

# Heat research guides current practices in professional tennis

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Professional tennis places extraordinary demands on elite tennis players. Previously published profiles characterise the inherent physiological demands of tennis play and the adaptations incurred by elite-level tennis players. These include the requirement of repeated maximal level exertions during points with average durations ranging between 2 and >8 s depending on the match surface and player's gender.<sup>1 2</sup> Match durations of greater than 5 h can be encountered. During these matches, a work rest ratio of 1 : 2 is reported with movement demands requiring a mean of three shots, 4.2 directional changes and an average distance of 3 m is required to optimally position the body for shot production and execution. All of this can occur during extreme environmental temperatures played in outdoor stadiums and tennis facilities.

Several previous studies have profiled the body core temperature responses during competition as well as estimated

sweat rates (1 to over 3.5 L/h) from elite-level tennis players during matches in challenging thermal environmental conditions.<sup>3 4</sup> Core body temperatures (CBTs) have been recorded and have peaked at 38.9–39.1°C in women and men professional players.<sup>5 6</sup> Even higher CBTs were recorded by Périard *et al*<sup>7</sup> who studied elite male tennis players during tennis match play in cool (~19°C wet bulb globe temperature (WBGT)) and hot conditions (~34°C WBGT). The mean CBTs were ~38.7°C under cool and ~39.4°C under hot conditions, respectively.

These high sweat rates and high CBTs do show that the body's cooling system has to work very hard to reduce excessive heat when the metabolic rate and environmental heat load are high.

The inherent demands imposed by the sport of tennis played at the highest level have led to procedural intervention by the medical teams caring for professional tennis players at events worldwide played in challenging environmental temperatures. Research works such as those presented in this special issue of the *BJSM* provide rationale and influence the development of these intervention strategies to optimise performance and prevent injury and illness from the environmental and physiological challenges of elite-level tennis play.

Currently, prevention strategies are employed on the Association of Tennis Professionals (ATP) and Women's Tennis Association (WTA) tours for its professional players that reflect evidence-based approaches to provide optimal care. These prevention strategies include player and coach education regarding proper nutrition and hydration for match preparation, match performance and post-match recovery. Knowledge of sweat rates and the body's cooling mechanisms allow clinicians to guide players through specific interventions to address these physiological responses with individualised sweat analysis and tailored personalised recommendations offered at ATP and WTA tournaments. Practices conducted in the training and locker rooms at ATP and WTA professional-level tournaments worldwide are employed to monitor fluid loss and recovery, such as weighing players, specific gravity urine strips and monitoring urine colour (see online supplementary figure S1) prior to and following practice sessions and matches. The provision and recommendation of water and electrolyte beverages to address fluid and electrolyte loss is an essential part of intervention strategies coupled with the careful monitoring of physiological parameters. The use of external body cooling procedures on court with the use of fans induced shade via umbrellas or court structures, and the application of ice towels<sup>8</sup> is currently recommended to provide on-court relief during tournament play in stressful thermal conditions. In addition, scientific advancements in sporting apparel and materials have

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improved on-court cooling capabilities. Evidence-driven use of ice bath immersion to reduce core temperature postcompetition in extreme temperatures is also commonly seen.<sup>8–10</sup>

Application of heat illness-related research led to the development of the WTA's Extreme Weather Conditions Rule. This rule, being designed with the players' safety in mind, allows for a short break in play to permit safety interventions, such as cooling measures, prior to the final set in singles matches being played in extreme weather conditions.<sup>5</sup>

Clinicians are indebted to the researchers who study and author scientific investigations and literature reviews on these topics to enable the continued evolution of clinical practices to protect, prevent and treat elite tennis players performing in extended thermal environmental conditions. The importance of this research can be demonstrated in the player and coaching education pieces provided by the professional tours (see online supplementary figure S2). Dissemination of research provided by the scientific community is essential to provide the evidence needed to educate and modify players' behaviours to optimise performance and prevent illness and injury. Continued advancement of knowledge in this area will lead to adapted and nouveau procedures that

optimise current athletic care in the sport of tennis.

