Correlation of Ingested Fluids to Urine Flow Rate and Urine Specific Gravity

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Introduction:

The kidneys are a two bean shaped structure, located in the back of the abdomen. They are the key organ of the urinary system, which play a major role in maintaining homeostasis by helping to preserve the constancy of the internal fluid. Kidneys are involved in regulating the balance in the body, maintaining the proper osmolarity of body fluids, which is important in preventing osmotic fluxes in or out of the cells. It also maintains concentration and quantity of many Extracellular Fluid ions including Sodium, Chloride, Potassium, and Calcium. Another function is maintaining proper plasma volume which is important in long term arterial blood pressure, along with maintaining the proper acid-base balance of the body by adjusting urinary output of and. Most importantly, they are essential in excreting the products of bodily metabolism also known as waste. In each kidney there are over one million microscopic functional units known as nephrons, they are the smallest unit within the kidney enabling it to produce the functions discussed above.

There are three basic processes involved in forming urine including glomerular filtration, tubular reabsorption and tubular secretion. Glomerular filtration is the first step in urine formation, as blood flows through the glomerulus filters protein free plasma filters into the glomerular capillaries and then into the Bowman's capsule. This is the first site of urine formation. As the filtrate flows through the tubules, it is taken from the tubular lumen into peritubular capillaries also known as tubular reabsorption. Reabsorbed substances are carried by the peritubular capillaries to the venous system and then the heart to be recirculated. The non-filtered substances are moved from peritubular capillaries into tubular lumen by the process of tubular secretion.

Three hormones are involved in regulating composition of plasma, Aldosterone, Atrial Natriuretic (ANP), and Anti-Diuretic Hormone (ADH). Aldosterone is synthesized in the adrenal cortex, and stimulated by a decrease in Blood pressure, plasma volume, and [] in extracellular fluid. One of the more prominent pathways for Aldosterone is the Renin-Angiotensin-Aldosterone System. Renin stimulates the production of Angiotension I, which is then converted to Angiotensin II. Angiotensin II causes blood vessels to constrict, causing an increased blood pressure. Angiotensin II also stimulates the secretion of aldosterone, resulting in an increase in [] in extracellular fluid. The second hormone, ANP is stimulated when the heart is stretched by an expansion of the blood volume. ANP will suppress the release of ADH, Renin & Aldosterone, and promote   excretion accompanied by dieresis. In general, ANP is a diuretic that will ultimately result in a decrease of blood volume, which will indirectly decrease blood pressure. ADH is secreted in the post pituitary gland, which is stimulated by a decrease in plasma volume, blood pressure and increase in plasma osmolarity. ADH increases aquaporin channels, which increase water reabsorption.

The purpose of this experiment was to compare the urine flow rate and specific gravity of adults during fasting and following consumption of water, coke and Gatorade. The composition of these liquids, allows us to study how the kidneys maintain fluid balance in the body, with the release of the hormones discussed above. In addition, to test our own urine samples for blood, ketone, glucose, protein and ph using a Labstix strip.

My Hypothesis for this experiment is that my Labstix test strip will have no presence of blood, ketone, glucose, and protein. I expect my urine ph to be in between the normal range of 6.0-6.5. Since there are going to be four groups, each group will have a different urine flow rate and specific gravity. The water-drinking group will have the highest urine flow rate, and the

lowest urine specific gravity. The non -drinking group did not consume any liquids so I expect them to have the lowest urine flow rate of all the groups but have the highest urine specific density. The coke and Gatorade group will have higher urine flow rates than the non-drinking group.

Method:

The experiment had a procedure before the lab started and during the process of the lab experiment. Prior to the lab experiment, it was important for the subjects too fast for four hours prior to the lab, which included avoiding any water or food. If needed the subjects could consume 8 oz of water, during the first two hours of fasting to avoid getting dehydrated. To be specific it was recommended no strenuous activity be done before the experiment, and to avoid excess fats, salt, caffeine and alcohol the night before. One hour before the lab, the subjects were asked to empty their bladders and to record the time on a separate table.

