EXERCISE AND BODY FLUIDS

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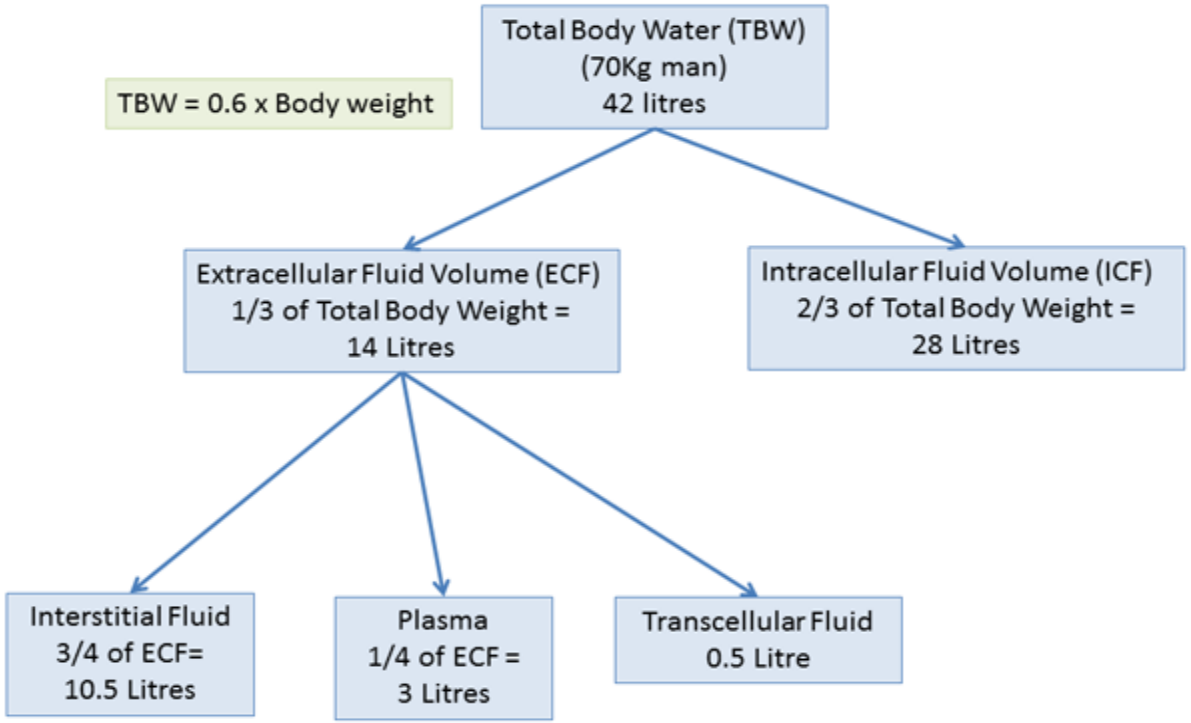
Measurement and Regulation of Body Fluids



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- Alterations to extracellular fluid osmolality can cause cell swelling or shrinking, which can lead to cell death.
- The kidney plays a key role in the close regulation of extracellular fluid osmolality via two primary mechanisms: the osmoreceptor-antidiuretic hormone (ADH, or vasopressin) system; and the thirst mechanism.

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Antidiuretic hormone

- The secretion of **antidiuretic hormone** (ADH, also known as vasopressin, from the posterior pituitary is influenced by the osmolality of body fluids (osmotic), and the volume and pressure of the vascular system
- **Osmotic control** of ADH secretion is highly sensitive, with a change of 1% being sufficient to alter ADH release. Shrinkage of **osmoreceptor cells** located in the anterior hypothalamus (close to supraoptic nuclei) in response to an increase in extracellular fluid osmolality (due to water deficit, for example) leads to nerve signals being sent to hypothalamic ADH-producing neuroendocrine cells, culminating in the release of ADH from axon termini in the posterior pituitary.

