

## The cardiovascular effects of regular and decaffeinated coffee

P. SMITS, TH. THIEN & A. VAN 'T LAAR

Division of General Internal Medicine, Department of Medicine, University of Nijmegen, Nijmegen, The Netherlands

In a single-blind study the effects of drinking two cups of regular or decaffeinated coffee on blood pressure, heart rate, forearm blood flow and plasma concentrations of caffeine, renin and catecholamines were studied in 12 normotensive subjects. Drinking regular coffee led to a rise of blood pressure, a fall of heart rate and an increase of plasma catecholamines. Decaffeinated coffee induced a smaller increase of diastolic blood pressure without changing other parameters. This study shows that the cardiovascular effects of drinking coffee are mainly the result of its caffeine content.

**Keywords** coffee decaffeinated coffee catecholamines blood pressure

### Introduction

The pharmacological effects of caffeine have been the subject of many recent studies. After drinking regular coffee changes of blood pressure heart rate and plasma catecholamines have been reported (Smits *et al.*, 1983; Whitsett *et al.*, 1984). It is generally accepted that caffeine is the most important pharmacological compound with respect to the circulatory effects of drinking coffee (Eichler, 1976). Only few studies report on the cardiovascular effects of decaffeinated coffee. Decaffeinated coffee powder has a very low caffeine content, approximately 0.05% vs 1.2-2.0% of regular coffee. Dose-response studies on the haemodynamic effects of caffeine only are available in dose ranges equivalent to two to eight cups of coffee (Whitsett *et al.*, 1980) but not in the range of low caffeine doses as in decaffeinated coffee. Therefore we studied haemodynamic and humoral variables before and after drinking regular and decaffeinated coffee.

### Methods

Six men and six women, all healthy and normotensive, gave their informed consent for this study. Age, weight, length and quetelet-index

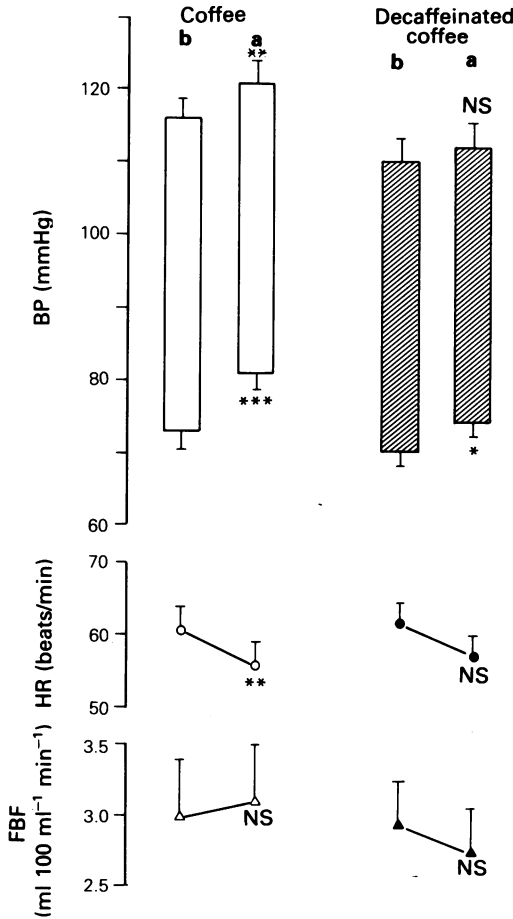
(mean  $\pm$  s.d.) of these subjects numbered respectively  $25 \pm 4.7$  years,  $68.6 \pm 11.8$  kg,  $179.5 \pm 6.0$  cm and  $21.2 \pm 3.3$  kg/m<sup>2</sup>. All persons were used to daily coffee intake and mean daily coffee consumption varied from three to 10 cups of coffee per day. In random sequence, all subjects underwent two single-blind tests, one with regular coffee, and one with decaffeinated coffee. Percolated regular coffee was automatically prepared with 350 ml water and 24 g of coffee resulting in two cups of coffee containing together about 280 mg caffeine. Decaffeinated coffee was prepared in the same way. The subjects were asked to abstain from caffeine for 17 h and from smoking for 4 h before the start of each test. After arrival at the laboratory a supine rest period of 20 min started, and in the next 20 min systolic and diastolic blood pressure (SBP and DBP by arteriosonde 1225), heart rate (HR by ECG) and forearm blood flow (FBF by venous occlusion plethysmography) were measured each 5 min. In eight out of 12 subjects blood was sampled for humoral parameters. Afterwards the subjects were asked to drink the coffee within 10 min. At 90 min after the start of the test the same periods of rest and measurements were repeated. Plasma caffeine concentrations were measured with a reversed phase h.p.l.c. method.

