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Gender-Based Comparative Study Of The Influence Of Cola Nitida On The Sweat Sodium, Potassium And Chloride Concentrations Of Humans

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ABSTRACT : The study investigated how Cola nitida affects the sweat concentrations of sodium (Na), potassium (K), and chloride (Cl) in male and female subjects. Sixty healthy participants (30 males, 30 females) aged 18–28 years, with varying body weights (underweight, normal weight, overweight), were selected. Subjects were exposed to three conditions: normal chamber temperature (27°C, 70% RH), raised temperature (37°C, 90% RH), and exercise at normal temperature (27°C, 70% RH) while riding a bicycle ergometer at 750J/min for 20 minutes. Prior to the experiment, 0.5g/kg body weight of Cola nitida was consumed, followed by a 90-minute rest. Sweat samples were collected to measure ion concentrations. Results showed no significant changes in sodium (Na) concentrations between males and females under normal and raised temperature conditions. However, under exercise conditions, there was a significant increase in sweat Na in female underweight subjects compared to males. Regarding chloride (Cl), there was no significant difference between males and females under all conditions. For potassium (K), significant increases were observed in the sweat of female underweight subjects compared to males in normal, raised temperature, and exercise conditions. Conversely, decreases in sweat potassium were noted in female normal weight subjects under normal conditions and overweight subjects under raised temperature and exercise conditions compared to males.

Keywords: *Cola nitida*, sweat sodium, potassium and chloride concentrations, chamber temperature with exercise

1. INTRODUCTION

Found in the blood and elsewhere, fluids and electrolytes, are crucial to the physiology of the body (Carlson,1997). Some factors like environmental and ill-health states might change their balance. The fluids are ICF and ECF Sodium ions are majorly found in the ECF whereas potassium ions are in the ICF (Thune and Lund 1996). Some investigators have observed that some factors such as temperature amongst others would determine heat production and the heat could be detrimental to the human body. However, through the process thermoregulation, the body is still able to adjust. Too much heat could negatively impact the body fluids, the heart and blood vessels and the renal system (Semenza., 1999). Workers such as those working in the bakeries could easily be impacted by much heat with resultant effects on the renal functions (Laux *et al*., 2011). Knowing that body mass index has a direct bearing to sweating pattern, the underweight, normal weight and overweight could therefore be subjects of interest regarding such a study (Kenchaiah *et al*., 2002). To keep fit, the place of exercise cannot be overemphasized (Thune and Lund, 1996); (Blair and Church, 2004). This is quite advisable as

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most individuals are beginning to adopt more of a sedentary lifestyle (Eaton and Eaton, 2003). A major essence of sweating is to remove heat from the body, especially when the environment is overheated. (Cheuvront *et al*., 2010).

During an exercise, body fluid might be lost which should be replaced subsequently for the avoidance of abnormality. In order not to aggravate a rather worse scenario already existing, the replacement fluid should be caffeine or alcohol free. It is a common knowledge that caffeine is a diuretic. The most active ingredient in *Cola nitida* is caffeine amongst others (McCarthy *et al*., 2008); (Umoren *et al*., 2009). It has been observed that a number of people are ignorantly abusing caffeine. Presently, the said substance is applicable in drink and drug production (Mednick *et al*., 2008). *Cola nitida* is fondly consumed as a stimulant (Igwe *et al*., 2007) and prior to this time, a gender-based comparative study involving the human subjects using the said Cola nut and under the aforesaid experimental conditions has not been done. Therefore, how *Cola nitida* influenced the sweat rate in all the three body weight was considered in this present study.

2. LITERATURE REVIEW

Thermoregulatory mechanism is key to the survival of humans. The thermoregulatory system, body fluid regulatory and cardiovascular systems are functionally linked together (Takamata *et al*., 2001). Such an interaction is crucial to the prevention of progressively banormally high body temperature during exercise in a hot surrounding (Sawka and Montain, 2000). After exposing the body to heat, the sweat glands begin to produce sweat in an attempt to help cool down the body back to its usual physiological state. The higher the temperature, the more the volume and rate of sweat production (Libert *et al*., 1988; Armstrong and Maresh, 1991; Ugwu,2007).The sweating process is controlled by the sympathetic nervous system. How the sweat glands handle fluid and ions determines the sweat contents and whether such will be diluted or concentrated (Ugwu, 1986). It should be noteworthy that as a thermoregulatory organ, the sweat glands also serve a special role in reducing the amount of both fluid and electrolyte. There are mainly two types of sweat glands: Eccrine and Apocrine. The former are more widely distributed in area like the forehead amongst others. They actually come to play in respect to thermoregulation and their ducts drain directly to the skin (Sato *et al*., 1989).

