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Hydration Interventions Among Agricultural Workers:

A Pilot Study

Roxana Chicas, PhD,
Jonathan Suarez, MD,
Lisa Elon, MA,
Nezahualcoyotl Xiuhtecutli, MS,
Madelyn C. House, PhD,
Liris Berra, BS,
Jeff M. Sands, MD,
Vicki Hertzberg, PhD,
Linda McCauley, PhD

Nell Hodgson Woodruff School of Nursing (Dr Chicas, Dr Houser, Dr Hertzberg, Dr McCauley); Division of Renal Medicine, Department of Medicine (Dr Suarez, Dr Sands); Rollins School of Public Health (Ms Elon, Ms Berra), Emory University, Atlanta, Georgia; Anthropology Department, Tulane University, New Orleans, Louisiana (Mr Xiuhtecutli); and Farmworker Association of Florida, Apopka, Florida (Mr Xiuhtecutli).

Abstract

Objective: To estimate the impact of hydration interventions on postworkday hydration status and incidence of acute kidney injury (AKI).

Methods: Thirty agricultural workers were first monitored on a workday without any interventions. On the intervention workday, the same workers were randomized to one of two groups: 169 ounces (oz) (5 L) of plain water (n=16) or 169 oz (5L) of water with electrolytes (n=14).

Results: No participants in the electrolyte group had an estimate glomerular filtration rate (eGFR) at the end of the workday of less than 90 mL/min/1.73 m2 or met the criteria for AKI in comparison to the water group (eGFR < 90: 15%; AKI: 23%) or the control group (eGFR < 90: 28%; AKI: 18%).

Conclusion: The study showed that drinking water with electrolytes may lower the risk for development of AKI among agricultural workers.

Keywords

acute kidney injury; agricultural workers; hydration interventions; occupational health

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Address correspondence to: Roxana Chicas, PhD, 1520 Clifton Road, Atlanta, GA 30322 (rchicas@emory.edu).

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Conflict of Interest: None declared.

Climate change has led to more frequent and intense heat waves.Nine of the warmest years on record have occurred since 2010.[1] Bearing the brunt of climate change are vulnerable occupational groups that work outdoors, such as agricultural workers, who are at higher risk of heat-related fatalities,[2] heat-related illness (HRI),[3] and dehydration than other occupational groups.[4,5] More recently, they have also been shown to be at risk of acute kidney injury (AKI) and chronic kidney disease of unknown etiology (CKDu).[4–7] Drinking enough water is an important factor in preventing HRI.[8] The National Institute for Occupational Health and Safety (NIOSH) recommends drinking 24 to 32 ounces (oz) (0.7 to 0.9 L) of water per hour when working in the heat to stay hydrated.[8] Drinking sports drinks with balanced electrolytes is also recommend; however, NIOSH does not specify what is considered a balanced mixture of electrolytes or how much to drink.[8]

A study in Florida with 192 agricultural workers found that 53% of workers were dehydrated (urine specific gravity [USG] more than or equal to 1.020) pre-shift and 81% post-shift, and 33% of participants developed AKI on at least 1 of 3 workdays.[4] Studies in Central America found that sugarcane workers who self-reported drinking water with electrolytes had a lower riskof developingAKI.[7,9] In Guatemala, a study with 50 sugarcane workers compared the consumption of electrolyte solution at 2.5 L per day, 5 L per day, and 10 L per day.[6] While kidney function remained normal in the three groups, workers reported that 5 L was the best quantity to drink.[6]

As of yet, there are no field-based US studies of electrolyte interventions to protect agricultural workers from dehydration and AKI. The purpose of this study was to determine the feasibility of implementing hydration interventions in agricultural workplaces and to estimate the impact of the intervention on post-workday hydration status and incidence of AKI.

