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(RESEARCH ARTICLE)

Taking caffeinated beverages at rest affects hormone metabolism

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Abstract

It is generally accepted, that drinking tea and coffee causes an increase in cortisol levels in majority of people, due to the presence of alkaloids in these drinks, main of which is caffeine. The literature data about the ability of alkaloids to increase the cortisol secretion, and the high consumption of these beverages by men in our population, as well as the relatively scarce information on their effects on the body, forced us to focus in this study on examination the role of tea and coffee on the change in cortisol and testosterone levels in young men after taking strong tea or coffee at rest. İn this study we examined influence of coffee and tea on 21 healthy young men on testosterone and cortisol levels in the blood. For this, Hema kit (Russia) enzyme immunoassay method was used for testosterone definition, and Steroid ELISA-cortisol kit (Russia) – for serum cortisol levels in blood serum. We found out that cortisol may be lowered or raised depending on individuals, while testosterone does not change significantly either under action of coffee or tea.

Keywords: Alkaloids; Coffee; Cortisol; Diabetes; Tea; Testosterone

1. Introduction

Literature data suggest that caffeine increases cortisol secretion [1]. To data, the rise in levels of cortisol in response to caffeine occurs under mental and physical stress [2]. Scientists claim that caffeine before exercise increases cortisol levels in both men and women. There are also reports in the literature that cortisol release in response to mental stress and dependent on the type of stress and gender. Systematic intake of caffeine with diet results in adverse side effects on organism including cardiovascular, behavioral, reproductive & developmental effects, as well as problems with calcium, and therefore bone tissue [3]. There are researchers that state, heavy coffee and caffeine intake is potentially harmful on pregnancy outcomes [4]. Tea consumption has been shown to prevent atherosclerosis, coronary heart disease due to polyphenolic compounds present in green and black tea [5]. The catechins and theaflavins, the main polyphenolic compounds of tea, show anti-aging, antidiabetic effects. As for coffee consumption, it is often associated with a range of health outcomes across exposures including high versus low, any versus none, and one extra cup a day. To data, high versus low consumption of coffee is associated with an 18% lower risk of incident cancer, and neurological, metabolic, and liver conditions. There was observed an association between coffee drinking and risk of fracture in women but not in men [6]. Caffeine is shown to be able to increase muscle contractility. To data, it has no ergogenic effect on intense exercise of brief duration, but prevents exhaustion. Caffeine is also shown to be able to improve endurance during prolonged physical activity with submaximal intensity [7].

Some scientists recommend green tea for the prevention of diseases, health maintenance, and weight loss due to the presence of catechins and polyphenols, specifically (-)-epigallocatechin-3-gallate. These substances exhibit an antioxidant and anti-inflammatory properties. By reducing the reactive oxygen species content in the tissues, the tea

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components allow restore physical activity, prevent aging, normalize blood pressure and metabolism[8]. According to Pham NM et al., 2014, the higher consumption of green tea, coffee and caffeine may protect against depression[9].

Steptoe et al., 2007 state that 6 weeks tea consumption lowers the post-stress cortisol leading to relaxation, together with reduced platelet activation [10]. It is acknown that testosterone administration for prostatitis induces oxidative stress in the prostate resulting in the development of prostate cancer. However, some scientists [11] declare that administration of testosterone along with the aqueous tea extract exhibits a significant protective effect of black tea against testosterone-induced oxidative damage was reported. Therefore, the study shows that the components present in black tea protect against androgen-induced oxidative damage.

Opuwari CS & Monsees TK. (2020) focused on the effects of black tea on the male reproductive system as well as the kidney and liver functions. They observed that black tea increased kidney weight, significantly reduced serum levels of alanine aminotransaminase and aspartate aminotransaminase. Black tea also improved several reproductive parameters [12].

Our study presents data that help clinicians prevent complications of tea-related diabetes. Thus, the data available in the literature are quite contradictory regarding the effect of coffee alkaloids on the body, and therefore we decided to conduct our own study and find out whether there are really concerns about the use of these drinks, or whether they can serve as an adjunct to the treatment of certain diseases.

Usually, researchers investigate the effect of alkaloids on organisms under additional physical or mental stress. Moreover for investigation, the main alkaloid of coffee and tea is taken - caffeine. Unlike the majority of the scientists, we aimed investigation of the caffeine alkaloid effect in the composition of natural beverages, and in a state of relaxation, in which in fact, it is taken by most people in the population.

