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International Federation of Clinical Chemistry and Laboratory Medicine individuals, and that water turnover is directly related to exercise intensity and duration even in relatively cool conditions. A measure of non-renal water losses can also be made from the difference between daily water turnover rate and 24 hour urine volumes. Subtracting the estimated faecal, insensible and respiratory water losses from the non-renal water loss can give an approximation of daily sweat losses. Most individuals, even those who very active, tend to maintain total body water content on a daily basis, however, there are some exceptions to this general finding.

INFLUENCE OF MILD DEHYDRATION ON HEALTH

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In the past scientific interest of medicine concerning water metabolism was mainly directed to the extremes, severe dehydration and water intoxication. There is increasing evidence, however, that mild dehydration as well may account for different morbidity. Thus, the topic "Health Effects of Mild Dehydration" was discussed on the "2nd International Conference on Hydration throughout Life" in Dortmund, Oct. 8 – 9, 2001. There is no accepted "gold standard" for hydration markers. As a consequence, the effects of mild dehydration on the development of several disorders and diseases have not been well documented.

Based on data of urine osmolality (Uosm) there are remarkable ontogenetic, individual and cultural differences of hydration status. Uosm is a concentration. It does not quantify volumes. Therefore, free water reserve (FWR) in ml/24h was defined to quantify individual 24h hydration status. FWR corresponds to the difference between the measured 24h urine volume and the ideal urine volume (ml/24h) necessary to excrete the actual urine solutes (mosm/24h) at an Uosm corresponding to the 3rd percentile of maximum Uosm of the group. In healthy children and young adults with a typical western style of diet this physiological criterion of water requirement is 830 mosm/kg. Using individual data of FWR and total water intake in 4 groups of healthy children of the DONALD Study adequate total water intake values were calculated.

In the month of Ramadan Muslims practice voluntary restriction of food and fluid intake between the sun rise and the sun set. The Holy book, Quran, exempts, however, several groups of the population. Several scientific expert groups recommended a regular high fluid intake in secondary prevention in patients with urolithiasis, constipation and broncho-pulmonary disorders. The conference showed that there is varying strength of evidence for a relatively high level of water intake for a high exercise performance, wellness, cognitive function and mental performance as well as in the prevention or therapy of chronic renal failure, diabetic nephropathy, salt-sensitive hypertension, urolithiasis, urinary tract infection, dental diseases, brochopulmonary disorders and constipation. In epidemiologic studies the association between fluid intake and bladder and colorectal cancer was far from consistent. Although acute hypohydration results in an increased protein catabolism and a decreased lipolysis and lipid oxidation, there are no clinical data hinting to a beneficial effect of a high level of total water intake in the treatment of adiposity. Much more research is needed to increase the strength of evidence of the beneficial effects of a high water intake in most of these disorders.

INFLUENCE OF MILD DEHYDRATION ON EXERCISE PERFORMANCE

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A considerable amount of attention has been paid to the consequences of severe dehydration during physical activity. During ultra-endurance events such as marathons and triathlons, many of the competitors will finish with dehydration of 4 % body mass or more, and such levels of hypohydration have been shown to significantly impair exercise performance. However, it is possible to argue that most recreational athletes and physically-active people do not incur more than a mild dehydration. How serious are the performance effects of this mild dehydration?

"Mild dehydration" could be defined conveniently as that level of dehydration that has no negative impact on exercise performance, but this would cut the abstract and presentation a bit too short! Two alternative trends are found in the scientific literature. One is to consider dehydration as mild when it corresponds to a moderate, shorter effort in a "mild" environment. This would correspond to values from 1.8 %[10], to 2.6 %[7], to about 3.6 %[3] body weight (BW). The other trend is to discuss mild dehydration as a chronic hypohydration typical of certain groups with apparently inadequate fluid intake or excessive fluid loss such as institutionalized elderly patients, persons subject to diuretics, or people who live in the desert[6]. Because of the subjective nature of this latter definition, it does not lend itself properly to systematic experimental analysis. However, to the extent that performance or physiological responses are improved by temporarily increasing daily fluid intake, it may be concluded that some normal people are indeed chronically hypohydrated[5,8].

Even a small amount of dehydration (1 % BW) can increase cardiovascular strain and limit thermoregulatory function during exercise[1]. Although they could not show a VO2max decrement with dehydration, Armstrong et al.[2] demonstrated a clear deterioration of running speed and race times for outdoor races of 1,500 m, 5,000 m, and 10,000 m, resulting from 2 % BW dehydration induced by a diuretic.

