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Hydration Choices, Sugary Beverages, and Kidney Injury in Agricultural Workers in California

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Abstract

Purpose: Agricultural workers working in high ambient temperatures are at risk for acute kidney injury. Despite recommendations to maintain hydration, workers likely do not drink enough to protect their renal function. Additionally, new research suggests that rehydration with sugary beverages adds additional risk to kidneys already stressed by high heat and workload. We assessed hydration choices during a work shift and tested associations of rehydration using sugary beverages with acute kidney injury.

Methods: We recruited a convenience sample of workers on farms over two summers. We estimated acute kidney injury via pre- and post-shift serum creatinine readings from capillary blood samples. We used self-reported measures of the volume and type of fluids workers consumed during their shifts. We also measured changes in core body temperature, ambient temperature, and workload. We used logistic regression to estimate associations of sugary drinks with acute kidney injury, while controlling for physiologic and occupational variables.

Findings: In our sample of 445 participants, we found that men drink more than women do overall, including more than a liter of water than women (2.9 L compared to 1.9 L, respectively). The total volume workers drank was associated with increased odds of acute kidney injury (adjusted odds ratio 1.47, 95% confidence interval 1.09–1.99). We found no association of sugary drinks with acute kidney injury.

Conclusions: These findings provide important information about what men and women use to hydrate during the work day and suggest that they do not drink enough to maintain adequate hydration. Increased fluid intake during the work day may be a result of vigorous workload, which could explain the increased risk for acute kidney injury. Nurses play an important role in educating agricultural workers about the importance of maintaining hydration at work.

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Clinical Relevance: This study advances current knowledge of occupational risk factors for acute kidney injury in agricultural workers. Nurses may be the only point of care for this vulnerable population and are therefore in a unique position to educate on the importance of proper hydration during work.

Keywords

Acute kidney injury; agricultural workers; hydration practices; sugary drinks

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Increasing attention is focused on an epidemic of chronic kidney disease of unknown origin (CKDu), which affects young men, mostly agricultural workers, in their third through fifth decades of life who lack the known risk factors for traditional chronic kidney disease, including diabetes or hypertension. Current hypotheses about the origin of this disease center around the occupational exposures of heat stress and dehydration as contributory factors to decreased kidney function (García-Trabanino et al., 2015; Glaser et al., 2016). An additional hypothesis suggests that workers who rehydrate with sugary beverages are at increased risk for kidney injury due to the metabolism of fructose in the kidneys (Roncal-Jimenez, Lanaspa, Jensen, Sanchez-Lozada, & Johnson, 2015). In animal studies, fructose has been linked to damage in the proximal tubules and tubulointerstitial injury and increases biomarkers of acute kidney injury (AKI; García-Arroyo et al., 2016). High intake of fructose, particularly during periods of dehydration, leads to kidney injury through the activation of fructokinase, which induces inflammatory mediators that lead to interstitial damage (Aoyama et al., 2012; Jimenez et al., 2014; Madero, García-Arroyo, & Sánchez-Lozada, 2017; Nakayama et al., 2010). However, we lack an in-depth understanding of the effect of sugary beverages on the kidney function in humans. In a study of 12 adults in the laboratory setting, Chapman and colleagues found higher rates of AKI after exercise in those who rehydrated with soda compared to those who hydrated with water (Chapman, Johnson, Sackett, Parker, & Schlader, 2019). We do not know if this is true in an agricultural field setting.

The National Institutes of Occupational Safety and Health (NIOSH) recommends that employers encourage workers to hydrate with 1 cup of water every 15 to 20 min in hot conditions (Centers for Disease Control and Prevention, 2018). While we assume agricultural workers often do not drink enough to stay hydrated throughout the day (Jackson & Rosenberg, 2010), we know little about what they actually do drink. In the United States, only a few studies have addressed this. In a qualitative study exploring hydration practices, workers in Washington state reported that they often do not have enough water with them while working. They also reported drinking electrolyte-containing beverages, including sports drinks or energy drinks, and soda with caffeine to help themselves work faster (Lam et al., 2013). In a study of kidney function in agricultural workers in Florida, Mix and colleagues (2018) reported the types of beverages workers drink during the day, with water and sports drinks being the most often consumed. Similarly, in a comparison of workers in Oregon and Washington states, Bethel, Spector, and Krenz (2017) reported that workers predominantly drink water, followed by energy drinks and soda.

