SESSION 2

Chair: Prof. Marcela González-Gross, PhD. Professor at the Department of Health and Human Performance. Technical University of Madrid. Spain.

Hydration of body cell mass and fat free mass: functional effects in elite athletes

Luís B. Sardinha, PhD.

Professor and Head of Exercise and Health Laboratory. Faculty of Human Kinetics. University of Lisbon. Portugal.

At the cellular body composition level, body mass includes cells, extracellular fluids and extracellular solids. The cellular mass is further divided into fat and body cell mass that includes the body components involved in biochemical processes and energy metabolism. The sum of body cell mass, extracellular fluids and extracellular solids forms the fat-free mass compartment. Both components, body cell mass and fat-free mass are considered the "metabolically active" body components. Total body water can be expressed as the sum of intracellular water and extracellular water. Intracellular water is a body cell mass component and the hydration of fat-free mass includes intracellular and extracellular water. Fat-free mass hydration is relatively stable in adult humans, while water distribution in the intracellular and extracellular compartments is highly variable between subjects and within subjects over time under different conditions, including the training status of athletes. When the extracellular water to intracellular water ratio is approximately 1, there is a normal fat-free mass hydration. When this ratio is greater than 1.2, there is a fat-free mass overhydration, while when the same ratio is less than 0.8 there is a fat-free mass dehydration. Considering that water plays a major role in nutrient transport, waste removal, maintenance of cell volume, and thermal regulation, water changes in the extracellular and intracellular pools may have relevant effects on cell function. This means that total body hydration does not take into account the relative role of cellular level of body composition and the related functional effects of the major ions found in the two cellular water pools.

Using dilution techniques such as deuterium and sodium bromide to estimate total body water and extracellular water, respectively, cross sectional and prospective observational studies with elite athletes have shown that intracellular hydration (total body water-extracellular water) seems to be more related with functional testing than the extracellular water pool. This lecture will address the methodological and biological issues and challenges related to cellular hydration that elite athletes need to deal with in order to maintain or improve their performance.

Key words: body cell mass, hydration, elite athletes.

Dehydration and team sports performance

Juan del Coso Garrigós, PhD.

Head of the Exercise Physiology Laboratory. Camilo José Cela University. Madrid. Spain.

Most field and court team sports are characterized by intermittent activities at near maximal effort interspersed with intervals of low intensity exercise or rest. Such activity patterns are associated with high metabolic demands that produce moderate-to-high body temperatures and a significant loss of body water and electrolytes by sweating. Sweat evaporation dissipates the excess of metabolic heat produced during exercise but it might also affect the body homeostasis of water and electrolytes if these nutrients are not appropriately replenished by drinking. In team sports, the sweating response is influenced by the specific characteristic of the sport such as the frequency and intensity of the efforts, the duration of the play and the pauses during the match and the clothing and equipment worn. In addition, indoor team sports are performed under well-controlled environmental conditions while outdoor team sports are subjected to the stress imposed by the environment conditions. Hot and/or humid environments can increase the amount of sweat lost during exercise. Generally, a dehydration equivalent to a body mass loss of 2% is considered the threshold for reduced physical performance, especially in hot environments. Apart from the physical demands, team sports players perform decision-making actions combined with continuous technical and tactical movements. Thus, dehydration in team sports can affect both the physical performance and the mental qualities related to concentration, precision and decision. An inadequate rehydration during training or competition can also increase the likelihood of suffering heat-related illnesses.

