Sports: The Infectious Hazards

AREZOU MINOOEE,1 JEFF WANG,1 and GEETA K. GUPTA1
1Department of Medicine, Infectious Diseases, University of California Irvine, CityTower, Orange, CA 92868

ABSTRACT Although the medical complications of sports are usually traumatic in nature, infectious hazards also arise. While blood-borne pathogens such as HIV, hepatitis B, and hepatitis C, cause significant illness, the risk of acquiring these agents during sporting activities is minimal. Skin infections are more commonplace, arising from a variety of microbial agents including bacterial, fungal, and viral pathogens. Sports involving water contact can lead to enteric infections, eye infections, or disseminated infections such as leptospirosis. Mumps, measles, and influenza are vaccine-preventable diseases that have been transmitted during sporting events, both in players and in spectators. Prevention is the key to many of these infections. Players should be vaccinated and should not participate in sports if their infection can be spread by contact, airborne, or droplet transmission.

INTRODUCTION Sporting events have been a favorite pastime for countless generations. We participate in sports for recreation, competition, and good health (Fig. 1). The hazards usually associated with sports are traumatic: strains, sprains, fractures, and concussion. People are generally unaware of infectious complications until they are highlighted by the media, such as when several players in the National Football League (NFL) developed skin infections involving antibiotic-resistant bacteria, when professional basketball star Magic Johnson was diagnosed with the human immunodeficiency virus (HIV), and the recent outbreak of mumps in the National Hockey League. Alas, recreational athletes and even spectators are not exempt from infectious hazards either. An outbreak of campylobacteriosis among participants of a long-distance obstacle adventure course has shown that even weekend warriors may be affected by sports-related infections. This chapter highlights the mechanisms by which infectious agents may be spread during sports, the treatment options available, and preventive strategies.

There are several mechanisms by which infectious agents may be spread during sports. The main routes of transmission include direct and indirect contact, droplet, common-source, and airborne transmission. Direct-contact transmission involves person-to-person contact in which infectious agents are physically transferred from one person to a susceptible host. Indirect-contact transmission occurs when a susceptible host comes into contact with contaminated objects or fomites, such as equipment, towels, or clothing. A type of indirect contact is droplet transmission, which occurs when droplets containing infectious agents are generated through coughing, sneezing, or talking and are deposited on the host’s conjunctivae, nasal mucosa, or mouth after being propelled in the air a short distance. Common-source transmission happens when infectious agents are transmitted by contaminated items, such as food, water, beverage containers, or other equipment with which multiple people may have had contact. Airborne transmission occurs when extremely small particles called droplet nuclei containing infectious agents are suspended in the air for long periods and are subsequently inhaled by the susceptible host. Vector-borne diseases are spread by insects, mites, ticks, animals, or other

Received: 22 March 2015, Accepted: 1 April 2015, Published: 9 October 2015
Editor: David Schlossberg, Philadelphia Health Department, Philadelphia, PA
Correspondence: Geeta K. Gupta, ggupta@uci.edu
© 2015 American Society for Microbiology. All rights reserved.
carriers and may pose a risk to the host exposed in endemic areas. Table 1 summarizes potential sports-related infectious diseases.

**BLOOD-BORNE PATHOGENS**

**HIV**

HIV is the etiologic agent which leads to the suppression of the immune system and the development of AIDS (acquired immunodeficiency syndrome). Modes of transmission include sexual contact, parenteral exposure to blood or blood components, contamination of open wounds or mucous membranes by infected blood or body fluids, needle sharing, and perinatal transmission from infected mother to fetus. The virus is distributed throughout a variety of bodily fluids but is found in high concentrations in blood.

Millions of people worldwide have been affected by HIV and AIDS. In the absence of a cure or vaccine, there is much concern regarding infection during athletic competitions in which bleeding and skin abrasions are common, such as in boxing and football. Since the initial description of AIDS in 1981, there has been no evidence of transmission of the virus through sweat, tears, urine, sputum, vomitus, saliva, or respiratory droplets.

American football is one sport for which the potential risk of HIV transmission has been investigated. Based on the frequency of bleeding injuries and player contact observed in one study, the risk of infection was estimated to be less than 1 per 85 million game contacts. Athletes actually have a greater probability of becoming infected off the field through unsafe sexual practices and injection of drugs or anabolic steroids. For example, a bodybuilder who injected intramuscular steroids with a shared, unsterilized needle became infected with HIV. Other risk factors were ruled out for this individual.

There has been one documented case of HIV transmission during sports contact. The report concerned an Italian soccer player who allegedly seroconverted after a bloody head-to-head collision with an HIV-positive individual during a recreational soccer match. However, after careful review of the case, health officials were unable to rule out other risk factors to verify the actual mode of transmission.

