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Original Research Article

Effects of Fluid Loading with Water, Normal Saline, Coffee and Coke on Urinary Output, pH and Specific Gravity in Young Healthy Undergraduate Students

Obehi E. Ebo*, Chinyem N. Ighodaro, Wisdom J. Silas

Department of Physiology, College of Basic Medical Sciences, University of Benin, Edo State, Nigeria.

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ABSTRACT

Balance of water and electrolyte is an important homeostatic function of the kidneys. Their excretion depends on various factors such as, state of hydration, plasma osmolarity, etc. There are rare reports on diuretic effect of Coffee and Coke on some urinary parameters. Hence, the study is aimed at investigating the effect of Water, Normal Saline, Coffee and Coke in young healthy undergraduate students. A total of forty (40) randomly selected, healthy undergraduate students were recruited for this study. They were randomly divided into four groups. One liter (1 L) of Water, Normal Saline, Coffee and Coke were administered on different days to the same subjects. The subjects were made to void their bladders before ingesting these substances and the urine samples collected were taken as control sample at the time zero (T = 0). Thereafter, all the subjects emptied their bladders and their urine was collected at 30 minutes interval for 150 minutes. The urinary output, pH and specific gravity were determined. The results showed that urine output for Water, Coffee and Coke produced diuresis while Normal Saline did not. The reductions in specific gravity and pH of urine also accompanied these diuretic effects.

Keywords: Fluid loading, Homeostatic function, Diuresis, Coffee, Coke.

Introduction

One of the homeostatic functions of the Kidney is the regulation of water and electrolyte balance. Their excretion depends on various physiological factors such as state of hydration, state of solute load, plasma osmolarity, salt intake, etc.[1, 2] Urinary output, pH and specific gravity are altered in various pathological states and it is an important routine practice to measure these parameters for monitoring condition of patients, especially of those who are critically ill. However, evidence establishing the effects of fluid load with water and saline on diuresis have been reported,[1,3] but report on the effect of this diuresis following ingestion of Coffee and Coke on urinary output, pH and specific gravity are scarce.

Water is essential for a variety of physiological functions and its intake must balance its daily losses or output.[4] Ingestion of water is regular at meal time and it also forms a major component of most foods and drinks.

Normal saline is frequently used in hospital setting as an extracellular fluid replacement in conditions of dehydration, hypovolaemia, haemorrhage, sepsis, and for the treatment of metabolic alkalosis in the presence of fluid loss. Also, it is used to initiate and terminate blood transfusions. Furthermore, it has been used as a priming solution for various procedures (e.g., hemodialysis).[5]

Coca-Cola soda or Coke is a carbonated soft drink that is manufactured by the Coca-Cola Company. It is widely consumed all over the world either as part of a meal or as a replenishing drink especially in people who perform manual labour in hot environment.[6] Also, the popular soft drink is the *'go-to refreshment'* for many, especially students throughout the world. It is a high-fructose, phosphoric acid and caffeinated drink.

In several observational studies, consumption of coke has been increasing over the last few years.[7]

Coffee is said to be a pharmacologically active, socially accepted and most widely consumed beverage. Scientific interest in relation to ingestion of Coffee has increased over the past decades, as new light is shed on coffee's potential health benefit.[8] Caffeine (1, 3, 7-trimethylxanthine) is a naturally occurring methylxanthine found in coffee drink, chocolate, carbonated soft drinks and energy drinks.[9]

However, few studies have specifically investigated the effects of caffeine in the form of coffee on fluid balance and other electrolytes but there is paucity of information on the effects of carbonated soft drinks on diuresis in humans. Therefore, this study was aimed at ascertaining their effects on diuresis as well as the pH and specific gravity of urine.

Materials and Methods

Subjects

A total of 40 male undergraduate students of age 19-22 years, were recruited for the study. They were randomly divided into four groups. Four (4) experimental sessions were held, on four (4) separate days. Each participant was fully informed of the experimental procedures and possible risks (if any) and the informed consent were signed. All participants were physically active, nonsmokers and reported to be free from any known cardiovascular, renal and gastrointestinal diseases. Seven (7) days prior to the experiment, the participants were instructed to abstain from food and beverages containing caffeine, strenuous exercises and smoking for 5 days prior to the treatment (effectively making them 'caffeine naïve'). They were also told to have dinner at the same time with minimum of 6 hours of sleep.

