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Possible advantages of sodium induced hyperhydration before physical activity

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Introduction and objective:

Athlete's performance depends both on training and nutrition. Although athletes analyze macronutrients intake, micronutrients are often omitted, with sodium among them. It is proven to boost performance, due to its hydrating qualities. The aim of this study is to explore positive effects of salt induced hyperhydration, its effect on muscle cramps, exercise associated hyponatremia, prevention of dehydration and possible endurance gain.

Purpose of the study:

The aim of this study is to look further into the positive effects of sodium loading induced hyperhydration, its effect on muscle cramps, exercise associated hyponatremia, prevention of dehydration and possible endurance gain using PubMed databases from the last 25 years.

Review methods:

Articles were searched by entering keywords in PubMed databases. Scientific articles written from 2016 to 2024 make up 76% of the literature. Guidelines from global societies of dietary health and sport. Studies from specialized research centers including meta-analyses and double-blind randomized trials were included. Ones conducted with methodological errors were rejected.

Basic results and conclusions:

We can draw a conclusion that salt-loading might indeed prove useful in endurance training preparation, and should be included in an athlete's supplements arsenal. Dehydrating nature of heat and long training make salt induced hyperhydration more efficient in such conditions. Sportsmen can improve results in both endurance performance and reduction of the occurrence of possible negative outcomes connected with metabolic and physical strain. Presented studies also advocate for the importance of sodium loading in prevention of hyponatremia and muscle cramps.

Keywords: micronutrients, sports performance, supplementation, physical activity, salt, sodium

Sodium- why so important

Sodium chloride is a non-organic compound, which cannot be produced by the human body and thus, must be provided from an exogenous source. The proper NaCl intake guarantees optimal blood volume and increases blood pressure [1]. Sodium also presents itself as the key element of neuromuscular junction, which carries information from the central nervous system, through motor neurons to muscle fibers [2]. During physical activity, our body produces heat, which must be discharged - mostly while sweating [3]. This leads to the loss of both water and

minerals and although the results are not identical amongst researched groups - athletes lose from 0,51g to 6.7g of sodium per an hour of exercise [4, 5] - meaning that in just one hour of exercise we can lose an amount of salt that far exceeds the recommended daily intake, which is 5 grams a day according to WHO, 5.75 grams according to CDC and 3.75g according to AHA [6, 7, 8]. There are studies, which claim that there might be a connection between hyponatremia and exercise-associated muscle cramps [9]. Exercise-associated hyponatremia may present symptoms such as: nausea and vomiting, headache, confusion, loss of energy, and even seizures or coma [10]. Sodium also lowers urine production [11] and increases thirst [12].

Dehydration

Dehydration is defined as a condition that occurs when the loss of body water exceeds the water intake. It can lead to a disruption of the body's normal balance of electrolytes and fluids that are necessary for maintaining homeostasis. It is most often associated with either an increased loss due to excessive sweating and breathing, or insufficient fluid and mineral intake. Even the slight levels of the dehydration (2% of body mass) can lead to an impaired exercise capacity, thermoregulatory responses and fluid management, as well as a depreciated mental capacity and motor skills [13,14,15]. The effects of dehydration are even more evident in long lasting exercises, or in hot environments. Dehydrated individuals tend to have a higher post-exercise core body temperature which might indicate imperfect heat dissipation. Many athletes start the exercise already dehydrated [16]. Even the slightest feeling of thirst can suggest the need to replenish water demand. Conducted research has shown that dehydration may leave a mark on physical performance for up to 24 hours [17]. It was measured with handgrip strength tests, sled push time trials and medical ball throw distance, and also present worse motor-cognitive function [18]. Furthermore, athletes tend to run slower due to dehydration [19,20]. Impaired hydration might also affect the mood and increase tension/anxiety of competing sportsmen, which ultimately leads to unsatisfactory results [21]. Due to the fact that humans mostly drink as a response to the feeling of thirst, we tend to enter the activity either in a state of euhydration or slightly dehydrated. Researchers found out that dehydration impairs sportsman performance independently of perceived feel of thirst, meaning we can not rely on instinct when it comes to hydration status. [44,45,46]

Exercise-associated muscle cramps- EAMC

Muscle cramps are non-voluntary spasms of muscle tissue, which can last anywhere from seconds, up to a few minutes [22]. Although muscle cramps are most often self-resolving, they can impair physical performance. They may happen for no distinct reason, but several factors might lead to more common occurrences. There are many types of cramps, one of them being EAMC which is a type of muscle spasm that occurs during or shortly after physical performance. It most often concerns the muscles that part take in a multiple joint movement and are commonly used during exercise [23]. Researchers observed that muscle cramping associated with exercise has boosted occurrence during the hot season [24]. Similar cases are miners, roofers and steelworkers toiling in hot environments - they tend to cramp more often [25]. Jumping to the conclusion, we can develop a theory that excessive water, or mineral loss with sweat might diminish proper muscle function. Research conducted by Wing Yin Lau and his team proved that multimineral drinks after exercise prevents muscle cramping, whilst drinking

pure water worsen the situation due to further electrolyte dilution [26]. Researchers found out that prior dehydration plays a role in EAMC etiology[27,28]. This information presents us with the idea that the intake of heavily salted beverages, prior to exertion, could prove useful in prevention of developing EAMC, due to the effect of increasing plasma volume [29], as well as condensing electrolyte concentration.

