european hydration institute

SCIENTIFIC DOSSIER ON:

Development of a hydration index: a randomised trial to assess the potential of different beverages to affect hydration status

INDEX

Notes:
Data are Mean ± SD.
The Hydration Index (HI) of a drink is defined as the volume of urine produced after drinking one litre expressed relative to a standard treatment of still water.[3] It can be thought of as the short-term hydration potential of a drink.

1. Citation

Maughan RJ, Watson P, Cordery PA, Walsh NP, Oliver SJ, Dolci A, Rodriguez-Sanchez N, & Galloway SD. (2016). A randomized trial to assess the potential of different beverages to affect hydration status: development of a beverage hydration index. Am J Clin Nutr. 103(3):717-23.

2. Published paper's abstract

Background: The water content of ingested beverages enters the body water pool at a rate dictated by the rates of gastric emptying and intestinal absorption. Water is subsequently lost from the body by various routes, primarily urine in the absence of sweating. The post-ingestion diuretic response following prior hypohydration is influenced by several characteristics of the drink, including primarily volume, energy density, electrolyte content, and the presence of diuretic agents.

Objective: This study investigated the effects of 13 different commonly-consumed drinks on urine output and fluid balance when ingested in a euhydrated state, with a view to establishing a Hydration Index (HI; i.e. volume of urine produced after drinking expressed relative to a standard treatment [still water]).

Design: Each subject (n = 72, euhydrated and fasted males) ingested 1 L of still water or one of three other commercially-available beverages over a period of 30 minutes. Urine output was then collected for the subsequent 4h. HI was corrected for water content of drinks and was calculated as the amount of water retained at 2h after ingestion, relative to that observed following ingestion of still water.

Results: Total urine masses (mean (SD)) over 4h were smaller than the still water control (1337(330) g) after oral rehydration solution (ORS, 1038(333) g, *P*=0.004), full-fat milk (1052(267) g, *P*=0.006) and skimmed milk (1049(334) g, *P*=0.005). Cumulative urine output at 4h after ingestion of cola, diet cola, tea, cold tea, coffee, lager, orange juice, sparkling water and a sports drink were not different from the response to water ingestion. The mean HI at 2h was 1.53(0.74) for ORS, 1.32(0.51) for full-fat milk, and 1.44(0.54) for skimmed milk.

Conclusions: A HI may be a useful measure to identify the short-term hydration potential of different beverages when ingested in a euhydrated state.

3. Background

Maintaining an appropriate body water content (hydration status) helps prevent adverse outcomes that can result from acute or chronic over- or under-hydration. Body water is lost continually throughout the day and night but intake is episodic. Therefore it is normal for hydration status to fluctuate throughout the day.

Adequate daily water intakes have been defined by the Institute of Medicine in the US (3.7 L for men and 3.0 L for women) and by the European Food Safety Authority in Europe (2.5 L for men and 2.0 L for women). But these do not address the distribution of consumption over the course of the 24h period, or the composition of these intakes and both these factors may be important in determining how well an individual is able to maintain an adequate hydration status.

The volume and composition of drinks influence the rates at which they empty from the stomach and are absorbed in the small intestine, thus affecting how quickly or slowly they enter into the body water pool. The ingredients in a beverage are also metabolised and excreted on different time scales. Increasing osmolality and energy density will slow gastric emptying, limiting the rate of entry of nutrients (and water) into the small intestine. Osmolality, carbohydrate type and concentration and electrolyte (primarily sodium) content will all affect the rate of intestinal solute and water absorption. Rapid absorption of a drink will tend to promote a diuretic response while the presence of high concentrations of electrolytes, and perhaps also other solutes, will tend to delay urinary water losses. All this together can influence the resulting hydration status profiles of a person in the first few hours after ingestion of different beverages.

A Hydration Index (HI) could be used to define the hydration response to any particular drink, in a similar manner to the Glycemic Index (GI) defining the blood glucose response to ingestion of foods. For the HI, the cumulative volume of urine passed over a fixed period of time is in effect the area under the curve for renal water excretion. The urine volume passed relative to a standard treatment (still water) can therefore be calculated as the HI of a beverage. This was the aim of the present study.

4. Study aims and objectives

To assess the fluid balance responses (when euhydrated) to the ingestion of one litre of different beverages, with the data used to establish the feasibility of establishing a HI.