Administration of fluid and determination of parameters

On the day of the experiments, the consented students were asked to report to the Laboratory at 9 am. They were asked to void urine and measure their weight just before the experiment. This was taken as control sample at time zero (T = 0). They were divided into four groups (A, B, C and D) based on the fluid to be taken and each group was made up of ten participants. Group A was served with water,

*Corresponding author. E mail: emmanuella.okojie@uniben.edu
Tel: +2347035522957

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Group B was served with Normal Saline, Group C was served with Coffee and group D was served with Coke.
The students consumed 1 L each of these substances in 5 minutes. In the case of Coffee, 1 sachet (about 300 mg) was dissolved in 1 L of Hot Water, refrigerated and served cold. The students were made to empty their bladder and their urine was collected for 150 minutes at 30 minutes intervals (T = 0; 30; 60; 90; 120; 150 minutes). The volume of the urine, pH and specific gravity were determined.
The samples were collected with an appropriate measuring cylinder and transferred to volumetric flask to determine the volume. A sample of urine was placed in a small cylinder, after that a Urinometer was placed into the cylinder. When reading the Urinometer, it was read from the bottom of the meniscus.

Statistical analysis
The results are presented as mean values ± SEM. Statistical analysis was done using the Graph pad prism 8.0 software. Obtained results were compared with control values for each group using unpaired students t-test and one way analysis of variance (ANOVA). A p-value less or equal to 0.05 was considered significant.

Results and Discussion

Urinary output
With water load, there was no significant difference in urinary output (mL) at 30 minutes when compared with the control ($P > 0.05$). Urinary output began to rise at 60 minutes (123.700 ± 16.700; $P < 0.05$) and peaked at 90 minutes (132.000 ± 15.160; $P < 0.05$). Furthermore, the urinary output steadily declined at 120 minutes (70.400 ± 8.391) and declined even further at 150 minutes (43.00 ± 17.200; $P < 0.05$).
The rate of urine formation in men varies with the excretory solute load and the extent of Antidiuretic Hormone (ADH) activity.[10] In the present study, Water, Coffee and Coke produced diuresis while Normal Saline did not. Diuresis was seen from 60 minutes following the ingestion of Water and Coffee. Moreover, following the ingestion of Coke, diuresis was observed after 90 minutes which agrees with the work of Oyebola,[11] where it was noted that the ingestion of water produced a decrease in the Osmolarity of the body fluid with a decrease in the secretion of ADH, due to the increased extracellular volume it creates.
No diuretic effect was produced with normal saline load. Urinary output dropped to significantly low values compared with control beginning from 30 minutes (73.900 ± 14.670; $P < 0.001$). However, it was significantly different at 150 minutes (53.780 ± 7.845; $P < 0.001$). Coke load gave rise to diuresis. An increase in urine volume was seen on ingestion of Coke at 90 minutes (116.200 ± 17.240) when compared with the control (112.700 ± 12.080); however, this was statistically not significant.
There was diuresis with Coffee. Urinary output showed a gradual rise from 60 minutes (181.500 ± 13.390) with a Peak at 90 minutes (203.900 ± 14.680). The diuretic effect at all-time intervals, were however significant when compared with control urinary output ($P < 0.05$). Urinary output at 120 minutes (131.100 ± 9.940; $P < 0.05$) and 150 minutes (66.300 ± 6.717; $P < 0.05$) were less than control as showed in Table 1.
Therefore, this may explain the diuretic effect of Coffee and Coke which contain a lot of water. The observance of diuresis following the ingestion of Coffee and Coke may be as a result of the large extracellular fluid volume created by the water content and more importantly the xanthine content of the caffeine, which increases the urine output.[12] An increase in extracellular fluid volume results in an increase in blood volume which leads to an increase in cardiac output and stroke volume; thus an increase in the activation and firing of baroreceptors in the carotid and aorta will in turn send signals to the posterior pituitary to reduce the secretion of Antidiuretic hormone (ADH).[13] Furthermore, it reduces facilitated reabsorption of water in the proximal convoluted tubule and collecting duct of the nephron, thus increasing the volume of urine produced.
According to a new finding by the National Institute of Consumption in Paris, trace amounts of alcohol can be found in popular soft drinks including Coke and Pepsi, which is used to dissolve some constituents of the drinks such as colour and flavour. More often, it should not be confused with the modern source of the flavourant which is probably caffeine citrate, a byproduct of decaffeination of coffee.[14]
Diuresis peaked at 90 minutes in all three fluids ingestion. There was a decline thereafter with complete cessation of the diuresis at 150 minutes and 120 minutes for the Water and Coffee. This may be due to its direct inhibitory effect on antidiuretic hormone production by coffee and Coke. Also, it was observed that Coke produced a brisker and short-lived diuretic effect.
Normal Saline had no significant effect on diuresis when compared with the control value.[15] This increase in body fluid osmolarity stimulates the release of vasopressin which inhibits diuresis (via Aquaporin-2 water channel water in the collecting ducts). [3, 15]

