European Journal of Biology and Medical Science Research
Vol.5, No.4, pp.33-48, June 2017
Published by European Centre for Research Training and Development UK (www.eajournals.org)

# THIRST PERCEPTION AND FLUID INTAKE IN PREGNANT FEMALE HUMANS IN THE THREE TRIMESTERS OF PREGNANCY

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**ABSTRACT**: *This work was done to access the thirst perception and fluid intake of pregnant women in the three trimesters of pregnancy in pregnant women. The study was divided into two main groups Group 1 was made up of euhydrated pregnant women while group 2 was made up of dehydrated pregnant women. For the group 1, a total of thirty pregnant women were used, ten in each trimester of pregnancy. The subjects had water ad libitum. For the group 2, a total of seventy five pregnant women, twenty five in each trimester of pregnancy were dehydrated for eighteen hours. Thirst perceptions were taken 8am the following morning using the visual analogue scale of Thompson et al., (1986). Blood and urine samples were collected and analyzed for electrolyte concentrations. Plasma osmolality was estimated using the formula of Leonard (2003). Results for group 1, showed statistically significant increase ($p<0.05$) in the thirst perception in the first, second and third trimesters of pregnancy when compared with the non-pregnant women. The volume of water intake till satiety was significantly higher ($P<0.05$) in the third trimester of pregnancy when compared with non-pregnant women. The increases in volume of water intake in first and second trimesters were not statistically significant. Results for group 2, showed that thirst perception was significantly higher ($P<0.05$) in pregnant women when compared with non-pregnant women. The thirst perception was significantly increased in the three trimesters of pregnancy when compared with non- pregnant women. The volume of water intake was significantly increased ($p<0.05$) in the first, second and third trimesters in pregnant women when compared with the non-pregnant women. Our result reveals a significant drop ($p<0.05$) in plasma osmolality in the pregnant women when compared with the non- pregnant women.. Conclusively, this research has been able to establish that there is decrease in plasma osmolality, but increase in thirst perception, in the three trimesters of pregnancy.*

**KEYWORDS**: Thirst Perception, Fluid Intake, Pregnancy, Trimester

## INTRODUCTION

Water is by far the largest single component of the body, constituting 45-75% of total body mass, depending on age and gender. The body can gain water in two ways: through ingestion and metabolic synthesis (Tortora and Graboski, 2000). Adequate amount of water is needed for optimum regulation of the chemical pump at the cell wall, efficiency of all protein and enzymatic pathways in the body, and optimum hormonal function. Every function inside the body is regulated and is dependent on water. The intake and urinary loss of water are both controlled by thirst and anti-diuretic hormone (ADH//Vasopressin), respectively. In health, the primary determinant of both thirst and ADH/vasopressin release is the osmolality of the plasma perfusing the hypothalamus. The receptors that signal thirst have an osmotic threshold of about 10 mOsmol higher than that of the osmoreceptors involved in ADH/Vasopressin release. Thus, normally, thirst is not experienced until ADH release has ensured that the ingested water will


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be retained by the kidneys (John *et al.*, 1999). The intensity of thirst is measured on a visual analogue scale (Thompson *et al.*, 1986). A visual analogue scale (VAS) is a psychometric response scale which can be used in questionnaires. It is a 10 cm marked but un calibrated line with two extremes indicating not thirsty and very thirsty respectively. When responding to a VAS item, respondents specify their level of agreement to a statement by indicating a position along a continuous line between two end-points. Visual analogue scales have been used extensively for psychophysical assessments in both older and younger subjects and corresponds well to physiological determinants of thirst such as plasma osmolality.

The effect of ECF volume depletion on thirst is mediated in part through the renin – angiotensin system. Renin secretion is increased by hypovolaemia and results in an increase in circulating angiotensin II. The angiotensin II acts on the subfornical organ, a specialized receptor area in the diencephalon, to stimulate the neural area concerned with thirst. Some evidence suggests that it acts on the organum vasculosum of the lamina terminals (OVLT) as well. These areas are highly permeable and are two of the circumventricular organs located "outside the blood brain barrier. During pregnancy, plasma osmolality levels fall in some species. This should exert an inhibitory influence on thirst mechanisms; however, water intake is maintained or even increased despite this plasma hypotonicity. Relaxin secreted during pregnancy may be one of the factors that promotes fluid intake during this period, and it has been suggested that there is a resetting of the central osmostat controlling thirst and vasopressin secretion as a result of the actions of relaxin on the brain. The aim of the study was to access the osmolar changes in the three trimesters of pregnancy and relate same to thirst perception and volume of water intake during pregnancy. The thirst perception will also be correlated with the volume of water intake. Correlating thirst perception with the volume of water intake could help address issues of inability to assess thirst perception appropriately as in the case of animals who cannot express their feelings of thirst.

## METHODOLOGY

The research was divided into two groups

### Group 1: Preliminary study on euhydrated pregnant women in the three trimesters of pregnancy.

A total of 10 pregnant women in each trimester of pregnancy were used for preliminary study on thirst perception in the three trimesters of pregnancy. Subjects were allowed water intake without restriction till the morning of the research. They were all instructed to collect urine from 8pm till 8am next day. This is twelve (12) hours urine collection. The level of thirst perception was assessed using the visual analogue scale(VAS) (Thompson et al, 1986) on arrival at the clinic 8am in the morning. Subjects were then given water to drink after blood and urine samples were collected. Blood and urine samples were analyzed in the laboratory for electrolyte concentrations. Ten non -pregnant females served as controls in this group.

### Group 2: Dehydrated pregnant women in the three trimesters of pregnancy

Twenty-five (25) pregnant women each in the first, second and third trimesters of pregnancies were used. Consents to participate in the study were received from subjects and approval of Hospital's Medical Ethics Committee was received. Patients with hypertension and diabetes



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were excluded. Twenty-five non pregnant female subjects who had no hypertension or diabetes served as control.

