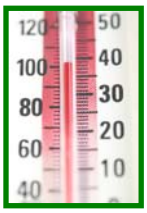
# SUMMERS IN SADDLEBROOKE: KEEPING COOL ON THE COURT

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## KEY POINTS

- Body temperature during a tennis match is a balance between how fast the body gains and loses heat: In addition to air temperature, how hard one plays and the dryness of the air are the two most critical factors in the control of body temperature on the court.
- Fatigue (mental and/or physical) and heat illness can be of concern as body temperature rises, sweat production increases, and the body loses too much water. Early fatigue is the most common effect of increased body temperature in SaddleBrooke tennis players, but heat cramps and fainting are also possible. Heat exhaustion, heat stroke and low blood sodium levels can be deadly but are highly unlikely for SaddleBrooke players.
- The risk of heat illness can be minimized by playing early in the day, taking lots of rest breaks, and by appropriate drinking during and after exercise.
- The vast majority of tennis players in SaddleBrooke will gain nothing more than a possible psychological boost by eating bananas, ingesting sports drinks, or consuming electrolyte powders or extra vitamins. But caffeine ingested an hour before tennis might help you win a few more games.

## HOW THE BODY ATTEMPTS TO MAINTAIN A NORMAL TEMPERATURE

### *BODY HEAT GAIN DURING EXERCISE*

At rest, the body attempts to regulate its "core" temperature—the temperature of the heart, lungs, and other internal organs—at about 100° F, but that temperature can rise several degrees during intense exercise. On the tennis court on a summer day, heat from the environment is transferred to the body mostly by *radiation* from the sun and from hot surrounding surfaces such as the court itself. Additionally, the body can absorb heat from warm air molecules that come in contact with the skin; this is called *convective heat gain*. ***But the most important way the body gains heat during exercise is by its own metabolic activity.*** Roughly 75-80% of the energy the body produces by converting fats and carbohydrates to ATP (adenosine triphosphate), the fuel for muscle contraction and other metabolic processes, is "wasted" as heat. During strenuous exercise, the muscles can produce 100 times more heat than they do at rest, and if most of this heat is not rapidly removed, the body will cook its own proteins. (*Most of us tennis players need not worry about cooking our proteins; if we are not breathing hard and are spending lots of time complaining about line calls and joking with our opponents, we are not participating in "strenuous exercise."*)

### *BODY HEAT LOSS DURING EXERCISE*

The heat produced by the exercising muscles is rapidly transferred to the cooler blood that circulates through the muscles and eventually to the skin. On a cool day, this heat can then be transferred from the warm skin to the cooler air by radiation and convection. But neither of these mechanisms can operate on a hot day when the environment is warmer than the skin. ***Thus, the evaporation of sweat from the skin is the only way to lose body heat on a hot summer day.*** (*Evaporation of sweat is the process by which liquid water droplets on the skin are converted into gaseous water vapor. Heat from the skin drives this process—similar to how heat on a burner can change a pan of water into steam.)*

Evaporation of sweat from the skin is a very effective way to rid the body of excess heat. For every quart of sweat that is evaporated, nearly 600 Calories of heat are removed. Interestingly, nationally-ranked players in their mid-40s generate approximately 580 Calories of heat per hour during a 2-hour singles match, and they produce a bit more than a quart of sweat each hour to offset that metabolic heat gain.[6] Players in SaddleBrooke, especially doubles player, may lose sweat at a rate of 1 quart per hour on a hot day, but they would presumably generate less

than half the heat that younger singles players do.

