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The Effect of Caffeinated Beverages on Urinary Excretion of Minerals in Females

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Abstract

Caffeinated beverages represent an important part of modern food for many societies. This study was conducted to determine the extent to which caffeinated beverages affect minerals in the human body. The results of questionnaire analysis illustrating that 70% of the study samples highly used to drink caffeinated beverages for more than three years with 1-3 bottles daily and cola was the popular drink. Urine samples were taken from those female students who highly consume caffeinated beverages comparing with female students who do not drink caffeinated beverages. The results indicated that caffeine and phosphoric acid has negative effect on minerals of human body especially calcium and phosphorus. The amount of calcium, sodium, phosphorus, potassium, magnesium and chloride increased significantly ($p \leq 0.05$) in urine of female students who highly consume caffeinated beverages compared to female students who was not. While zinc showed no significant difference ($p \geq 0.05$) on both groups.

Keywords: Caffeinated beverages; Urine excretion; Minerals; Female students.

1. Introduction

Caffeine has been used for thousands of years and is one of the most widely consumed active food ingredient throughout the world. It is found in common beverages including coffee, tea and soft drinks, as well as products containing cocoa or chocolate, and a variety of medications and dietary supplements [1, 2]. Caffeine is a common ingredient of soft drinks, in classic colas which contain 35 to 38 milligrams per 12-ounce can, diet colas — usually chosen by those who are trying to dodge calories and/or sugar — often pack a lot more caffeine. A 12-ounce can of Diet Coke, for example, has about 42 milligrams of caffeine, a can of Pepsi Cola has about 56 milligrams of caffeine [3]. The caffeinated soft drink market grew enormously during the 2nd half of the 20th century all over the world with increased popularity occurring among the beverages containing higher amounts of caffeine. The increased popularity inspired the arrival of energy drinks, which have become very prevalent. Today, approximately 80% of the world's population consumes a caffeinated product every day and 90% of adults in North America consume caffeine on a daily basis [4].

Long-term consumption at sufficiently high doses has been associated with chronic arterial stiffness [5] can affect gastrointestinal motility and acid secretion [6] in postmenopausal women, high caffeine consumption can accelerate Osteoporosis [7]. The effects of caffeine on the kidney have been investigated in a number of studies [8]. Massey and Wise [9] published a pooled analysis of the experiments performed by their research group on the renal effects of an acute caffeine load in relatively small samples of healthy volunteers. The administration of an average dose of 5.91 mg caffeine/kg resulted in a 23% increase of urine output at 2 h and significantly increased urinary excretion of calcium (78%), magnesium (45%), sodium (74%), potassium (18%), and chloride (69%). With regard to 24-h urine composition and caffeine intake, an association between the intake of caffeine and higher urinary excretion of calcium. Animal studies demonstrated that phosphoric acid, a common ingredient in soda, can deplete bones of calcium. Two recent human studies suggest that girls who drink more soda are more prone to broken bones. The industry denies that caffeinated beverages play a role in bone weakening (http://www.thehealthyarchive.info/2015/05) [10]. Caffeine when consumes in large doses has numerous side effects on health. The objective of this research was to study the effect of caffeine on urinary excretion of body minerals in females who highly consume caffeinated beverages.

2. Materials and Methods

2.1. Subjects

A questionnaire was designed to collect data from 100 female students in The National University at Khartoum, Sudan. Each data in the questionnaires were used to designate the information of the students who daily consume caffeinated beverages and the students who do no consume caffeinated beverages. Thirty females of ages from (20-

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35) who highly drink caffeinated beverages on daily basis were chosen and compared with 30 females of ages (20-35) who do not drink caffeinated beverages.

2.2. Materials

Based on the questionnaire data one type of caffeinated commercial brand that highly consumed by the female students was purchased from local market.

