

Immunizations in Athletes

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Context: Immunizations are a cornerstone of preventive care and an important consideration for team physicians caring for athletes.

Evidence Acquisition: A PubMed search was performed from August 2016 through May 2017 as well as a website review of the Centers for Disease Control and Prevention, World Health Organization, and Immunization Action Coalition.

Study Design: Clinical review.

Level of Evidence: Level 4.

Results: By keeping abreast of diseases endemic to nations to which athletes may be traveling as well as the vaccination status of the athletes, team physicians can provide appropriate advice regarding immunization and prevention of disease.

Conclusion: There are a host of regularly updated reliable websites to assist the team physician in these recommendations.

Keywords: athletes; immunization; vaccination; disease outbreak; sports

In caring for the athlete, clinicians may quickly think of event coverage, managing overuse injuries, or treating acute issues such as fractures, sprains, and strains, but as with the care of any patient, preventive medicine is paramount. In fact, infectious diseases are the most common maladies that affect athletes.¹⁴ Participation in organized sports provides a mechanism for enhanced spreading of communicable disease in a number of ways: shared activities, equipment, living and training spaces as well as travel to at-risk areas.^{14,20,27} Risks such as sharing water bottles, soap, weights, and living in close contact during competition along with a decreased rate of practicing safer sex put the athlete at a higher risk of infection than the general populace.²⁷ Contact or collision sports increase the athlete's risk for exposure to body fluids, open wounds, and potential infection.²² All team physicians should be prepared to offer appropriate advice regarding vaccinations to athletes to protect them from communicable diseases and to decrease chances of outbreaks while they pursue their endeavors.

When approaching the immunization requirements of an athlete, a multifaceted approach is important. Beyond ensuring that routine nationally recommended vaccines are up to date, the physician should consider any situations that might be unique to the athlete. The immunocompromised athlete and athletes traveling outside of the country may warrant additional vaccinations.¹² Vaccine recommendations can vary not only from nation to nation but also by specific region within a

country. Injection site and the potential for a localized reaction as well as timing of vaccines in relation to sports participation are important. Even illnesses typically mild in the general population such as pertussis or a mild case of influenza can have greater impact on the competitive athlete.¹² Systemic reactions or side effects to vaccination such as fever and pain can cause significant problems for the athlete and are why vaccinations should be appropriately timed in advance of competition.¹² A localized reaction might interfere with athletic performance, so clinicians might consider locations other than the dominant arm for a throwing athlete who is actively training for competition. Take measures to ensure the vaccine itself affects performance as minimally as possible. When addressing vaccine-preventable disease in athletes, staff and volunteers at athletic events and those who work directly with the athlete should also be appropriately vaccinated to try to decrease outbreaks of infectious disease.^{11,12}

No vaccine can take the place of good hygiene, safe sexual practices, and travel precautions. Pretravel counseling regarding malaria prophylaxis, insect exposure, and the risks associated with local water and cuisine is important.²²

The time to consider immunizing athletes is prior to a competitive event or season. This provides an opportunity to acquire and administer the appropriate vaccines early enough so that any temporary effects of the vaccine are resolved prior to sports activity and allows enough time for an adequate

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The authors report no potential conflicts of interest in the development and publication of this article.

DOI: 10.1177/1941738118788279

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immune response. Ideally, a discussion should be held during the athlete's preparticipation examination (PPE), which should be completed at least 6 weeks prior to competition.³³ While this is the standard timeline, the team physician may consider planning the immunization regimen as much as 4 months prior to the event to allow adequate time for vaccination response.²² Up to one-third of athletes use the PPE as their only contact with a health care provider, and a similar proportion of parents think that the PPE should address medical issues unrelated to athletics.²¹ Many parents believe that immunizations should be provided at the time of the PPE, and a minority of high school senior athletes receive the recommended adolescent vaccines.²¹ Thus, the PPE provides an ideal opportunity to vaccinate the athlete and to provide a thorough health assessment including seatbelt use, sexuality, and substance use.^{19,21} This positively influences the health of the individual athlete as well as the safety of the local sports program or team.³³

