ORIGINAL ARTICLE

EFFECTS OF VARIED DOSES OF COFFEE-CAFFEINE ON RESTING CARDIOVASCULAR SYSTEM OF HEALTHY BLACK AFRICAN ADULTS

Lamina Sikiru, BSc, Musa D. B.Ed, PhD

ABSTRACT

BACKGROUND: ***Caffeine is a methyl derivative of xanthine which is a naturally occurring chemical found in leaves, seeds and fruits of over 60 species of plants. People of all ages use this 'miracle foods' in attempts to improve athletic performance, alter body composition and increased levels of energy. Many studies have reported no significant effect of caffeine on the cardiovascular system. On the contrary several other studies reported significant effect on the cardiovascular system. Some studies have shown no dose response relationship between caffeine and cardiovascular system. The objective of this study was to determine the effect of varied doses of caffeine on cardiovascular system of apparently healthy black African adults.***

METHODS: ***A repeated measure of 4 randomized crossover (counterbalanced) double blind design was used. The total study period was 4 weeks of once weekly test. One hour post caffeine (5, 10 and 15mg/kg body weight) and placebo doses ingestion cardiovascular parameters including Systolic Blood Pressure, Diastolic Blood Pressure and Heart Rate were assessed. Repeated measures ANOVA was used to assess the level of significance in all variables of interest at the level of significance of 5%.***

RESULT: ***Twenty subjects with mean age of 22.3 (SD±4.0) years participated in the study. Five, ten and 15mg/kg doses of coffee and placebo of coffee and caffeine free was used. The result showed no significant effect of the 3 doses of caffeine over placebo in all cardiovascular parameters (P<0.05).***

CONCLUSION: ***the finding of this study demonstrated that instant soluble coffee dose up to approximately 9499mg (caffeine content of 889mg) seems not to stress the cardiovascular system of normal African black adults'.***

KEYWORDS: ***Black African; Caffeine; Cardiovascular; Coffee, Nigeria.***

INTRODUCTION

Caffeine (1, 3, 7-trimethylxanthine) is a methyl derivative of xanthine. It is basically a purine compound containing two condensed heterocyclic rings and it is a naturally occurring chemical found in leaves, seeds and fruits of over 60 species of plants. Specially, much caffeine is found in tea, coffee (*Coffee arabica*), Cola nuts (*Cola acuminata*) and cocoa (*Theobroma cacao*) (1-3).

People of all ages use stimulants as 'miracle foods' in attempts to improve athletic performance, alter body composition and increased levels of energy. The use of these "miracle" foods can be considered wholesome as long as they are used to supplement rather than to supplant and they constitute no health hazard (4). Caffeine one of the readily available stimulants consumed daily by more than 80% of the world's population, making it the most widely consumed drug in history (5).

The controversy on the use of caffeine as a food beverage by laymen or its use as an ergogenic aid by local, national and international athletes has drawn the attention of many scientists to research into the effect of this wonderful drug (3, 6-8). Due to the controversial reports of some scientists (9-12) on the ergogenic effect of caffeine on performance, the World Antidoping Agency(WADA) and the International Olympic Committee (IOC) had a series of banned, un-banned and finally pegged the use of caffeine in sports competition to a tolerance limit of 12 ug/ml-^{1} urine (13,14). Many researches reported that doses below 6mg/kg-^{1} caffeine do not exceed the IOC/WADA urinary caffeine limit (14-16). However, since 2004, the WADA again removed caffeine from the list of banned substances (17, 18).

Caffeine stimulates the heart, increasing the rate and force of contraction of the heart at rest, causing peripheral vasoconstriction (19). The effects of caffeine on the cardiovascular system are mediated either through stimulation of the central nervous system (CNS) or direct action on the heart and blood vessels. This actually increases the systemic blood pressure, such that chronic use of caffeine has been linked with coronary heart disease risk (20). However, following caffeine ingestion, bradycardia is also possible because xanthine stimulates the medullary vagal nuclei; which in turn decreases the heat rate (2, 21).

