University of Arkansas, Fayetteville
ScholarWorks@UARK

Health, Human Performance and Recreation Undergraduate Honors Theses

Health, Human Performance and Recreation

5-2017

Validity of 24-h Void Duration as an Indicator of Hydration Status

Miriah C. Hadley

Validity of 24-h Void Duration as an Indicator of Hydration Status

Miriah Hadley

University of Arkansas

Primary Investigator: Matthew S. Ganio, Ph.D.

Committee Members: Tyrone A. Washington, Ph.D. & Nicholas P. Greene, Ph.D.

Project assisted by Aaron Caldwell

A thesis submitted to the Honors College at the University of Arkansas is partial fulfillment of the requirements for the degree Bachelor of Science in Kinesiology with Honors

April 19, 2017

Abstract

Context: Few user-friendly hydration assessment techniques exist for the general population to use on a daily basis. **Objective:** This study evaluated 24-h urine duration as a valid indicator of hydration status. **Design:** For two trials, subjects voided into a large, medical grade container at the first urge to void. For the other two trials, subjects voided at any level of urgency they desired. Participants were given a stopwatch and asked to record the duration of each void to the nearest whole second, voiding at a "normal", unforced pace. Specific order of the trials was randomized and counter-balanced. **Setting:** Materials were distributed and returned to the Human Performance Laboratory at the University of Arkansas, Fayetteville. Participants collected their voids outside of the laboratory. **Participants:** 13 males and 18 females volunteered for this study (Age=23± 9y, Body Mass=25.1±4.1kg). **Interventions:** The intervention was hydration status, euhydrated versus dehydrated. For the dehydrated trials, participants were given 500 mL of water and asked to only drink that during the 24-h collection period. For the euhydrated trials, fluid consumption was encouraged. Participants were instructed to void into the container at the first urge to void during one of the euhydrated trials and one of the dehydrated trials. For the other euhydrated and dehydrated trials, the participants voided at free will (i.e., ad libitum). The participants were asked to draw a straight line on the container at the level of urine, mark the urge to void, and the duration of each void. The hydration status of each sample was classified by urine specific gravity (U_{SG}) as either euhydrated (U_{SG} <1.020) or dehydrated (U_{SG} ≥ 1.020). **Results:** U_{SG} was different in the euhydrated and dehydrated trials (1.012 ± .004 versus 1.023 ± .003 for first urge and 1.012 ± .004 versus 1.024 ± .003 for ad libitum urge, respectively; p<0.05). For both the first urge and ad libitum trials, individual voids were longer when euhydrated versus dehydrated (19 ± 5s versus 15 ± 6s for first urge and 20± 5s versus 16 ± 3s for ad libitum urge, p<.05). Total duration of all voids over 24-h were longer in the euhydrated compared to the dehydrated trials (133 ± 84s versus 61 ± 45s, p<.0001 for first urge and 149 ± 93s versus 64 ± 52s, p<.0001 for ad libitum urge). Duration was not affected by void urgency when voiding in a euhydrated (P=0.208) and dehydrated (P=.097) state. **Conclusions:** This data suggests that over 24-h, healthy adults tend to void for a longer period of time when they are hydrated compared to dehydrated, regardless if voiding at first urge or ad libitum. These findings validate 24-h urine duration as a valid and simple indicator of hydration status for the general public.

Introduction

The human body is composed of 50-70% water, mainly held within cells, which drives physiological and homeostatic processes, making it crucial that the body maintains its optimal water level. However, water is lost from vital bodily functions such as breathing, sweating, and urinating, which can cause the body to become water deficient, or dehydrated if the amount of fluid lost is greater than the amount of fluids consumed (1). Dehydration negatively impacts various cognitive and physical functions causing symptoms such as headaches and fatigue and illnesses such as cardiovascular disease and diabetes, emphasizing the importance of staying hydrated (1).