**How the humidity in the air affects the evaporation of sweat**. The rate of evaporation of a given amount of sweat is largely dependent on the amount of water vapor in the air that circulates next to the skin. In other words, if the air is dry—as in the Arizona desert, the evaporation of sweat can easily keep the body cool at rest and during light exercise, even when the air temperature exceeds 110° F. (Your skin may feel mighty hot, but your body core temperature will be O.K. as long as you continue to produce sweat and don't exercise too strenuously.) However, when the humidity in the air is high, even if the air temperature is moderate, heat loss by the evaporation of sweat may be unable to keep pace with the heat gain generated by contracting muscles. It is in such conditions of high humidity that severe heat illness is most likely to occur. In SaddleBrooke, the most dangerous time to play tennis is during those days of the summer monsoon when the humidity rises. But even then, the relative humidity typically is less than 50%, compared to 80-90% in other parts of the country. Note that the relative humidity (the amount of water vapor in the air relative to how much the air can hold at a given temperature) is usually greater in the early morning; the air can hold more moisture when it warms up, so the relative humidity is lower as the sun rises higher in the sky. This explains the counterintuitive sensation of feeling less sweaty as the air temperature rises.

## *THE IMPORTANCE OF MINIMIZING DEHYDRATION AND MAINTAINING BLOOD VOLUME*

On average, we have only about 5 quarts of blood in our bodies. Maintaining an adequate volume of blood is critical, especially during exercise in the heat. Why? Because we need to deliver lots of blood to the working muscles to 1) provide nutrients, 2) remove lactic acid, ammonia and other byproducts of metabolism, and 3) to carry away the excess heat created by muscle contraction. Also, adequate blood volume is required to fill the expanded capillary beds in the skin to dissipate heat to the environment (by the evaporation of sweat and, if the environment is cool, convection and radiation). If we sweat profusely during tennis play and fail to replace the evaporated sweat by drinking, we risk losing too much body water, leading to a diminished blood volume. Such a loss of body water can lead to deterioration in tennis performance and possible heat illness. To summarize, there are two vital reasons for keeping body fluids high: to help cool the body by the evaporation of sweat and to minimize any fall of blood volume.

### Potential Sweat Loss during Prolonged Exercise

In young, fit adults, sweat losses of 1- 2 quarts per hour are common during strenuous endurance exercise in the heat; in highly trained athletes, this value can reach 3.5 quarts per hour. Young adult tennis players have achieved sweat rates of more than 3 quarts per hour.[2] Because each quart of fluid weighs about 2 pounds, highly trained athletes can lose more than 7 pounds per hour by sweating. It is obvious that sweat rates of this magnitude would quickly lead to severe dehydration if the fluid were not replaced by drinking. But few athletes can force themselves to drink much more than about 1 quart per hour. On average, athletes replace only about half of their sweat loss during exercise when they drink according to their thirst.

### How Much Sweat Do You Lose Playing Tennis?

Let's face it; even a brief observation of doubles play in SaddleBrooke reveals that most players spend the bulk of their time on the court standing still. Of course, there are exceptions, especially among highly competitive players. Also, singles players are more likely to expend lots of energy and to lose lots of sweat. There are no scientific studies that describe the average sweat rate of club-level senior tennis players in the desert, but one could hazard a guess that it is about one pint per hour for most players at SaddleBrooke. You can determine your personal sweat rate by recording your nude body weight before and after you play and recording the volume of fluid that you drink during play. Your total sweat loss in quarts is

the difference in body weight divided by 2.1 (to convert pounds to quarts) added to the volume of beverage consumed. Divide this value by the duration of your match in hours to find your sweat rate in liters per hour. (*This calculation assumes that you don't take any bathroom breaks during your match.*)

**Sweat Volume (quarts) =**
**[weight before – weight after match (lbs)]/2.1**
**+**
**Volume of beverage consumed (quarts)**

**Sweat Rate (quarts/hour) =**
**Sweat Volume (quarts)/time of match (hours)**

***Calculation Example:***

*Weight before match = 150 lbs*
*Weight after match = 148 lbs*
*Water consumed during match = 1 quart*
*Match duration = 2 hours*

- *Weight loss: 150 – 148 = 2 lbs*
- *Conversion of weight loss to quarts: 2 lbs/2.1 = 0.95 quarts*
- *Total sweat loss during 2-hour match: 0.95 quarts + 1 quart of water = 1.95 quarts*
- *Sweat rate: 1.95 quarts/2 hours = 0.975 qts/h*