5. Methods

Study = Three centre randomised cross-over trials completed after Research Ethics Committee approval at all three centres and written informed consent of volunteers.

Subjects = 72 recreationally active, healthy males.

- Age 25 ± 4 years
- Body mass 77.3 ± 9.9 kg
- Height 178 ± 6 cm
- BMI 24 ± 3
- Daily water intake 2.0 ± 0.8 litres

Each subject took part in a maximum of 4 experimental trials (i.e. four different drinks, one of which was still water). The full list of drinks tested is:

- Still water
- Sparkling water
- Cola
- Diet cola
- Sports drink
- Oral rehydration solution (ORS)
- Orange juice
- Lager beer
- Hot black coffee
- Hot black tea
- Cold black tea
- Full fat milk
- Skimmed milk

Subject exclusion criteria were a history of cardiovascular, renal, musculo-skeletal or metabolic diseases, and those on a energy-restricted diet or exercise plan.

Protocol outline =

- Two days pre-trial food and activity standardisation.
- No alcohol or strenuous activity 24h before trials.
- >8h overnight fast, except 500mL plain water 1h before lab arrival; urine sample upon waking.
- At laboratory, blood sample after 10 min seated rest, urine sample and near-nude (underwear only) body mass.
- Consumption of 1L of test drink, consumed in four equal aliquots 7.5 min apart.
- Urine sample at end of drinking and hourly for 4h.
- Repeat of near-nude body mass measurement.

Data collected during the study =

- Subject characteristics (summarised above).
- Drink composition (osmolality, Na, K) from a sample of each drink.
- Urine volume and osmolality, Na and K concentrations.
- Serum osmolality.