Prior to vaccinating, a discussion should be held regarding potential adverse reactions. With any vaccine, there is always a chance of a reaction, but typically these are mild. Local reactions are fairly common, occur within 3 days of administration, and typically resolve within 1 week.¹² Local reactions vary depending on route of administration as well as the type of vaccination that is being given, but erythema and swelling are commonly seen. Generalized reactions, including fever, headache, fatigue, and lymphadenopathy, occur with variable frequency and are typically seen within days after administration, though they may occur up to a couple of weeks afterward.⁷ More serious reactions are rare and include seizures, neurological manifestations, severe allergic reactions (approximately 1:10 million for influenza and measles vaccines), and in extremely rare instances, death.^{7,12} Some adverse reactions may be minimized by proper injection technique (Table 1) or by premedicating with acetaminophen or a nonsteroidal anti-inflammatory medication. The safety of vaccines is constantly being improved.⁷

The Centers for Disease Control and Prevention (CDC) updates and maintains safety data on vaccines as well as makes annual recommendations regarding routine vaccinations for residents of the United States (<https://www.cdc.gov/vaccines/index.html>). These recommendations are supported by the American Academy of Pediatrics as well as the American Academy of Family Physicians and are the standard by which we vaccinate US citizens. In addition to routine childhood vaccines, preteens and teenagers should be vaccinated annually against influenza, receive a Tdap (tetanus, diphtheria, and pertussis) booster at age 11 or 12 years, and should be vaccinated appropriately against human papilloma virus and meningitis.⁵ Similarly to the CDC, the World Health Organization (WHO) (http://www.who.int/immunization/policy/immunization_tables/en/) also makes yearly recommendations. The CDC, WHO, and other reputable organizations maintain websites that can aid the team physician in advising an athlete on additional vaccination needs prior to traveling internationally. In some countries, these national recommendations are even

further broken down into region-specific ones. These guidelines are not limited to the athlete but are also in place to provide protection for the general traveler from diseases endemic to a specific location.⁹ These websites are excellent sources of information regarding vaccines, and the team physician should monitor any recent infectious disease outbreaks in the area of sport participation as well as prepare the athlete for diseases endemic to the region.²⁸

Once an athlete enters college, vaccinations should be reassessed and updated where warranted. An annual influenza vaccination is recommended along with a Tdap booster if it has been over 10 years since last administered. If the athlete did not receive MMR (measles, mumps, and rubella), HPV (human papillomavirus), varicella, hepatitis A, or hepatitis B vaccines in childhood, they should be given at this point. Pneumococcal conjugate vaccine 13 and/or pneumococcal polysaccharide vaccine 23 should be considered for athletes with chronic or immunocompromising conditions.^{5,26} A full list of indications can be found on the CDC website.

It is the team physician's responsibility to formulate an individualized vaccination plan for each athlete. Factors including vaccination site, date of completion, risk of exposure to communicable disease, and past medical history should be considered along with the routine vaccines listed previously. Outlined in the following paragraphs are vaccine-preventable diseases with a discussion of common symptoms and complications.

VARICELLA

Varicella, more commonly known as chickenpox, is spread via inhalation or direct contact with an infected individual.⁵ Vaccination in athletes is important since acute infection can lead to substantial time out of sport. The typical symptoms of varicella are rash, headache, fatigue, and fever, though it can be complicated by such serious events as infected blisters, encephalitis, pneumonia, and death.^{5,39} The vaccine is given subcutaneously in a 1- or 2-dose schedule.¹⁶ A recent meta-analysis determined that the 1-dose vaccine was 81% effective against all varicella severity types and 98% effective against moderate to severe disease. Adding a second dose increased effectiveness to 92% against all varicella severity types.^{24,39} It is a live vaccine, so it would not be recommended for individuals with significant immunosuppression, including those on large doses of systemic steroids, those who are pregnant, or those with a current moderate to severe illness as well as other immunosuppressive processes.

TETANUS, DIPHTHERIA, AND PERTUSSIS (TDAP)

Tdap is a combination vaccination that protects against diphtheria and pertussis (both spread via inhalation or direct contact) and tetanus (spread via exposure through a break in the epidermis).⁵ It is given intramuscularly.¹⁶ Pertussis is better known as whooping cough. Though it is typically a mild illness