2. Material and methods

2.1. Subjects

2.1.1. Inclusion criteria

21 young volunteers in good health were recruited to participate in the study. Subjects were given printed instructions on the food list to abstain from all caffeinated products pending laboratory testing. Volunteers had normal blood pressure within 20% of ideal body weight. An electrocardiogram ruled out cases of tachycardia.

2.1.2. Exclusion criteria

People with caffeine intolerance were also excluded.

All subjects were divided into two groups: those who preferred coffee (the first group- 7 persons) and those who preferred tea (the second group- 14 individuals). In the second group, we identified two subgroups: 2a - those whose cortisol was elevated (N=7), and 2b - those whose cortisol dropped after tea (N=7).

Each participant drank a cup of strong “Azerchay” tea or strong freshly ground Italian coffee at will and has a rest for an hour. Each participant signed an informed consent form approved by the respective Department of Institutional Oversight of the Medical University. At the end of the study, the subjects consumed a standard meal.

The cortisol test was done at 9 am in the lab. To prevent circadian rhythms from affecting cortisol levels, cortisol sampling times were held constant for all subjects.

2.2. Methods of study

Testosterone levels in blood serum were determined by enzyme immunoassay using the Hema kit (Russia), while serum cortisol was determined by competitive enzyme immunoassay using the Steroid ELISA-cortisol kit (Russia).

2.3. Statistical analysis

The characteristics were compared by the Mann-Whitney rank method. Cortisol and testosterone levels were measured initially on an empty stomach and 60 minutes after strong tea (coffee); all analyzes were performed using SPSS 26 (SPSS for Windows).

3. Results

The coffee impact on the testosterone levels in young men ıs presented ın table 1. As can be seen from the table 1, the testosterone levels on the empty.

Table 1 Effect of coffee on the testosterone levels in young healthy men

	N	Minimal levels	Maximal levels	Mean	standard error	Standard deviation
Basal Testosterone	7	8.3	10.8	9.86	0.37	0.98
Testosterone after coffee	7	8.3	10.8	9.49	0.33	0.86

stomach were between (8,3) and (10,8) with mean 9,86±0,98, and after cup of strong coffee the average data does not change. But after analyzing the data by the rank approach, it can be seen that testosterone in subjects after coffee tends to decrease (Fig. 1).

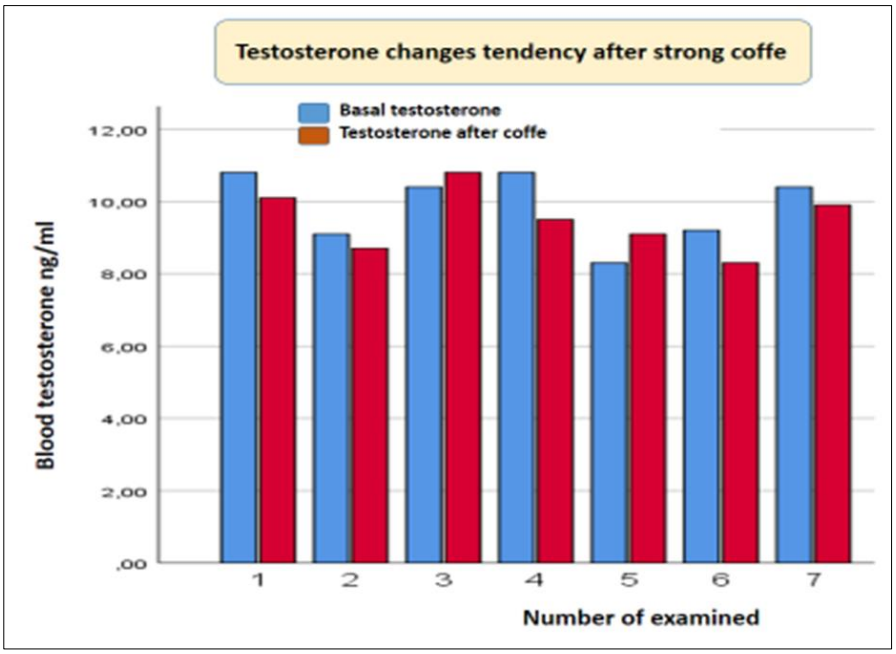

Figure 1 Downward trend in testosterone levels after consumption strong coffee in majority of examined

We also determined the testosterone after drinking strong tea, and the data of laboratory analyzes are presented in the table below (Tab. 2). As follows from the table, the level of testosterone after tea fluctuates both in the direction of decrease and in the direction of increase, without revealing a significant jump in this indicator. The mean before and after tea remains constant, namely 10,6 with low differences in low (10,8 and 10,5) and high (10,8 and 10,5) levels in basal and after tea levels respectively.