METHODS

Recruitment

In January 2020, in collaboration with the Farmworker Association of Florida (FWAF), trained community health workers (CHW) recruited a convenience sample of 113 agricultural workers to participate in a longitudinal study to examine the inter-relationships between environmental heat exposure, physical exertion, biomarkers of renal function, persistence of AKI, and indicators of diminishing renal function over time. CHW recruited individuals from rosters that FWAF maintains of agricultural workers and during community outreach events.Agricultural workers worked primarily in the fernery, field crop, and nursery industries of the north-central Florida towns of Apopka and Pierson. Although the goal was to have equal representation of male and female agricultural workers,morewomen agreed to enroll in the study. Participants were assessed at four times between January 2020 and July 2021. Informed consent was obtained at the first visit. Questionnaires were administered to participants by the FWAF team. Each data collection assessment included pre-shift and postshift workday visits. Participants provided urine and blood samples preand post-shift. Inclusion criteria for the longitudinal study included being between 18 and 49 years of age and working in the agricultural sector for at least the last 4 weeks at the time of enrollment. Workers were excluded if they reported being pregnant, had type I or 2 diabetes mellitus, were under treatment for hypertension, or reported a history of glomerulonephritis, pyelonephritis, renal calculi, or a snake bite. Publications are forthcoming on this longitudinal study.

In July 2021, CHW recruited a convenience sample of 30 agricultural workers from the longitudinal study described above, after they completed the workday assessment. Workers who consented to participate were scheduled for the hydration intervention on a workday and assessed pre- and post-work shift; their 4th longitudinal workday in the parent study was used in this analysis as their control day. The Institutional Review Board at Emory University provided approval (IRB00112681) for the study, and all participants provided informed consent. At the end of the workday, each participant received a US $70 gift card.

Intervention

This single-subject experimental study used an observational workday as the control condition to compare with the two hydration interventions. Subsequently, workers were randomized to one of two groups for the oral hydration workday intervention: 169 oz (5 L) of plain water, or 169 oz (5 L) of water with an electrolyte solution based on the World Health Organization (WHO)-recommended oral rehydration formula (glucose 13.5 g, trisodium citrate dihydrate 2.9 g, sodium chloride 2.6 g, potassium chloride 1.5 g per 1 L).[10] Research staff and participants were blinded to the a priori computer-generated randomization schedule; water bottles were distributed to the participants as randomized by a study team member at the FWAF office. Each participant on the intervention day received two 84.5 oz (2.5 L) water bottles filled with their assigned beverage. Participants were encouraged to drink as much of the fluids as they could throughout their workday. At the post-workday visit, we documented fluid remaining in the bottles and confirmed that the participant did not share the beverage with others. On both days, a post-workday survey collected self-reported consumption of selfprovided beverages(water, soda, diet soda, energy drinks, sports drinks, tea, coffee, alcohol, and other). Beverage consumption per hour was estimated by total consumption divided by self-reported work hours.

Procedure

Baseline demographics of the participants were retrieved from the longitudinal study, which included sociodemographic questions and anthropometric measurements. Both on the control and intervention workdays, participants provided urine and blood samples pre- and post-shift. USG was measured using a digital refractometer (Atago PAL-10S digital refractometer, Bellevue, WA). Pre-shift and post-shift USG values were categorized into values of more than or equal to 1.020 (dehydrated) or less than 1.020 (euhydrated). Creatinine and blood urea nitrogen (BUN) were used to indicate kidney function and measured by finger-stick blood samples that were analyzed with an iSTAT Blood Analyzer with CHEM 8+cartridges (Abbott Point of Care, Inc., East Windsor, NJ). Theþ Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation was used to estimate glomerular filtration rate (eGFR).[11] We categorized eGFR into two categories: more than or equal to 90 mL/min/1.73 m^2 (normal) or less than 90 mL/min/ 1.73 m^2 (reduced kidney function). Development of AKI over thework shift was defined using the Kidney

Disease Improving Global Outcomes (KDIGO) criteria[12]: incident AKI over the workday was considered to be present if serum creatinine values after the work shift increased at least 0.3 mg/dL from values before work or the ratio of post- to pre-shift values was more than or equal to 1.5.[12] Temperature and relative humidity data during the study workdays were retrieved from the Florida Automated Weather Network (FAWN) and used to calculate a daily average heat index for each participant. FAWN is a 42-station weather data collection network spanning the length and breadth of mainland Florida for agricultural purposes. Based on each participant's work hours, we quantified exposure by extracting weather data summaries from FAWN and calculated heat index (HI) by using the National Weather Service algorithm.[13]

Statistical Analysis

Descriptive statistics were reported as mean and standard deviation, median and quartiles, and percent and sample size. Analyses were performed using SAS 9.4 software (SAS Institute Inc., Cary, NC).