An assessment of the amount and type of beverages used to rehydrate during the workday is an important step in understanding hydration practices and the effect of beverage choices on kidney function. Knowledge of what beverages agricultural workers choose during the day can give insight into their hydration practices and into ways to refine policies to protect their health during high ambient temperatures. In addition, it is important to know if hydrating with sugary beverages has a negative impact on the kidneys. Therefore, we assessed hydration choices during the course of a work shift and tested associations of AKI and rehydration using sugary beverages during periods of heavy work in high ambient temperatures in a sample of agricultural workers.

Methods

Data Collection

Data for this analysis were collected as part of the California Heat Illness Prevention Study, whose methods are described elsewhere (Mitchell et al., 2017). Briefly, bilingual and bicultural field staff recruited a convenience sample of workers employed at 29 farms in California in the summers of 2014 and 2015. Participation in the study was for a single day and included pre-shift and post-shift measures. Pre-shift, field staff weighed participants in a base layer of clothing using a medical scale (Seca Model 874, Seca GMBH, Hamburg, Germany), took a seated blood pressure reading, collected a capillary blood sample, and administered a brief oral questionnaire in either Spanish or English. Participants swallowed a CorTemp HT15002 ingestible wireless temperature transmitter probe (HQInc, Palmetto, Florida, USA). The probe transmitted core temperature measurements at 1-min intervals (Engels, Yarandi, & Davis, 2009). Signals from the probe were recorded using a CorTemp HT150016 Data Recorder (HQInc) attached to their belts. Actical accelerometers (Philips Respironics, Murrysville, PA, USA), calibrated by the manufacturer, were firmly attached to the workers' waist belts at the iliac crest of the hip using both a Velcro band through the mounting tabs and zip ties to ensure it remained in place during rough fieldwork. The Actical accelerometer measures activity in all directions and provides counts per minute (cpm) (Heil, Brage, & Rothney, 2012). Following the shift, participants returned to the data collection point for post-shift measurements. Field staff weighed participants in the same base layer of clothes, took another capillary blood sample, and administered a more extensive questionnaire, which included questions about what workers drank during the shift.

All staff involved in data collection were trained and supervised, and all equipment was regularly calibrated to ensure accuracy. In addition, data collection procedures were pilot tested during a previous summer to determine their reliability. Study protocol and methods were approved by the Institutional Review Board at the University of California, Davis. Participants were given a monetary incentive for their participation.

Predictor Variable: Beverage Consumption

At the post-shift data collection, field staff asked participants to estimate the quantity and type of beverage consumed during the workday. Field staff were trained in accurately estimating fluid intake based on protocols developed in the pilot study. They showed participants examples of various quantities of beverages in different containers to assist in estimates of ounces consumed. The mean ounces consumed of each type of beverage (water, soda, sports drink, energy drink, beer, or juice) were calculated and are reported as raw values and as ounces per kilogram. We combined all beverages to calculate a total volume consumed. To estimate the effect of sugary beverages, we combined all beverages containing sugar (soda, sports drinks, energy drinks, and juice) and created a variable of ounces sugar drinks and ounces per kilogram.

Outcome Variable: Acute Kidney Injury

The capillary blood samples taken before and after the shift were analyzed using the handheld i-STAT point of care test (Abbot Point of Care, Inc., Princeton, NJ, USA) to measure serum creatinine, traceable to isotope dilution mass spectrometry reference standards (Shephard, 2011). The pre- and post-shift creatinine measurements were compared and used to estimate stages of AKI based on recommendations from the Kidney Disease: Improving Global Outcomes Working Group (2012). In previous work, we reported a break-down of AKI stage based on changes in creatinine over the work shift for data collected in 2014–2015 (Moyce, Joseph, Tancredi, Mitchell, & Schenker, 2016). For this analysis, we used a binary variable for AKI: those who had any stage of AKI (66 of 445, 14.8%) versus no injury.