Table 1. Administering vaccines: dose, route, site, and needle size^a

Administering Vaccines: Dose, Route, Site, and Needle Size

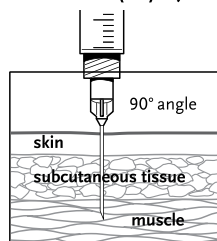
Vaccine	Dose	Route
Diphtheria, Tetanus, Pertussis (DTaP, DT, Tdap, Td)	0.5 mL	IM
<i>Haemophilus influenzae</i> type b (Hib)	0.5 mL	IM
Hepatitis A (HepA)	≤18 yrs: 0.5 mL ≥19 yrs: 1.0 mL	IM
Hepatitis B (HepB) <i>Persons 11–15 yrs may be given Recombivax HB (Merck) 1.0 mL adult formulation on a 2-dose schedule.</i>	≤19 yrs: 0.5 mL HepBisav-B ≥18 yrs: 0.5 mL Recombivax HB; Engerix-B ≥20 yrs: 1.0 mL	IM
Human papillomavirus (HPV)	0.5 mL	IM
Influenza, live attenuated (LAIV)	0.2 mL (0.1 mL in each nostril)	Intranasal spray
Influenza, inactivated (IIV); for ages 6–35 months	Fluzone: 0.25 mL FluLaval; Fluarix: 0.5 mL	IM
Influenza, inactivated (IIV), for ages 3 years & older; recombinant (RIV), for ages 18 years and older	0.5 mL	IM
Influenza (IIV) Fluzone Intradermal, for ages 18 through 64 years	0.1 mL	ID
Measles, Mumps, Rubella (MMR)	0.5 mL	Subcut
Meningococcal serogroups A, C, W, Y (MenACWY)	0.5 mL	IM
Meningococcal serogroup B (MenB)	0.5 mL	IM
Pneumococcal conjugate (PCV)	0.5 mL	IM
Pneumococcal polysaccharide (PPSV)	0.5 mL	IM or Subcut
Polio, inactivated (IPV)	0.5 mL	IM or Subcut
Rotavirus (RV)	Rotarix: 1.0 mL Rotateq: 2.0 mL	Oral
Varicella (Var)	0.5 mL	Subcut
Zoster (Zos)	Shingrix: 0.5 mL Zostavax: 0.65 mL	IM Subcut
Combination Vaccines		
DTaP-HepB-IPV (Pediarix) DTaP-IPV/Hib (Pentacel) DTaP-IPV (Kinrix; Quadacel)	0.5 mL	IM
MMRV (ProQuad)	≤12 yrs: 0.5 mL	Subcut
HepA-HepB (Twinrix)	≥18 yrs: 1.0 mL	IM

Injection Site and Needle Size		
Subcutaneous (Subcut) injection Use a 23–25 gauge needle. Choose the injection site that is appropriate to the person's age and body mass.		
AGE	NEEDLE LENGTH	INJECTION SITE
Infants (1–12 mos)	5/8"	Fatty tissue over anterolateral thigh muscle
Children 12 mos or older, adolescents, and adults	5/8"	Fatty tissue over anterolateral thigh muscle or fatty tissue over triceps
Intramuscular (IM) injection Use a 22–25 gauge needle. Choose the injection site and needle length that is appropriate to the person's age and body mass.		
AGE	NEEDLE LENGTH	INJECTION SITE
Newborns (1st 28 days)	5/8"	Anterolateral thigh muscle
Infants (1–12 mos)	1"	Anterolateral thigh muscle
Toddlers (1–2 years)	1–1¼"	Anterolateral thigh muscle
	5/8–1"	Deltoid muscle of arm
Children (3–10 years)	5/8–1"*	Deltoid muscle of arm
	1–1¼"	Anterolateral thigh muscle
Adolescents and teens (11–18 years)	5/8–1"*	Deltoid muscle of arm
	1–1½"	Anterolateral thigh muscle
Adults 19 years or older		
Female or male <130 lbs	5/8–1"*	Deltoid muscle of arm
Female or male 130–152 lbs	1"	Deltoid muscle of arm
Female 153–200 lbs Male 153–260 lbs	1–1½"	Deltoid muscle of arm
Female 200+ lbs Male 260+ lbs	1½"	Deltoid muscle of arm

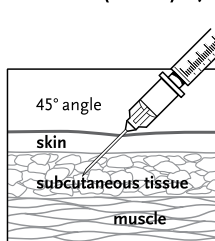
* A 5/8" needle may be used for patients weighing less than 130 lbs (<60 kg) for IM injection in the deltoid muscle only if the skin stretched tight, the subcutaneous tissue is not bunched, and the injection is made at a 90-degree angle.

NOTE: Always refer to the package insert included with each biologic for complete vaccine administration information. CDC's Advisory Committee on Immunization Practices (ACIP) recommendations for the particular vaccine should be reviewed as well. Access the ACIP recommendations at www.immunize.org/acip.