Physiology, Body Fluids - StatPearls - NCBI Bookshelf (nih.gov)
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- **Haemodynamic control** of ADH release involves receptors in low pressure (left atrium and large pulmonary vessels) and high pressure (aortic arch and carotid sinus) regions of the circulation, which detect changes in blood volume and pressure, with afferent signals leading to appropriate control of ADH release to restore blood volume/pressure to normal
- This is a much less sensitive mechanism than that of osmotic control; change of 5–10% reduction in blood volume is required for plasma ADH levels to change appreciably.

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- Fluid intake is regulated by the **thirst response**, the conscious desire to drink water.
- Neural centres involved in regulating water intake (thirst centre) located in the hypothalamus (in regions similar to those in control of ADH release) respond to a number of stimuli
- It seems that the ADH and thirst systems work in concert to maintain water balance , although with regard to body fluid osmolality, ADH secretion is secreted at a lower threshold than that for thirst.
- Thus, an increase in plasma osmolality evokes thirst with water ingestion and secretion of ADH with resultant conservation of water, while a fall in plasma osmolality leads to suppressed thirst and a lack of ADH release with enhanced renal water excretion.

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- At the kidney, ADH interact with V_2 receptors on principal (P) cells, promoting the translocation of **aquaporin-2 water channels** to the apical membrane, which results in increased water reabsorption and excretion of a small volume of concentrated urine
- The water conserved dilutes extracellular solutes, thereby correcting the initial hyperosmotic extracellular fluid. The opposite sequence of events occurs with hypo-osmotic extracellular fluid (such as with excess water ingestion).

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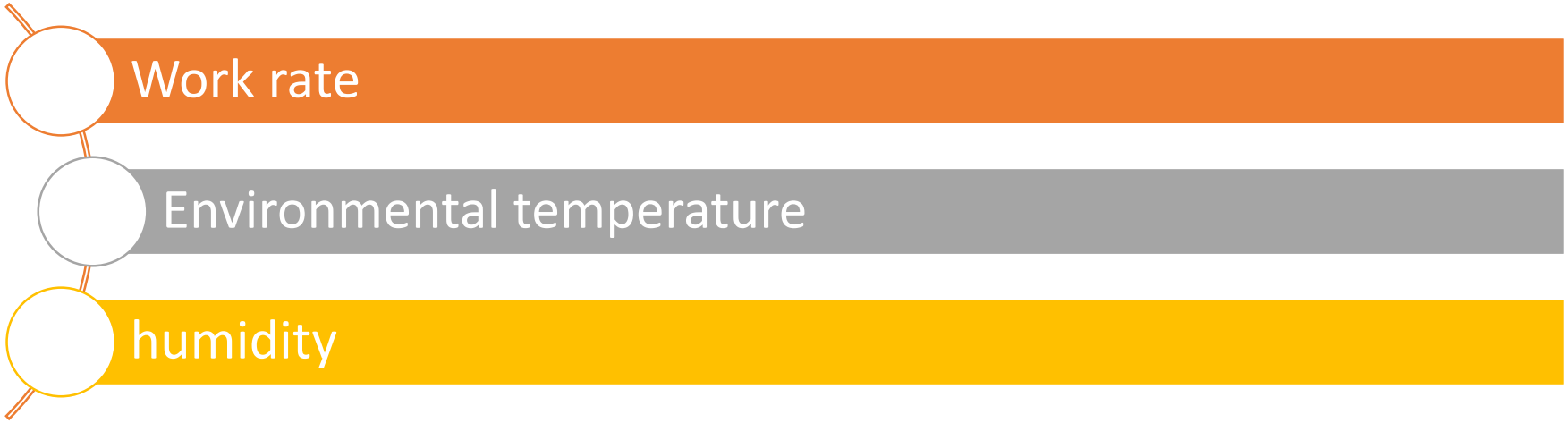
Body fluid loss:

- Prolonged exercise leads to progressive water and electrolyte loss from the body as sweat is secreted to promote heat loss. The rate of sweating depends on many factors and increases in proportion to:

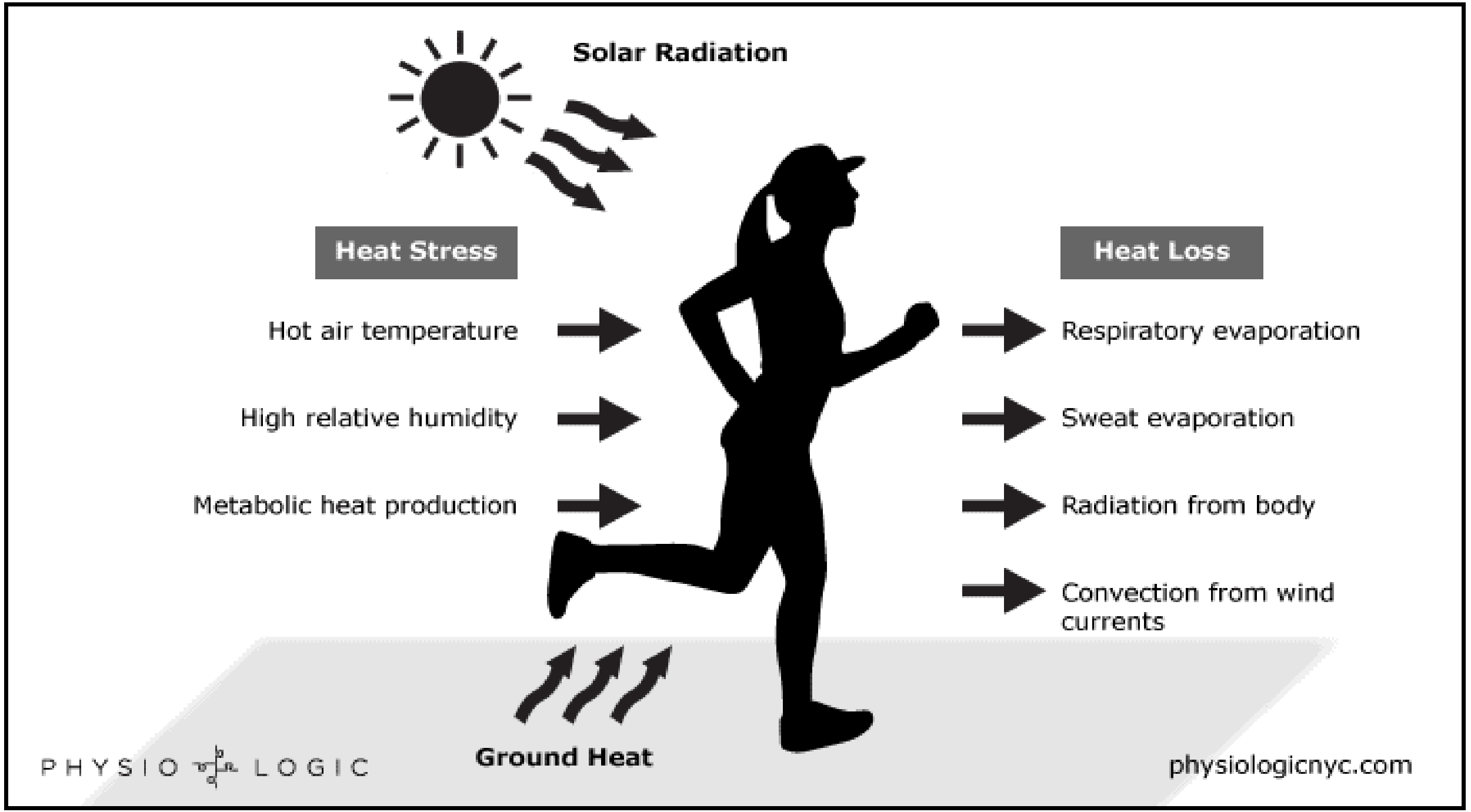


Singh R Jr. Fluid balance and exercise performance. Malays J Nutr. 2003 Mar;9(1):53-74.