## WHAT DEGREE OF DEHYDRATION IS HARMFUL?

**Effects of dehydration on athletic performance.** There are no data on senior tennis players, but studies on fit young adults suggest that a weight loss of more than 2% of body weight can lead to impaired exercise performance. Thus, a 150-pound tennis player could presumably lose 3 pounds during a match without any adverse effects on tennis play. As dehydration progressively exceeds 2% loss of body weight, a decrement of performance in hot environments is increasingly likely[4]. Why does exercise performance get worse? In many cases it is likely that minor dehydration leads to an increase in brain temperature that adversely affects motivation and coordination. Also, as blood volume is diminished due to dehydration, the ability of the cardiovascular system to deliver adequate amounts of blood to the muscles and other organs begins to decline. This could be especially critical in seniors who have cardiovascular disease.

**Effects of dehydration on the risk of heat illness.** Heat illness begins to be a concern when dehydration exceeds 3-5% of body mass. At this level of dehydration, sweat production, cardiac output, and skin blood flow are worsened and core temperature rises.[9]

## *HEAT ILLNESS[3]*

Heat cramps and heat syncope (fainting) are the types of heat illness most likely to affect SaddleBrooke tennis players, especially those who are less fit or suffer from cardiovascular illness.

**Heat cramps** are muscle spasms, often in the legs, arms, and abdomen, and are thought to be caused by dehydration and a loss of sodium due to heavy sweating. Heat cramps are more likely in tennis players who are not accustomed to strenuous tennis matches and/or have not become acclimatized to the hot environment. Treatment of heat cramps includes consumption of salty fluids and foods before, during, and after exercise, plus rest and stretching of the affected muscles when cramping is severe.

**Heat syncope** (fainting) is preceded by dizziness and weakness during standing in the heat, especially when rising quickly from a seated position. These symptoms are caused by blood collecting in the dilated veins and capillaries of the skin and legs; as more blood collects in these areas, less is available to be returned to the brain. Fainting is more likely in dehydrated, unfit players who have recently moved to a hot climate[11].

For SaddleBrooke tennis players, dizziness or fainting might occur when a player stands up after being seated for a few minutes between games late in a match. This is a self-correcting ailment because blood more easily returns to the brain when the person collapses. Players who feel dizzy should lie down with their legs elevated, preferably in the shade or in an air-conditioned room, and drink cool fluids.
**CAUTION:** *Be aware that a heart weakened by cardiovascular disease can also cause dizziness. If there is any question about the quality of a player's cardiovascular health, a physician should be consulted before the athlete resumes play.*

**Heat exhaustion** is similar to heat syncope, i.e., the affected person fails to maintain an adequate pumping of blood by the heart,

resulting in collapse, but heat exhaustion is accompanied by a high core temperature (101°F to 104°F). It is possible that a SaddleBrooke player with a compromised cardiovascular system could suffer heat exhaustion. Treatment is the same as with heat syncope with the addition of the application of cold towels to the legs and arms. Like heat syncope, cardiovascular disease may be a contributor to any collapse of a player on the tennis court. Finally, if there are any signs of delirium or confusion when a player collapses, what appears to be heat stroke; emergency personnel should be summoned immediately. Fortunately, this scenario is highly unlikely in SaddleBrooke tennis players,

**Heat stroke** is a serious illness and is accompanied by confusion, disorientation, impaired judgment, and a very high core body temperature (>105°F). Heat stroke can lead to kidney failure, brain and liver damage, and widespread blood clotting. Risk factors for heat stroke include poor fitness, lack of adaptation to a hot environment, dehydration, and excess body weight. It is highly improbable that 2 hours of typical doubles play in SaddleBrooke would bring on heat stroke unless a player had been working in the heat for several hours before playing tennis. Heat stroke is a medical emergency, and 911 should be called immediately if heat stroke is suspected.