The day before the experiment, the patients and control subjects were instructed not to drink water or any other form of fluid after 2pm. They however continued to void and discard urine until 8.00pm. Thereafter, and up until 8.00am on the next day which is the day of the experiment all urine was voided into the provided container. Some urine was collected in the universal bottle. All the subjects were educated on how to use the VAS to estimate their level of thirst. They were all asked to mark on the line rating scale in response to the question "HOW THIRSTY ARE YOU NOW?" Their thirst perception readings were obtained and recorded in centimeter. Their heights in meters and weights in kilogram were recorded.

The average of three blood pressures readings were recorded in mmHg. Water intake, specific gravity, volume and pH of the urine were determined in the Physiology Laboratory. Water was given to the subjects to drink until satiety. The maximum quantities of water intake by the subjects were recorded in milliliters using a measuring cylinder.

Plasma osmolality was estimated using the formula of Leonard (2003)

$$\text{Plasma Osmolality} = 2.P_{Na}{}^{+} + \frac{P_{glu}}{18} + \frac{BUN}{2.8} \ \text{mOsm/KgH}_2\text{O}.$$

**RESULTS**

**EUHYDRATED GROUP**

Results in the euhydrated pregnant women for body mass index, systolic blood pressure, diastolic blood pressure, and mean arterial blood pressure are shown in table 1. There was a statistically significant increase ($p<0.05$) in body mass index in the third trimester of pregnancy. There was a statistically significant reduction ($p<0.05$) in systolic blood pressure in the first and third trimesters of pregnancies. The mean arterial blood pressure also had a significant drop ($p<0.05$) in the first and third trimesters of pregnancies. The plasma parameters for the euhydrated pregnant women in first, second and third trimesters of pregnancy are shown compared with non-pregnant women in table 2. There was statistically significant reduction ($p<0.05$) in plasma sodium, potassium, urea and creatinine in pregnant women.

**Table 1:** Mean of Body mass index, systolic blood pressure, diastolic blood pressure and mean arterial blood pressure for euhydrated first, second and third trimesters of pregnancy compared with control (non-pregnant women).


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| PARAMETER | NON – PREGNANT | FIRST TRIMESTER | SECOND TRIMESTER | THIRD TRIMESTER |
|---|---|---|---|---|
| **Body Mass Index ($Kg/m^2$)** | 24.50±2.87 | 29.13±0.62 | 28.80±1.52 | 30.41±0.26* |
| **Systolic Blood Pressure (mmHg)** | 111.11±2.00 | 105.56±1.76* | 110.00±2.89 | 104.00±4.0* |
| **Diastolic Blood Pressure (mmHg)** | 72.22±1.42 | 67.78±1.47* | 66.67±2.89* | 63.00±3.0* |
| **Mean Arterial Blood Pressure, (mmHg)** | 85.16±1.58 | 79.61±1.30* | 81.44±2.77 | 76.57±3.27 |

* Represents statistical significance at $P<0.05$ between control (non-pregnant women) and first, second and third trimesters in pregnant women.

**Table 2:** Mean of plasma sodium, potassium, urea and creatinine for Euhydrated 1st, 2$^{nd}$, and 3$^{r}$ trimesters of pregnancy compared with non-pregnant women.

| PARAMETER | NON – PREGNANT | FIRST TRIMESTER | SECOND TRIMESTER | THIRD TRIMESTER |
|---|---|---|---|---|
| **Plasma Sodium (mMol/L)** | 137.75±0.67 | 135.29±2.09 | 135.75±1.58 | 132.0±0.0* |
| **Plasma Potassium (mMol/L)** | 3.98±0.90 | 4.743±0.59 | 2.971±0.81 | 5.8±0.0* |
| **Plasma Urea (mg/dL)** | 14.71±1.01 | 11.23±0.23* | 11.08±0.96* | 12.50±0.00* |
| **Plasma Creatinine (mg/dL)** | 0.82±0.04 | 0.700±0.04* | 0.625±0.37* | 0.60±0.00* |

* Represents statistical significance at $P<0.05$ between non-pregnant and three trimesters of pregnancy


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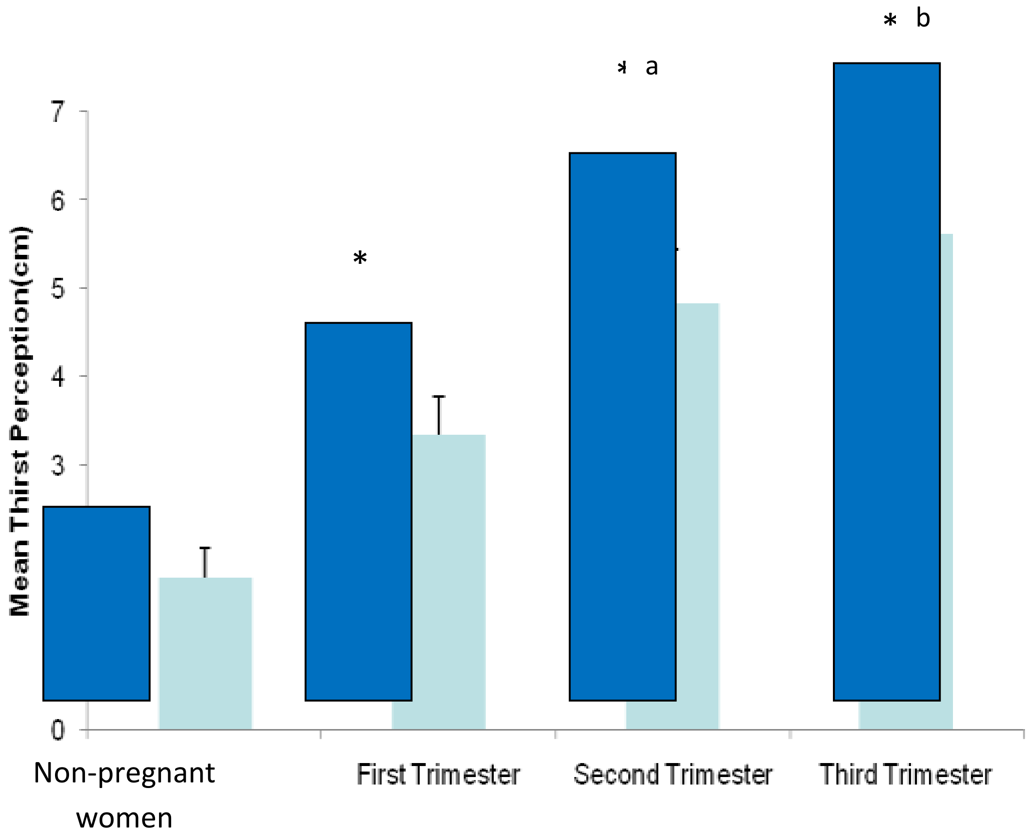


