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The Acute Effect of Adequate Water Intake on Glucose Regulation in Low Drinkers

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Abstract

Background: Arginine vasopressin (AVP), a key hormone in fluid balance, may be a modifiable contributor to hyperglycemia [1]. Low daily water drinkers often exhibit increased urine concentration and copeptin, a surrogate marker for AVP [2, 3]. ***Objective:*** The primary purpose was to investigate the acute effect of adequate water intake on daily glucose concentration in low drinkers. Secondarily, the study examined if adequate water intake could improve glucoregulatory hormonal profiles in low drinkers. ***Methods:*** Seven healthy (5 males, 2 females; age 43 ± 7 years, BMI 31 ± 3) low drinkers were recruited using a water frequency questionnaire and a 24-h urine sample. Participants were recruited using social media channels and flyers in local community. Classification of a low drinker was defined by a fluid intake (water and other beverages) <1.5 L·day^{-1} in males or <1.0 L·day^{-1} in females and a 24-h·UOsm of >800 mmol·kg^{-1}. In a crossover counterbalanced design, participants remained in the laboratory for 11 h (07:00–18:00) and were provided either the Institute of Medicine's recommended amount of water excluding fluid from food (males: 3 L·day^{-1}, females: 2 L·day^{-1}; high water intake, HWI) or an amount representing the bottom quartile of water consumption observed in the National Health and Nutrition Examination Survey (males: 0.5 L·day^{-1}, females: 0.4 L·day^{-1}; low iater intake, LWI) (Table 1) [4, 5]. Caloric intake was standardized to body weight (100 kJ·kg^{-1}) with an identical ratio of macronutrients and time of consumption between trials (Table 1). At 07:00, fasted baseline blood was drawn. Subsequent blood draws performed across the next 11 hours were analyzed for copeptin, glucose, insulin, glucagon, cortisol, and GLP-1 (Table 1). All urine voids during the 11-h protocol were pooled and analyzed for osmolality and glucose (n = 4). A two-way (water intake × time) repeated-measures ANOVA was used to determine differences in hydration and glucoregulatory measures. Dependent t tests were used to measure differences in urine samples. Statistical significance was determined a priori at an alpha of 0.05. ***Results:*** Participants were confirmed as low drinkers according to daily fluid intake, 24-h·UOsm, and copeptin (water frequency questionnaire volume: 823 ± 403 mL·day^{-1}, 24-h·UOsm: 961 ± 105 mmol·kg^{-1}, copeptin: 8.17 ± 3.05 pmol·L^{-1}). During the experiments, 11-h·UOsm (HWI: 224 ± 48 mmol·kg^{-1}, LWI: 956 ± 120 mmol·kg^{-1}), plasma osmolality, and copeptin were lower in HWI as than in LWI (p = < 0.05, Fig. 1). There was a borderline significant main effect of water intake on plasma glucose (p = 0.07, Fig. 2) and total urinary glucose output (HWI: 51.4 ± 6.9 mg, LWI: 40.1 ± 10.4 mg, p = 0.07). Cortisol was significantly higher in LWI as than in HWI (p = 0.009, Fig. 2); however, no pairwise differences were observed in post hoc analysis. Glucagon, insulin, and GLP-1 were similar between trials (p > 0.05). ***Conclusion:*** Acute increases in water intake may mildly reduce daily plasma glucose concentrations in low drinkers. This may be due to acutely increased urinary glucose output when low drinkers are given adequate amounts of water. Increased water intake also led to decreased cortisol concentration.