RESULTS

The study sample included 30 agricultural workers who were monitored on 2 workdays (1 control workday and 1 intervention workday), with 16 workers randomized to the water group and 14 to the electrolyte group. The heat index during working hours was very similar for the two intervention groups on both the control day and intervention day. The electrolyte group was on average older in age, had more years working in agriculture, worked slightly fewer hours, and drank less fluid compared with the water group (Table 1). Both intervention groups drank substantially more on the intervention day than on the control day.In addition to the 5L offluids that we provided, some participants drank other beverages, primarily small amounts of water or sugary drinks. Fluid consumption per hour nearly doubled in both groups to 15 ounces on the intervention day. The water group was well hydrated at the post-workday visit with a median USG of 1.005 (Q1 1.002, Q3 1.009) while the median USG in the electrolyte group was 1.018. Among the water group, there was a larger drop in median eGFR on the intervention day than on the control study day (114.2 to 104.9 vs 115.6 to 111.4, respectively). In contrast, participants in the electrolyte group had increased eGFR on the intervention day (120.1 to 124.7) compared with a 10 unit drop in afternoon eGFR on the control day (122.5 to 112.3). The number of participants with post-workday eGFR less than 90 mL/min/1.73 m^2 declined from the control to intervention day by 5 (5 v 0) in the electrolyte group compared with 1 (3 v 2) in the water group. The incidence of AKI was reduced from 30%to0% in the electrolyte group and increased from 9%to23%in the water group.

DISCUSSION

This is the first field-based study to pilot test hydration interventions among agricultural workers in the United States and demonstrates that it is feasible to implement hydration interventions in agricultural workplaces. The study showed that drinking water with electrolytes may lower the risk for the development of AKI among agricultural workers, supporting previous research findings.[7,9] Provision of water and encouragement of its consumption improved hydration but did not protect workers from developing AKI.

Maintaining adequate hydration and electrolyte balance during prolonged bouts of physical activity in high environmental temperatures is essential to homeostasis, enabling improved blood flow to the skin for heat dissipation.[14] Prolonged exposure to heat may lead to isotonic losses of both water and electrolytes through sweat.[15] The kidney can preserve GFR in states of mild fluid losses, which may only lead to dehydration that can be replaced solely by water.[16] However, severe fluid losses lead to volume depletion which causes a decrease in GFR.[16,17] The water group showed that the increase in water consumption decreased the proportion of participants with an eGFR less than 90 mL/min/1.73 m^2 but did not protect workers from less severe AKI. In this setting it is preferable to give isotonic solutions with electrolytes to restore blood volume and reverse loss in GFR, which may explain the favorable results with the electrolyte solutions.[16,17]

Our findings present preliminary evidence of the beneficial effect of ingesting isotonic solutions when working in heat; however, our small sample size limits the ability to demonstrate statistically significant differences between the two hydration interventions. Additionally, we were not at the participants' work site to observe consumption of the provided fluids and of other beverages. Further studies with larger sample sizes are needed to further quantify the beneficial effects of isotonic liquids on preventing AKI. In addition, different agricultural work types with various degrees of occupational heat exposure are needed to assess the optimum quantity of electrolyte fluid hydration needed to protect workers from AKI and dehydration. This should be examined in conjunction with studying what factors will improve regular daily beverage consumption since we found that even though we provided fluids and encouraged drinking throughout the day, consumption increased but not to the quantities recommended by NIOSH. The participants were predominantly overweight, which may impact generalizability; however, recent studies have shown agricultural workers are generally overweight.[18,19]

With the association of extreme heat temperatures and increased risk for the developing AKI and dehydration among agricultural workers, it is essential that we study hydration intervention strategies to protect vulnerable outside workers from adverse health effects due to climate change.