Correspondence: Dr Th. Thien, Department of Medicine, Division of General Internal Medicine, Geert Grooteplein Zuid 8, St Radboud Hospital, P.O. Box 9101, 6500 HB Nijmegen, The Netherlands

Plasma catecholamines were determined by a radioenzymatic assay and PRA by a radioimmunoassay. All individual haemodynamic measurements were averaged to one mean value respectively before and after the beverage ingestion. Haemodynamic and humoral results were analysed by respectively Student's *t*-test and Wilcoxon test for paired observations. All results are presented as mean  $\pm$  s.e. mean.

**Results**

Figure 1 shows the mean values of BP, HR and FBF before and after use of coffee and decaffeinated coffee. Basal BP in the coffee and decaffeinated coffee test was not significantly



**Figure 1** Blood pressure (BP), heart rate (HR) and forearm blood flow (FBF) before (b) and after (a) the use of regular and decaffeinated coffee (mean  $\pm$  s.e. mean of 12 subjects). \**P* < 0.05, \*\**P* < 0.01, \*\*\**P* < 0.001, NS not significant.

different measuring respectively  $116 \pm 3.1/73 \pm 2.4$  mm Hg and  $115 \pm 3.0/70 \pm 2.2$  mm Hg. Mean basal HR also was similar in both tests ( $60 \pm 2.2$  beats/min and  $62 \pm 1.8$  beats/min respectively). After coffee there was a significant rise of SBP and DBP of  $4.4 \pm 1.4\%$  and  $11.8 \pm$

**Table 1** Plasma concentrations of caffeine (CF), remin (PRA) and (nor)adrenaline (NA, A) before and after ingestion of regular and decaffeinated coffee. Mean changes ( $\Delta$ ) of the humoral parameters are also given (mean  $\pm$  s.e. mean of eight subjects)

	Regular coffee (RC)		Decaffeinated coffee (DC)		RC $\Delta$	DC $\Delta$
	Before	After	Before	After		
CF (mg/l)	0.3 $\pm$ 0.1	8.8 $\pm$ 0.7	0.2 $\pm$ 0.1	0.4 $\pm$ 0.1	8.5 $\pm$ 0.7	0.1 $\pm$ 0.1
PRA (ng ml <sup>-1</sup> h <sup>-1</sup> )	2.49 $\pm$ 0.48	1.81 $\pm$ 0.38	2.33 $\pm$ 0.54	1.85 $\pm$ 0.40	-0.68 $\pm$ 0.22	-0.48 $\pm$ 0.20
A (nmol/l)	0.15 $\pm$ 0.02	0.38 $\pm$ 0.07	0.16 $\pm$ 0.02	0.22 $\pm$ 0.04	0.23 $\pm$ 0.07	0.07 $\pm$ 0.03
NA (nmol/l)	1.72 $\pm$ 0.22	2.16 $\pm$ 0.26	1.59 $\pm$ 0.14	1.69 $\pm$ 0.15	0.44 $\pm$ 0.11	0.11 $\pm$ 0.15

\**P* < 0.05; \*\**P* < 0.01; \*\*\**P* < 0.0001; NS: not significant

2.5% and HR decreased with  $8.4 \pm 3.1\%$ . After decaffeinated coffee SBP and HR did not alter significantly, but DBP showed a rise of  $4 \pm 1.4$  mm Hg. The coffee induced rise of DBP was significantly higher than the increase of DBP after decaffeinated coffee ( $P < 0.05$ ). In both tests mean FBF remained unchanged.

Table 1 summarizes the responses of all humoral variables to the drinking of regular and decaffeinated coffee. Basal values of these parameters were the same in both tests. In contrast to the drinking of decaffeinated coffee, regular coffee gave a significant rise of plasma caffeine concentration. Table 1 shows that the coffee induced rises of plasma catecholamines were significantly higher than the changes after decaffeinated coffee. In both tests PRA showed an insignificant fall after the beverage ingestion.