It is important for all individuals to know how to determine his or her hydration status. There are various methods to determine hydration status such as measuring plasma osmolality, urine osmolality, and urine specific gravity (3). However, these methods require highly trained technical skill and/or are not convenient for someone to measure outside of a laboratory setting.

There are some “field” measures of hydration such as urine color and thirst (3). When the kidneys are functioning properly, urine is more concentrated and darker in color when the body is dehydrated and conserving water, and more diluted and lighter in color when the amount of water in the body is plentiful. Urine color has a strong correlation with level of hydration, making it a viable method to determine hydration status, however it may not be user friendly in some situations because a valid assessment requires urinating into a small cup and observing the color against a white background (18). Thirst for regulatory drinking is not triggered until total fluid loss reaches 1-2% of body mass (3), which means an individual is already dehydrated by the time they are thirsty. This makes thirst an unreliable method of assessing hydration status.

The lower urinary tract serves to store urine and eliminate through micturition when the bladder is full. Hydration is dictated by the amount of fluids consumed versus the amount of fluids excreted by the body. If fluid consumption increases with no change in fluids lost through sweat/respiration, the amount of water stored in the bladder increases, which means that the bladder is full more regularly than if an individual were dehydrated and not consuming as many fluids. When the bladder reaches 40-50% of its maximal capacity, the mid-pons, cingulate cortex, and frontal lobes trigger the first urge to void (8). Previous studies have shown that when voiding at first urge, the number of voids and 24-h void volume relative to the subjects' body mass was significantly greater for euhydrated versus dehydrated subjects, which coincides with the fact that euhydrated individuals tend to void more often and in greater amounts than when dehydrated (7).

Since it has been shown by previous research that the number of voids and void volume increases when an individual is euhydrated, it can be hypothesized that the sum duration of all voids throughout a 24-h period is greater when euhydrated versus dehydrated. Therefore, the purpose of this study is to evaluate 24-h void duration a valid indicator of hydration status as a simple, user- friendly technique for the general public to assess their hydration status. We hypothesize that 24-h urine duration will be a valid method to determine hydration status.

Methods

A mix of 31 healthy male and female young adults were recruited to participate in the study composed of two trials and 5 overall visits to the Human Performance Lab, one being a familiarization. For two trials, subjects were educated on how to stay euhydrated and were encourage to drink fluids throughout the day. During the two dehydrated trials, subjects were limited to drinking 500 mL of fluids to ensure dehydration.

On the 1st visit, directly after signing a consent form, the participant's age, height and body mass were measured. Both the height and the body mass were recorded with the participant wearing no shoes and light clothing. Standing height was measured and recorded to the nearest 0.1 cm. Body mass was measured using a scale (Seca, model: 7701321004, Vogel & Hamburg, Germany or Health-o-meter) and recorded to the nearest 100 g. Participants were then instructed on how to record fluid intake and physical activity with diaries. They were described the Thirst and Urge Scale. For example, subjects were educated on the differences between first urge to void, normal urge to void, and strong urge to void. Throughout one of the euhydrated and dehydrated trials, subjects were instructed to void at "normal urge" as a control. For the other euhydrated and dehydrated trials, subjects voided at any level of urgency they desired.

During the four trials, participants were asked to record their food, fluid intake, and daily activity and were asked to refrain from exercise and alcohol because exercise and alcohol might affect fluid loss. For the dehydrated trials, participants were given a 500 mL bottle of water and instructed to only drink that during the 24-hour collection period. For the euhydrated trials, participants were encouraged to drink fluid throughout the day. Specific order of the trials were randomized and counter-balanced.

For each trial, participants were given one large, medical grade urine container to collect urine over a 24-hour time period. For the “first urge trials,” the participants were educated on void urgency using a 0-4 urge to void scale, and instructed to void at the first urge to void (the number “2”) during the 24-hour collection period (8). Since studying the duration of the voids, participants were given a stopwatch and asked to record the duration of each void, voiding at a “normal”, unforced pace. The participants were asked to draw a straight line at the level of urine, mark the urge to void, the thirst level, along with the duration for each void, rounding the time to the nearest whole second.