Many studies reported no significant effect of caffeine on the cardiovascular system (13, 22, 23). Several other studies on the contrary reported significant effect of caffeine on cardiovascular system (20, 24, 25). Some studies have shown no dose response relationship

between caffeine and cardiovascular system (13,15), while others reported a contrary notion (14,25). However; most of the studies investigating the effects of caffeine on health have been conducted using white or other mixed black subjects.

Many studies have examined the effects of caffeine on exercise performance relative to WADA/IOC previous doping limit, few focused on its concomitant action on the cardiovascular system. The objective of the present study was therefore to investigate the effects of varied doses of caffeine on the cardiovascular system of apparently healthy black African adults with reference to previous IOC doping limit.

SUBJECTS AND METHODS

Subjects: The study included 20 male volunteer students of Bayero University, kano, Nigeria. Subjects were non regular users of caffeine non smokers, non cardiac patients and apparently healthy. Their age ranged from 18 to 25 years. Heath information was obtained from the self reported health history and life style questionnaire developed and validated by the Institute of Aerobic Research Dallas Texas (26). Subjects were fully informed about the experimental procedures, risk and protocol after which they gave their consent in accordance with the American College Sports Medical guidelines regarding the use of human subjects (27). Ethical approval was obtained from the Faculty of Education, Bayero University Ethical and Research Committee. Subjects were advised to avoid caffeinated food and beverages and also vigorous physical activities 24 hours to the test days.

Design of the study: In this experimental study, repeated measure design in which each subject served as his own control (pretest-post test placebo- controlled design) was used to determine the effect of varied doses of caffeine and placebo on the variables of interest. The ingestion of caffeine and placebo was in a double blind 4 randomized crossover order (counter balanced test). The crossover ingestion of caffeine was separated by 7 days interval to avoid carry-over effect (15,25,28).

Setting and Procedures: The anthropometric, physiological, and caffeine/placebo measurement and ingestion were conducted in the exercise physiology laboratory of the Physical and Health Education Department. All tests and measurements were performed in the morning between 8.00 and 10.00 AM at a room temperature of between 23-25^{0}C (74-77^{0}F) each test day, and altitude of 481m.

Anthropometric measurement: Subjects' physical (height and weight) characteristics were measured using standardized anthropometric protocols (29, 30).

Physiological measurement: subjects systolic blood pressure (SBP), Diastolic blood pressure (DBP) and Heart rate (HR) were monitored from the right arm using automated (omron digital BP monitor, model 11 EM-403c;Tokyo, Japan) blood pressure monitor (31) at rest and 1 hour after caffeine ingestion. This procedure was repeated and an average of the two readings was recorded.

Caffeine and placebo measurement: The quantity of coffee to give the amount of caffeine needed (5 mg, 10mg and15mg/Kg body weight) was quantified by multiplying amount of coffee by 10.68 (1mg of caffeine = 10 68 mg of coffee). Capra Nescafe Coffee commonly found in Nigeria (instant soluble coffee) contain about 0.09366mg caffeine per mg of coffee (32). Since pure caffeine was not readily available, pure coffee was used instead. Subjects ingest 5, 10 and 15 mg/kg caffeine (measured using electronic weighing machine) dissolved in 200 ml warm water (23) and sweetened with artificial sweetener (33).

Placebo was in form of food colour (coffee colour), 0.1 ml liquid food colour was also dissolved in 200 ml warm water sweetened with artificial sweetener. The purpose of coffee colour placebo was to blind the subjects of ingested substance.

Test procedure: On arrival to the exercise Physiology Laboratory of the Department of Physical and Health Education, subjects rested for about 10 minutes in a sitting position, and their BPs and HRs were monitored. Subjects ingested caffeine doses and placebo doses in random order, and rested quietly in sitting position. One hour post caffeine ingestion; SBP, DBP and HR were measured as described earlier. Studies (20, 23, 33, 34) have shown that peak plasma caffeine concentration is achieved approximately 60 minutes post ingestion regardless of the dose. This procedure was repeated on the second, third and fourth test days in a 4 randomized crossover (counterbalance) order in a double blind manner. There was one test per week for duration of 4 weeks.