**Exertional hyponatremia** is a rare condition characterized by an abnormally low level of sodium (Latin*: natrium*) in the blood. Although not strictly a heat illness, hyponatremia is seen in endurance athletes in hot environments and in military trainees. The most common cause of hyponatremia in athletes is the drinking of excessive amounts of water and other beverages that contain little or no sodium. Military recruits undergoing basic training in hot, humid environments have died after they drank more than 20 quarts of water in a few hours in a misguided attempt to counteract the heat. This overzealous drinking dilutes the sodium concentration in the blood, which can lead to brain swelling, seizures, coma, and death. It is highly unlikely that SaddleBrooke tennis players would suffer from hyponatremia unless they consumed huge volumes of water before they began a match.

## *WHAT PLAYERS SHOULD DO TO MINIMIZE THE RISK OF HEAT ILLNESS*

- Get accustomed to living in the heat and playing tennis (see below).
- Play early in the day or later in the evening
- Wear light-colored clothing and a wide-brimmed hat during the day.
- Don't play as hard or as long as you do when it's cool.
- Take longer breaks between games.
- Drink plenty of cool fluids.
- Players who feel ill during a match should stop playing, move to the shade or air conditioned room, lie down, and consider having a friend or relative drive them home or to the emergency room.

### Adapting to Tennis Play in a Hot Environment to Minimize the Risk of Heat Illness

How should beginning players who have just moved to SaddleBrooke from a cool environment prepare for regular play in the summer heat? It only requires a week or two of heat exposure for 90-120 minutes daily plus a gradual increase in duration of tennis play to become acclimatized to exercise in the heat. In other words, players need both heat exposure and tennis training. Leisurely walking or cycling for 90 minutes in the hottest part of the day provides the heat exposure, and playing tennis in the cool part of the day or in the evening is the best way to achieve the tennis training. One might begin the tennis training part of the regimen with 45 minutes of play for the first 2 days, 60 minutes for days 3 and 4, 90 minutes for days 5 and 6, and then 2 hours each day.

### Are You Drinking Enough? Too Much?

For most people who exercise, thirst is sufficient to stimulate only enough drinking to replace about half of the sweat they lose during exercise. If you don't sweat much, this is O.K., but if you are a heavy sweater, you should probably be drinking more than your thirst tells you to. By recording your body weight before and after a match, you can easily tell if you are drinking too much or too little. If you find that you are losing more than 2% of your body weight after your usual drinking during tennis, you need to drink more; if you are gaining weight, you need to drink less (each quart of water weighs about 2.1 lbs). If you are losing weight even when you are drinking as much as comfortable during exercise, drink more than

you normally would during the first few hours of recovery until your weight returns to normal.

**Is Water O.K., or Do I Need a Sports Drink?**
With some exceptions, water is a suitable beverage for SaddleBrooke tennis players. The reason is that most SaddleBrooke players do not exercise strenuously enough to benefit from a sports drink. Therefore, the only value of using a sports drink is if the flavor of the beverage encourages players to drink more than if they drank water[10].

High-level players in SaddleBrooke may get a small performance advantage by consuming a sports drink rather than water during their tennis matches. Tennis play relies mostly on carbohydrate for energy, and intense play can decrease the availability of the carbohydrate fuel in muscles. Sports drinks like Gatorade® and Powerade® contain various forms of carbohydrate and small amounts of sodium, potassium, and other electrolytes. There is abundant research proving that sports drinks have beneficial effects on exercise performance —typically a 5-7% improvement—for fit athletes who exercise very intensely, usually in continuous prolonged exercise such as cycling on a laboratory ergometer for 60 minutes or longer.[5, 8] Also, there is a report of a simulated tennis match in which carbohydrate ingestion in a sports drink improved stroke performance when compared to water.[12]

Sports drinks that are effective in improving performance contain carbohydrate in concentrations ranging from about 5-7%, i.e., 5-7 grams/100 ml of liquid. Less concentrated drinks provide too little carbohydrate to be of significant value, and more concentrated drinks tend to empty too slowly from the stomach and can cause gastrointestinal upset. Accordingly, drinks marketed as low-calorie options, e.g., Powerade Zero®, G2 Low Cal®, Propel®, may taste good and stimulate drinking somewhat, but they will not improve exercise performance compared to a similar volume of water. Likewise, diluting a sports drink with water will erase any potential benefit of the beverage compared to water. Most carbonated soft drinks, fruit juices, and the so-called "energy drinks" such as Red Bull® have a carbohydrate concentration above 10% and are thus more likely to trigger gastrointestinal discomfort if consumed during exercise. However, the caffeine in energy drinks may have some value if the drink is ingested 1 hour before exercise (see below).

