Heat stress advisory

Preparing for Tokyo 2020

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Why Should You Be Concerned?

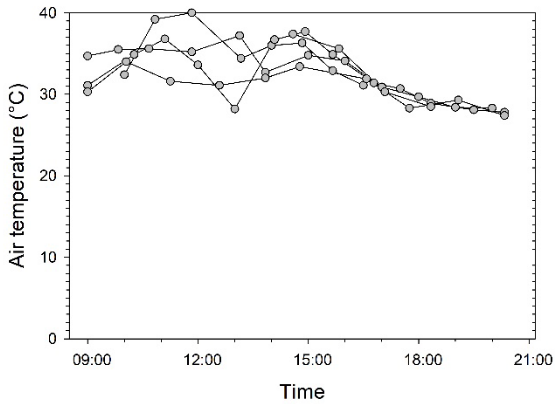
The environment in which beach volleyball athletes train and compete can influence both their ability to perform, as well as represent a risk for their health. The most important environmental health concern is exertional heat illness. Although the incidence of serious heat illness among athletes competing on the FIVB World Tour is low, our weather records from World Tour venues show that events are regularly played in challenging weather conditions.

The 2020 Tokyo Olympic Games are expected to be the hottest games ever, and this advisory is intended to help athletes and officials prepare for hot and humid conditions.

Weather conditions in Tokyo

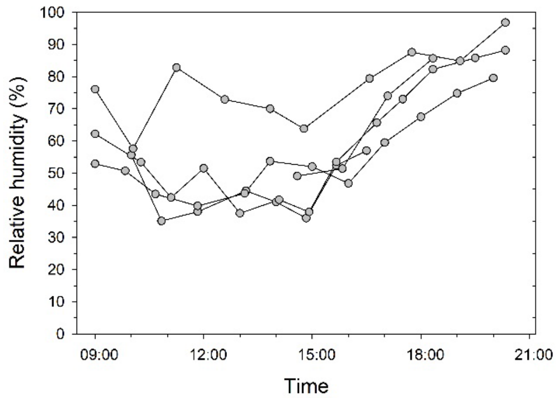
Implemented in 2009, the FIVB Heat Stress Monitoring Protocol has consisted of two elements: (1) recording Wet Bulb Globe Temperature (WBGT) measurements obtained on centre court of the competition venue 5 minutes before to the start of all matches on that court, and (2) identification and recording of any heat-related medical forfeits during the tournament. Data collection and reporting is the responsibility of the FIVB Referee Delegate.

Our data from the 2019 pre-Olympic 4 Star-tournament in Tokyo, held July 24 - July 28, confirm that hot and humid conditions should be expected for the 2020 Olympic games, when the beach volleyball competition will take place July 24 – August #. Matches are scheduled to be played from # AM until # PM.



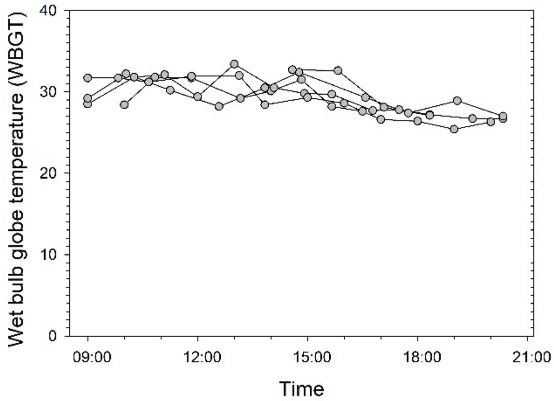
The daily average air temperature during the five days of competition ranged between 30.9°C and 35.5°C, while the daily peak air temperature ranged between 34.0°C and 40.0°C. Temperature was measured on center court before the start of every match.

Tokyo is typically humid in late summer, and the 2019 World Tour was no exception. The relative was consistently high, increasing in the afternoon and peaking at 97%.



Wet Bulb Globe Temperature (WBGT) represents a measure of total heat exposure, combining air temperature, humidity and radiation from the sun. Instruments that measure WBGT also factor in any wind cooling effect; less wind means less effective sweat evaporation. This means that WBGT is the best available index of climate stress.

The daily average WBGT during the five days of competition ranged between 29.1°C and 30.1°C, while the daily peak WBGT ranged between 31.8°C and 33.4°C.



This means that the peak WBGT recorded in Tokyo exceeded the US Navy black flag condition of >32.3°C, considered to be the upper limit for physical activity in hot and humid conditions. In comparison, the peak WBGT during the 2016 Olympic Games in Rio de Janeiro was typically 23-25°C.