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REFERENCES

1. Information NNCfE. State of the Climate: Global Climate Report for August 2021. NOAA National Centers for Environmental Information; 2021.
2. Gubernot DM, Anderson GB, Hunting KL. Characterizing occupational heat-related mortality in the United States, 2000–2010: an analysis using the Census of Fatal Occupational Injuries database. Am J Ind Med. 2015;58:203– 211. [PubMed: 25603942]
3. Mutic AD, Mix JM, Elon L, et al. Classification of heat-related illness symptoms among Florida farmworkers. J Nurs Scholarsh. 2018;50:74–82. [PubMed: 29024370]

4. Mix J, Elon L, Vi Thien Mac V, et al. Hydration status, kidney function, and kidney injury in Florida agricultural workers. J Occup Environ Med. 2018;60: e253–e260. [PubMed: 29271837]
5. Moyce S, Mitchell D, Armitage T, Tancredi D, Joseph J, Schenker M. Heat strain, volume depletion and kidney function in California agricultural workers. Occup Environ Med. 2017;74:402–409. [PubMed: 28093502]
6. Krisher L, Butler-Dawson J, Yoder H, et al. Electrolyte beverage intake to promote hydration and maintain kidney function in Guatemalan sugarcane workers laboring in hot conditions. J Occup Environ Med. 2020;62:e696– e703. [PubMed: 33003044]
7. Laws RL, Brooks DR, Amador JJ, et al. Changes in kidney function among Nicaraguan sugarcane workers. Int J Occup Environ Health. 2015;21:241– 250. [PubMed: 25631575]
8. NIOSH. Heat Stress - Recommendations. The National Institute for Occupational Safety and Health (NIOSH); 2018.
9. Butler-Dawson J, Krisher L, Yoder H, et al. Evaluation of heat stress and cumulative incidence of acute kidney injury in sugarcane workers in Guatemala. Int Arch Occup Environ Health. 2019;92:977–990. [PubMed: 30997573]
10. WHO. Who Drug Information. Geneva, Switzerland: World Health Organization; 2002, 16.
11. Levey AS, Atkins R, Coresh J, et al. Chronic kidney disease as a global public health problem: approaches and initiatives - a position statement from Kidney Disease Improving Global Outcomes. Kidney Int. 2007;72:247–259. [PubMed: 17568785]
12. Kellum JA, Lameire N. Diagnosis, evaluation, and management of acute kidney injury: a KDIGO summary (Part 1). Crit Care. 2013;17:204. [PubMed: 23394211]
13. Rothfusz L The Heat Index “Equation” (or, More Than You Ever Wanted to Know About Heat Index). Fort Worth, TX: NWS Southern Region Headquarters: National Weather Service Scientific Services Division; 1990.
14. Casa DJ, Armstrong LE, Hillman SK, et al. National athletic trainers’ association position statement: fluid replacement for athletes. J Athl Train. 2000;35:212–224. [PubMed: 16558633]
15. McDermott BP, Anderson SA, Armstrong LE, et al. National athletic Trainers’ association position statement: fluid replacement for the physically active. J Athl Train. 2017;52:877–895. [PubMed: 28985128]
16. Bhave G, Neilson EG. Volume depletion versus dehydration: how understanding the difference can guide therapy. Am J Kidney Dis. 2011;58:302– 309. [PubMed: 21705120]
17. Roncal-Jimenez C, Lanaspa MA, Jensen T, Sanchez-Lozada LG, Johnson RJ. Mechanisms by which dehydration may lead to chronic kidney disease. Ann Nutr Metab. 2015;66(suppl):10–13.
18. Chicas RC, Elon L, Houser MC, et al. The health status of hispanic agricultural workers in Georgia and Florida. J Immigr Minor Health. 2022. doi: 10.1007/s10903-021-01326-0. Online ahead of print.
19. Moyce S, Hernandez K, Schenker M. Diagnosed and undiagnosed diabetes among agricultural workers in California. J Health Care Poor Underserved. 2019;30:1289–1301. [PubMed: 31680099]

TABLE 1.