## Discussion

The relation between caffeine ingestion and blood pressure gains interest from pharmacologists as well as epidemiologists. Epidemiological studies report a positive association between blood pressure and coffee consumption (Lang *et al.*, 1983). In other studies correlations were analysed between coffee ingestion and morbidity or mortality from coronary heart disease, and most of them observed no significant association (Dawber *et al.*, 1974). In pharmacological studies there is also evidence for a positive association between blood pressure and caffeine intake (Smits *et al.*, 1983; Whitsett *et al.*, 1984). Other studies, however, suggested that after

chronic caffeine ingestion the pressor response to coffee disappears (Robertson *et al.*, 1981; Ammon *et al.*, 1983). In this study we also observed a rise of SBP and DBP after coffee with a caffeine-abstinence of only 17 h. In agreement with our results other investigators also observed a decrease of HR after coffee (Whitsett *et al.*, 1984).

No epidemiological and only few pharmacological studies report on decaffeinated coffee (Fleish *et al.*, 1954; Ammon *et al.*, 1983). In both studies decaffeinated coffee did not elevate BP in contrast to regular coffee. Our results also indicate that drinking of decaffeinated coffee has almost no haemodynamic effects. In the literature no data of radioenzymatic determined plasma catecholamines and of PRA after decaffeinated coffee are available. After coffee we observed a rise of plasma adrenaline and to a lesser extent of plasma noradrenaline, whereas PRA showed no alteration. These results are in close agreement with a previous report (Smits *et al.*, 1983). In our tests decaffeinated coffee had no influence on humoral parameters. In spite of the small caffeine content of decaffeinated coffee mean plasma caffeine concentration did not rise significantly.

From this study we conclude that drinking regular coffee results in a rise of BP, a fall of HR and an increase of plasma catecholamines. Decaffeinated coffee only induces a slight increase of DBP, and so the circulatory effects of regular coffee are mainly brought about by the caffeine load. If further studies suggest a causal role for coffee in the development of cardiovascular disease, then the use of decaffeinated coffee would become advisable.

## References

- Ammon, H. P. T., Bieck, P. R., Mandalaz, D. & Verspohl, E. J. (1983). Adaptation of blood pressure to continuous heavy coffee drinking in young volunteers. A double blind cross-over study. *Br. J. clin. Pharmacol.*, **15**, 701-706.
- Dawber, T. R., Kannel, W. B. & Gordon, T. (1974). Coffee and cardiovascular disease: observations from the Framingham study. *New Engl. J. Med.*, **291**, 871-874.
- Eichler, O. (1976). *Kaffee und Caffein*, 2e Auflage. Springer Verlag: Berlin.
- Fleish, A. & Wenner, V. (1954). Les effets physiologiques du cafe et des extraits de cafe. *Schweiz. med. Wochenschr.*, **84**, 223-226.
- Lang, T., Degoulet, P., Aime, F., Fouriand, C., Jacquinet-Salord, M., Laprugne, J., Main, J., Oeconomos, J., Phalente, J. & Prades, A. (1983). Relation between coffee drinking and blood pressure: analysis of 6321 subjects in the Paris region. *Am. J. Cardiol.*, **52**, 1238-1242.
- Robertson, D., Wade, D., Workman, R., Woosley, R. L. & Oates, J. A. (1981). Tolerance to the humoral and haemodynamic effects of caffeine in man. *J. clin. Invest.*, **67**, 1111-1117.
- Smits, P., Hoffmann, H., Thien, Th., Houben, H. & van 't Laar, A. (1983). Hemodynamic and humoral effects of coffee after  $\beta_1$ -selective and non-selective  $\beta$ -blockade. *Clin. Pharmacol. Ther.*, **34**, 153-158.
- Whitsett, T. L., Christensen, H. D. & Hirsch, K. R. (1980). Cardiovascular effects of caffeine in humans. In *Central control mechanisms and related topics*, eds Wang, H. H., Blumethal, M. R. & Nagai, S. N. pp 247-259. New York: Futura.
- Whitsett, T. L., Manion, C. V. & Christensen, H. D. (1984). Cardiovascular effects of coffee and caffeine. *Am. J. Cardiol.*, **53**, 918-922.

(Received December 19, 1984,  
accepted February 16, 1985)