At least two instances of HIV transmission have been reported to be due to fistfighting episodes involving bloody injuries. Such reports reinforce the theoretical risks that athletes face and indicate the necessity of taking precautions during events in which blood exposure may occur. The following preventive strategies and

**TABLE 1** Common etiologies of sports-related infections

<table>
<thead>
<tr>
<th>Blood-borne infections</th>
<th>Skin infections</th>
<th>Nonskin infectious syndromes</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV infection, AIDS</td>
<td>Viral infections</td>
<td>Conjunctivitis</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>Herpes simplex virus (HSV) infection</td>
<td>Infectious mononucleosis</td>
</tr>
<tr>
<td>Hepatitis C</td>
<td>Molluscum contagiosum</td>
<td>Meningitis</td>
</tr>
<tr>
<td></td>
<td>Human papilloma virus (HPV)</td>
<td>Mumps</td>
</tr>
<tr>
<td></td>
<td>Bacterial infections</td>
<td>Upper respiratory tract infections</td>
</tr>
<tr>
<td></td>
<td><em>Staphylococcus aureus</em>, MRSA</td>
<td>Vector-borne infections</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus</em></td>
<td>Water sports-associated transmission*</td>
</tr>
<tr>
<td></td>
<td><em>Corynebacterium minutissimum</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Pseudomonas aeruginosa</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fungal infections</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Tinea</em> infections</td>
<td></td>
</tr>
</tbody>
</table>

*See Table 2 for a list of related infections.
recommendations adopted from the American Medical Society for Sports Medicine, American Academy of Sports Medicine, American Academy of Pediatrics, NFL, National Collegiate Athletic Association, and World Health Organization should be considered with regard to HIV in sports.

1. If a skin lesion is observed, it should be immediately cleansed with a suitable antiseptic and securely covered with an occlusive dressing that will withstand the demands of competition.

2. If a bleeding wound occurs, the individual’s participation should be interrupted until the bleeding has been stopped and the wound has been both cleansed with antiseptics and securely covered or occluded. Any participant whose uniform is saturated with blood, regardless of the source, must have it changed before returning to competition.

3. Coaches and athletic trainers should receive training in first aid and emergency care; they should also be provided with the necessary supplies to treat open wounds, such as latex or vinyl gloves, disinfectant, bleach, antiseptic, designated receptacles for soiled equipment or uniforms, bandages or dressings, and a container for appropriate disposal of needles, syringes, or scalpels.

4. Athletic equipment that is visibly contaminated with blood should be wiped clean and disinfected with a bleach solution before being used.

5. Gloves should be worn by people attending to injuries when direct contact with blood or body fluids is anticipated. The gloves should be changed after individual participants have been treated, and hands should be washed after every glove removal. Emergency care, however, should never be delayed when protective equipment is not available.

6. Athletes should not be restricted from participating in sports merely on the basis of their HIV status unless substantial numbers of cases of transmission in sporting competitions occur.

7. The enforcement of mandatory HIV testing in athletic settings is unnecessary. Instead, voluntary testing and HIV education should be promoted to achieve public health benefits.

**Viral Hepatitis**

Hepatitis B virus (HBV) and hepatitis C virus (HCV) are transmitted via the same routes as HIV: sexual contact, parenteral blood exposure, and perinatally. Although the routes of transmission are similar to those of HIV, HBV transmission rates are 100-fold higher than those of HIV. A well-documented outbreak of HBV infection was reported among several members of a high school sumo wrestling club. It was suggested that HBV was transmitted percutaneously through the cuts and abrasions suffered during wrestling. In another report, horizontal transmission of HBV was documented among five players of an American football team due to contact with open wounds during training.

Other sports-related outbreaks of HBV have occurred among Swedish orienteers. Orienteering is a sport in which runners are given the bearings of a number of checkpoints and, with the aid of a compass and map, choose their own route to the finish line. It was suggested that inoculation of HBV might have occurred when the runners scratched themselves on the same bushes or, after the competition, when the participants bathed in stagnant waters or shared the same plastic bathtubs. Immediately after preventive measures were applied, the incidence of HBV infection among the orienteers decreased.

The risk of HCV infection from percutaneous exposure to infected blood is estimated to be 10 times greater than that of HIV but lower than that of HBV. Although there are no confirmed cases of HCV transmission through sporting activities, there is some evidence of increased risk in athletes who play contact sports. Transmission resulting from nonathletic bloody fistfights has been reported. However, the greatest risk of HCV acquisition in athletes is not from the sport itself but rather from the injection use of anabolic steroids, vitamins, or other performance-enhancing agents. The risk of HIV, HBV, or HCV transmission to other athletes is generally very low; therefore, on the basis of risk of infection, infected athletes should be allowed to participate in sporting activities.