Data analyses: Following data collection, the measured variables were statistically analyzed. Mean and standard deviation for all variables were determined. The pre and post caffeine doses (5, 10 &15 mg/kg) and placebo dose SBP, DBP & HR were analyzed using one way analysis of variance (ANOVA) with repeated measures (repeated measure ANOVA). All statistical analysis was performed on an IBM compatible microcomputer using the statistical package for the Social Science SPSS, version 15.0, Chicago IL, USA. Statistical tests were performed at the level of significance of 0.05.

RESULTS

Twenty subjects age 18-25 years participated in the study; all were males of African (Nigeria) origin. Study subjects had mean age of 22.3 (SD±4.0) years, mean weight 59.3 (SD±5.5) kilogram and body mass index 21 (SD±4.6)

Table 1. Physical characteristics of subjects (N=20)

Variables	Mean	SD	Range
Age (years)	22. 3	4.0	18.0-25.0
Height (cm)	169. 3	5.4	160.0-180.0
Weight (kg)	59. 3	5.5	52.0-73.0
Body mass index (kg/m^2)	21.0	4.6	20.3-22.5

Five, ten and 15mg/kg doses of coffee equivalent to 3198.66mg (caffeine content =299.5mg), 6397.32mg (caffeine content=599mg) and 9499.86mg (caffeine content=889mg) mean coffee, respectively were used; while placebo was coffee and caffeine free (Table 2).

Table 2. Quantity of coffee and equivalent caffeine content ingested

Variables	Mean coffee(mg) ingested	Mean caffeine content (mg)
placebo	0.00	0.00
5mg/kg	3198.66	299.50
10mg/kg	6397.32	599.00
15mg/kg	9499.86	889.5

Mean cardiovascular (SBP, DBP & HR) responses to pre and post caffeine and placebo doses were measured. Result of the present study indicated no significant difference in pre-caffeine and pre-placebo measurements of SBP (F_{test}=.325, p=.808); DBP (F_{test} =1.795, p=.158) and HR (F_{test}=1.612 p=.197) compared to post-ingestion measurements for the doses of 5, 10 & 15mg/kg over placebo in SBP (F_{test}=1.402 ,p=.250); DBP (F_{test}= 1.971, p=.129) and HR (F_{test}=1.426, p=.245) (Table 4).

Table 3. Cardiovascular responses to varied caffeine and placebo doses (mean± SD)

Caffeine doses	Pre caffeine ingestion Mean ±SD	Post-caffeine ingestion Mean ±SD
	SBP (mmHg)	SBP (mmHg)
Placebo	127.9 ±2.5	132±2.4
5mg/kg	127.1 ±3.1	130±2.6
10mg/kg	127.9 ±2.5	138±3.5
15mg/kg	127.3±3.2	132±2.1
	DBP (mmHg)	DBP (mmHg)
Placebo	79.0 ±1.1	80±2.1
5mg/kg	78.7 ±2.3	80±3.2
10mg/kg	77.9 ±2.0	82±1.8
15mg/kg	79.0 ±0.8	82±1.2
	HR (b/m)	HR (b/m)
Placebo	73.0 ±2.4	72.9±4.1
5mg/kg	74.6 ± 3.5	78.2±2.6
10mg/kg	74.9± 3.4	74.8±4.3
15mg/kg	74.1± 2.7	80.4±3.4

b/m= beats per minute

There was no significant interaction and variation of measurements between trials and within trials for SBP, DBP and HR (Table 4)

Table 4. Cardiovascular responses to varied doses of caffeine ingestion (ANOVA)

Variables	Source of variation	Sum of Squares	Degree of Freedom	Mean Square	F_{test}	P-value
SBP(mmHg)	Between Trials	12380	3	284.5	1.402	.250**
	Within Trials	8063.1	19	424.4		
	Interaction	11527.0	57	202.2		
DBP(mmHg)	Between Trials	794.5	3	264.8		
	Within Trials	2779.2	19	146.3	1.971	.129**
	Interaction	7657.7	57	134.3		
HR(beats/min)	Between Trials	467.2	3	351.9	1.426	.245**
	Within Trials	6685.6	19	155.7		
	Interaction	6226.5	57	109.2		

F_{test} =3.521, ** Not significant at 0.05

DISCUSSION

This study was designed to assess the effects of varied does of caffeine on cardiovascular parameters. Results of the study indicated no significant effect of caffeine doses (5, 10 & 15mg/kg) over placebo on the cardiovascular system (SBP, DBP and HR).