Table 2 Effect of strong tea on the distribution of testosterone levels in young healthy men

	N	Minimal levels	Maximal levels	Mean	standard error	Standard deviation
Basal Testosterone	12	5.2	10.8	8.6	0.61	2.13
Testosterone after tea	12	5.4	10.5	8.59	0.56	1.95

Based on ranking Fig.2. also demonstrates the absence of any preferential decrease or increase in testosterone after tea consumption on empty stomach at rest.

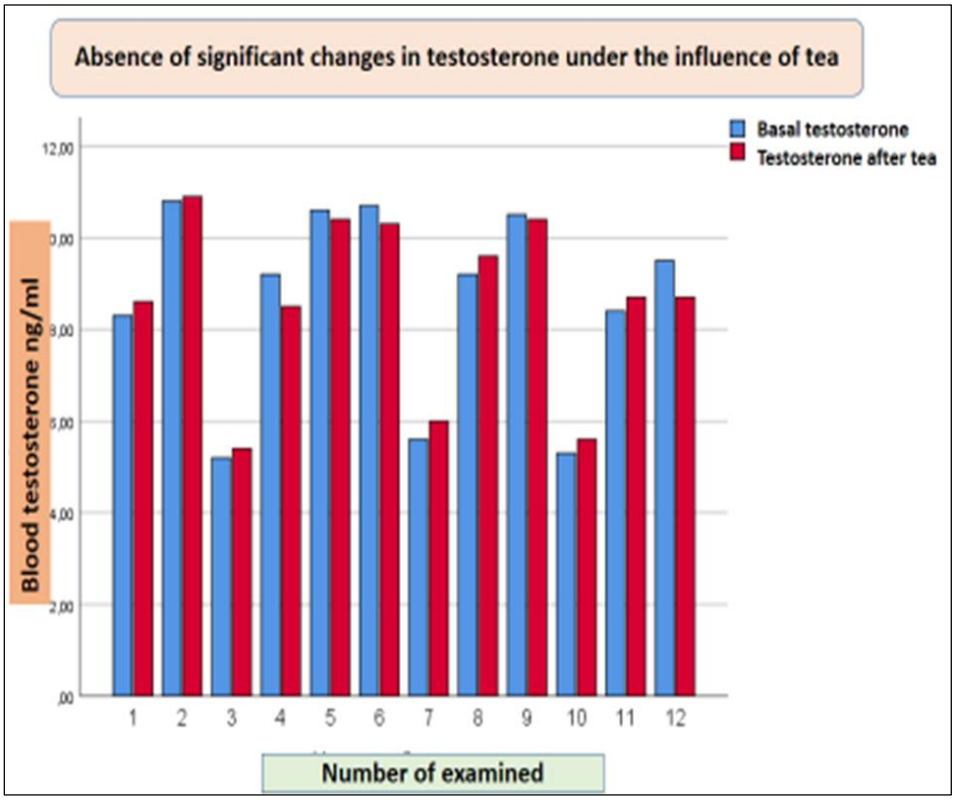

Figure 2 Changes in the blood testosterone levels under the influence of strong tea

As can be seen from the data presented in Table 3, the average fasting cortisol concentration in young healthy men is 128,83±60,86 (58,60; 165,90), while after drinking tea this indicator elevated to 160,46±44,43(109,40; 190,30), i.e. after this indicator was 1,25 fold higher than the basal cortisol levels with 95% of significance Spearman correlation =1).