Demographic and Clinical Characteristics

	Water Group (n=16)				Electrolyte Group (n=14)			
	Control day		Water 169 oz (5 L)		Control day		Electrolyte 169 oz (5 L)	
	n	**%, mean [std], or median (q1, q3)**	***n***	**%, mean [std], or median (q1, q3)**	***n***	**%, mean [std], or median (q1, q3)**	***n***	**%, mean [std], or median (q1, q3)**
Demographics and Work Female	12/16	75%			11/14	79%		
Married/coupled	12/16	75%			11/14	79%		
Age, years	16	39 (36, 47)			14	44 (37, 47)		
BMI	16	28 (25, 33)			14	30 (28, 31)		
Years in AgricultureĆWork Type	16	13 (6, 20)			14	16 (11, 19)		
Fernery	5/16	31%	5/16	31%	6/14	43%	6/14	43%
Nursery	9/16	56%	9/16	56%	7/14	50%	7/14	50%
Yardwork	2/16	13%	2/16	13%	1/14	7%	1/14	7%
Hours Worked	16	9.3 (7.3, 10.5)	16	9.5 (8.8, 10.5)	14	8.7 (5.5, 9.0)	14	8.8 (6.0, 9.5)
Heat Index, per person mean	16	89.6 [5.5]	16	92.3 [5.1]	14	90.1 [4.7]	14	91.7 [3.8]
Heat Index, per person max Beverage Consumption	16	102.6 [4.7]	16	102.0 [4.3]	14	102.8 [4.3]	14	101.2 [3.4]
Total overall, oz	16	80 (64, 100)	16	134 (98, 165)	14	62 (44, 88)	14	119 (93, 146)
Provided hydration beverage		-		116 (85, 156)		-	14	103 (85, 132)
Total per hour, oz	16	8 (7, 15)	16	15 (11, 19)	14	9 (5, 11)	14	15, (13, 19)
Water (personal provisions)	16	64 (40, 80)	15	0 (0, 16)	14	42 (32, 72)	12	0 (9, 16)
Sugary drinks (sports, energy, juice, sugared soda)	16	12 (0, 26)	15	0 (0, 16)	14	14 (0, 24)	13	4 (0, 12)
Clinical VariablesĆUSG								
Pre-work	15	1.023 (1.013, 1.025)	16	1.020 (1.017,1.023)	12	1.018 (1.015, 1.023)	14	1.019 (1.015, 1.027)
Post-work	16	1.015 (1.006, 1.022)	16	1.005 (1.002, 1.009)	12	1.021 (1.015, 1.029)	14	1.018 (1.005, 1.025)
eGFR (mL/min/1.73 m^2)								
Pre-work	14	115.6 (109.6, 122.3)	16	114.2 (109.8, 124.3)	12	122.5 (112.5, 130.6)	14	120.1 (110.5, 127.1)
Post-work	13	111.4 (97.2, 117.4)	13	104.9 (96.4, 120.1)	12	112.3 (82.9, 119.7)	11	124.7 (109.3,127.3)
eGFR < 90 mL/min/1.73 m^2								
Pre-work	0/14	0%	0/16	0%	0/12	0%	0/14	0%
Post-work	3/13	23%	2/13	15%	5/12	42%	0/11	0%

	Water Group (n=16)				Electrolyte Group (n=14)			
	Control day		Water 169 oz (5 L)		Control day		Electrolyte 169 oz (5 L)	
	n	**%, mean [std], or median (q1, q3)**	***n***	**%, mean [std], or median (q1, q3)**	***n***	**%, mean [std], or median (q1, q3)**	***n***	**%, mean [std], or median (q1, q3)**
AKI	1/11	9%	3/13	23%	3/10	30%	0/11	0%

AKI indicates acute kidney injury; eGFR, estimate glomerular filtration rate.