**Figure 1:**Mean Thirst Perception (cm) for Euhydrate non pregnant, first, second and third trimesters of pregnancy

* = statistical significance at P<0.05 when compared with control (Non- pregnant women).

a = statistical significance at P<0.05 between first and second trimesters.

b = statistical significance at P<0.05 between first and third trimesters.

For the Euhydrated group, result shows statistically significant increase (P<0.05) in the thirst perception in the first trimester, second trimester and third trimesters of pregnancy when compared with the control.


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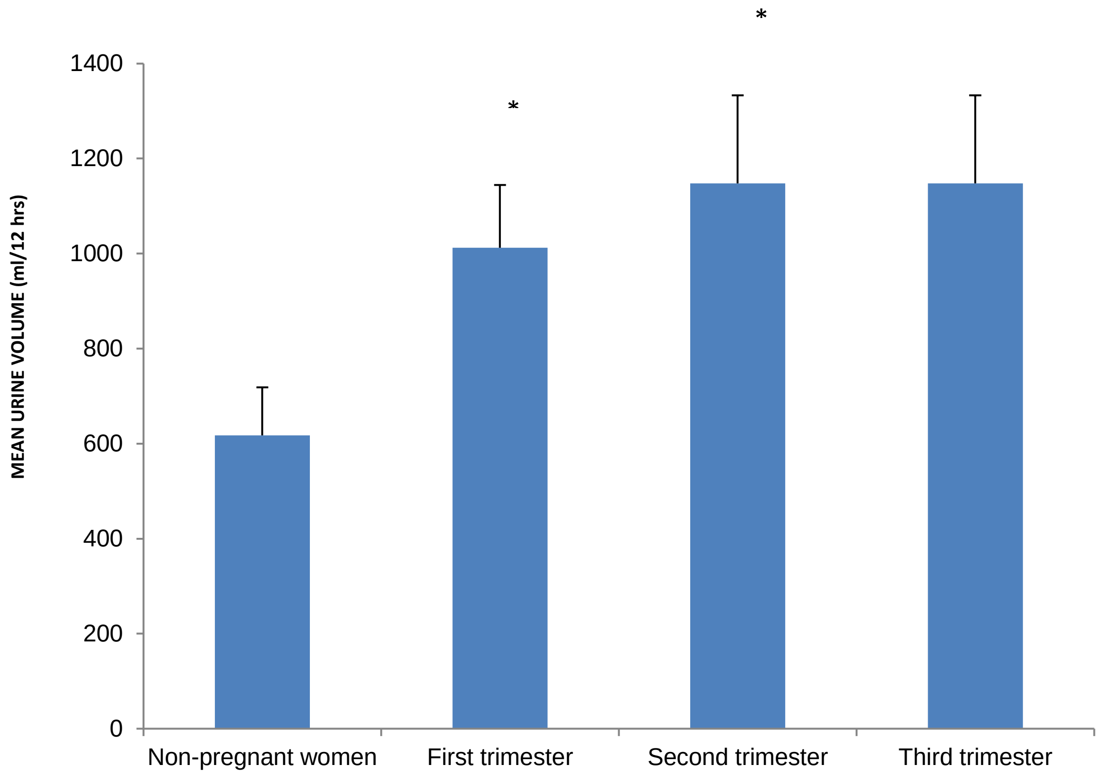


**Figure 2:** Mean Urine Volume (ml) per 12hrs for Euhydrate non-pregnant women, first, second and third trimesters of pregnancy.

* = statistical significance at P<0.05 when compared with control (Non- pregnant women).

b = statistical significance at P<0.05 between first and third trimesters.

There was statistically significant increase (P<0.05) in the urine volume in the first trimester (2024ml/day), second trimester (2295ml/day) and third trimester of pregnancy (2295ml/day) when compared with non-pregnant women (1234ml/ day).


