International Tennis Federation
www.itfcoachingreview.com
April 2011. 19th Year. Issue 53. 31-35
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v19i53.549

Hydration, Dehydration, and Performance: A Literature Review.

Mark Kovacs.

United States Tennis Association.

ABSTRACT

Hydration at any level of competitive sport is crucial to optimal performance and recovery. The present article outlines how dehydration can affect bodily functioning and presents research outlining preferable hydration strategies and techniques. Practical applications include how to measure dehydration levels, and what appropriate fluids are available for consumption to optimise performance and recovery.

Key words: Hydration, Recovery, Sodium, Cramp, Sports drinks
Received: 17 September 2010.
Acepted: 6 February 2011.
Corresponding author: Mark Kovacs, United States Tennis Association.
Email: Kovacs@usta.com,

INTRODUCTION

At any competitive level, it is commonly understood that proper rehydration- the restoration of carbohydrate stores, along with fluid and electrolyte levels- after practice or competition is vital to performance, health and safety. However, specific guidelines or recommendations have not yet been well established in the literature for tennis. This is partly due to the fact that tournament tennis play is often varied in terms of matches per day, tournament length, and actual length of a match (ranging from 30 minutes, to over 11 hours).

SWEATING AND DEHYDRATION

Evaporative cooling (sweating) is the most effective method that humans use to limit the rise in core temperature(Kovacs, 2006). Sweating is maintained by intracellular water shifting to the extracellular space, which results in cell dehydration. The goal of adequate hydration is to limit fluid loss from sweat and respiration.

Effects of dehydration on cognitive and mental functioning

Researchers have studied the influence of limiting fluid volumes and human body function. Evidence is emerging that hyperthermia (increases in body temperature induced by dehydration) directly affects brain function by altering cerebral blood flow and metabolism, thereby decreasing the level of central cognitive or neuromuscular drive, which may in turn decrease muscle function, alter the perception of effort, or both (Cheung & Sleivert, 2004).

Dehydration has also been shown to manifest with clinical symptomatology similar to concussion, including fatigue, drowsiness, headaches, poor concentration and balance problems (Patel et al., 2007).

It is clear that more needs to be done to reduce the aforementioned effects, as research has shown that there is a high prevalence of junior players walking onto court already dehydrated (Bergeron, Waller & Marinik, 2006).

Effect of dehydration on muscle groups and muscle action

No specific muscle group or action appears more susceptible to hypohydration than others (Judelson et al., 2007), however muscular performance is reduced when athletes are dehydrated. This study found that high intensity muscular endurance, as measured during 30- 120 seconds of repeated activity, is reduced by 10% when the athlete is dehydrated by 3-4%. Upper and lower body power which is crucial in tennis has also been shown to effected (Jones et al., 2008).

REHYDRATION

When discussing tennis recovery, specifically post-training or post- competition, one of the most important areas to consider is rehydration. As mentioned previously, many tennis players go into practice and/or competition already in varying states of the rehydration needs of the athletes relative to a euhydrated (normal) state before practice or competition.

Water vs Carbohydrate solutions

Shireffs et al. (2007) along with previous studies has shown that the ingestion of a carbohydrate-electrolyte beverage resulted in more effective rehydration than plain water (Gonzalez-Alonso, Heaps & Coyle, 1992); others have also observed a lower urine output with carbohydrate-electrolyte solution than with water- which will aid positive hydration status (Costell & Sparks, 1973).

Name	Carbohydrate Content	Carbohydrate (grams)	Protein (grams)	Calories	Sodium (mg)	Potassium (mg)	Caffeine (mg)	High Fructose Corn Syrup
Accelerade® RTD	6%	15	4	80	120	15	No	No
Amino Vital®	3%	8	<1	35	10	35	No	No
Bottled Water	0%	0	0	0	0	0	No	No
Cytomax®	5%	13	0	50	55	30	No	No
Gatorade®	6%	14	0	50	110	30	No	Yes
Gatorade® Endurance	6%	14	0	50	200	90	No	Yes
Gatorade G2®	3%	7	0	25	110	30	No	Yes
Life Water®	5%	13	0	50	120	20	No	No
Powerade®	7%	17	0	64	53	32	No	Yes
Propel® Fitness Water	1%	3	0	10	35	0	No	No
Soda, Cola	25%	25	0	100	30	?	Yes	Yes
Vitamin Water®	5%	13	0	50	0	70	0-75	Yes

Table 1. Comparison of popular sports drinks and beverages. Information adapted from Von Duvillard et al. (2008).