In the nutshell, body temperature is controlled by the Preoptic area of the Anterior Hypothalamus by influencing the activities of the eccrine sweat glands (Holzle, 2002). The Apocrine sweat glands are concentrated on somewhere like the armpits amongst others. They drain to the hair follicles. Also noteworthy here is the fact that they are not involved in thermoregulation through sweating (Sato *et al*., 1989).

3. MATERIALS AND METHODS

Subjects

Sixty subjects (males=30 and females=30) and unaccustomed to Cola nut eating were involved. Their age range was between 18 and 28years. Three (3) sub-categories were involved: underweight=10, normal weight=10 and overweight=10. Hypertensive, renal and any subject with cardio-pulmonary-related conditions were exempted from the study. Informed consent was obtained from each subject before the study and permission of the ethical committee of the university was also obtained. Their health status was assessed with the aid of questionnaires and physical examination. All the subjects were active but none was athletically trained as defined by the absence of a regular physical exercise programme during the last six months before the experiment. Three environmental conditions were involved:

- The normal chamber temperature condition, with a room temperature (RT) of 27^0C and a relative humidity (RH) of 70%.
- The raised chamber temperature condition, with RT of 37^0C and RH of 90%.
- The normal chamber temperature with exercise condition, when RT and RH were maintained at 27^0C and 70% respectively.

The Sweat Chamber

Professor (Sir) A.C. Ugwu's Sweat Chamber (situated in the University of Benin) was used for the study. It is a room with the dimension 4m x 3m. A heater was used in raising the room temperature and a thermometer used in measuring it. An air conditioner was used to maintain the relative humidity while a hygrometer was used to measure it at the desired level. Prior to the studies, the subject's age (years), weight (kilogram), height (metre), blood pressure (mmHg), pulse rate (beats/minute) and timed urine volume (milliliter) were recorded.

Inclusion/Exclusion Criteria

Subjects with hypertension, kidney and heart-related conditions were excluded from the study. Knowing that the commonly accepted body mass indices (BMI) are: underweight (under 18.5 kg/m^2), normal weight (between 18.5-25.0 kg/m^2), overweight (between 25.0-30.0 kg/m^2) and obese (over 30.0 kg/m^2) only the subjects that were underweight, normal weight and overweight but not obese were so categorized and included in the study. Volunteers discontinued the experiment on reaching any one of the two criteria: 20 continuous minutes of exercise and voluntary cessation.

Each subject was studied on different days and studies commenced without breakfast (Marriot, 1993). 0.5g/Kg body weight of *Cola nitida* which refers to a preliminary study in which the dose of *Cola nitida* taken in the study was worked out by allowing an ad-libitum intake until the subjects were satisfied. The range of the intake was between 0.39g/kg and 0.57g/kg body weight was administered to each subject to be chewed as a bolus. After ingestion, 50ml of deionized water was given to each volunteer to flush the masticated *Cola nitida* down the gut. The subject was allowed to rest for 90 minutes (preliminary experiments had suggested that the effects of the nuts were observable in body tissues 90 minutes after ingestion). Thereafter, the subject was admitted into the sweat chamber.

Sweat Output

In the normal chamber temperature and raised chamber temperature conditions, the subject sat quietly in the sweat chamber for 20 minutes. While in the normal chamber temperature with exercise condition, the subjects pedaled a bicycle ergometer at moderate workload of 750J/minute for 20 minutes.

Sweat Collection

(The Sweat Capsule Method)

Sweat was collected from the mid-forehead in each subject using the sweat capsule technique as invented by (Ugwu and Oyebola 1996) from an area of $28.3cm^2$ using a 3cm radius filter papers and applying the formula πr^2-where π=3.142 x 3^2. The sweat capsule consisted of three genuine Whatman filter papers stacked over each other and placed over the demarcated collection site on the mid-forehead with the aid of a watch glass for 20mins. It was weighed before sweat collection and re-weighed immediately after each collection in order to give the weight of the sweat produced over the calculated area. The difference gave the apparent sweat volume produced in the given period of sweating from which the sweat rate was calculated. After weighing, the filter papers were quickly transferred into a clean sample bottle and soaked in 4ml of deionized water and thereafter centrifuged for 15minutes at 3500 rpm. The supernatant was then collected for analyses. Aliquot parts of the supernatant was used for the estimation of the sweat electrolytes.

