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Investigating the Interplay between Body Mass Index, Mineral Status, and Age, Gender, Dietary, and Behavioural Factors

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Abstract:

This study explores the association between body mass index (BMI) and serum mineral levels (calcium, potassium, sodium, and chloride) in adults residing in Aden Governorate, Yemen. Additionally, it investigates the potential influence of dietary and behavioral habits on both BMI and mineral concentrations. Utilizing a descriptive approach, the study recruited 65 participants (38 males, 27 females) within the 20-40 year age range (excluding pregnant women). BMI measurements were obtained alongside self-reported dietary questionnaires. Subsequently, blood samples were collected and analyzed for the specified minerals at Almadenah Medical Center laboratories in Aden Governorate, Yemen in February 2023. Statistical analysis (SPSS software) revealed no significant quantitative correlations between BMI and individual mineral levels (sodium, potassium, calcium, and chloride) at respective p-values of 0.791, 0.482, 0.953, and 0.581. However, significant associations were identified between serum sodium levels and both fruit/vegetable consumption (p-values of 0.009 and 0.029, respectively) and coffee intake with serum potassium levels (p-value of 0.018). Notably, gender exhibited an effect on mineral levels, with males generally demonstrating higher values compared to females. While the association between BMI and mineral levels remained elusive due to potential confounding factors, this study highlights the influence of dietary habits on specific minerals such as sodium and potassium. Additionally, gender disparities in mineral concentrations were observed. Future research with larger sample sizes and more in-depth dietary intake assessments may elucidate the complex interplay between BMI, mineral status, and lifestyle choices in this population.

Keywords: Nutrition, BMI, Minerals.

دراسة التفاعل بين مؤشر كتلة الجسم وحالة المعادن والعمر والجنس والعوامل الغذائية والسلوكية

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الملخص

تستكشف هذه الدراسة العلاقة بين مؤشر كتلة الجسم (BMI) ومستويات المعادن في الدم (الكالسيوم والبوتاسيوم والصوديوم والكلوريد) لدى البالغين المقيمين في محافظة عدن، اليمن. بالإضافة إلى ذلك، فإنه يبحث في التأثير المحتمل للعادات الغذائية والسلوكية على كل من مؤشر كتلة الجسم وتركيزات المعادن. باستخدام المنهج الوصفي، قامت الدراسة بتوظيف 65 مشاركًا (38 ذكرًا و27 أنثى) ضمن الفئة العمرية 20-40 عامًا (باستثناء النساء الحوامل). تم الحصول على قياسات مؤشر كتلة الجسم جنبًا إلى جنب مع الاستبيانات الغذائية المبلغ عنها ذاتيًا. بعد ذلك، تم جمع عينات الدم وتحليلها للمعادن المحددة في مختبرات مركز المدينة الطبي في محافظة عدن، اليمن في فبراير 2023. وكشف التحليل الإحصائي (برنامج SPSS) عن عدم وجود ارتباطات كمية كبيرة بين مؤشر كتلة الجسم ومستويات المعادن الفردية (الصوديوم، البوتاسيوم، الكالسيوم، والكلوريد) بقيمها p البالغة 0.791 و 0.482 و 0.953 و 0.581. ومع ذلك، تم تحديد ارتباطات مهمة بين مستويات الصوديوم في الدم وكل من استهلاك الفاكهة/الخضروات (قيمة p تبلغ 0.009 و0.029 على التوالي) وتناول القهوة مع مستويات البوتاسيوم في الدم (قيمة p تبلغ 0.018). والجدير بالذكر أن الجنس أظهر تأثيرًا على مستويات المعادن، حيث أظهر الذكور عمومًا قيمًا أعلى مقارنة بالإناث. في حين أن الارتباط بين مؤشر كتلة الجسم ومستويات المعادن ظل بعيد المنال بسبب عوامل مربكة محتملة، فإن هذه الدراسة تسلط الضوء على تأثير العادات الغذائية على معادن معينة مثل الصوديوم والبوتاسيوم. وبالإضافة إلى ذلك، لوحظت فوارق بين الجنسين في تركيزات المعادن. قد توضح الأبحاث المستقبلية بأحجام عينات أكبر وتقييمات أكثر تعمقًا للمدخول الغذائي التفاعل المعقد بين مؤشر كتلة الجسم والحالة المعدنية واختيارات نمط الحياة لدى هذه الفئة من السكان.

