COFFEE INTAKE ABOLISHES HYPOTENSION INDUCED BY AEROBIC EXERCISE: A PILOT STUDY

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ABSTRACT
To analyze the effect of coffee intake in post exercise blood pressure response in hypertensive people, six subjects of both genders (56.7±4.5 years old) performed three sessions of aerobic exercise on treadmill. They ingested three cups (140mL each) of coffee (CO), placebo (PL) or water (WT), 10, 20 and 30 minutes after exercising. Blood pressure was verified immediately before each intake and, from then, at intervals of 15 minutes until completing 120 min of rest. In the WT procedure, blood pressure decreased 8.4mmHg for the systolic blood pressure, and 5.6mmHg for the diastolic blood pressure, in relation to basal values. On the other hand, in the CO procedure, there was an increase of 4.3mmHg for the systolic blood pressure and 7.7mmHg for the diastolic blood pressure. In PL, there was post exercise hypertension, but with attenuated values in relation to the CO. In conclusion, coffee intake not only abolishes post exercise hypotension in hypertensive people, but also causes a hypertensive response.
Key-words: Blood pressure. Hypotension. Adenosine. Caffeine.

INTRODUCTION

Systemic arterial hypertension (SAH) is the most prevalent chronic disease in industrialized countries. In Brazil, the prevalence varies between 22.3% and 44.4%, depending on the region studied (FUCHS et al., 1994; BOING; BOING, 2007; CASTRO; MONCAU; MARCOPITO, 2007; LATERZA; RONDON; NEGRÃO, 2007). Besides, it represents an important socioeconomic problem, being one of the main causes for early retirement and absences from work, resulting in high costs to government spending (ROLIM; AMARAL; MONTEIRO, 2007).

Physical exercise has been proving an important tool in the treatment of SAH, reducing blood pressure (BP) in hypertensive subjects in a similar range to that obtained through the use of one of the classes of anti-hypertensive drugs (BASTER; BASTER-BROOKS, 2005). One single section of aerobic physical exercise is capable of causing BP to reduce from 2 to 17 mmHg for systolic blood pressure (SBP), and from 2 to 7 mmHg for diastolic blood pressure (DBP), when compared to levels of pre-exercise rest (FORJAZ; RONDON; NEGRÃO, 2005). Such reduction in blood pressure after exercise is called post exercise hypotension (PEH), and may last up to 24 hours (FAGARD, 2001; BASTER; BASTER-BROOKS, 2005). The range of PEH relates to factors such as pre-exercise level, the type of exercise performed, the intensity of the exertion and the duration of the session (FAGARD, 2001).

Although not well clarified, the most accepted mechanisms involved in PEH now are of neural, metabolic and hemodynamic order, including improvement in the bar reflex sensitivity, reduction in the sympathetic nervous activity, increase in the endothelial production of nitric oxide and reduction in the plasmatic volume (HALLIWILL, 2001; ZANESCO; ANTUNES, 2007; ANUNCIACAO; POLITO, 2011).

Activities of the daily life of most of subjects, like the intake of some foods, may act over some of these mechanisms, which could interfere with the PEH. As examples of that, there are the foods rich in caffeine, such as cola soft drinks, soda, chocolates, teas and coffee. Of these foods, coffee is part of the culture of many peoples, especially in Brazil, one of the main producers of this grain in the world.

A portion of 150 mL of coffee (equivalent to one cup) contains between 64 and 124 mg of caffeine, depending on the species, roasting and preparation technique (BARONE; ROBERTS, 1996). The amount of caffeine present in three cups of coffee is already enough to onset a vasoconstriction, which can be mediated by an increase in the sympathetic nervous activity or, intrinsically, by competitive inhibition of adenosine activity (a potent vasodilator) in its A_1 receptors (CAVALCANTE et al., 2000; NOTARIUS et al., 2001; NOTARIUS; MORRIS; FLORAS, 2006; RIKSEN; RONGEN; SMITS, 2009). Besides, it is a classic knowledge that caffeine stimulates ryanodine receptors in the sarcoplasmic reticulum, leading to the release of calcium into the cytosol and consequent vasoconstriction (UREÑA; VALLE-RODRÍGUEZ; LÓPEZ-BARNEO, 2007).