Specific gravity
Diuresis resulting from administration of water gave rise to the excretion of dilute urine. The greatest lowering effect on specific gravity was produced by ingestion of Coke, followed by water, then coffee.
Normal saline load was seen to affect urinary specific gravity significantly except at 120 minutes (1.019 ± 0.003) and at 150 minutes (1.018 ± 0.001) when the specific gravity was lower than its control value as shown in Table 2.
According to Zontine,[16] the most important single test in urinalysis is the determination of specific gravity. In the Coke drinking group, there was an initial high specific gravity; probably caused by change in osmolarity and the kidneys response to increase in the concentration of extracellular fluid. The kidneys do this by reabsorbing water and excreting concentrated urine which could explain the increase in specific gravity.

Urinary pH
The pH of the urine following water load began to drop significantly ($P < 0.05$), compared with control (6.100 ± 0.067). At 30 minutes it was (7.220 ± 1.150); at 90 minutes it was (6.800 ± 0.050, $P < 0.05$) and remained low till 150 minutes ($P < 0.05$).
With normal saline load, the mean values were significantly different at ($P < 0.05$). Urine became less acidic (i.e., pH increased) at 30 minutes (7.200 ± 0.990) and at 60 minutes (7.670 ± 0.111). This trend was maintained till 150 minutes (7.480 ± 0.116).
With Coffee load there was a significant reduction in the urinary pH beginning from 30 minutes (8.040 ± 0.880) to 150 minutes (7.630 ± 0.200; $P < 0.001$) when compared with the Control (6.100 ± 0.067)
Coke on the other hand resulted in acidification of urine probably because of its inorganic acid content.[17] The ingestion of coffee did not obviously affect the urinary pH as it was with Coke. However, Coke did not have the effect of increasing urine acidity in 30 minutes as seen in Coffee. The results showed a decrease in pH of subjects who ingested coke as can be seen in Table 3 below.

Table 1: Urinary output (mL) in human subjects following fluid loading at varying time intervals

Duration	Control	30 min	60 min	90 min	120 min	150 min
Water	102.200 ± 15.510	85.800 ± 13.200^{ns}	123.700 ± 16.700^{ns}	132.000 ± 15.160^{ns}	70.400 ± 8.391^{ns}	120.000 ± 17.200^{ns}
Normal saline	98.700 ± 14.540	73.900 ± 14.670^{ns}	64.700 ± 13.880^{ns}	32.500 ± 12.010^{ns}	29.700± 8.031***	53.780 ± 7.845***
Coffee	164.601 ± 9.211	62.400 ± 7.513***	181.500 ± 13.390^{ns}	203.900 ± 14.680*	131.100 ± 9.924*	66.300 ± 6.717***
Coke	112.001 ± 12.080	100.600 ± 13.020^{ns}	109.200 ± 15.270^{ns}	116.200 ± 17.240^{ns}	87.100 ± 8.727^{ns}	85.700 ± 10.440^{ns}

Values are expressed as mean ± SEM. ns = not significant, * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

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Table 2: Urinary specific gravity in human subjects following fluid loading at varying time intervals

Duration	Control	30 min	60 min	90 min	120 min	150 min
Water	1.016 ± 0.001	1.023 ± 0.001***	1.026 ± 0.001***	1.028 ± 0.001***	1.029 ± 0.001***	1.012 ± 0.002^{ns}
Normal saline	1.019 ± 0.001	1.022 ± 0.001*	1.023 ± 0.002^{ns}	1.026 ± 0.001***	1.019 ± 0.003^{ns}	1.018 ± 0.001^{ns}
Coffee	1.019 ± 0.002	1.023 ± 0.001 ^{ns}	1.027 ± 0.001 *	1.028 ± 0.001 **	1.029 ± 0.001 **	1.014 ± 0.002 ^{ns}
Coke	1.020 ± 0.001	1.023 ± 0.001*	1.025 ± 0.001**	1.027 ± 0.001***	1.028 ± 0.001***	1.008 ± 0.001***

Values are mean ± SEM, ns = not significant, * = P < 0.05, ** = P < 0.01, *** = P < 0.001

Table 3: Urinary pH in human subjects following fluid loading at varying time intervals