The 24-hour collection period began the morning after the first void of the day. Following the first void, the participant voided into the 24-hour container. The 24-hour collection period ended the following day, after the first morning void was collected into the large urine container. Materials were returned to the Human Performance Lab on the same day as the morning collection, and the participant participated in a brief follow-up meeting to ensure they adhered to the instructions, specifically if they marked the duration of each individual void.

Volume of the 24-h container was measured using a desktop electronic scale (Ohaus Corporation, Catapult 1000—C11P9, Pine Brook, NJ, USA) (17). A well-mixed sample was assessed for urine color by the same researcher in the same well-lit environment (19) and urine osmolality (UOSM) by freezing point depression (3D3 Advanced Instruments osmometer, Model 3250, Norwood, MA, USA). To classify participants as euhydrated or dehydrated, urine specific gravity values set by the American College of Sports Medicine (ACSM) were used. According to these values, individuals with a urine specific gravity ≤1.020 were designated as euhydrated, and dehydrated individuals were indicated by a urine specific gravity of >1.020. 24-h urine duration was calculated by adding up the time of each individual void.

Statistical analyses were performed using SAS (SAS Institute, Cary, North Carolina). Data are reported as mean ± s.d., and an alpha level of 0.05 defined significance for all tests (7). A repeated measure ANOVA with two factors, type (hydration status) and trial (ad libitum versus first urge), was utilized to determine differences in U_{SG} and void duration. If a significant effect was determined a paired samples t-tests was used to compare specific differences between trials.

Results

Results for relationship between U_{SG}, U_{OSM}, and void volume, and void duration are presented as mean ± s.d. and illustrated in Table 1. For the first urge trials, the level of urge was consistent (2 ± 0; ‘first urge to void’) showing participant’s compliance to study protocol for those trials. Over 24h, euhydrated individuals produced a lower U_{SG} and U_{OSM} than dehydrated subjects. As a result of greater hydrated, subjects voided a greater 24-h urine volume (Table 1; P <0.001) and voided more often throughout the day (Table 1; P <.001).

Additionally, subjects' 24-h urine collection duration was greater for euhydrated than dehydrated collection periods. We found consistent results when subjects were asked to void ad libitum (2 ± 1; voiding at free will).

There were no significant differences in the number of voids between the first urge and ad libitum trials for euhydrated or dehydrated collection period (P <.001). Overall, subjects voided more often when euhydrated than dehydrated. The average volume and duration of each individual void was longer for the euhydrated ad libitum trials and first urge trials when compared to the dehydrated collections (P < 0.05).

Discussion

The purpose of this study was to evaluate 24-h urine duration as a valid indicator of hydration status to find a simple, user-friendly technique for the general public to assess their hydration status. This study was unique in that it evaluated 24-h urine duration when voiding at the first urge to void and ad libitum. The primary finding of this study was that the 24-h void duration was significantly greater in euhydrated versus dehydrated trials (P < 0.001). Consistent results were found in the first urge and ad libitum trials, leading us to conclude that urge to void does not have a significant impact on 24-h void duration as a valid method for assessing hydration status.

Previous research has shown that void number directly correlates with hydration status when controlling the urge to void, asking participants to void at the 'first urge' (7). Euhydrated individuals voiding at 'first urge' were found to have greater individual urine volume and a greater number of voids throughout a

24-h collection period. Urine duration was not a measurement of the previous study, so hypothesizing that 24-h urine duration would be a result of greater urine volume per void and an increase in void number when an individual was euhydrated seemed reasonable. This study found when voiding at first urge, there was an increased number of voids, individual void volume, duration of each void, and total 24-h duration when euhydrated versus dehydrated.