الكلمات المفتاحية: التغذية، مؤشر كتلة الجسم، المعادن.

Introduction

Maintaining an optimal body weight is essential for general well-being, with ramifications that extend beyond mere appearance. The body mass index (BMI), despite its shortcomings, functions as a readily available measure of weight status and possible health hazards. Nevertheless, the relationship between BMI and the numerous elements that impact health is not fully comprehended. This study investigates the complex correlation between BMI and mineral levels, examining how age, gender, food habits, and behavioral patterns influence this relationship [1].

Increasing research indicates a complex connection between mineral levels and body composition. Minerals such as calcium, magnesium, and potassium have important functions in controlling metabolism, hormone activity, and energy usage, which might potentially affect weight control [2]. On the other hand, BMI might affect the process of absorbing and using minerals, resulting in a complicated cycle of feedback [3].

Adding to the complexity of this situation are the indisputable impacts of age and gender. Physiological changes that occur with age might affect the way our bodies absorb and process nutrients. This can potentially disrupt the connection between BMI (Body Mass Index) and minerals [4].Moreover, the intricate interplay between hormone profiles and body composition necessitates a detailed examination of gender disparities [5].

In addition to physiological considerations, food habits and behavioral patterns have a substantial impact on both BMI and mineral intake. Hruby and Gibson [6]. state that consuming diets that are abundant in fruits, vegetables, and whole grains not only supply necessary nutrients but also support the maintenance of a healthy body weight. In contrast, diets that are rich in processed foods and sugary drinks can lead to both deficits in essential minerals and the accumulation of undesirable body weight [7]. Furthermore, variables such as exercise, tobacco use, and length of sleep can impact both mineral levels and body mass index (BMI), thereby highlighting the complex nature of this association [8;9].

Obesity is a long-term process, and BMI and weight are sensitive indicators for detecting obesity [10]. Cross-sectional studies in Poland and Mexico have shown that daily mineral intake is related to BMI, with overweight individuals having lower potassium and magnesium intakes and higher sodium intake [11]. Obese individuals may have insufficient intake of antioxidants such as zinc, magnesium, and selenium. In Japanese schizophrenia, phosphorus and salt intakes were higher in overweight and obese individuals [12]. However, there is no epidemiological study on mineral intakes and obesity in Yemen. The aim of this study is to analyze the relationship between BMI and mineral intakes and the effect of dietary and behavioral habits on BMI and minerals in Aden's adults.

Methods

Subjects:

The participants examined were individuals aged 20 to 40 years. Due to their lower vulnerability to illnesses, full growth, and generally high nutritional state, individuals in this age range are also capable of providing more accurate information. The investigation was conducted in several residential localities inside Aden City, Yemen. The study included a total of 65 participants, comprising individuals from the community as well as their family members and relations.

The study included a total of 65 individuals, consisting of 27 girls and 38 males. We collected their data using a questionnaire, followed by obtaining their physical measurements, and ultimately conducted laboratory investigations to determine the mineral composition percentage in their bodies.

Data collection:
Data regarding the participant's background characteristics was collected through a pretested questionnaire. Inquiries regarding gender, age, name, height, body mass index assessment, social status, consumption of dietary supplements, and presence of specific food sensitivities, medication intake, telephone number, and behavioral and nutritional patterns. Anthropometry measurements were performed according to the established protocol.
The subject's standing height, measured in centimeters, was recorded without footwear using a wall-mounted measuring tape. The measurement was rounded to the nearest 0.01 meter for the purpose of calculating the BMI. The body weight was measured using a digital weighing scale with a precision of 0.1 kg. The scale was utilized to measure weight while wearing lightweight clothing and without footwear.

Sample Collection
We obtained blood samples without employing a tourniquet and extracted roughly 4 cc of blood into a tube without the inclusion of any anticoagulant agent. The sample tubes were subjected to centrifugation for 10 minutes at a variable speed between 3000 and 3500. We transferred the serum sample into the cryogenic tube and stored it in the freezer until it was ready for analysis.