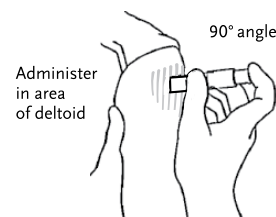
Intramuscular (IM) injection



Subcutaneous (Subcut) injection



Intradermal (ID) administration of Fluzone ID vaccine



Intranasal (NAS) administration of Flumist (LAIV) vaccine



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www.immunize.org/catg.d/p3085.pdf • Item #P3085 (1/18)

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in adults, pertussis can present as a severe respiratory illness and may progress to pneumonia. Typically, diphtheria presents with pharyngitis, fatigue, fever, and lymphadenopathy, though it can be complicated by heart failure and death in 5% to 10% of patients. Individuals are most infectious during the first 1 to 2 weeks but can be contagious for several weeks, especially if not treated with antibiotics.^{4,5,22} Diphtheria and pertussis vaccinations are recommended because of the fact that they can be severe illnesses that interfere with training and competition, and the vaccine is generally well tolerated.¹² Tetanus can lead to muscle spasms, respiratory failure, and death.⁵ Though most are vaccinated in childhood, a Td (tetanus and diphtheria) booster is recommended every 10 years. Sports where athletes have bodily contact with soil and/or sustain breaks in the skin put them at increased risk of *Clostridium tetani* infection.¹² Routine vaccination with Tdap should be undertaken at age 11 or 12 years, during each pregnancy (specifically at 27-36 weeks' gestation), and at least once as an adult.³²

HAEMOPHILUS INFLUENZAE TYPE B (HIB)

The Hib vaccine is an intramuscular vaccine that provides protection against *Haemophilus influenzae* type b, which is transmitted by inhalation and direct contact.^{5,16} Patients can be completely asymptomatic or it can progress to such severe complications as meningitis, epiglottitis, pneumonia, and death. With regard to the athlete, this vaccine is only advised if the patient is asplenic after being routinely vaccinated as a child.¹²

HEPATITIS A

Hepatitis A is spread by the fecal-oral route and is the most common cause of acute viral hepatitis in the world.³⁰ The inactivated vaccine is administered intramuscularly.^{16,40} This vaccine affords protection after 1 administration and can be given with as little lead time as 1 day prior to travel. A second vaccine 6 to 12 months later is recommended.¹¹ This virus may lead to liver failure and/or hepatocellular carcinoma, but it may also be self-limiting. While younger children have less of a tendency of developing symptoms (5%-10%), this increases to 75% to 90% in adulthood, and infection carries a mortality rate of 0.1% to 2%, which increases with patient age.¹⁷ Symptoms range from mild to severe and can include fever, malaise, anorexia, diarrhea, nausea, abdominal pain, and jaundice. With reference to the athlete, it can take weeks or months to recover from hepatitis A.⁴⁰ Completing a hepatitis A vaccine series may provide immunity for more than 20 years, and a booster vaccine is likely unnecessary for at least 25 to 30 years.²⁹ Both the CDC and WHO recommend all children receive the hepatitis A vaccine series, and incorporation of universal mass vaccination has been shown to produce herd immunity.^{5,34}

HEPATITIS B

Hepatitis B is transmitted via blood and/or body fluid exposure.^{5,16} It should be considered in all athletes, but would

be highly recommended in those who participate in contact and collision sports because of the risk of injuries with bleeding and potential exposure of wounds to bodily fluids.³¹ Similar to the effects of hepatitis A, hepatitis B infection may be asymptomatic or may cause jaundice, malaise, or arthralgias and can progress to liver failure and/or hepatocellular carcinoma.^{5,10} Universal hepatitis B vaccination has been shown to be up to 90% to 95% effective in preventing chronic hepatitis B virus infection and has a protective efficacy against hepatocellular carcinoma of about 70%.¹⁰ The immune response to a standard 3-shot vaccination series at 0, 1, and 6 months is robust.³¹ Since the vaccine is administered over a 6-month period, it would be ideal to start well in advance of competition or training; 98.8% of individuals had protective levels of antibody titer within 30 days from the second dose.²⁵ In special circumstances where the physician deems the athlete is at increased risk of exposure and there has been limited time to prepare, an accelerated schedule is acceptable and is given at day 0, day 7, and again between days 21 and 30 prior to departure followed by a booster 12 months later.^{6,11} Like hepatitis A, the hepatitis B vaccine is highly recommended in athletes as infection could lead to a period of several months with reduced or no training.

