequency of contact sports such as wrestling, rugby, and football in which skin trauma facilitates the introduction of infection. In some cases, the cutaneous infection was severe, requiring hospitalization and/or intravenous antibiotic therapy for soft tissue bacterial infections.[11,60,65,76] Some athletes with initial HSV infections were also hospitalized.[10] Outbreaks of infectious diseases of the upper respiratory tract, such as pharyngitis[33] and conjunctivitis,[13,14,73,75] have been reported. In addition, outbreaks of hepatitis[40,54,70] and meningitis[3,6,35,36,52,69,80] have been reported among competitive athletes.

The quality of the epidemiologic data in these reports was highly variable. Few studies provided sufficient data to calculate attack rates, measures of association between

[§]References 7, 10-13, 16, 30, 33, 38, 47, 48, 63, 64, 66, 67, 73-75, 77-79, 82-84.

exposures and infectious disease, or incubation periods. In many outbreaks, the numerator data (number of cases) included coaches, athletic staff, and/or social contacts, thus overestimating the attack rate among athletes. In some instances, cases were not clearly defined. In others, the outbreak included cases from additional teams of the same sport or cases from consecutive seasons, making it difficult to compare seasonal attack rates for a given sport across different studies. With respect to HSV outbreaks, many of the studies did not do the serological testing necessary to discriminate between primary or recurrent infections. Only in outbreaks that involved hepatitis were there generally sufficiently specific laboratory data to confirm incident cases and identify source carriers.[40,81]

Post hoc attack rates were calculated for each outbreak if sufficient information was provided in the results section of the study (Table 1). Only 6 studies performed sufficient analyses to identify likely sources of exposure, an important component of outbreak investigation for identifying primary prevention strategies.[11,13,39,41,60,76]

DISCUSSION

Contact sports provide an excellent setting for the transmission of communicable diseases. Outbreaks of viral, fungal, and bacterial skin infections are common in contact sports such as wrestling, rugby, and football because of the close physical contact and trauma to the skin involved in these sports.

Herpes Simplex Virus

The HSV infection appears to be endemic among wrestlers and rugby players, with no single strain responsible for the outbreaks.[5,13,24,50,67,74,82,84] The prevalence of antibodies to HSV-1 is between 25% and 60% in college students, depending on race.[62] In a small study of serologically tested college wrestlers in 1988, Becker et al[10] reported a prevalence of antibodies to HSV of 42% (5/12). In the same study, histories of clinical presentations consistent with HSV were reported by athletic trainers in 199 (7.6%) of 2625 college wrestlers and 62 (2.6%) of 2354 high school wrestlers during the 1984–1985 season. In one study, the frequencies of recurrent HSV infections in a collegiate wrestling team over 3 consecutive years were 4%, 62%, and 47%, respectively, suggesting that reactivation of infection in wrestlers may be common.[79] Recurrence was defined based on reported symptoms. Concomitant skin infections from organisms such as staphylococcus and streptococcus can sometime confuse the diagnosis of HSV infection.[5,24,48,75,84]

The HSV infections in wrestlers and rugby players predominantly occur on the head, face, and neck,[5,25,66,73,83,84] and rarely on the lower extremities.[24] In rugby players, forwards appear to be at higher risk, possibly because of their greater face-to-face contact with opposing players. In wrestling, there does not appear to be a difference in risk by weight class, although this finding has not been adequately examined.[4] The facts that the skin lesions are not evenly distributed over the body, that skin lesions occur on the face after face-to-face contact in wrestling or during a scrum (ie, in forwards), and that there is a failure to isolate HSV from wrestling mats suggest person-to-person transmission by direct contact.[5,24,66,74,82,83]

Typically, initial HSV infections start with mild, flu-like symptoms followed by a papular rash and vesicles 1 to 2 days later.[13,24] Great variability in the appearance of the rash as well as in clinical symptoms in athletes has been reported. These symptoms include malaise to extreme fatigue,[84] weight loss,[84] pharyngitis,[84] lymphadenopathy,[5,13] and conjunctivitis.[13,37,73] In some cases of initial infection, the athletes have required hospitalization.[10,37,73,75,84]

In 2003, Anderson[5] reported a mean "transmission" time (time from presumed exposure to vesicle formation, ie, the incubation period) of 6.8 ± 1.7 days and a "probability" of HSV-1 transmission of 32% if herpes simplex develops on a sparring partner. Risk factors for HSV transmission, other than contact with an infected athlete, include open wounds and abrasions. Despite experimental evidence suggesting HSV can survive for hours on inanimate objects,[62] there are no studies that have shown wrestling mats to be a source of HSV transmission. Equipment such as nonabrasive shirts may reduce transmission of HSV-1 by minimizing abrasions to the face, neck, and arms,[79] although this hypothesis has not been systematically evaluated.

