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Daily Variability of Body Weight and Hydration Markers in Free Living Men and Women

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Daily Variability of Body Weight and Hydration Markers in Free Living Men and Women

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by

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Abstract

Body weight and hydration markers change greatly during strenuous exercise, especially in the heat. However, in a non-athletic population, changes in body weight and hydration markers may not be so obvious. It is important to classify the normal fluctuation of these measurements for future studies in order to delineate when an intervention results in a change outside of what can be expected during normal daily living. **PURPOSE:** The purpose of this study was to describe the normal fluctuations in body weight and urine hydration markers over the course of 29 days. **METHODS:** One-hundred two male and female participants, ranging from 18 to 65 years were measured on 12 separate morning visits over the course of 29 days. All the subjects were apparently healthy and none of them exercised more than four hours per week. During each visit, subjects were weighed and provided a urine sample for analysis of osmolality (UOsmo) and specific gravity (USG) measurement. The results from these measurements were analyzed using a one-way, repeated measures, analysis of variance test to evaluate main effects of time on body weight, UOsmo, and USG. The coefficient of variance was also used to compare week to week values. **RESULTS:** Urine osmolality and USG showed no statistical significance across time. Mean average for urine osomolality was 582 ± 278 with $p = 0.056$ and USG means were 1.015 ± 0.008 with $p = 0.239$. Body weight did show change across time with a mean average of 76 ± 17 with $p = 0.005$. **CONCLUSION:** Urine osmolality and USG biomarkers indicate stability over a period of 29 days, while body weight seems to be a more inconsistent factor.

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Introduction/Review of Literature

According to the Merriam-Webster Dictionary, one definition of “hydration” is “the condition of having adequate fluid in the body tissues.” The Institute of Medicine of the National Academies (2005) uses the term, “water body balance,” to describe fluid homeostasis within the body and how a decrease in this balance leads to dehydration or a lack of sufficient fluid in the body. Sufficient hydration plays an important role in the composition and function of the human body and viability of tissues is critically important since the human body is constantly in a state of dynamic water balance and fluid fluctuation (Armstrong, 2007). An extensive review by Jequier and Constant determined that in order for an individual to function at a maximal level, a good hydration level is required (2010). A “good” hydration level can be determined by several methods of analyses that have been used over past years, however, the variability of these methods needs to be determined to show the reliability of these measures over time.

Body weight measurements are a well-used method of evaluating hydration status among athletic populations (Popowski et al., 2001). These measurements are most often taken before and after strenuous bouts of exercise, and the difference between the values indicates the amount of water difference through sweat losses (Baker, Lang, & Kenney, 2009). Body weight variability has shown significant stability in active/athletic men within measurements of three, consecutive days (Cheuvront, Carter, Montain, & Sawka, 2004). They performed trials in six and nine consecutive days, but three consecutive days still showed stability in body weight, implying that measurements taken did not vary significantly from one day to the next in athletes replacing 100% of fluid losses.

However, this study by Cheuvront et al. (2004) focused on the regulation and assessment of hydration status and body weight balance within the athletic and exercise-testing environments involving strenuous bouts of physical activity, but much has yet to be done extensively in the testing of free-living populations over an extended period of time. Another study by Cheuvront, Ely, Kenefick, and Sawka (2010) also looked at variation in hydration biomarkers of military populations that showed consistency depending on a dynamic or static hydration assessment again, showing consistency in a highly active population. Testing within free-living populations is critical because knowing normal, standard variation between repeated measures of hydration biomarkers and body weight creates the ability to accurately identify fluctuations in body fluid balance during interventions involving exercise, hydration, and nutrition. In assessing body weight fluctuation as well as well-established hydration biomarkers like urine osmolality, urine specific gravity, serum osmolality, and urine color (Armstrong et al., 1998), a baseline needs to be established to indicate the normal amount of variation as well as stability within these hydration biomarkers in day to day free-living conditions.

Purpose of the Study

Therefore, the purpose of this study was to determine the variability of body weight and urine hydration biomarkers over a 29-day period of men and women in free-living conditions.

Hypotheses

The hypotheses listed below were tested:

- There will be no significant variability in body weight over a twenty-nine day period.
- There will be no significant inter-individual variability in assessment of urine osmolality or urine specific gravity over the course of twenty-nine days.