Other Variables

We selected potentially confounding variables thought to be associated with AKI and rehydration a priori based on a review of the literature and availability of data collection. Variables related to the risks of working in outdoor agricultural settings included volume depletion, core body temperature elevations, workload, and ambient temperature. We estimated volume depletion based on a change in weight by comparing the post-shift weight to the pre-shift weight. In field conditions, body mass change is considered the most accurate method for estimating hydration status (Armstrong, 2007; Baker, Lang, & Kenney, 2009; Ganio, Armstrong, & Kavouras, 2018), and 1 kg of body weight represents 1 L of body fluid (Kavouras, 2002). Core body temperature is the sum of external heat plus internal heat due to workload and metabolism, minus evaporative heat loss from sweating. We measured core body temperature using the ingestible wireless transmitters, which transmitted readings at 1-min intervals. We calculated the sum of every 3-min reading, took the mean, and then used the maximum value of those to estimate the 3-min maximum core temperature reading during the day (Mitchell et al., 2017). We then calculated a change in body temperature by subtracting the 3-min maximum from the baseline reading. All participants had at least some increase in core body temperature over the course of the day, so we categorized the change as either ≥1°C versus <1°C. We estimated a sustained 3-min maximum workload from the cpm data from accelerometers and classified workload: sedentary (<100 cpm), light activity (100 to <1,535 cpm), moderate activity (1,535 to <3,962 cpm), and vigorous activity (≥3,962 cpm; Colley & Tremblay, 2011). Using the wet bulb globe temperature (WBGT), we estimated daily maximum ambient heat. We used QUESTemp 36 weather stations (Quest Technologies, Inc. Oconomowoc, WI, USA) located in the same field as the participants (Mitchell et al., 2017) to collect those measurements.

Physiologic variables thought to influence the effect of sugary drinks on the kidneys included age, diabetes status, blood pressure, and body mass index (BMI). Participants reported their age in the pre-shift questionnaire. We collected a second capillary blood sample at the post-shift data collection point to estimate diabetes status based on hemoglobin A1c (HgbA1c) levels using the DCA Vantage Analyzer (Siemens Health Engineers, Tarrytown, NY, USA). Diabetes status was defined by standard categories of HgbA1c (American Diabetes Association, 2017). We took a seated blood pressure reading and categorized it as recommended by the American College of Cardiology (Carey & Whelton, 2018). We used a stadiometer to measure height while participants wore socks, and with the morning weight calculated a BMI (kg/m^2).

Occupational variables were collected via self-report and included years in farm work, payment type (hourly or salaried vs. piece-rate), and farm task (picking vs. other task, such as hoeing, irrigation, packing or planting, weeding, machine repair, etc).

Data Analysis

We calculated descriptive statistics and stratified them by sex. We compared differences using chi-square tests with Bonferroni correction to control for type 1 error. We compared differences between sexes in both raw mean volumes and ounces per kilogram using the Wilcoxon rank sum test for nonparametric data, and also using the Bonferroni correction. We ran logistic regression models in pooled data and data stratified by sex to test associations between AKI (yes vs. no) and sugary beverages (oz/kg), controlling for percentage of body mass lost (continuous), change in core body temperature (continuous), maximum WBGT (continuous), total volume consumed (oz/kg), 3-min maximum workload (cpm, continuous), age (continuous), diabetes (HgbA1c <6.5% vs. ≥6.5%), blood pressure (<120/80 mm Hg vs. ≥120/80 mm Hg), BMI (continuous), years in agricultural work (continuous), payment method (piece rate vs. hourly or salary), and farm task (picking vs. other tasks). To test the potential effect modification, we tested interactions between sugary drinks and a number of variables, including volume depletion, change in core body temperature, workload, female sex, payment method, and picking. We tested interactions between variables in pooled data and used backwards stepwise regression to determine the best models, with a $p < .05$ threshold. No interactions were significantly associated with AKI, and our final model retained total volume and picking. We report the final models in both pooled and stratified data without interaction terms, due to their lack of significance. We conducted all statistical analyses using Stata 12 software (Stata Corp LP, College Station, TX, USA).

