

# The Effects of Different Types of Fluids on the Renal System

Lisa Ta  
March 16, 2012.  
Biology 611.02  
Principles of Human Physiology  
Butt, Shamim

## **Introduction**

Kidneys are a key function to the human body because it regulates plasma volume, ionic composition, osmolarity, pH, and removes metabolic waste products and waste substances. All these regulations work together to maintain homeostasis in the body. A person has five liters of blood circulating the body and twenty percent (which is one liter) of blood is circulated to the kidneys. The functions of the kidneys are the billions of nephrons they contain that filter the blood. Each nephron contains the renal corpuscle and renal tubules. The renal corpuscle contains the Bowman's capsule and glomerulus and the renal tubules contain the proximal tubule, loop of Henle, distal convoluted tubule, and the connecting tubule to connect to the collecting duct. The proximal tubule has two parts: the proximal convoluted tubule and proximal straight tubule. The loop of Henle is split into three parts: the descending limb, thin ascending limb, and thick ascending limb.

Blood first enters through the afferent arteriole, into the glomerulus and is filtered out to the Bowman's capsule. The filtrate is called the glomerular filtrate, which is the protein-free plasma, that goes through the proximal convoluted tubule, then to the proximal straight tubule, through to the descending loop of Henle, up the thin ascending loop of Henle, onto the thick ascending loop of Henle, to the distal convoluted tubule, through the connecting tubule, to the collecting duct, and excreted.

Reabsorption and secretion of water, solutes, and ions occur in the kidneys. Reabsorption is the movement of nutrients, water, and ions from the filtrate in the tubules back to the blood through peritubular capillaries. Most reabsorption occurs in the proximal convoluted tubule and some in the distal convoluted tubule. In the proximal

convoluted tubule, one hundred percent of glucose and seventy percent of water and sodium are reabsorbed. The purpose of the loop of Henle is to concentrate the urine and to reabsorb water (in the descending limb) and ions (in the ascending limbs). The distal convoluted tubule reabsorbs water and other ions. Lastly, the collecting duct reabsorbs ions, water, urea, and bicarbonate.

There are three hormones that help the kidneys function properly and they are the Anti-Diuretic Hormone (ADH), Aldosterone, and Atrial Natriuretic Peptide (ANP). ADH is a vasoconstrictor that elevates blood pressure, increases water reabsorption, plasma volume, urine specific gravity, and decreases urine flow rate. When ADH is stimulated, it targets the distal tubule and collecting duct, which causes the reabsorption of water. To inhibit ADH, the plasma osmolarity must be low and both plasma volume and blood pressure must be high. The Aldosterone is produced in the adrenal cortex. When a decrease in plasma osmolarity, volume, and pressure occurs, it stimulates the Renin-Angiotensin-Aldosterone System (RAAS), which functions to increase sodium reabsorption through the distal tubule. ANP is a hormone secreted by the cells in the atria of the heart and is stimulated when an increase in plasma volume and vast amounts of sodium is in the extracellular fluid; it inhibits the reabsorption of sodium in the distal tubule and increases sodium excretion.

The purpose of this experiment was to determine the osmotic regulation of the kidneys in keeping fluid balance in the body with the association of hormone regulation. The subjects were chosen at random and placed into four different categories: Non-drinking, Water, Coke, and Gatorade. Within the four different groups listed, the Coke group should have a higher average urine flow rate compared to Gatorade, compared to

Water group and the Non-drinking group will have a low urine flow rate. The Non-drinking group will exhibit the highest average corrected urine specific gravity, followed by the Coke, Gatorade, and Water groups.

## **Methods**

Before the experiment was conducted, the subject(s) had to fast. Food and any liquids must not be consumed five hours prior to the experiment. Three hours before the experiment, an eight-ounce cup of water may be consumed. Urination is not allowed one hour prior to the experiment. Weight and time of last excretion were recorded for calculation purposes. Then the subject(s) were split into four different groups: the non-drinkers, Water, Coke, and Gatorade. Calculations needed to be worked out beforehand to determine how much fluid an individual had to take. The formula for the amount of fluid intake is:

$$\text{mLs of fluid intake} = [\text{body weight(lbs)} \times 7\text{mLs/lbs}] \times 0.80 \quad **$$

I was in the water group and I had to ingest 661mL of water.