Table 3 Significantly elevated cortisol levels in the blood of healthy young men after consumption a cup of strong tea (P< 0,05)

	N	Minimal levels	Maximal levels	Mean	standard error	Standard deviation
Basal cortisol	7	58.60	165.90	128.83	35.13	60.86
Elevated cortisol	7	109.40	190.30	160.46	25.65	44.43

Figure 3 Visualizes data on cortisol levels obtained from drinking tea in 2a group

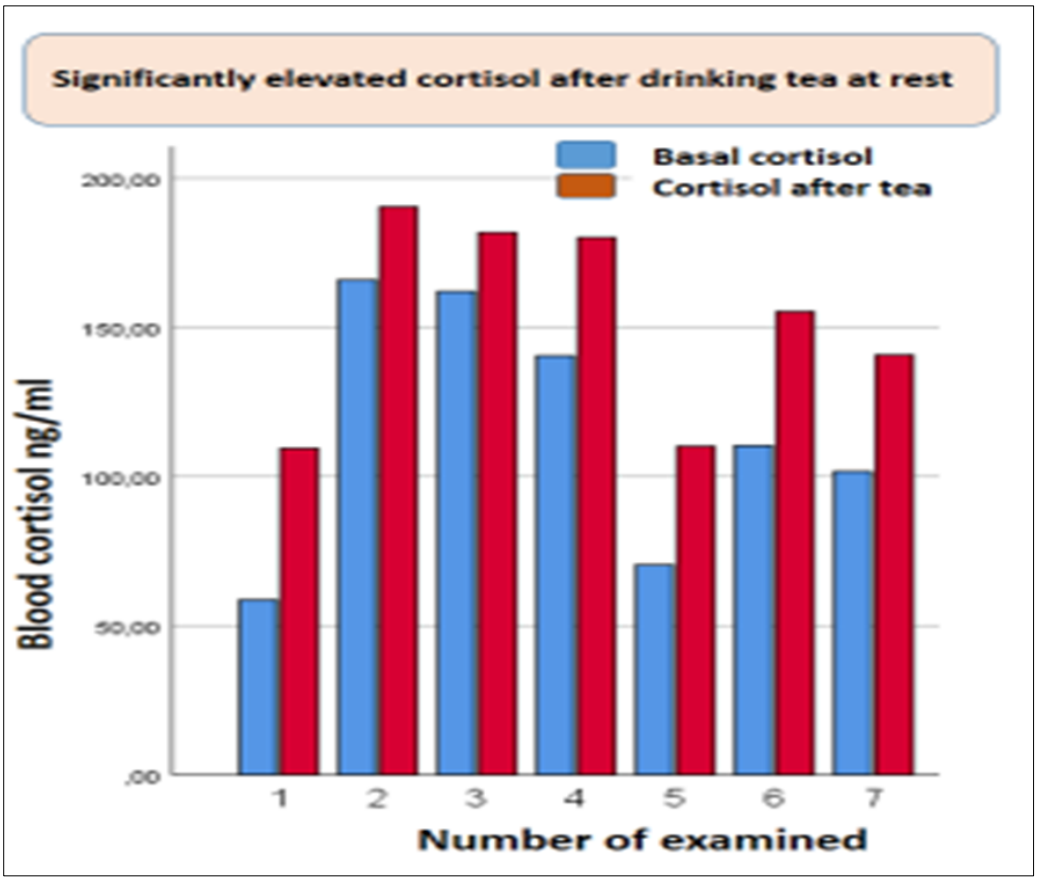

Figure 3 Comparison of cortisol levels in group 2a on an empty stomach and after drinking strong tea

Very interesting was the result on the cortisol levels in group 2b. Cortisol levels in this subgroup significantly decreased after strong tea. So, So in these subjects, on an empty stomach blood cortisol was on average 140,92±30,48with a 95% confidence level in the interval 108,2 to 178,3, while after taking tea, this indicator was on average 103,62±45,46 (min 58,5; max162,9; P<0.05).

Table 4 Significantly decreased cortisol levels in the blood of healthy young men after consumption a cup of strong tea (P< 0,05)

	N	Minimal levels	Maximal levels	Mean	standard error	Standard deviation
Basal cortisol	7	108.2	178.3	140.92	11.52	30.48
Decreased cortisol	7	58.5	162.9	103.62	17.18	45.46

Fig. 4 visualizes the presence of a significant decrease in cortisol in the 2b subgroup in ranking of the effect of tea

