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The acute effect of coffee intake on hormones that affect glucose and glucose metabolism in healthy individuals.

Uğur Bilge[1*], İlhami Ünlüoğlu[1], Gözde Gültekin Şari[1] , Nehir Özgül Mengüllüoğlu[2], Nazife Şule Yaşar Bilge[3], Muzaffer Bilgin[4]

[1]Department of Family Medicine, Faculty of Medicine, Eskişehir Osmangazi University, Turkey

[2]Karaduvar İsa Öner Family Health Center, Turkey

[3]Department of Internal Medicine, Division of Rheumatology, Faculty of Medicine, Eskişehir Osmangazi University, Turkey

[4]Department of Biostatistics, Faculty of Medicine, Eskişehir Osmangazi University, Turkey

Abstract

Aim: The purpose of this study was to seek the acute effects of coffee intake on glucose metabolism and some hormones.
Materials and methods: The participants were asked to drink a cup of instant coffee (2 g). Three hours later, the glucose, insulin, glucagon, leptin, cortisol, total cholesterol, triglyceride, HDL, LDL, CRP, TSH and free T4 tests were repeated. The participants did not consume any other drink or food between 0 and 3 h. The participants were called back one week later. In 0 h, the glucose, insulin, glucagon, leptin, cortisol, total cholesterol, triglyceride, HDL, LDL, CRP, TSH and free T4 tests were performed. This time, the participants were asked to drink a glass of hot water. Three hours later, same tests were repeated.
Results: There weren't any significant changes in the levels of insulin, glucagon, cortisol, lipid levels, CRP, TSH and free T4 tests after coffee intake but we found significant changes in the leptin and plasma glucose values.
Conclusions: In conclusion, acute coffee intake does not have an acute impact on glucagon, cortisol, and TSH levels but affects leptin levels which can be one of the mechanisms of type diabetes mellitus reduction with coffee intake.

Keywords: Coffee intake, Glucagon, Leptin.

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Introduction

Coffee, one of the most consumed beverages across the world, consists of several bioactive molecules, including caffeine. A cup of coffee includes caffeine, chlorogenic acid and magnesium, i.e. compositions that are potentially effective in the reduction of Type 2 DM risk. A great number of prospective studies conducted with different genders and races suggest that coffee, with or without caffeine, reduce the risk of Type 2 DM, depending on its dose [1-3]. In recent years, owing to the studies reporting that decaffeinated coffee also lowers the risk of Type 2 DM, there has been an increase in research on chlorogenic and caffeic acid, i.e. coffee components that particularly have antioxidant effects. Furthermore, coffee has positive effects on insulin resistance and impaired glucose tolerance [4,5].

In their research of 2009, Rachel et al. examined the studies conducted on coffee and tea between 1966 and 2009, and reached the information that daily coffee consumption lowered diabetes by 7% [6]. In their research published in 2006, Pereira et al. worked with 28,812 postmenopausal women that had cardiovascular diseases and diabetes; and inquiring their coffee consumption, the researchers found out that women drinking six or more cups of coffee per day had a 22% lower rate of diabetes than nondrinkers [7]. Studies on the effect of caffeine on metabolic parameters suggest that caffeine is likely to increase glucose uptake of cells and lower insulin concentration, and that such effect is likely to vary in obese and non-obese individuals. There are studies reporting that caffeine lowers the risk of type 2 DM. Yet, the mechanism cannot be defined clearly. This study sets out to evaluate the acute effects of coffee consumption in obese and non-obese individuals in a more detailed way than other studies.

Studies on the effects of coffee provide data that coffee is likely to reduce the risk of developing type 2 DM; however, the source of this effect is not clear. That is why we believe that there is a need to discover the effects of coffee on TSH, insulin and especially glucagon (which has not been the topic of previous studies). The purpose of this study was to seek the effects of coffee on glucose metabolism and some hormones.

Material and Methods

Patients admitted to Family Medicine Clinics of Eskişehir Osmangazi University that did not have a chronic disease and did not use any drugs were included in the study.

The participants underwent the following tests in hour 0 for differential diagnosis: complete blood count, Alanine Transaminase (ALT), Aspartate Transaminase AST, creatinine, sedimentation, and HbA1C. Furthermore, blood was taken from participants for following tests in hour 0: glucose, insulin, glucagon, leptin, cortisol, total cholesterol, and triglyceride, Low-Density Lipoprotein (LDL), High-Density Lipoprotein (HDL), C-Reactive Protein (CRP), Thyroid Stimulating Hormone (TSH) and free T4.