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## REFERENCES

- 1 Reid M, Schneiker K. Strength and conditioning in tennis: current research and practice. *J Sc Med Sport* 2008;11:248–56.
- 2 Fernandez J, Mendez-Villanueva A, Pluim B. Intensity of tennis match play. *Br J Sports Med* 2006;40:387–91.
- 3 Bergeron MF, Waller J, Marinik E. Voluntary fluid intake and core temperature responses in adolescent tennis players. *Br J Sports Med* 2006;40:406–10.
- 4 Bergeron MF, McLeod K, Coyle J. Core body temperature during competition in the heat: National Boys 14's Junior Tennis Championships. *Br J Sports Med* 2007;41:779–83.
- 5 Tippet M, Stofan J, Lacambra M, *et al*. Core temperature and sweat responses in professional women's tennis players during tournament play in the heat. *J Athl Train* 2011;46:55–60.
- 6 Hornery D, Farrow D, Mujika L, *et al*. An integrated physiological and performance profile of professional tennis. *Br J Sports Med* 2007;41:531–6.
- 7 Périard J, Racinais S, Knez W, *et al*. Thermal, physiological and perceptual strain mediate alterations in match-play tennis under heat stress. *Br J Sports Med* 2014;48:i32–8.
- 8 Ranalli GF, DeMartini JK, Casa DJ, *et al*. Effect of body cooling on subsequent aerobic and anaerobic exercise performance. *J Strength Cond Res* 2010;24:3488–96.
- 9 Costello JT, Donnelly AE. Effects of cold water immersion on knee joint position sense in healthy volunteers. *J Sport Science* 2011;29:449–56.
- 10 Howatson G, Goodall K, van Someren A. The influence of cold water immersion on adaptation following a single bout of damaging exercise. *Eur J Appl Physiol* 2009;105:615–21.



# LIQUEFY YOUR ASSETS

Physically Speaking

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As a professional athlete, you need to pay attention to ALL aspects of your game. Hydration is one critical component to good preparation and recovery that is sometimes underemphasized. Good hydration habits not only help a player to optimize performance, but also help to reduce the risk of exertional heat illness. Adequate water intake should be the principal focus of maintaining hydration, but certain sport drinks can offer you at times a performance and safety advantage over consuming water alone.



## WHAT SHOULD I LOOK FOR IN A SPORTS DRINK?



- Sport drinks should focus on the primary nutrients in the appropriate amounts that are needed before, during and after play: **WATER, CARBOHYDRATE & ELECTROLYTES**. Protein (or additional amino acids) and higher levels of carbohydrate are more effective for after play.
- Choose a sport drink that also tastes good, so you will want to drink it!
- Choose a **Non-carbonated** sport drink. Carbonation can make you feel full, so you won't drink as much.
- Be careful with caffeine. While low-moderate caffeine intake has been shown to be effective in delaying fatigue, too much can interfere with performance and health.

## KEY FACTORS FOR ULTIMATE HYDRATION & PERFORMANCE

### 1. WATER

All sport drinks contain mostly water. On court, you can offset much of your fluid loss from sweating by drinking a combination of sports drink & water. Most players can comfortably drink about 1 to 1.5 liters each hour during play or practice.

- One way to measure how much fluid you have to replace after play is to **weigh** yourself pre- and post-match.
- For each **1 kg of body weight you lose by the end of play or practice**, you have to drink about **1-1.2 liters of fluid** (or 16-20 oz of fluid for each pound lost).
- Use the scales provided at tournaments to monitor your fluid loss and determine your rehydration needs. Remember to weigh yourself in minimal (same) clothes before and after play, for the most accurate measurement.



Sweat = Fluid Loss → Dehydration → ↓ Performance & ↑ Heat Illness Risk

## DEHYDRATION LEADS TO ↓ PERFORMANCE

- As little as 2% loss of body weight can significantly affect performance. A loss of 4% or more of body weight can be **DANGEROUS**, as this level of dehydration will certainly increase the risk of exertional heat illness & collapse and potentially life-threatening heatstroke.
- When you feel **thirsty**, you may be **already 1 - 2% dehydrated...**

Drinking **too much water** or too much low-sodium fluid can also lead to problems. Excess water in the blood indicated by a low blood sodium level (**hyponatremia**) can readily occur by rapidly drinking too much water or other low-sodium fluids. Signs and symptoms can range from fatigue, nausea, & headache to muscle cramps, seizure, or even worse!

### DRINKING WATER ALONE IS NOT ENOUGH FOR ADEQUATE REHYDRATION!

A properly formulated sport drink with the right amount of sodium and carbohydrate helps you to distribute and retain fluid, **fuels** the body and **delays the onset of fatigue**.



### ENERGY and MUSCLE RECOVERY!

**2. CARBOHYDRATE** needs should be primarily provided by carbohydrate-rich foods during regular meals & snacks. A sports drink can provide additional energy on court (via carbohydrates) that will help you to perform at your best.