**SKIN INFECTIONS**

**Viral Infections**

**HSV**

Herpes simplex virus (HSV) is the cause of a contagious viral infection of the skin and mucous membranes. Herpes labialis (cold sores) and herpes progenitalis are two forms of the disease, so named because of their anatomical locations. Since HSV infection is so prevalent among rugby players and wrestlers, it has also been referred to as herpes gladiatorum, herpes venatorum, herpes rugbeiorum, and scrumpox. The virus may be transmitted directly through skin-to-skin contact or indirectly through the sharing of towels, clothes, or other
Molluscum contagiosum
Molluscum contagiosum is a benign viral skin infection caused by a poxvirus. The lesions present as 2- to 5-mm smooth papules that are often umbilicated. The incubation period ranges between 14 and 50 days. Minor skin injuries are thought to be the sites at which the virus is introduced. Athletes participating in close-contact sports where skin trauma is common are at risk of infection. Wrestlers and boxers, for example, are commonly infected in the areas of the hands, face, and upper body. The virus may also be spread in connection with bathing and washing. In one study, the infection was recognized among young children who used communal swimming pools. Infections may also arise if athletes come into direct skin contact with each other in the sauna or shower or on benches and also if they share their soap, brushes, and towels.

Cutaneous transmission of molluscum contagiosum was reported in cross-country runners and in a 48-year-old woman during an orienteering competition. The female orienteer had endured minor abrasions around her knees after running through a bush, and she developed lesions in the same area several weeks later. Because this individual had no other opportunity for contact with the virus, it was thought to have been spread by other athletes who had passed along the same track and brushed vigorously against the same plants.

Untreated infections usually resolve spontaneously within 6 to 9 months. Prolonged or severe infection can be seen in patients with untreated HIV infection or impaired cellular immunity. Some methods of treatment include curettage, skin abrasion with granules or an abrasive pad after bathing, topical tretinoin (Retin-A) gel or cream, liquid nitrogen, and chemical treatments with retinoic acid, phenol, salicylic acid, lactic acid, or cantharidin. Protective clothing and good hygienic conditions are recommended to help prevent infection.

Human Papillomavirus (HPV)
Warts, also called verrucae, are benign epithelial tumors caused by several HPVs, with an average incubation period of approximately 6 months. Common warts seen on the extremities appear as raised areas that are irregular and rough. Plantar warts, seen on weight-bearing surfaces such as the feet, appear as flat lesions extending deep into the skin with hyperkeratotic surfaces. Athletes are predisposed to infection due to the effects of perspiration, since moist environments create conditions favoring the spread of verrucae. Although the infectivity rate is generally low, it is postulated that repetitive trauma to wet skin surfaces increases the risk of inoculation of HPV. Individuals competing in sports in which calluses are likely to develop, such as gymnastics, track, football, tennis, baseball, and wrestling, are more susceptible to acquiring warts.

In the athletic setting, it is likely that plantar warts are transmitted by contaminated floors, such as swimming pool decks or shower rooms, while hand warts are transmitted by contaminated gym equipment or weight apparatus. To prevent the transmission of HPV, warts should always be covered during contact sports. Athletes who are prone to warts should consider using drying powders on their feet and wearing rubber sandals in the locker room and shower.

Since warts may cause irritation in crucial locations, such as the fingers, hands, or feet, an athlete’s performance in many sports may be hampered. Effective treatment methods are available but may sometimes cause short-term disabilities. For example, athletic participation is likely to be interrupted when cryotherapy with liquid nitrogen is applied. Surgical removal and electrical desiccation techniques are also quite disabling. Less aggressive treatments include the application of salicylic acid plasters, tretinoin gel, and other topical preparations.

Bacterial Infections
Staphylococcus aureus
Bacterial skin infections are commonly caused by S. aureus, which may cause abscesses, cellulitis, impetigo,
foliculitis, furuncles, and carbuncles. In recent years, the incidence of community-acquired skin infections caused by methicillin-resistant *S. aureus* (MRSA) has significantly risen.

**MRSA**

Although the clinical presentations of methicillin-sensitive *S. aureus* and MRSA may be identical, community MRSA strains have a greater propensity to lead to abscesses and give a more toxic presentation. The severity may be due to certain virulence factors unique to the community MRSA strain.

Community outbreaks of MRSA infections have been reported with increasing frequency over the past decade among young people without health care exposures or associated risk factors, such as athletes. In the 2013 season of the NFL, three players on the Tampa Bay Buccaneers team contracted MRSA infections, with one player having recurrence after treatment. Between 2006 and 2008, 33 cases of MRSA infections were documented in the NFL. During the 2003 NFL season, eight MRSA infections occurred among five St. Louis Rams players at turf abrasion sites. Some opposing team members also developed MRSA abscesses, suggesting that transmission occurred during game play. Other reported outbreaks involved direct-contact transmission or common-source transmission of MRSA resulting from the sharing of gym equipment or hygiene products, such as towels, soaps, razors, and other objects, among athletes participating in wrestling, rugby, baseball, basketball, fencing, canoeing, and other sports.