Research Design

This study was a repeated measures design to assess the variability of urine osmolality, urine specific gravity, and body weight measured 12 times over a span of 29 days.

Participants

The study participants included 102 men and women between the ages of 18-65. These participants were selected from Northwest Arkansas. The subject *inclusion* criteria included that the individual be healthy but not an athlete—not exercising more than four hours per week at a high intensity— and that the subject must sign a consent form before any testing begins. The subject *exclusion* criteria included pregnancy or breastfeeding, surgical operation on digestive tract (except appendectomy), regular drug treatment within fifteen days prior to the study, currently exercising more than four hours per week, inability to participate in the entire study, significant changes in diet in the last month, and a change in weight greater than 2.5 kilograms in the last month.

Measures

Urine Osmolality. Subjects provided a morning urine sample upon arrival at the laboratory. The urine osmolality was measured from fresh samples by use of freezing point depression with the use of an Advanced Model 3250 Single-Sample Osmometer. The measurements were taken at least twice or until two measures were within 2 mmol/kg.

Urine Specific Gravity. Urine specific gravity (USG) was assessed from each morning urine sample with the use of a refractometer, the Atago MASTER-SUR/Nα. This was measured to the nearest thousandth, between 1.000 and 1.060.

Body Weight. Upon arrival at the lab before voiding a urine sample, subjects provided a body weight. This was assessed with the use of a digital scale, the Healthometer 349KLX, with the participant semi-nude with the most clothing being undergarments.

These three components – urine osmolality, USG, and body weight – were measured upon each of the participant’s 12 visits to the lab.

Procedures

The participants came into the laboratory three times per week over the course of twenty-nine days. The specific visit days were days 1, 2, 5, 8, 9, 12, 15, 16, 19, 22, 25, and 29. These visits were between the time of 6:00 AM and 12:00 PM. Written consent was obtained before the first visit as well as full disclosure to the participant of the procedures and requirement involved. Subjects filled out a medical history questionnaire to be screened for inclusion and exclusion criteria. Subjects physical activity was screened by use of the International Physical Activity Questionnaire (IPAQ) to ensure no more than four hours of vigorous physical activity was conducted weekly. There were no specifications for food or fluid intake prior to each visit. Urine osmolality, urine specific gravity, and body weight were analyzed in the laboratory after each visit.

Data Analysis

Each variable from all of the participants was assessed calculating the standard deviation and mean and determining coefficient of variance for between days within the protocol timeframe. Coefficient of variance was calculated by using visits 1-3, 1-6, 1-9, and 1-12. These values were then compared to each other using one-way analysis of variance for repeated measures to observe if any significant changes were detected in body weight, osmolality, and USG. A Post Hoc Test was to detect inter-visit differences. Euhydration in subjects was measured using urine osmolality measurements of less than 800 mmol/kg. Statistical calculations were assessed using IBM SPSS Statistics 22 and IBM SPSS Statistics 24 with a statistical significance level set at $P = <0.05$ and Microsoft Excel 2011.

Results

Urine Osmolality

The coefficient of variance showed no significant change over the course of the four weeks of analysis for urine osmolality. Visits 1-3 had an average coefficient of variance (%CV) of 31% while visits 1-6, 1-9, and 1-12 showed 34%, 33%, and 33% coefficient of variance respectively (Figure 1). The average percent change for urine osmolality was 11% (CI: 1.5- 23.3%, $P < 0.05$). The ANOVA for CV% showed no statistical significance between overall osmolality values (p = 0.056) and no significance between week to week (p = 0.261, 0.522, 1.000).