Prevention of HSV transmission includes screening participants for active lesions and removing affected athletes from competition.[4,5,57] Antiviral prophylaxis is also used in athletes with a history of HSV to reduce the risk of recurrence.[4,5,57] Vaccination has been used in the United Kingdom to control an outbreak of HSV in rugby players,[75] but a vaccine is not available in the United States. The National Collegiate Athletic Association and National Federation of State High School Associations have developed guidelines for the removal and return to competition of athletes who have active lesions.[57,59] Additional studies are needed to evaluate the natural history of HSV infection among athletes—in particular, how much viral shedding occurs in asymptomatic athletes, in athletes receiving antiviral therapy, and after the skin lesions have healed.[5,46,75]

Tinea

Several outbreaks of tinea corporis, or "ringworm," have recently been reported in high school and college wrestling.[1,12,27,43,64] Whether this finding reflects a true increase in the incidence of these infections or better reporting is unknown. *Trichophyton tonsurans* infection is the most commonly reported fungal infection among wrestlers.[1] In some cases, the lesions are atypical.[12] In a cross-sectional study by Adams,[2] the point prevalence of tinea in a high school wrestling team was 24%, suggesting endemicity. Asymptomatic carriage of *T tonsurans* can occur in the scalps of both children[31] and adults,[28] suggesting that humans are a likely reservoir and transmission most likely occurs person to person. Sharing of wrestling equipment such as headgear may also contribute to the spread of infection.[19] Wrestling mats do not appear to be a

source of ringworm infection. However, colony variation and reduced sporulation make it difficult to identify strains of trichophyton by conventional methods.[27,44] International wrestling tournaments have been cited as the source of transmission of strains of trichophyton indigenous to athletes of the host country.[38] Because the infection is typically benign, outbreaks probably occur much more often than is reported.[78]

Primary prevention of tinea corporis in the athletic setting begins with the systematic screening of wrestlers before practice and competition, particularly during international events. Those identified with lesions should be treated based on the current recommendations, and recommendations regarding return to play should also be followed.[57,59] Pharmacological prophylaxis with fluconazole has shown promising results in reducing the incidence of tinea in wrestlers,[45] but additional studies are warranted. Until further evidence implicates wrestling mats as a reservoir for tinea,[44] time-consuming and costly sterilizing practices should not be encouraged,[1] but standard methods of maintaining mat cleanliness should be followed.[20] The sharing of athletic equipment, however, should be discouraged. Further studies are necessary to understand the epidemiology of tinea corporis in athletes (ie, potential reservoirs, asymptomatic carrier status, transmission) and to evaluate treatment protocols specific for athletes involved in wrestling as well as other contact sports in which the risk of infection is high.

S aureus, Including Methicillin-Resistant *S aureus*

Outbreaks of *S aureus* infection have been reported in football, basketball, and amateur rugby players as well as recreational river rafting guides.[7,17,22,60,65,76] The infection is typically cutaneous and is spread person to person, although in some reports, common-source exposure contributed to transmission.[17,65] Skin trauma appears to be a significant risk factor for acquisition of infection.[7,76]

Methicillin-resistant *S aureus* (MRSA), once thought of as solely a hospital-acquired infection, has recently been responsible for several community-obtained outbreaks of soft tissue and skin infections among collegiate and professional football players,[11,15,41,60] high school wrestlers,[47] amateur rugby players,[77] and fencing teams.[15] In all cases, the infections were cutaneous. Of the 55 infected athletes, 16 (29%) required hospitalization for their infections. In 3 outbreaks, the likely source was an asymptomatic carrier identified through positive nasal cultures.[47,60,77] In an outbreak among fencers, a contaminated sensor wire shared among athletes during competition was likely responsible for transmission. In the largest outbreak of MRSA infections reported among competitive athletes, the sharing of soap bars with teammates was identified as the strongest risk factor for disease acquisition among collegiate football players (odds ratio, 15.0; 95% confidence interval, 1.69-180).[60] Multiple modes of transmission (eg, person-to-person and common-source exposure) were possible in a similar outbreak in collegiate and professional football players with no single source identified.[11,41] The MRSA USA-300 was the strain responsible for 3 separate outbreaks among football players. This strain has been identified as a common strain responsible for outbreaks of community-obtained MRSA infection.[51]