Once the experiment began, the subject(s) had to urinate in a urinary measuring cup, record the time, and calculate the urine flow rate. The formula to calculate urine flow rate is:

$$\text{Urine Flow Rate (mL/min)} = \text{volume voided (mL)} / \text{duration of time since the last void(min)} \quad **$$

The specimen's temperature and urine specific gravity using a urinometer were measured. To measure urine specific gravity, fill a cylinder half-full with the urine sample and carefully place the urinometer in. Make sure the urinometer is floating, if it is touching the bottom of the cylinder, remove the urinometer and pour more of the urine sample into the cylinder. Once afloat, look for the meniscus to determine urine specific gravity (note: correct reading of meniscus is to read at eye level with the cylinder on a flat surface and locate the meniscus curvature). To correct for urine specific gravity, for every three degrees above fifteen degrees Celsius, 0.001 must be added. For example, if urine temperature was 30°C and measured urine specific gravity from the urinometer was 1.025 then the calculation is as follows:

$$30^{\circ}\text{C} - 15^{\circ}\text{C} = 15^{\circ}\text{C}$$

$$15^{\circ}\text{C} / 3^{\circ}\text{C} = 5^{\circ}\text{C}$$

$$5 \times 0.001 = 0.005$$

$$\text{then: } 1.025 + 0.005 = 1.030 \quad **$$

Which means the corrected urine specific gravity is 1.030

At time zero, the labstix strip was used to determine the presence of blood, ketones, glucose, protein, and the pH of urine. The labstix strip was immersed in the fresh urine sample and removed immediately. To check for the contents in the urine sample, the Color Chart on the labstix strip bottle was used as a guide. After the first urination, the subject(s) must consume their assigned fluid within fifteen minutes and wait another fifteen minutes for the full half hour to discharge urine. This was the only time the subject(s) were allowed to intake fluids. After every thirty minutes for a total of two hours, the subject(s) urinated, recorded time, and measured temperature and specific gravity.