Sodium's role in hydration and rehydration for tennis

Research has shown that rehydration capabilities are improved for athletes who ingest sodium enriched fluids compared to plain water, and that many sports drinks do not contain enough sodium, albeit more than water. Shirreffs and Maughan (1998) have shown that athletes typically recover faster to adequate sodium and plasma volume levels with a 6% carbohydrate-electrolyte drink in comparison with water.

The right amount of sodium?

Excessive drinking of water alone, will not allow for adequate hydration after exercise. Shirreffs et al. (1996) demonstrated that even when a volume equal to twice the amount lost in sweat is ingested after exercise, subjects could not remain in positive fluid balance when a low sodium drink (23 mmol/L) was consumed. A positive fluid balance was eventually maintained when drinks containing 61 mmol/L of sodium were consumed in amounts > 1.5 times the loss of water.

However, if excessive sodium is added to the fluid it can make the liquid unpalatable, thereby reducing the total volume consumed (Wemple, Morocco & Mack, 1997). Therefore, the balance between palatability which effects consumption level, and actual sodium content must be achieved. A 6% carbohydrate-electrolyte drink will achieve a preferable balance. It is possible to make your own 6% drink by mixing five tablespoons of table sugar, and one-third teaspoon of salt per litre of water.

OTHER ELECTROLYTES – ARE THERE BENEFITS?

Potassium

Potassium is the major ion in the intracellular fluid, whereas sodium is the major ion in the extracellular fluid. Potassium is thought to be important in achieving rehydration by aiding the retention of water in the intracellular space. However, more research data is needed before conclusive evidence is able to show the benefits of potassium supplementation for rehydration.

The banana effect

It has previously been speculated that potassium may be a beneficial electrolyte for athletes in general since it is a major cation (positively charged ion or group of ions) in the intracellular space, and potassium supplementation could enhance the replacement of intracellular water after exercise and thus promote rehydration (Nadal, Mack & Nose, 1990). Experimental investigation has demonstrated that inclusion of potassium (25 mmol•l-1) may, in some situations, be as effective as sodium (60 mmol•l-1) in retaining water ingested after exercise- induced dehydration however it appears that there is no additive effect of including both ions (potassium and sodium).

CRAMPING

Muscle cramping during and after tennis play is an unwarranted aspect of high-level competitive tennis. Cramps typically occur with slight muscle fasciculations (Bergeron, 2007) or "twitches" that the athlete only notices between points or at the changeover. With respect to exercise-related muscle cramping, there are typically two forms of cramping that tennis players are most often confronted with:

1) Overworked muscle fibers

2) Muscle cramps related to extensive sweat losses and a sodium deficit, known as exertional heat cramps.

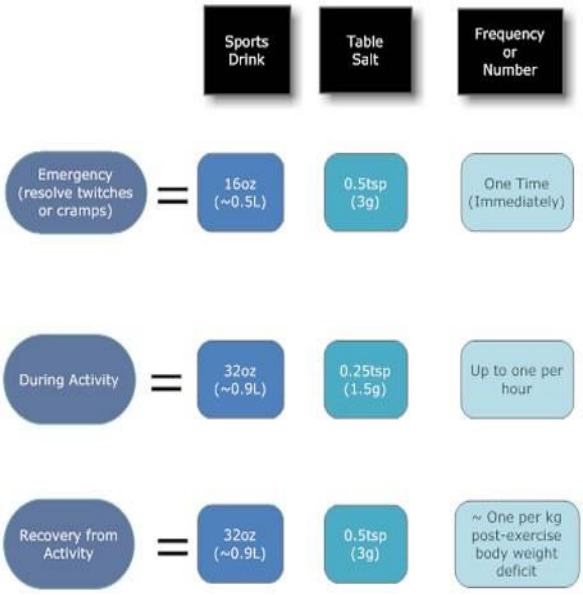

Figure 1. Suggested Fluid Mixtures for Exertional Heat Cramp-Prone Athletes Using Sports Drink and Table Salt (NaCl) (adapted from Bergeron, 2007).

PRACTICAL APPLICATIONS & TOOLS

Due to the fact that individual sweat rates are highly variable and the sweat sodium concentrations between athletes can range between 20-80 mmol/L (Verde et al., 1982), it would be an oversimplification to prescribe a universal drink formulation for all tennis players. This is why an individualized fluid program is suggested.