Blood pressure response promoted by physical exercise in relation to caffeine intake has already been investigated, and it has been documented that this substance attenuates the hypotensive effect of exercise (CAVALCANTE et al., 2000; NOTARIUS et al., NOTARIUS; MORRIS; FLORAS, 2006). In spite of the importance of information obtained in these studies, they were conducted with pure caffeine, and not with foods that are made of it, which detaches such laboratorial data from the daily reality of people. Therefore, studies investigating the effects of foods rich in caffeine are pertinent to provide a greater support to those previous studies, besides serving as a guide to orientate hypertensive subjects who perform exercise as an anti-hypertensive therapy.

In face of the exposed, the purpose of this study was to investigate the effects of coffee intake after physical exercise on the hypertensive response of hypertensive subjects who performed physical exercises as an anti-hypertensive therapy and who present a history of acute reduction in BP in the first hours after exercising.

METHODS

Sample selection

The study was conducted with a population of hypertensive people of both genders, practitioners of walking in a project developed by the division of Physical Education of the university hospital of the Federal University of Paraíba (UFPB). To participate in the study, the subjects should have being practicing physical activity for at least three months and three times a week, besides having, at most, three absences per month. They should consume coffee in at least one of their meals and present history of reduction in blood pressure after the exercises they performed (PEH). The project was submitted to the Ethics Committee on Research Involving Humans of the Center of Health Sciences of the UFPB and approved by it under protocol No 1428/07.

To select the subjects, it was taken into account that they had their rest BP measured 10, 15 and 20 minutes after exercise regularly registered in individual records. With these records in hands, the researchers determined the subjects who presented PEH of at least 2mmHg for both SBP and DBP. This hypotension should repeat in at least seven of the ten last sessions of exercise. As the intention was to work only with those subjects who clearly presented PEH, we selected only those subjects who presented quick post exercise hypertensive response.

It was verified that eight subjects suffered from PEH. Six of them – out of whom three were men – with average age of 56.7±4.5 years old (51 to 60 years old), borderline hypertensive, users of antihypertensive drugs of the class of beta blockers and calcium channel blockers (always in the morning), accepted to participate in the study by signing an informed consent form, in accordance with the norms of Resolution No 196/96 of the National Council of Health.

Study design

The design of this research followed the double blind, randomized and placebo-controlled method. Each subject performed three sessions of exercises, 40 minutes each, with intensity between 60% and 70% of the maximum heart rate (MHR), with an interval of 48 hours in between, under the following conditions: 1 – Intake of three cups of coffee, 10, 20 and 30 minutes after the exercise (CO); 2- Intake of a placebo product in the same moments (PL): 3- Intake of water, also in the same moments (WT). BP was measured before, immediately after, and 9, 19 and 29 minutes after the completion of the exercise and, from then, every 15 minutes, until completing 120 minutes after the exercise. To minimize possible monotonies in this space of 120 minutes, a movie with no emotional character was showed (animation), from the moment the protocol of liquid intake finished. The subjects were allowed to get up and go to the bathroom at any moment, if they needed to. The study was conducted always between 2pm and 5pm.

Preparation and intake of coffee, placebo and water

The coffee chosen is composed of 1.2% of caffeine. The placebo used was decaffeinated coffee of the same brand, containing 0.3% of caffeine. These data were acquired after a visit to the industry with the company's food engineer, after the presentation of the technical report about the manufacturing of the product. All packages of conventional or decaffeinated coffee belonged to the same manufacturing lot.

To prepare an amount equivalent to three cups of coffee, 40g of conventional or decaffeinated coffee powder were used, containing 480mg and 120 mg of caffeine, respectively. The powder was weighed on a Plenna precision scale (Apollo model, Plenna manufacturer). 500 mL of water were heated for 5 minutes, to avoid boiling and decrease in the volume of water and, consequently, of the concentration of caffeine. This volume was enough to all three cups, each one with a volume of 140 mL. To ensure that the subjects ingested this same volume in all moments, the same precision scale was used to weigh the 140 mL as representative of 140g, without adding the weight of the cup. The coffee and the placebo were percolated with Mellita® paper filters appropriate to this purpose.