The prevention of dehydration in team sports is obtained with routines performed before, during and after exercise. *Before:* Players should be encouraged to begin exercise well hydrated by ingesting individualized amounts of fluid 2 h before exercise. Consuming beverages that contain sodium or salted snacks will help to stimulate thirst and to retain the liquids consumed before exercise. *During:* Dehydration and fluid demands will be very different among players despite all of them perform the same training routine or play with the same intensity. This is mostly produced by the high inter-individual variability in the sweating responses. It is recommended to estimate the individual sweat rates by measuring body mass before and after exercise. The individualization of players' rehydration bottles might aid in the prevention of dehydration during exercise. Most investigations with team sports have also shown a great inter-individual variability in sweat electrolyte concentrations and it is necessary to pay special attention to "salty sweaters". The use of beverages that include moderate amounts of electrolytes (mainly sodium) will reduce electrolyte deficits during exercise and might prevent muscle cramps in cramp-prone players. The intake of sports drinks, with 6-8% of carbohydrate concentration, might offer some advantages over water rehydration in training or competitions with duration longer than 60 minutes. The accessibility, temperature and palatability of the drink are also important pieces of the fluid intake regime since they will influence the physiological responses of rehydration. Simple tools as body mass scales, urine specific gravity refractometers or urine colour charts can be used for assessing dehydration or hypohydration in the field setting. *After:* A fluid volume equivalent to 1.5 times body mass lost during exercise is recommended. Water ingestion is recommended while the inclusion of sodium (food or drinks) is essential for retention of the water consumed after exercise. To improve the attitudes and behaviours regarding hydration and fluid replacement of team sports players, it is important to increase players' knowledge about the effects of dehydration on performance and the benefits of a proper rehydration. Finally, certain sport situations exclusive of elite teams, such as the existence of more than one competition per week and the continuous domestic and international travelling, require more investigation to elucidate fluid requirements of elite team sports players.

Key words: hydration, fluid balance, sodium, thirst, sweat.

Dehydration and endurance performance in competitive athletes

Bob Murray, PhD.

FACSM. Founder and principal of Sports Science Insights, LLC. United States of America.

The negative impact of dehydration on physiological function and physical performance was noted in the scientific literature during the late 1800s, although the performance-sapping impact of dehydration was undoubtedly apparent for centuries before that to anyone who labored without adequate fluid intake. The reduction in body water from normal levels (also referred to as hypohydration) is associated with unavoidable changes in physiological function that become increasingly greater as dehydration worsens. Specifically, a wide variety of cardiovascular, thermoregulatory, metabolic, and central nervous functions are measurably altered and the combined effect of those alterations degrade performance capacity, especially when physical activity is performed in warm environments (e.g., > 15° C). When dehydration occurs during physical activity in the heat, the resulting performance decrements are greater than when similar activity occurs in cooler conditions, a difference thought to be due at least in part to the greater cardiovascular and thermoregulatory strain associated with heat exposure. Physical performance during prolonged, continuous exercise in the heat is consistently impaired by levels of dehydration ≥ -2% body mass, and there is accumulating evidence that lower levels of dehydration (< -2% body mass) can also impair performance, even during relatively short-duration, intermittent exercise. Future research is bound to improve our understanding of how low-level dehydration impacts physical performance, but on the basis of the existing scientific evidence, it can be said that when performance is at stake, it is always better to be well hydrated than dehydrated, a generalization that holds true in athletic, occupational, and military settings.

Key words: dehydration, performance, hypohydration.

Ingestion of salt and fluid: effects on blood volume and exercise performance

Ricardo Mora Rodríguez, PhD.

Professor and Head of the Exercise Physiology Laboratory. University of Castilla-La Mancha.Toledo. Spain.

One of the more visible responses to prolonged exercise in a hot environment is a progressive elevation in heart rate as the subjects become dehydrated and hot. As a consequence, for a given exercise intensity, heart rate could be increased by 10-30 beats when exercise takes place in the summer time *vs.* winter time. The increases in heart rate have implications for exercise prescription. Heart rate is often used as an index of exercise intensity when athletes and patients train to improve their performance and health, respectively. Large differences in heart rate due to environmental conditions (hot *vs.* thermoneutral) despite similar absolute workload insinuate that heart rate is an invalid index of exercise intensity when exercising in a hot environment. However, in recent studies it has been shown that maximal aerobic capacity (i.e., VO_2max) also declines during exercise in hyperthermic or dehydrated subjects (Gonzalez-Alonso et al., 2003). Thus, some authors argue that heart rate remains a useful index of exercise intensity because the increase in heart rate is proportional to the increase in the relative VO_2max due to the reduction in absolute VO_2max (Wingo et al., 2012). However, it is unknown if lowering exercise intensity during exercise in the heat in an attempt to maintain the target heart rate would undermine the training adaptations.

