EFFECT OF HYDRATION STATUS ON NEUROCOGNITIVE TEST RESULTS

Michelle A. Moreland, MS, ATC; Brendon P. McDermott, PhD, ATC; Scott L. Bruce, MS, ATC

THE UNIVERSITY of TENNESSEE CHATTANOOGA

BACKGROUND AND PURPOSE

- The human body is much less capable of adapting to fluid loss than food restriction[1]
- Research findings have demonstrated that neurocognitive abilities decrease with increasing dehydration[1,2]
- When acute exercise dehydration is evaluated, there is a negative effect on neurocognitive ability[3]
- There is a paucity of research regarding the isolated effect of fluid restriction on neurocognitive performance[2]
- There is debate regarding:
  - The specific components of neurocognition that are negatively affected by dehydration
  - The degree of dehydration at which an adverse effect on neurocognition becomes apparent[2,3]
- Neurocognitive assessment methods and induced level of dehydration have been inconsistent among studies[2]
- ImPACT™ is a widely used neurocognitive test battery that was designed for concussion management
- No studies have examined the effects of dehydration on ImPACT™ test battery performance
- The purpose of this study was to quantify the effect of mild to moderate dehydration, brought on by controlled fluid restriction and exercise, on neurocognitive test scores of male college students using the ImPACT™ test battery

SUBJECT CHARACTERISTICS

- Participants were 17 male college students:
  - Age: 22 2 years; Height: 147 38 cm; Body mass: 85.1 15.6 kg
- Exclusionary criteria included the following:
  - Participation in an intercollegiate sport (within the past 12 months)
  - Attempting to gain or lose weight, or taking supplements to facilitate weight alteration goals
  - A condition / disease that has symptoms which are exacerbated by dehydration

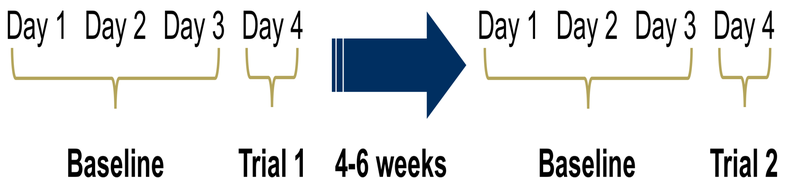

Figure 1. Data collection sequence

METHODS

- Three-day baseline hydrated body mass was assessed using a standard scale (Tanita, Arlington Heights, IL)
- Hydration status for baseline body mass was confirmed using urine color (Ucol) and urine specific gravity (USG)
- Following Day 3, subjects were randomly assigned to be hydrated or dehydrated for Day 4 neurocognitive testing
  - For hydrated trial: subjects instructed to continue fluid intake for maintenance of hydrated status
  - For dehydrated trial: subjects instructed to restrict fluids for 20 hours preceding testing
    - Participants were also instructed to limit high water-content foods, such as fruits and vegetables
- Subjects completed an identical 30-minute cardiovascular workout on each day preceding trials
- Subjects were instructed to avoid consumption of alcohol or caffeine throughout the 4-day period
  - 24-hour diet logs submitted to document consistency of kilocalorie and carbohydrate consumption on Day 3
    - Dependent t-tests performed to confirm intake consistency between trials (P > .05)
- ImPACT™ testing was performed on Day 4 at the same time of day as baseline assessments
- Day 4 hydration assessment included Ucol, USG, and urine osmolality (Advanced Instruments, Norwood, MA)
  - Neurocognitive assessment was conducted only if subject was within goal range of hydration status
    - Dehydrated trial: 1.5% to 2.5% loss of body mass
    - Hydrated trial: -1.0% to +1.0% of baseline body mass
  - Dependent t-tests performed to assess significance of change in body mass and hydration status (P < .05)
- Trials separated by 4-6 weeks to avoid a learning effect on the ImPACT™ test battery
  - The difference between trials was hydration status
- Following ImPACT™ testing in both hydration states, results were analyzed to determine differences between trials
  - Dependent t-tests were performed for each of 27 ImPACT™ scores (α = .05)

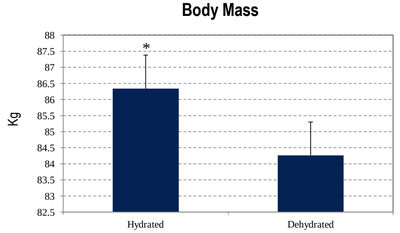

Figure 2. Change in body mass between trials (*P* < .05)