Even when presented the opportunity to void at free will, on average subjects still voided at the first urge (2±1), which was probably due to the neurological effect of increased urine formation (14). Slight variation from the first urge to void was probably due to the convenience of holding a particular void for a longer period of time (i.e. if a subject was in a meeting, class, etc.). Adding the ad libitum trials as a variable in this study showed that the findings from the previous study were still valid if an individual was voiding at an uncontrolled urge. When voiding at free will, individuals still had a greater number of voids when euhydrated (141 ± 89s) versus dehydrated (62 ± 49s) and had a greater urine volume per void, leading to a greater duration of individual voids and overall 24-h duration.

Limitations

One possible limitation to this study was the number of adults that presented over the age of 40. This study only had two subjects over this age. Further research should be done to validate void number and void duration as a valid indicator of hydration status in older adults and/ or compare void number and void duration to individuals under the age of 40. Those aged 60 years and over have different metabolic rates and physiological cues on thirst and urination than younger adults, which makes them particularly susceptible to dehydration and the consequential effects (4). The most recent statistics show that in the U.S. $1.36 billion dollars was spent to treat hospitalized “elderly” patients with dehydration as their primary diagnosis. The economic and health burden of dehydration in older individuals highlights the need to validate user-friendly methods of assessing hydration status for people particularly over the age of 60.

Conclusion

The purpose of this study was to evaluate 24-h urine duration as a valid indicator of hydration status to find a simple, user-friendly technique for the general public to assess their hydration status. Over 24-h, healthy adults voided for a longer period of time when they are hydrated compared to dehydrated, regardless if voiding at first urge or ad libitum. Individual voids were also longer in seconds when euhydrated versus dehydrated. The study helped us evaluate 24-h urine duration as valid and simple indicator of hydration status for the general public.

ACKNOWLEDGEMENTS

This study was funded by the University of Arkansas Honors College. The authors would like thank all of the subjects for their time and participation in making this project possible. The authors would also like to thank Alex Wileman and Paige Steiner for their contributions to this study.

References

1. **Nicolaidis S. Arnaud MJ, ed.** (1998). Physiology of thirst. In: Hydration Throughout Life. Montrouge: *John Libbey Eurotext;* 247.

2. **Davies I, O'Neill PA, McLean KA, Catania J, Bennett D.** (1995). Age-associated alterations in thirst and arginine vasopressin in response to a water or sodium load. *Age and Ageing:* 24:151–159.

3. **Armstrong LE.** (2005). Hydration assessment techniques. *Nutr Rev:* 63(Suppl): S40-S54, 2005.

4. **Phillips PA, Rolls BJ, Ledingham JG, et al.** (1984). Reduced thirst after water deprivation in healthy elderly men. *N Engl J Med.* 311:753–759.

5. **Mack GW, Weseman CA, Langhans GW, Scherzer H, Gillen CM, Nadel ER.** (1994). Body fluid balance in dehydrated healthy older men: thirst and renal osmoregulation. *J Appl Physiol*. 76:1615–1623.

6. **Van Haarst E.P., Heldweg E.A., Newling D.W., Schlatmann T.J.** The 24-h frequency- volume chart in adults reporting no voiding complaints: defining reference values and analysis variables. *BJU International* 93*:*1257-1251, 2004.

7. **Burchfield JM, Ganio MS, Kavouras SA, Adams JD, MA Gonzalez MA, Ridings CB, Moyen NE, Tucker MA.** (2015). 24-hour void number as an indicator of hydration status. *Eur J of Clin Nutr*: 69: 5: 638-641.

8. **Athwal BS, Berkley KJ, Hussain I, Brennan A, Craggs M, Sakakibara R et al.** (2001). Brain responses to changes in bladder volume and urge to void in healthy men. *Brain*; 124: 369–377.

9. **Maughan RJ.** (2003). Impact of mild dehydration on wellness and on exercise performance. *Eur J of Clin Nutr*: 57**:** Suppl 2: S19–S23.