*S. aureus* infections are usually treated with semi-synthetic penicillins; however, MRSA is resistant to all semisynthetic penicillins, including cephalosporins. Therefore, commonly used antibiotics such as dicloxacillin and cephalaxin are not effective. Obtaining cultures in suspected cases of infection and performing antimicrobial-susceptibility testing facilitate the early identification and appropriate treatment of MRSA infection. Unlike certain hospital-acquired strains, community-acquired MRSA is usually susceptible to tetracyclines, trimethoprim-sulfamethoxazole, and clindamycin. Surgical management remains a cornerstone of therapy in cases of drainable lesions. Abscesses should be drained early and the wounds covered with clean, dry dressings. Infected people should receive guidance regarding enhanced hand and personal hygiene to prevent further transmission. Chlorhexidine-containing soap and nasal decolonization with mupirocin have been recommended to control recurrent disease and outbreaks; however, data demonstrating the independent benefit of these agents in controlling MRSA in community clusters are lacking.

**Folliculitis and furunculosis**

Folliculitis is an infection of hair follicles and is usually caused by *S. aureus*, but it may also be caused by Gram-negative organisms. It has also been described among students who endured skin trauma during mud wrestling. Folliculitis often resolves spontaneously within a few days. Topical treatment is usually recommended, with compresses, topical antibacterial agents, and/or astringent agents which remove the tops of pustules to prevent furuncles from developing.

Furunculosis is an infection involving the hair follicles, sebaceous glands, or skin compromised by abrasions, wounds, or burns. It is usually caused by *S. aureus* and can arise from preexisting folliculitis. Outbreaks of staphylococcal skin infections reported among high school football teams and river-rafting guides have been attributed to direct person-to-person contact, with an increased risk of infection in the presence of skin injuries. Wearing uniforms that cover all parts of the body may reduce the frequency of ecchymoses and microabrasions on the skin. To prevent the spread of infection, infected athletes should refrain from participation in contact sports until lesions have resolved. Also, ointments and powders should not be distributed by hand from common containers. Treatment consists of warm compresses and benzoyl peroxide along with oral antibiotics. Large deep lesions (carbuncles) may require surgical drainage.

**Impetigo**

Impetigo is a contagious bacterial skin infection caused by *S. aureus* or *Streptococcus pyogenes* and is most commonly seen among wrestlers, swimmers, gymnasts, football players, and soccer players. Lesions are superficial and vary from small vesicles to large bullae. After the lesions become pustular and rupture, they become covered with a heavy, honey-colored serosanguineous crust. The infection spreads quickly to multiple areas of the body and may lead to deeper, invasive infections. A bacterial skin culture can confirm the microbiologic diagnosis. Treatment consists of local cleansing and debridement with hydrogen peroxide. Administration of oral or topical antibiotic treatments directed at the specific causative agent may also be helpful. Because the infection is contagious, epidemics can occur if coaches and athletes do not attend to the lesions. To prevent the spread of infection, athletic equipment and towels should not be shared, and infected athletes should be discouraged from participation until their infections have healed.
Streptococcal infections
Skin infections caused by *S. pyogenes* are typically transmitted by close physical contact. A possible complication of *S. pyogenes* is acute glomerulonephritis. Epidemic pyoderma caused by nephritogenic streptococci has been documented among members of college athletic teams. Strategies such as keeping players with cutaneous streptococcal infections from participating on the field and applying skin antiseptics to traumatized skin after competition may help prevent the spread of infection.

Other bacterial infections
Erythrasma
Erythrasma is an infection caused by *Corynebacterium minutissimum* that can clinically mimic a fungal infection in appearance. The typical rash develops as a reddish-brown patch with desquamation in the axillae and groin. The lesions are erythematous, with a fine scale, and are well demarcated at their borders. The infection may be pruritic and can be diagnosed with a Wood’s light (black light), which reveals a coral red fluorescence. It is often confused with a fungal infection. In addition to topical cleansing agents and topical germicidal agents, erythrasma also may be treated with topical or oral antibiotics. Using antibacterial soaps and wearing loose clothing may help prevent or eliminate infection, but recurrence is common.

Pitted keratolysis
Pitted keratolysis, also known as “stinky foot” or “toxic-sock syndrome,” is an asymptomatic skin infection associated with *C. minutissimum*, micrococcus, and other organisms. Athletes participating in basketball, tennis, volleyball, and track often develop pitted keratolysis. The lesions are superficial pits up to 7 mm in diameter and are typically seen on weight-bearing areas of the body. The feet and toes are more frequently involved and are typically malodorous (Fig. 2). Two cases of pitted keratolysis in non-weight-bearing areas involved a volleyball player and a field athlete. It was presumed that the non-weight-bearing areas of the body were infected with the organism following infection of the weight-bearing regions. Infections are precipitated by occlusive footwear and excessive sweating. The lesions can clear rapidly with the elimination of local moisture, which may be achieved by wearing absorbent wicking socks and with the application of drying agents to the foot. Topical antibiotics are often utilized. The use of botulinum toxin has been shown to be effective in cases of pitted keratolysis associated with hyperhidrosis.

