european hydration institute

SCIENTIFIC DOSSIER ON:

The effects of hydration status on performance in a simulated driving challenge

INDEX

Notes:
Data are presented as MEAN ± SD throughout.
HYD = Normally hydrated trial.
FR = Fluid restricted, dehydrated trial.

1. Citation

Watson P, Whale A, Mears SA, Reyner LA, Maughan RJ (2015) Mild hypohydration increases the frequency of driver errors during a prolonged, monotonous driving task. *Physiology & Behavior* 147, 313-318.

2. Published paper's abstract

The aim of the present study was to examine the effect of mild hypohydration on performance during a prolonged, monotonous driving task.

Methods: Eleven healthy males (age 22 ± 4 y) were instructed to consume a volume of fluid in line with published guidelines (HYD trial) or 25% of this intake (FR trial) in a crossover manner. Participants came to the laboratory the following morning after an overnight fast. One hour following a standard breakfast, a 120 min driving simulation task began. Driver errors, including instances of lane drifting or late breaking, EEG and heart rate were recorded throughout the driving task.

Results: Pre-trial body mass (P = 0.692), urine osmolality (P = 0.838) and serum osmolality (P = 0.574) were the same on both trials. FR resulted in a 1.1 ± 0.7% reduction in body mass, compared to – 0.1 ± 0.6% in the HYD trial (P = 0.002). Urine and serum osmolality were both increased following FR (P < 0.05). There was a progressive increase in the total number of driver errors observed during both the HYD and FR trials, but significantly more incidents were recorded throughout the FR trial (HYD 47 ± 44; FR 101 ± 84; ES = 0.81; P = 0.006).

Conclusions: The results of the present study suggest that mild hypohydration produced a significant increase in minor driving errors during a prolonged, monotonous drive, compared to that observed while performing the same task in a hydrated condition. The magnitude of decrement reported was similar to that observed following the ingestion of an alcoholic beverage resulting in a blood alcohol content of approximately 0.08% (the current UK legal driving limit), or while sleep deprived.

3. Published paper's highlights

- Mild hypohydration has been shown to cause impaired cognitive function and altered mood.
- This study reports an increase in driver errors with mild dehydration.
- Error incidence increased over time, but occurred at a greater rate following fluid restriction.
- Higher subjective feelings of thirst, as well as impaired concentration and alertness, were also apparent.
- Driver education programmes should also encourage appropriate hydration practices.

4. Background

The consequences of drivers making mistakes when driving are recognized by the general public as being potentially serious. And most will recognize the impact that driving whilst under the influence of alcohol or drugs, or whilst sleep deprived or whilst distracted by operating gadgets can have on driving.

It has been estimated that 1.2 million people worldwide are killed as a result of road traffic accidents each year, with around 50 million people injured. Driver error is by far the largest cause of these accidents –data available indicates this accounts for approximately 68% of all vehicle crashes in the UK. Factors including failing to look properly, misjudging another driver's path or speed and driver distraction are cited in the top ten most common causes of traffic accidents. During long and monotonous driving, most drivers progressively show signs of visual fatigue and loss of vigilance.

Being in hot environments and sitting in direct sunlight can lead to significant water losses via sweating. Although air conditioning in vehicles are now much more common, and so may reduce these sweat losses, evaporative water losses from the skin and lungs will take place and these may become significant during a long journey.

Dehydration has been shown to result in altered mood and cause deficits in cognition. Dehydrated drivers may be more susceptible to errors in judgment and / or the successful execution of driving skills.

The European Hydration Institute recommends the regular ingestion of non-alcoholic beverages during long automobile journeys to help to reduce road fatigue[1]. But anecdotal reports suggest that many drivers avoid drinking when on journeys in an attempt to limiting the need for bathroom stops during long journeys.

5. Study aims and objectives

To investigate the effects of mild hypohydration, on driving performance during a 2-hour long, monotonous drive in a driving simulator.

6. Methods

Study = randomised cross over design completed after Ethics Committee Approval.

Subjects = 11 healthy males:

- Driving at least 2h/week for at least 2 years
- Age 22 ± 4 y
- Height 1.75 ± 0.06 m
- Body mass 77.4 ± 10.0 kg

