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Original Research Article

Impact of Energy Drink Consumption on Plasma Urea, Creatinine, Uric Acid, and Electrolytes Among Students of the College of Health Sciences in Okofia Nnewi, Nigeria

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ABSRTACT

Kidney disease is a public health concern, and the use of energy drinks can negatively impact kidney health. This study assessed the impact of energy drink intake on kidney function among college students. A total of thirty (30) healthy males aged between 18 and 26 years were randomly chosen for the research and separated into two groups: Group A (consumers of fearless energy drink (FED), n=15) and Group B (consumers of predator energy drink (PED), n=15). Group A subjects received one bottle of FED (500 ml) each, while Group B individuals received one bottle of PED (400 ml) four times per week for twenty-eight days before their regular breakfast. Venous blood samples of 5 milliliters (5 mL) each were collected from participants on days 0, 14, and 29, respectively, and then analyzed following an overnight fast to estimate plasma creatinine (CRT), urea, uric acid (UA), and electrolyte levels using standard laboratory methods. Results showed the plasma creatinine, UA, Na^+, and Ca^{2+} levels were variably altered at 2 weeks and 1 month post-PED consumption than at baseline (p = 0.001), respectively. At 2 weeks after FED consumption, plasma creatinine levels were significantly lower (63.27±19.68 vs 82.73±9.10; p=0.006) and UA levels were higher (214.33±39.64 vs 270.38±20.22; p=0.001) than at baseline, but at 1 month after FED consumption, creatinine levels were higher (80.93±16.59 vs 63.27±19.68; p=0.025). Consumers of both PED and FED showed significant changes in renal indices, which could have a deleterious impact on kidney health.

Keywords: Energy drink, Fearless energy drink, Predator energy drink, Kidney, Renal function Parameters.

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Introduction

Kidney disease is a global public health issue affecting over 750 million people.[1] Chronic kidney disease (CKD) is a significant, ubiquitous, and pervasive health condition whose incidence is steadily increasing,[2] with over one million CKD patients dying each year.[3,4] Although the scope and impact of renal sickness are better understood in developed countries, emerging research indicates that the burden of kidney disease in developing countries is equivalent to, if not greater.[5] CKD affects 10% of the world's population, and millions die each year due to a lack of affordable treatment options.[1] Race, high blood pressure (BP), male gender, obesity, hypertension, type 2 diabetes, smoking, alcohol usage, familial history of CKD, aging, and lifestyle behaviors such as dietary habits are all key risk factors for CKD.[6-8]

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Importantly, the majority of these risk factors are changeable and can be addressed to reduce the debilitating effects of renal disease. Consuming energy drinks has been linked to a higher incidence of renal disease in youth. [9,10]

Energy drinks, defined as caffeine-rich beverages, are believed to enhance energy, physical and athletic performance, and mental alertness. Caffeine, guarana, taurine, D-glucuronolactone, L-carnitine, and vitamin B are all known to be included in most energy drinks in varying amounts [11-17] and may act individually or synergistically to produce diverse effects that may harm the kidneys.[18,19] Energy drinks should be avoided in young people's diets due to their stimulant effects.[15] Caffeine use and its consequences on human health are thus crucial problems for both scientists and the general public. Currently, there are considerable concerns about the safety of these items. There have been numerous reports of detrimental health consequences from energy drinks, especially on kidney function.[9,10, 20-22]

This study included renal biomarkers such as urea, creatinine, uric acid, and electrolytes, which are commonly examined in the blood to establish renal function status.[23] The kidneys produce blood urea nitrogen, [24] a main nitrogenous end product of protein and amino acid catabolism,[23] as well as creatinine,[24] a breakdown product of creatine phosphate in muscle.[23] Elevated levels of these biomarkers indicate renal impairment. [24, 25]

Energy drink consumers have been found to have increased creatinine and urea levels.[9, 10] Plasma creatinine and urea levels remain critical

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indications of kidney disease. Previous research has found that energy drinks have a deleterious impact on kidney health in both humans and animals.[9, 10, 20, 22] Despite this, there have been few studies on the influence of energy drinks on renal function. Consequently, this study examined the effects of Predator and Fearless energy drinks on kidney function among students at Nnamdi Azikiwe University, Nnewi campus.