Mechanism of fluid loss:

- During exercise, our body uses various fuels (carbohydrate, fat, and protein) to provide energy for our muscles to work.
- The breakdown of these fuel substrates and the resulting muscular contraction produce heat that increases core temperature.
- To prevent excessive heat buildup, our body responds by increasing skin blood flow and sweat secretion.
- Heat exchange between the skin and environment, especially via sweat evaporation, is the primary mechanism for dissipating the excess heat.
- This crucial process also results in a loss of body water and electrolytes.

Exercise and Fluid Replacement.American College of Sports Medicine www.acsm.org


Solar Radiation
Heat Stress
Hot air temperature
High relative humidity
Metabolic heat production
Heat Loss
Respiratory evaporation
Sweat evaporation
Radiation from body
Convection from wind currents
Ground Heat
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Hyponatremia:

A condition that occurs when the level of sodium in the blood is too low.

- With this condition, the body holds onto too much water. This dilutes the amount of sodium in the blood and causes levels to be low.
- Exercise-associated hyponatremia is a serious medical condition that can result in death.
- Risk factors associated with hyponatremia include preexercise overhydration, excessive drinking during exercise, low body weight, female gender, extreme environmental temperatures, exercise pace, and extended exercise duration.

Maintaining fluid balance:

- Fluid replacement must focus on maintain plasma volume so circulation and sweating progress at optimal level.

- Ingesting fluid during exercise increases blood flow to the skin for more effective cooling, independent of any change in plasma volume.

- Adequate hydration provides the most effective defence against heat stress.

ehrer NJ. The maintenance of fluid balance during exercise. Int J Sports Med. 1994 Apr;15(3):122-5.

Before exercise:

- Beverage consumption with meals will enhance fluid replacement and preexercise/event hydration.
- Recovery from the previous exercise session should be 8 to 12 hours or more to enhance fluid replacement.
- Tracking daily weight is helpful in evaluating hydration status because postexercise and day-to-day variations are likely from fluid loss.
- Drinking 16 to 20 fluid oz 4 hours before exercise, especially if preexercise weight is reduced.

•Archer DT, Shirreffs SM. Effect of fluid ingestion rate on post-exercise rehydration in human subjects (Abstract). ***Proc Nutr Soc* 60**: 200A, 2001.

During exercise

- Drinking more than 800 mL per hour is not recommended and may increase the risk for developing dilutional hyponatremia.
- For prolonged exercise, beverages containing 6% to 8% carbohydrate may provide additional benefit.

After exercise:

- Drink 16 to 24 oz of fluid for every pound lost.
- Postexercise meals should include fluid intake.

Glycerol :

- The carbon glycerol molecule achieved clinical notoriety (along with mannitol, sorbitol and urea) for its role in producing osmotic diuresis.
- The capacity to influence water movement within the body makes glycerol effective in reducing excess fluid accumulation (edema) in brain and eye.
- When consumed with 1 to 2L of water, glycerol facilitates intestinal water absorption and extracellular fluid retention, mainly in the plasma and intestinal fluid compartments.

Miller JM, Coyle EF, Sherman WM, Hagberg JM, Costill DL, Fink WJ, Terblanche SE, Holloszy JO. Effect of glycerol feeding on endurance and metabolism during prolonged exercise in man. Med Sci Sports Exerc. 1983;15(3):237-42.

Sodium:

- Restoration of water and electrolyte balance in recovery occurs more rapidly by adding moderate to high amounts of sodium (between 20 and 60mmol/l) to the rehydration drink or combining solid food with appropriate sodium content with plain water.
- Potassium (25mmol/l) enhance water retention in the intracellular space and reestablish by the kidney.

Anastasiou CA, Kavouras SA, Arnaoutis G, et al. Sodium replacement and plasma sodium drop during exercise in the heat when fluid intake matches fluid loss. *J Athl Train*. 2009;44(2):117-123.

