TRACKING ACUTE CHANGES IN HYDRATION
USING URINALYSIS AND BIOIMPEDANCE TECHNIQUES

Matt Mosman, Laura Carson, Chin Yin Tai, Paul Falcone, Jordan Joy, Justin Straight, Susan Oury, Carlos Mendez, Nick Loveridge, Michael Kim, and Jordan Moon

ABSTRACT

PURPOSE: Compare multiple-frequency bioimpedance (MFBIA), bioimpedance spectroscopy (BIS), urine color (UC), urine specific gravity (USG), and dry body mass (BM), in athletic men and women after dehydrating to around 2% BM loss. **METHODS**: Seven women and thirteen men between the ages of 18 and 35 participated in the study (27 +/- 4yr, 77.3 +/- 14.3 kg, 174.0 +/- 7.5 cm). Subjects reported to the lab in a fasted and normally hydrated state and provided a urine sample and had their BM, MFBIA, BIS, UC, and USG measured. Subjects then ran on a treadmill for 30 minutes at 80% estimated max HR followed by multiple 15 minute sessions in a dry sauna at approximately 150 degrees F. After reaching the dehydrated body weight (2% +/- 0.4%) subjects provided a urine sample and BM, MFBIA, BIS, UC, and USG were measured again. **RESULTS**: BM, UC, and USG significantly detected the change in water loss ($p < 0.008$) while MFBIA detected no significant change in total body water (TBW) ($p = 0.245$) and BIS detected a significant increase (PRE: 46.5, POST: 47.6 L) in TBW after dehydration ($p < 0.001$). However, when delta values were analyzed only MFBIA and BM were significantly correlated ($r = 0.525$, $p = 0.017$). **CONCLUSION**: Urinary markers of dehydration appear to be independent of BM while MFBIA seems to be highly related to BM. MFBIA uses BM to estimate TBW along with bioimpedance variables and therefore is not an independent measurement of TBW changes when compared to BM alone. Furthermore, MFBIA did not detect a significant change in TBW and therefore is not acceptable for detecting changes in hydration status. Alternatively, BIS detected a significant change in TBW but in the opposite direction, suggesting the method is sensitive enough to track acute changes in hydration, but the model used to calculate TBW needs to be investigated. Therefore, urinary methods to track changes in hydration may be used along with or in place of BM, but further research is needed before BIS or MFBIA can be used to detect acute changes in TBW after physical dehydration in an athletic population.

INTRODUCTION

Hydration plays a crucial role in exercise, especially for thermoregulation. Dehydration not only affects performance, but also causes serious complications if not managed properly. Unless sweat losses are replaced, body temperature rises, leading to heat exhaustion, heatstroke, and even death. Fluid loss as little as 1% of total body weight can be associated with an elevation in core temperature during exercise. Fluid loss of 3% to 5% of body weight results in cardiovascular strain and an impaired ability to dissipate heat. At 7% loss, collapse is likely. It is common for athletes to dehydrate 2% to 6% during practice in the heat. Therefore, tracking changes in hydration is important for coaches, trainers, and physicians in order to provide optimal re-hydration and care for athletes. Commonly used methods to detect dehydration in athletes include changes in urine color and body weight pre and post exercise. However, there are several other methods that may be used to track acute changes in hydration yet limited research is available as to the agreement between methods.

PURPOSE

The purpose of this investigation was to determine the agreement between multiple methods of tracking acute changes in hydration (multiple-frequency bioimpedance, bioimpedance spectroscopy, urine color, urine specific gravity, and dry body mass) in athletic men and women after dehydrating to around 2% body mass loss.

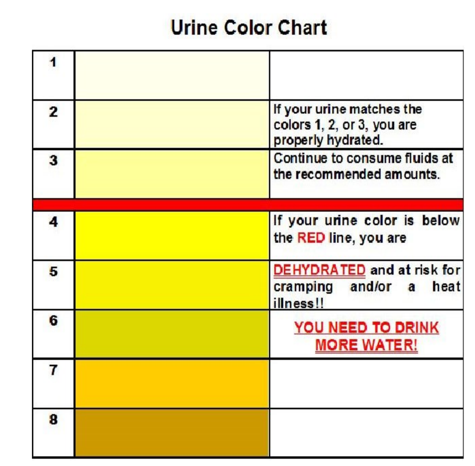
METHODS

Dehydration Protocol

Subjects reported to the lab in a fasted and normally hydrated state and provided a urine sample and had their BM, MFBIA, BIS, UC, and USG measured. Subjects then ran on a treadmill for 30 minutes at 80% estimated max HR followed by multiple 15 minute sessions in a dry sauna at approximately 150 degrees F. After reaching the dehydrated body weight (2% +/- 0.4%) subjects provided a urine sample and BM, MFBIA, BIS, UC, and USG were measured again

Urine Color (UC)

Hydration/dehydration status utilizing urine color was determined using the Armstrong Urine Color Chart. The chart allows hydration levels to be assessed via urine color. Ideally, urine should be pale yellow or 'straw-colored', corresponding with a state of optimal hydration. The darker the color, the more concentrated the urine and the more dehydrated the individual.