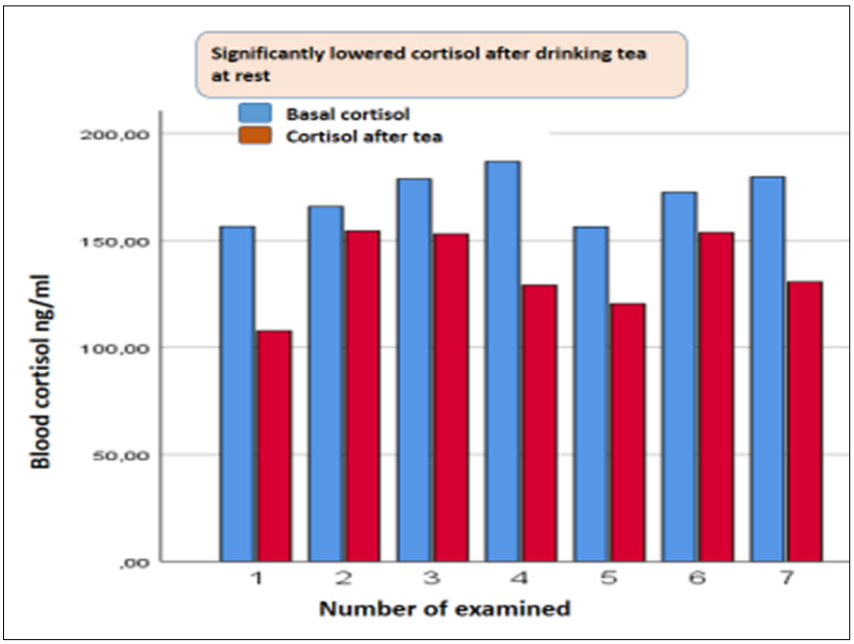

Figure 4 Cortisol decreased under strong tea action

4. Discussion

Determining the testosterone concentration in the blood of young men after coffee and tea, we found the following patterns. Relying only on the data in the table 1 and taking into account the mean, and even the maximum and minimum of this indicator without an individual approach to changes in testosterone in the blood, we can conclude that testosterone does not change at all under the influence of coffee at rest. However, it is not the truth. To data, in general caffeine increases the level of testosterone, however, after examining the effect of coffee alkaloids on the body at rest, we observed in the majority of those surveyed a general trend towards its decrease. This reality can be detected only by rank analysis. According Wedick NM et al., 2012, consumption of instant coffee per day with each meal impacts the sex-hormone binding hormone and sex hormones testosterone and estradiol. At 4 weeks, decaffeinated coffee was associated with a significant increase in sex-hormone binding hormone in women, but not in men. Consumption of caffeinated coffee increased total testosterone and decreased total and free estradiol in men. Amid women, caffeinated coffee decreased total testosterone [13]. Comparing literature data with ours brings to light the fact that testosterone levels is fluctuating under coffee consumption, and we state that the change of blood testosterone starts with first cup of coffee.

We also used a ranking method in hopes of determining the change in testosterone levels after taking strong tea on an empty stomach at rest. However, as shown in Fig. 2, testosterone tends to decrease or increase in different individuals, but whithout any preferential derection of change in testosterone levels.

When comparing the effects of coffee and tea on testosterone levels, it is safe to say that coffee will have a more pronounced inhibitory effect on testosterone release (Fig.1. vs Fig.2). This factor can be counted by countries in which it is planned to reduce the population due to overpopulation of the country: they may replace tea consumption by coffee.

Table 3 presents data for the subgroup 2a, in which cortisol levels increased with taking cup of strong tea. Interestingly, we found a significant increase in cortisol levels under the influence of strong tea without load on the mental and physical activity. It is acknown that cortisol is responsible for the supply of nutrients to the bloodstream, for which it interferes with the process of gluconeogenesis, lipolysis and ketogenesis and, thus, the entry of energy substrates into the bloodstream. Under the influence of cortisol, the concentration of glucose formed in gluconeogenesis is increased in the blood. But in our case, cortisol cannot act by this way, since the activation of gluconeogenesis requires the cortisol action at the gene level: an increase in the expression of genes involved in the synthesis of enzymes of gluconeogenesis, namely rate limiting pyruvate carboxylase and phosphoenolpyruvate carboxykinase takes hours, or even days, while our testing lasts one hour. Nevertheless, since it is well known that cortisol increases blood glucose, research is needed to determine the effect of tea on *glucose levels in diabetic patients*. Thus, although our study lasted only an hour, we should keep in mind that the daily use of strong tea is widespread in our population, especially amid males. So, a daily

increase in cortisol, even when drinking tea at rest, as we disclosed, should be of concern to physicians responsible for the treatment of patients with hyperglycemia, for example, patients with diabetes mellitus. Of course, under chronic cortisol exposure, activation of gluconeogenesis and concomitant hyperglycemia are inevitable. So, it would be better if, based on the data we received, doctors responsible for the health of patients with hyperglycemia carried out blood glucose control after strong tea, especially taken on an empty stomach.