Results

We had complete data on 445 participants (283 males and 162 females) for this analysis. The majority of the sample was over 26 years old, from Mexico, and spoke Spanish as their primary language. More males than females had a change in core body temperature that was at least 1°C (131 compared to 39, respectively). Additionally, more males than females lost at least 1.5% of their body mass (43 compared to 4, respectively). Females were less likely to have a BMI < 25 (13.0% compared to 23.3% males), though males had higher blood pressure than females (88.0% had blood pressure ≥120/80 mm Hg compared to 57.4% of females). Males also reported working in farm work for more years than females (Table 1).

The maximum WBGT of the 3-min moving average had a mean of 30.32°C (*SD* 3.16°C; data not shown). Overall, males drank more fluids during the work day than females (112.8 oz vs. 77.6 oz, or 1.42 oz/kg vs. 1.11 oz/kg; $p < .01$). Males also drank more water than females (97.4 oz vs. 64.5 oz, respectively, $p < .01$; and 1.22 oz/kg vs. 0.91 oz/kg, respectively, $p < .01$). Males also drank more energy drinks than females (1.8 oz vs. 0.6 oz, respectively, $p = .02$). When looking at raw volume, males reported drinking more sugary drinks than females (15.8 oz vs. 13.1 oz, respectively, $p = .04$). Males reported drinking beer at work, though females did not. When we looked at ounces per kilogram, males drank more total fluids than females (1.42 oz/kg vs. 1.11 oz/kg, respectively, $p < .01$). Males also drank more water per kilogram. The differences between the sexes in sugary drinks were no longer statistically significant when we looked at volume per kilogram (Table 2).

In pooled data, logistic regression models showed a statistically significant association between AKI and the total volume consumed, with an adjusted odds ratio (AOR) of 1.47 (95% confidence interval [CI] 1.09–1.99). Maximum workload was associated with a slightly elevated AOR of 1.01 (95% CI 1.01–1.02). Picking was also associated with an AOR of 2.51 (95% CI 1.39–4.54).

We ran models on the sample stratified by sex. Among males, 45 of the 283 experienced AKI (15.9%); 21 of the 162 females had AKI (12.9%) When we ran our models on the stratified data, the association between sugary drinks and AKI was not statistically significant. In fact, in females, we found no statistically significant associations in any of the variables that we included. In males, however, diabetes was associated with elevated odds of AKI (AOR 6.76, 95% CI 1.49–30.77). The association with picking increased to AOR of 4.12 (95% CI 1.87–9.08; Table 3).

Discussion

This study provides important estimates of what agricultural workers in California use to rehydrate during the course of a work shift. We found that males drank more fluids than females overall: males reported drinking 3.3 L, and females reported drinking 2.3 L. Most of these differences are seen in the amount of water consumed, and males reported drinking over a liter more water than females (2.9 L vs. 1.9 L). Males also lost more body weight over the course of the workday. While 11% of our sample lost more than 1.5% of their body weight, indicating dehydration according to NIOSH recommendations, significantly more males were classified as dehydrated according to our estimates. This suggests that, despite drinking more than females, they are still not drinking enough to maintain adequate hydration levels during the workday. Participants in our sample worked on average 8 to 10 hr a day. Assuming 6 hr of exposure to heat, participants would need to drink 4.2 to 5.6 L (144–192 oz) to meet hydration recommendations (Jacklitsch et al., 2016). Reported consumption in this study is nearly a liter less than what NIOSH recommends. These findings are echoed in other studies of agricultural workers in the United States (Bethel, Spector, & Krenz, 2017; Lam et al., 2013; Mix et al., 2018). Due to the importance of maintaining hydration while working in the heat, this represents an area for a potential health intervention and improved worker education as part of trainings to prevent heat-related illness.