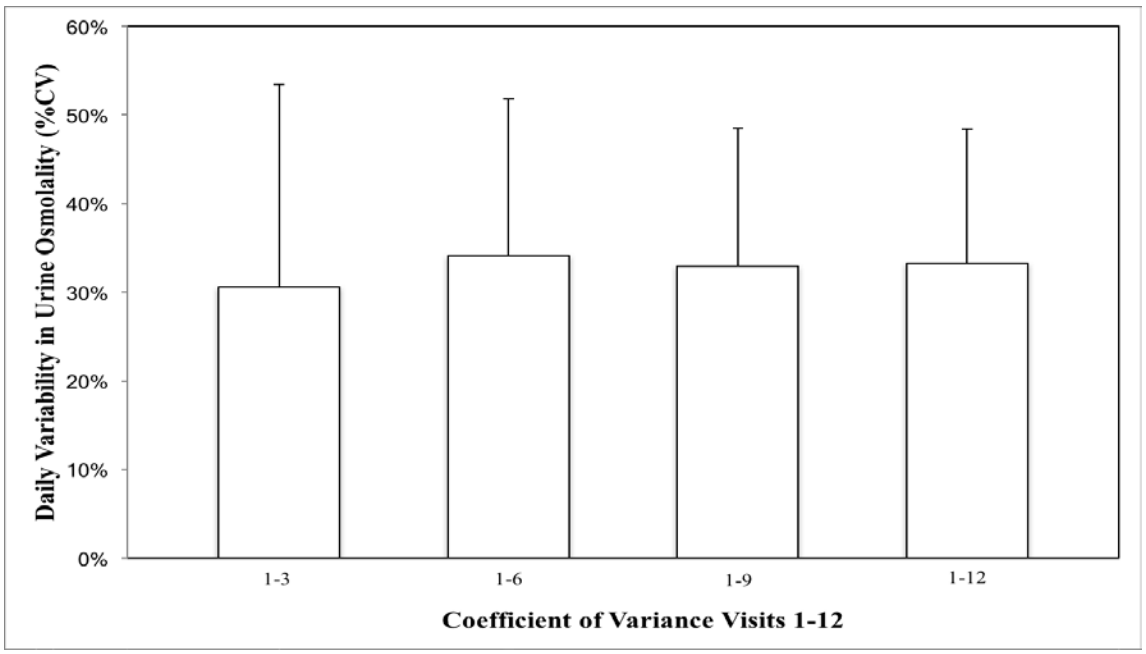

Figure 1. Coefficient of Variance for Urine Osmolality (95% CI, *P* = 0.056)

Urine Specific Gravity

The %CV in USG measures were 0.47%, 0.50%, 0.49%, and 0.50% (Figure 2). The average percent change for USG was -0.084% (CI: -0.051-0.128%, $P < 0.05$). No statistical significance was present in overall USG ANOVA values (p = 0.239). No significance was present between any pairings of the visits with inter-visit p values being 0.673 or 1.000.

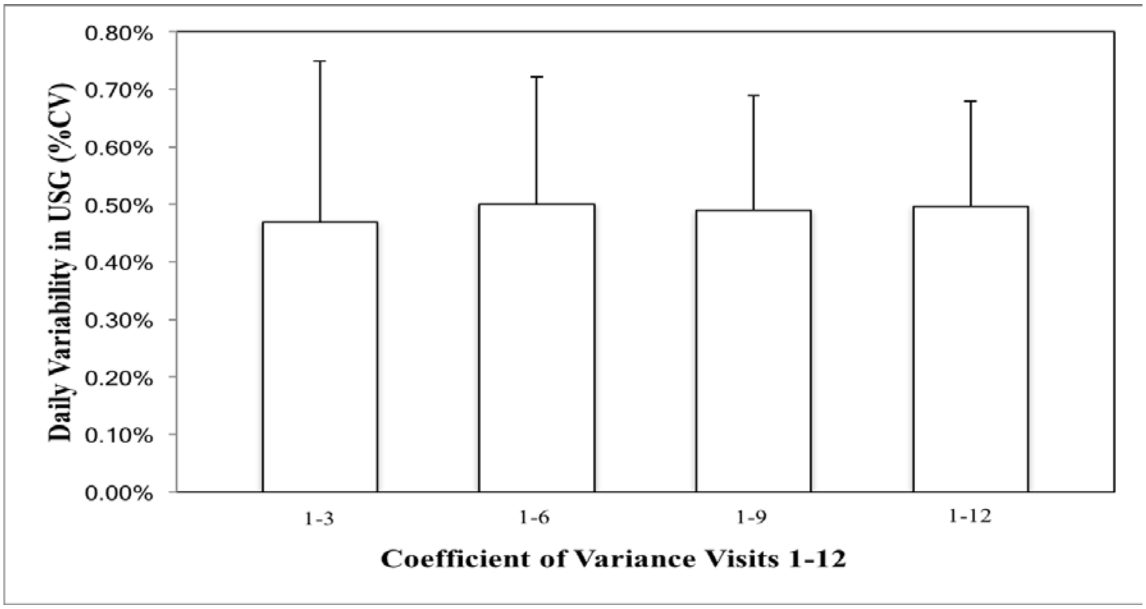

Figure 2. Coefficient of Variance for USG (95% CI, *P* = 0.239)