More than 10 years of data collection from the FIVB Heat Stress Monitoring Protocol documents that the incidence of significant heat illness among athletes competing on the FIVB World Tour is low, even though weather conditions frequently result in a WBGT index of >32°C (for more information, see Bahr R, Reeser JC. Br J Sports Med (2012). doi:10.1136/bjsports-2012-091102).

Still, during the 2019 pre-Olympic tournament in Tokyo, there were four matches where heat-related illness caused a medical time-out to be called. Although there were no forfeits, the experience clearly underlines the need to prepare carefully for the Olympic Games. One match was also delayed because the referee suffered from heat exhaustion and had to be replaced. This emphasizes that the advice below applies not only to players, but also officials, team staff and volunteers.

Generating (and Losing) Heat

The heat load on an athlete depend on the balance between heat production (e.g. exercise intensity) and dissipation (e.g. environmental heat and humidity). From the minimal heat production associated with basal metabolic rate, heat production dramatically increases at the onset of a muscle contraction, doubling over the first minutes of intense dynamic exercise. But because the body is only 25% efficient, only one quarter of the energy expended during exercise results in useful work. The other 75% results in heat production that must be dissipated if the athlete is to continue functioning.

There are four processes by which heat may be dissipated to the environment: radiation, conduction, convection, and evaporation. **Radiation** works both ways; i.e. an athlete can gain heat from the direct radiation of the sun or the reflected radiation on the ground, but can lose heat as the body also emits radiant heat. **Conduction** is the transfer of heat through direct contact. It also works both ways, but is limited in sport as there is minimal contact with external objects. Both radiation and conduction are very limited and are even negative avenues for heat loss in the heat.

Convection is loss of heat via the movement of ambient air. On a windy day, heat will be lost more effectively through convection. However, heat will only be lost if air is at a lower temperature than the skin (i.e. <~36°C). Thus, heat dissipation when exercising in the heat depend mainly or even solely of sweat evaporation.

Evaporation results in heat loss because of the conversion of liquid (sweat) to gas on the surface of the skin. Evaporation is the body's most effective mechanism for heat loss.

Sweating begins within 30 s to 3 min after the onset of exercise. The sweat rate usually increases for the next 10 min and then levels off. Sweating is one of the body's adaptive responses to exercising in the heat: sweat rate increases rapidly, after only a few training sessions in the heat, allowing better dissipation of the heat load. Athlete acclimatised to exercising in hot climates may generate two to three litres of sweat per hour. The evaporation of 1 ml of water dissipates approximately 0.6 kcal of heat energy. Thus, a well-trained athlete who is acclimatised to exercising in the heat is capable of transferring heat energy to the environment at a rate of greater than 1000 kcal/h.

Risk Factors for Heat Illness

Athletes who exercise at high intensity but who are not acclimatised to the conditions in which they are competing are more likely to suffer from exertional heat illness. Humid environments are also more challenging than hot and dry environments. As mentioned, evaporation is the major mechanism by which sweating effects heat loss. High ambient humidity reduces the rate of sweat evaporation and therefore impairs the athlete's heat loss capacity. Without the benefit of effective evaporation, the athlete's body core temperature can rise quickly, resulting in heat illness. It is particularly important to identify and watch those athletes who have suffered from heat illness in the past, as they are more likely to be affected again. Any recent infections or diarrhea are also risk factors requiring close surveillance.

Consequences of Heat Stress

Heat stress may precipitate different types of heat illness in athletes: heat cramps, heat exhaustion, and heat stroke. There are unique identifying characteristics for each of these conditions. Often, serious problems can be avoided if the affected athlete is identified early on, prior to the onset of severe symptoms. Players who feel dizzy or restless or who exhibit even minimal mental status changes (i.e. confusion) should (in the appropriate setting) be suspected of having heat stress. Cooling the athlete in a shaded area and giving cool fluids to drink may prevent the onset of more serious, life threatening symptoms.

Heat cramps are spasms of exercising muscles. The athlete's core body temperature may be elevated or normal. Heat cramps may even occur hours after exercise. Dehydration is thought to play a major role in the onset of heat cramps. Sodium deficiency may also be a contributing factor, as might magnesium deficiency. The muscles most frequently involved are the muscles of the lower limb such as the gastrocnemius (calf) and hamstrings.

Heat exhaustion is characterised by symptoms of irritability, light-headedness, nausea with or without vomiting, and generalised weakness. Heat exhaustion is worsened by dehydration. The core temperature is elevated, but is less than 41.8°C.

Exertional **heat stroke** (EHS) is the most severe form of heat illness, typically characterized by a neuropsychiatric impairment coupled with a high core body temperature (>40.5˚C). Athletes will likely have no sequela if their internal body temperature is reduced to <40°C within 30 minutes. They may, however, suffer permanent disability beyond this point and even death if treatment is postponed by more than 1 h.