We also found that men and women drink about 0.2 oz/kg of sugary drinks during work. We did not find any associations between sugary drinks and AKI in our estimates. In animal models, researchers found that rehydration with sugary beverages after heat-induced dehydration worsened hydration levels and increased kidney damage (García-Arroyo et al., 2016). However, in a study of workers in Nicaragua, Wesseling and colleagues reported that decreased kidney function was associated with a lower intake of sugary drinks (Wesseling, Aragón, González, Weiss, Glaser, Rivard, et al., 2016). In another study in Nicaragua, researchers examined the effects of daily fructose consumption and rehydration solutions separately. In univariate models, they found that increased fructose consumption was not associated with reduced estimated glomerular filtration rate (eGFR), but that the rehydration solution was associated with decreased kidney function (Raines et al., 2014). Our findings suggest a lack of an association with sugary drinks and kidney damage, at least acutely. However, in the context of these other studies, further research is needed to elucidate the relationship between sugar consumption and kidney health in humans, particularly in the occupational setting.

The finding that increased fluid intake is positively associated with AKI, while paradoxical, is not unfounded in the literature. In an analysis of nearly 1,000 workers in Nicaragua, researchers reported that higher levels of water consumption were associated with increased odds of reduced eGFR (Lebov et al., 2015). They hypothesized that increased water intake indicates a potential problem of the kidneys in concentrating urine. Another hypothesis is that those who drink large amounts of water during the day compensate for working hard. In previous analysis, we found that the maximum workload was also associated with a slightly elevated risk for AKI (Moyce, Armitage, Mitchell, & Schenker, 2020). Additionally, we found that workers involved in picking had higher odds of AKI. Potentially, these three factors may work in combination to increase the risk for AKI. However, our findings differ from many of the estimates of kidney function among workers in places where CKDu is prevalent. Current theories into the etiology of that disease explore the role of dehydration, which may elevate vasopressin or uric acid and cause kidney damage (Roncal-Jimenez et al., 2015). Recent interventions focus on improving hydration measures in susceptible worker populations, and have found that drinking more protects kidneys (García-Trabanino et al., 2015; Wegman et al., 2018). Despite the contradictory nature of our findings, the importance of encouraging proper hydration among workers cannot be overstated.

Additionally, in males, we found increased odds of AKI with diabetes. In our previous analyses of these data, we did not see this association; however, this finding is not surprising, given the risk for kidney damage with diabetes. Moreover, diabetes is a risk factor for AKI (James et al., 2015), which may explain the association we found, suggesting that the kidney injury in our sample may be a result of a previously known risk factor. Moreover, elevated HgbA1c levels indicate a chronic state of hyperglycemia, which puts the kidneys at risk for injury, perhaps exacerbated by dehydration. Among agricultural workers, diabetes is likely to be undiagnosed (Moyce, Hernandez, & Schenker, 2019); therefore, education related to lifestyle factors that may reduce the risk for diabetes is important, particularly related to its effect on renal health.

Limitations

One important limitation to address in our findings is that we were unable to isolate the effects of fructose on kidney function and are thus unable to fully address the hypothesis that fructose metabolism leads to kidney injury. We did not ask workers specifically what types of drinks they consumed, only the kind of drinks. Soda, for example, may contain high fructose corn syrup, while diet soda does not. However, we present estimates of sugary drinks as a whole and estimates of total volume, which are important to consider when discussing hydration in the fields.

It is possible that our estimations of AKI represent not structural damage to the kidneys but a rise in response to volume depletion (Johnson, Wesseling, & Newman, 2019). However multiple studies of kidney injury in Central America have reported that persons with AKI continued to have decreased kidney function when assessed months later (Kupferman et al., 2018; Wesseling, Aragón, González, Weiss, Glaser, Bobadilla, et al., 2016), suggesting that the AKI that occurs in the work shift may be a precursor to more chronic damage. It is also important to note that creatinine is not always a reliable marker of actual injury to the kidneys (Griffin et al., 2018); however, in field studies with agricultural workers, its ease of use and relatively noninvasive methods of collection make it the most feasible measure.

Finally, statistical limitations in our analysis include the convenience sample recruited from farms in California. Due to the convenience sample, results cannot be generalized to the larger agricultural worker population, though our large sample size makes our analyses robust. Our access to farm workers was constrained by feasibility issues, and the sample was optimized within the limits of our ability and resources. Additionally, despite our statistical tests to ensure independence of the data, there may be a potential lack of independence between workers within a single farm.

