

Ricardo Pereira Igreja

4.1 Introduction

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, propagating the outbreak into the community. 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 [1].

Adventure travel has led to an increasing risk for contact with pathogens uncommon in industrialized countries. Extreme sport athletes may be at increased risk because they often travel through poorer, rural areas of tropical and subtropical regions to reach their destinations. In addition, competitions can take place in extreme locations like jungles, mountains, or deserts. Risk from a specific infectious agent depends on the region of the world traveled, contact with food or water, and whether traveling in rural or urban area [2].

Common sources of exposure include contaminated lakes, rivers, caves, and canyons. Athletes may be exposed to insect vectors.

R.P. Igreja
Departamento de Medicina Preventiva, Faculdade de Medicina, Universidade Federal do Rio de Janeiro,
Rua von Martius 325/608, Rio de Janeiro
CEP:22460-040, Brazil
e-mail: rpigreja@cives.ufrj.br

African ticks were responsible for an outbreak of African tick-bite fever in participants of an Eco-challenge [3].

Besides the lack of immediate medical care that can complicate and worsen the severity of these diseases, these illnesses may be unfamiliar to practitioners in the travelers' home countries, and symptoms may go unrecognized. Physicians caring for extreme sport competitors must take a careful travel and exposure history and have a high index of suspicion for unusual diseases.

4.2 Infectious Diseases and Extreme Sports

The following discusses infections that may be more likely to occur in the extreme sport athlete. Epidemiology, presentation, and prophylaxis are discussed for each of these diseases. Infections that were solely food borne were excluded.

4.2.1 Malaria

Malaria continues to be a major global health problem, with over 40 % of the world's population—more than 3.3 billion people—at risk for malaria to varying degrees in countries with ongoing transmission (transmission still occurs in 99 countries). In addition, with modern, rapid means of travel, large numbers of people from nonmalarious areas are being infected,

which may seriously affect them after they have returned home. *Plasmodium falciparum* is common in the tropics and causes the most serious form of the disease. The risk of severe malaria is increased if treatment of an uncomplicated attack of malaria is delayed. As infections with this parasite can be fatal, recognizing and promptly treating uncomplicated malaria is therefore of vital importance. The presentation of uncomplicated *P. falciparum* malaria is highly variable and mimics that of many other diseases. Although fever is common, it may be absent in some cases. The fever is typically irregular initially and commonly associated with chills. The patient commonly complains of fever, headache, aches, and pains elsewhere in the body and occasionally abdominal pain and diarrhea. On physical examination, fever may be the only sign. In some patients, the liver and spleen are palpable. This clinical presentation is usually indistinguishable clinically from those of influenza and a variety of other common causes of fever. Unless the condition is diagnosed and treated promptly, a patient with *P. falciparum* malaria may deteriorate rapidly [4].

All travelers to areas with malaria risk are advised to use personal protective measures to prevent bites from *Anopheles* mosquitoes. Because of the nocturnal feeding habits of *Anopheles* mosquitoes, malaria transmission occurs primarily between dusk and dawn. Mosquito repellents containing DEET (N,N-diethyl-3-methylbenzamide) are especially useful for protection during outdoor activities. They should be applied to exposed skin surfaces and repeated after 4–6 h. Repellents should not be sprayed on the face nor applied to lips or eyelids, and the dosage should not be exceeded, especially for small children. Icaridin (picaridin) and *P-menthane-3,8-diol* (lemon eucalyptus oil) may be used as a second-line alternative repellent. If travelers are also wearing sunscreen, sunscreen should be applied first and insect repellent second. Combining DEET and permethrin-impregnated clothing enhances protection against biting arthropods. Insecticide-treated (permethrin) mosquito nets have been proven effective and are advised for all travelers visiting disease-endemic areas where they are at risk from biting arthropods while sleeping [5].