Cortisol is also responsible for the raise of fatty acids in the blood and the increase in ketone bodies (ketonemia), which is especially true during times of famine. It is desirable to carry out research on the presence of the fact of increase in ketone bodies after use of tea in patients with diabetes mellitus. Lovallo WR et al.,2005, state that the caffeine raises both adrenocorticotropic hormone and cortisol levels in the blood. These data means that, most probably, it is caffeine that increases the cortisol levels in our study. In MacKenzie T et al., work caffeine has been shown to increase insulin levels, but reduce insulin sensitivity, and increase cortisol levels. However, some studies indicated that long-term consumption of coffee and green tea is associated with a reduced risk of type 2 diabetes mellitus. Their study provides evidence that daily caffeine intake reduces insulin sensitivity; the effect persists for at least a week. This study alsojustifies our concerns about the health of diabetics after caffeinated drinks [14].

It is traditionally considered that the main active ingredient of tea is caffeine, however, it is overlooked that tea contains at least 3 additional biologically active substances with a pronounced effect, amid which is theanine. Hidese, S., 2019, revealed very interesting results after administration one of black tea componnts, L-theanine. A stratified analysis carried out by this group of scientists showed that fluency scores in speech and writing increased after L-theanine administration compared with placebo administration in subjects. Their results suggest that L-theanine may promote mental health in the general population with stress-related illnesses and cognitive impairment [15]. These data are consistent with ours which show that in group of investigated black tes stimulates increase of cortisol.

Since in our study we determined both a decrease (subgroup 2a) and an increase (subgroup 2b) of cortisol levels, it is reasonable to assume a change in the level of ergogens in the blood of tthese subgroups in the opposite direction, which is especially important for drivers and people engaged in intellectual and physical activity. Since cortisol simultaneously increases the concentration of ketone bodies in the blood, studies are also needed regarding the eligibility of drinking tea by patients with diabetes mellitus, especially in the stage of decompensation.

The results we found on the level of cortisol in group 2b are also interesting. Steptoe et al., 2007 state that 6 weeks tea consumption lowers the post-stress cortisol leading to relaxation, together with reduced platelet activation [10]. But we observed the significant drop in blood cortisol levels in 2b subgroup after one cup of strong tea. This suggests, that there are individuals predisposed to a decrease in cortisol after strong tea on an empty stomach, and this phenomenon can serve as an excellent complementary tool to drugs for regulating glucose and ketone bodies in the blood of diabetic patients, in whom, as it is known, in response to the inhibition of glucose entry to the cell due to insulin deficiency, additional energy fuels are required by cells, and the ACTH-cortisol axis is activated for the supply of alternative ergogens to the blood. This is good news for those who have high sugar levels or whose work is stressful. Consumption a cup of strong tea on an empty stomach will significantly lower their cortisol and relieve their state of tension. For this reason, “Azerchay” tea may be recommended to this category of people as a stress-reducing drink. To determine, which category an individual belongs to, i.e. his cortisol decreases after tea or increases, it is enough to conduct parallel testing of glucose, taking into account the main, hyperglycemic effect of cortisol. Thus, those whose cortisol is lowered after tea may use it to reduce the stress and, maybe glucose levels in the blood.

5. Conclusion

It is advisable for patients with diabetes to check blood glucose after drinking strong tea, especially on an empty stomach.

Tea is able to significantly increase and decrease cortisol at rest, without exposure to additional stressors, and this fact can be used by doctors in their practice of treating patients with diabetes.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

All authors declare we have no conflict of interest in relation to the publication of the data presented in the article.

Statement of informed consent

Informed consent was obtained from each individual participant included in the study, as well as a personal phone number for a late post-study health survey.

Findings

- A significant increase in cortisol levels under the cup of strong tea may complicate the condition of patients with decompensated diabetes mellitus.
- Those whose cortisol is lowered after tea may use it to reduce the stress and glucose levels in the blood.

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