SPORTING PERFORMANCE IN HOT AMBIENT CONDITIONS

– Written by Sebastien Racinais, Qatar

It is 2 December, 2010 at the FIFA Headquarters in Zurich, Switzerland. This is the official announcement ceremony for the hosting rights of the FIFA World Cup 2022. Qatar has just won the bid to host these games. For the first time, an Arabic country will host such a major sporting event. Some participating countries express concern over whether the heat will effect their athletes' performance.

In addressing this, we firstly need to consider the impact that environmental conditions have on physiological function. Humans are exposed to a wide range of environmental conditions, with extreme recorded temperatures ranging from -89.2°C (Vostok Station, Russia, 1983) to +57.8°C (Al Aziziyah, Libya, 1922). However, for optimal physiological function, the body core needs to stay at approximately 37°C. If external temperatures are either too low or too high, body core temperature will become affected, cellular structure will be compromised and function will diminish. If we take this information and apply it to a sporting context then the issues which will impact on physiological function include the following: the environmental conditions (such as temperature, time of day and humidity), the characteristics of exercise (duration and intensity) and athlete characteristics (ability to dissipate heat and acclimatisation). Here we will focus on the characteristics of the exercise and the athlete characteristics.

EXERCISE DURATION AND INTENSITY

Short duration, high intensity exercise

If we consider a sporting event which only requires some seconds of effort (long jump, 100 m sprint), an increase in temperature may in fact benefit muscle function. It appears that part of the mechanism accounting for such an improvement is similar to that seen with a warm-up prior to exercise.

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Long duration, lower intensity exercise

In longer events such as the marathon, hot ambient conditions can negatively affect core body temperature and subsequently impair performance. This is compounded by the fact that contracting muscle also generates heat and therefore increases core temperature. Muscle temperature at rest is slightly lower (~35°C) than central body temperature (~37°C). However, the

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temperature of the muscle increases during exercise, reaching and overcoming core temperature within approximately 10 to 20 minutes. It has been previously established that a core temperature of 40°C (with an inter-individual variation of ±0.5°C) and muscle temperature of 42°C represents the limits which can be tolerated by the human body. Luckily, just as your car has been equipped with a fan and a cooling system, your body also has ways to dissipate the heat and maintain optimum function.

ATHLETE CHARACTERISTICS

Heat dissipation

The primary way we lose heat in hot or thermo-neutral environments is via our ability to sweat and subsequent evaporation of that sweat, which cools down the surface of the skin and creates a heat gradient across the skin, further encouraging heat loss. Therefore, it is important for athletes to keep their skin wet if they want to stay cool. However, these systems are limited, especially if the environmental temperature is similar to or higher than the skin temperature, or if conditions are too humid to allow evaporation. This means that warm and humid environments (e.g. tropical environments) could be more damaging for performance than hot and dry environments. Given the high humidity in tropical areas, sweat cannot evaporate but rather drips off the body without noticeably reducing body temperature. This could also potentially lead to dehydration. Therefore, it might be relatively easier to exercise in a hot and dry country than in a moderately warm and humid environment.

There are other issues to consider when assessing the overall effect of hot conditions on different types of sports. For example, sports with an elevated speed (e.g. cycling) will not be affected in the same way as sports performed at low speed (e.g. walking, running), even if it is at the same temperature. The first reason for this is that the heat dissipation is increased by wind flow as the increased air movement favors both evaporative and convective heat loss. The second reason is that an increase in ambient temperature leads to a decrease in air density, thereby reducing the aerodynamic resistance in activities such as cycling.

The effect of temperature on performance is even more complex to quantify if we consider team sports where performance is multi-factorial. We recently compared the activity pattern of Scandinavian football players while playing in a hot environment (~43°C) to playing in thermo-neutral environment (~21°C). As a result of playing in the heat, the total game distance declined by 7% and high intensity running by 26%. However, there were no differences in the quantity or length of sprints and the peak sprint speed was 4% higher. The success rate for passes and crosses was also better in the heat. Therefore, the global physical performance during a soccer game in the heat was modified but not impaired.

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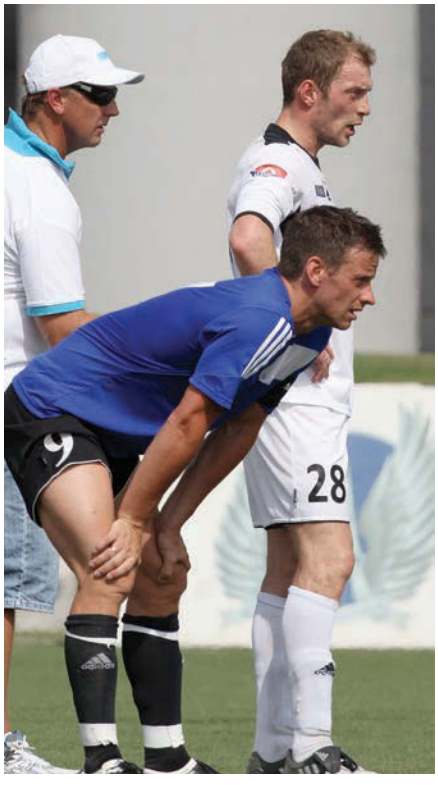
Heat acclimatisation

Heat production is mainly dependent on exercise intensity. Heat release is mainly dependent on the global (e.g. temperature and humidity) and specific (e.g. clothing, speed of displacement) ambient conditions surrounding the athlete. If the heat production exceeds the heat release, the body temperature will increase. However, this does not mean that it is impossible to exercise, only that the intensity will have to be reduced in order for heat production to match the heat dissipation capacity. A good example of the human capacity to exercise in the heat is the Ironman World Championships held in Hawaii, where both professional and amateur athletes compete for over 8 hours at their maximum capacity in hot and humid conditions.

Athletes can also improve their heat dissipation capacity with acclimatisation. The clinical signs of heat acclimatisation include a decrease in body temperature at rest and exercising in the heat, as well as a decrease in heart rate. The physiological adaptations behind these clinical signs include an increase in sweat rate associated with a decrease in concentration in sodium to minimise the total sodium loss. Heat acclimatisation also increases the resting plasma volume thus reducing the consequences of the haemoconcentration while exercising in the heat. We observed a good correlation between the acclimatisation response (i.e. plasma volume expansion) in the Scandinavian soccer players mentioned above and their ability to maintain their usual amount of activity while playing in the heat.

Players who did not acclimatise properly needed to reduce their activity amount during a game whereas the players who acclimatised well were able to maintain the same amount of activity when playing in the heat as when playing in a thermo-neutral environment.



IN SUMMARY

The effect of hot ambient conditions on sporting performance is dependent on the event. Short-duration activities such as some track and field events might benefit from warm conditions. Athletes involved in longer activities might have to reduce their exercise intensity but the relative competition between athletes will remain. Mixed activities such as team sports may reflect these different responses and display a modification in the pattern of activity (i.e. less distance covered but faster sprints and more successful passes). Finally, athletes can acclimatise but there are inter-individual variations in the rate of acclimatisation. The physicians, physiologists and coaches of the national teams have to work together to individualise the training/acclimatisation camps and adapt their selection of athletes according to their ability to acclimatise.

Images: Staff from the Aspetar Research and Education Centre performing tests on Scandinavian football players at the Aspire Zone, Qatar

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