2.3. Urine Samples Collection

Urine Samples were collected in clean disposable plastic cups. Key individual's data (full name, date of birth, gender, collection date and time) were affixed to the container using waterproof materials before the Sample was collected. Depending on the time and nature of the sample, a distinction was drawn between spontaneous urine, first morning urine, second morning urine (collected before noon) and timed urine (usually 24-hours urine). The samples were examined within two hours of urination, since longer standing times can lead to false results.

2.4. Methods

Na	ISE	Easy light fully automated analyzers
K	ISE	
Cl	ISE	
Zn	end point colorimetric methods	BTS plus Semi automated analyzers
P	Molybdate UV methods	
Ca	O - Cresolephthalin end point colorimetric methods	
Mg	Calmagite end point colorimetric methods	

Na, P, Ca [11]; Cl [12]
K [13]; Mg,Zn [14]

2.5. Determination of Minerals in Urine

2.5.1. Sample Preparation

Calcium as chloride: dilute the urine sample 1:100 with 0.5% (w/v) with lanthanum diluent. Magnesium: dilute the urine sample 1:200 with deionized water. Sodium: dilute the urine sample 1:5000 with deionized water. Potassium: dilute the urine sample 1:2000 with deionized water. Zinc: dilute the urine sample 1:5 with deionized water.

2.5.2. Determination of Ca, Mg, Na, K and Zn

The concentrations of the minerals of interest were determined using the Conditions listed in the "Standard Conditions" section [11] Standards are prepared by dilution of the stock standard solutions described under the Standard Conditions for the mineral of interest. Calcium standards should be diluted with the 0.5% (w/v) lanthanum diluent, and the Lanthanum diluent should be used as a blank. Standards for Mg, Na, K and Zn are diluted with deionized water, and deionized water is used as a blank.

2.5.3. Phosphorus

Inorganic phosphate 5 mg/dl reacts with 3.5 mmole/L ammonium molybdate in presence of sulfuric acid 750 mmole/L to form nonreduced phospho molybdate.

Phosphate + Ammonium molybdate $\rightarrow^{H_2SO_4}\rightarrow$ Nonreduced phospho molybdate

The concentration of phospho molybdate formed is directly proportional to the inorganic phosphate concentration. Then it was determined by measuring the increase in absorbance at 340 nm [11].

2.6. Statistical Analysis

Data was statistically analyzed using (SAS) software system for standard analysis of variance procedures. Means were separated using Duncan's Multiple Range Test at 5% level of significance [15].

3. Results and Discussion

3.1. Questionnaire Analysis

The questionnaire displays results for participants through descriptive analysis which clarifies the replicates and percentages. Six questions were asked to the female students. The results of questionnaire analysis illustrating that 73% of the study samples highly used to drink caffeinated beverages (Fig.1). 70% of them used to drink caffeinated beverages for more than three years (Fig.2). 58% of the study samples used to drink daily the most higher group among the study samples (Fig 3). Fig. 4 shows the distribution of the participators in relation to their drinking number of caffeinated beverages per day whereas the study showed that 38% of the study subjects used to drink two bottles per day. 19% of the study samples were higher drinkers of three bottles a day. The higher group of student samples was 43% used to drink one bottle per day. The study showed that 18% of the study samples had urine disease and 82% did not have (Fig. 5).