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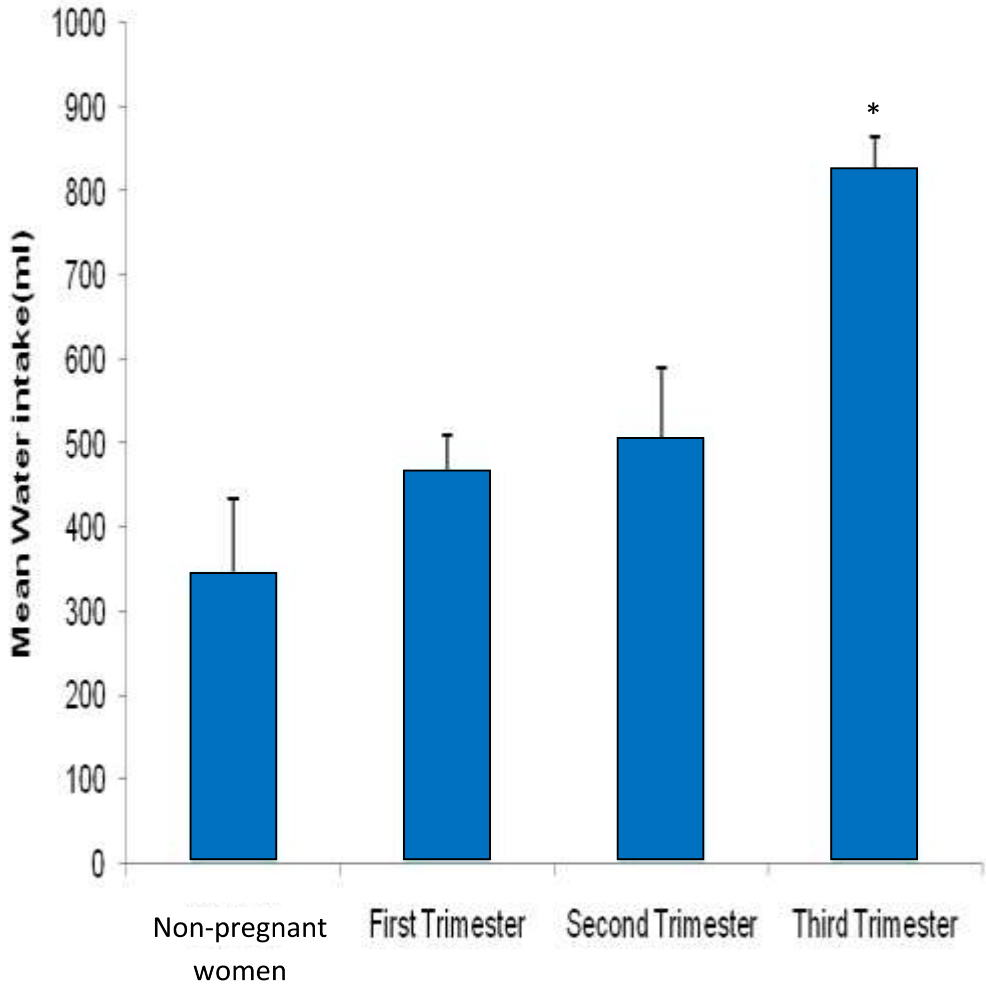


**Figure 3:** Showing Mean Water Intake (ml) till satiety) for Euhydrate non pregnant, first, Second and third trimester of pregnancy.

* = statistical significance at P<0.05 when compared with control (Non- pregnant women).

b = statistical significance at P<0.05 between first and third trimesters.

c = statistical significance at P<0.05 between second and third trimesters

Water intake was significantly higher (P<0.05) in the third trimester of pregnancy with a mean of 826.0±39.33ml when compared with non-pregnant women with a mean of 347.43±86.79ml. It was observed, however, that the subjects did not have a uniform baseline. In order to set a uniform baseline for study, a second methodology (phase 2) in which the subjects and control were uniformly dehydrated for the same periods of eighteen hours was used. This was to uniformly challenge the body for thirst.



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**The results in dehydrated pregnant women in the three trimesters of pregnancy**

Table 3: Mean of Urine parameters in dehydrated pregnant women in the 1st, 2nd, and 3rd trimesters of pregnancy compared with control (non – pregnant women).

| PARAMETER | NON PREGNANT | FIRST TRIMESTER | SECOND TRIMESTER | THIRD TRIMESTER |
|---|---|---|---|---|
| **pH of urine** | 5.92±0.17 | 6.22 ±0.26 | 5.84 ±0.19 | 6.15 ±0.22 |
| **Urine Sodium (mMol/L)** | 156.78±4.15 | 147.67 ± 6.88 | 147.90 ± 7.01 | 122.91 ± 7.31* |
| **Urine Potassium(mMol/L)** | 15.69±1.06 | 16.98 ± 1.38 | 15.81 ± 1.46 | 10.28 ± 1.30* |
| **Urine Urea(mg/dl)** | 2258.70±217.24 | 1811.47± 254.1 | 1540.90±169.02* | 1497.90±157.41* |
| **Urine Creatinine (mMol/L)** | 52.481±7.01 | 54.69 ± 7.42 | 44.34 ± 5.12 | 34.42 ± 5.73* |
| **Specific Gravity** | 1.023±0.001 | 1.021 ± 0.001 | 1.021 ± 0.009 | 1.021 ± 0.001 |

* represents statistical significance at P<0.05 when compared with control (Non- pregnant women).

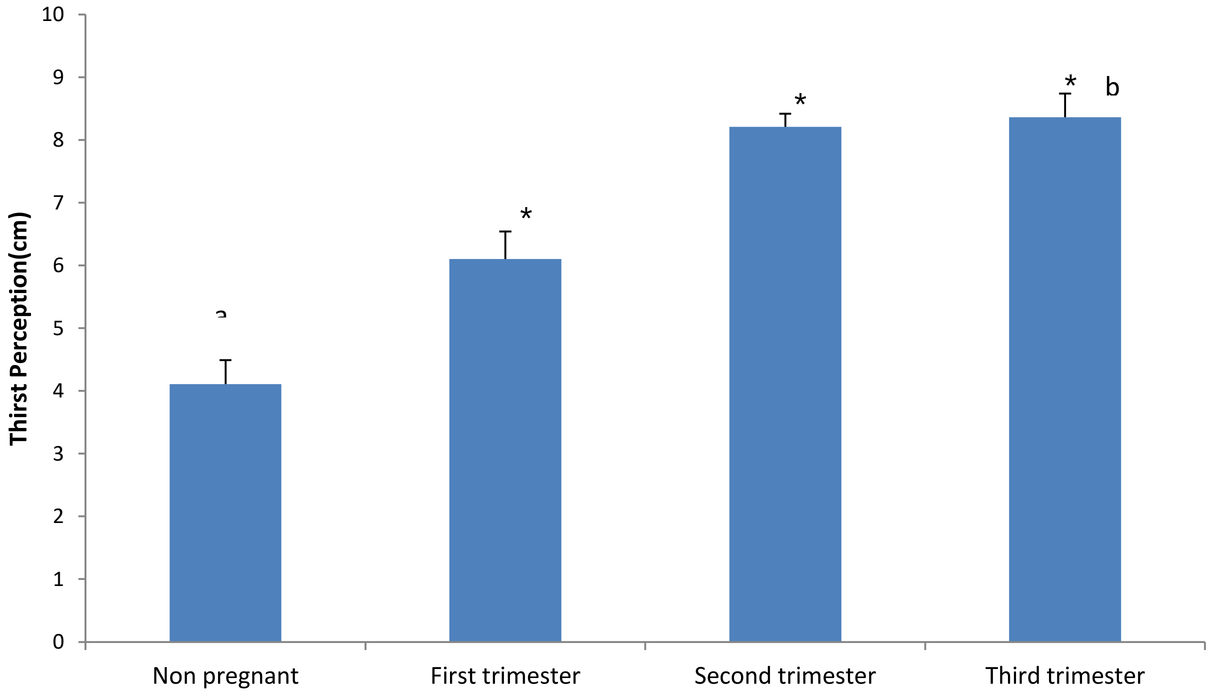


**Figure 4:** Mean Thirst Perception (cm) in Non-pregnant and the three trimesters of pregnancy.

* = statistical significance at P<0.05 when compared with control (Non- pregnant women).

a = statistical significance at P<0.05 between first and second trimesters.