This result corroborated the findings of many studies (23, 41-44) while it is inconsistent with the reports of other studies (20, 24, 35-40). Review of relevant literatures indicated a raise in BP following ingestion of caffeine (45). A significant increase in SBP and DBP after oral administration of 250 mg of Caffeine which is equivalent to the 5 mg kg^{-1} (299.5 mg) caffeine in the present study was reported (20). Despite the fact that both studies utilized lower doses compared to the present study, they reported a significant effect of caffeine on cardiovascular system. Another review of relevant literature concluded that there is no direct relationship between caffeine intake and elevated blood pressure (44). In a randomized placebo control study which examined the effect of 300mg caffeine on blood pressure of 20 healthy adults it was reported no effect of caffeine on blood pressure while caffeine increased the central blood pressure (46).

The non-significant effect of caffeine on the cardiovascular system in the preset study and as opposed to others mentioned earlier might be connected to inter-racial differences in caffeine pharmacodynamics and pharmacokinetics (6, 23). On the other hand, the effect of the type of caffeine used could not be ruled out. Better coffees are lower in acid, higher in caffeine and have a longer lasting effect. Ground coffees are generally preferable to canned or instant coffee (47). Several coffees also contain several other substances that may exert cardiovascular effects such as estrogen, nicotine and phenols (48) whose effect could not be ruled out.

The effect of the type of placebo used also worth consideration, most previous studies use decaffeinated coffee as placebo, decaffeinated coffee vary considerably in the chemical used or process in reducing their caffeine content. These chemicals and processes my affect Caffeine metabolism and tolerance (48). Also failure by past studies to distinguish between pure coffee and pure caffeine is another important factor worth considering.

Though, the present study indicated no significant effects of caffeine on cardiovascular system of black African adults, there are limitations of the study; they included failure to consider gender effect on caffeine pharmacodynamics, the utilization of instant soluble coffee due to the unavailability of pure caffeine. Apart from caffeine, coffee contains several other substances whose effects on cardiovascular system could not be ascertained. Also limited number of participants in the study, it is an experimental study with repeated measure design which is powerful since it multiplies the number of subjects. However, these limiting factors warrant more attention in future studies.

Based on the result of the present study, it was concluded that instant soluble coffee of approximately less than 9,596 mg (899 mg caffeine) has no effect on resting cardiovascular (SBP, DBP & HR) system of normal black African adult males.

REFERENCES

1. Essig D, Costill D, VanHandel PJ. Effects of caffeine ingestion on utilization of muscle glycogen and lipid during leg ergometer cycling. *Int. J Sports Med.* 1980; 1:86-90.
2. VanHandel P. Caffeine. In: M.H Williams MH, ed. Ergogenic aids in sports. Champaign, Human kinetics Publishers, 1983:128-163.
3. Wilcox AR. Caffeine and endurance performance. *Sports Sc. Exch.* 1990; 3(26):1-5.
4. Williams MH. Rating the sports erogenic. In: William MH,ed. The erogenic edge: pushing the limits of sports performance. Champaign ILL: Human kinetics, 1998: 115-278.
5. James JE. Understanding Caffeine: A Biobehavioral Analysis. Thousand Oaks, CA: Sage Publications; 1997.
6. Clark W (1997) Caffeine a users guides. *The Phys. & Sports Med.* 1977; 25(11):4-8.