Bioelectrical Impedance Spectroscopy (BIS)

Total body water (TBW) was measured using bioimpedance spectroscopy via the ImpediMed SFB7 following the procedures recommended by the manufacturer (ImpediMed Limited, Queensland, Australia). Total body water estimates were taken while the subjects laid supine on a table with their arms ≥ 30 degrees away from their torso with their legs separated from each other. Electrodes were placed at the distal ends of the subjects' right hand and foot following the manufacturer guidelines. Excess body hair was removed prior to electrode placement and cleaned with alcohol. The average of two trials within ± 0.05 liters were used to represent the subjects' TBW. Prior to analysis, each subject's height, weight, age, and sex were entered into the SFB7 device. Internal to the device, the SFB7 utilized 256 frequencies and a complex impedance plot to estimate TBW. Previous test retest measurements of 10 men and women measured 24-48 hours apart for the SFB7 produced a TEM of 0.564 liters for TBW.

Urine Specific Gravity (USG)

Urine specific gravity was measured using the Atago Master refractometer.(Atago U.S.A, Bellevue, WA). Urine specific gravity is a laboratory test that measures the concentration of all chemical particles in the urine and is used as an index of hydration status. A refractometer determines the density of the urine as compared to the density of water. The higher the density, or specific gravity, the more dehydrated the sample is. A urine specific gravity of 1.000-1.019 is considered hydrated, 1.020-1.027 is considered minimally to moderately dehydrated, and 1.028-1.035 is considered severely dehydrated. Subjects provided a urine sample prior to and after the dehydration protocol. Two to three drops of urine from the sample were placed on the prism surface of the refractometer, held up to the light, and USG was determined.

Multiple-Frequency Bioimpedance (MFBIA)

Total body water (TBW) was measured using multiple-frequency bioimpedance via the InBody 720 following the procedures recommended by the manufacturer (Biospace, Seoul, Korea). The InBody 720 is a multi-frequency impedance plethysmograph body composition analyzer, which takes readings from the body using an eight-point tactile electrode method, measuring resistance at five specific frequencies (1 kHz, 50 kHz, 250 kHz, 500 kHz, and 1 MHz) and reactance at three specific frequencies (5 kHz, 50 kHz, and 250 kHz). TBW was estimated from area, volume, length, impedance, and a constant proportion (specific resistivity). TBW estimates were taken while subjects stood erect on the device with their palms, fingers, and bare soles in direct contact with the electrodes. Subjects were instructed to wear light clothing and stand comfortably (muscles relaxed) with arms abducted 15 degrees during the testing session..

Dry Body Mass (DBM)

Dry body mass (DBM) was measured using a calibrated SECA 703 high capacity column scale following the procedures recommended by the manfacturer (SECA, Chino, CA). Measuring DBM before and after exercise is a common method to determine dehydration and fluid replacement needs of athletes. Monitoring body mass and replacing each pound lost with at least 1 pint of fluid is a helpful guideline to ensure adequate fluid replacement. Each subject's naked DBM was taken pre and post the dehydration protocol. The protocol required subjects to run on a treadmill for 30 minutes at 80% estimated max HR followed by multiple 15 minute sessions in a dry sauna at approximately 150 degrees F until reaching the desired dehydrated DBM (2% +/- 0.4%) .

STUDY PARTICIPANTS

	Age (yrs)	Weight (kg)	Height (cm)
Total (N= 20)	27 ± 4	77.3 ± 14.3	174.0 ± 7.5
Male (N= 13)	26.4 ± 4.2	84.6 ± 14.5	176.9 ± 7.1
Female (N =7)	29.3 ± 4.6	67.4 ± 6.0	169.0 ± 6.1

RESULTS

Table 1. Pre and post parameters comparison. (N=20).

	Pre		Post			
	Mean	SD	Mean	SD	Mean Difference	P value
BM	77.3	14.3	75.7	13.9	1.645	0.001*
MFBIA	47.6	10.4	47.7	10.3	-0.155	0.245
BIS	46.5	9.9	47.6	10.1	-1.100	0.001*
UC	3.6	1.2	5.1	1.4	-1.525	0.001*
USG	1.0108	0.0061	1.0182	0.0076	-0.0074	0.001*

*$P < 0.05$

Table 2. Correlation between parameters. (N= 20).

	BM	MFBIA	BIS	UC
BM				
MFBIA	0.525*			
BIS	0.136	0.233		
UC	-0.088	-0.028	-0.251	
USG	0.029	0.036	-0.277	0.291

*$P < 0.05$

CONCLUSION

Urinary markers of dehydration appear to be independent of BM while MFBIA seems to be highly related to BM. MFBIA uses BM to estimate TBW along with bioimpedance variables and therefore is not an independent measurement of TBW changes when compared to BM alone. Furthermore, MFBIA did not detect a significant change in TBW and therefore is not acceptable for detecting changes in hydration status. Alternatively, BIS detected a significant change in TBW but in the opposite direction, suggesting the method is sensitive enough to track acute changes in hydration, but the model used to calculate TBW needs to be investigated. Therefore, urinary methods to track changes in hydration may be used along with or in place of BM, but further research is needed before BIS or MFBIA can be used to detect acute changes in TBW after physical dehydration in an athletic population.

REFERENCES

1. Baechle, T.R., and Earle, R.W. Essentials of Strength and Conditioning. Human Kinetics; 3 edition (June 2, 2008)