Fig-1. Percentages of female students taking caffeinated beverages

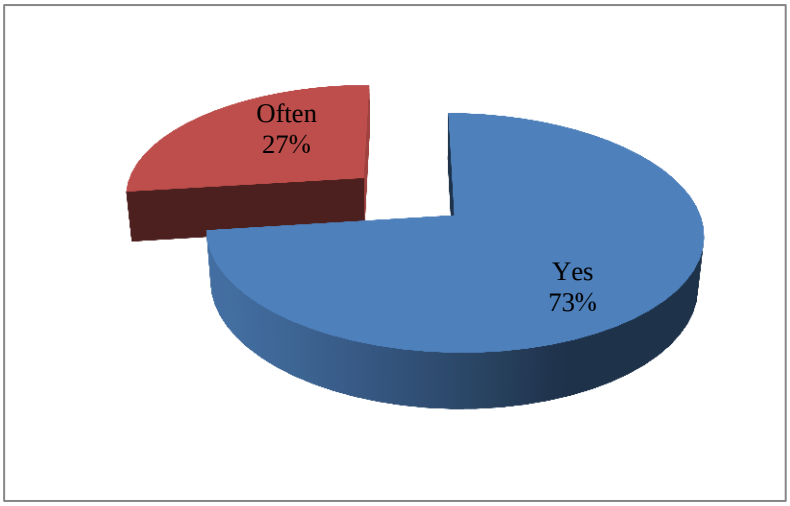


Fig-2. Percentages of female students dealing with caffeinated Beverages within year periods

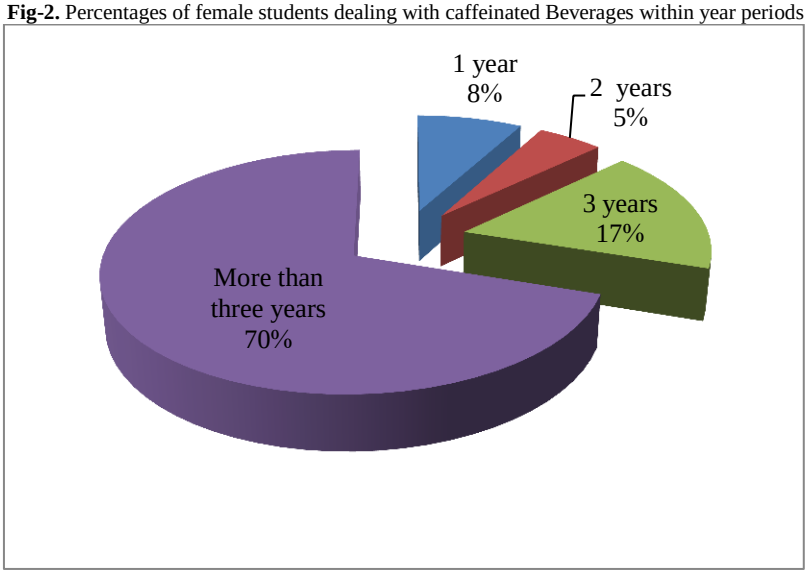


Fig-3. Percentage of female students drinking caffeinated beverages on daily basis

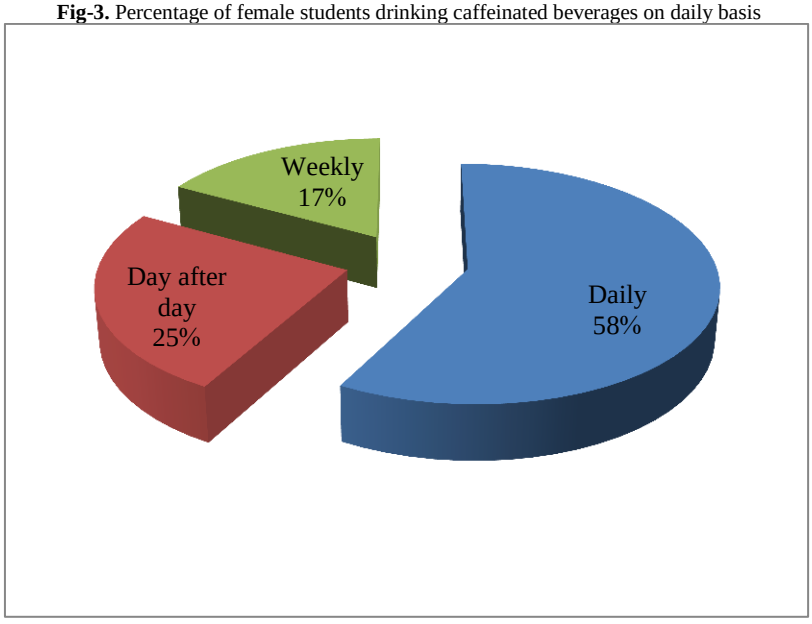


Fig-4. Percentages of female students drinking number of caffeinated beverages per day