Laboratory methods:
We have analyzed blood sample after separate by centrifuge in 10 minutes in 3500 cycle and we have analysed them in laboratory of by electrolyte addition and used spectrophotometer method depending specific w.v (wavelength)

Statistical analysis:
For both parts, data were processed by the SPSS program (Version 20) (Statistical Package for the Social Sciences). The differences between the groups were tested for significance by t-test and T-square test. Data were expressed as P-values < 0.05 are considered statistically significant. Also, correlations were considered significant at $p<0.05$. The Data was recorded in Microsoft office excel23.

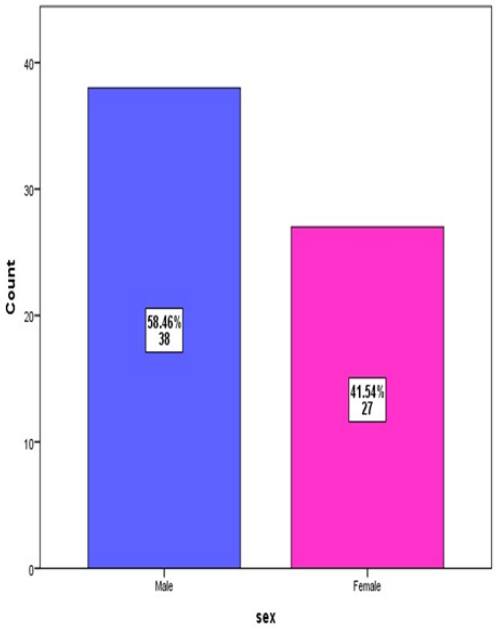
Results & Discussion
The study's findings regarding the correlation between body mass index and the concentration of minerals in the blood serum. Furthermore, the impact of behavioral and nutritional patterns on the concentration of minerals in the bloodstream.

Table 1. The relationship between body mass index and serum minerals concentration

		Pearson Correlation	**p-value**
BMI	**Na**	-0.034	0.791
	K	0.089	0.482
	Ca	0.007	0.953
	Cl	0.070	0.581

The relationship between body mass index and serum minerals concentration at ($p> 0.05$).

Table (1) showed that there is no statistically significant relationship between body mass index and serum mineral concentration (potassium, sodium, calcium, and chloride) at $p > 0.05$, probably due to the different dietary patterns. The choice was according to the specific age of our study (20–40 years), given that the rate of physical activity and the concentration of general health are often in better condition during this age stage. Much middle-aged weight gain occurs due to a lack of physical activity, which makes individuals lose muscle and gain fat [13].



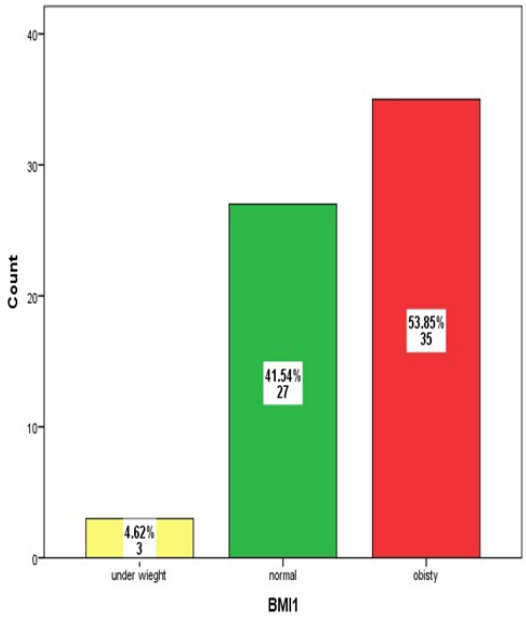


Figure 1: The percentage of gender in the participants **Figure (2):** The percentage of BMI in the participants

Upon examining various studies pertaining to our research topic, we observed that the majority of investigations demonstrating a link between serum mineral levels and BMI encompassed a substantial sample size. Furthermore, the age range of participants in these studies was broad, predominantly encompassing adults aged 18 to 65 years. [14].