\*\*taken from lab manual

## Results

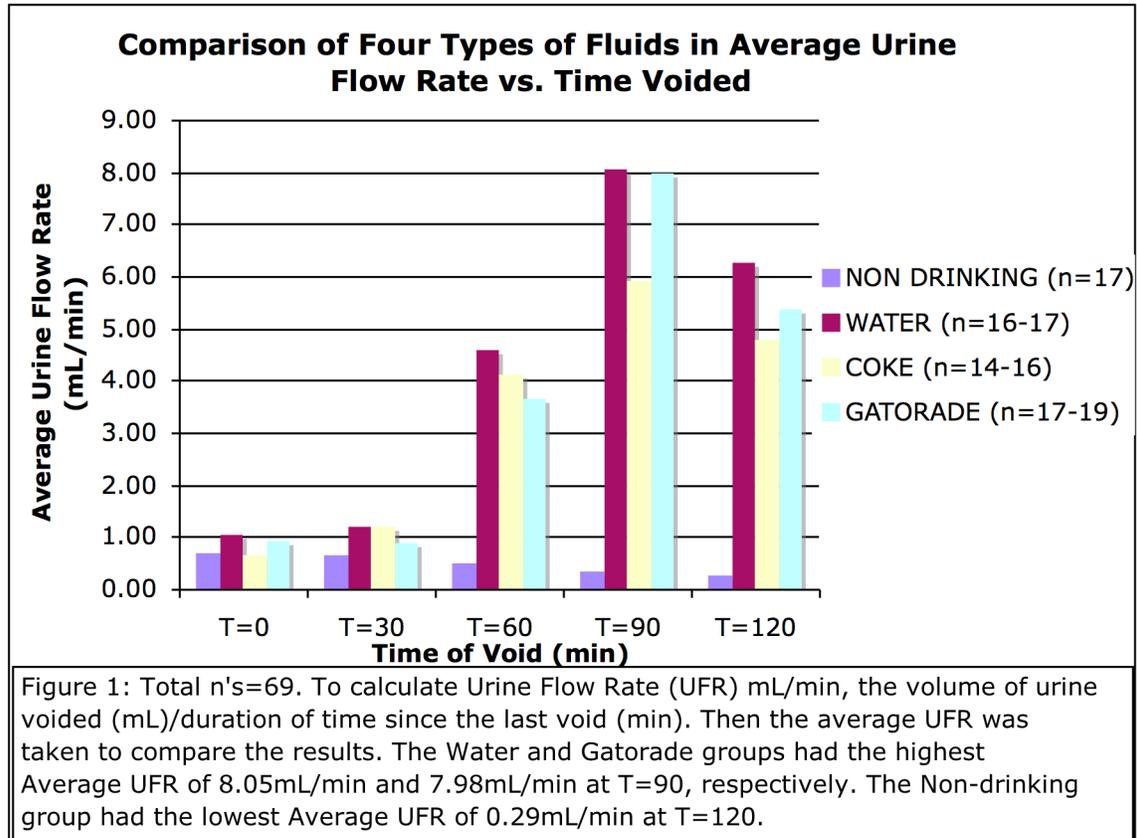


Figure 1 shows the class average urine flow rate of the Non-drinking, Water, Coke, and Gatorade groups versus the time voided. For T=0, the Non-drinking, Water, Coke, and Gatorade groups had an average urine flow rate of 0.71mL/min, 1.07mL/min, 0.68mL/min, and 0.92mL/min respectively. The average urine flow rate for T=30 were 0.67mL/min, 1.19mL/min, 1.19mL/min, and 0.89mL/min, respectively. At T=60, average urine flow rate were 0.49mL/min, 4.61mL/min, 4.13mL/min, and 3.68mL/min, respectively. For T=90, average urine flow rate were 0.36mL/min, 8.05mL/min, 5.93mL/min, and 7.98mL/min, respectively. Lastly at T=120, the average urine flow rate were 0.29mL/min, 6.26mL/min, 4.80mL/min, and 5.36mL/min, respectively. In

observing the data and figure above, for every time period, the Water group had the highest average urine flow rate and the Non-drinking group had the lowest average urine flow rate.