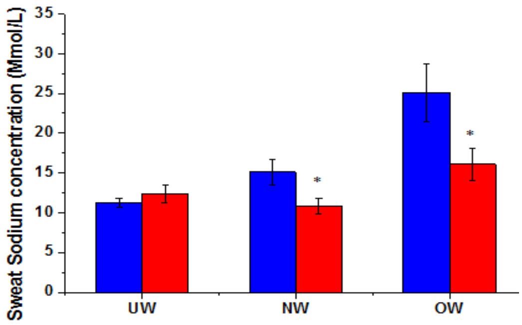
Estimation Of Sweat Electrolytes

- **Sodium and Potassium ions:** Flame Spectrophotometry
- **Chloride ion:** "Teco Diagnostics" Chloride reagent kit/Colorimetric method; for the quantitative colorimetric determination of chloride in human sweat

Data Analysis

All results were expressed by suitable tables and graphs as the Mean ± SEM. Statistical analyses were carried out using Analysis of Variance (ANOVA) in relation to Microcal Origin version 8.0 statistical software and the 0.05 level of probability ($P<0.05$) was regarded as significant.

4. RESULTS



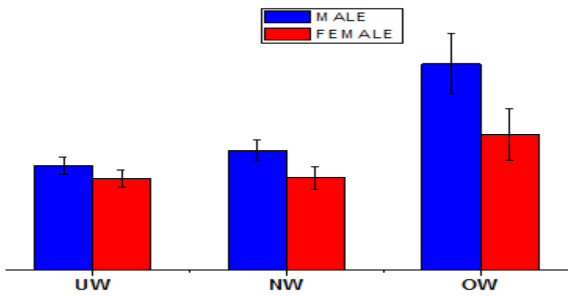
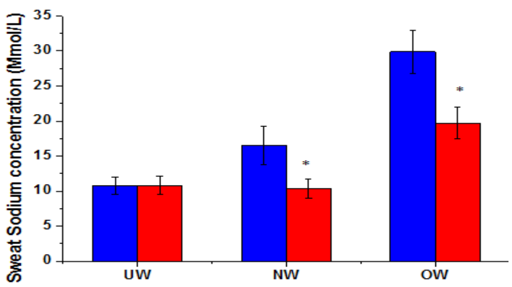


Diagram 1. BEFORE **Diagram 2. AFTER**

NORMAL CHAMBER TEMPERATURE(RT= 27^{0}C, RH= 70%) NORMAL CHAMBER TEMPERATURE(RT= 27^{0}C, RH= 70%)

FIG I: SHOWING THE ***SWEAT SODIUM CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT NORMAL CHAMBER TEMPERATURE.



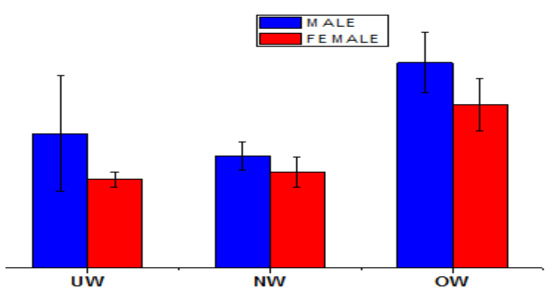


Diagram 3. BEFORE **Diagram 4. AFTER**

RAISED CHAMBER TEMPERATURE(RT= 37^{0}C, RH= 90%) RAISED CHAMBER TEMPERATURE (RT= 37^{0}C, RH= 90%)

FIG. II: SHOWING THE ***SWEAT SODIUM CONCENTRATION***IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT RAISED CHAMBER TEMPERATURE.