INFLUENZA

Influenza is a major concern as it is very contagious and the illness can be severe, even life-threatening.¹² Influenza can prevent an athlete not only from competing but also from participating in training for weeks.¹² It is typically a self-limiting respiratory illness consisting of fever, malaise, arthralgias, myalgias, rhinitis, and cough but can progress to pneumonia, myocarditis, pericarditis, other serious complications, and in rare cases, death.^{5,22} This vaccine should be given at a minimum of 2 weeks prior to the athletic event to allow for development of immune response. When events are held in the southern hemisphere in summer months, consider influenza prophylaxis and coordinate with the local health department for influenza vaccine availability.¹¹ The same consideration should be given for northern hemisphere events in winter months. It is best practice to vaccinate twice yearly for athletes traveling between the 2 hemispheres.¹²

The influenza virus is spread via inhalation and direct contact.^{5,16} Effectiveness varies from year to year.²³ In addition to the intramuscular vaccine, live-attenuated intranasal spray and intradermal formulations exist. There are differences in how they are manufactured as well as which strains are included in the various vaccines.¹² Though there are multiple influenza vaccination options, the quadrivalent influenza vaccine appears to be most effective at prevention in general.² Recommendations change periodically, and it is important to note that the Advisory Committee on Immunization Practices and CDC did not recommend the intranasal vaccine for the most recent 2016-2017 and 2017-2018 influenza seasons. It generally takes 2 weeks for antibodies to form after immunization.²²

Regarding which vaccine application is best in an athlete, each route brings different side effects.¹² The intradermal vaccine

may be less painful but causes more localized reaction than the intramuscular vaccine, and both have similar efficacy.⁴³ The live intranasal vaccine has a small risk of actually making the athlete contagious for the first few days after immunization but has low risk of side effects.¹² This route has not been proven effective in adults, however, and therefore is not routinely recommended.¹²

MEASLES, MUMPS, AND RUBELLA

Measles, mumps, and rubella are all spread through inhalation and/or direct contact.^{5,16} Measles is highly contagious and the hallmark rash, fever, and cold symptoms are typical of acute infection. In some instances it leads to encephalitis, pneumonia, or death.⁵ An epidemic of measles in multiple European nations as well as South Africa occurred during soccer tournaments in recent years.¹² There was also a measles outbreak in Vancouver during the 2010 Winter Games that took months to resolve. No cases were reported in athletes during that competition.¹¹ Mumps is characterized by a host of symptoms, including lymphadenopathy, fatigue, myalgias, and headache, and can progress to meningitis, encephalitis, loss of hearing, as well as inflammation of the ovaries and/or testicles.^{5,12} Rubella can affect children with a rash and fever but is more serious in pregnant patients, leading to issues such as stillbirth, miscarriage, and birth defects.⁵ Characteristically milder than either mumps or measles, it is predominantly asymptomatic. The population is typically vaccinated to prevent risk to pregnant mothers and fetuses.¹² Women who received the rubella vaccine reported arthritis 30% of the time compared with a control group at 20%, and the recurrence of chronic arthralgia after vaccination was marginally significant.³⁸ The risk of the vaccine causing arthralgia is likely limited but should be discussed. The risk appears to be less in men, but the risk/benefit ratio must be taken into account regarding counseling an athlete to receive this vaccine.¹³

POLIO

The polio virus is spread via inhalation or direct contact.^{5,16} In addition to the inactivated intramuscular vaccine, there is an oral live vaccine available.¹² Though efficacious, the live vaccine can rarely convert to a pathogen via mutation and spread, potentially leading to an outbreak.⁴² The disease process may range from asymptomatic infection to mild upper respiratory symptoms to disabling paralysis and death.⁵ Side effects of the intramuscular vaccine are typically localized near the injection site, and the oral vaccine is usually well tolerated, with diarrhea being a minor side effect.^{1,35}

PNEUMOCOCCAL PNEUMONIA

Both conjugate and polysaccharide pneumococcal vaccines provide protection against pneumococcal pneumonia, which is transmitted via air and direct contact.⁵ Both vaccines can be administered intramuscularly, and the polysaccharide can be given subcutaneously as well.¹⁶ Pneumonia may present with

cough, fever, or malaise and may also progress to a much more severe course, including sepsis, meningitis, and death.⁵ Pneumococcal vaccination is only recommended for athletes with specific underlying conditions.¹²