The objective was to assess the demographic profile of elderly residents in Petrozavodsk and compare it to the corresponding features of the Nordic population. Individuals aged 60 years and above were subjected to hair sampling. The subjects underwent examination to analyze the composition of 25 elements, including calcium. It was observed that the calcium concentrations were lower than the standard reference levels for this element. The researchers stated that the indicated fundamental characteristics can be associated with the process of aging and certain ecological, environmental, and social factors of Nordic lifestyle. They also warned that the initial imbalance identified could result in the decline of health in older adults. [14].

Jiang et al. [15]. did a study that examined the correlation between body mass index (BMI), waist circumference (WC), and dietary mineral intakes. The quantitative regression analysis revealed that the consumption of calcium, magnesium, potassium, copper, zinc, and iron was inversely correlated with body mass index and waist circumference. However, when age and gender were taken into account, it was found that sodium intake was positively correlated with body mass index and waist circumference. These findings indicate that the link between BMI and body minerals is influenced by age and gender.

The subsequent presentation showcases the quantitative findings acquired from data analysis, which are not statistically significant. The results provide a quantitative description of the correlation between BMI and the levels of serum minerals, specifically potassium (K), calcium (Ca), chloride (Cl), and sodium (Na).

1. The relationship between BMI and minerals concentration

The information depicted in Figure (3) revealed that the serum sodium concentration in the blood of obese individuals was within the normal range for 43.06% of the participants. However, 9.23% had high levels of serum sodium, while 1.54% had low levels. This can be attributed to the dietary habits of obese individuals, which often include high sodium intake from various sources. These findings align with a previous study conducted by Jiang et al. (2020) in the United States, which investigated the association between body mass index (BMI) and waist circumference (WC). Regarding dietary mineral intake, it was found that there is a positive correlation between salt intake and both waist circumference and body mass index. Furthermore, in line with another investigation, it was discovered that obesity and hypertension are linked to the disruption of physiological fluid control, which in turn impacts the levels of sodium in the bloodstream. Given that even mild hyponatremia, occurring within the

normal range of sodium levels, is linked to higher overall mortality and significant cardiovascular events, blood sodium levels could serve as a possible risk indicator in obese individuals [15].

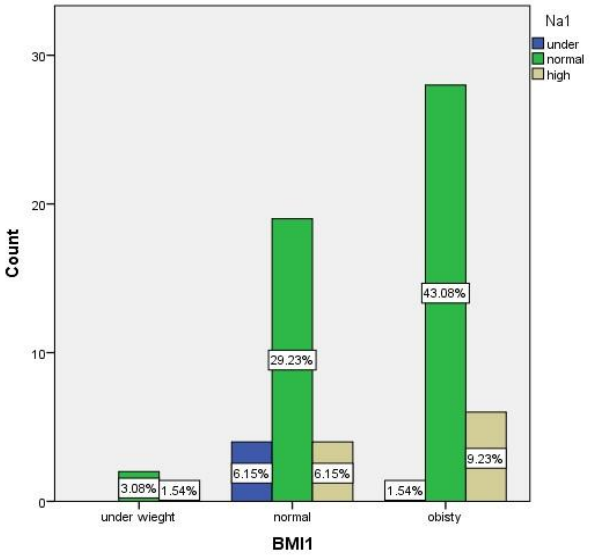


Figure 3: The relationship between BMI and minerals concentration

The data presented in Figure (4) indicates that obese individuals have a normal serum concentration of chloride in the blood, with a rise of 9.23% and a drop of 10.77%. In a study conducted by Timerga and Haile [16], the objective was to identify and predict chloride abnormalities among obese individuals in southern Ethiopia. The study revealed a high prevalence of hypochloremia among obese adults in the region. Electrolyte abnormalities were predicted by factors such as advancing age, diuretic usage, weight gain, and insufficient physical exercise. Perhaps this is due to the consumption of a diet that is rich in sodium and table salt (NaCl), leading to fluid retention and subsequent weight gain.