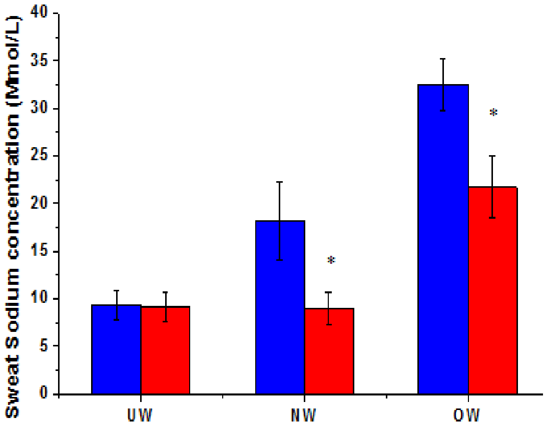


Diagram 5. BEFORE NORMAL CHAMBER TEMPERATURE WITH EXERCISE (RT= 27^{0}C, RH= 70%)

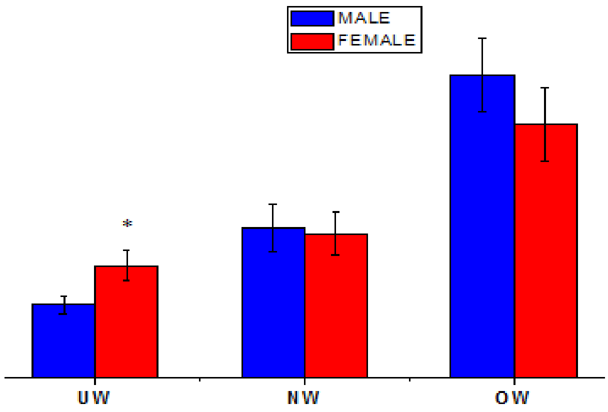


Diagram 6. AFTER NORMAL CHAMBER TEMPERATURE WITH EXERCISE (RT= 27^{0}C, RH= 70%)

FIG. III: SHOWING THE ***SWEAT SODIUM CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT NORMAL CHAMBER TEMPERATURE WITH EXERCISE.

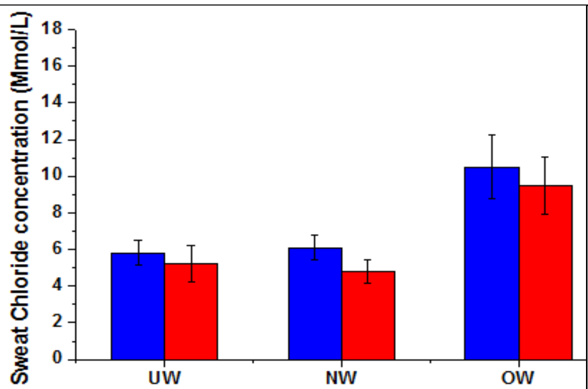


Diagram 7. BEFORE

NORMAL CHAMBER TEMPERATURE(RT= 27^{0}C, RH= 70%)

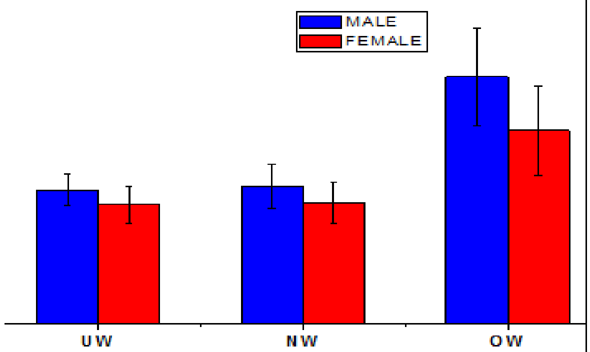


Diagram 8. AFTER

NORMAL CHAMBER TEMPERATURE(RT= 27^{0}C, RH= 70%)

FIG. IV: SHOWING THE ***SWEAT CHLORIDE CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT NORMAL CHAMBER TEMPERATURE.

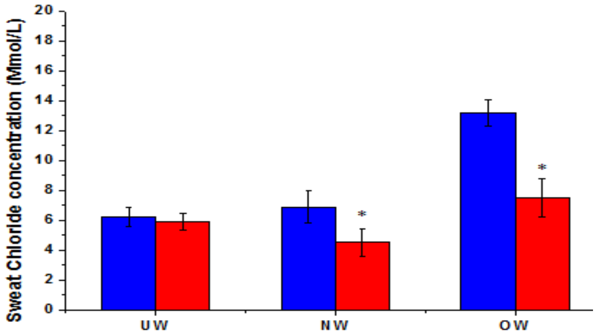


Diagram 9. BEFORE RAISED CHAMBER TEMPERATURE(RT= 37⁰C, RH= 90%)