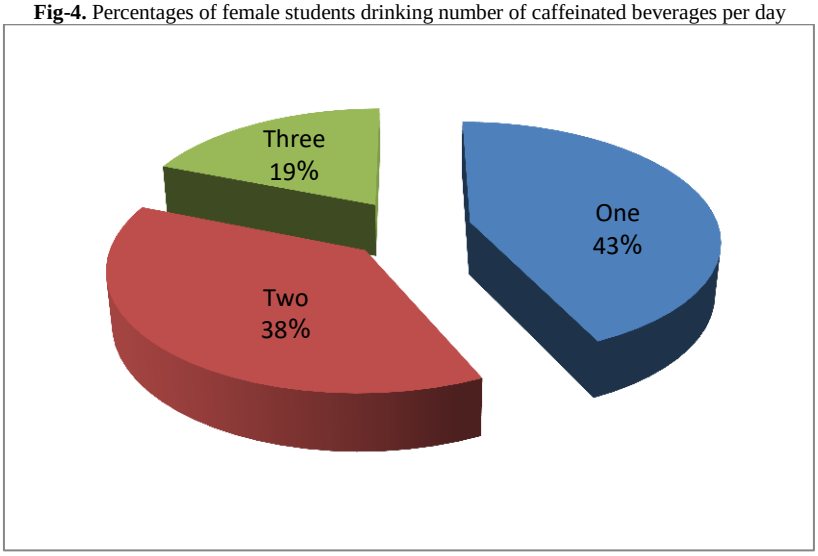
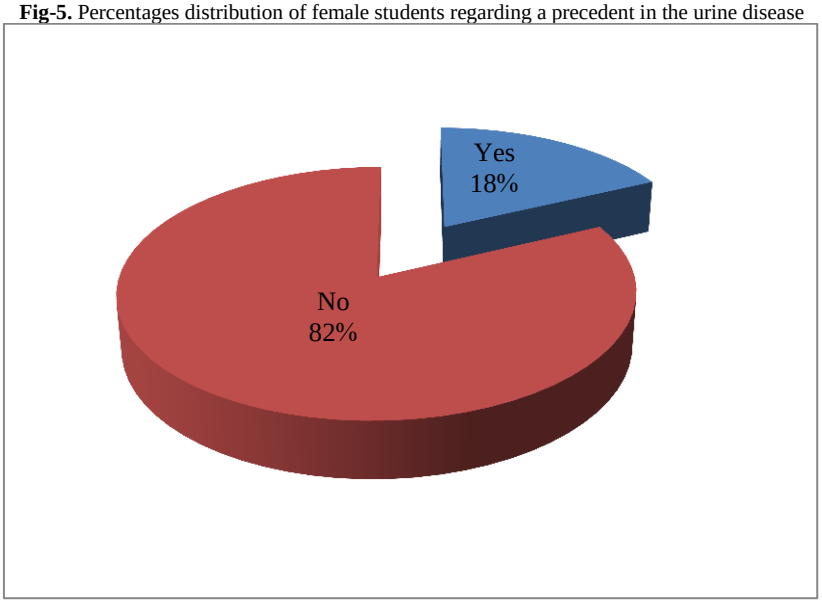


Fig-5. Percentages distribution of female students regarding a precedent in the urine disease



3.2. Determination of Minerals in Urine

The results showed that Ca values in urine of group (1) who highly drink caffeinated beverages was higher than control sample group (2) (Fig.1). Ca contents of samples of subject (Ca1) tested, showed significant increase ($p \leq 0.05$) with overconsumption for caffeinated beverage. The results are in agreement with those reported by Heaney and Rafferty [16] who stated that the caffeinated beverages consumption in the day was positively associated with increased 24-h urinary calcium excretion. Consumption of large amounts of caffeine has been shown to increase urinary excretion of calcium and magnesium [17]. Bone deterioration becomes more pronounced when dietary calcium is inadequate, and less pronounced when dietary calcium intake is adequate. Nawrot, *et al.* [18] concluded that caffeine's potential to adversely affect calcium balance and bone metabolism is dependent on lifetime caffeine and calcium intakes, and is critical for women.