The decision as to whether chemoprophylaxis is necessary depends on the areas to be visited and the risk that the traveler has of being exposed to mosquitoes and of developing malaria. The greater the traveler's risk of contracting malaria and developing complications, the greater the need for chemoprophylaxis. When deciding on the need for chemoprophylaxis, it must be remembered that all medicines have adverse effects and that the risk of developing a serious adverse effect must be weighed against the risk of developing malaria. Doxycycline, chloroquine, atovaquone-proguanil, or mefloquine can be used prophylactically. Mefloquine does lower the seizure threshold, and its side effects could potentially be confused with decompression or narcosis events. It should also be noted that some sub-aqua centers do not permit those taking mefloquine to dive. Mefloquine might therefore be better avoided for those undertaking diving holidays, but there is no contraindication to its use in occasional divers who have taken and tolerated the drug before, or those able to start taking it early to ensure that no adverse events occur. Dizziness is one of the side effects that have occurred in chemoprophylaxis studies. Doxycycline may cause photosensitivity which is mostly mild and transient. The prescriber should warn against excessive sun exposure (and advise on the correct use of a broad spectrum sunscreen) [6]. No chemoprophylaxis is 100 % effective. However, disease in those taking chemoprophylaxis is likely to be milder or less rapidly progressive even if the parasites exhibit a degree of drug resistance. Chemoprophylaxis needs to be used in addition to, and not instead of, personal protection measures. The most reliable way of preventing malaria is to avoid mosquito bites.

4.2.2 Myiasis

Myiasis is the infestation of live humans and vertebrate animals by fly larvae. The risk of a traveler's acquiring a screwworm infestation has been considered negligible, but with the increasing popularity of adventure sports and wildlife travel, this risk may need to be reassessed. One

case was reported in a Finnish man, who was participating in an international adventure sports race in Pará (a jungle area in Brazilian Amazon), and tripped at night over a loose rock while he was riding a bicycle [7].

Myiasis occurs in tropical and subtropical areas. People typically get the infection when they travel to tropical areas in Africa and South America. People traveling with untreated and open wounds are more at risk for getting myiasis.

Even physicians unfamiliar with this condition can easily diagnose cases in which maggots are visible. On the other hand, furuncular, migratory, and cavitory cases and pseudomyiasis pose a diagnostic challenge, especially to those doctors unacquainted with myiasis and its possibilities [8]. Fly larvae need to be surgically removed.

Preventing possible exposure is key advice for patients traveling in endemic areas. In regions of endemicity, sleeping nude, outdoors, and on the floor should be avoided. Appropriate precautions will help avoid infestations. The use of screens and mosquito nets is essential to prevent flies from reaching the skin. Some fly species infestation may be thwarted by the application of insect repellents containing DEET. Drying clothes in bright sunlight and ironing them are effective methods of destroying occult eggs laid in clothing. Other general precautions include wearing long-sleeved clothing and covering wounds [8].

4.2.3 Schistosomiasis

Human schistosomiasis is a major health issue in many parts of Africa, Asia, and Latin America. It is estimated that 200 million people, in 76 countries, are infected with one of the schistosome species that cause the disease [9]. Most infections worldwide are attributable to three species: *Schistosoma mansoni*, *S. haematobium*, and *S. japonicum*. Infection in humans comes from water contact, and transmission occurs via the penetration of larval cercariae in contaminated freshwater.

Schistosomiasis in travelers is well established, including outbreaks among athletes after

freshwater exposure, mainly prolonged exposure, such as rafting or kayak competition [10, 11].

Many of the travelers, who have never been exposed to the disease, can develop its acute form. Acute schistosomiasis is a transient hypersensitivity syndrome that is caused by the juvenile forms of *Schistosoma* species. The clinical manifestations of this syndrome appear 2–8 weeks after exposure, and the common manifestations are fever, urticaria, malaise, cough, myalgia, and gastrointestinal complaints [12]. As asymptomatic schistosomiasis in travelers is also common (43 % in one series) [11], all travelers exposed to freshwater in endemic areas should be encouraged to undergo screening tests.

No vaccine is available. No drugs for preventing infection are available. Preventive measures are primarily avoiding wading, swimming, or other contact with freshwater in disease-endemic countries. Untreated piped water coming directly from freshwater sources may contain cercariae, but filtering with fine mesh filters, heating bathing water to 122 °F (50 °C) for 5 min, or allowing water to stand for ≥ 24 h before exposure can eliminate risk for infection. Swimming in adequately chlorinated swimming pools is virtually always safe, even in disease-endemic countries. Vigorous towel drying after accidental exposure to water has been suggested as a way to remove cercariae before they can penetrate, but this may only prevent some infections and should not be recommended as a preventive measure. Topical applications of insect repellents such as DEET can block penetrating cercariae, but the effect depends on the repellent formulation, may be short lived, and cannot reliably prevent infection [13].