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b = statistical significance at P<0.05 between first and third trimesters.

A comparison of the thirst perception of the first trimester (6.10 ± 0.44cm), second trimester (8.21 ± 0.21cm) and third trimester (8.36 ± 0.38 cm) of pregnancies shows that the thirst perception significantly increased in the first, second and third trimesters of pregnancy when compared with non-pregnant(4.11±0.38). Thirst perception peaks at second trimester remains so till term.

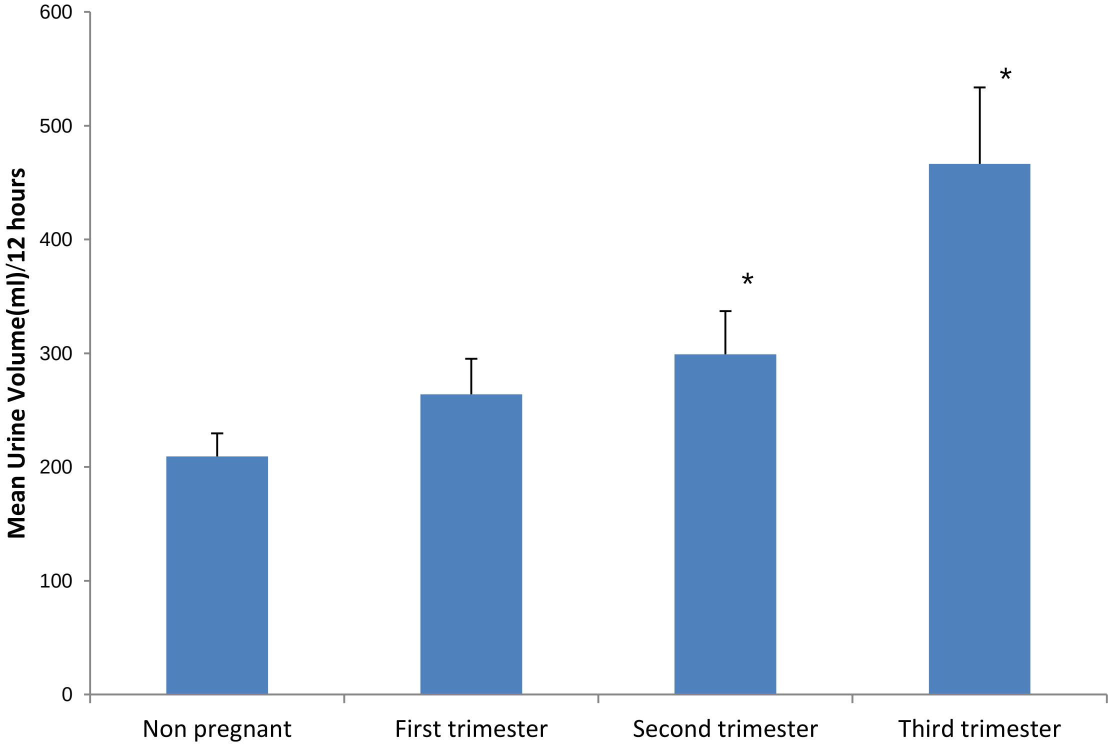


**Figure 5:** Mean Urine Volume (ml) in Non pregnant women and the three trimesters of pregnancy.

* = statistical significance at P<0.05 when compared with control (Non- pregnant women).

b = statistical significance at P<0.05 between first and third trimesters.

c = statistical significance at P<0.05 between second and third trimesters.


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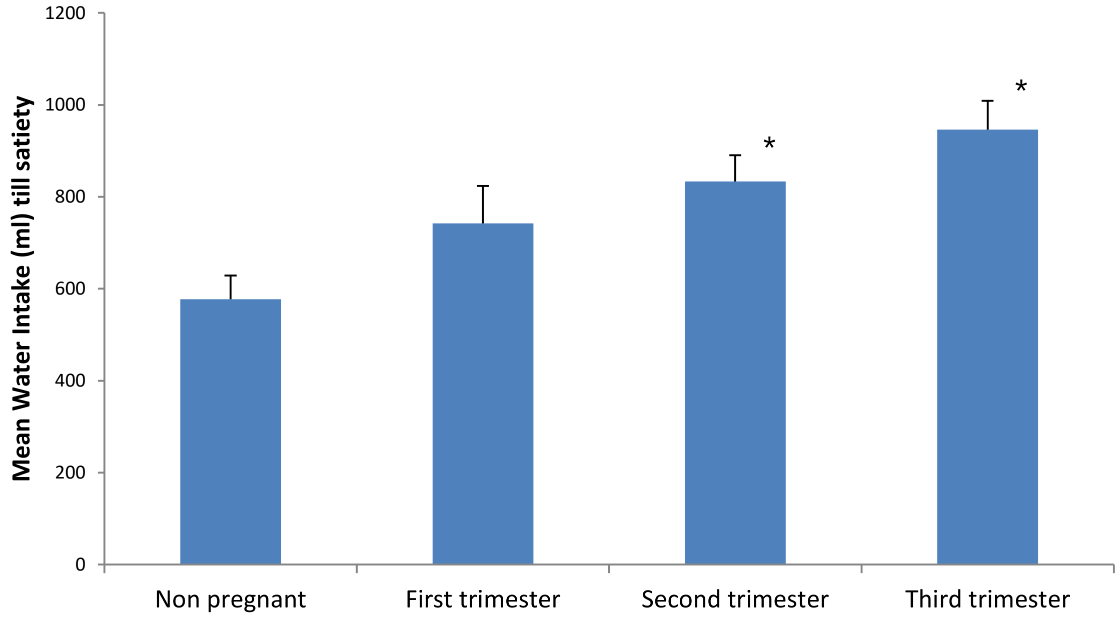


**Figure 6:** Mean Water Intake (ml) till satiety in Non-pregnant women and the three trimesters of pregnancy.

* = statistical significance at $P<0.05$ when compared with control (Non- pregnant women).

b = statistical significance at $P<0.05$ between first and third trimesters.