Fig-6. Urinary calcium excretion in subject and control samples (mg/L)

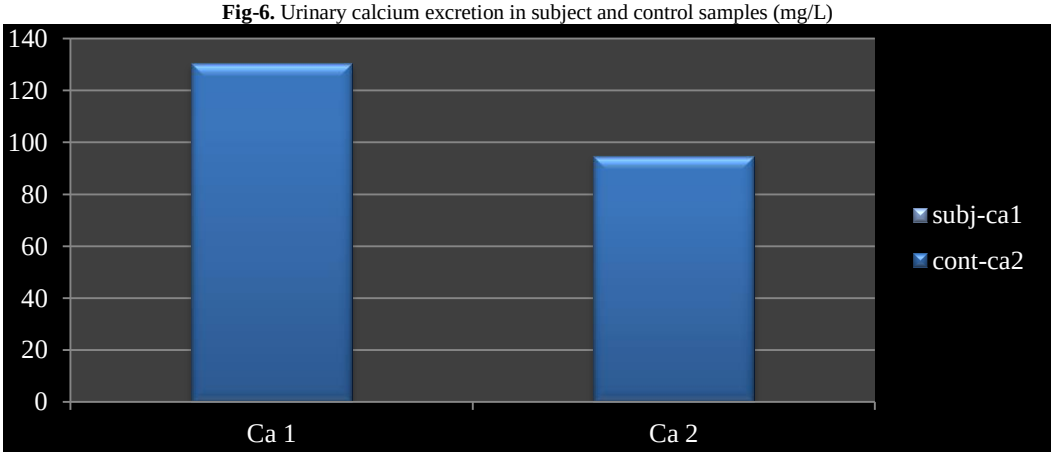
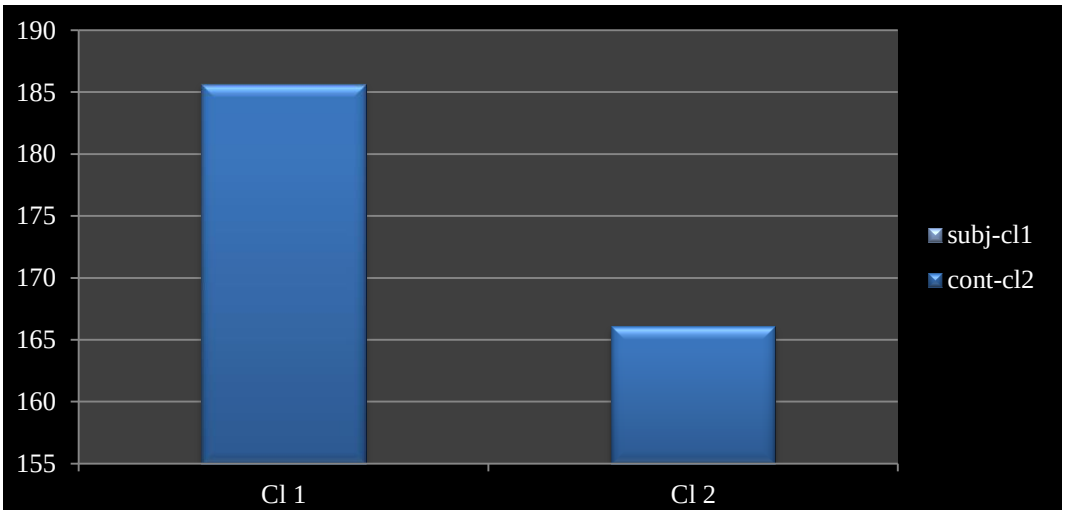