During the experiment, multiple measurements and calculations were taken every thirty minutes. At T=0, T=30, T=60, T=90, and T=120 the students calculated their urine flow rate, measured urine specific gravity and corrected urine specific gravity. At T=0 all the students emptied their bladders into the clear cups provided and recorded the time. The urine samples were brought back to the lab and tested. For the non-drinking group, they did not consume any fluids throughout the lab and measured and calculated their urine specific gravity and urine flow rate through this process. The specific gravity compares the density of a substance to the density of water at a specific temperature. For the urine specific gravity, we compared the density of urine to the density of water. In order to get the measured urine specific density a urinometer is used. A sample of your urine is placed in a small cylinder, after that a urinometer was placed into

the cylinder. When reading the urionemeter, read from the bottom of the meniscus. The number that was read is the <u>measured urine specific gravity</u>. The next step was to calculate the <u>corrected urine specific gravity</u>, by using a formula. At T=0, the non-drinking group should take the temperature of their urine sample in C˚. For every 3 degrees above 15˚, they had to add 0.001 to the previously measured urine specific density. Example of calculations:

Measured urine specific gravity: 1.026   Temperature of Urine: 31˚

$$31˚ - 15˚ = 16˚$$

$$16˚$$

$$5$$

1.026 + 0.005 = 1.031 <u>corrected urine specific gravity</u>

The urine flow rate at T=0 was the next calculation. The urine flow rate formula At T=0, for the non-drinking group, they measured the amount of urine in ml and calculated the last time they had voided before this lab began. Example of calculation **gave a urine flow rate of 2.86 ml/min.** The last measurement the non-drinking group took was using a test strip. A Labstix test strip was used to test for the presence of blood, ketone, glucose, and protein in urine along with measuring the ph of urine. The test tube was immersed into urine for a few seconds. Once removed the test strip was lined up against the bottle, lining it with the color blocks. If the test reveals negative presence of blood, ketone, glucose and protein than this part of did not need to be re-measured every 30 minutes. The non drinker repeated these steps for measuring urine specific gravity, corrected urine specific gravity and urine flow rate every 30 minutes until it reached T=120. The drinking groups, also had to follow the same steps as the non drinking group at T=0, T=30, T=60, T=90, and T=120 in order to calculate the measured urine specific gravity, corrected urine specific gravity, urine flow rate, and the Labstix test strip. The drinking

groups however had one extra calculation. After emptying their bladder at T=0, the drinking group put the urine aside and calculated the amount of fluid consumed. The amount of fluid intake was calculated by using this equation. Based on this calculation I drank 924 ml of Gatorade. After calculating their fluid intake, each drinking group member had 15 minutes to drink their assigned fluid. After drinking their fluid, they could processed and calculate the measured urine specific gravity, corrected urine specific gravity, urine flow rate, and the Labstix test strip for T=0. Both groups will repeat the calculations and measurements for T=30, T=60, T=90, and T=120.

Results:

Figure 1: Bar graph representing Average Urine Flow Rate vs Time

Figure 1: At T=0, the non-drinking group had the lowest average urine flow rate and the coke drinking group had the highest average urine flow rate. At T=0 the water drinking group had an average urine flow rate of 0.69 ml/min but at T=30, the water drinking group had an average urine flow rate of 1.66 ml/min significantly higher than at T=0. At T=60 the water drinking group had increased their average urine flow rate to 6.14 ml/min, as water had time to process through the body. T=60 and T=90 overall had the highest average urine flow rate for water and coke drinking groups. The average urine flow rate of Gatorade was greater towards the end of the experiment with 6.74 ml/min at T=90.

Figure 2: Bar graph representing Corrected Urine Specfic Gravity vs Time

At T=0, the water drinking group had the highest corrected urine specific gravity when compared to all the other groups at T=0. Over time from T=0 to T=120, the corrected urine specific gravity for water drinking group had decreased from being 1.031 at T=0 to 1.012 at T=120. The non-

drinking group experiences the highest corrected urine specific gravity at T=60 and T=120 at

1.028. The coke drinking group started off with the second highest corrected urine specific

gravity at T=0 equaling 1.029, by the time it was T=30 the coke drinking group had the highest

average urine specific gravity at 1.032 being higher than the original average urine specific

gravity at T=0. By T=60, T=90, and T=120 the average urine specific gravity for coke and

Gatorade had started to dramatically decrease.

Table 1. Labstix test results

Test Reagent	Test Result
Blood	Negative
Ketone	Negative
Glucose	Negative
Protein	Negative
PH	6.0

Table 1. Represents the Labstix test results on the urine for the presence of blood,

ketone, glucose, protein and ph. This test was only performed once during T=0, as the reagents

all showed up negative the first time around. The ph level of my urine was 6.0 at T=0.