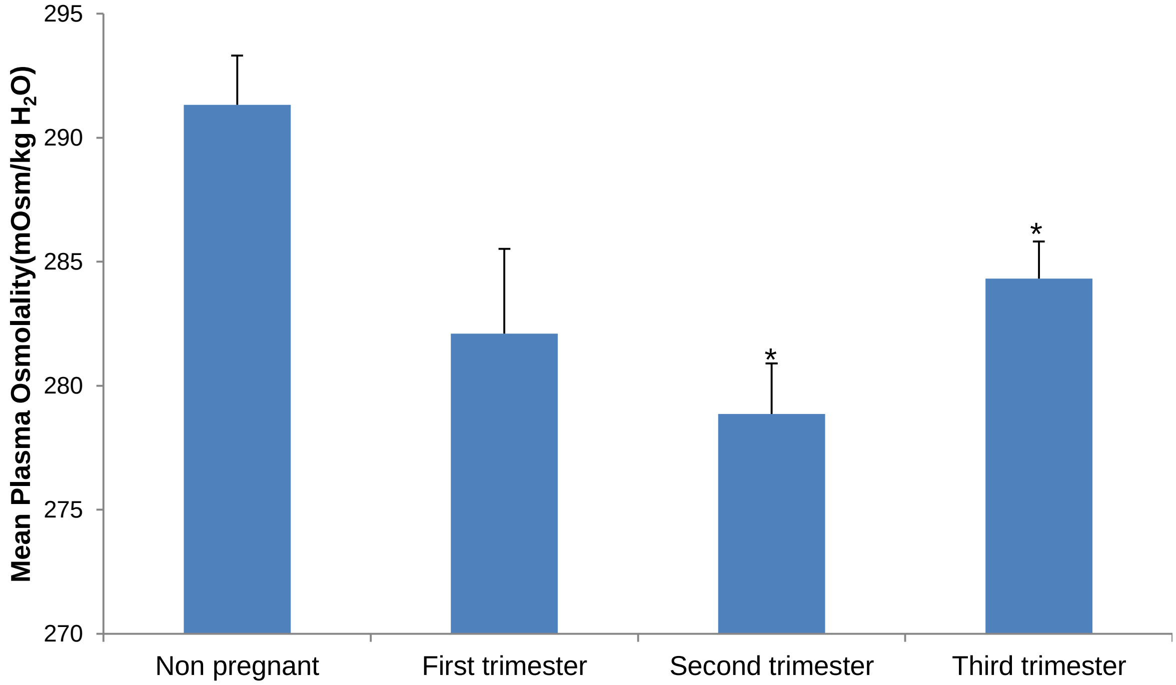


**Figure 7:** Mean Plasma Osmolality (mOsmol/kg $H_2O$) in Non - pregnant women and the three trimesters of pregnancy.

* = statistical significance at $P<0.05$ when compared with control (Non- pregnant women).



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**Correlation between thirst perception and water intake**

Our study shows correlations between thirst perception and water intake in pregnant women (Figure 8. . The correlation was, however not very strong (0.422). Thirst can thus be predicted from the volume of water ingested by the pregnant women.

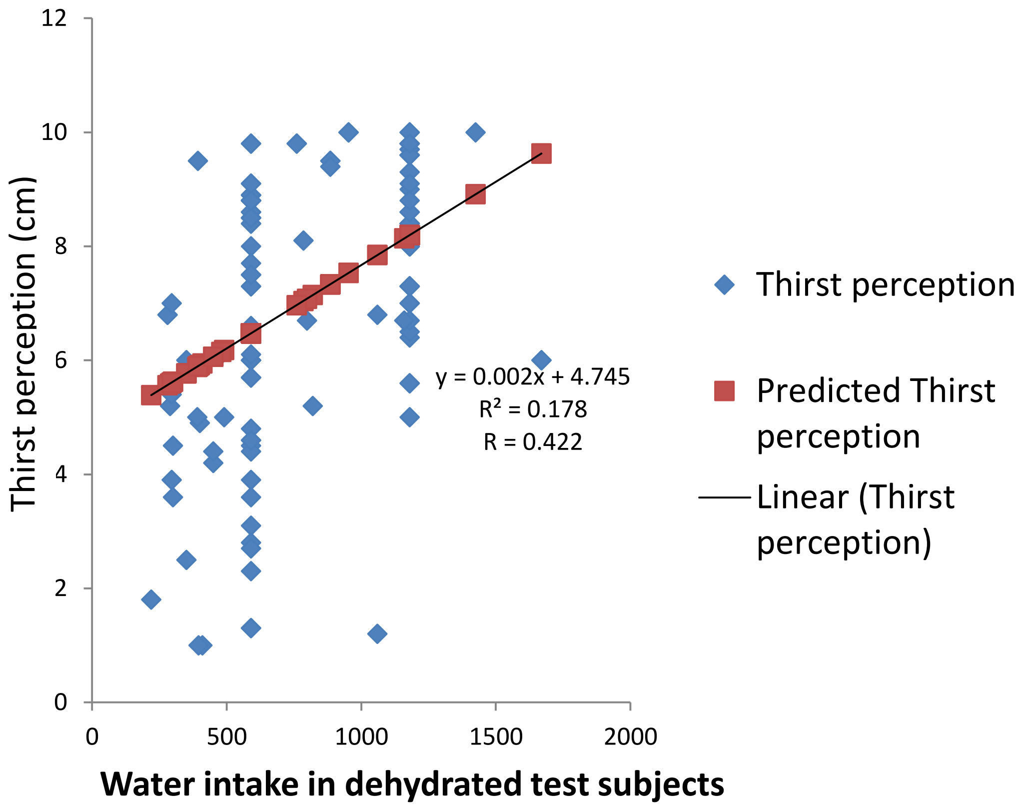


**Figure 8:** Graph showing correlation between thirst perception and water intake in dehydrated pregnant women

**Comparing euhydrate with dehydrated subjects**

Group comparison of the euhydrated and dehydrated subjects for thirst perception and water intake are shown side by side is shown in figures 3.35 and 3.36 respectively.