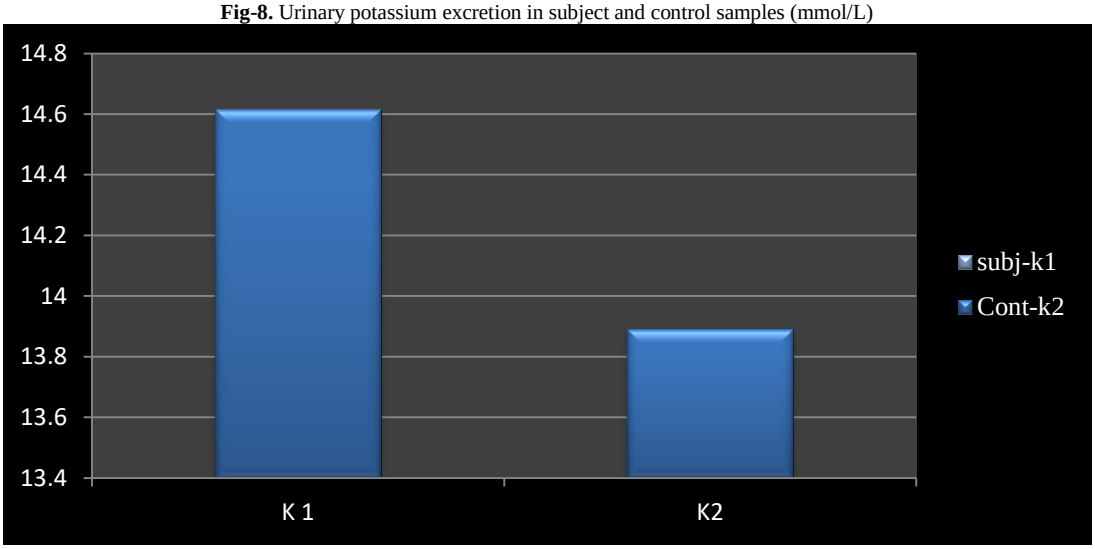
Fig.7 shows the increase of the urinary Cl excretion value was significantly higher ($p \leq 0.05$) in the subject individuals than the control. Massey and Wise [9] found that oral doses of caffeine increased the urinary excretion of calcium, Magnesium, Sodium and chloride for at least 3 h after consumption.

Fig-7. Urinary chloride excretion in subject and control samples (mg/L)



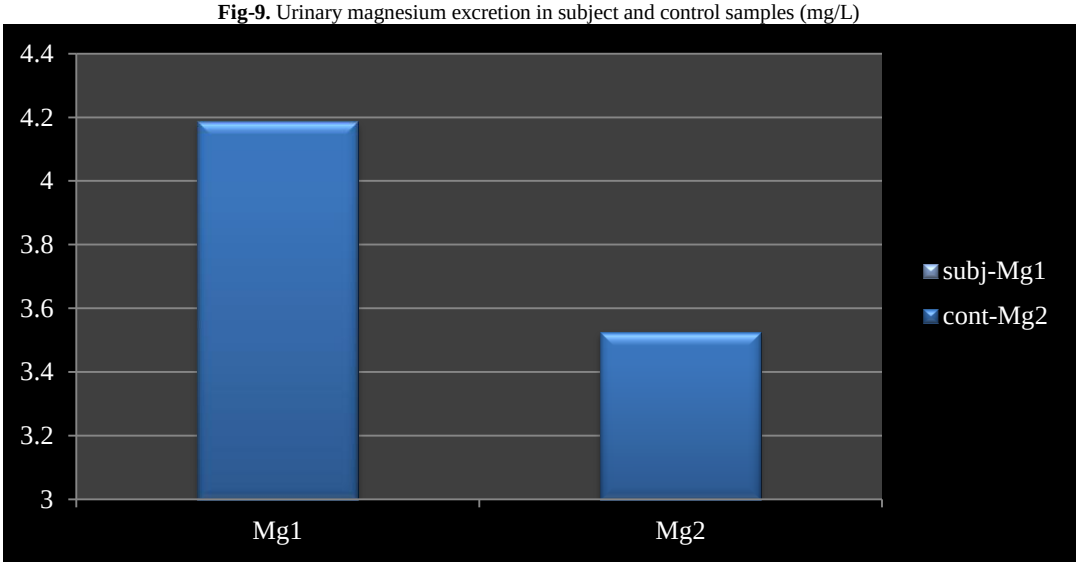
It is clearly from Fig. (8) that the percentage of potassium urinary excretion increased with consumption of caffeinated beverages. The increase of K in urine was affected with the consumption of caffeinated beverages and this result was found to be significant ($p \leq 0.05$) when compared with control samples. Caffeine inhibits the absorption of some nutrients and causes the urinary excretion of calcium, magnesium, potassium, iron and trace minerals [19-21].