In each one of the three days when the exercise was performed, one cup of coffee, placebo or water was ingested 10, 20 and 30 minutes after the completion of the exercise. During the moment of intake, the individuals remained seated and were asked to ingest the coffee, placebo or water, at most, in five minutes. The order the liquids were ingested every day was randomly defined. It is worth stressing that the coffee or placebo was administered through the double-blind method.

Blood pressure measurement

When the subjects arrived to the place of data collection, they were asked to remain seated for 10 minutes, and then had their rest BP measured. Right after this first measurement, the subjects performed a warm-up and fulfilled the exercise protocol.

At the end of the exercise, new measures were taken immediately after the exercise and during the rest period, 9, 19 and 29 minutes immediately before the moments of intake of coffee, placebo or water. From this last measurement, new verifications of BP were carried out every 15 minutes until completing all 120 minutes of rest proposed in the study. During this entire period, the subjects remained seated.

BP was verified through the auscultator method, strictly following the protocol proposed in the VI Brazilian Guidelines on Hypertension (SOCIEDADE BRASILEIRA DE HIPERTENSÃO, 2010). To measure BP, a BD® aneroid sphygmomanometer, with precision of 2mL of mercury, previously calibrated against a column of mercury and a stethoscope of the same brand, were used.

Physical Exercise

Each subject performed three sessions of aerobic exercise on three alternate days, separated by 48 hours in between each of them. Each session consisted of 40 minutes of walking on a Proaction BH Fitness® treadmill, with intensity of 60% - 70% of the MHR. To determine the heart rate zone that corresponds to this intensity of training, the equation proposed by Karvonen, Kenatal and Mustala (1957) was used.

$$THR=RHR+\%I\ (MHR-RHR)$$

Where:

THR = Training Heart Rate

RHR = Resting Heart Rate

%I = Intensity (60% - 70% of the MHR)

MHR – 204-1.07* age (BRUCE et al., 1974)

To determine the resting HR, a Polar® heart rate monitor, F5 model, with precision of one systole per minute, was used. The subjects were instrumented with the monitor and remained seated for 10 minutes before performing the exercise. The lowest value of heart rate registered in this period was considered as the resting heart rate. The MHR used in this equation was determined according to the protocol by Bruce, Fisher and Cooper (1974). This equation, to estimate the maximum HR, was chosen for having been developed with a specific hypertensive population.

For the subjects who use beta blockers, a correction in the results found in the calculation of the target zone was necessary, because this class of antihypertensive drug reduces the chronotropic activity, observed both at rest and during exercise. To correct this phenomenon, the equation proposed by Passaro and Godoy was used (SOCIEDADE BRASILEIRA DE CARDIOLOGIA, 2005), described below.

$$\%R = \frac{Y + 95.58}{9.74}$$

Where:

%R= Percentage of reduction Y = Drug dosage

To guarantee that the subjects performed the exercise within the prescribed heart rate zone, the HR was monitored every 3 minutes. The subjects performed the exercise with the same monitor used to determine the resting heart rate. The first three minutes of exercise were used to adjust the speed of the treadmill, until HR stood within the prescribed training zone. From this moment, this speed was maintained, as long as every 3 minutes the HR continued within the training zone or was adjusted when this chronotropic response stood above or below the prescribed training zone.

Data treatment

Data are presented as mean of heart rate and of blood pressure. To determine possible differences in the blood pressure behavior between the procedures carried out, a two-way ANOVA was used and, later, Tukey's Post Hoc too, with level of significance set at P <0.05. All data were analyzed through the software SPSSO, version 16.0.

