

Effect of decaffeination of coffee or tea on gastro-oesophageal reflux

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SUMMARY

Background: Coffee and tea are believed to cause gastro-oesophageal reflux; however, the effects of these beverages and of their major component, caffeine, have not been quantified. The aim of this study was to evaluate gastro-oesophageal reflux induced by coffee and tea before and after a decaffeination process, and to compare it with water and water-containing caffeine.

Methods: Three-hour ambulatory pH-metry was performed on 16 healthy volunteers, who received 300 ml of (i) regular coffee, decaffeinated coffee or tap water ($n = 16$), (ii) normal tea, decaffeinated tea, tap water, or coffee adapted to normal tea in caffeine concentration ($n = 6$), and (iii) caffeine-free and

caffeine-containing water ($n = 8$) together with a standardized breakfast.

Results: Regular coffee induced a significant ($P < 0.05$) gastro-oesophageal reflux compared with tap water and normal tea, which were not different from each other. Decaffeination of coffee significantly ($P < 0.05$) diminished gastro-oesophageal reflux, whereas decaffeination of tea or addition of caffeine to water had no effect. Coffee adapted to normal tea in caffeine concentration significantly ($P < 0.05$) increased gastro-oesophageal reflux.

Conclusions: Coffee, in contrast to tea, increases gastro-oesophageal reflux, an effect that is less pronounced after decaffeination. Caffeine does not seem to be responsible for gastro-oesophageal reflux which must be attributed to other components of coffee.

INTRODUCTION

Coffee, and to a lesser extent also tea, have been implicated in causing or aggravating heartburn.^{1,2} This clinical observation has been supported by the study of Thomas *et al.*³ which demonstrated that coffee decreased lower oesophageal sphincter pressure. However, data on the effect of coffee and tea on the gastro-oesophageal reflux are not available. Since caffeine is a major component of coffee and tea, it is tempting to suggest its involvement in the occurrence of heartburn.⁴ The aim of the present study was to evaluate the effect of coffee and tea before and after decaffeination on the acidity in the lower oesophagus in comparison with tap water and caffeine-containing water.

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MATERIALS AND METHODS

Subjects

Sixteen healthy volunteers (7 men, 9 women) with a mean age of 25.9 (range 20–41) years without current or previous history of heartburn or other gastrointestinal symptoms and diseases (and without abdominal surgery, except appendectomy) participated in the study. The subjects did not take any medication and consumed usually not more than four cups of coffee or tea daily. After explanation of the study protocol, which was in accordance with the Declaration of Helsinki and approved by the local ethics committee, all subjects gave their written informed consent.

Study protocol

In the first part of the study, all 16 volunteers underwent three ambulatory oesophageal 3-h pH measurements with an interval of at least 24 h. After an overnight fast of 10 h, pH electrodes were placed at 08.00 hours. Then, the subjects received in a randomized order 300 ml coffee, decaffeinated coffee or tap water together with a standardized breakfast consisting of two rolls, 50 g jam and 40 g butter (800 kcal, 15% proteins, 60% carbohydrates, 25% lipids). During the subsequent 3-h investigation period, the subjects followed their usual activities, but they were not allowed to eat, drink, smoke, or to lie down.

In the second part of the study, 6 of the 16 subjects repeated the study protocol, drinking in a randomized order 300 ml normal tea, decaffeinated tea, and a coffee which had been adapted to normal tea in caffeine concentration by dilution of regular coffee with water.

In a third part of the study, the effect of caffeine added to tap water was investigated in 8 of the 16 subjects who received 300 ml caffeine-free and 300 ml caffeine-containing water, together with the standardized breakfast in a randomized order. The caffeine-containing water had the same caffeine concentration as the regular coffee.

All coffees originated from the same bean batch. The decaffeination, using the green beans, was by a supercritical carbon dioxide extraction (SCE) process at a temperature of 80 to 90 °C and a pressure of 250 to 300 bar.⁵ The decaffeinated beans were then roasted. Decaffeination of tea was performed by a similar procedure at a temperature of 50 °C. Teas and coffees were kindly provided by SKW Trostberg AG, Trostberg, Germany.