Body Mass

The coefficient of variance for body mass was 0.54%, 0.67%, 0.76%, and 0.78% (Figure 3). The average percent of change for body mass was -0.04% (CI: -0.22%-0.23%, $P = <0.05$). With the ANOVA for CV%, there was statistical significance shown in body mass values overall ($p = 0.005$). In comparing weeks, only one comparison, 1-9 compared to 1-12, showed insignificance ($p = 0.650$). All other pairings of weeks were $p = 0.000$ or $p = 0.002$.

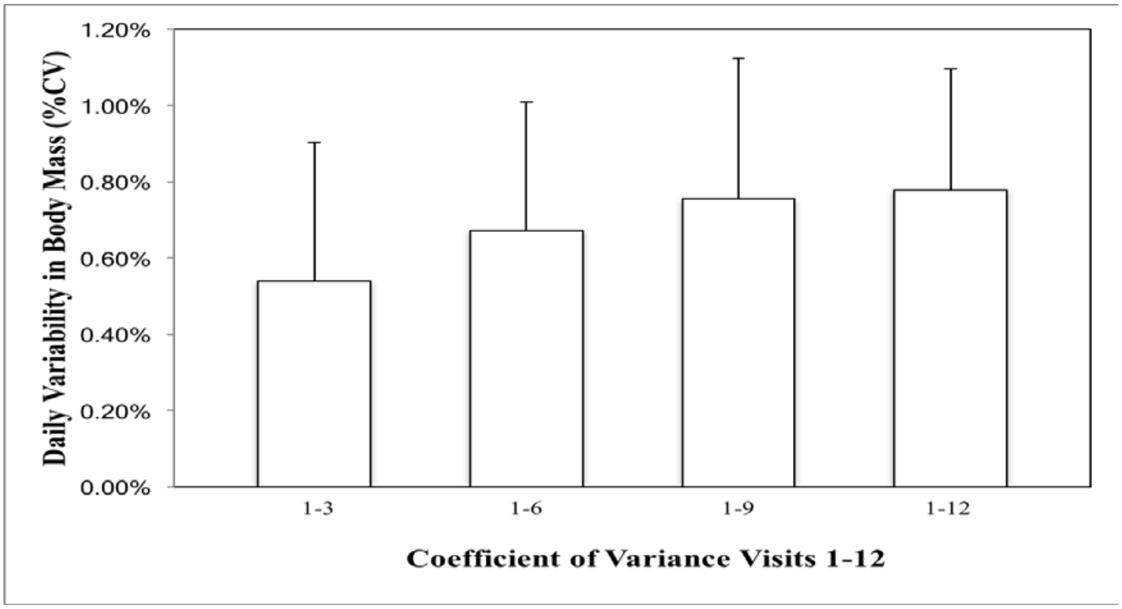

Figure 3. Coefficient of Variance for Body Mass (95% CI, *P* = 0.005)