More resistant infections may require treatment with oral erythromycin or with mupirocin ointment.

“Hot tub” folliculitis
Hot tub folliculitis differs from typical folliculitis in that it is caused by *Pseudomonas aeruginosa* and is associated with water exposure. This infection has been associated with the use of hot tubs, whirlpools, and swimming pools. In one report, hot tub–associated folliculitis was described to occur among individuals who had bathed in a tub that was shared by several people and had not been cleaned for 10 days. In another report, an infection was described in a college football player following whirlpool use for the treatment of an ankle strain. To prevent infection, it is necessary to reduce the quantity of the bacterial organism in the water. This is achieved by appropriate monitoring of the temperature, pH, disinfectant level, and chlorine concentration. Hot tub folliculitis is a self-limiting condition lasting 7 to 10 days and therefore requires no specific treatment.

Fungal Infections
Tinea corporis, cruris, pedis, and versicolor
Tinea is the name applied to fungal infections in the keratin of the skin, hair, and nails. They are named according to the site of infection, such as tinea corporis (body), tinea cruris (groin), tinea pedis (feet), tinea capitis (scalp), and tinea onychomycosis (nail). A definitive diagnosis may be made by fungal cultures or potassium hydroxide (KOH) preparations of skin.
scrapings. The treatments may vary according to the type of fungal organism involved and the site of infection. The factors contributing to most cases in athletes are the presence of increased moisture from sweat (worsened by occlusive footwear), shared towels, skin injuries, and contaminated floors in the locker room, gymnasium, or showering facilities.

Tinea pedis, also known as athlete’s foot, is commonly seen among marathon runners, swimmers, and professional ice hockey players, as well as participants in basketball, judo, tennis, water polo, and football. *Trichophyton rubrum*, which generally causes an erythematous and scaling eruption on the plantar surface of the foot, and *Trichophyton mentagrophytes*, which may present as painful, pruritic blisters, are the usual causative organisms. One study suggests that fungal infections of the toenail (onychomycosis) are three times more prevalent among swimmers and athletes already afflicted with tinea pedis than among the general population. Keeping the feet dry by wearing appropriate shoes and socks, using drying powders, and wearing sandals in the locker room or shower may help prevent infection. Topical treatments with antifungal agents are effective and should be applied several times a day. Oral antifungal therapy is also available.

Tinea corporis, also known as tinea corporis gladiatorum, or ringworm, is a fungal infection usually occurring on the face, trunk, and limbs (Fig. 3). Athletes participating in close-contact sports such as football, rugby, and wrestling are at risk of becoming infected. Although *T. rubrum* is the most frequent causative organism, several outbreaks involving *Trichophyton tonsurans* have been reported among high school and college wrestlers. Lesions generally respond well to topical or oral antifungals. Athletes should either cover lesions or refrain from participating in sports to prevent the spread of infection. Other preventive strategies include inspecting the skin regularly and avoiding the use of shared equipment. Prophylactic treatment of tinea gladiatorum with intermittent doses of oral itraconazole or 100 mg of fluconazole once weekly has been shown to be effective. Though antifungals are effective prophylactic agents, the cost, the increased risk of microbial resistance, and the potential adverse effects of the medications make general prophylaxis for all team members impractical.

Tinea cruris, also known as “jock itch,” is an infection involving the groin and upper thighs. The fungal organisms and treatment methods involved are similar to those of tinea pedis. The pruritic rash appears as red, scaly patches, usually with sharp margins, covering the moist areas. Symptoms include pain and pruritus with occasional production of a weeping discharge. Keeping the areas dry and maintaining good hygiene may help prevent infection.

Tinea versicolor, or “fungus of many colors,” is caused by *Malassezia* species. The diagnosis is confirmed by KOH staining of a skin scraping, and a characteristic yellow-orange color appears under inspection with a Wood’s light. Typical lesions are asymptomatic, irregularly shaped, scaly, hyperpigmented or hypopigmented patches which are located on the back, trunk, neck, arms, and upper extremities. After acne, tinea versicolor is the most common skin affliction observed in athletes participating in college football and basketball. Topical antifungal treatments and oral regimens are effective therapeutic measures.

**OTHER INFECTIOUS SYNDROMES**

**Conjunctivitis**

 Conjunctivitis is an inflammation of the outer lining of the eye and eyelid and causes a sore or itchy red eye
with watery or purulent discharge. While many cases are associated with allergies, it can also be caused by viral, bacterial, or microsporidial infections. Several etiologic agents of conjunctivitis may be spread by direct contact, through contaminated swimming pools, or by fomites. The most common bacterial organisms involved are *S. aureus, Staphylococcus epidermidis,* and *Haemophilus* species.