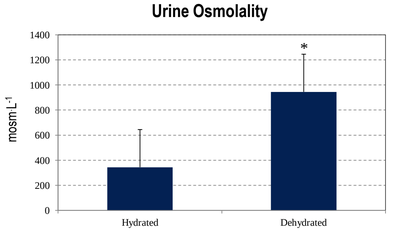

Figure 3. Change in urine osmolality between trials (*P* < .05)

RESULTS

- There was a significant difference in body mass between hydrated and dehydrated trials (-1.88 1.23%, P < .001)
- Dehydrated USG (1.027 0.005) was elevated when compared to hydrated USG (1.009 0.006; P < .001)
- Dehydrated osmolality (944.8 142.4 mosm.L-1) was elevated when compared to hydrated osmolality (344.4 229.8 mosm.L-1; P < .001)
- Diet log analysis demonstrated no significant trial differences in kilocalorie or carbohydrate consumption (P ≥ .122)
- A significant increase in pre- and post-trial symptom scores were identified during dehydration (Table 1)
- The subject's immediate and delayed word memory were significantly impaired by dehydration (Table 1)
- Consistent with previous research using a computer-based neurocognitive test battery and the effect of dehydration, we identified deficits in performance for a small number of variables

Variable	Hydrated	Dehydrated	*P*-value
Verbal Memory	86.44 ± 11.88	88.19 ± 10.28	.402
Visual Memory	70.25 ± 15.27	67.94 ± 14.66	.479
Visual Motor Speed	40.22 ± 7.05	39.51 ± 7.65	.566
Reaction Time	0.59 ± 0.05	0.60 ± 0.07	.310
Impulse Control	5.31 ± 3.52	7.25 ± 7.51	.281
Symptom Score	**2.19 ± 4.58**	**8.25 ± 7.91**	**.002**
Cognitive Efficiency Index	0.36 ± 0.13	0.38 ± 0.12	.514
WM Hits (Immediate)	**11.81 ± 0.54**	**11.19 ± 1.11**	**.046**
WM Distractors (Immediate)	11.81 ± 0.40	11.19 ± 1.42	.076
WM Hits (Delayed)	**11.06 ± 1.00**	**9.94 ± 1.57**	**.001**
WM Distractors (Delayed)	10.75 ± 1.34	10.13 ± 1.86	.251
DM Hits (Immediate)	9.50 ± 1.55	9.06 ± 1.77	.362
DM Distractors (Immediate)	8.75 ± 2.35	7.75 ± 3.00	.135
DM Hits (Delayed)	8.88 ± 1.78	8.75 ± 2.14	.837

Variable	Hydrated	Dehydrated	*P*-value
DM Distractors (Delayed)	7.25 ± 2.24	6.63 ± 1.93	.328
XO Correct (Memory)	8.25 ± 2.49	8.25 ± 2.35	>.999
XO Correct (Interference)	110.88 ± 7.72	107.69 ± 9.44	.127
XO Incorrect (Interference)	4.88 ± 3.28	6.88 ± 6.84	.256
SM Correct (Visible)	26.94 ± 0.25	26.88 ± 0.34	.580
SM Correct (Hidden)	6.63 ± 2.13	7.19 ± 1.83	.278
Color Match Correct	9.00 ± 0.00	8.94 ± 0.25	.333
TL Sequence Correct	4.38 ± 0.89	4.63 ± 0.62	.300
Three Letters Correct	13.63 ± 2.06	14.44 ± 0.89	.103
Avg. Time to First Click	1.99 ± 0.45	1.97 ± 0.47	.887
Average Counted	17.69 ± 4.29	17.51 ± 4.72	.821
Avg. Counted Correctly	17.58 ± 4.23	17.36 ± 4.71	.790
Final Symptom Score	**1.88 ± 3.24**	**10.63 ± 11.16**	**.003**

Table 1. ImPACT™ output variables. WM – Word Memory; DM – Design Memory; XO – X's and O's; SM – Symbol Match; TL – Three Letter

CONCLUSIONS

- At modest levels of dehydration (1.88% body mass loss), we identified neurocognitive deficits in college-aged males
  - Deficits would not alter clinical decision-making when utilizing the ImPACT™ test battery
- Dehydration and traumatic brain injury produce similar and overlapping symptoms
- Adequate hydration is important for maintenance of neurocognitive performance and should not be neglected

REFERENCES

1. Maughan R. Impact of mild dehydration on wellness and on exercise performance. *Euro J Clin Nutr.* 2003;57(2):S19-S23.
2. Lieberman HR. Hydration and cognition: a critical review and recommendations for future research. *J Am Coll Nutr.* 2007;26:555S-561S.
3. Ganio M, Armstrong L, Casa D, et al. Mild dehydration impairs cognitive performance and mood of men. *Br J Nutr.* 2011;13(5):1-9.