The participants were asked to drink a cup of instant coffee (2 gr). Three hours later, the glucose, insulin, glucagon, leptin, cortisol, total cholesterol, triglyceride, HDL, LDL, CRP, TSH and free T4 tests were repeated. The participants did not consume any other drink or food between hours 0 and 3.

The participants were called back one week later. In hour 0, the glucose, insulin, glucagon, leptin, cortisol, total cholesterol, triglyceride, HDL, LDL, CRP, TSH and free T4 tests were performed. This time, the participants were asked drink a glass (200 ml) of hot water. Three hours later, the glucose, insulin, glucagon, leptin, cortisol, total cholesterol, triglyceride, HDL, LDL, CRP, TSH and free T4 tests were repeated. The participants did not consume any other drink or food between 0 and 3 h.

The acute-phase effect of coffee on glucose, insulin, glucagon, leptin, cortisol, total cholesterol, triglyceride, HDL, LDL, CRP, TSH and free T4 was evaluated. The participants' age, gender and test results were recorded on a form that the researchers developed. The participants of the study were aged from 20 to 45.

Roche Integra 400 Plus biochemistry analyser was used to measure glucose, creatinine, ALT, AST, cholesterol, triglyceride, HDL cholesterol and LDL cholesterol levels by colometry, and CRP and HbA1c levels by turbidimetry.

Roche Cobas E 411 was used to measure the levels of TSH, free T4, insulin and cortisol by electrochemiluminescence assay method.

Sun-Red Elisa kit was used to measure leptin and glucagon levels by enzyme-linked immunosorbent assay method.

Statistical analysis

Continuous variables were given as mean ± standard deviation while categorical ones were given as number and percentage (%). The normality was tested with Shapiro-Wilk Test. Student t test was used for comparison two groups with normally distributed, Mann-Whitney U test was used for comparison of non-normally distributed. Pearson and Pearson Exact Chi-Square and Fisher's Exact Test were used to analyse the crosstabs. 3 Way ANOVA (One Factor Repetition) Test was used for repeated measurements. Statistical analysis was done with IBM SPSS for Windows version 21.0 package (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). The level of significance used was $p<0.05$.

Results (Findings)

The study was planned to be conducted with a total of 32 patients. Because one of the patients had infection during the data-collecting process, this participant was excluded from the study (considering that the process may affect his blood glucose and metabolism).

Twelve (38.70%) men and nineteen (61.30%) women were included to the study. The average BMI was 28.36 ± 6.80 kg/m^2 and average age was 31.39 ± 6.97 y in the whole group.

Effect of coffee intake on blood glucose

There was no significant difference in average blood glucose levels of 31 patients between before water intake and before coffee intake (p=0.079). The average blood glucose was measured as 92.35 ± 5.96 mg/dl before coffee intake, and as 90.16 ± 10.75 mg/dl before water intake.

There was a significant difference in average blood glucose levels measured three hours after the patients drank coffee and water (p=0,034) but differences were in normal ranges. The average blood glucose was measured as 91.71 ± 10.56 mg/dl three hours after coffee intake and as 86.16 ± 6.12 mg/dl three h after water intake.

Effect of coffee intake on insulin

There was no significant difference in average insulin levels of 31 patients between before water intake and before coffee intake (p=0.871). The average insulin was measured as 11.89 ± 7.95 uU/ml before coffee intake, and as 15.77 ± 21.73 uU/ml before water intake.

There was no significant difference in average insulin levels measured three hours after the patients drank coffee and water (p=0.949). The average insulin was measured as 9.28 ± 5.92 uU/ml three hours after coffee intake, and as 8.76 ± 5.11 uU/ml three h after water intake.

Effect of coffee intake on HOMA

There was no significant difference in average HOMA levels of 31 patients between before water intake and before coffee intake (p=0.885). The average HOMA was measured as 2.74 ± 1.88 coffee intake, and as 2.63 ± 1.89 before water intake.

There was no significant difference in average HOMA measured three hours after the patients drank coffee and water (p=0.693). The average HOMA was measured as 2.12 ± 1.42

three h after coffee intake and as 1.86 ± 1.07 three h after water intake.

Effect of coffee intake on leptin

There was no significant difference in average leptin levels of 31 patients between before water intake and before coffee intake (p=0.447). The average leptin was measured as 8.48 ± 6.16 ng/ml before coffee intake, and as 7.36 ± 5.01 ng/ml before water intake.

There was a significant difference in average leptin measured three hours after the patients drank coffee and water (p=0.012). The average leptin was measured as 8.77 ± 5.90 ng/ml three hours after coffee intake, and as 5.93 ± 5.21 ng/ml three h after water intake.