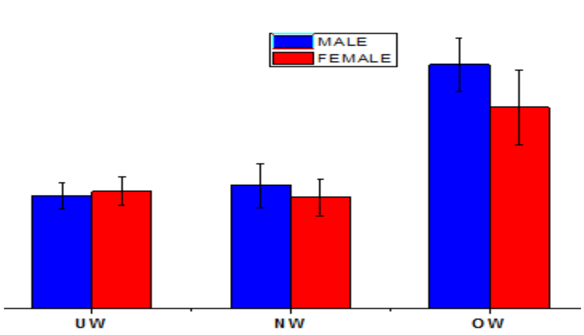


Diagram 10. AFTER RAISED CHAMBER TEMPERATURE (RT= 37⁰C, RH= 90%)

FIG. V: SHOWING THE ***SWEAT CHLORIDE CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT RAISED CHAMBER TEMPERATURE.

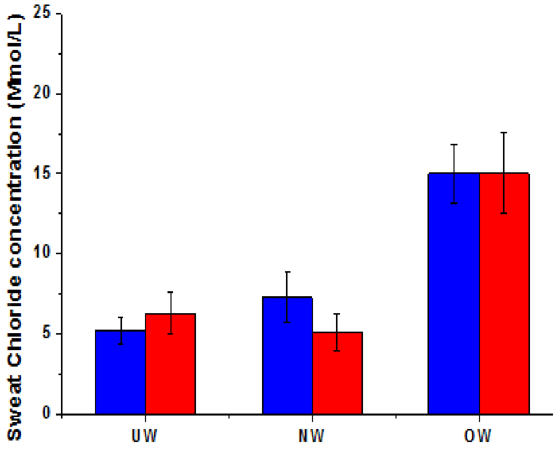
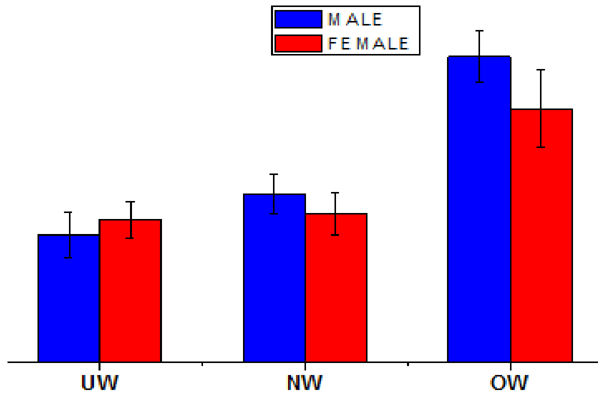
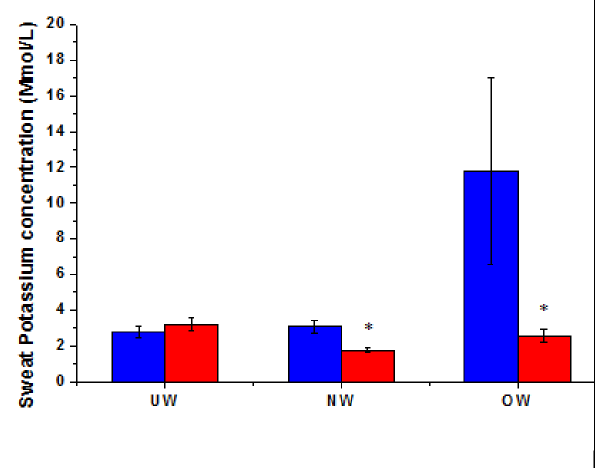
	

Diagram 11. BEFORE	**Diagram 12. AFTER**
NORMAL CHAMBER TEMPERATURE WITH EXERCISE	**NORMAL CHAMBER TEMPERATURE WITH EXERCISE**
(RT= 27⁰C, RH= 70%)	**(RT= 27⁰C, RH= 70%)**

FIG. VI: SHOWING THE ***SWEAT CHLORIDE CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT NORMAL CHAMBER TEMPERATURE WITH EXERCISE.