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Table 1. Water intake, meals, and blood draws during experimental protocol

Time	Water intake, mL				Meal	Blood draw
	male		female			
	HWI	LWI	HWI	LWI		
07:00	500	100	250	50	Breakfast	Yes
08:00	250	–	125	–	–	Yes
09:00	250	100	125	100	–	Yes
10:00	250	–	250	–	Snack 1	–
11:00	250	–	125	–	–	–
12:00	250	50	250	50	Lunch	Yes
13:00	250	–	125	–	–	Yes
14:00	250	100	250	100	Snack 2	Yes
15:00	250	–	125	–	–	–
16:00	250	50	250	50	Dinner	Yes
17:00	250	100	125	50	–	Yes
18:00	–	–	–	–	–	Yes

HWI, high water intake; LWI, low water intake.

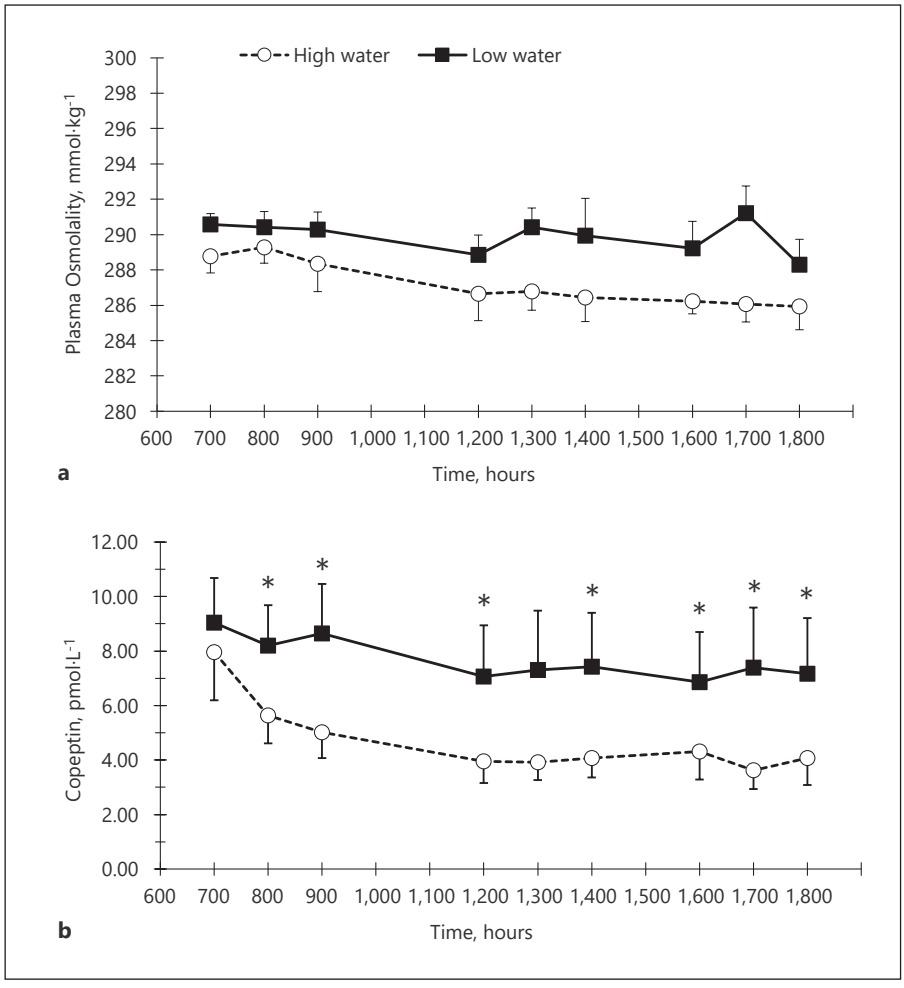

Fig. 1. Plasma osmolality (**a**) and copeptin (**b**) during HWI (males: 3 L; females: 2 L) and LWI (males: 1 L; females: 0.5 L) trials. *Represents significantly different from HWI for time point ($p < 0.05$). Error bars = SE. HWI, high water intake; LWI, low water intake.