4.2.4 Rickettsiosis

Tickborne rickettsial diseases (TBRD) are clinically similar yet epidemiologically and etiologically distinct illnesses. TBRD continue to cause severe illness and death in otherwise healthy adults and children, despite the availability of low cost, effective antimicrobial therapy [14].

Tickborne diseases potentially pose a threat to athletes who participate in outdoor activities. In France, 13 cases of *R. africae* infection were diagnosed in competitors returning from an adventure race in South Africa [3].

The greatest challenge to clinicians is the difficult diagnostic dilemma posed by these infections early in their clinical course, when antibiotic therapy is most effective. Early signs and symptoms of these illnesses are notoriously nonspecific or mimic benign viral illnesses, making diagnosis difficult [14].

No licensed vaccines for TBRD exist. Avoiding tick bites and promptly removing attached ticks remain the best disease prevention strategies. Protective clothing, including a hat, long-sleeved shirts, pants, socks, and closed-toe shoes are helpful in preventing ticks from reaching the skin and attaching. Wearing light-colored clothing is preferred because crawling ticks can be seen easily. Prevention is best accomplished by applying a deet-containing repellent before outdoor activities. Products containing permethrin can be used to treat outer clothing (e.g., shirts and pants) and should not be applied to skin.

If an attached tick is found, it should be removed by grasping with tweezers or fine-tipped forceps close to the skin and gently pulling with constant pressure. Folk remedies—including gasoline, kerosene, petroleum jelly, fingernail polish, or lit matches—should never be used to extract ticks. Removing the tick with bare hands should be avoided because fluids containing infectious organisms might be present in the tick's body and at the wound site. Ticks that have been removed should not be crushed between the fingers to prevent contamination, and hands should be washed to avoid potential conjunctival inoculation. The bite wound should then be disinfected [14].

4.2.5 Leptospirosis

Leptospirosis is a worldwide public health problem, but it is a greater problem in humid tropical and subtropical areas, where most developing

countries are found, than in temperate climates. The disease is associated with exposure to water or soil that has been contaminated by a variety of wild and domestic animals, which serve as reservoirs for leptospire and transmit infection by shedding the organisms in their urine. Humans are usually infected through abraded skin or mucous membrane contact with water contaminated by the urine of animal reservoirs, and less frequently by direct contact with animals or their urine [15].

Increased interest in participation in water sports has led to an increase in the frequency that leptospirosis has been reported in association with a variety of recreational sport activities. Outbreaks of leptospirosis have been associated with caving, canoeing, kayaking, rafting, triathlons, and multisport races in distinct places such as Thailand, Costa Rica, Martinique, Malaysia, the Philippines, and USA (Wisconsin, Illinois, and Florida) [15, 16]. At least 68 cases of leptospirosis occurred in association with the multisport Eco-Challenge event in Borneo, in which on univariate analysis, statistically significant risk factors for illness included kayaking, swimming in the Segama River, swallowing water from the Segama River, and spelunking [17].

Clinicians should have a high index of suspicion for leptospirosis in patients who experience acute febrile illness after recreational exposure to natural bodies of fresh water. The diagnosis of leptospirosis should be considered in any patient presenting with an abrupt onset of fever, chills, conjunctival suffusion, headache, myalgia, and jaundice. The incubation period is usually 5–14 days, with a range of 2–30 days. Its symptoms may mimic those of a number of other unrelated infections such as influenza, meningitis, hepatitis, or dengue and viral hemorrhagic fevers. For this reason, it is important to distinguish leptospirosis from dengue and viral hemorrhagic fevers in patients acquiring infections in countries where these diseases are endemic [5].