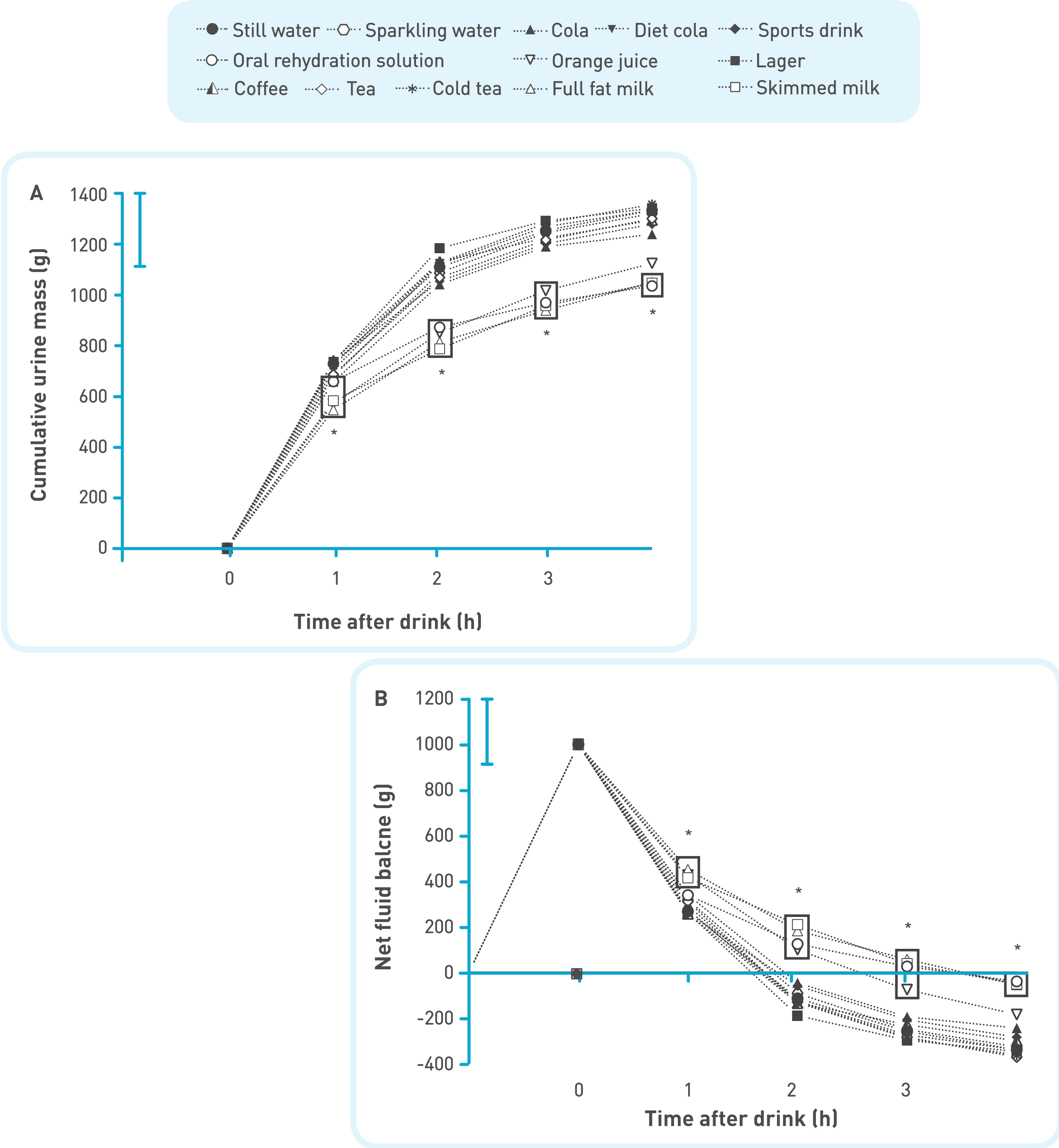
6. Key results

Comparison of control trial data from the three study centres indicated that subjects were similar and had similar fluid regulation thus data from the three centres was combined.

a) URINE OUTPUT AND FLUID BALANCE

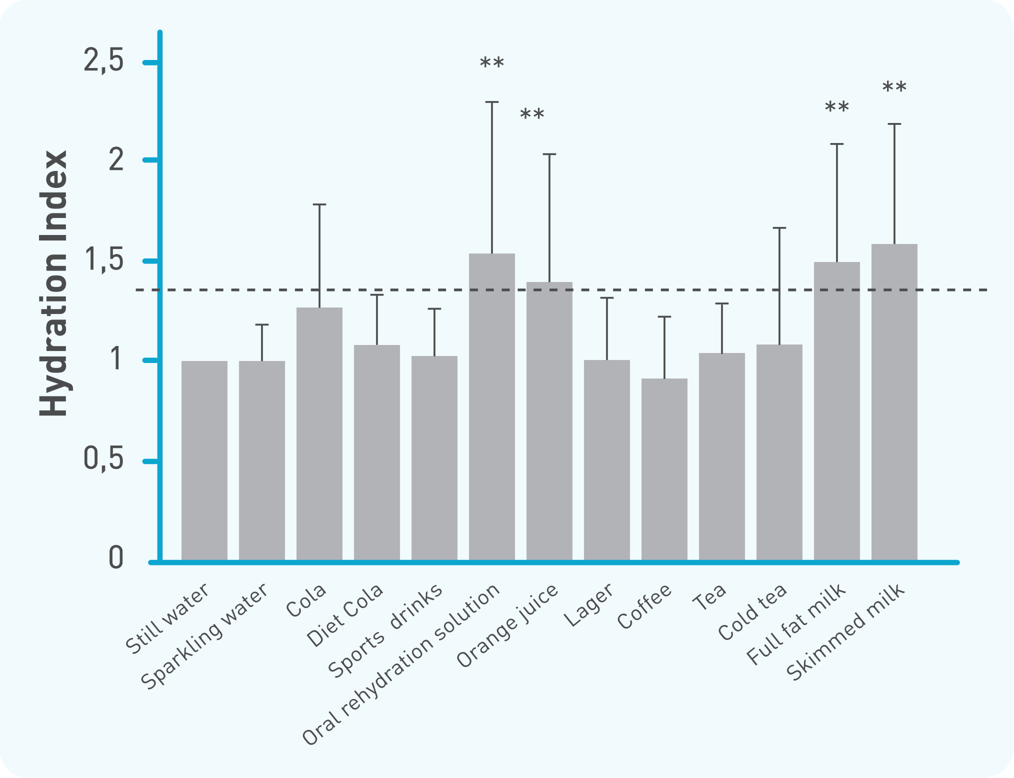
Differences in urine output, and calculated net fluid balance, became apparent from 2h after finishing drinking.