HUMAN PAPILLOMAVIRUS

Human papillomavirus (HPV) is usually transmitted through sexual contact, which is of concern to the athlete since they are less likely to practice safe sex, and though most infections will resolve, it can persist and lead to serious complications.^{27,41} HPV-exposed individuals can develop cervical, vaginal, anal, throat, or penile cancers, and routine vaccination can prevent infection and these related complications.²² The CDC currently recommends routine vaccination at ages 11 to 12 years, but patients can receive the vaccine between the ages of 9 and 26 years.⁵ Newer recommendations state that those starting the vaccine prior to age 15 years can be vaccinated with a 2-shot series separated by at least 5 months. Those who start the series after age 15 years should have a 3-shot series with a similar schedule to the hepatitis B vaccine.³²

MENINGOCOCCAL DISEASE

Meningococcal disease is a serious bacterial disease and a leading cause of meningitis in children and adolescents. Prevention is paramount since even after treatment with antibiotics the disease carries a 10% to 50% mortality rate, with another 11% to 19% having other serious long-term complications.^{12,22} It is often contracted through close contact with an infected individual and is associated with living in close quarters with others such as dormitories. The majority of meningitis is caused by serogroups A, C, W, Y, and B. A conjugated meningococcal vaccine that provides protection against serogroups A, C, W, and Y should be given to all athletes at age 11 to 12 years, with a booster after age 16 years, and therefore the preparticipation physical can be an ideal time to discuss this vaccine. Those with certain medical conditions such as asplenia should also be given the serogroup B vaccine, which may be offered to all adolescents preferably at age 16 through 18 years.⁵ While it is recommended to vaccinate all individuals, strong consideration should be given to those traveling to endemic areas (sub-Saharan Africa) or those who will be staying in crowded living quarters.³⁷

TRAVEL-SPECIFIC VACCINES

Depending on travel plans, consideration should be given to typhoid, yellow fever, and Japanese encephalitis vaccines.¹¹ Vector-borne diseases must be considered and recommendations made accordingly. It is best to consult with a travel clinic or use the resources available through the CDC, WHO, and similar websites to coordinate recommended region-specific vaccines. Also, some countries require a vaccination certificate to enter their territory, especially for yellow fever in African and South American regions.¹⁵ The CDC website

maintains a list of countries requiring a certificate, but they encourage travelers to check with the country's embassy or consulate prior to travel as the information changes periodically. Should there be a medical contraindication to the yellow fever vaccine, the team physician should compose a letter of exemption for the athlete, and these are typically accepted at requiring nations' borders.⁸

Awareness of recent disease outbreaks and large disease surveillance programs protect the competing athletes and attendees.^{18,36} Currently chikungunya virus, dengue virus, West Nile virus, and Zika virus are all of heightened concern due to the possibility of affecting athletes and the public. There is currently no vaccine available for any of these agents.¹⁵ There is a vaccine that is in stage 1 trials for Zika.¹⁵ For these diseases, the focus must be on prevention. Malaria is vector-borne, and prophylaxis should be considered prior to travel to endemic areas.¹¹

The Food and Drug Administration has recently approved a cholera vaccine that has a favorable side-effect profile and is very effective. Though not available in the United States, 2 additional cholera vaccines are on the market, Dukoral (SBL Vaccines) and ShanChol (Shantha Biotec).³

At any international event, people will be traveling from all over the world for the competition, and importation of communicable disease should be anticipated.¹¹ Some of these diseases may be unexpected in the area where the competition is being held as they may be virtually nonexistent there normally. It is important to recognize the risk of disease importation from athletes, support staff, and spectators traveling from other regions and to think globally when it comes to disease prevention.²²

In addition to traditional sports, there has been a recent interest in extreme sports, sometimes held in regions with poor sanitation and limited access to health care or preventive measures. These events can be held on multiple days in jungles, mountains, deserts, and other intense environments. These athletes may have increased risk of infection due to exposure to vectors and the general conditions under which they are competing.¹⁴

CONCLUSION

With careful preparation and vaccination of the athlete, the team physician can facilitate the athlete's attempt to reach top performance with low risk of adverse effect. Immunization helps protect not only the athlete but also support staff and the public from vaccine-preventable illness.

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