Effect of coffee intake on glucagon

There was no significant difference in average glucagon levels of 31 patients between before water intake and before coffee intake (p=0.294). The average glucagon was measured as 66.37 ± 51.73 before coffee intake, and as 43.25 ± 28.53 before water intake.

There was no significant difference in average glucagon levels measured three hours after the patients drank coffee and water (p=0.155). The average glucagon was measured as 58.41 ± 37.43 three hours after coffee intake, and as 40.57 ± 15.74 three h after water intake.

Effect of coffee intake on cortisol

There was no significant difference in average cortisol levels of 31 patients between before water intake and before coffee intake (p=0.460). The average cortisol was measured as 12.32 ± 5.02 ug/dl before coffee intake, and as 13.01 ± 5.30 ug/dl before water intake.

There was no significant difference in average cortisol levels measured three hours after the patients drank coffee and water (p=0.513). The average cortisol was measured as 7.14 ± 3.56 ug/dl three hours after coffee intake, and as 6.48 ± 3.18 ug/dl three hours after water intake.

Effect of coffee intake on total cholesterol

There was no significant difference in average total cholesterol levels of 31 patients between before water intake and before coffee intake (p=0.657). The average total cholesterol was measured as 182.16 ± 29.88 mg/dl before coffee intake, and as 186.71 ± 32.76 mg/dl before water intake.

There was no significant difference in average total cholesterol levels measured three hours after the patients drank coffee and water (p=0.994). The average total cholesterol was measured as 188.42 ± 29.50 mg/dl three h after coffee intake, and as 190.06 ± 33.72 mg/dl three hours after water intake.

Effect of coffee intake on triglyceride

There was no significant difference in average triglyceride levels of 31 patients between before water intake and before coffee intake (p=0.730). The average triglyceride was measured as 94.84 ± 40.75 mg/dl before coffee intake, and as 105.65 ± 67.20 mg/dl before water intake.

There was no significant difference in average triglyceride levels measured three hours after the patients drank coffee and water (p=0.811). The average triglyceride was measured as 94.45 ± 42.26 mg/dl three hours after coffee intake and as 100.26 ± 68.95 mg/dl three h after water intake.

Effect of coffee intake on LDL

There was no significant difference in average LDL levels of 31 patients between before water intake and before coffee intake (p=0.989). The average LDL was measured as 112.16 ± 28.34 mg/dl before coffee intake, and as 112.03 ± 28.47 mg/dl before water intake.

There was no significant difference in average LDL levels measured three hours after the patients drank coffee and water (p=0.855). The average LDL was measured as 115.42 ± 27.78 mg/dl three h after coffee intake and as 114.52 ± 30.26 mg/dl three h after water intake.

Effect of coffee intake on HDL

There was no significant difference in average HDL levels of 31 patients between before water intake and before coffee intake (p=0.871). The average HDL was measured as 49.23 ± 12.95 mg/dl before coffee intake, and as 50.03 ± 13.19 mg/dl before water intake.

There was no significant difference in average HDL levels measured three hours after the patients drank coffee and water (p=0.978). The average HDL was measured as 51.68 ± 13.64 mg/dl three h after coffee intake and as 52.03 ± 13.77 mg/dl three h after water intake.

Effect of coffee intake on CRP

There was no significant difference in average CRP levels of 31 patients between before water intake and before coffee intake (p=0.597). The average CRP was measured as 0.19 ± 0.15 mg/dl before coffee intake, and as 0.16 ± 0.12 mg/dl before water intake.

There was no significant difference in average CRP levels measured three hours after the patients drank coffee and water (p=0.491). The average CRP was measured as 0.20±0.16 mg/dl three hours after coffee intake and as 0.17 ± 0.13 mg/dl three hours after water intake.

Effect of coffee intake on TSH

There was no significant difference in average TSH levels of 31 patients between before water intake and before coffee intake (p=0.657). The average TSH was measured as 2.69 ±

1.17 uIU/ml before coffee intake, and as 2.47 ± 0.95 uIU/ml before water intake.

There was no significant difference in average TSH levels measured three hours after the patients drank coffee and water (p=0.360). The average TSH measured as 2.19 ± 1.01 uIU/ml three h after coffee intake, and as 1.95 ± 0.91 uIU/ml three h after water intake.

Effect of coffee intake on free T4

There was no significant difference in average free T4 levels of 31 patients between before water intake and before coffee intake (p=0.190). The average free T4 was measured as 1.27 ± 0.13 ng/dl before coffee intake, and as 1.22 ± 0.14 ng/dl before water intake.

