Does a single cup of caffeinated drink significantly increase blood pressure in young adults? A randomised controlled trial

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This paper was accepted as part of AFP's commitment to, on occasion, publish research that will 'make people laugh, then think' as highlighted in the annual IgNobel Prizes.

Background

Previous studies have shown that the blood pressure elevating effect of acute caffeine consumption was variable because of the heterogeneity of study participants, dosage of caffeine and study designs.

Objective

This research aimed to examine the effect of a single cup of coffee on the blood pressure of young adults.

Methods

Normotensive adults were randomised to receive either a cup of caffeinated drink (intervention group) or a cup of decaffeinated drink (control group). The main outcome measure was mean change in systolic blood pressure (SBP) and diastolic blood pressure (DBP) between intervention and control groups.

Results

Enrolled participants (n = 104) were randomly assigned to the intervention group (n = 53) or the control group (n = 51). The mean differences in SBP and DBP of the two groups were +2.77 mmHg (*P* = 0.05) and +2.11 mmHg (*P* = 0.64), respectively. Therefore, the rise in both SBP and DBP after caffeine consumption was not statistically significant.

Discussion

Our study confirmed that drinking a single cup of coffee (containing 80 mg of caffeine) does not have a significant impact on the blood pressure of healthy normotensive young adults one hour after the drink.

The potentially deleterious effect of coffee intake on cardiovascular health has been a subject of research interest.[1,2] Systematic reviews of randomised controlled trials on the chronic consumption of coffee/caffeine confirmed a small but statistically significant increase in systolic blood pressure (SBP; 2.0–2.4 mmHg) and diastolic blood pressure (DBP; 0.7–1.2 mmHg).[3,4] Interestingly, the reviews identified a somewhat larger blood pressure elevating effect of caffeine versus coffee[3] and a greater effect among younger study participants.[4] Reviews of the hypertensive effect of acute consumption of coffee/caffeine highlighted the heterogeneity of study participants, dosage of caffeine and study designs.[5–7]

In a review by Nurminen et al,[5] a single dose of caffeine (200–250 mg, equivalent to two to three cups of coffee) increased SBP by 3–14 mmHg and DBP by 4–13 mmHg in normotensive study participants. On the other hand, a review by James estimated that dietary caffeine will raise mean population blood pressure by approximately 4/2 mmHg.[6] The Australia New Zealand Food Standards states that there is 80 mg of caffeine in a 250 ml cup of caffeinated beverage, whereas percolated coffee has 60–120 mg of caffeine per cup.[8] However, in the US, a standard 8-ounce (240 ml) cup of coffee contains around 100 mg of caffeine, whereas espresso has a much higher content of caffeine (240–720 mg per 8 ounces).[9] Thus, we think it is more useful to ascertain if a typical cup of coffee (with 80 mg of caffeine) can produce a significant hypertensive effect.

Methods

Our study design was a randomised, double-blind, placebo-controlled clinical trial. The study participants were medical

students from the International Medical University (IMU) Clinical School in Seremban, Malaysia. The intervention and placebo were standard coffee drinks (caffeinated and decaffeinated, respectively) in Styrofoam cups (250 ml). The drinks were made with two teaspoons of instant coffee (2.6 g), 250 ml of warm water and one packet each of non-dairy creamer and sugar. The instant coffee chosen consisted of the caffeinated and decaffeinated varieties of a popular brand available commercially. The amount of caffeine in the intervention and placebo drinks was verified by a private laboratory (name available from the investigators) as 82.2 mg and undetectable, respectively. The amount of caffeine received by the participants in the intervention group was approximately 1.4 mg/kg of body weight. The drinks (labelled as 'A' and 'B' respectively) were freshly prepared by an investigator who was not involved in the subsequent part of the study.

A quiet room in the IMU library was used for this study. Medical students studying in the library were invited to participate. Eligible study participants were healthy male and female students aged >18 years and were free of chronic diseases, including hypertension. After obtaining informed consent, study participants were randomly assigned to either the intervention or control group. The randomisation list was created using the online Research Randomizer software,[10] and 110 codes (labelled as 'A' and 'B') were placed in opaque envelops, which were opened at enrolment. The investigators who recorded the study participants' blood pressure did not know which drink was caffeinated.