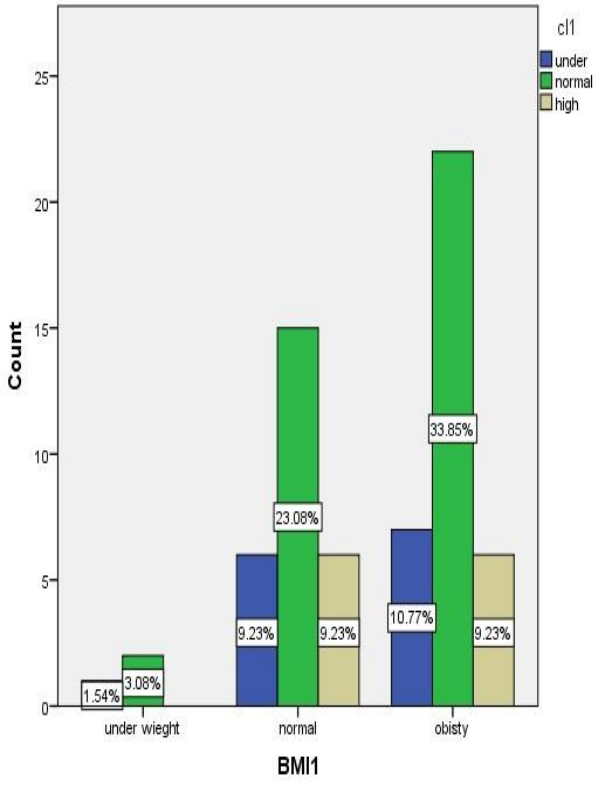


Figure 4: The relationship between body mass index and the concentration of chloride in the blood

The data in Figure (5) shows that the concentration of serum potassium in the blood is normal in obese adults (52.31%), with a slight rise (1.54%), which contradicts with what was found in a study investigating the influence of abdominal obesity on potassium depletion [17]**.** and glucose homeostasis in thiazide-treated hypertensive individuals The authors discovered that obese diuretic therapy patients had lower plasma potassium levels and higher glucose levels than nonobese diuretic therapy patients. As a result, abdominal obesity, in combination with impacts on glucose homeostasis, predisposes to potassium depletion during diuretic therapy. This study also was consistent with what, [18] mentioned in a study conducted to find out the possibility that the intake of high amounts of sodium and low potassium is associated with the early development of chronic diseases (such as high blood pressure and obesity), where the results showed a positive association between urinary sodium and obesity in While no significant association was found between 24-hour urinary potassium and obesity

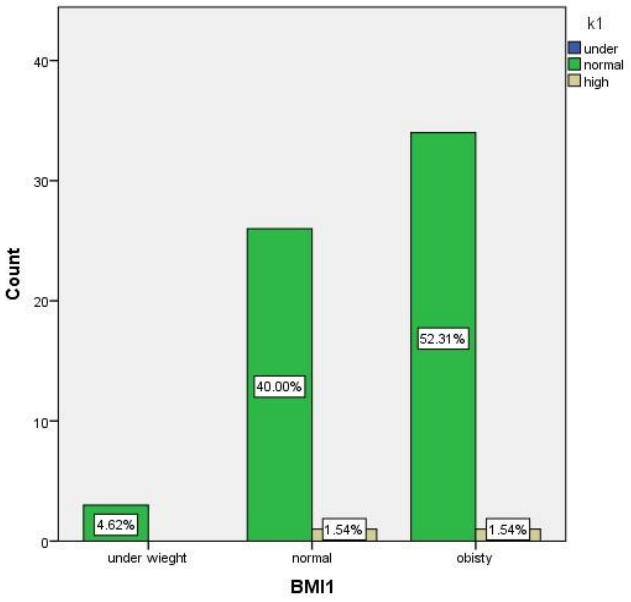
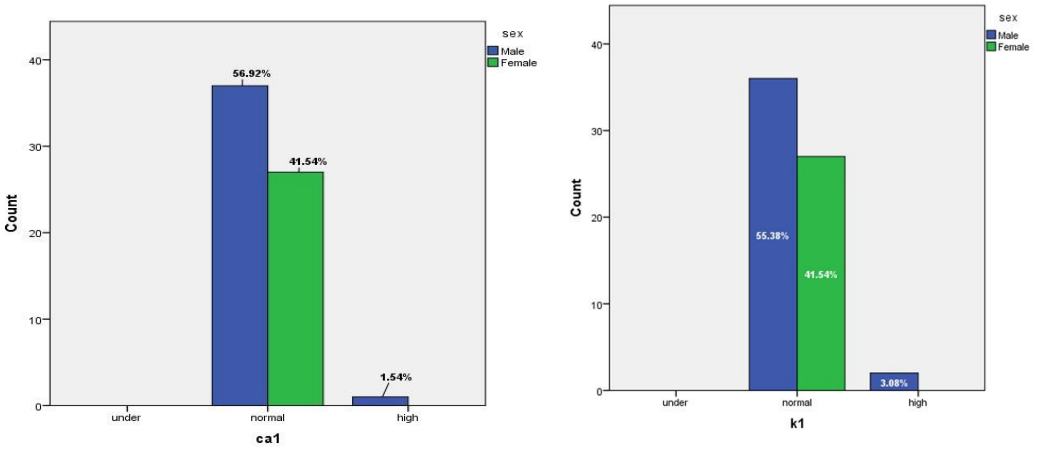