There was no significant difference in average free T4 levels measured three hours after the patients drank coffee and water (p=0.190). The average free T4 measured as 1.29 ± 0.15 ng/dl three h after coffee intake, and as 1.23 ± 0.14 ng/dl three h after water intake.

Table 1 represents the comparison of the baseline values of both groups of patients and Table 2 represents the comparison of the 3rd h values of both groups of patients.

Table 1. *Comparison of the baseline values of both groups of participants.*

	Mean ± SD; Median (Q1-Q3)		**p**
	3 h after the coffee intake	**3 h after hot water intake**	
Plasma Glucose (mg/dL)	92.35 ± 5.96; 93.00 (89.00-97.00)	90.16 ± 10.76; 90.00 (85.00-94.00)	0.079
Insulin (UU/ml)	11.89 ± 7.95; 8.72 (5.55-14.57)	15.77 ± 21.73; 9.31 (5.88-17.01)	0.871
HOMA-IR	2.74 ± 1.88; 2.11 (1.26-3.39)	2.63 ± 1.89; 1.93 (1.29-3.66)	0.885
Leptin (ng/ml)	8.48 ± 6.16; 6.23 (3.12-12.65)	7.36 ± 5.01; 5.29 (2.94-11.98)	0.447
Glucagon (pg/ml)	66.37 ± 51.73; 34.13 (24.42-106.82)	43.25 ± 28.53; 32.16 (25.14-57.68)	0.294
Cortisol (ug/dl)	12.32 ± 5.02; 10.83 (9.24-14.19)	13.01 ± 5.30; 12.17 (8.63-15.88)	0.46
Total Cholesterol (mg/dL)	182.16 ± 29.88; 179.00 (158.00-199.00)	186.71 ± 32.76; 176.00 (165.00-203.00)	0.657
Triglyceride (mg/dL)	94.84 ± 40.75; 87.00 (56.00-128.00)	105.65 ± 67.20; 91.00 (62.00-117.00)	0.73
LDL (mg/dL)	112.16 ± 28.34; 104.00 (91.00-134.00)	112.03 ± 28.47; 103.00 (88.00-130.00)	0.989
HDL (mg/dL)	49.23 ± 12.95; 50.00 (39.00-59.00)	50.03 ± 13.19; 50.00 (39.00-59.00)	0.871
CRP (mg/dL)	0.19 ± 0.15; 0.10 (0.10-0.30)	0.16 ± 0.12; 0.10 (0.10-0.30)	0.597
TSH (uIU/ml)	2.69 ± 1.17; 2.46 (1.73-3.60)	2.47 ± 0.95; 2.37 (1.74-3.28)	0.657
fT4 (ng/dL)	1.27 ± 0.13; 1.28 (1.17-1.36)	1.22 ± 0.14; 1.24 (1.11-1.34)	0.19

Table 2. *Comparison of the 3rd h values of both groups of participants.*

	Mean ± SD; Median (Q1-Q3)		**p**
	3 h after the coffee intake	**3 h after hot water intake**	
Plasma glucose (mg/dL)	91.71 ± 10.56; 90.00 (86.00-94.00)	86.16 ± 6.12; 86.00 (81.00-9.002)	
Insulin (UU/ml)	9.28 ± 5.92; 7.82 (4.71-12.46)	8.76 ± 5.11; 7.18 (5.34-11.06)	0.949
HOMA-IR	2.12 ± 1.42; 1.74 (1-2.84)	1.86 ± 1.07; 1.56 (1.14-2.54)	0.693
Leptin (ng/ml)	8.77 ± 5.90 7.15 (3.44-14.15)	5.93 ± 5.21 4.13 (1.27-10.94)	0.012
Glucagon (pg/ml)	58.41 ± 37.43 58.79 (27.13-72.84)	40.57 ± 15.74 39.16 (25.42-44.24)	0.155
Cortisol (ug/dl)	7.14 ± 3.56; 6.49 (4.23-9.07)	6.48 ± 3.18; 5.63 (3.72-8.61)	0.513
Total Cholesterol (mg/dL)	188.42 ± 29.50; 185.00 (165.00-206.00)	190.06 ± 33.72; 179.00 (168.00-207.00)	0.994
Triglyceride (mg/dL)	94.45 ± 42.26; 83.00 (59.00-120.00)	100.26 ± 68.95; 82.00 (56.00-119.00)	0.811
LDL (mg/dL)	115.42 ± 27.78; 106.00 (94.00-137.00)	114.52 ± 30.26; 102.00 (93.00-132.00)	0.855
HDL (mg/dL)	51.68 ± 13.64; 50.00 (43.00-61.00)	52.03 ± 13.77; 50.00 (42.00-61.00)	0.978