Factor that modify heat tolerance:

Acclimatization

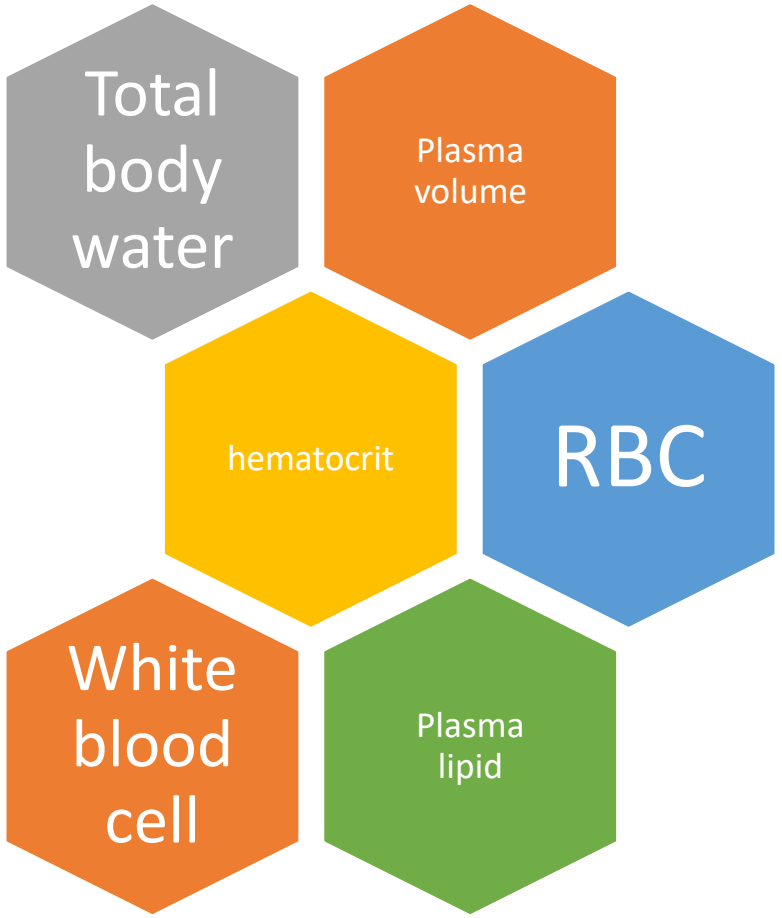
Training status

Age

Gender

Body fat level

Body fluid adjustment:



Sports drink

- A sports drink is any drink consumed in association with sports or exercise, in preparation for exercise, during exercise itself, or as a recovery drink after exercise.
- The main role of a sports beverage is to stimulate rapid fluid absorption, to supply carbohydrate as substrate for use during exercise, to speed rehydration, and to promote overall recovery after exercise.
- Basic sports drinks refer to those drinks formulated for quick replacement of fluids and electrolytes lost during exercise and that provide carbohydrate fuel to the muscles. Sports beverages usually contain a source of carbohydrates, various salts to provide electrolytes, and water.
- Secondary components of sports beverages include vitamins, minerals, choline, and carbonation.

Bagchi D, Nair S and Sen CK . Nutrition and Enhanced Sports Performance. *Muscle Building, Endurance, and Strength.* Second Edition .2019