A practical tool for coaches and trainers to help athletes with their hydration monitoring is to utilize a urine color chart (Kovacs & Yorio, 2008). Figure 2. is a simple chart that can help athletes' awareness of their hydration status in a simple, non-invasive manner.

Post-practice or match hydration is not only important for immediate recovery, but also for subsequent performance during play in a subsequent session on the same or the following day. Rehydration post exercise has three major purposes:

1) Replace fluid volume to an equal or greater extent than the volume lost while sweating

2) Ingest liquid and/or solid carbohydrates to aid in glycogen resynthesis (Sherman, 1992)

3) Replace electrolytes lost during sweating

Water cannot be the only fluid consumed after tennis play, as the athlete is typically in a hypohydrated (dehydrated) state and an increase in plain water will dilute the lowered electrolyte concentration in the blood and plasma even further. This fall in plasma osmolality and Na+ (Sodium/Salt) concentration reduces the athlete's drive to drink and stimulates urine output, which could lead to adverse consequences such as excessive hypohydration and hyponatraemia. The addition of Salt (Na+) in post-exercise beverages has been supported by multiple position stands (Convertino et al., 1996).

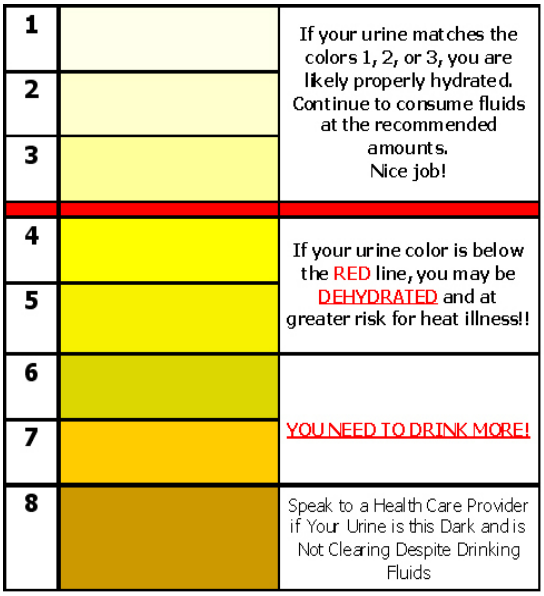

Figure 2. Am I Hydrated? – Urine Color Chart.

CONCLUSIONS & PRACTICAL REHYDRATION GUIDELINES (WENDT ET AL., 2007)

• The use of sports drinks with 6-8% carbohydrate solution and sodium improves intestinal water absorption. In addition, flavoured, more palatable drinks lead to more fluid being consumed when compared with water.

• Water retention can be optimized by the ingestion of solutions containing at least 50mmol/L of sodium (~3 grams/L of table salt) in a volume of liquid 1-1.5 times the amount of sweat lost. It is possible to make your own 6% drink by mixing five tablespoons of table sugar, and one-third teaspoon of salt per litre of water. Assistance from a professional nutritionist is advised.

• Rehydrating with water alone can have negative effects because this can result in a rapid fall in plasma osmolality and sodium concentration.

• Consumption of fluids during rehydration after exercise should exceed fluid lost (130-150%).

• It takes 20-30 min for ingested fluids to be evenly distributed throughout the body.

• Heart rate, core temperature and hydration do influence each other during and after exercise- keep on top of hydration.

PUBLICATION NOTE

This information has been reprinted in an adapted form with permission from: Kovacs, M. S., Ellenbecker, T. S., & Kibler, W. B. (Eds.). (2009). Tennis recovery: A comprehensive review of the research. Boca Raton, Florida: USTA.

REFERENCES

Bergeron MF. Exertional heat cramps: recovery and return to play. Journal of Sport Rehabilitation. 2007;16:190-196. https://doi.org/10.1123/jsr.16.3.190

Bergeron MF, Waller JL, Marinik EL. Voluntary fluid intake and core temperature responses in adolscent tennis players: sports beverages versus water. Br J Sports Med. 2006;40:406-410. https://doi.org/10.1136/bjsm.2005.023333

Cheung SS, Sleivert GG. Multiple triggers for hyperthermic fatigue and exhaustion. Exerc Sport Sci Rev. 2004;2004:100-106. https://doi.org/10.1097/00003677-200407000-00005

Convertino V, Armstrong LE, Coyle EF, et al. American College of Sports Medicine position stand: exercise and fluid replacement. Med Sci Sport Exercise. 1996;28:i-vii. https://doi.org/10.1097/00005768-199610000-00045