CRP (mg/dL)	0.2 ± 0.16; 0.10 (0.10-0.30)	0.17 ± 0.13; 0.10 (0.10-0.30)	0.491
TSH (uIU/ml)	2.19 ± 1.01; 1.89 (1.50-2.86)	1.95 ± 0.91; 1.73 (1.36-2.37)	0.36
fT4 (ng/dL)	1.29 ± 0.15; 1.29 (1.18-1.39)	1.23 ± 0.14; 1.24 (1.12-1.36)	0.19

Discussion

The aim of this study was to investigate the effects of acute coffee intake on levels of various hormones and blood glucose. This study distinguishes from others in that we also focused on the levels of glucagon and leptin. For the purpose of this paper, we studied the effects of coffee intake on an empty stomach by making the same participants drink hot water without any food intake.

There was a significant difference between blood glucose levels of the participants three hours after coffee intake and water intake. While the average blood glucose was 91.71 ± 10.56 mg/dl three hours after coffee intake, it was 86.16 ± 6.12 mg/dl three hours after water intake. The difference between two blood glucose levels was significant; however, both levels were within the range determined for normal fasting blood glucose. Coffee intake caused no difference in cortisol, TSH, sT4 and CRP values. This is a finding that supports the results of similar studies [8,9].

Different from the results of other studies, our results showed no change in insulin and lipid levels after coffee intake. This may be because other similar studies investigated the effect on insulin and lipid levels after longer periods of coffee intake. Our findings suggest that coffee intake on an empty stomach-with no other food intake-causes no increase in insulin secretion and change in lipid profile [10-12].

Our results suggest no significant relationship between coffee intake and glucagon level. The literature provides several studies that focused on the relationship between coffee intake and glucagon-like peptide levels. However, to the best of our knowledge, there no previous studies that investigate the relationship between coffee intake and glucagon levels. It is one of the important findings of our study that coffee intake on an empty stomach has no effects on glucagon [13].

There was a significant difference in average leptin three h after coffee intake and water intake (p=0.012). This finding is considered significant given that leptin has impacts on diabetes. Leptin modulates insulin sensitivity and glucose use, independently of food intake, and leptin deficiency is likely to cause insulin resistance [14].

According to the results of a survey of studies on leptin, leptin is an armamentarium against diabetes. Long-term leptin therapy significantly modulates glycemic control and insulin sensitivity [15].

There is an inverse correlation between coffee (both caffeinated and decaffeinated) or tea intake and risk of type 2 diabetes, which is dependent on the dose [6,16]. Decaffeinated coffee is also found to cause reduced hemoglobin A1c (A1C) concentrations [6,17]. There are studies showing that long-term coffee consumption reduces the risk of type 2 diabetes [17,18].

Nine cohort studies were revised in a systematic way, and it was found out that diabetes risk was the lowest in subjects that consumed more than six cups of coffee per day and significantly lower in subjects that consumed four to six cups daily, as compared to subjects with minimal coffee consumption (less than two cups per day) [19]. The relationship does not differ by variables such as sex, obesity, or region. The same study shows that there is an inverse correlation with regard to decaffeinated coffee.

Even a small amount of daily coffee consumption reduces the risk of diabetes according to a prospective study conducted with 88,000 women aged between 26 and 46. In this study, the RR was 0.87 (95% CI 0.73-1.03) in one cup of coffee consumption per day, 0.58 (0.49-0.68) in two to three cups of coffee consumption, and 0.53 (0.41-0.68) in four or more cups of coffee consumption, compared with non-drinkers. Non-caffeinated and caffeinated coffee had same effects, and tea consumption did not affect risk [19].

Also, in another study conducted with over 17,000 participants aged 40 between 65 in Japan (where diabetes has increased twofold in the past two decades), it was found out that participants who drank green tea six or more cups of green tea per day had lower risk of developing diabetes over a period of five years [20].

It is suggested that chlorogenic acid has an effect on glucose metabolism through several mechanisms. First, it is revealed that chlorogenic acid inhibits α-glycosidase and glucose-6-phosphatase and hence may delay intestinal glucose uptake [21-23]. Furthermore, inhibition of glucose-6-phosphatase can reduce hepatic glucose output, and this may cause the reduction of fasting insulin concentrations [23,24].

In conclusion, acute coffee intake does not have an acute impact on glucagon, cortisol, and TSH levels but affects leptin levels which can be one of the mechanisms of type diabetes mellitus reduction with coffee intake.

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*Correspondence to

Uğur Bilge

Department of Family Medicine

Faculty of Medicine

Eskişehir Osmangazi University

Turkey