10. **MA, Gonzalez MA, Adams JD, Burchfield JM, Moyen NE, Robinson FB, Schreiber BA, Ganio MS.** Reliability of 24-h void frequency as an index of hydration status when euhydrated and hypohydrated. *Eur J Clin Nutr.* 2016 Feb 10. doi: 10.1038/ejcn.2015.233. [Epub ahead of print]

11. **Frangeskou M, Lopez-Valcarcel B, Serra-Majem L.** (2015). Dehydration in the elderly: A review focused on economic burden. *J Nutr Heal Aging.*

12. **Das R.N., Grimmer-Somers K.A.** (2012). Fluid intake and voiding; habits and health knowledge in young, health population*. Research and Reports in Urology;* 9-15.

13. **Mckinley, M. J., & Johnson, A. K.** (2004). The Physiological Regulation of Thirst and Fluid Intake. *American Physiological Society, 19*(1), 1-16.

14. **Hewitt, M. J., Going, S. B., Williams, D. P., & Lohman, T. G.** (1993). Hydration and fat-free body mass in children and adults: Implications for body composition assessment. *American Physiological Society, 265*(1), 88-95.

15. **Flower, C.J., Griffiths, D., Groat, W.C.** (2008). The neural control of micturition. *Nat Rev Neurosci,* 9(6), 453-466.

16. **Convertino, V.A., Brock, P.J., Keil, L.C. Bernauer, J.E.** (1980). Exercise training- induced hypervolemia: role of plasma albumin, renin, and vasopressin. *Journal of Applied Physiology.* 48 (4), 665-669.

17. **Raman A, Schoeller DA, Subar AF, Troiano RP, Schatzkin A, Harris T et al.** Water turnover in 458 American adults 40–79 yr of age. *Am J Physiol Renal Physiol* 2004; 286: F394–F401.

18. **Armstrong LE, Costill DL, Fink WJ.** Influence of diuretic-induced dehydration on competitive running performance. *Med Sci Sports Exerc* 1985; 17: 456.

19. **Ganio MS, Armstrong LE, Casa DJ, McDermott BP, Lee EC, Yamamoto LM et al.** Mild dehydration impairs cognitive performance and mood of men. *Br J Nutr* 2011; 106: 1535–1543.

20. **Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS.** American College of Sports Medicine position stand: exercise and fluid replacement. *Med Sci Sports Exerc* 2007; 39: 377–390.

Table 1: Mean ± s.d. of 24-h hydration markers for all participants

	OVERALL		1ST URGE		AD LIBITUM	
	EUH	DEH	EUH	DEH	EUH	DEH
24-h urine duration (s)	141 ±89	62 ±49*	133 ±84	61 ±45*	149 ±94	61 ±53*
Single void duration(s)	20 ±5	16 ±5*	19 ±5	15 ±6*	20 ±5	16 ±3*
U_{SG}	1.012 ±.004	1.024 ±.003*	1.012 ±.004	1.023 ±.003*	1.011 ±.004	1.024 ±.003*
24-h void volume (mL)	2233 ±1234	875 ±425*	2127 ±1257	889 ±385*	2341 ±1220	861 ±470*
Single void volume (mL)	307 ±197	213 ±121*	284 ±179	209 ±122*	330 ±215	217 ±120*
U_{OSM} (mOsm/kg H_2O)	440 ±175	886 ±137*	450 ±165	878 ±133*	429 ±186	895 ±143*
Number of voids	7 ±3	4 ±1*	7 ±3	4 ±2*	7 ±3	4 ±1*
Urge to void	2 ±1	2 ±1	2 ±0	2 ±0	2 ±1	2 ±1

* Significanty different than the corresponding euhydrated (EUH) value (P <0.05). DEH, dehydrated; U_{SG}, urine specific gravity; O_{OSM}, urine osmolality.