7. Spriet LL. Caffeine and performance. *International Journal of Sport Nutrition* 1995; 5 (suppl.): S 84-99.
8. 8. Anhrendt DM. Erogenic aid. Counseling the athlete. American Family. *Physician* 2001; 63 (5): 913-22.
9. Perkins R, William MH. Effect of Caffeine upon maximal muscular endurance of female. *Med. Sc. in Sports and Exer.* 1975; 7:221-224.
10. Costil FL.Performance secrets. *Runner' World* 1978;13: 50-55
11. 11.Costil DL, Dalski GP, Fink WJ. Effects of caffeine ingestion on metabolic and exercise performance. *Med. & Sc. in Sports and Exer.* 1978; 10: 155-158.
12. 12. Ivy JL, Costill DL, Fink WJ, Lower W.Influence of caffeine and carbohydrate feedings on endurance performance. *Med. Sci.Sports Exer.* 1979;11:6-11.
13. Devries HD, Housh TT. Physiology of exercise for physical education, athletics and exercise science 15th ed. Madison WCB Brown and Benchmark Publishers, 1994.
14. Pasma WJ,VanBaak MA, Jeukendrup AF,Dehan A. The effect of different dosages of Caffeine on endurance performance time. *Int. J Sports Med.* 1995; 16(4): 225-230.
15. Kovacs EM, Stegen JH, Broun F. Effect of caffeine drink on substrate metabolism, caffeine excretion and performance. *J of App. Physio.* 1998; 85(2): 709-715.
16. Bruce CR. Enhancement of 2000meters rowing performance after caffeine ingestion. *Med. Sci.Sports and Exer.* 2000; 32 (11): 1958-63.
17. World Anti-Doping Agency (2003) The 2004 prohibited list. Available via URL:http:www2.triathlon.org/itu/itu-doping-rules/2004/banned-list-13sep04.pdf. Cited 3rd Dec 2007.
18. World Anti-Doping Agency. The 2008 prohibited list [On line].2007 Sept [Cited 2007 Nov 31]; Available fromURL:http:www.wada-ama.org/rtecontent/document/ 2008_list_En.pdf.
19. Brooks GA, Fahey TD, White T P. Exercise physiology, human Bioenergetics and its application.2nd ed. Mountain View, May Field Publishing Company, 1996.
20. Robertson D,Wade D, Workman R Woosley R, Oates JA. Tolerance of the humoral and homodynamic effects of caffeine in man. *J of Clin Invest.* 1981; 64: 1111-1117.
21. Lane JD, Adcock RA, Williams RB, Kuhn CM. Caffeine effects on cardiovascular and neuroendocrine responses to acute psychosocial stress and their relationship to level of habitual caffeine consumption. *Psychosom Med* 1990; 52: 320–36.
22. Tarnopolsky MA,Atkinson SA,.Mcdougall JD,SaleDG,Sutton JR. physiological responses to caffeine during endurance running in habitual caffeine users. *Med Sc.Sports and Exer.* 1989; 24: 418 – 424.
23. Gamba AA. Effect of caffeine ingestion on the P.P and R.R intervals of adult males. *J of Health Physical Edu. Sports and Leisure Stud.* 2001; 2 (2): 17-24.
24. VanHandel PJ,Burke E, Costill DL, Cote R.Physiological responses to cola ingestion. *Research Quaterly* 1977; 48: 436 - 444
25. Anderson MC, BruceCR , Frase SF, Stepto NK, Klein R, Hopkins WJ et al. Improved 200 meter rowing performance in competitive oarswoman after caffeine ingestion. *Int. J Sports Nutr.* 2000; 10(4):646-675.
26. Pollock M.L and Wilmore J.H. (1990) Exercise in health and disease; evaluation and prescription for prevention and rehabilitation.2nd ed. Philadelphia, WB Saunders Company 1990.
27. American College of Sports Medicine. Policy statement regarding the use of human subjects and informed consent. *Med.Sc. Sports and Exer.*1991; 16:467.
28. Anderson MC, Bruce CR , Frase SF, Stepto NK, Klein R, Hopkins WJ et al. Improved 200 meter rowing performance in competitive oarswoman after caffeine ingestion. *Int J Sports Nutr.* 2000; 10(4):646-675.
29. Rose WD, Marfell-Jones MJ. Physiological testing of the high performance athletes . In MacDugall JD; Wenger HA, Green HJ, eds. Kinanthropometry. Champaign,IL. *Human Kinetics Books*, 1991: 223 – 308.
30. International Society for the Advancement of kinanthropometry. International standards for anthropometric assessment. Potchefstroom, South Africa. Author; 2001.
31. Walker AJ, Bassett DR, Duey WJ, Howley ET,Bond V, Torok DJ.) Cardiovascular and plasma catecholamine responses to exercise in blacks and white. *Hypertension*1992; 20(4):542-548
32. Eteng MR, Eyong EU, Eka OU, Umoh IB, Ebong PE, Ettarh RR. Nigeria Nescafe coffee. *Plant Food for Hum. Nutr.1*999; 54(4):337-344
33. Engels, H.J and Haymes, E.M. Effect of caffeine ingestion on metabolic responses to prolonged waking in sedentary males. *International Journal of Sports Nutrition* 1992; 2: 386-396
34. Graham TE, Spriet LL. Metabolic, catecholamine and exercise performance responses to various doses of caffeine. *Journal of Physiology* 1995; 78(3):867-874.
35. Hartley TR, Sung BH, Pincomb GA, Whitsett TL, Wilson MF, Lovallo WR. Hypertension risk status and effect of caffeine on blood pressure. *Hypertension* 2000; 36: 1337–41.
36. Lovallo WR, al'Absi M, Pincomb GA, Green A, Passey RB, Sung BH, Wilson MF. Caffeine