Despite its limitations, this work is unique in that it describes hydration choices among agricultural workers in California during their work shifts. It also suggests that increased sugar intake during the work shift is not a risk factor for AKI. Findings from this study can be used in educational campaigns to promote proper hydration in agricultural workers and can help inform efforts to improve hydration practices.

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Clinical Resources

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- Occupational Safety and Health Administration. Heat Related Illness Prevention Campaign. https://www.osha.gov/heat/

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Table 1.

Characteristics of Study Sample

	Male (*n* = 283)		Female (*n* = 162)		*p* value[a]
	n	%	*n*	%	
Age group (years)					0.35
18–25	49	17.4	18	11.1	
26–40	116	41.3	76	46.9	
41–54	80	28.5	49	30.2	
>55	36	12.8	19	11.7	
Country of origin					<.01
United States	30	10.6	4	2.5	
Mexico	245	86.6	150	92.6	
Other	8	2.8	8	4.9	
Primary language					0.16
English	19	6.7	6	3.7	
Spanish	256	90.5	154	95.1	
Indigenous language	8	2.8	2	1.2	
Income					0.03
$10,000 or less	68	24.0	54	33.3	
$10,001–30,000	149	52.7	78	48.1	
$30,001 or more	66	23.3	30	18.5	
Change in core body temperature					<.01
<1°C	152	53.7	123	75.9	
≥1°C	131	46.3	39	24.1	
Change in body mass					<.01
Gained weight	50	17.7	51	31.5	
No change	15	5.3	14	8.6	
Lost <1.5%	175	61.8	93	57.4	
Lost ≥1.5%	43	15.2	4	2.5	
Workload					<.01
Sedentary (<100 cpm)	0	0.0	0	0.0	

	Male (n = 283)		Female (n = 162)		p value[a]
	n	**%**	***n***	**%**	
Light (100–1,534 cpm)	11	3.9	9	5.6	
Moderate (1,535–3,691 cpm)	208	73.5	129	79.6	
Vigorous (≥3,692 cpm)	64	22.6	24	14.8	
eGFR					0.21
60–90 mL/min/1.73 m^2	267	94.3	158	97.5	
>90 mL/min/1.73 m^2	16	5.7	4	2.5	
Diabetes status[b]					0.23
HgbA1c < 6.5%	272	96.1	151	93.2	
HgbA1c ≥ 6.5%	11	3.9	11	6.8	
Body mass index[c]					0.03
Normal weight (<25)	66	23.3	21	13.0	
Overweight (25–30)	120	42.4	75	46.3	
Obese (>30)	97	34.3	66	40.7	
Blood pressure (mm Hg)[d]					<.01
<120/80	34	12.0	69	42.6	
≥120/80	249	88.0	93	57.4	
Years in farmwork					<.01
5 or less	79	27.9	54	33.3	
6–10	44	15.5	39	24.1	
11–20	78	27.6	48	29.6	
>20	82	29.0	21	13.0	
Payment type					0.42
Hourly/salary	31	11.0	13	8.0	
Piece-rate	252	89.0	149	92.0	
Farm task					0.18
Picking	194	68.6	127	78.4	
Other[e]	89	31.4	35	21.6	

[a] *p* value based on results from chi-square tests with Bonferroni correction.

[b] Based on hemoglobin A1c taken from capillary blood sample.

[c] Body mass index calculated as kg/m^2.

[d] Blood pressure based on JNC7 Categories.

[e] Other farm task includes hoeing, irrigation, packing/planting, weeding, machine repair, etc.

Table 2.