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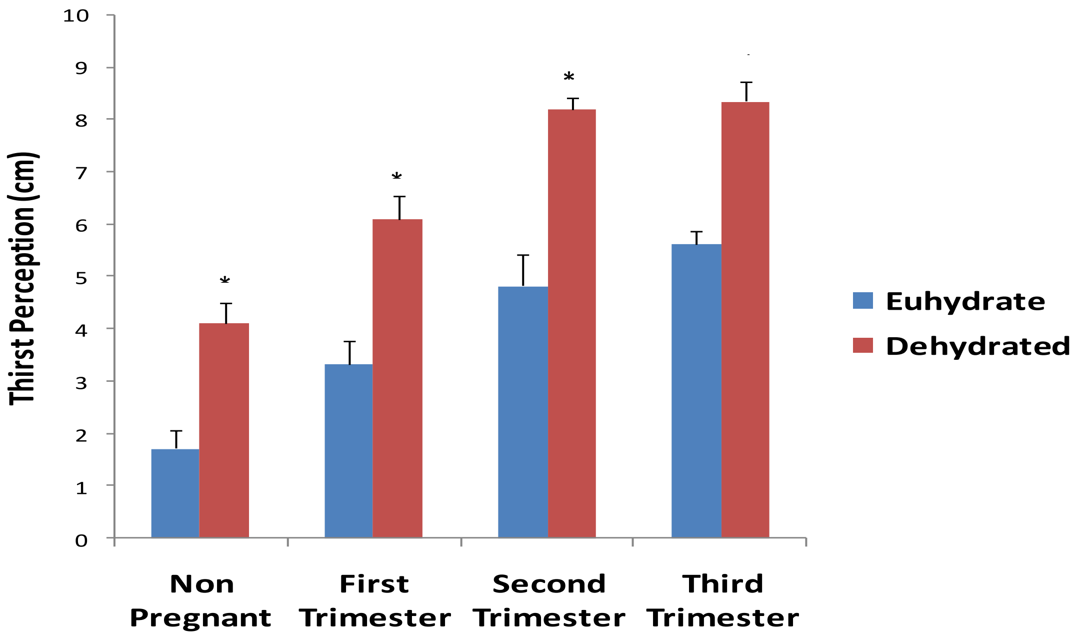
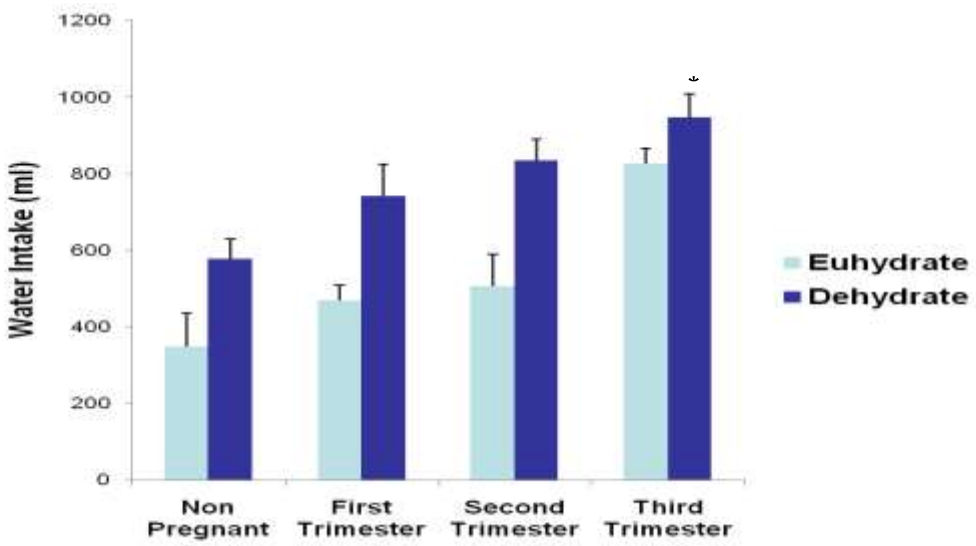



**Figure 9**: Bar chart showing Thirst Perception for Euhydrate and dehydrated Non Pregnant and the three trimesters of pregnancy

* = statistical significance at P<0.05 when euhydrate subjects are compared with dehydrated subjects.




## Follow Up Dehydrated Group

**Figure 10**: Bar chart showing water intake for Euhydrate and dehydrated Non-Pregnant and the three trimesters of pregnant subjects.

* = statistical significance at P<0.05 when euhydrate subjects are compared with dehydrated

## DISCUSSION

In both euhydrated and dehydrated pregnant women, there were increases in thirst perception and water intake during the first, second and third trimesters of pregnancy.(Figures 9 and 10) Ershow *et al.,* (1991) reported that weight gain during pregnancy causes increase in the physiological requirement for water or fluids but intake are likely to vary among individuals. It was also reported by Hasta *et al.,* (1990) that dehydration and transport of nutrients from the food pregnant women eat to the baby enhances intake of water. Weight gain is due to enlargement of uterus, increase in breast tissue, and blood and water values in form of extra-vascular and extracellular fluid (Ershow *et al.,* 1991). Both extracellular (Lindheimer and Katz, 1971; Alexander et al., 1980 and Atherton and Pirie, 1981) and intravascular (Baylis, 1979; Atherton et al., 1982) volumes are known to increase during pregnancy in rats. In this research, there was an increase in body mass index (Tables 1) which is a reflection of an increase in the weight and this increase was statistically significant in the third trimester of pregnancy.