Figure 5: The relationship between body mass index and the concentration of serum potassium blood

2. Influence of gender on serum minerals concentration

The data presented in Figure 6 (A.B) shows that both males and females do not exhibit any significant changes in blood levels of calcium and potassium when compared to normal mineral levels. However, males show a slight increase in serum levels of calcium and potassium, with a respective rise of 1.54% and 3.08%. This is in line with the findings of Fijorek K, et al. [19], which indicate that males exhibit higher levels of potassium, calcium, and sodium compared to females.



(A) **(B)**

Figure 6: Influence of gender on the concentration of minerals (calcium and potassium) in the blood

The data presented in Figure (7) indicates that there is a disparity in low serum chloride levels between males and females, with a difference of 15.38% - 6.15%. Similarly, there is a difference in high serum chloride levels between males and females, with a range of 10.77% - 7.69%. These findings align with the previous research conducted by Tschaika et al. [20], which investigated the impact of gender on chlorine excretion in male and female rats

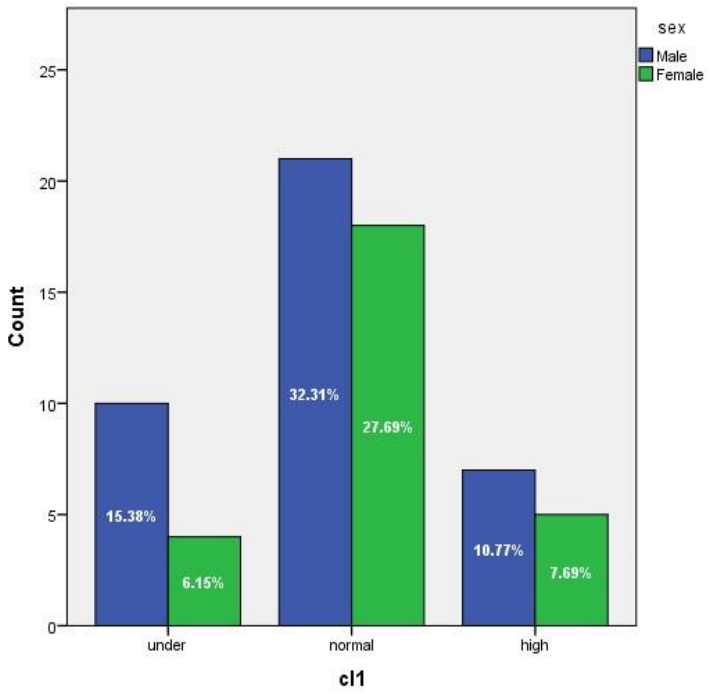


Figure 7: The influence of gender on serum chloride levels

3. Influence of behavioral and dietary habits on serum minerals concentration

Table (2) indicates that there is no statistically significant relationship between hazardous behavioral patterns (namely, beverage consumption, tea consumption, qat consumption, and smoking) and serum minerals concentration ($p > 0.05$). However, there is a statistically significant relationship between coffee consumption and serum potassium concentration ($p > 0.05$).

The table clearly demonstrates an inverse correlation between coffee and potassium (P-value: 0.018), which aligns with the findings of a previous study. This study revealed that consuming a significant amount of caffeine, equivalent to at least 250-300 mg or 2-3 cups of coffee, or 5-8 cups of tea, leads to a moderate increase in urine production. This suggests that caffeine consumption may result in elevated excretion of both potassium and sodium.