**Electrolytes in sports drinks: Sodium is the important one.** Sports drinks also contain sodium and other electrolytes and are designed to replace some of the electrolytes lost in sweat. Sodium is the only electrolyte lost in substantial amounts in sweat (880-1350 mg/quart of sweat), although the amounts lost are highly variable among individuals. The sodium content of the most popular sports drinks is quite low, i.e., 450 mg/quart (166 mg/12 oz) or less. Thus, 12 oz of a sports drink contains less sodium than the 200 mg found in 12 oz of skim milk. In fact, even if one drank a sufficient volume of a sports drink during exercise to replace all sweat losses, only about half the sodium would be replenished (about *900 mg sodium/quart of sweat versus 450 mg sodium/quart of sports drink*). (There is wide agreement among experts that an optimally formulated sports drink would contain more sodium. There are two main reasons why manufacturers don't put more sodium in sports drinks: First, more sodium makes the drink taste too salty. Second,many consumers believe that dietary sodium is harmful). Still, if an athlete is hot and sweaty, the sodium present in sports drinks can enhance the flavor of the beverage and may increase fluid consumption. Moreover, the sodium does help the body retain the fluid consumed rather than having the kidneys produce more urine. Also, the small concentration of sodium in sports drinks may be of some value in minimizing muscle cramps during and after exercise. However, making sure that the diet has adequate salt is probably more important in preventing cramps. High-level athletes who regularly suffer severe cramps can often minimize cramping by adding extra salt (sodium chloride) to their sports drinks.

**Should Sports Drinks Include Vitamins?**
No. Although food companies have been trying for decades to find it, there is no reliable scientific evidence that supplementary vitamins are of any value for improving exercise performance of any type.

## Do Bananas and Potassium/Electrolyte Powders Help Avoid Cramps?

Because only small amounts of potassium are lost in sweat, eating bananas for their potassium content or ingesting various electrolyte formulations that emphasize potassium is unlikely to have any effect on muscle cramps or body fluid balance. Still, bananas are a good source of carbohydrates and can be useful as an energy replacement.

Because of taste problems in attempts to formulate an effective product, electrolyte powders and most electrolyte solutions contain too little sodium to have any important value in sodium replacement.

## Does Caffeine Enhance Exercise Performance and Does It Cause Greater Dehydration?

Caffeine ingestion equivalent to a few cups of coffee or a caffeine tablet an hour before exercise is one of the few dietary supplement regimens that actually works to improve exercise performance, especially in exercise lasting 45 minutes or longer.[7] But contrary to conventional wisdom, consuming caffeinated beverages does not lead to more urine formation during exercise that is at least moderately strenuous.[13] It is true that caffeine consumption at rest does tend to cause somewhat more urine production (although the main culprit is the volume of coffee, tea, or cola consumed), but during exercise the blood flow to the kidneys is reduced by as much as 80% so that little urine is produced, caffeine or no caffeine.

## *SUMMARY*

If a player's body temperature gets too high during a tennis match, performance is likely to deteriorate and the risk of heat illness increases. Body temperature during tennis play in the summer in SaddleBrooke is largely a function of the intensity of play and the dryness of the air. Unless they have cardiovascular disease, most doubles players in SaddleBrooke will have no problem keeping their body temperatures in bounds because the intensity of play is low and the air is very dry. But higher-level competitive doubles players and especially singles players may have difficulty reigning in their core body temperatures, particularly during the relatively humid days of the monsoon.