Costill DL, Sparks KE. Rapid fluid replacement following thermal dehydration. J Appl Physiol. 1973;34:299-303. https://doi.org/10.1152/jappl.1973.34.3.299

Gisolfi CV, Duchman SM. Guidelines for optimal replacement beverages for different athletic events. Med Sci Sports Exerc. 1992;24:679-687. https://doi.org/10.1249/00005768-199206000-00010

Gonzalez-Alonso J, Heaps CL, Coyle EF. Rehydration after exercise with common beverages and water. Int J Sport Med. 1992;13:399-406. https://doi.org/10.1055/s-2007-1021288

Judelson DA, Maresh CM, Anderson CP, et al. Hydration and muscular performance: Does fluid balance affect strength, power, and high- intensity endurance? Spots Med. 2007;37(10):907-921. https://doi.org/10.2165/00007256-200737100-00006

Jones LC, Cleary MA, Lopez RM, Zuri RE, Lopez R. Active dehydration impairs upper and lower body anaerobic muscular power. J Strength Cond Res. 2008;22(2):455-463. https://doi.org/10.1519/JSC.0b013e3181635ba5

Kovacs MS. Hydration and temperature in tennis - a practical review. J Sports Sci Med. 2006;5:1-9.

Kovacs M, Yorio M. The kids are on fire! Heat and hydration tips for junior tennis players. ADDvantage. 2008;32(7):19-21.

Maughan RJ, Leiper JB. Effects of sodium content of ingested fluids on post-exercise rehydration in man. Eur J Appl Physiol. 1995;71:311- 319. https://doi.org/10.1007/BF00240410

Maughan RJ, Shirreffs SM. Recoveryfromprolongedexercise: Restoration of water and electrolyte balance. J Sport Sci. 1997;15(3):297-303. https://doi.org/10.1080/026404197367308

Nadel ER, Mack GW, Nose H. Influence of fluid replacement beverages on body fluid homeostasis during exercise and recovery. In: Gisolfi CV, Lamb DB, eds. Perspectives in Exercise Science and Sports Medicine. Vol 3. Carmel, IN: Benchmark Press; 1990:181-205.

Patel AV, Mihalik JP, Notebaert AJ, Guskiewicz KM, Prentice WE. Neuropsychological Performance, Postural Stability, and Symptoms after Dehydration. Journal of Athletic Training. 2007;42(1):66-75.

Sherman WM. Recovery from endurance exercise. Med Sci Sports Exerc. 1992;24:S336-S339. https://doi.org/10.1249/00005768-199209001-00006

Shirreffs SM, Aragon-Vargas LF, Keil M, Love TD, Phillips S. Rehydration after exercise in the heat: A comparsion of 4 commonly used drinks. Int J Sport Nutr Exerc Metab. 2007;17:244-258. https://doi.org/10.1123/ijsnem.17.3.244

Shirreffs SM, Maughan RJ. Volume repletion after exercise-induced volume depletion in humans: replacement of water and sodium losses. Med Sci Sport Exercise. 1998;274:F868-F875. https://doi.org/10.1152/ajprenal.1998.274.5.F868

Shirreffs SM, Taylor AJ, Leiper JB, Maughan RJ. Post-exercise rehydration in man: effects of volume consumed and drink sodium content. Med Sci Sport Exercise. 1996;28:1260-1271. https://doi.org/10.1097/00005768-199610000-00009

Verde T, Shephard RJ, Corey P, Moore R. Sweat composition in exercise and the heat. J Appl Physiol. 1982;53:1540-1545. https://doi.org/10.1152/jappl.1982.53.6.1540

Von Duvillard SP, Arciero PJ, Tietjen-Smith T, Alford K. Sports drinks, exercise training, and competition. Curr. Sports Med. Rep. 2008;7(4):202-208. https://doi.org/10.1249/JSR.0b013e31817ffa37

Wemple R, Morocco T, Mack G. Influence of sodium replacement on fluid ingestion following exercise-induced dehydration. International Journal of Sports Nutrition. 1997;7:104-116. https://doi.org/10.1123/ijsn.7.2.104

Wendt D, van Loon LJC, van Marken Lichtenbelt WD. Thermoregulation during exercise in the heat: Strategies for maintaining health and performance. Sports Med. 2007;37(8):669-682. https://doi.org/10.2165/00007256-200737080-00002

RECOMMENDED ITF TENNIS ACADEMY CONTENT (CLICK BELOW)