After randomisation, study participants completed a brief questionnaire about their sociodemographic data and personal history of hypertension. Then, their blood pressure was measured twice using the Omron SEM-1 digital blood pressure monitor. Measurement of blood pressure followed the recommendations of a guideline.[11] Study participants who had elevated blood pressure (≥140/90 mmHg) were excluded from the study. Sixty minutes after consumption of the coffee, the same study participants were invited for repeat blood pressure measurement (measured twice). The timing of the second set of blood pressure readings was based on the fact that peak plasma concentration of caffeine after a typical drink is reached within 40–60 minutes.[12]

Sample size estimation

We assumed that SBP elevation by 5 mmHg was clinically significant on the basis of data from Nurminen et al.[5,6] Using StudySize 2.0.4 software,[13] and assuming SD = 10 mmHg, at one-sided test of significance, we estimated the sample size to be 100 study participants (50 for each group). We increased the sample size by 10% (110, 55 per group) to account for possible dropouts.

Statistical analysis

We analysed the data using SPSS version 19. The main outcome measure was mean change in blood pressure after consuming the intervention or placebo drinks (mean of two blood pressure readings one hour after drink minus mean of two blood pressure readings just before drink). The mean difference in blood pressure and pulse rate between caffeinated and decaffeinated groups was compared using a paired t-test.

In view of the slight imbalance of sociodemographic variables in the two treatment groups, we used multiple linear regression to check if these variables independently influenced the change in SBP, and also to verify the value and direction of the standardised coefficient of treatment group as an independent variable.

The proportion of participants with ≥5 mmHg of blood pressure change in the intervention and control groups was compared using a chi-square test. Test of agreement using kappa statistic was used to check whether the participants could guess correctly the type of drink given. Statistical significance was set at $P < 0.05$.

The study was carried out from 9 to 20 December 2013 in the IMU library. The research proposal received approval from the International Medical University Joint Research & Ethics Committee (Grant Number: CSc/Sem6[23]2013) and was registered with the National Medical Research Registry (NMRR ID: NMRR-14-868-20259).

Results

Study participants

One hundred and ten participants were enrolled in this study. Of these, six participants were excluded from analysis as their initial blood pressure was ≥140/90 mmHg. All enrolled participants completed the randomised controlled trial. Their mean age was 22.41 years (SD = 1.02; range 19–26 years; Table 1).

Baseline and outcome data

A comparison of the study participants' baseline characteristics revealed similarities in the intervention and placebo groups (Table 1). As shown in Table 2, in the intervention group, both SBP and DBP showed a small increase (0.65 and 0.62 mmHg, respectively) one hour after coffee intake, but pulse rate showed a small reduction (–3.68 beats per minute). In the placebo group, SBP, DBP and pulse rate showed small decreases (–2.12 mmHg, –1.49 mmHg and –3.05 beats per minute, respectively) one hour after coffee intake. Comparing the intervention and placebo groups, there was no statistically significant change in SBP ($P = 0.05$). We explored the change in SBP using multiple linear regression (dependent variable: change in systolic blood pressure; independent variables: treatment groups, age, gender, ethnicity and daily coffee consumption) but did not find a statistically significant change in SBP by any of the five independent variables. The standardised coefficient of the treatment group was +0.172 (95% CI: 0.099, –0.468), but the change in SBP was not statistically significant). The change in DBP and pulse rate between the two groups did not reach statistical significance.

Other data

All study participants were asked to guess whether they were given the caffeinated drink. Forty-five participants (43.7%) guessed their drink correctly (one participant in the placebo group did not give an answer; kappa = –0.13; $P = 0.17$). We noted that 20 participants in the intervention group had an SBP elevation of at least 5 mmHg. The proportion of participants showing a change in SBP of ≥5 mmHg did not reach statistical significance ($x^2 = 3.591$, $P = 0.058$). However, when we stratified the above data by their coffee consumption, we found that participants who did not drink coffee daily were statistically more likely to have a change in SBP of ≥5 mmHg (Table 3).

Discussion

This randomised controlled trial showed that a single cup of coffee containing about 80 mg of caffeine produced a small change in SBP and DBP (3 and 2 mmHg, respectively). This change in blood pressure was not statistically significant and did not reach the a priori 5-mmHg elevation that we had set. We note that most of the difference in SBP between the intervention and control group was due to the lowering of blood pressure by around 2 mg in the decaffeinated group. However, we found that participants who did not consume coffee daily were more likely to show a change in SBP of ≥5 mmHg. This is in keeping with other observations that caffeine tolerance diminishes the acute effect of caffeine on blood pressure.[6]

Nurminen et al[5] identified 20 controlled studies that produced data on the hypertensive effect of caffeine on normotensive participants, with SBP elevation of 2–12 mmHg. Only two small controlled studies used a caffeine dose that was close to that in our study: Passmore[14] (n = 8, caffeine dose = 90 mg, SBP change = 5 mmHg) and Astrup[15] (n = 6, caffeine dose = 100 mg, SBP change = 2 mmHg). In comparison with the aforementioned studies, our randomised controlled trial has the strength of a larger sample size evaluating a specific research question.