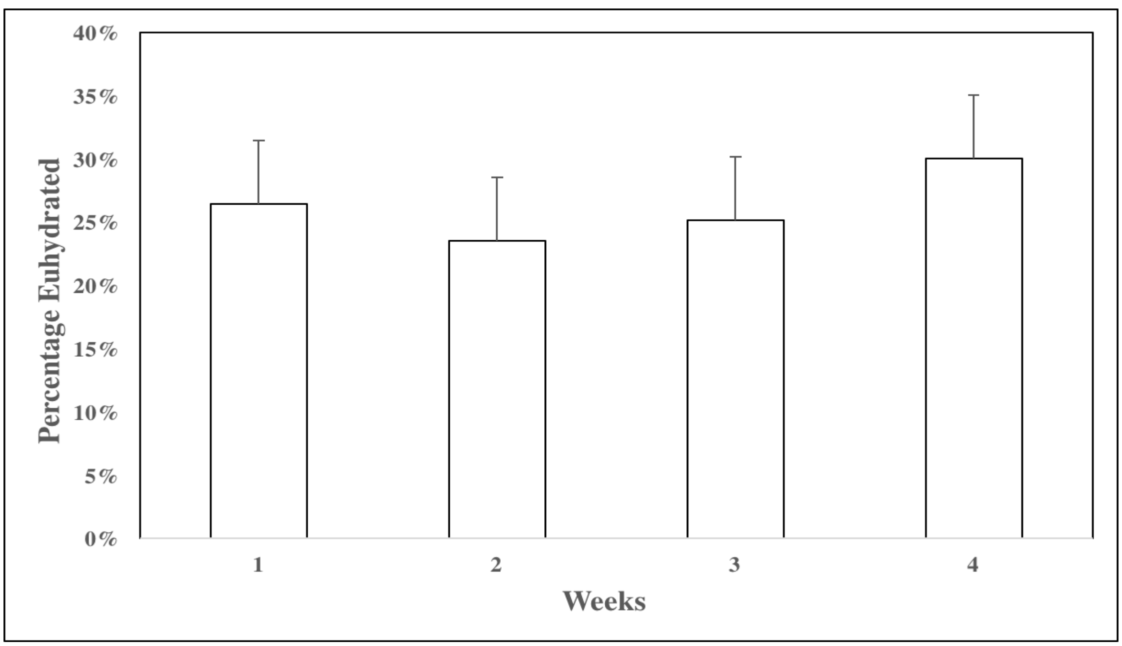

Figure 4. Percentage of Euhydrated Subjects Across Weeks 1-4

Discussion

Awareness of the variability in hydration indices plays an important role in knowing how to conduct current and future hydration studies. These indices have been shown in and of themselves to be accurate at points in time (Armstrong, 1998). However, our study is one of the first to show the changes or lack thereof in variability amongst these indices across a span of time as long as a month helping to establish a reliable baseline. The lack of baseline measurements has been evidenced in the literature, and while baseline studies have been done to measure total body water turnover and water intake, an analysis of the measurements involved has never been thoroughly assessed (Kavouras, 2002; Raman et al., 2004).

When comparing 3, 6, 9, or 12 days for urine osmolality, the coefficient of variance values were 0.31%, 0.34%, 0.33%, and 0.33% respectively offering no significant change in hydration levels over time. USG measurements also reflected similar results in this study, which reflects the interchangeability of USG and urine osmolality (Armstrong, 1994). However, body weight did reflect significant change over the course of the 29-day period. This differs from Cheuvront's study which stated that body weight measurements are a stable indicator of hydration status (Cheuvront, 2004). We also know that body mass correlates with water loss and gains (Baker et al., 2009) as well as showing some correlations with urine biomarkers such as USG (Munoz, McKenzie, & Armstrong, 2014). It is important to note though that Cheuvront only took into account body mass during this particular assessment with no other hydration assessments such as urine osmolality and urine specific gravity (Cheuvront, 2004), which are considered to be the standard biomarkers for hydration assessment (Armstrong, 1998).

Possible causes of greater difference in body mass in this study compared to Cheuvront's could be less control and monitoring of exercise and fluid intake and replacement. Restrictions were in place for physical activity (less than four hours per week), but again, no control of amount of exercise less than four hours. Also, Cheuvront had a much shorter assessment period of three consecutive days (2004) versus this study which took twelve samples over the course of 29 days giving a more comprehensive look at an individual's hydration fluctuations.

In Figure Four, we also looked at the overall hydration status of individuals between the weeks. Percentage euhydrated were 26% followed by 24%, 25%, and 30% for weeks two, three, and four. There is a slight increase in hydration towards the end of the 29 days for the larger group, but showing that about 25% will be hydrated in a given 29 days. Within the last week, percentage of euhydration increased. One thing to consider is that the subjects had been performing the same protocol and tests for the previous three weeks. This would then stand to reason that some influence of knowing it is a hydration could have an effect on subjects consuming more water/liquids.