Materials and Methods

Study design and participant recruitment

This pre-post study, evaluated the impact of various energy beverages on kidney function among students at the College of Health Sciences in Nnewi, Anambra State, Nigeria. A total of thirty (30) healthy male participants, aged between eighteen (18) and thirty (30) years, were randomly selected for this research and divided into two groups: group A (consumers of Fearless energy drink) and group B (consumers of Predator energy drink), with each group consisting of fifteen male participants. The study methodology was thoroughly described to each subject in order to obtain their consent to participate. Each participant was instructed to refrain from consuming any caffeine-containing products, including tea, chocolate, cola beverages, energy drinks, and similar items, for two weeks. Following that, for twenty-eight days, individuals in group A received a 500 ml bottle of Fearless Energy Drink, while those in group B were provided with a 400 ml bottle of Predator Energy Drink four times a week (on Tuesdays, Thursdays, Saturdays, and Mondays) before their morning meals. Venous blood samples of 5 milliliters (5 mL) each were collected from participants on days 0, 14, and 29, respectively, and then analyzed following an overnight fast to estimate plasma creatinine (CRT), urea, uric acid (UA), and electrolyte (sodium, potassium, chloride, bicarbonate and calcium) levels using standard laboratory methods. Data on the respondents' age, health background, and dietary habits were collected through a standardized questionnaire.

Study Area

The pre-post study was conducted at the College of Health Sciences, Nnamdi Azikiwe University, located in the Okofia area of Nnewi town (June-August, 2021).

Inclusion criteria

The subjects involved in the research were male students from the College of Health Sciences, Nnewi, aged from 18 to 30 years, who were considered to be in good health.

Exclusion criteria

This research did not include smokers, individuals with alcohol dependency, those who have existing health conditions (like kidney disease, diabetes, hypertension, or cardiovascular problems), or participants using diuretics.

Ethical consideration

The ethics committee at Nnamdi Azikiwe University's Faculty of Health Sciences and Technology approved this study (NAU/FHST/2021/MLS20) in line with the ethical guidelines for research involving human subjects.[26]

Informed consent

Before the start of the investigation, subjects provided written informed consent. Participants were allowed to withdraw from the study at any time, and their data were treated with maximum confidentiality.

Collection of blood samples

After 10-12 hours of fasting, aseptic venipuncture was performed to collect 5 mL of venous fasting blood from the antecubital vein of each participant using a plastic syringe, ensuring minimal stasis, and transferred into a lithium heparin container. It was then centrifuged at 4000 rpm for 5 minutes, and the plasma was separated and used for analysis of biochemical parameters (creatinine, urea, uric acid, and electrolytes) using the standard laboratory method. Samples that were not analyzed immediately were stored frozen (-20°C).

Laboratory Methods

The plasma sodium, potassium, chloride, bicarbonate, and calcium levels of the participants were measured using an ion-selective electrode (ISE) on an Audicom electrolyte analyzer AC9000 series, model AC9900 from China. The plasma urea level was determined using urea reagents according to the Urease-Berthelot's urea procedure, as described by.[27] In addition, plasma creatinine levels were determined using the Jaffe-Slot alkaline pirate creatinine method described by [27] using creatinine reagents, while the Uricase method, which uses a uric acid reagent as described by [28], was used to determine the levels of uric acid. The urea, creatinine, and uric acid reagents were obtained from Spectrum (Hannover, Germany), and quantification was done using a Biobase-EL 10A ELISA Plate Reader. Centrifuges were used for plasma separation, spectrophotometers for biochemical analysis, and IBM SPSS version 26.0 for data analysis.

Statistical Analysis

The data were evaluated employing the Statistical Package for the Social Sciences (SPSS) version 26.0. Results were presented as mean ± standard deviation (SD), and the paired Student's t-test was utilized for statistical analysis. A significance level of $p < 0.05$ was established.