The coffees were brewed in an electric coffee maker (Siemens AG, Munich, Germany) by dripping boiling tap water on the preweighed ground coffee and filtering it through a paper. Teas were prepared by pouring boiling water on the tea leaves and drawing the mixture for 5 min, before decanting the liquid using a sieve. The caffeine-containing tap water was obtained by addition and dissolution of caffeine, which was also provided by SKW Trostberg AG. The data for the applied quantities of coffee and tea, the pH values, the osmolalities and the final caffeine concentrations of each beverage and the total amounts of ingested caffeine are given in Table 1. Caffeine concentrations were determined by an HPLC method.⁶

All beverages were consumed at a temperature between 48 and 55 °C. The examiners and the subjects were blinded to the caffeine content of the beverages.

pH Measurement

Oesophageal pH measurement was performed with a portable unit consisting of a glass electrode (Ingold, Switzerland) and a solid-state memory box (Synectics, Bad Soden, Germany). The glass electrode was placed intra-oesophageally 5 cm above the point at which there was a sudden rise above gastric pH. The electrode was calibrated with buffer solutions at pH 1 and 7 before and after each measurement. A maximal electrode drift of 0.2 pH units was accepted. Further details of the ambulatory oesophageal pH measurement are given elsewhere.⁶

	Quantities coffee/tea (g/300 ml)	pH	Osmolality (mosmol/kg)	Caffeine concentration (mg/ml)	Consumed amounts of caffeine (mg)
Coffee	16	5.7	215	0.69	207
Decaffeinated coffee	16	5.5	215	< 0.05	< 15
Coffee adapted to tea in caffeine concentration	9.2	5.8	200	0.40	120
Tea	4	5.9	175	0.40	120
Decaffeinated tea	4	5.9	160	< 0.05	< 15
Tap water		6.4		0	0
Tap water with caffeine		6.4		0.69	207

Table 1. Applied quantities of coffee and tea, pH values, osmolalities and caffeine concentrations and the total amounts of caffeine ingested with 300 ml of each beverage

Data analysis

Computerized analysis of data was performed with a personal computer (Commodore PC 40/40, Germany) and commercially available software (Gastrosoft Esophogram 9802, Irving, Texas, USA). Gastro-oesophageal reflux was defined as a drop of the oesophageal pH below 4. The percentage of time with a pH below 4 (fraction time) during the three postprandial hours was calculated. Results are given as medians and ranges. The Wilcoxon rank sum test was applied for the evaluation of statistical significance which was set at the 5% level.

RESULTS

Part I

Fraction times pH < 4 during the three postprandial hours after the intake of the standardized breakfast together with regular coffee, decaffeinated coffee and tap water are shown in Figure 1. Gastro-oesophageal reflux was significantly ($P < 0.05$) more pronounced after the ingestion of regular coffee than after tap water. The decrease in gastro-oesophageal reflux with coffee which had undergone the decaffeination process reached a significant level ($P < 0.05$) compared to regular coffee. The difference in gastro-oesophageal reflux between the intake of decaffeinated coffee and tap water was not statistically significant.

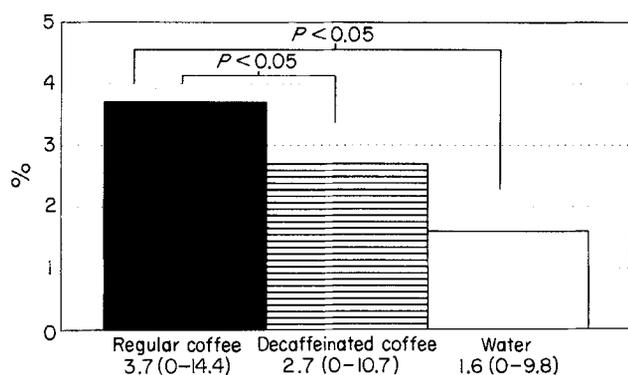


Figure 1. Percentage of time oesophageal pH < 4 during the three postprandial hours in 16 subjects after the intake of a standardized breakfast together with regular coffee, decaffeinated coffee, or tap water. Data are given as medians (ranges).

Part II

Gastro-oesophageal reflux after the intake of normal tea, decaffeinated tea and tap water was in the same range (Figure 2). Comparing gastro-oesophageal reflux after normal and decaffeinated tea with gastro-oesophageal reflux after coffee in the six subjects who underwent parts I and II of the study, the value obtained for the regular coffee (3.2% median, range 1.3-14.4%), but not that of the decaffeinated coffee (0.9%, 0.1-3.6%) was significantly ($P < 0.05$) higher. Comparing the normal tea with a coffee adapted to the caffeine concentration in tea by dilution of regular coffee with water, a significantly ($P < 0.05$) higher fraction time pH < 4 was detected with the coffee (Figure 3).