The first steps of prevention in athletes should be to avoid swimming in rivers, swallowing lake or river water, and prevent dermal cuts [15]. Transmission can be prevented by wearing protective clothing (boots, gloves, spectacles,

masks), covering skin lesions with waterproof dressings, washing or showering after exposure to urine or contaminated soil or water, and washing and cleaning wounds [18]. Such preventive measures are important but may not be feasible or sufficient for athletes who are likely to have water immersion, so they should consider doxycycline prophylaxis, balancing the risk of unwanted side effects against that of acquiring leptospirosis. Usual leptospirosis prophylaxis (200 mg of doxycycline once a week) for cavers may be insufficient. Although unproven, cavers should consider augmenting daily or weekly prophylaxis by adding 200 mg of doxycycline at a time for any high-risk exposures—such as immersions, swallowing river water, or contacts with bat or rat urine [19]. When occupational, recreational, or social circumstances put people at risk, those concerned should be made aware of the symptoms of leptospirosis and, if an illness compatible with leptospirosis develops, should seek medical help without delay and inform the health-care provider about the exposure [18].

4.2.6 Rabies

Rabies is a zoonotic disease caused by ribonucleic acid (RNA) viruses in the family *Rhabdoviridae*, genus *Lyssavirus*. Rabies is transmitted by infected animal bites or scratches or by contamination of abrasions, open wounds, or mucous membranes by infectious material (almost always saliva). The main transmitter of this virus to humans in urban areas is the domestic dog. In countries where urban rabies has been controlled by the authorities, great attention has been given to sylvatic rabies, where the virus has been isolated in several animal species (raccoons, skunks, and foxes and various species of bats and nonhuman primates), in addition to proven cases of human rabies by contact with these animals. Exposures to bats deserve special assessment because bats can pose a greater risk for infecting humans under certain circumstances that might be considered inconsequential from a human perspective (i.e., a minor bite or lesion).

Globally, rabies is the tenth leading cause of death due to infection in humans. The threat of rabies exists in most parts of the world. Predominantly, it affects poor people in developing countries, and its true incidence may be underestimated. In the year 2005, there were reports estimating that nearly 60,000 human fatalities occur each year mostly in Asia and Africa. A WHO-sponsored multicentric study estimated that at least 20,000 deaths occurred annually in India alone [20].

International travelers to areas where canine rabies remains enzootic are at risk for exposure to rabies from domestic and feral dogs. Dog bites in off-road cyclists were reported [21].

After entering the central nervous system, the virus causes an acute, progressive encephalomyelitis that is almost always fatal. The incubation period in humans usually ranges from 1 to 3 months after exposure but can range from days to years. Rabies should be included in the differential diagnosis of any unexplained acute, rapidly progressive encephalitis, especially in the presence of autonomic instability, dysphagia, hydrophobia, paresis, or paresthesia [5].

Rabies can be prevented by avoidance of viral exposure and initiation of prompt medical intervention when exposure does occur. In general, people know that dogs and cats can transmit rabies, but they are unaware that bats, foxes, monkeys, and other wild animals are also transmitters of the disease. So, they do not seek medical care after being bitten by these animals and thus are at serious risk of being victims of rabies [22]. Preexposure vaccination should be considered for persons whose activities bring them into frequent contact with the rabies virus or potentially rabid bats, raccoons, skunks, cats, dogs, or other at-risk species. Although cavers seldom have direct contact with bats, they are included in a frequent-risk category by the current CDC recommendations for preexposure vaccination because of the potential for bite, nonbite, or aerosol exposure to the rabies virus [23].

After any potentially rabid animal exposure, immediate washing and flushing of the wound with soap and water is imperative and is probably the most effective procedure in the prevention of

rabies. Prompt wound care and the administration of rabies immune globulin and vaccine are highly effective in preventing human rabies following exposure.

Conclusion

Infections may occur during outdoor activities and to reduce the risk of illness while practicing extreme sports, knowledge of potential risks before engaging in these activities is important. General recommendations are prophylactic medications; vaccine should be updated; athletes should resist the temptation to approach animals and to maintain minimum distances from them at all times; and advice regarding other protective measures.

As outdoor activities become increasingly popular, health-care providers will be forced to recognize the unique niche that wilderness medical care occupies in this patient population, and it will become important for them to understand the nature of illness experienced by outdoor enthusiasts in their specific area of patient care.

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