Results and Discussion

The mean ± SD of the subjects' plasma levels of creatinine, urea, and uric acid at baseline, two weeks, and one month after consuming energy drinks are compared in Table 1. Two weeks after consuming predator energy drinks, the mean plasma creatinine level was significantly decreased than at two weeks after consuming fearless energy drinks (63.27 ±16.05 vs 82.73 ±9.10; p=0.001). After two weeks of consuming predator energy drink (63.27± 16.05 vs 84.20 ±14.03; p=0.001) and fearless energy drink (63.27 ±19.68 vs 82.73± 9.10; p=0.006), the mean plasma creatinine levels were statistically significantly lower than their baseline levels (63.27± 16.05 vs 84.20 ±14.03; p=0.001). However, after consuming predator energy drinks for a month, the mean plasma creatinine level significantly increased compared to baseline (89.33 ±16.36 vs 84.20 ±14.03; 0.000). Also, the plasma creatinine level was significantly increased in both predator (89.33 ±16.36 vs 63.27 ±16.05; p=0.001) and fearless (80.93 ±16.59 Vs 63.27 ±19.68; p=0.025) energy drink consumers after one month than at two weeks post consumption (89.33 ±16.36 vs 63.27 ±16.05; p=0.001).

However, when the mean plasma urea levels of the participants tested were compared between the different groups studied (p>0.05), no significant differences were observed (table 1). When predator energy drinks were consumed for two weeks, the mean plasma uric acid level was significantly decreased than when fearless energy drinks were consumed (220.40±29.21 vs 270.38± 20.22; p=0.001). In comparison to baseline measurements, the plasma uric acid levels showed a significant decrease after two weeks of consuming predator (220.40±29.21 vs 272.40±28.14; p=0.001) and fearless (214.33±39.64 vs 270.38±20.22; p=0.001) energy drinks (refer to Table 1). There was no significant difference in any of the other paired-wise comparisons (p>0.05).

Table 2 compares the electrolyte profile levels of the participants before, two weeks after, and one month following the consumption of predator and fearless energy drinks. After two weeks of consuming predator energy drinks, the mean plasma sodium content was significantly decreased than it was before using fearless energy drinks (129.83 ±10.91 vs 138.81±1.45; p = 0.02).

Table 1: The mean ± SD of the subjects' plasma levels of creatinine, urea, and uric acid at baseline, two weeks, and one month after consuming energy drinks.

Variables	Creatinine (µmol/L)	Urea (mmol/L)	Uric acid (µmol/L)
A) Before consumption:			
1) Fearless energy consumers (n=15)	82.73± 9.10	3.77± 1.43	270.38± 20.22
2) predator energy consumers (n=15)	84.20± 14.03	3.76±1.21	272.40±28.14
B) After 2 weeks' consumption:			
3) Fearless energy consumers (n=15)	63.27± 19.68	4.12± 1.16	214.33±39.64
4) predator energy consumers (n=15)	63.27± 16.05	4.19± 1.03	220.40±29.21
C)After 1month consumption:			
5) Fearless energy consumers (n=15)	80.93± 16.59	4.41± 1.01	328.73±43.17
6) predator energy consumers (n=15)	89.33± 16.36	4.25± 0.68	213.80± 24.17
1 V2 (p-value)	0.74	0.99	0.82
3 V4 (p-value)	1.00	0.86	0.64
5 V 6 (p-value)	0.17	0.61	0.31
1 V 4 (p-value)	0.001*	0.32	0.001*
2 V 4 (p-value)	0.001*	0.28	0.001*
1 V 5 (p-value)	0.84	0.38	0.10
2 V 6 (p-value)	0.001*	0.83	0.43
1 V 3 (p-value)	0.006*	0.48	0.001*
1 V 6 (p-value)	0.23	0.18	0.48
3 V 6 (p-value)	0.71	0.13	0.62
3 V 5 (p-value)	0.025*	0.39	0.32
4 V 6 (p-value)	0.001*	0.20	0.44

*Statistically significant with a p-value less than 0.05

Additionally, compared to baseline values (138.81±1.45), there were significant decreases in plasma sodium content at 2 weeks (129.83 ±10.91; p = 0.006) and 1 month (136.14±2.73; p = 0.03) after consuming predator energy drinks. In contrast to two weeks of intake, the plasma sodium level was significantly elevated following a month of consuming predator energy drinks (136.14±2.73 vs 129.83±10.91; p=0.001). Additionally, following one month of intake, the mean plasma sodium concentration in predator energy drink users increased significantly compared to the levels seen in fearless energy drink users after two weeks (136.14±2.73 vs 130.94±14.44; p=0.003).