Discussion:

Before this experiment, I had made a hypothesis regarding the corrected urine specific

gravity, urine flow rate and the presence of reagents using the Labstix test strip. My original

hypothesis for the Labstix test strip was that my urine sample would have a negative presence of

the the listed reagents, at the end of the experiment my hypothesis matched up to the results.

With no blood in the urine, it exemplified the lack of an infection and no leak in the glomerular

capillaries. No ketone was present in the blood, with keotne in the blood it would be pushing

towards glucose being unavailable to the cells, and instead fat is the main source of energy.

Normally our urine should not contain glucose but can in rare cases of pregnancy or high

carbohydrate diet. The protein was also negative in the urine; protein is not normally found in urine and if it is can signify a renal dysfunction and a leak in the glomerular membrane.

For the non-drinking group, my hypothesis was that they would have the highest urine flow rate, and the lowest urine specific gravity but that was not correct. Gatorade actually had the highest urine flow rate, and the lowest urine specific gravity instead. With the Gatorade drinking group, initially their plasma osmolarity and blood pressure are high, the change in osmolarity will cause osmo receptors to release ADH in the posterior pituitary gland causing an increase in water reabsorption by the increased aquaporins. With an increase in aquaporins, the Gatorade started to act like water, and increase blood pressure and blood volume along with decreasing the plasma osmolarity. The important of aquaporins in the renal system, is detailed through a article by Dr. Witowski from Poznań University in Poland explains that there are Seven types of Aquaporins (AQP) in the kidney. AQP1 has been localized in the proximal tubule and descending thin limb, while AQP2, AQP3, and AQP4 are expressed in the collecting duct. He describes how decreased expression of renal AQP has been detected in several disorders "associated with polyuria and impaired ability to concentrate urine, as exemplified by nephrogenic diabetes insipidus or renal failure. In contrast, increased expression of AQP is seen in conditions leading to water retention, such as congestive heart failure, and liver cirrhosis." (Witowski 2002) This is why the understanding of molecular structure and function of aquaporins may have important implications for therapy of water balance disorders. Once the plasma osmolarity starts to decrease, ADH stimulation is inhibited and ANP will begin to be stimulated. The coke group functioned similarly like the Gatorade group. With an initial increase in plasma volume, and blood pressure the osmo receptors in the posterior pituitary gland stimulated the secretion of ADH. The ADH secretion brought the plasma osmolarity change,

which than would eventually inhibit the secretion of ADH. Since coke had caffeine in it, the caffeine increased the blood pressure, but by inhibiting the ADH pathways the blood pressure was also brought down.

My original hypothesis for the non-drinking group was that they would have the lowest urine flow rate but have the highest urine specific gravity. My hypothesis for the non-drinking group was correct. The non-drinking group begins this experiment like everyone else with a low plasma volume, blood pressure and high plasma osmolarity making them dehydrated. Dr. Thornton from the Nancy University, of France, highlights the response of the ADH hormone in regards to thirst and sodium. "The constant supply of water (and sodium) for cardiovascular function is the role of thirst and sodium appetite and kidney function. This physiological regulation ensures that plasma volume and osmolarity are maintained within set limits by release of hormones necessary to ingest and conserve water and sodium within the body. An increased osmolarity draws water from cells into the blood thus dehydrating specific brain osmo receptors that stimulate drinking and release of anti diuretic hormone (ADH or vasopressin). ADH reduces water loss via lowered urine volume" the non-drinking group being dehydrated has a high stimulation of ADH in the distal convoluted tubules, which increases the number of aquaporins reabsorbing the water. As more water is reabsorbed, that would cause a low urine flow rate because of the little to none excretion of water. In general, the non-drinking group had highest urine specific gravity, because ADH stimulation increases the concentration of the urine ultimately displaying a high urine specific density.

For future direction, many variables could have altered these results. In our class, there were some people who could not empty their bladder multiple times and most of them were actually athletes. Since they are athletes, there is always the possibility that they are still

dehydrated from a game or practice, and that is why they are not able to empty their bladders. A different set of instructions for athletes, that made sure they were properly hydrated before this experiment could have helped to get better data. Another error that could have happened through this experiment is that we do not know if everyone followed the correct prior to procedure. Since we were all supposed to be fasting, that is what created the initial conditions of an increase in plasma osmolarity (dehydration), if a person did not fast they would not start dehydrated and different hormones could be involved in regulating their body water balance. In addition, the size of our classroom had an effect on our data. Since we were a class of all girls and one guy, some of the girls had to empty their bladder out in different bathrooms and if someone was late in calculating their measurements that could shift the data.

References

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