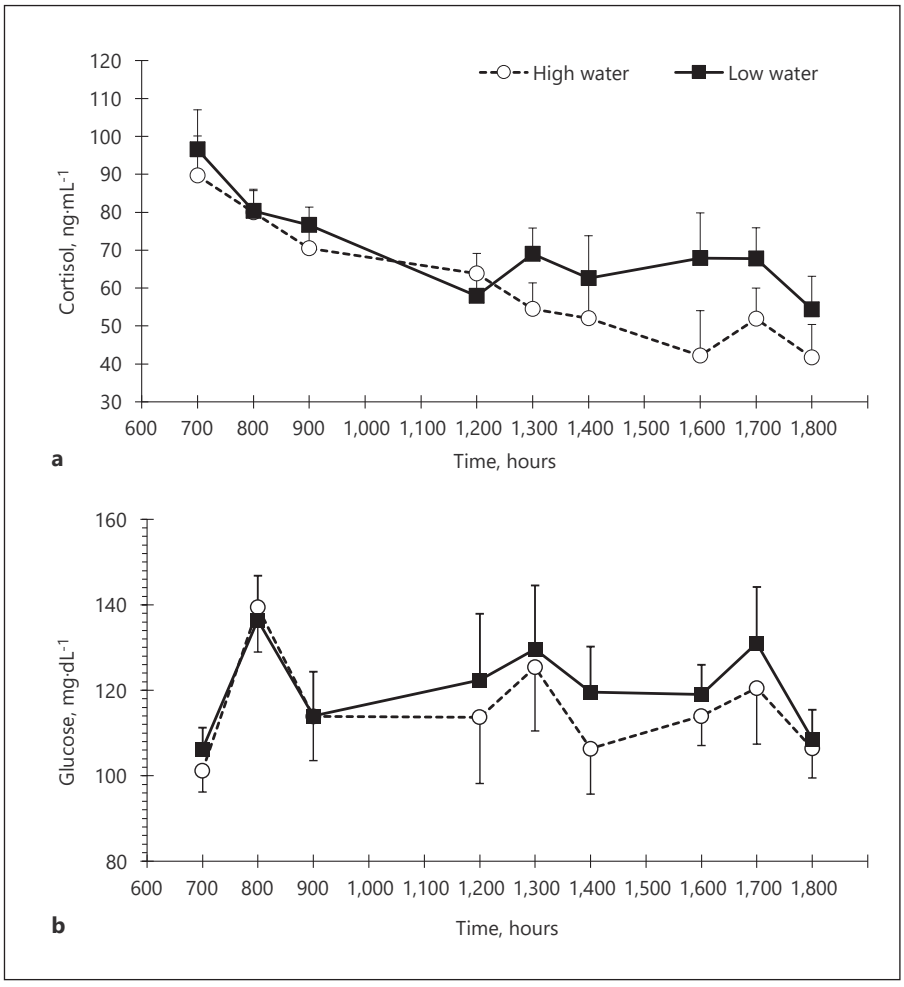

Fig. 2. Significant main effect of water intake on cortisol ($p < 0.05$) (**a**) and borderline significant main effect of water intake on plasma glucose ($p = 0.07$) (**b**) during HWI (males: 3 L; females: 2 L) and LWI (males: 1 L; females: 0.5 L) trials. Error bars = SE. HWI, high water intake; LWI, low water intake.

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Statement of Ethics

The research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. Subjects gave their written informed consent and the study protocol was approved by the Arizona State University Institutional Review Board, approval number STUDY00010276.

Conflict of Interest Statement

S.A.K. has served as scientific consultant for Quest Diagnostics, Standard Process, and Danone Research and has received grants from Danone Research and Standard Process. A.S. has received speakers fees from Danone Research.

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Author Contributions

All authors designed the study; A.S., A.T.C., and H.S. conducted data collection and sample analysis; A.S. and S.A.K. analyzed the data; A.S. wrote the paper; S.A.K. was the principal investigator. All authors read, critically revised, and approved the final manuscript.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author, A.S., upon reasonable request.

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