Exercise associated hyponatremia-EAH

Exercise associated hyponatremia is a type of hyponatremia that occurs during, or within 24 hours after physical activity. In general, hyponatremia is a state when blood's sodium concentration drops below 135 mmol/L, and its severe variant concerns sodium level below 125 mmol/L [30]. Prevalence of EAH varies on different factors - temperature conditions, gender (women are more prone to EAH), polydipsia, low BMI [31,32,33]. This disease most commonly affects endurance athletes and its incidence is calculated at 2 to 7 percent [34]. Probable pathophysiological causes are sodium loss while sweat, an increased intake of hypotonic drinks during the race and persistent secretion of antidiuretic hormone (ADH). That results in inadequate water retention [35,36]. Symptoms vary on severity of hyponatremia and level of individual adaptation to low sodium level. Nausea, vomiting and headaches mostly represent moderate hyponatremia, whereas coma and seizures are signs of a more developed one [37,38].
Researches and guidelines agree, that the most effective treatment of severe hyponatremia is intravenous administration of hypertonic saline (eg. 3% NaCL), mostly using a bolus of 150ml 3%NaCl, with follow-up infusions with constant sodium level reevaluations [39-42]. Patients suffering from mild to moderate hyponatremia can be treated with an oral administration of heavily salted beverage or fluid intake restriction, in order to concentrate sodium density [36,43].
The main strategies of EAH prevention consider reduced fluid administration before and during long-lasting races in order to avoid overhydration. We suggest that salt intake before physical performance might also be useful, due to its hypertonic characteristic and thirst suppression.

Examples highlighting the positive impact of salt loading on endurance

For all reasons above, salt administration before training might prove useful for endurance athletes. But how does it look in numbers? We gathered plenty of research in order to extrapolate and further analyze the data.

David M Morris conducted a research in which a group of subjects was divided into two subgroups. The first one has ingested sodium, and the other one has not [47]. Both groups then performed a 60 minute ride followed by a 200kJ performance time trial. Below table [Table 1] shows the numerical data collected during said research. The study shows that individuals who ingested sodium before the trial had an overall better performance than the other subgroup. They also had a significantly lower dehydration rate.

Table 1: Results of salt administrated and non-administered individuals in David M Morris' research.

	Dehydration	Completion time	Water consumption and retention
Salt administered individuals	0.7 ± 0.6%	773 ± 158 s	1380 ± 580 mL consumed, 821 ± 367 ml retained
No salt	1.6 ± 0.4%)	851 ± 156 s	782 ± 454 ml consumed, 148 ± 289 mL retained

Stacy T Sims' has conducted a study in which they analyzed the effect of sodium loading on eight endurance trained male runners [48]. The group was asked to run at 70% VO2max to either exhaustion or a body temperature that exceeded 39.5*C. One to three weeks later, the same group was asked to do the same but this time they were administered an additional salt serving beforehand. The following table [Table 2] shows the data collected during the study. Cases in which the individuals were administered salt proved to have a better effect on both time to exercise termination due to reached exhaustion and Time to exercise termination due to reached 39.5*C body temperature.

Table 2:Results of salt administrated and non-administered trials in Stacy T Sims' research.

	Average time to exercise termination due to reached exhaustion	Average Time to exercise termination due to reached 39.5*C body temperature
Salt administered trial	96,1 min	57,6 min
No salt	75,3 min	46,4min

A different research conducted by Stacy T Sims' put under the microscope a group of thirteen moderately trained women in a high-hormone phase, either natural or stimulated by an oral contraceptive pill (OCP) [49]. Six of the women ingested highly concentrated sodium beverages, and seven did not. Then both groups were asked to cycle in warm conditions up to a point of exhaustion. Below table [Table 3] shows the data collected during the research. It was once again proved that salt intake benefits endurance as the salt-administered group performed better than the second one.

Table 3: Results of salt administered and non-administrated moderately-trained women cycling in warm condition

	Time to exhaustion
Salt administered females+OCP	100.3 min
Salt administered females	96.3 min

No salt, only OCP	82.1 min
No salt, no OCP	77.6 min

In research conducted by M G Coles, a group of fourteen 23 to 32 year-old, moderately fit, male, recreational cyclists were divided into two groups [50]. Half of them were given a highly salted beverage and the other one was not. Both groups were then asked to first cycle for 45 minutes at 70% of maximal work rate, then tested in a 15 minutes time-trial performance. The following table [Table 4] shows the results of the time-trial distance reached. Salt administered individuals on average performed almost 10% better than the second group.

Table 4: Results of salt administered individuals in comparison to athletes without salt loading

	Distance traveled
Salt administered individuals	9.98 ± 0.64 km
No salt	10.94 ± 0.48 km

Disclosure:

Author's contribution:

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