When compared to the baseline value, the plasma potassium concentration was significantly decreased one month after using fearless energy drinks (3.54±0.35 vs 3.56±0.42; p=0.001) (Table 2). Other paired-wise comparisons between the tested groups did not show significant differences (p>0.05).

One month after the intake of predator energy drinks, the plasma chloride level was significantly increased (97.27 ±2.08 vs 96.03 ±9.88; p=0.005) compared to the level observed after two weeks of consuming fearless energy drinks (Table 2), whereas other paired comparisons did not reveal any significant differences (p>0.05).

The plasma bicarbonate level showed a significant increase after two weeks of consuming predator energy drinks (25.20 ±1.26 compared to 24.00 ±1.46; p=0.005), while other comparisons among the groups studied did not reveal significant differences (p>0.05) (Table 2).

Following two weeks of predator energy drink consumption, the mean plasma calcium level significantly decreased (2.10±0.18 versus 2.25±0.14; p=0.009), but after one month of usage, it increased significantly (2.62±0.07 versus 2.25±0.14; p=0.001) compared to the baseline values (Table 2).

Again, when comparing two weeks of fearless energy drink intake, the plasma calcium level significantly increased after one month of predator energy drink consumption (2.62±0.07 versus 2.16±0.18; p=0.001). Furthermore, the plasma calcium levels among those consuming both predator and fearless energy drinks were significantly increased after one month of consumption than after two weeks (p<0.05) (Table 2).

This study evaluated the effect of consumption of energy drinks on plasma urea, creatinine, uric acid, and electrolytes of College of Health Science students in Okofia Nnewi, Nigeria.

Caffeine-containing energy drinks are commonly advertised as being able to increase energy, reduce fatigue, improve focus, and improve mental alertness. [29] Many students believe that drinking energy drinks will help them achieve academic success. These and other potential effects of these energy drinks entice many students. However, widespread concern about the use and effects of caffeinated energy drinks is growing, particularly among young adults such as college students. Energy drink consumers could suffer from the unfavorable impacts of energy drinks, including health problems, caffeine overdose, and death.[30] Despite the dangers of energy drinks, they are nonetheless widely consumed by college students, who utilize them to boost their academic performance.

Two weeks after consuming predator and fearless energy drinks, the plasma creatinine levels were found to be significantly decreased than their baseline levels. Also, after using Predator energy drinks for a month, the plasma creatinine levels were significantly increased than baseline levels. Furthermore, both predator and fearless energy drink users had significantly increased plasma creatinine levels after a month of use compared to two weeks. These results imply that the effects of energy drinks on the kidney may vary depending on the duration of consumption.

Table 2: The electrolyte profile levels of the participants before, two weeks after, and one month following the consumption of predator and fearless energy drinks (mean± SD).

* Statistically significant with a p-value less than 0.05.