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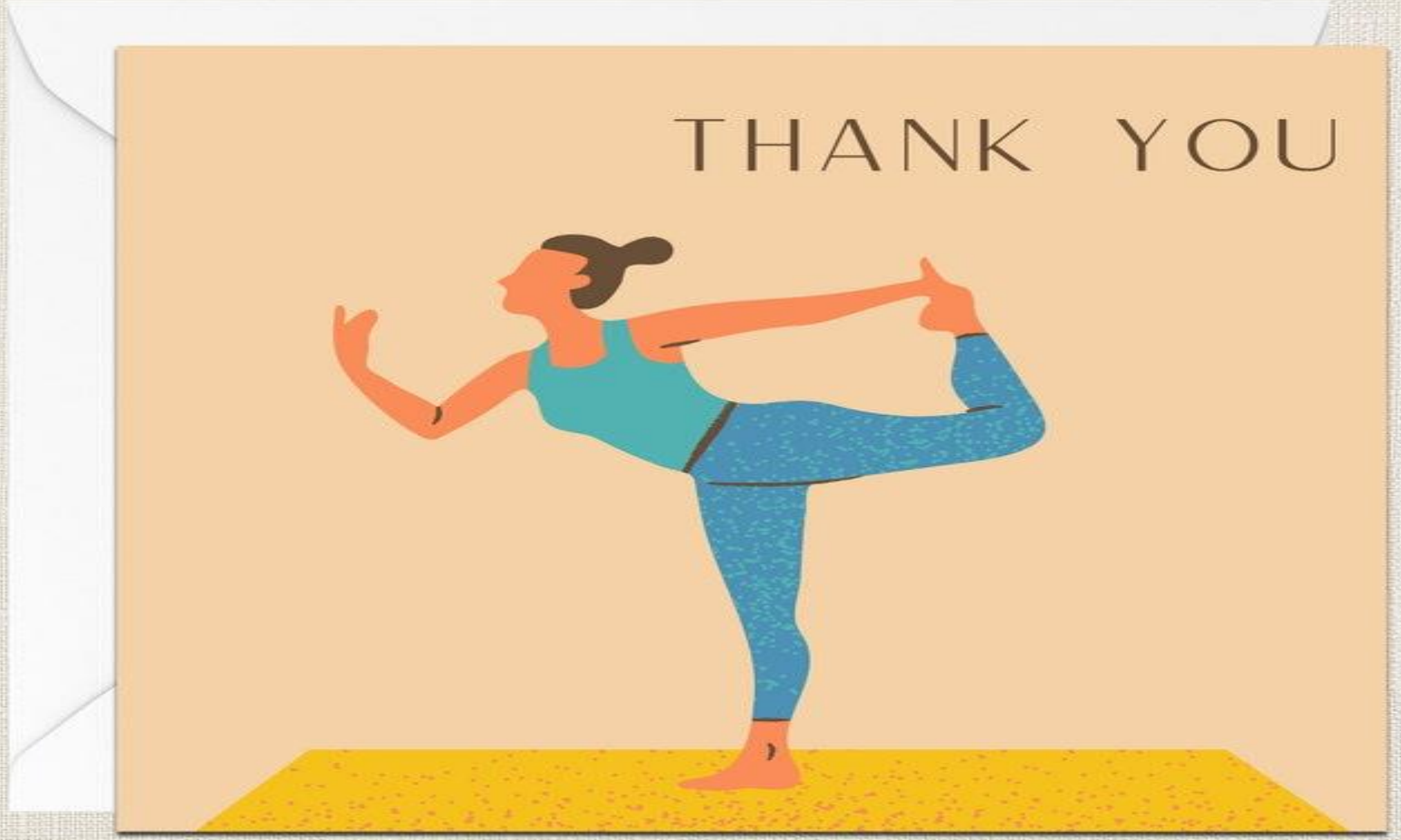
- The hydration effect of sports beverages is not immediate because the fluid must be absorbed in the proximal small intestines, and 50%–60% of any given fluid ingested orally is absorbed here .
- Sports drinks are hypertonic, isotonic, or hypotonic. Most sports beverages tend to be moderately isotonic, meaning their concentration of salts and carbohydrates is similar to that found in the human body. Most sports drink have a carbohydrate content of 6%–9% weight/volume and contain small amounts of electrolytes in the form of salts, most commonly sodium .

Bagchi D, Nair S and Sen CK . Nutrition and Enhanced Sports Performance. *Muscle Building, Endurance, and Strength.* Second Edition .2019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