Direct contact with HSV lesions can also result in conjunctival infection. Athletes competing in contact sports such as rugby and wrestling are usually at greater risk. In one case, follicular conjunctivitis was among the complications observed when two players on a rugby team contracted HSV infections while in competition. In another report, conjunctival erythema among seven members of a college wrestling team who had developed extensive cutaneous herpesvirus infections during a 2-week period in the wrestling season was described. The best preventive strategy is to carefully screen out symptomatic athletes before competition. Regular hand washing will also help prevent person-to-person transmission. Swimmers with conjunctivitis must refrain from entering swimming pools to avoid spreading viral agents in the water.

Waterborne transmission of adenoviruses has also been shown to cause community-wide outbreaks of febrile disease with conjunctivitis. It can be prevented by proper chlorination of swimming pools.

Since the early 2000s, microsporidial keratoconjunctivitis has been increasingly reported among healthy, immunocompetent people including athletes whose eyes contacted soil or mud during outdoor activities. Microsporidia are spore-forming, single-cell, intracellular parasites related to fungi. At least 14 species of microsporidia have been implicated in human infections. In April 2012, an outbreak of microsporidial keratoconjunctivitis was reported after an international rugby tournament was held at a Singapore sports venue. Players were exposed to soil and muddy water by playing on fields following a heavy rainfall. It was found that players who subsequently washed their eyes with bottled or tap water had a lower risk of contracting the infection. However, group eye washing, where a trainer held a hose and players washed their eyes together, showed no decreased risk.

**Infectious Mononucleosis**
Fever, sore throat, and enlarged lymph nodes are the classic symptoms associated with infectious mononucleosis. Infectious mononucleosis is caused by the Epstein-Barr virus, which is a herpesvirus. Transmission may occur by direct contact but is more common through droplet transmission (i.e., through infected oral secretions such as saliva). It has been demonstrated that repeated and prolonged exposure to the virus does not necessarily contribute to infection. In one study, it was concluded that college roommates of infected patients had no increased risk of infection. The incubation period for primary Epstein-Barr virus infection is generally 30 to 45 days. The illness may persist for 1 to several weeks, while the infectious state may last for up to a year in some cases. Even though life-threatening complications are remarkably infrequent, spontaneous rupture of the spleen and airway obstruction due to massive lymphoid hyperplasia during the acute phase of illness have accounted for a number of reported deaths.

Treatment consists of rest, fluids, and analgesics. Acetaminophen is recommended for fever, headache, and muscle pain, along with lozenges, saltwater gargles, or viscous lidocaine for sore throat. Although athletes may recover from infectious mononucleosis more quickly than nonathletes, their athletic performance may be suboptimal for up to 3 months. It is important to restrict all kinds of strenuous activity for at least a month after the onset of clinical illness, since the risk of splenic rupture is highest within the first 21 days and could be precipitated by trauma. Treatment for infectious mononucleosis should be individualized, and athletes should return to activity only when they feel physically ready.

**Mumps**
Mumps is a viral disease caused by an RNA virus. Although it was previously a common childhood illness, it is rarely seen today due to effective vaccination. It is highly contagious, and transmission occurs by respiratory droplet, contact, or fomites. In late 2014, an outbreak of mumps was noted among professional hockey players in the National Hockey League. By 2015, players from teams across North America had come down with the infection. Most of the players were previously vaccinated, although they only received one dose of vaccine. The Centers for Disease Control (CDC) is working with the National Hockey League to investigate this ongoing problem.

**Meningitis**
Meningitis may be caused by one of several microorganisms, including bacteria or viruses. Viral meningitis is commonly associated with enteroviral infections such as echoviruses and coxsackie B viruses. Several outbreaks of viral meningitis have been reported among members of high school football teams. Most of the
reports indicate that infections were associated with the peak seasonal incidence of aseptic meningitis (summer and fall) and occurred through close physical contact among the athletes or by common-source transmission, such as the unhygienic sharing of water containers or the dipping of cups into a common water source.

Bacterial meningitis is an unlikely, but theoretically possible, consequence of sports. Neisseria meningitidis, for example, can be transmitted by droplet transmission or direct contact of infectious fluid from the nose or throat of an asymptomatic carrier. The infection is normally spread in places where people live closely together, such as in school dormitories, on religious pilgrimages, or in military camps. Although there have been episodes of infections occurring in overcrowded environments, such as in dance clubs and bars, no cases pertaining to the crowded conditions of sporting events have been cited. Meningococcal vaccine is available for prevention.

**Upper Respiratory Tract Infection (URI)**

URI, which is caused by a number of viruses and bacteria, is a common illness encountered in sports. Symptoms vary according to the type of agent and the individual’s immune response. The most common symptoms include runny nose, sneezing, congestion, sore throat, cough, myalgias, and a general feeling of weakness. There are over 200 viruses that may cause URI, but the most common ones include rhinoviruses, coronaviruses, respiratory syncytial viruses, parainfluenza viruses, and adenoviruses. Although viruses account for over 60 to 90% of URIs, bacteria also cause respiratory infections. In one report, three cases of respiratory infection relating to deep-sea diving involved a penicillin-resistant strain of *Streptococcus pneumoniae*.