Variables	Na^+ (mmol/L)	K^+ (mmol/L)	Cl^- (mmol/L)	Ca^{2+}(mmol/L)	HCO_3^-(mmol/L)
A) Before consumption:					
1)Fearless energy consumers (n=15)	138.62± 2.11	3.56 ±0.42	99.25 ±1.64	2.23 ±0.14	24.20 ±1.21
2)Predator energy consumers (n=15)	138.81 ±.1.45	3.56 ±0.31	99.62 ±2.30	2.25 ±0.14	24.00 ±1.46
B) After 2 weeks' consumption:					
3)Fearless energy consumers (n=15)	130.94 ±14.44	3.54 ±0.46	96.03 ±9.88	2.16 ±0.18	25.60 ±1.55
4)Predator energy consumers (n=15)	129.83 ±10.91	3.57 ±0.70	94.91 ±8.32	2.10 ±0.18	25.20± 1.26
C)After 1month consumption:					
5)Fearless energy consumers (n=15)	136.33 ±1.73	3.54 ±0.35	97.71 ±1.70	2.61 ±0.08	24.93 ±1.03
6)Predator energy consumers (n=15)	136.14 ±2.73	3.50 ±0.28	97.27 ±2.08	2.62 ±0.07	24.47 ±1.55
1 V2 (p-value)	0.78	0.96	0.59	0.70	0.84
3 V4 (p-value)	0.81	0.91	0.74	0.45	0.70
5 V 6 (p-value)	0.83	0.73	0.53	0.79	0.81
1 V 4 (p-value)	0.02*	0.94	0.49	0.63	0.69
2 V 4 (p-value)	0.006*	0.95	0.05	0.009*	0.012*
1 V 5 (p-value)	0.46	0.001*	0.100	0.80	0.63
2 V 6 (p-value)	0.03*	0.73	0.27	0.0010*	0.36
1 V 3 (p-value)	0.06	0.85	0.22	0.22	0.80
1 V 6 (p-value)	0.51	0.68	0.27	0.38	0.55
3 V 6 (p-value)	0.003*	0.75	0.005*	0.001*	0.90
3 V 5 (p-value)	0.18	0.97	0.52	0.001*	0.78
4 V 6 (p-value)	0.001*	0.29	0.44	0.003*	0.76

Plasma creatinine is a key indicator of kidney function, and high levels are common in patients with renal illness or failure. Creatinine levels were elevated in energy drink users in the past, which is consistent with the current finding.[9,10] Furthermore, multiple other publications in both human and animal studies have shown the negative health consequences of energy drink use on the kidneys, which is consistent with our current report.[20-22]

Surprisingly, there were no significant variations in mean plasma urea levels in the participants evaluated before and after ingestion of an energy drink. Urea is a metabolic waste product that is excreted in urine by the kidneys. Kidney disease is linked to a decrease in urea excretion and, as a result, a rise in blood urea concentration. Low-protein diets are linked to lower urea synthesis and, as a result, lower plasma/serum urea concentrations. This could account for the present urea levels found in this study. This is in keeping with the reports of previous studies. [31,32] However, in contrast to the current finding, other similar previous studies found significant changes in plasma urea levels in participants after energy drink consumption.[33,34]

Intriguingly, the plasma uric acid level was significantly lower two weeks after the consumption of both predator and fearless energy drinks. The poor purine diet usually taken by students may have mediated this fall in plasma uric acid levels. Uric acid is the final oxidation product of purine metabolism and is renally excreted.[35] Therefore, elevated serum uric acid levels are seen in patients with reduced glomerular filtration rate (GFR). However, in recent years, it has been proposed that uric acid itself plays a causal role in the pathophysiology of chronic kidney disease and possibly in acute kidney injury.[36] Uric acids are accumulated in the body due to increased production, such as with cell death, intake of alcohol, or a purine-rich diet.[37] Also, a diet with excess sugar increases the serum uric acid level, because the sugar component fructose causes increased uric acid production. Otherwise, accumulation of uric acid is caused by decreased elimination, which is the case when kidney function is diminished or when diuretics or other drugs are used. Our findings are similar to other documented reports, which found that energy drinks did not produce substantial changes in uric acid levels.[32] However, this stands in contrast to the Khayyat *et al*. investigation, which discovered that energy drinks raised blood urea and uric acid levels. [21] These researchers claimed that caffeine raised urea, uric acid, and creatinine by blocking A2A adenosine receptors, which led to interstitial inflammation, elevated proteinuria, and detrimental alterations in renal structure and function. [21] Poor renal function is often associated with elevated blood levels of creatinine and uric acid. [38]