SaddleBrooke tennis players should undergo annual physical exams to help detect potential heart disease. Before undertaking strenuous tennis competition, those who are unfit and unaccustomed to desert heat should be exposed to the heat for 90 min each day for a week or two and train for tennis during the cooler parts of the day during that period.

The goal for maintaining the proper body fluid balance is to drink enough fluids to lose no more than 2% of body weight during match play. Losing more than 2% of body weight can mean poor performance; losing more than 3% can lead to heat illness. Heat cramps and fainting are the minor heat illnesses most likely to afflict SaddleBrooke players, but heat exhaustion or even potentially deadly heat stroke are possible in highly competitive players in the summer heat. Weight loss can be easily determined by weighing oneself before and after tennis. If weight loss is greater than 2%, drink more; if weight is gained, drink less because excessive drinking can lead to dangerously low levels of blood sodium.

For most SaddleBrooke players, water is an appropriate beverage for replacing sweat loss. Highly competitive players may benefit from sports drinks. There is no reliable evidence that vitamins, bananas, and electrolyte concoctions provide any benefit to tennis players, but caffeine ingested 1 hour before tennis may help a player concentrate and feel energized without causing additional dehydration.

To minimize the risk of heat illness, players should wear light-colored clothing and a wide-brimmed hat, play less strenuously, take longer breaks between games, drink plenty of cool fluids, and quit earlier than normal.

Players who feel ill during a match should stop playing, move to the shade or air conditioned room, lie down, and consider having a friend or relative drive them home or to the emergency room.

## *REFERENCES*


1. Bergeron MF (2003). Heat cramps: fluid and electrolyte challenges during tennis in the heat. *J Sci Med Sport* **6**, 19-27.

2. Bergeron MF, Maresh CM , Armstrong LE, Signorile JF, Castellani JW, Kenefick RW, LaGasse KE & Riebe DA. (1995). Fluid-electrolyte balance associated with tennis match play in a hot environment. *Int J Sports Med* **5**, 180-193.

3. Carter III R, Cheuvront SN & Sawka MN (2006). Heat related illnesses. Gatorade Sports Science Institute: *Sports Science Exchange* **19**(3):1-6. http://www.gssiweb.com/Article_Detail.aspx?articleid=728&level=4&topic=4

4. Cheuvront SN, Carter R & Sawka N (2003). Fluid balance and endurance performance. *Curr Sports Med Rep* **2**, 202-208

5. Coyle EF & Montain SJ (1992). Benefits of fluid replacement with carbohydrate during exercise. *Med Sci Sports Exerc* **24**, S324-S340.

6. Ferrauti A, Bergeron MF, Pluim BM & Weber K (2001). Physiological responses in tennis and running with similar oxygen uptake. *Eur J Appl Physiol.* 85(1-2):27-33.

7. Hulston CJ & Jeukendrup AE (2008). Substrate metabolism and exercise performance with caffeine and carbohydrate intake. *Med Sci Sports Exerc.* 40(12):2096-2104.

8. Jeukendrup AE (2004). Carbohydrate intake during exercise and performance. *Nutrition*. **20**(7-8):669-677.

9. Montain SJ & Coyle EF (1992). Influence of graded dehydration on hyperthermia and cardiovascular drift during exercise. *J Appl Physiol.* **73**(4):1340-50.

10. Passe DH, Horn M & Murray R (2000). Impact of beverage acceptability on fluid intake during exercise. *Appetite* **35**, 219-229.

11. Seto CK, Way D & O'Connor N (2005). Environmental illness in athletes. *Clin. Sports Med.* **24**(3):695-718.

12. Vergauwen L, Brouns F & Hespel P (1998). Carbohydrate supplementation improves stroke performance in tennis. *Med Sci Sports Exerc*. **30**(8):1289-1295.

13. Wemple RD, Lamb DR & McKeever KH (1997). Caffeine vs caffeine-free sports drinks: effects on urine production at rest and during prolonged exercise. *Int J Sports Med*. **18**(1):40-6.



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