Fig-8. Urinary potassium excretion in subject and control samples (mmol/L)



The results indicated that the magnesium urinary excretion increased with overconsumption of caffeinated beverages. The results showed that there was significant difference ($p \leq 0.05$) for Magnesium urinary excretion higher in the subject compared with control samples (Fig.9). These results finding agreed with [22] who reported that Caffeine can cause nutrient depletion of important nutrients, like vitamin B6, and interfere with nutrient absorption of essential minerals, including calcium, iron, magnesium, and B vitamins.

Fig-9. Urinary magnesium excretion in subject and control samples (mg/L)



The females' urinary excretions of sodium results for the two groups are shown in Fig. (10). The increases in sodium urinary excretion with overconsumption of caffeinated beverages in this study were in agreement with Massey and Wise [9] who found that oral doses of caffeine increase the urinary excretion of calcium, Magnesium, Sodium for at least three hours after consumption.

The results showed that high significant increase ($P \leq 0.05$) of phosphorus in the subjects urine of group(1) who highly drink caffeinated beverages compared with the control of group(2) (Fig.11). Nehad and Rania [23] determined the effect of some soft drinks on the public health of twenty male rats (weighing 140 ± 5 g) when receiving different soft drinks (6 ml soft drink Twice/day/rat) about 12 hr. showed significant increase ($P \leq 0.05$) in the phosphorus and magnesium levels in urine of the male rats consuming soft drinks when compared to the control group male rats.

Fig-10. Urinary Sodium Excretion in Subject and Control Samples (mmol/L)