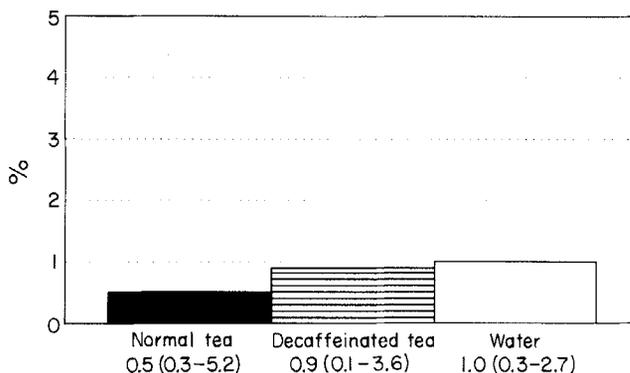


Figure 2. Percentage of time oesophageal pH < 4 during the three postprandial hours in 6 subjects after the intake of standardized breakfast together with normal tea, decaffeinated tea, or tap water. Data are given as medians (ranges).

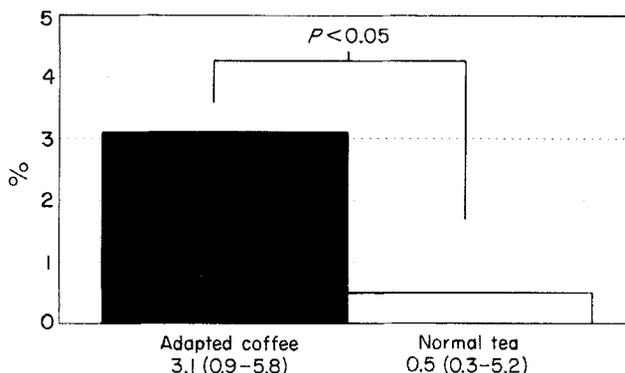


Figure 3. Percentage of time oesophageal pH < 4 during the three postprandial hours in 8 subjects after the intake of a standardized breakfast together with normal tea and a coffee adapted to tea in caffeine concentration by dilution of regular coffee, or water. Data are given as medians (ranges).

Part III

The addition of caffeine to tap water to obtain the caffeine concentration of regular coffee had no effect on gastro-oesophageal reflux compared with tap water alone (median 1.2%, range 0.7–7.6% vs 1.9%, 0.3–9.4%).

DISCUSSION

Physicians have often forbidden coffee for patients with heartburn. Based on the observation that caffeine-containing beverages were detrimental to these patients,⁸ the use of decaffeinated substitutes has been advised. Studies on the effect of coffee on the lower oesophageal sphincter pressure demonstrated controversial results;^{3,9–12} data on gastro-oesophageal reflux evaluated by oesophageal pH measurement were not available.

In the present study the intake of regular coffee induced a significant increase in gastro-oesophageal reflux compared with tap water. The gastro-oesophageal reflux observed with coffee which had undergone the decaffeination process was found to be between that of regular coffee and tap water. Compared with the regular coffee, the difference reached a statistically significant level. Independent of its caffeine content, tea did not induce gastro-oesophageal reflux.

The observation that tea had no effect on gastro-oesophageal reflux might have been due to the lower caffeine concentration of tea compared with the coffee. Therefore, two further investigations were performed. First, caffeine was added to tap water to obtain the same concentration which was found in regular coffee. Second, regular coffee was diluted with water to obtain a caffeine concentration which was the same as that of normal tea. Caffeine added to tap water did not increase gastro-oesophageal reflux. When coffee was prepared at the caffeine concentration of normal tea, an abnormally high gastro-oesophageal reflux was seen. These results suggest that it is the presence or absence of coffee components other than caffeine that are responsible for changes in gastro-oesophageal reflux. Similarly, Cohen & Booth⁹ have found that caffeine alone had no effect on the lower oesophageal sphincter pressure. From their results of the effect of eight differently processed coffees on the lower oesophageal sphincter pressure, Van Deventer *et al.*¹² concluded that some of the observed variability in oesophageal response to coffee consumption can be traced to differences in how the green coffee beans are

processed and not to the caffeine content. In other studies demonstrating an increasing effect of coffee on gastric acid secretion,^{13,14} there was more evidence that so-called roasting products increased gastric acid secretion than caffeine alone. Also for the gastric distress after coffee consumption roasting products and not caffeine have been taken into consideration.¹³

In our decaffeinated coffee, the reduction of the caffeine content was achieved by the supercritical carbon dioxide extraction. By this process hydroxytryptamides, which have recently been shown to exert an ulcerogenic effect on the gastric mucosa of the rat,¹⁵ were also decreased by about 50%.¹⁶ Whether gastro-oesophageal reflux after the intake of regular coffee is due to hydroxytryptamides or to any other of the several hundred compounds of coffee¹⁷ which might have also been modified in their concentration by the supercritical carbon dioxide extraction process can only be speculated.

From our results we conclude that caffeine alone does not induce gastro-oesophageal reflux. Although the effect of our regular coffee in patients with heartburn is unknown, it seems appropriate to advise these patients to prefer coffee which has undergone the supercritical carbon dioxide extraction decaffeination process or—**even better—to drink tea.**

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