Conclusion

In looking at the values for hydration biomarkers, it can be concluded that there was significant difference in body mass over the 29 day time period. This would show that use of this method of hydration evaluation over a longer period of time may not be consistent or always accurate. Armstrong concluded that body mass measurements prove to be one of the most reliable methods of assessing TBW when close together, as in after a bout of exercise (2007). However, this study has shown that the effect of time on body mass may contribute to the lack of stability in multiple assessments. Body mass has also been shown to be a more accurate measure of hydration status in a dynamic versus static state (Cheuvront, 2009), which could also contribute to the variation exhibited in this study.

Even though body mass did notably fluctuate, the recorded statistical insignificance of variation of urine osmolality and USG, stands to indicate that they are reliable measures of hydration status in a free-living population.

References

Armstrong, L. E., Maresh, C. M., Castellani, J. W., Bergeron, M. F., Kenefick, R. W., LaGasse, K. E., & Riebe, D. (1994). Urinary indices of hydration status. *Int J Sport Nutr, 4*(3), 265-279.

Armstrong, L. E., Soto, J. A., Hacker, F. T., Casa, D. J., Kavouras, S. A., & Maresh, C. M. (1998). Urinary indices during dehydration, exercise, and rehydration. *Int J Sport Nutr, 8*(4), 345-355.

Armstrong, L. E. (2007). Assessing hydration status: the elusive gold standard. *J Am Coll Nutr, 26*(5 Suppl), 575S-584S.

Baker, L. B., Lang, J. A., & Kenney, W. L. (2009). Change in body mass accurately and reliably predicts change in body water after endurance exercise. *Eur J Appl Physiol, 105*(6), 959-967. doi: 10.1007/s00421-009-0982-0

Cheuvront, S. N., Carter, R., Montain, S. J., & Sawka, M. N. (2004). Daily body mass variability and stability in active men undergoing exercise-heat stress. *Int J Sport Nutr Exerc Metab, 14*(5), 532-540.

Cheuvront, S. N., Ely, B. R., Kenefick, R. W., & Sawka, M. N. (2010). Biological variation and diagnostic accuracy of dehydration assessment markers. *Am J Clin Nutr, 92*(3), 565-573. doi: 10.3945/ajcn.2010.29490

Institute of Medicine of the National Academies. Water. Dietary Reference Intakes for Water, Sodium, Chloride, Potassium and Sulfate. Washington, D.C: National Academy Press; 2005. p. 79

Jéquier, E., & Constant, F. (2010). Water as an essential nutrient: the physiological basis of hydration. *Eur J Clin Nutr, 64*(2), 115-123. doi: 10.1038/ejcn.2009.111

Kavouras, S. A. (2002). Assessing hydration status. *Curr Opin Clin Nutr Metab Care, 5*(5), 519-524.

Muñoz, C. X., McKenzie, A. L., & Armstrong, L. E. (2014a). Optimal hydration biomarkers: consideration of daily activities. *Obes Facts, 7 Suppl 2*, 13-18. doi: 10.1159/000360655

Popowski, L. A., Oppliger, R. A., Patrick Lambert, G., Johnson, R. F., Kim Johnson, A., & Gisolf, C. V. (2001). Blood and urinary measures of hydration status during progressive acute dehydration. *Med Sci Sports Exerc, 33*(5), 747-753.

Raman, A., Schoeller, D. A., Subar, A. F., Troiano, R. P., Schatzkin, A., Harris, T., . . . Tylavsky, F. A. (2004). Water turnover in 458 American adults 40-79 yr of age. *Am J Physiol Renal Physiol, 286*(2), F394-401. doi: 10.1152/ajprenal.00295.2003

UNIVERSITY OF ARKANSAS

Office of Research Compliance Institutional Review Board

March 21, 2014

MEMORANDUM

TO:	Stavros Kavouras J.D. Adams	Evan Johnson Lynndee Summers
	Thomas Vidal Joseph Robillard	Mikell Hammer Rebecca Mishler
	Weldon Murray Ainsley Huffman	Ryan Peters Costas Bardis
FROM:	Ro Windwalker IRB Coordinator	
RE:	New Protocol Approval	
IRB Protocol #:	14-03-555	
Protocol Title:	*Assessing Dietary Water Intake: A Validation Study*	
Review Type:	EXEMPT EXPEDITED FULL IRB	
Approved Project Period:	Start Date:03/21/2014 Expiration Date: 03/16/2015	

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (http://vpred.uark.edu/210.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 133 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu.

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