This was also demonstrated in another study involving two groups of rats, one with caffeine and one without. The first group received daily subcutaneous injections of either 2.5 mg or 10 mg per 100 g of body weight for duration of two weeks. The findings revealed that the group administered with caffeine exhibited higher urine excretion compared to the group without caffeine. Furthermore, the urinary excretion of potassium and sodium was also increased, indicating that caffeine induced a negative balance of these electrolytes. These results align with the findings of our present study [21].

The presence of caffeine in coffee, being a diuretic, leads to the excretion of minerals, such as potassium, through urine. Consequently, the consumption of coffee results in a drop in potassium levels, thus explaining the inverse correlation between coffee and potassium.

Table 2: Influence of behavioral habits on serum minerals concentration

		Na	K	Ca	Cl
Beverage	Correlation Coefficient	0.108	-.218-	.176	-.038-
	p- value	0.393	.081	.162	.763
Tea	Correlation Coefficient	0.115	-.093-	.016	.066
	p- value	0.361	.463	.900	.603
Coffee	Correlation Coefficient	-0.077-	**-.293-***	.080	.106
	p- value	0.543	**.018**	.524	.399
Qat	Correlation Coefficient	.0028	.238	.144	.070
	p- value	0.824	.057	.253	.580
Smoking	Correlation Coefficient	-0.060-	.080	.150	.144
	p- value	0.633	.527	.232	.252

Table (3) indicates that there is no statistically significant correlation between dietary habits including canned food and fast food, and serum minerals concentration (p> 0.05). However, there is a statistically significant correlation between dietary habits involving fruit and vegetable consumption, and serum salt concentration (p> 0.05). This aligns with the findings presented by [14].

The potential cause of this could be attributed to the quality and handling of the vegetables and fruits consumed. Vegetables that are cooked with salt or preserved in cans or frozen with sauce tend to have high sodium content, ranging from 140 to 460 mg per 1/2 cup, unlike fresh produce. Fruits, like other foods, include approximately 8 mg of salt per half cup [22].

Table 3: Influence of dietary habits on serum minerals concentration

		Na	K	Ca	Cl
Fruit	Correlation Coefficient	**.271***	.003	-.023-	-.172-
	p- value	**.029**	.981	.858	.171
Vegetable	Correlation Coefficient	**.321****	.110	-.071-	-.230-
	p- value	**.009**	.384	.575	.066
Fast food	Correlation Coefficient	-0.018-	-.002-	.081	-.074-

	p- value	0.886	.985	.524	.558
Canned food	Correlation Coefficient	0.019	-.014-	-.011-	-.143-
	p- value	0.879	.913	.928	.257

Conclusion

In conclusion, this study revealed significant differences in mineral levels and dietary patterns between men and women. Men exhibited higher levels of potassium and calcium, while women showed higher sodium and chloride levels. Interestingly, coffee consumption was negatively associated with potassium levels, suggesting a potential influence of dietary habits on mineral status. Furthermore, a positive correlation between salt intake and fruit and vegetable consumption highlights the complex interplay between dietary choices and mineral intake. These findings underscore the importance of considering gender-specific differences and dietary habits when assessing mineral status and its role in maintaining health. Calcium, in particular, emerged as a crucial mineral for bone health, while sodium, chloride, and potassium were identified as key players in regulating water balance. Future research exploring the mechanisms underlying these associations and their potential implications for personalized dietary recommendations is warranted

Recommendation

First this study recommended daily intake of sodium should not surpass 2,300 milligrams (mg), equivalent to fewer than 500 mg per serving. Second it also recommended to consume unprocessed meals. The majority of fresh fruits and vegetables have inherently low salt content. Additionally, fresh meat has a low salt content. Further it is very useful to substitute salt with herbs, spices, and other seasonings. Moreover consume a minimum of 3500 mg of potassium daily by consuming foods such as tomatoes, beets, vegetables, potatoes, and bananas. Finally the results of this study recommended consuming foods rich in vitamin D to improve the absorption of calcium, such as fatty fish (including salmon, sardines, and mackerel), eggs, mushrooms, and liver.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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