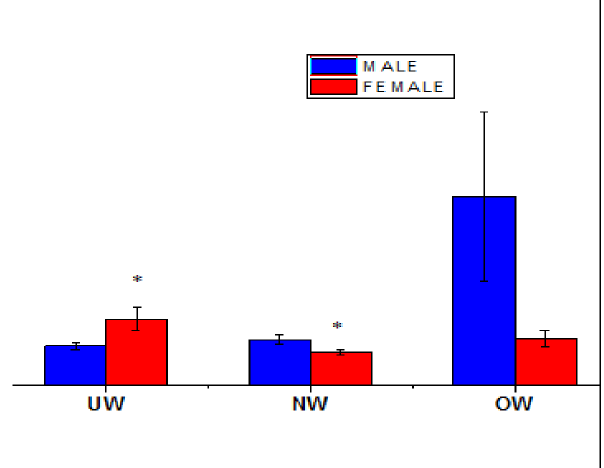
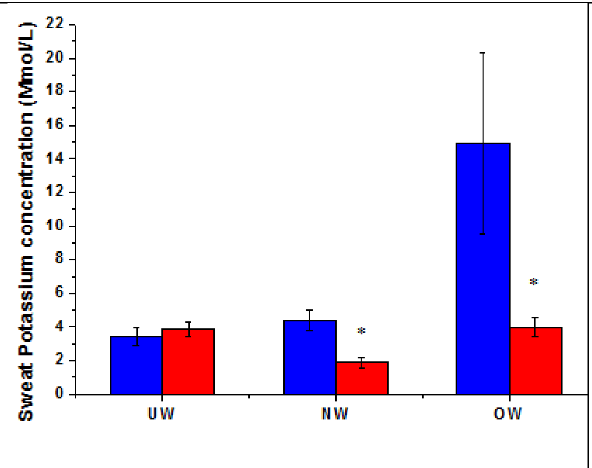


Diagram 13. BEFORE	**Diagram 14. AFTER**
NORMAL CHAMBER TEMPERATURE(RT= 27^{0}C, RH= 70%)	**NORMAL CHAMBER TEMPERATURE(RT= 27^{0}C, RH= 70%)**

FIG. VII: SHOWING THE ***SWEAT POTASSIUM CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT NORMAL CHAMBER TEMPERATURE.



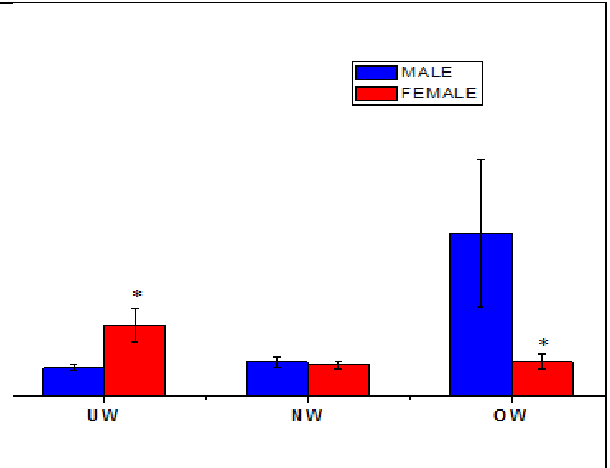
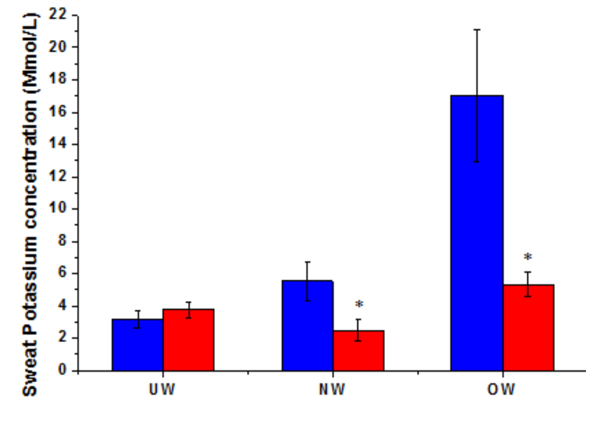


Diagram 15. BEFORE	**Diagram 16. AFTER**
RAISED CHAMBER TEMPERATURE(RT= 37^{0}C, RH= 90%)	**RAISED CHAMBER TEMPERATURE (RT= 37^{0}C, RH= 90%)**

FIG. VIII: SHOWING THE ***SWEAT POTASSIUM CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF *COLA NITIDA* AT RAISED CHAMBER TEMPERATURE.