Outbreaks from other bacteria such as *S pyogenes* have also been reported in football and rugby teams.[23,33,48,49] Interestingly, we were unable to identify any reports of tetanus among athletes who participated in sports on natural outdoor fields, suggesting effective immunization practices.

Primary prevention of bacterial infections in the athletic setting includes proper immunization for all personnel and athletes, adherence to standard precautions, diligent hand washing and access to hand disinfectants (particularly for trainers but also for athletes), proper disinfecting and storage of portable water containers, proper laundering of towels and uniforms, and proper disinfection of athletic equipment, training tables, and exercise equipment. The Occupational Safety and Health Administration provides guidelines for the proper disinfection and maintenance of whirlpools, saunas, ice machines, and swimming pools.[61] Individual states may also have specific guidelines that must be followed. Further information on infection control can be found at the Centers for Disease Control and Prevention[16] and National Collegiate Athletic Association[55] Web sites.

Enteroviral and Meningococcal Meningitis

Outbreaks of aseptic meningitis-like illnesses have occurred in high school football[3,6,35,36,52,80] and during an international soccer tournament in Belgium.[69] Aseptic meningitis-like illnesses are generally seasonal, occurring in the summer months (July, August, and September), and typically affect either the young or the elderly.[8] Spread of the organisms is so ubiquitous during the peak months that control methods are generally useless. The organisms responsible for outbreaks in football teams were mostly echoviruses (5, 9, 16, 24) and Coxsackie viruses (B1, B2, B4, B5). In these outbreaks, transmission occurred either through the sharing of water bottles or drinking cups or from water and ice from a contaminated watercooler.[3,6,35,36,52,80]

N meningitidis was responsible for 2 outbreaks of bacterial meningitis: one in soccer players during an international soccer tournament and another in rugby players from a rugby club. In only 1 outbreak was the source of infection identified.[42,69] Untreated bacterial meningitis can rapidly progress to a fatal outcome even in healthy individuals. Vaccines for some types of bacterial meningitis are commercially available, but there is currently no vaccine for viral meningitis.

Measles

Indoor sporting events offer a unique opportunity for the transmission of viruses. Measles is one of the most highly contagious infectious diseases and is passed person to person, primarily by airborne transmission. Measles has been responsible for a number of outbreaks after athletic events in domed stadiums.[14,21,26,71] International sporting events provide an excellent opportunity for the spread of indigenous

measles, as reported in 1 outbreak that occurred during an international gymnastics event.[14] Prevention of measles is through vaccination of susceptible individuals with the live attenuated measles vaccine and isolation of indigenous and domestic cases away from the general population. Prompt reporting to public health officials is obligatory to aid in prevention of further transmission. Prophylactic vaccination of individuals who have been exposed to measles can provide protection if given within 72 hours of exposure.[18]

SUMMARY

Recent outbreaks of infectious diseases in competitive sports have stimulated considerable interest in the role of infections in the health of athletes. Sports provide an excellent opportunity for the transmission of communicable diseases to athletes, athletic staff, and social contacts. Furthermore, the increasing popularity of international sporting events is likely to expose athletes to indigenous diseases for which they have little, if any, natural immunity. Knowledge of the most common agents producing infectious disease outbreaks in specific sports can be used to guide targeted prevention efforts. Sufficient surveillance of the frequency of infections per team each season will also allow athletic staff to identify outbreaks quickly and take necessary measures to contain further transmission and prevent future outbreaks. Appropriate outbreak investigations should identify potential sources of exposure empirically. This procedure will allow prevention methods to be based on data rather than on expert opinion or suggestion. Furthermore, athletic personnel should be trained in the proper identification of outbreaks and in control measures for specific infectious diseases to prevent further spread of an outbreak if one truly exists.

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