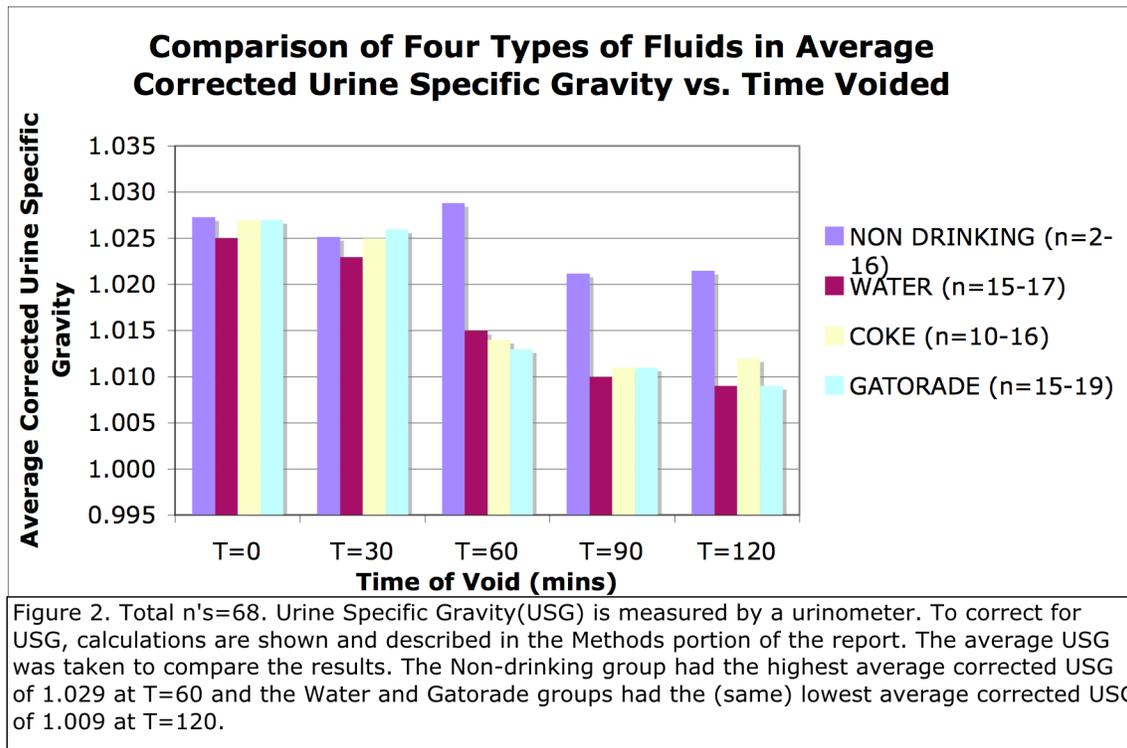


Figure 2 shows the class average corrected urine specific gravity of the Non-drinking, Water, Coke, and Gatorade groups versus the time voided. The average corrected urine specific gravity of the Non-drinking, Water, Coke, and Gatorade groups at T=0 were 1.027, 1.025, 1.027, and 1.027, respectively. The average corrected urine specific gravity for T=30 were 1.025, 1.023, 1.025, and 1.026, respectively. For T=60, the average corrected urine specific gravity were 1.029, 1.015, 1.014, and 1.013, respectively. At T=90, average corrected urine specific gravity were 1.021, 1.010, 1.011, and 1.011, respectively. Lastly for T=120, average corrected urine specific gravity were 1.022, 1.009, 1.012, and 1.009, respectively. In observing the data and figure above, during

each time period, the non-drinking group had the highest average corrected urine specific gravity and the water group had the lowest average corrected urine specific gravity.

Table 1. Labstix Test Results on Blood, Ketone, Glucose, Protein, and pH of the urine sample at T=0. The results on the labstix was compared to the corresponding color chart of the bottle show presence of blood, ketone, glucose, and protein to be negative and the pH of the urine to be 5, which is in the range of normal urine pH.

<b>Test Reagent</b>		<b>Results</b>
a) presence of blood		negative
b) presence of ketone		negative
c) presence of glucose		negative
d) presence of protein		negative
e) urine in pH		pH 5

## **Discussion**

The purpose of this experiment was to determine the osmotic regulation of the kidneys in keeping fluid balance in the body with the association of hormone regulation. The subjects were chosen at random and placed into four different categories: Non-drinking, Water, Coke, and Gatorade. Within the four different groups listed, the Coke group should have a higher average urine flow rate compared to Gatorade, compared to Water group and the Non-drinking group will have a low urine flow rate. The Non-drinking group will exhibit the highest average corrected urine specific gravity, followed by the Coke, Gatorade, and Water groups.

From the data shown in Figure 1, at T=90, the Water and Gatorade groups had the highest average urine flow rate of 8.05mL/min and 7.98mL/min, respectively, out of the

four groups. The Water group for each time period (T=0, 30, 60, 90, 120) exhibited the highest average urine flow rate of 1.07mL/min, 1.19mL/min, 4.61mL/min, 8.05mL/min, 6.26mL/min, respectively. On the contrary, the Coke group had an average urine flow rate of 1.19mL/min at T=30, which meant that the Water and Coke groups had the highest average urine flow rate. The Non-drinking group exhibited a low average urine flow rate of 0.71mL/min, 0.67mL/min, 0.49mL/min, 0.36mL/min, 0.29mL/min, for every time period (T=0, 30, 60, 90, and 120, respectively). On the other hand, at T=0, the Coke group exhibited a lower average urine flow rate of 0.68mL/min. In a fasting condition of this experiment, the human body wants to maintain homeostasis. Since there was no fluid intake for the past three hours, ADH was secreted by the posterior pituitary gland to reabsorb and retain water. This explains why at all time intervals for the Non-drinking group and T=0 and 30 for all the drinking groups exhibited low average urine flow rates. At T=60, the Water, Coke, and Gatorade groups showed an average urine flow rate of 4.61mL/min, 4.13mL/min, and 3.68mL/min, respectively; thus ADH becomes inactivated and ANP is activated, causing an increase in urine flow rate. During this process, the body has finally re-hydrated itself to allow for excretion of fluids. The average urine flow rate at T=90 was the highest for all drinking groups with the Water, Coke, and Gatorade groups showing 8.05mL/min, 5.93mL/min, and 7.98mL/min, respectively. At T=120, the Water group continued to exhibit the highest average urine flow rate of 6.26mL/min and the Coke and Gatorade groups were at 4.80mL/min and 5.36mL/min, respectively. The decrease in average urine flow rate for the Coke group beginning at T=90 could be due to the high sugar content of the drink, which can aid the process of glycolysis to produce energy and water for the dehydrated body. Since Gatorade does