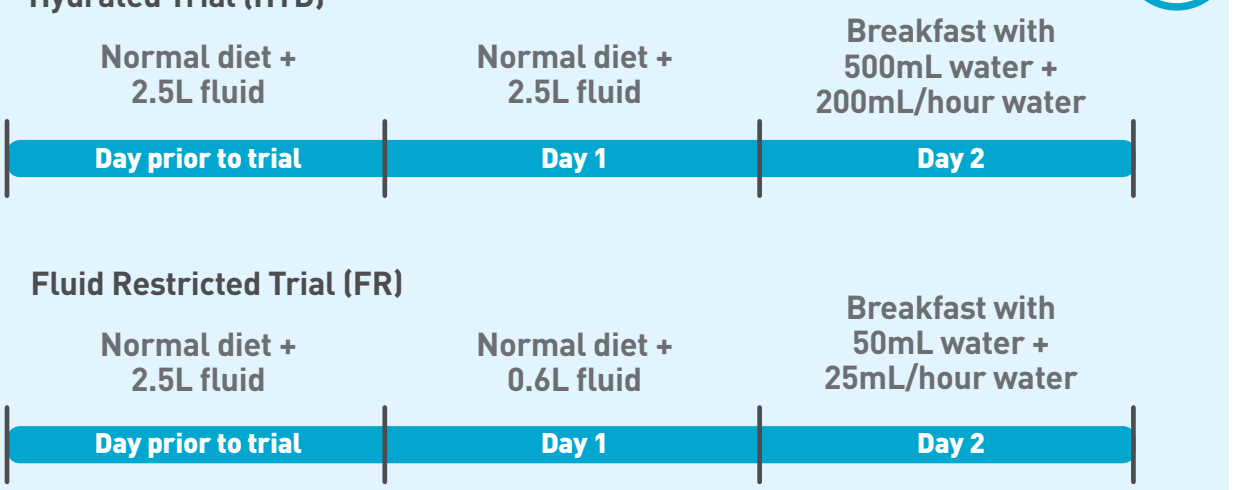
Protocol outline = Two experimental trials undertaken by each subject AFTER full familiarisation and practice of the driving task.

Trial HYD = normally hydrated trial

- At least 2.5L of fluid was drunk, spread evenly across the day, one day before driving

Trial FR = Fluid restricted (dehydrated) trial

- Only 25% of the fluid consumed on the HYD trial was drunk one day before driving



Driving task =

- A 2 h continuous drive in a driving simulator.
- Road selection was a dull monotonous dual carriageway journey.
- Long straight sections were followed by gradual bends.
- Slow moving vehicles were met occasionally, and had to be overtaken.
- Drivers had to remain in their lane unless overtaking.

In HYD drivers were given 200mL of fluid every hour, but on FR only 25mL was available.

Driving performance assessment =

Minor incidents = Lane drifting or late breaking.
Major incidents = Car completely leaves the lane, hits the barrier or another car.

Incidents were identified as being due to sleepiness (e.g. excessive blinking, eye closure, eyes rolling upwards or vacant staring ahead) or as non-sleep related incidents (driver distraction, fidgeting or looking around).

7. Key results

a) HYDRATION DATA

Subjects' hydration status was the same at the start of the study and at the start of the fluid restricting days (established from the same pre-trial body mass, urine osmolality and serum osmolality data). The day before driving, subjects consumed from drinks AND the water in their food.

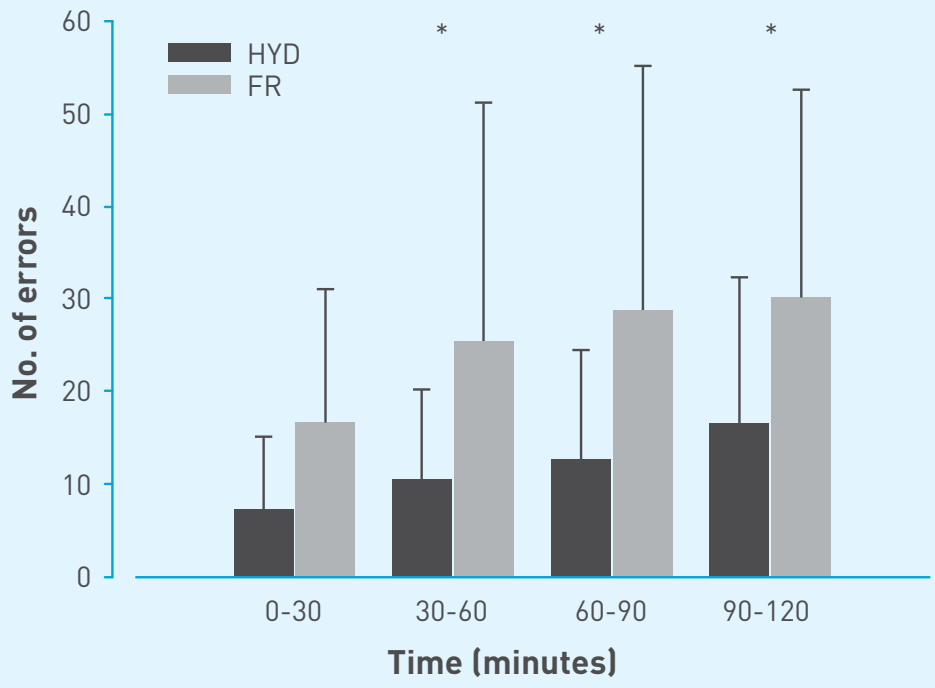
3.0 ± 0.2L of water on the hydrated trial (HYD)	0.9 ± 0.1L of water on the dehydrated trial (FR)
[2.6 ± 0.2L from drinks, 0.4 ± 0.2L from foods]	[0.5 ± 0.2L from drinks, 0.4 ± 0.1L from foods]

Immediately before the driving task, subjects were dehydrated by 1.1 ± 0.7% (range –0.7 to –2.3%) of their body mass on the FR trial but were euhydrated (0.1 ± 0.6% range +1.1 to –0.7%) body mass change on the HYD trial.