Transmission may occur by contact with respiratory secretions such as virus-containing droplets produced by a cough or sneeze, or by contact with hands, skin, or equipment contaminated with secretions from mucous membranes. Good personal hygiene and avoidance of close contact with infected individuals may help prevent infections. It has been suggested that there is a relationship between acute stress and susceptibility to infection. In one study, it was observed that faster marathon runners developed more URI symptoms than slower or more moderate runners, and the frequency of symptoms was inversely proportional to the time taken to complete a race.

Influenza is an important health issue in the general population as well as among healthy athletes. Given that the disease can be severe and is highly contagious, infection could result in significant impact on athletes: absence from training and spread of infection within sports teams. The most effective preventative measure is vaccination accompanied by proper hygiene, such as frequent hand washing. Symptomatic players should refrain from participation until well. It should be kept in mind that the influenza season varies by hemisphere: winter for the northern hemisphere, summer in the southern hemisphere. In equatorial regions, influenza occurs year-round. Therefore, for athletes who travel to these areas, twice yearly vaccination is recommended.

**WATER SPORTS–ASSOCIATED INFECTIONS**

Water acts as a passive carrier for numerous infectious agents. Athletes participating in water sports may be at risk, depending on the type of activity and water quality. Water-based infections known to have been acquired by athletes either by prolonged contact with water or by ingestion during a sporting event are listed in **Table 2**. Leptospirosis, otitis externa, and bacterial colitis are some of the waterborne diseases faced by athletes and are discussed below.

**TABLE 2** Infectious diseases associated with water sports

<table>
<thead>
<tr>
<th>Disseminated infections</th>
<th>Leptospirosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enteric infections</strong></td>
<td><strong>Amoebic dysentery</strong></td>
</tr>
<tr>
<td>Campylobacteriosis</td>
<td>Cryptosporidiosis</td>
</tr>
<tr>
<td><em>Escherichia coli</em> infections</td>
<td></td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>Giardiasis</td>
</tr>
<tr>
<td>Infectious hepatitis</td>
<td>Shigellosis</td>
</tr>
<tr>
<td>Norwalk virus infection</td>
<td>Typhoid fever</td>
</tr>
</tbody>
</table>

**Eye infections**

| Acanthamoebic keratitis |
| Adenoviruses |

**Skin and soft tissue infections**

| Otitis externa |
| Schistosome dermatitis (swimmer’s itch) |
| Schistosomiasis |

**Respiratory infections**

| Legionnaires’ disease (e.g., Pontiac fever) |
| Pneumonia following near drowning |

**Wound infections**

| Aeromonas primary wound infection |
Leptospirosis
Small rodents and some domesticated animals act as the reservoir for leptospirosis. Humans can become infected by means of direct contact with infected tissue or urine or by exposure to contaminated water, such as lakes or streams. Often the infection is a mild, acute, self-limited illness with chills, fever, headache, and myalgias. In 10% of patients, the acute illness is followed by a severe illness characterized by fever, inflammation of the liver, kidney damage, and bleeding, which can be fatal. Enthusiasts participating in water sports in environmental waters are at greater risk of infection. Several leptospiral outbreaks involving white-water rafters, swimmers, kayakers, and other recreational water users have been documented. Outbreaks involving athletes participating in triathlons (races consisting of swimming, biking, and running competitions) with exposure to contaminated waters have also been reported. Antimicrobial agents such as doxycycline, amoxicillin, or ceftriaxone should be administered to treat the disease, and preventive measures, such as wearing protective clothing to minimize contact with potentially contaminated water, should be implemented.

Otitis Externa
Acute otitis externa, also known as swimmer’s ear, is an inflammation of the external auditory canal. It is typically seen among athletes participating in water sports who commonly experience mechanical trauma to the external ear. Swimmers, divers, surfers, sailboarders, and kayakers who are exposed to polluted bodies of water are at risk of infection. The infection is most commonly caused by *Pseudomonas aeruginosa* but may also be caused by organisms such as *S. aureus* or *Aspergillus*. Prolonged exposure to water causes maceration of the epithelial tissue in the ear canal and removes the ear wax, which normally aids in repelling water and maintaining an acidic pH to prevent bacterial and fungal growth. Cleaning the external auditory canal and keeping it as dry as possible are important aspects of therapy, along with topical steroid and antimicrobial agents. Systemic therapy is recommended in severe cases of otitis externa.