Thirst perception was significantly higher in pregnant women when compared to non-pregnant women. These increases in the thirst perception were observed in the three trimesters of pregnancy. The thirst perception gets to a peak in the second trimester and remains at this peak until term. During pregnancy, plasma osmolality levels fall in some species, including humans. This should exert an inhibitory influence on thirst mechanisms; however, water intake is maintained or even increased despite this plasma hypotonicity (McKinley and Johnson (2004).

The volume of water intake was significantly increased in the first, second and third trimesters of pregnancy when compared with the non-pregnant women (Figures 3 and 10). Women are known to experience fluid retention during Pregnancy and the luteal phase of the menstrual cycle (Vokes et al., 1988; Celia et al., 2008). Increases in thirst perception and water intake were also reported during menstrual phase of the menstrual cycle (Agoreyo and Orifa 2010.) Female sex hormones may play a role in the fluid retention and increase in thirst during physiologic conditions like pregnancy. Conditions like pregnancy can cause an increase in estrogen level, and that the estradiol is mostly secreted by the ovaries, while estrone and estriol were secreted by the placenta. During the first trimester, estrogen production is mostly made by the placenta, and this continues until near the end of the pregnancy when the amount circulating in the body is a thousand times the amount when not pregnant (Nelson and Bulun, 2001).There was a correlation between the thirst perception and the volume of water intake. The amount of water taken can thus be related to the thirst perception of subjects although there may be other factors. In animal research on thirst, where the animals cannot exactly express their thirst desire, the volume of water intake may be a good guide to knowing their level of thirst. This research has been able to correlate thirst perception with the volume of water taken by the subjects The level of thirst in an animal can thus be inferred from the amount of water consumed by animal. This is important in accessing the level of thirst in Animals

There was an increase in the volume of urine during pregnancy when compared with non-pregnant women. The urine volume of the first trimester, second trimester and third trimester of pregnancy shows that the volume of urine significantly increased ($P<0.05$) in the third trimester of pregnancy when compared with non-pregnant women**.**

During pregnancy (third trimester), the glomerular filtration rate (GFR) increases. The renal plasma flow and sodium excretion rate increases (Priscilla, 2009). Therefore, the increase in urinary outflow in the last trimester may be due to the increase in glomerular filtration rate and plasma flow rate.

In this research, our findings also showed that although there was an increase in thirst and volume of water intake during pregnancy; General fluid needs increase during pregnancy in order to support fetal circulation, amniotic fluid, and a higher blood volume (Montgomery, 2002). In addition there was also a decrease in the concentration of plasma $Na^+$ and plasma osmolality. The sodium concentration under normal conditions is a major contributor to thirst sensation. Plasma osmolality elevation is the most potent stimulus of thirst with only a 2% - 3% change in osmolality required to induce thirst in humans (Stachenfeld et al., 1996, 2001). In pregnancy, this is not so. There is a desire to drink water even when the sodium level and plasma osmolality are significantly decreased.

The decrease in plasma osmolality reported in this study is similar to that reported in rats (Jacques et al., 1981). Similarly, studies during pregnancy in Battleboro rats shows that the osmotic threshold for arginine vasopressin secretion was lower in pregnant groups (Durr et al., 1982). If such a drop in osmolality should occur in non-pregnant subjects, there may be a decrease secretion of antidiuretic hormone and may lead to a state of water diuresis (Jacques et al., 1981). In humans, strong positive correlations exist between plasma osmolality and both thirst and AVP concentration (Stachenfield et al., 1996, 1997 and 2001; Calzone et al., 2001) and the major contribution to osmolality is sod ium ion concentration in the plasma.

Study on pregnant Sprague – Dawley rats demonstrated a resetting of the threshold for arginine vasopressin secretion to a lower plasma osmolality (Jacques et al., 1981). This may be the case in pregnant humans. Davidson et al. (1987) reported a decrease in the apparent threshold for AVP release during gestation and the same trend was reported for osmotic threshold for thirst. The osmotic threshold for vasopressin (VP) secretion is reset during pregnancy (Lindheimer and Davison, 1995) and during the luteal phase of the menstrual cycle (Spruce et al., 1985; Stachenfeld 1999). Thus there is a desire to drink water even when the sodium level and plasma osmolality levels are significantly decreased. The hormone relaxin may be responsible for such resetting of threshold for arginine vasopressin as this resetting occurs at a time when relaxin is detectable in plasma ( Weisinger et al., 1993).

The decrease in osmolality which brings the osmolality below the osmotic thirst threshold (Lindheimer et al., 1989) may be accounted for by decrease in the concentrations of sodium, blood urine nitrogen (BUN) as well as decrease in concentration of blood glucose but the major osmotically active cation is sodium (Kirksey et al., 1962; Churchill et al., 1980). The plasma sodium level is an index of the Osmolality of the plasma. In this study, it was observed that blood urea nitrogen (BUN) concentration dropped in pregnant women when compared with the non-pregnant women. The overall effect is a drop in osmolality which normally should reduce thirst perception but instead, the thirst perception is kept on the increase to meet the increased water needs of the pregnant woman. This will prevent dehydration.

## CONCLUSION

This research has been able to establish that there is decrease in plasma osmolality but with an increase in thirst perception and water intakes in pregnancy. This is possible when the osmotic threshold for arginine vasopressin secretion is reduced to a lower level such that reduced levels of plasma osmolality can trigger arginine vasopressin secretion. Pregnancy is a physiological state in the body with alterations in body composition to accommodate the growing fetus.


Print ISSN: ISSN 2053-406X, Online ISSN: ISSN 2053-4078

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Print ISSN: ISSN 2053-406X, Online ISSN: ISSN 2053-4078