Mean Fluid Consumption at Work

	Volume (ounces)					Ounces/kg				
	Males (n = 283)		Females (n = 162)			Males (n = 283)		Females (n = 162)		
	Mean	95% CI	Mean	95% CI	p value[a]	Mean	95% CI	Mean	95% CI	p value[a]
Total volume	112.8	104.6–121.1	77.6	69.6–85.5	<.01	1.42	1.32–1.53	1.11	1.00–2.12	<.01
Water	97.0	89.0–105.1	64.5	56.6–72.3	<.01	1.22	1.11–1.32	0.91	0.80–1.01	<.01
Soda	6.4	5.4–7.4	5.9	4.8–7.1	0.07	0.08	0.07–0.10	0.08	0.07–0.10	0.12
Sports drink	5.7	4.3–7.1	5.0	3.4–6.7	0.07	0.70	0.05–0.09	0.07	0.05–0.10	0.04
Energy drink	1.8	1.0–2.7	0.6	0.1–1.1	0.02	0.02	0.01–0.03	0.01	0.00–0.02	0.00
Juice	1.9	1.1–2.6	1.5	0.8–2.12	0.07	0.02	0.01–0.03	0.02	0.01–0.03	0.06
Beer	15.3	4.9–25.6	—	—	—	0.22	0.01–0.43	—	—	—
Sugary drinks[b]	15.8	14.2–17.4	13.1	11.4–14.8	0.04	0.20	0.18–0.23	0.19	0.16–0.21	0.10

CI = confidence interval.

[a]The Wilcoxon rank sum test was used to determine differences between sexes.

[b]Sugary drinks are defined as the combined consumption of all drinks except water and beer.

Table 3.

Association of Risk Factors With Acute Kidney Injury[a] Based on Logistic Regression

	Pooled data (n = 473)			Males (n = 283)			Females (n = 162)		
	AOR	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**	**AOR**	**95% CI**	***p* value**
Sugary drinks (oz/kg)	0.87	0.18–4.21	0.87	2.28	0.32–16.56	0.41	0.18	0.01–4.39	0.29
Percentage body mass lost[b]	1.07	0.77–1.49	0.68	1.19	0.79–1.73	0.40	0.78	0.33–1.81	0.56
Change in core temperature	1.16	0.66–2.05	0.60	1.69	0.82–3.48	0.15	0.63	0.17–2.28	0.48
3-min maximum WBGT	1.05	0.96–1.15	0.27	1.12	0.99–1.27	0.08	0.97	0.82–1.15	0.74
Total volume consumed (oz/kg)	1.47	1.09–1.99	0.01*	1.38	0.94–2.05	0.10	1.63	0.90–2.96	0.11
Maximum workload[c]	1.01	1.01–1.02	0.04*	1.00	0.99–1.03	0.09	1.00	0.99–1.00	0.09
Age (years)	0.98	0.94–1.00	0.07	0.97	0.93–1.01	0.14	0.95	0.89–1.01	0.12
Diabetes									
HgbA1c < 6.5% (reference)									
HgbA1c ≥ 6.5%	2.92	0.94–9.12	0.06	6.76	1.49–30.77	0.01*	0.89	0.09–8.71	0.92
Blood pressure (mm Hg)[d]									
<120/80 (reference)									
≥120/80	0.82	0.42–1.63	0.58	0.64	0.23–1.72	0.37	1.39	0.46–4.17	0.55
BMI (kg/m^2)	1.03	0.97–1.10	0.30	1.07	0.98–1.18	0.08	0.98	0.89–1.09	0.71
Years in agricultural work	1.03	0.99–1.06	0.10	1.02	0.97–1.06	0.90	1.06	0.99–1.12	0.06
Payment method									
Piece rate (reference)									
Hourly/salary	0.67	0.29–1.55	0.35	0.75	0.26–2.15	0.56	0.47	0.11–2.09	0.32
Farm task									
Other (reference)[e]									
Picking	2.51	1.39–4.54	0.02*	4.12	1.87–9.08	<.01*	0.90	0.27–2.97	0.86

BMI = body mass index (continuous); CI = confidence interval; HgbA1c = hemoglobin A1c (from capillary blood sample); WBGT = wet bulb globe temperature.

[a]Acute kidney injury based on KDIGO classification of elevations in serum creatinine.

[b]Percentage body mass lost based on comparing pre-shift weight in kilograms and post-shift weight in kilograms.

[c]Counts per minute from accelerometer data (continous).

[d]Blood pressure based on JNC7 categories.

[e]Includes other farm tasks (e.g., irrigating, packing/sorting, hoeing, etc.).

*Significant at $\alpha < 0.05$.