Bacterial Colitis
Agents documented as causing enteric infections as a consequence of water sports have included protozoal infections, such as cryptosporidia and giardia, and bacterial and viral infections (see Table 2). Bacterial colitis has been linked to participation in long-distance obstacle adventure races where competitors frequently fall, face first, in mud or have their heads submerged in surface water. In 2012, an epidemiologic investigation revealed that 22 cases of *Campylobacter coli* infection were linked to a long-distance adventure race at a cattle ranch in Nevada. Suspected cases presented initially with hemorrhagic diarrhea, fever, and vomiting. Also in 2012, three cases of *Escherichia coli* O157 infection in Scotland were linked to similar adventure-obstacle races. The mechanism of transmission is thought to be due to fecal contamination from domestic or wild animals into surrounding nonchlorinated water, which is subsequently ingested by race participants. In the cases of campylobacteriosis, fewer than 500 organisms need to be ingested to cause clinical infection. Supportive care and antibiotics often play a role in recovery. The CDC has recommended that event planners fully advise participants of the risk of diarrheal illness.

**COMMON-SOURCE TRANSMISSION**
Common-source exposure to infectious diseases in athletic settings normally occurs in cases where water or food containers are contaminated and shared. Such outbreaks may involve a myriad of different infectious agents. For example, an outbreak of hepatitis A occurred among players and coaching staff of a college football team as a result of a contaminated water supply. Entervoiral infections, such as aseptic meningitis and pleurodynia, have also been documented to occur by similar means in other studies involving athletic teams.

**AIRBORNE TRANSMISSION**
There is a potential risk of spreading infectious diseases by airborne transmission during indoor sporting events where large groups of people are gathered in a confined environment. A packed, humid gym or stadium provides the classic conditions for the spread of illnesses such as measles, chickenpox, and influenza. Although usually not life-threatening, such illnesses may keep an athlete from competing, postpone sporting events, or compromise a team’s competitive edge. Airborne infections, however, are not confined to the athletes competing on the field. Spectators watching sporting events from afar are at risk of infection as well. For example, several outbreaks of measles have been reported in association with events in Germany, Switzerland, South Africa, Japan, and Poland. In fact, the travel medicine guidelines for those traveling to the FIFA World Cup
competition advised them to be current on measles vaccination.

Although outdoor sports, such as track and field, baseball, and football, are thought to pose a lower risk for airborne infections because of better ventilation, immunizations are recommended to help prevent the spread of infections.

VECTOR-BORNE PATHOGENS
Vector-borne pathogens are spread by carriers such as ticks, insects, or animals. Extreme-sport athletes competing in marathons or triathlons in exotic or foreign locations such as jungles, mountains, and deserts may be susceptible to unusual diseases endemic in the environment. For example, in the correct geographic scenario, mosquito bites may transmit the agents of malaria, dengue, chikungunya, or yellow fever. Even the more ordinary sports enthusiast may be exposed to vector-borne diseases while golfing, running, or hiking. Examples of vector-borne diseases include tick-borne infections such as Lyme disease, caused by the spirochete Borrelia burgdorferi, Rocky Mountain spotted fever, caused by Rickettsia rickettsii, human monocytecytic ehrlichiosis, caused by Ehrlichia chaffeensis, and babesiosis. While there have been no specific reports of outbreaks of vector-borne diseases among athletes, their risks are similar to those of others, such as travelers and campers, while participating in outdoor activities in areas that are endemic for these infections. Physicians caring for such athletes must take a careful exposure history and maintain a high level of suspicion for such diseases. For a more detailed discussion of vector-borne infectious diseases, please see “Arthropod-Borne Diseases: The Camper’s Uninvited Guests.”

CONCLUSION
Individual athletes, team members, people who come into contact with the participants, and spectators who merely watch the events from afar are at risk of infection at sporting events. Often, these infections can be avoided with proper hygiene, appropriate immunizations, early recognition, or exclusion of infected participants during the game. Physicians caring for athletes must play an active role in educating them about effective preventive strategies and in providing advice on appropriate treatment methods based on consideration of their individual situations. Fortunately, being a healthy population in general, athletes tend to respond well to treatment.

PRACTICAL TIPS

- Blood-borne infections such as HIV, HBV, and HCV are very difficult to acquire through sports contact; these infections are more likely to be acquired via off-the-field high-risk behaviors.
- Athletes should refrain from sharing or borrowing personal items such as towels and razors and should clean common gym or locker room equipment with a disinfectant before use to prevent the spread of infections such as MRSA.
- To avoid the spread of fungal infections of the feet, athletes should wear proper footwear, keep the feet and socks dry during sporting activities, and avoid going barefoot in shared areas such as the locker room and shower.
- Physicians caring for athletes must take a careful exposure history and have a high index of suspicion for diseases transmittable during sporting activities.
- Immunizations are recommended as a preventative measure for both spectators and athletes.

ACKNOWLEDGMENT
The authors wish to recognize Dr. Leland S. Rickman for his contribution to previous editions of this chapter.

RECOMMENDED READINGS