The European guideline on home blood pressure measurement recommends avoiding caffeinated drink for at least 30 minutes prior to blood pressure measurement.[16] This guideline does not provide a reference for their recommendation, while Mort and Kruse

Table 1. Baseline characteristics of study participants

Characteristics	Intervention (n = 53)	Placebo (n = 51)
Age, years*	22.55 (1.12)	22.27 (0.90)
Male gender	23 (43.4%)	31 (60.8%)
Chinese ethnicity	42 (79.2%)	34 (66.7%)
Overweight/obese	12 (22.6%)	15 (29.4%)
Daily coffee drinker	12 (22.6%)	10 (19.6%)
Number of cups of coffee consume per week†	1 (0–15)	1 (0–21)
Blood pressure, mmHg*	112/65 (13/9)	116/69 (11/7)
Pulse rate, beats per minute*	83 (15)	81 (11)

**Data are means (SD) or numbers (%)*
†Data are median (range)

Table 2. Effect of caffeine on blood pressure and pulse rate

Outcome	Intervention (n = 53)	Placebo (n = 51)	Mean difference (95% CI)
Mean SBP before (mmHg)	112.11 (12.93)	115.88 (11.48)	
Mean SBP after (mmHg)	112.76 (12.12)	113.77 (12.08)	
SBP change (mmHg)	+0.65 (7.81)	–2.12 (6.28)	+2.77mmHg (0.00, +5.53)*
Mean DBP before (mmHg)	65.27(8.54)	66.87 (7.42)	
Mean DBP after (mmHg)	65.90 (7.77)	65.38 (8.07)	
DBP change (mmHg)	+0.62 (6.46)	-1.49 (4.91)	+2.11mmHg (–0.40, +4.07)†
Mean PR before (beats per minute)	82.46 (14.83)	81.34 (10.58)	
Mean PR after (beats per minute)	78.78 (14.46)	78.29 (9.48)	
PR change (beats per minute)	–3.68 (6.91)	–3.05 (5.05)	–0.63 beats per minute (–2.99, +1.73)‡

CI, confidence interval; DBP, diastolic blood pressure; PR, pulse rate; SBP, systolic blood pressure
**t =1.986, df = 102, P = 0.05*
†t =1.873, df = 102, P = 0.64
‡t = –0.529, df =102, P = 0.60

Table 3. Systolic blood pressure change of at least 5 mmHg among study participants stratified by coffee consumption

Coffee consumption	Treatment group	SBP change ≥5 mmHg	SBP change <5 mmHg	Total
Daily*	Intervention	2 (20.0%)	8 (80.0%)	10
	Placebo	3 (25.0%)	9 (75.0%)	12
		5 (22.7%)	17 (77.3%)	22
Not daily†	Intervention	11 (26.8%)	30 (73.2%)	41
	Placebo	4 (9.8%)	37 (90.2%)	41
		15 (18.3%)	67 (81.7%)	82

*x^2=0.078, P = 0.781
† x^2=3.998, P = 0.046

mentioned that blood pressure changes due to caffeine occur within 30 minutes and peak in 1–2 hours.[7] Our study confirms that drinking a single cup of coffee (containing 80 mg of caffeine) does not have a major impact on blood pressure in healthy, normotensive young adults one hour after the drink, except in those who are not habitual coffee drinkers. We cannot exclude the possibility of a small but statistically significant blood pressure elevation (<5 mmHg) due to caffeine, which may be shown by a larger sample study. The findings of our study cannot be extrapolated to older adults or those with pre-existing hypertension, who may have a greater pressor response to caffeine.[17] In view of the common usage of home blood pressure monitors, this information will be of some help in giving clear advice to young adults prior to their home blood pressure measurement.

Acknowledgement

We wish to thank Zuhanariah Mohd Nordin, Chief Librarian of IMU Library, for allowing the study to be conducted in the library.

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Competing interests: None.

Provenance and peer review: Not commissioned, externally peer reviewed.

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