It is clear that exercising in a hypohydrated state has a negative effect on performance, but Walsh et al. criticized the conclusions drawn from studies where subjects initiated exercise already in a state of hypohydration, claiming that the negative physiological consequences tend to be more serious than when dehydration develops during exercise[10]. In their study, however, they showed that high-intensity cycling time to exhaustion was impaired when subjects were allowed to dehydrate by only 1.8 % BW during exercise, compared to a fluid replacement condition.

Many other studies have addressed the effects of dehydration DURING exercise. A clear dose-response relationship has been used to support the idea that mild dehydration has negative physiological and performance consequences[4,9]. Coyle and Montain (1992) argue against a dehydration threshold for the impairment of thermoregulation, cardiovascular function, and performance. Instead, they show a direct relationship between the degree of dehydration incurred during exercise (evaluating dehydration levels from 1 % to 4 % BW), and the change in rectal temperature, cardiac output, and heart rate.

In conclusion, the use of several different approaches allows for a confirmation of the hypothesis that mild (1 – 3 % BW) dehydration has a negative effect on exercise performance. This effect is greater when heat stress is greater, when exercise duration is longer, and when exercise intensity is higher.

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OPTIMISING HYDRATION: FLUID INTAKE STRATEGIES FOR THE PHYSICALLY ACTIVE

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The effects on performance of an uncorrected fluid deficit should persuade all athletes to attempt to remain fully hydrated at all times. Before exercise, fluid should be consumed to ensure euhydration. Pre-exercise hyperhydration has been investigated and attempted by infusion of saline or glycerol ingestion. During exercise, drinking to prevent or minimise as far as possible the development of hypohydration by replacing sweat losses should be attempted. After execise, hydration strategies should aim to correct a fluid deficit if it occurred as is almost inevitable if exercise took place in a warm environment or it was at a relatively high intensity.

The rates at which ingested substances, including water, can be supplied to the body are limited by the rates of gastric emptying and intestinal absorption. During exercise a person may have the twin nutritional aims of providing carbohydrate substrate to supplement the body glycogen stores and to provide water to replace the sweat losses. Increasing the energy content of drinks will increase the amount of fuel which can be supplied, but will tend to decrease the rate at which water can be made available. Even dilute glucose solutions (40g/l or more) will slow the rate of gastric emptying, but active absorption of glucose, which is co-transported with sodium in the small intestine, stimulates water absorption by producing suitable trans-mucosal osmotic gradients. The highest rates of oral water replacement are thus achieved with dilute solutions of glucose and sodium salts. Volume has a stimulating effect on the rate of gastric emptying, and if the volume in the stomach can be kept high by repeated ingestion of fluid, the rate of gastric emptying can be maintained high increasing the volume of fluid available in the intestine for absorption. During exercise where provision of water is the first priority, therefore, the carbohydrate content of drinks will be low, perhaps about 30 – 50 g/l, even though this restricts the rate at which substrate is provided. The addition of sodium to drinks has been questioned on the grounds that secretion of sodium into the intestinal lumen will occur sufficiently rapidly to stimulate maximal rates of glucose-sodium co-transport, although the evidence here is also questionable.

The effects of ingesting different types and amounts of beverages during exercise have been extensively investigated, using a wide variety of experimental models. Not all of these studies have shown a positive effect of fluid ingestion on performance, but, with the exception of a few investigations where the composition of the drinks administered was such as to result in gastro-intestinal disturbances, there are no studies showing that fluid ingestion will have an adverse effect on performance. In prolonged exercise where substrate depletion is likely to occur, or during exercise in the heat which is sufficiently prolonged to result in dehydration, there can be no question that performance is improved by the regular ingestion of suitable glucose-electrolyte drinks.

Replacement of water and electrolyte losses in the post-exercise period may be of crucial importance for maintenance of exercise capacity when repeated bouts of exercise have to be performed. The need for replacement will depend on the extent of the losses incurred during exercise, but will also be influenced by the time and nature of subsequent exercise bouts. Rapid rehydration may also be important in events where competitors undergo acute thermal and exercise-induced dehydration in order to make a weight category.

Rehydration after exercise requires not only replacement of volume losses, but also replacement of the electrolytes, primarily sodium, lost in the sweat. Where sweat losses are large, the total sodium loss will be high: 10 litres of sweat at a sodium concentration of 50 $mmol.l^{-1}$ amounts to about 29 g of sodium chloride.