By the end of the drive subjects were euhydrated 0.0 ± 0.4% body mass loss on the hydrated (HRD) trial but were hypohydrated by 1.3 ± 0.6% body mass on the dehydrated (FR) trial (note - these data were not included in the published paper but were obtained from the author).

Subjects started both trials reporting the same levels of thirst, throat dryness, hunger, alertness and ability to concentrate. But whilst thirst levels did not change over the hydrated trial (HYD), it increased by 107 ± 17% throughout the dehydrated (FR) trial. This was also the case for throat dryness. Subjects' reported ability to concentrate and their alertness also reduced over the course of the FR trial, and both of these were significantly lower at the end of the drive during the dehydrated (FR) trial than when subjects were hydrated (HYD).

b) DRIVING DATA



*The total number of driver errors made during each 30 min period of the trials. *Denotes a significant difference between trials at the corresponding time point (P < 0.05).*

The total number of errors was 47 ± 44 when hydrated (HYD) but 101 ± 84 when dehydrated (FR).

The number of errors made in each 30 min period of the drive increased the longer the drive had been progressing. But the frequency of driver error increased to a greater extent on the FR trial when subjects were dehydrated.

8. Practical implications / advice

1. Driving incidents / errors lead to accidents and significantly more of these occur when driving with mild dehydration when the drive is a long monotonous one.

    a) Dehydration equivalent to only 1.1% body mass loss was present at the beginning of the drive indicating that minor dehydration significantly influences driving ability in a negative way. Therefore, drivers should be cautioned against deliberate or inadvertent restriction of water intake the day prior to and / or during a long drive.

2. Comparing the results to previously published studies carried out in the same test conditions, the effect of hypohydration was similar to that seen after the ingestion of an alcoholic beverage that resulted in a blood alcohol concentration of approximately 0.08% (the current legal driving limit in England), or whilst sleep deprived.

    a) Driving whilst under the influence of alcohol has long been recognised as irresponsible and should this current data be confirmed, the same attitudes should be applied to driving after restricting water intake.

    b) Whilst this confirmatory work is taking place, it is prudent to ensure driving whilst dehydrated does not occur.

3. Distractions as a result of feelings of thirst and throat dryness may influence some of this driving behaviour.

    a) When these feelings occur because of restricted water intake, they should not be ignored and a break to allow some drinking should take place at the earliest opportunity.

4. Despite reporting lower levels of concentration and alertness, drivers were not able to rise above this and prevent driver errors occurring when they were dehydrated.

    a) Therefore, deliberate dehydration, perhaps to prevent journey breaks for toilet stops or safe drinking opportunities, should not be accepted with the belief that extra effort can be put into concentrating and staying alert to prevent driving errors.

5. Restricting normal fluid intake will mean a reduction in caffeine intake as well as water intake for many people. Caffeine consumption around long drives has been promoted as a mechanism for counteracting driver fatigue and individuals who regularly consume caffeine should consider if reducing its intake, if drinks are being restricted, may also be influencing their performance.

9. Study limitations

A. The driving task in this study was conducted in a laboratory rather than on open roads. This brings more control in terms of the hazards presented to the subjects, but the subjects would have been aware there were no real consequences of making a mistake. None-the-less, the findings of this study are original and do enhance our understanding of what the effects of driving whilst dehydrated might be. The challenge of repeating this study on "real" roads remains but there are substantial eithical issues to be addressed.

B. From the methods used in the study it is not possible to determine if the increase in driver errors are due to a physiological impairment caused by the dehydration and subsequent reduction in total body water and electrolyte imbalance, or whether they were simply due to the subjects feeling uncomfortable and easily distracted because of this. It is quite possible that the subtle changes in mood and cognition mostly explain the decrement in driving performance that was seen.

10. References

1. European Hydration Institute, 4 key moments in hydration: http://www.europeanhydrationinstitute.org/4_key_moments_in_hydration.html2014

11. Appendix

A useful summary of the research appears on the NHS Choices website: http://www.nhs.uk/news/2015/04April/Pages/Why-you-should-drink-water-before-you-drive.aspx