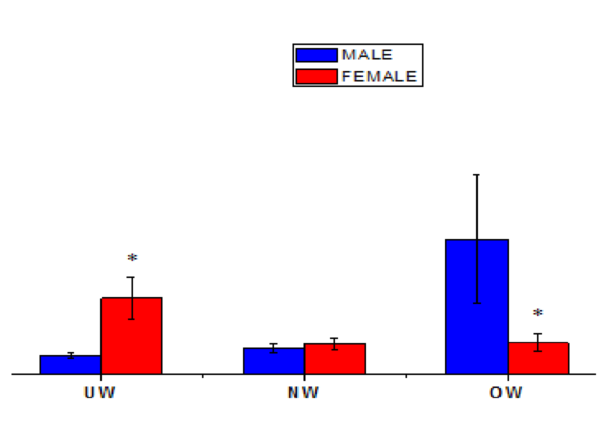


Diagram 17. BEFORE	Diagram 18. AFTER
NORMAL CHAMBER TEMPERATURE WITH EXERCISE	NORMAL CHAMBER TEMPERATURE WITH EXERCISE
(RT= 27^{0}C, RH= 70%)	(RT= 27^{0}C, RH= 70%)

FIG. IX: SHOWING THE ***SWEAT POTASSIUM CONCENTRATION*** IN INDIVIDUALS OF DIFFERENT BODY WEIGHT BEFORE AND AFTER INGESTING OF COLA NITIDA AT NORMAL CHAMBER TEMPERATURE WITH EXERCISE.

5. DISCUSSION

As regards sweat Na ions, there was no significant change observed in a comparison between the males and females after the ingestion of Cola nitida under normal (Figure I) and raised temperature (Figure II) conditions. However, a significant increase in sweat Na was observed in female UW subjects compared to the males after the ingestion of Cola nitida under exercise condition (Figure III). This could be because the males are better acclimatized to exercise in a heated environment than the females, hence the loss of more Na in the female sweat during exercise. It could also be because of the increased sweat rate in the females (under exercise condition), a limited time would have been allowed for the reabsorption of Na across the sweat duct (Blair and Church 2004): (Ugwu and Oyebola, 1992) and so much of the Na was lost to the sweat. Another factor that would have contributed to the above observations could be related to hormonal changes. Knowing that aldosterone stimulates Na+ and water reabsorption from the gut, salivary and sweat glands in exchange for K+, its level and potency could have been higher in the males than females during exercise. So, more Na would have been reabsorbed into the body fluids in the males than females.

Concerning Cl ions concentration, no significant change was observed in a comparison between the males and females after the ingestion of *Cola nitida* under normal (Figure IV), raised temperature (Figure V) and exercise (Figure VI) experimental conditions. From previous studies, Chloride ions concentration probably followed passively that of Na ions (Ugwu and Oyebola, 1992). and Cl^-ions were reabsorbed in conjunction with sodium cations to maintain the system's electrochemical balance. In the present study, the mobilization of Cl ions might have been inhibited or it could also be that a state of balance had been achieved already.

In respect to sweat potassium ions, there were significant increases in potassium ions in the female UW subjects compared to the males after the consumption of *Cola nitida* under normal (Figure VII), raised temperature (Figure VIII) and exercise (Figure IX) experimental conditions. This could be because of the reabsorptive effects of aldosterone on potassium ions in the sweat glands. It could also be due to the activation of Na^+-K^+ counter-transporter protein which is mediated by the enzyme Na^+-K^+ ATPase. Following the loss of Na ions in the sweat, both hormone and enzyme would have acted synergistically to reabsorb K ions, thereby conserving same in the body fluids. The activities of the hormone, carrier protein and enzyme might have been more pronounced in the males than females.

The results also showed significant decreases in female NW under normal (Figure 49) condition and OW under raised temperature (Figure 50) and exercise (Figure 51) conditions sweat potassium ions concentration compared to the males after the ingestion of *Cola nitida*. The reversed findings could again be due to the activities of the hormone, carrier protein and enzyme but then having their toll more on the females than males. The reversal might have also occurred because of the effects of raised temperature and exercise, both of which resulted in increased sweat rate and the subjects worst hit by it are the OW.

CONCLUSION

This study highlights the differential effects of *Cola nitida* on sweat sodium, potassium, and chloride concentrations among male and female human subjects under varying conditions of temperature and exercise. The findings suggest that while the overall impact of *Cola nitida* on sodium and chloride levels was consistent across genders, potassium concentrations exhibited significant gender-specific responses, particularly in underweight females. These insights deepen our understanding of how gender and body composition can influence electrolyte balance in response to stimulant consumption.

For future studies, it would be beneficial to expand the sample size and include a broader age range, as well as individuals with varying levels of physical fitness and habitual caffeine consumption.

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