extended stress, and blood pressure in borderline hypertensive men. *Int J Behav Med* 2000; 7: 183–8.

37. Shepard JD, al'Absi M, Whitsett TL, Passey RB, Lovallo WR. Additive pressor effects of caffeine and stress in male medical students at risk for hypertension. *Am J Hypertens* 2000; 13: 475–81
38. Vlachopoulos C, Hirata K, Stefanadis C, Toutouzas P, O'Rourke MF. Caffeine increases aortic stiffness in hypertensive patients. *Am J Hypertens* 2003; 16: 63–6.
39. Lane JD, Pieper CF, Phillips-Bute BG, Bryant JE, Kuhn CM. Caffeine Affects Cardiovascular and Neuroendocrine Activation at Work and Home. *Psychos. Med.* 2002;64:595-603.
40. Jee SH, He J, Whelton PK, Suh II, Klag MJ. A Meta-Analysis of Controlled Clinical Trials. Hypertension 1999;33:647-652.
41. 41.Salvaggio A, Periti M, Miano L, Zambelli C. Association between habitual coffee consumption and blood pressure levels. *J Hypertens* 1990; 8:585–590.
42. Salvaggio A, Periti M, Quaglia G, Marzorati D, Tavanelli M. The independent effect of habitual cigarette and coffee consumption on blood pressure. *Eur J Epidemiol* 1992; 8:776–782.
43. Kirchhoff M, Torp-Pedersen C, Hougaard K, Jacobsen TJ, Sjol A, Munch M, Tingleff J, Jorgensen T, Schroll M, Olsen ME. Casual blood pressure in a general Danish population: relation to age, sex, weight, height, diabetes, serum lipids and consumption of coffee, tobacco and alcohol. *J Clin Epidemiol* 1994;47:469–474.
44. Pitcher, M. (1984).Does coffee raise blood pressure? Am *J Cardio.* 53 (7) 918 – 22.
45. James JE. Critical Review of Dietary Caffeine and Blood Pressure: A Relationship That Should Be Taken More Seriously. Psychoso Med. 2004; 66: 63-71.
46. Waring WS, Goudsmith J, Marwick J, Webb D.A, Maxwell R.J(2003)Acute caffeine intake influence central more than peripheral blood pressure in young adults. *Am J of Hypertens.* 2003; 16(11): 919 – 924.
47. Marquis, T (1979). Effect of caffeine on performance. Unpublished Manuscript, University of Florida.
48. Burke V, Biejen LJ. Coffee, caffeine and blood pressure. *Card. Rounds Rev.* 2000; 4:187-197.