While the mean plasma sodium levels showed a notable increase after one month of consuming predator energy drinks compared to the levels observed two weeks after consumption, the plasma sodium concentration was significantly decreased after two weeks and one month of consuming predator energy drinks compared to baseline consumption. Furthermore, the mean plasma sodium content was significantly increased after using predator energy drinks for a month, as opposed to two weeks after consuming fearless energy drinks. This may be due to the caffeine content of these beverages. Caffeine has diuretic characteristics and causes natriuresis, which results in hyponatremia.[39,40] Caffeine competes with adenosine receptors (AR), which are G protein-coupled receptors found all over the body, including the brain, heart, arteries, and kidneys. Caffeine enhances glomerular filtration rate by counteracting the adenosine-mediated vasoconstriction of renal afferent arterioles via type 1 AR during tubuloglomerular feedback. [41] Caffeine also inhibits Na ($^+$) reabsorption at the level of the renal proximal tubules, resulting in hyponatremia that can be fatal if not treated. [41] A blood sodium concentration ([Na^+]) below the normal reference range for the laboratory doing the test (usually 135 mmol/L) is biochemically classified as hyponatremia.[42,43] Cerebral edema, seizures, coma, brainstem herniation, and neurogenic pulmonary edema are among documented side effects of chronic hyponatremia in humans.[44] The new result contradicts Mohammed's study, which revealed no significant effect of energy drink intake on blood electrolytes,[9] but it is consistent with other earlier research that found a significant decrease in sodium levels after consuming energy drinks. [32] Importantly, there was an interesting thing that happened in this study that we will not overlook: the fact that the plasma sodium level was later normalized at the end of the study (one month), pointing to the possibility that energy drink use causes hyponatremia on a short-term basis.

Moreover, a month after consuming fearless energy drinks, the plasma potassium content was decreased than the baseline value. Nevertheless, after a month of research, there were no discernible changes in the consumption of predator energy drinks. The primary intracellular cation is potassium (K+). Only around 2% (approximately 70 mEq) of the body's total pool of 3,500 mEq is located in the intracellular fluid (ICF), where concentrations vary between 3.5 to 5 mEq/l. The remaining 98 percent (about 70 mEq) is found in the extracellular fluid (ECF), where concentrations also range from 3.5 to 5 mEq/l.[45] Potassium is essential for the heart because low or high plasma potassium levels can cause cardiac problems. Our recent findings indicate that there was no notable change in plasma potassium levels after a month of consuming predator energy drinks, which aligns with the findings of Mohammed.[32]

Interestingly, following a month of consumption, there were no significant alterations in plasma chloride and bicarbonate levels in both fearless and predator energy drink consumers when compared to their initial values, which aligns with findings from a comparable study.[32]

Moreover, the mean plasma calcium level was significantly reduced compared to the baseline measurement after two weeks of consuming predator energy drinks; however, the plasma calcium level showed a notable increase after one month of usage. Additionally, in comparison to the results observed after two weeks of consuming fearless energy drinks, the plasma calcium level increased significantly after one month of using predator energy drinks. More so, after consuming predator and fearless energy drinks for a month, the mean plasma calcium concentrations were significantly increased than those after two weeks. This could be due to the diuretic effect of the caffeine component of the energy drink, which has been reported to alter calcium balance by reducing renal calcium reabsorption and possibly by reducing intestinal calcium absorption efficiency.[46] Because it increases diuresis and urinary calcium loss, reduces intestinal absorption, and inhibits bone mineralization, high caffeine consumption has been linked to osteoporosis.[47] The fact that the calcium level improved after a month of consumption is significant, though the mechanism behind this is unknown. It's possible, though, that another ingredient in the energy drink, such as taurine, was responsible for the effect. [46]

Conclusion

This study revealed significant changes in various renal indices in both predator and fearless energy drink users, which could have a severe impact on their kidney health. It is therefore critical to educate the public about the detrimental effects of energy drinks on human health, particularly renal function, through seminars and workshops. In circumstances where total abstinence appears to be unachievable, there is also a need for moderation of intake. Further studies with longer duration that incorporate more recent biomarkers are needed to confirm these findings and better understand the mechanisms underlying the present results.

Conflict of interest

The authors declare no conflict of interest

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them

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