Duration	Control	30 min	60 min	90 min	120 min	150 min
Water	6.100 ± 0.067	6.050 ± 0.050^{ns}	7.154 ± 0.040	7.950 ± 0.050^{ns}	8.650 ± 0.050 ^{ns}	8.850 ± 0.076*
Normal saline	7.400 ± 0.400	6.250 ± 0.083*	7.300 ± 0.111***	7.100 ± 0.179***	6.900 ± 0.145***	6.550 ± 0.116 **
Coffee	6.600 ± 0.245	6.200 ± 0.213^{ns}	5.800 ± 0.200*	5.250 ± 0.200***	4.950 ± 0.157***	4.800 ± 0.200***
Coke	6.100 ± 0.067	7.450 ± 0.229***	7.250 ± 0.291**	6.900 ± 0.233**	6.400 ± 0.249***	6.300 ± 0.082 ^{ns}

Values are mean ± SEM, ns = not significant, * = P < 0.05, ** = P < 0.01, *** = P < 0.001

Conclusion

It is concluded that ingestion of Coffee and Coke cause an increase in diuresis, with coffee having the greater stimulating effect in increasing urinary output overtime. Meanwhile, all four solutions (Water, Normal Saline, Coffee and Coke) showed a reduction in specific gravity, with Coffee and Coke having the greater effect in specific gravity of urine. Also, there was an increase in urinary pH in subjects who ingested Coffee and a decrease in subjects who consumed solutions of Normal saline and Water, with subjects who consumed Coke recording the lowest urinary pH.

Conflict of interest

The authors declare no conflicting interest

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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References

1. Paudel BH and Kumer S. Effect of water and saline load on urinary output in healthy undergraduate medical students. J Nepal Med Assoc. 2013; 43(6):23-26
2. Omolaso B, Uredo'ojo S, Akinola A, Adegbite O, Oluwole F. Effect of Water Load, Saline Load and Lipton Tea on Urine Output and Urine pH in Young Healthy Male and Female Human Subjects. IOSRJPBS. 2012; 4(3):05-09.
3. Udokang NE and Akpogromeh BA. Effect of volume loading with water, Normal Saline, Palm wine and Lipton tea on urinary output, pH, Specific Gravity, sodium and Potassium Concentration in Human Subjects. Nig J Physiol Sci. 2015; (1-2):101-106.
4. Perrier E, Rondeau P, Poupin M, Le Bellego L, Armstrong L, Lang F, Stookey J, Tack I, Vergne S, Klein A. Relation between urinary hydration biomarkers and total fluid intake in healthy adults. Eur J Clin Nutr. 2013; 67(9):939-943.
5. Chang R and Holcomb JB. Choice of Fluid Therapy in the Initial Management of Sepsis, Severe Sepsis, and Septic Shock. Shock. 2016; 46(1):17-26.
6. Chapman JR, Hill T, Unckless RL. Balancing Selection Drives the Maintenance of Genetic Variation in Drosophila Antimicrobial Peptides. Genome Biol. Evol. 2019; 11(9):2691-2701.
7. Dubey D, Sawhney A, Sharma A, Dubey DE. Paroxysmal Paralytic Attacks Secondary to Excessive Cola Consumption. Clin Med Res. 2014; 12(1-2):61-64.
8. Ludwig IA, Clifford M, Lean ME, Ashihara H, Crozier A. Coffee: Biochemistry and potential impact on health. Food Funct. 2014; 5(8):1695-717.
9. Armstrong LE. Caffeine, body fluid-electrolyte balance and exercise performance. Int J Sports Nutr Exerc Metab. 2002; 12:205-222.
10. Birchard WH, Rosenbaum JD, Strauss MB. Renal Excretion of Salt and Water Consequent to Hypertonic Saline Infusion Followed by Water Ingestion. J Appl Physiol. 1953; 6:1-22.
11. Oyebola DO. Kidney and body fluids in Essential physiology for students of Medical, dentistry, pharmacy and related disciplines. (1ST ed) NIHORT Press. 2002. 152 – 176 p.
12. Guyton AC. Roles of the kidneys and fluid volumes in arterial pressure regulation and hypertension. Chin J Physiol. 1989; 32(2):49-57.
13. Burg MB and Stoner L. Renal Chloride Transport and the mode of action of some diuretics. Ann Rev Physiol. 1976; 38:150.
14. D'Amato A, Fasoli E, Kravchuk A, Righetti P. "Going Nuts for Nuts? The Trace Proteome of a Cola Drink, as detected via Combinatorial Peptide Ligand Libraries". J Proteome Res. 2011; 10(5):2684-2686.
15. Guyton AC and Hall JE. Textbook of Medical Physiology. (10th ed). Philadelphia: W.B. Saunders; 2000. 134 p.
16. Zontine WJ. "Urine Specific Gravity*"*. Iowa State University Veterinarian. 1960; 22(1):11-12.
17. De Vries GE, Meyer C, Strubbe M, Mulder NH. Influence of various beverages on urine acid output. Cancer Res.1986; 46:430-432.