Dehydration accompanies hyperthermia and causes plasma volume reductions which accentuate heart rate drift resulting in cardiovascular strain. In turn, cardiovascular strain is closely associated with the perceived exertion and reductions in exercise performance. The plasma volume reductions with dehydration could be partially compensated by the use of plasma volume expanders. The infusion of plasma volume expanders has been used to investigate if that manipulation could alleviate the cardiovascular and thermal strain caused by exercise induced dehydration (Montain and Coyle, 1992). A more ecological approach is to use pre- exercise salt and fluid ingestion with the intention of expanding plasma volume. This manipulation has received an increasing amount of attention in the literature in recent years. In four studies, pre- exercise salt and fluid ingestion improved performance, measured as time to exhaustion, either during exercise in a hot (Hamouti et al., 2012; Sims et al., 2007) or thermoneutral environment (Nelson et al., 2008). In my talk I will present detailed information from these studies and discuss the mechanisms behind this ergogenic effect.

Key words: heart rate, stroke volume, cardiovascular drift, plasma volume expansion, performance.

CONFERENCE

Chair: Prof. Carmen Gómez-Candela, PhD. Head of Clinical Nutrition Department. La Paz University Hospital. Madrid. Spain.

Thirst and hydration status in daily life

Speaker: Prof. Mindy Millard-Stafford, PhD. Professor and Associate Chair of School of Applied Physiology. Georgia Institute of Technology. Atlanta. United States of America.

Water is an essential nutrient for all persons and is obtained mostly by drinking beverages along with contributions from food (~20% of total daily fluid). Daily water requirements have been systematically evaluated through water balance, water turnover, and/or water consumption studies. Numerous population-based survey data also have been published recently. The scientific basis for a common U.S. recommendation of drinking "8 glasses of 8 ounces of water per day" is lacking; consequently, limited evidence is available to assure drinking less will do *no* harm but neither does it validate that this dose (1.89 L) is optimal for health. A 2013 report from the Centers for Disease Control and Prevention indicated 7% of adults in the U.S. report no daily drinking of tap or bottled water, 36% drank 1-3 cups, 35% drank 4-7 cups, while 22% drank > 8 cups. The likelihood of drinking < 4 cups of water per day increased with age (> 55 yr), geographically cooler climates, low fruit/vegetable intake and sedentary lifestyle (< 150 minutes per week). This report is not inconsistent with 2005-2008 nationally-represented government survey data (NHANES) indicating U.S. adults drank an average of 4.3 cups of water per day. A reference document for Adequate Intake (AI) published by the Institute of Medicine (2004) acknowledges a range of daily fluid intake values can maintain daily hydration status with a median AI for healthy adult men and women (age 19- 50 yr) as 3.7 and 2.7 L per day (for those not physically active or exposed to hot weather). This AI is not different for older individuals (> 50 yr). The 2010 European Food Safety Authority AI for water is 2.5 and 2.0 L for men and women, respectively. Does the AI, however, assure optimal hydration status? Published data available suggest that with the exception of some diseases and special circumstances (strenuous exercise, long airplane flights, and climate), most adults are probably drinking enough total fluid (when accounting for all sources of water from all types of beverages combined with food). A recent investigation which examined hydration status biomarkers and thirst when ingesting the IOM median water intake will be discussed.

For the majority of healthy populations, fluid balance is maintained via thirst, a feedback-controlled variable, regulated acutely by central and peripheral mechanisms. However, voluntary drinking is also a behavior influenced by other environmental, social, and psychological cues. For example, during cold exposure, thirst is significantly blunted independently of hydration status or activity. Therefore, whether "thirst-guided" drinking maintains optimal hydration is a multi-factorial issue. Thirst perception is typically assessed by subjective ratings using categorical or visual analog scales. However, the timing of thirst perception may not correlate with the volume of fluid individuals ingest during periods of voluntary drinking. In cystic fibrosis patients who become dehydrated, drinking behaviour does not match their fluid loss due to this population's greater need for sodium which is lost in excess in the sweat. Whether ratings of perceived thirst or ad libitum drinking are preferred metrics of human thirst remains unclear. Understanding the neural correlates and activation pattern of brain regions associated with thirst due to dehydration is currently under investigation. The recommendation "drink to thirst" is frequently given to healthy individuals during daily life. However, factors and conditions (e.g., age, disease) that influence thirst as a biomarker should continue to be investigated along with improved non-invasive methodological techniques.

Key words: fluid balance, fluid intake, water, beverages.