Principles of Treatment

Acute treatment of heat cramps includes stretching the involved muscle(s) as quickly and completely as possible. Stretching is often more easily performed passively, by a physical therapist who may be attending to the athlete. Application of ice is often beneficial as well. Oral rehydration should be attempted, preferably with a beverage containing replacement electrolytes (such as a sports drink).

The acute treatment for heat exhaustion is to limit heat gain (i.e. stopping the exercise and going into the shade) and facilitate heat loss (i.e. drinking cool fluids, removing clothing, providing fanning and wet towels). The athlete should be placed in a cool environment and sprayed with cool or lukewarm water to facilitate evaporation and conductive heat loss. Placing the athlete in front of a fan helps to maximise convective heat loss. Oral rehydration is the preferred method of fluid replacement.

The most important goal in the treatment of exertional heat stroke is to cool down the body as quickly as possible. Exertional heat stroke should be confirmed immediately by measuring rectal temperature and, as soon as diagnosed, must be treated by cold water immersion. The most effective cooling method is to immerse the body in ice water, since heat is lost from the skin much more quickly by conduction to cold water than it is to the air. For competitions and training in warm/hot environments, it is recommended to have cold water baths already set-up with water temperatures around 10˚C to 15˚C (although a wide range of water temperatures will provide effective cooling rates). Remove from the cold water when the patient reaches about 39˚C. To minimize the duration at which an athlete remains at >40.5°C, it is mandatory to cool first - transport second. For instance, if an patient needed to wait for the ambulance to be called / arrive on-scene / transport / enter hospital / establish cooling at hospital; well over the established 30 min will be lost before aggressive cooling could even begin.

Preventing Heat Illness

Heat illness is preventable. Proper acclimatisation to exercise in the environment in which the athlete will be competing is probably the most important consideration. The process of acclimatisation should begin at least 10-14 days prior to the first day of competition. The athlete will begin sweating earlier and at a greater rate as he/she adapts to the heat stress. Maintaining hydration during activity is vitally important. Monitoring body weight is a convenient means of estimating hydration status. The loss of 2% of body weight due to dehydration can noticeably impair athletic performance. It is recommended that outdoor athletes "prehydrate" by consuming 500 ml of fluid approximately 90 minutes before training or competition. Thereafter, consume fluids on a regular basis during activity (drink 250 ml every 20 minutes). Athletes should not rely on thirst as a trigger for fluid replacement, as significant fluid losses can occur before they become thirsty. Keep in mind that muscle is about 80% water and that you can lose up to 1.5 litres of water before you demonstrate significant thirst! If the duration of competition is less than one hour, then water is probably the ideal fluid replacement beverage. If competition lasts more than one hour, then a carbohydrate/electrolyte solution (containing 4-8% carbohydrate) may be beneficial. An appropriate hydration plan should aim to limit weight loss to ~2%, but should never increase body weight, as over-hydration can result in serious (potentially deadly) hyponatremia (an imbalance of the salts in the body). Finally, after exercise, drink 1L of fluid replacement beverage per kilogram of body weight lost during exercise. Athletes who have suffered from heat cramps in the past should probably be advised to liberally salt their food. Predisposed individuals may benefit from regular dietary salt supplementation, although little well designed research on this topic exists.

FIVB Policy Regarding Heat Illness

The FIVB has policies in place to minimize the risk of heat illness to its athletes. The policy includes monitoring of heat and humidity during all World Tour events, and suspending play if conditions threaten athlete safety, shifting competitions to avoid the hottest parts of the day, and permitting additional breaks from play when conditions indicate an increased risk of heat illness.

The FIVB Beach Volleyball Handbook outlines the following specific procedures (chapter 16.3.4 High heat and/or humidity:

Deciding if weather conditions are proper for playing each match during the competition should be based on the WBGT. Continuing with the match should be carefully considered if the WBGT index exceeds 31. Whenever the prevailing weather conditions indicate that the WBGT index will exceed 31, the decision should be taken by the FIVB Technical Delegate, in consultation with the FIVB Medical Delegate and the FIVB Referee Delegate:

- To schedule matches in the morning and the evening to avoid the heat of the middle of the day;

- To permit quick water breaks at side changes; and if necessary:

  - To increase the time between rallies from 12 s to 15 s; and then:
  - To assign an extra technical time-out when the sum of points scored by the teams equals 42 points;

- To require electrolyte rehydration fluids to be available (not just water);

TOCOG medical personnel will be well trained and equipped for treating heat exhaustion, including rapid cooling and intravenous treatment, should emergencies occur in Tokyo.

Note: This document is adapted from the FIVB Heat Illness Advisory prepared in 2008 by dr Jonathan Reeser for the FIVB Medical Commission.

Photos: FIVB