**DURING PLAY**, look for sports drink that provides:

- About 30-60 grams of carbohydrate per liter (L). Sports drinks with this level of carbohydrate will **empty from the stomach quickly** and provide enough fuel for performance.
- Look for a carbohydrate blend to maximize absorption (Glucose, fructose, sucrose or a glucose polymer- such as Maltodextrin).  
This will give you **QUICK ENERGY**, because this amount/type of carbohydrate will be **absorbed into your bloodstream rapidly**.

**AFTER PLAY**, you can drink a sports drink as listed above or a drink with a higher carbohydrate content and some protein (amino acids) to help rebuild muscle.

**3. ELECTROLYTES, SODIUM & CHLORIDE (which forms salt)** are the most abundant electrolytes lost in sweating.

- Potassium, magnesium and calcium are also lost through sweat, but in much smaller amounts, and it is unlikely you would have a deficiency in these minerals.
- With adequate salt intake, your body can transport water to and around the muscles more efficiently and effectively. That is, you will maintain hydration better.
- The best treatment for heat-related muscle cramps is adequate salt & fluid intake, not potassium or any potassium-rich food (such as bananas). **NOTE:** Sudden onset of cramping in a single muscle or muscle group is more likely due to muscle overload – not an electrolyte deficiency.
- Everyone differs in electrolyte losses; therefore supplemental electrolytes (e.g. adding salt to sports drinks) should be individualized – that is, according to **YOUR** losses and needs.

**4. THE OTHER INGREDIENTS** found in some sport drinks, such as herbs, chromium, various vitamins, carnitine or lactate, are non-essential nutrients, and **may actually HURT your performance** and negatively affect your health.

### HOW MUCH SPORTS DRINK & WATER IS ENOUGH?

- Bring about **three 0.5 Liter (20 oz) bottles of an anti-doping approved Sports Drink** & at least **two 0.5 Liter (20 oz) bottles of water** on court for **EACH** match. Alternate between drinking sports drink & water on EVERY change of ends.
- Ensure you are mixing your own drinks, initialing your bottles, and opening your own bottles on court. You should be the only one breaking the seal of every drink you consume to ensure compliance with the anti-doping program.
- In hot & humid environments, you should bring additional bottles of an **anti-doping approved Sports Drink** & water on court for matches. You will be sweating more, and will have a greater fluid loss to replace.
- In general, including for indoor play, **one (1) liter** of an **anti-doping approved Sports Drink** (35 oz, containing about 60g Carbohydrate), and up to **0.5 liter** of water should be consumed for each hour of tennis.

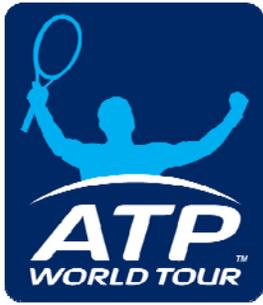
### SHOULD I ADD SALT?

- If you have experienced heat-related muscle cramps or heat illness: Trial about 1 packet of salt (1/8 teaspoon) OR ½ packet to each 0.5 liter bottle of an **anti-doping approved** Sports Drink for play.
- For hot & humid environments, ALL PLAYERS should add 1/8 tsp of salt OR ½ packet to each 0.5 Liter bottle of an **anti-doping approved** Sports Drink.
- If you don't like the taste of salt in your sports drink...you can add extra salt to your food. Try adding soy sauce, eating pretzels or adding salt to your diet in other ways.
- Taking **Salt tablets** alone (without taking a sufficient amount of water) is **NOT** recommended because the potential high concentration of sodium in your gastrointestinal tract can cause undesirable effects. Also, any time you are considering taking a supplement, be mindful of anti-doping regulations. **Always** check any supplements with IDTM **before** you take them.



### 5. RECOVERY DRINKS

- Low fat flavored milk and fruit smoothies are an ideal recovery drink.
- They contain ideal carbohydrate, protein and fluid ratio of 3:1 which helps to speed recovery.
- Ideally, you should drink this within 30 minutes following a match, training or practice.



# ARE YOU HYDRATED?

## Urine Color Chart

1		<p>If your urine matches the colors 1, 2, or 3, you are likely properly hydrated. Continue to consume fluids at the recommended amounts. Nice job!</p>
2		
3		
4		<p>If your urine color is below the <b>RED</b> line, you may be <b><u>DEHYDRATED</u></b> and at greater risk for heat illness!!</p>
5		
6		<p><b><u>YOU NEED TO DRINK MORE!</u></b></p>
7		
8		<p>Speak to a Health Care Provider if Your Urine is this Dark and is Not Clearing Despite Drinking Fluids</p>

Source: Recovery in Tennis, United States Tennis Association (Kovacs et al, 2010)