not contain as much sugar as coke, the average urine flow rate for the Gatorade group increased. According to the data, the Water group had the highest average urine flow rate, then the Gatorade and Coke groups, and the Non-drinking group exhibiting the lowest average urine flow rate; thus, the hypothesis is partially disproved.

From the data shown in Figure 2, at T=60, the Non-drinking group had the highest average corrected urine specific gravity of 1.029, out of all four groups. The Non-drinking group exhibited the highest average corrected urine specific gravity of 1.027, 1.025, 1.029, 1.021, and 1.022 at each time period (T=0, 30, 60, 90, and 120, respectively). On the contrary, at T=30, the Gatorade group showed a higher average corrected urine specific gravity of 1.026. The water group displayed the lowest average corrected urine specific gravity of 1.025, 1.023, 1.015, 1.010, and 1.009, for each time period (T=0, 20, 60, 90, and 120, respectively). At T=120, the Gatorade group also showed a low average corrected urine specific gravity of 1.009. As mentioned earlier, the ADH in the body was activated in the Non-drinking group, which caused the body to reabsorb and retain water. Since the reabsorption of water has taken place, the urine sample for the Non-drinking group decreased; which caused the corrected urine specific gravity to increase. Since Coke and Gatorade contain electrolytes (specifically sodium ions), the RAAS pathway was activated; which explains the reason why the two drinking groups shared a close value of average corrected urine specific gravity for all time intervals. With ANP activated in the Water group, urine specific gravity was decreased. According to the data, the Non-drinking group had the highest average corrected urine specific gravity, then the Coke and Gatorade groups synonymously, and the Water group

exhibited the lowest average correct urine specific gravity; thus the hypothesis is approved.

The labstix strip was used to determine the presence of blood, ketones, glucose, protein and pH in the urine sample provided at T=0. The result of the labstix strip showed to be negative for the presence of blood, ketones, glucose, and protein. The urine sample had an acidic pH of 5, which falls within the normal range of urine pH of about 4.5-8. The reason for the acidic pH in the urine sample is due to the low plasma pH in the kidneys; thus, hydrogen ions were excreted and reabsorption of bicarbonate ions increased. Methotrexate (MTX) is a chemotherapeutic drug that is effective in combating various tumors in high dose forms. A high dose of MTX requires an alkaline urine pH for a few days; thus, within this experiment, an acidic urine pH would be useless.

Sources that could provide for error at the start of the experiment would be not fasting for the five hours as stated, which may show ambiguity of data at T=0. If the subject(s) were not healthy or not feeling well, it could affect the urine flow rate and urine specific gravity. The values should have been the same at T=0, for average urine flow rate and average corrected urine specific gravity; however, due to differences in body weight and gender, results at T=0 fluctuated. For possible correction of error, obtain data from subjects who follows directions correctly, are healthy, in the same body weight range, and equal amount in gender between groups; thus, elimination of possible discrepancies.

## Reference

Butt,S. 2012.

De ries, E.G.E., Meyer, C., Strubbe, M., and Mulder, N.H. 1988. *Influence of Various Beverages on Urine Acid Output*. *Cancer Research* 46: 430-32

Tidyman,W.E., and Manuguid, C. 2012. *Biology 611 Experiments in Principles of Human Physiology: Laboratory Manual*. Spring 2012. San Francisco State University. pp 30-39.

Widmaier, E.P., Raff, H., Strang, K.T. 2008. *Vander's Human Physiology: The Mechanisms of Body Function*. 11<sup>th</sup> ed. McGraw Hill, New York. 487-89, 501-10, plus various pages.