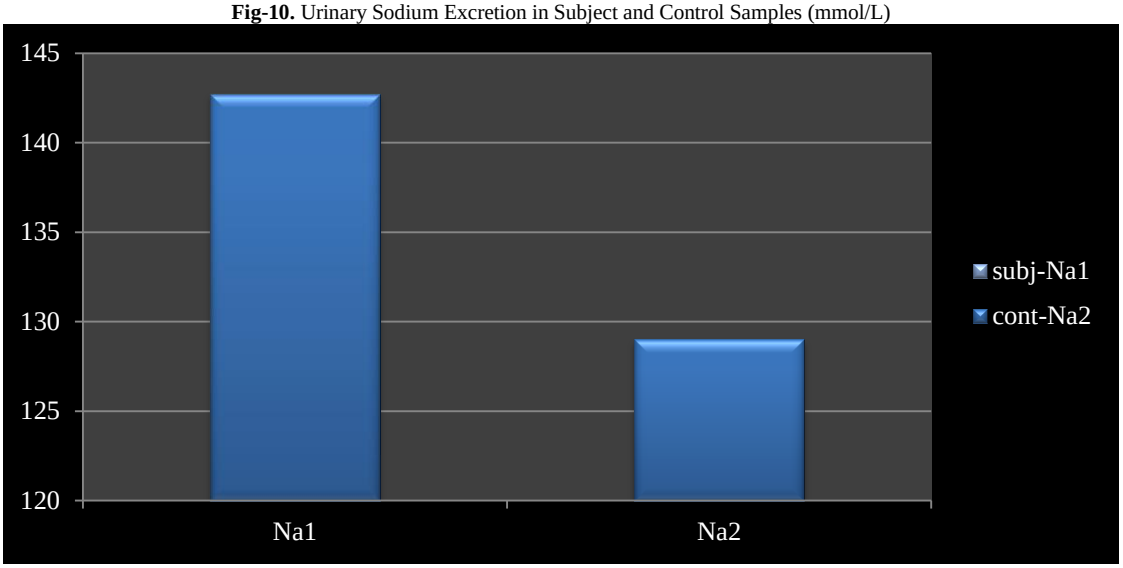
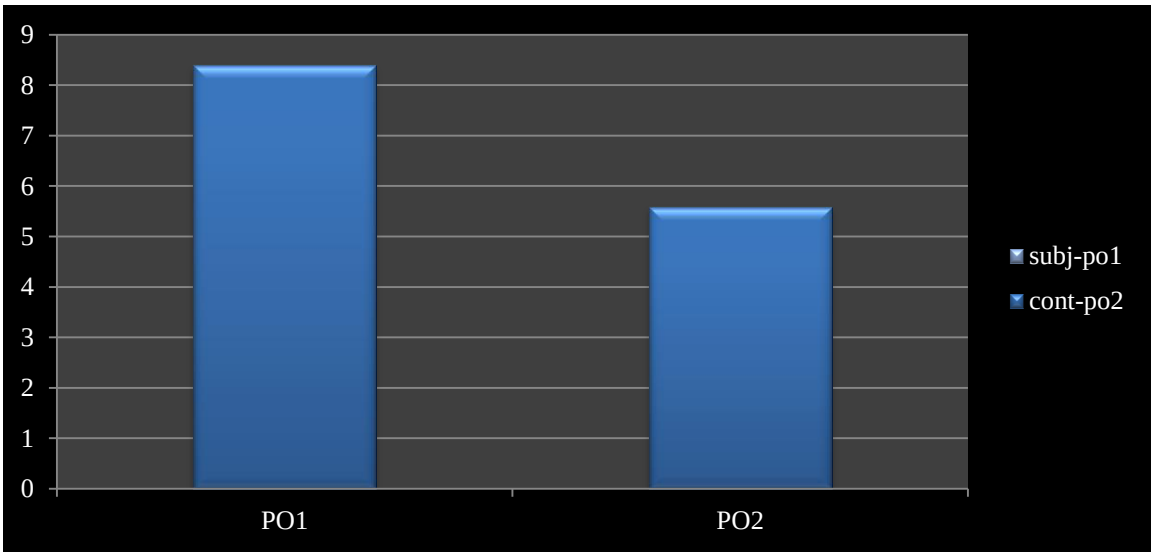


Fig-11. Urinary Phosphorus Excretion in Subject and Control Samples (mg/L)



The results showed no significant difference (P≥0.05) in Zn urinary excretion of subject samples, compared to that of the control samples (Table 1). These findings agreed with Massey [24] who collected urine samples at one, two and three hours after caffeine consumption. He found total urinary three excretions of zinc volume was unchanged.

Table-1. Mean values and T- value of Zinc urinary excretion for Group 1 (subject) and Group 2 (control)

Sample	Urine (mg/L).
Subj.Zn1	0.6168 ± 0.02596^{a}
Cont.Zn2	0.6746 ± 0.0263^{a}
T- value	$1.57^{n.s}$

Mean ±SD values having different superscript letters within columns are significantly different (p≤0.05). n.s = no significant different.

4. Conclusions

The results demonstrate there were significant differences (p≤0.05) found in minerals urinary excretion for females taking caffeinated beverages daily compared to control ones. while the Zn was not changed in both groups. The results reflect that the caffeine increases minerals excretion in urine except that Zn was not affected.

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