Both milks and the ORS resulted in a smaller volume of urine being produced. None of the other drinks resulted in urine volumes (and hence net fluid balance) different to water.

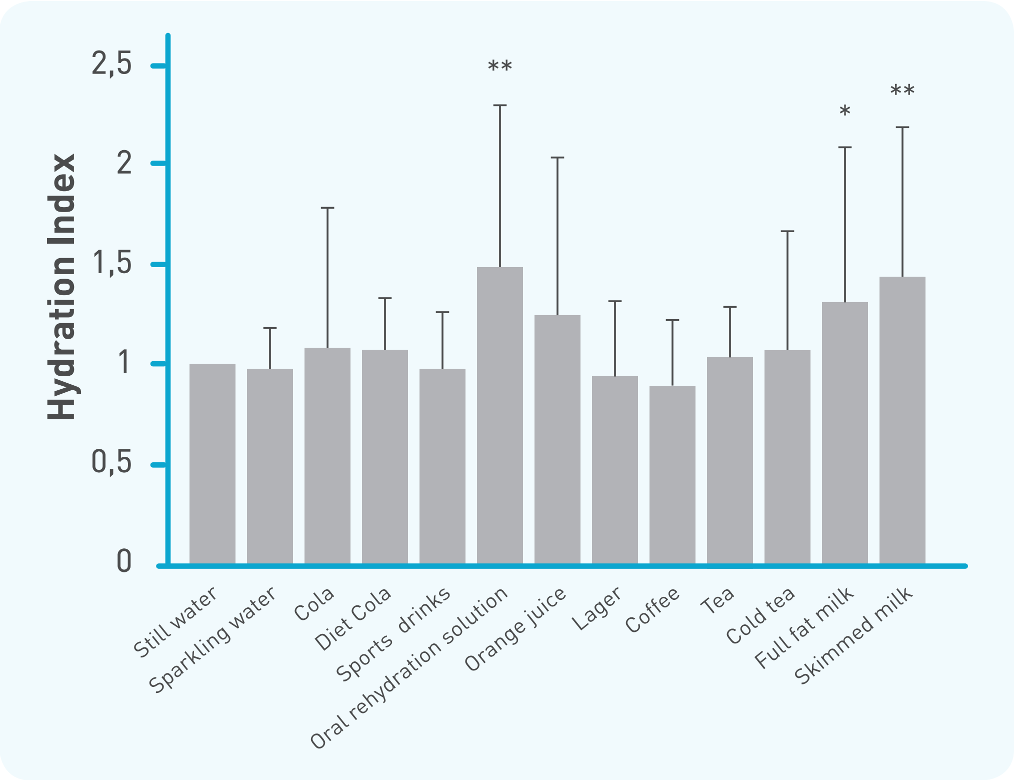


b) HYDRATION INDEX

The Hydration Index for both milk drinks, the ORS and orange juice was greater than still water from 2h after drinking until the end of the study period (4h after drinking).



The Hydration Index can be modified to take into account the differing amounts of water within the same volume of drinks (e.g. there is less water in 1 litre of orange juice than there is in 1 litre of plain water). Applying this correction resulted in the Hydration Index of orange juice being no different to that of water. No other changes resulted.



7. Practical implications/advice

1. This research has demonstrated that a Hydration Index (HI) for different beverages can be established. Further research is required to verify the values obtained in this study and to determine values for additional drinks.

2. The hydration status of a person at the point of drinking (i.e. euhydrated, hypohydated, hyperhydrated) will influence the renal handling of the drink consumed, and thus the urine output and consequently the HI. The HI in this study has been established with euhydrated subjects. The values obtained may not be immediately transferable to hypohydrated subjects. Further research is required in this area.

3. The current HIs have been calculated based on data at 2h after the end of drinking, but the findings are relevant to up to 4h after the end of a drinking period.

4. The HI is a tool that can describe the effectiveness of a drink at maintaining hydration status.

   A. When we drink, our primary consideration is not always hydration status maintenance, but when it is, the HI of drinks can be considered.

8. Study limitations

A. The Hydration Index values obtained need to be verified by subsequent studies and HI values defined for other beverage types if this is going to become a useful practical tool.

B. The drinking period was 30 min long and in this time 1 litre of drink was consumed. This is not a typical drinking behaviour of most euhydrated people. Work to establish the practical application of HI to typical free living situations may be warranted.