RESULTS

The characteristics of the participants of the study are described in Table 1. They are middle-aged, have average body mass index (BMI) compatible with overweight and present similar means of SBP, DBP and HR in both procedures

Table 1 – Anthropometric and resting cardiovascular parameters of the participants of the study (n=6) subjected to the coffee, placebo and water procedures

Parameters	Values
Age (years)	56.7± 4.5
Height (cm)	1.67± 0.1
Body mass (kg)	66. 2± 10.5
BMI (kg/m^2)	23.7± 2.1
SBP (mmHg)	
Coffee	114.7± 12.0
Placebo	114.0± 11.3
Water	106.0± 14.2
DBP (mmHg)	
Coffee	73.3± 8.8
Placebo	73.7± 9.9
Water	72.8± 7.2
HR (bpm)	
Coffee	68.7± 7.3
Placebo	72.3± 8.9
Water	65.3± 9.8*

Data are presented as mean and standard deviation. BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate. *statistic difference in relation to the placebo procedure ($p<0.05$).

The behavior of the SBP, in response to the three sessions of physical exercise and during the rest periods with intake of CO, PL or WT, is displayed in Figure 1. Immediately after the end of the exercise, the SBP was high in relation to the basal values in the three procedures, which corresponds to the physiological response to the exercise for this variable. In the same way, during the first nine minutes of rest, the SBP values suffered an important reduction, which characterized the classic PEH that usually occurs in response to exercises.

Nevertheless, this physiological behavior changed from the moment the subjects ingested coffee, placebo or water. The same figure shows that in the procedure with WT the PEH phenomenon occurred normally, with the SBP following its natural decrease until 120 minutes after exercise. Meanwhile, in the CO procedure, not only the PEH was abolished, but there was also a sharp decrease in the SBP, in such a way that the subjects finished the protocol with blood pressure levels superior to the basal values in this procedure. It is worth stressing that the decaffeinated coffee (used as placebo) has not promoted the same hypertensive response as coffee has; however, although the behavior of the SBP curve has proven similar to the WT procedure, the PEH phenomenon was lightly attenuated.

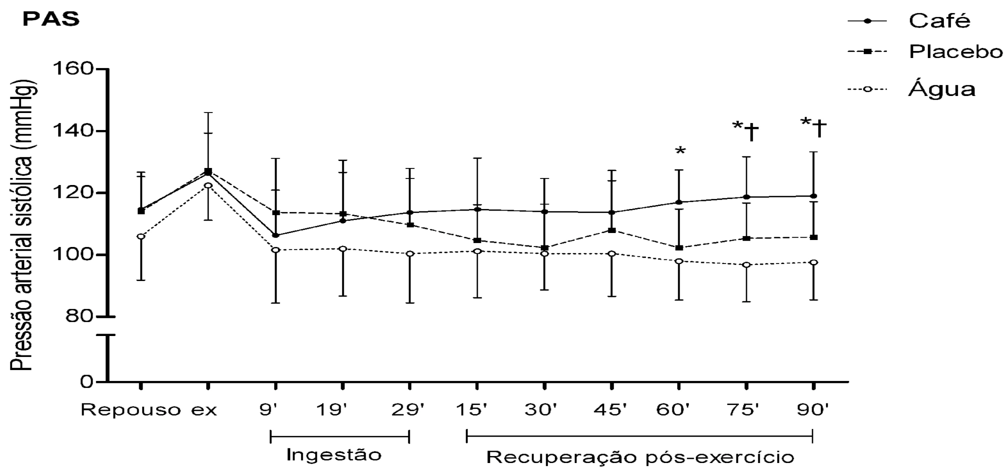

Figure 1 – Average behavior of the systolic blood pressure at rest, immediately after the exercise, 9, 19 and 29 minutes before the intake of coffee, placebo or water, and 90 minutes after the intake of the substances. E.g. immediately after the exercise.

† Statistic difference between coffee and placebo ($p < 0.05$).

Statistical tests for the SBP revealed that significant differences between CO and PL appeared from the 75th minute after the intake of the last cup of the substances, while in relation to the WT no statistically significant differences have been found from the 60th minute ($p < 0.05$).

Differently from what happened with the SBP, the CO, PL and WT procedures have not promoted so visible differences for the DBP (Figure 2). It is possible to observe that hypotension occurred naturally when water was ingested, but the DBP curves in the procedures with coffee and placebo were not distinct. Only after 60 minutes after the exercise (30 minutes after the intake of the last cup of all substances) the blood pressure values in the procedure with CO presented a trend to increase, in such a way that the value of the last BP measurement was statistically different in relation to the WT procedure.

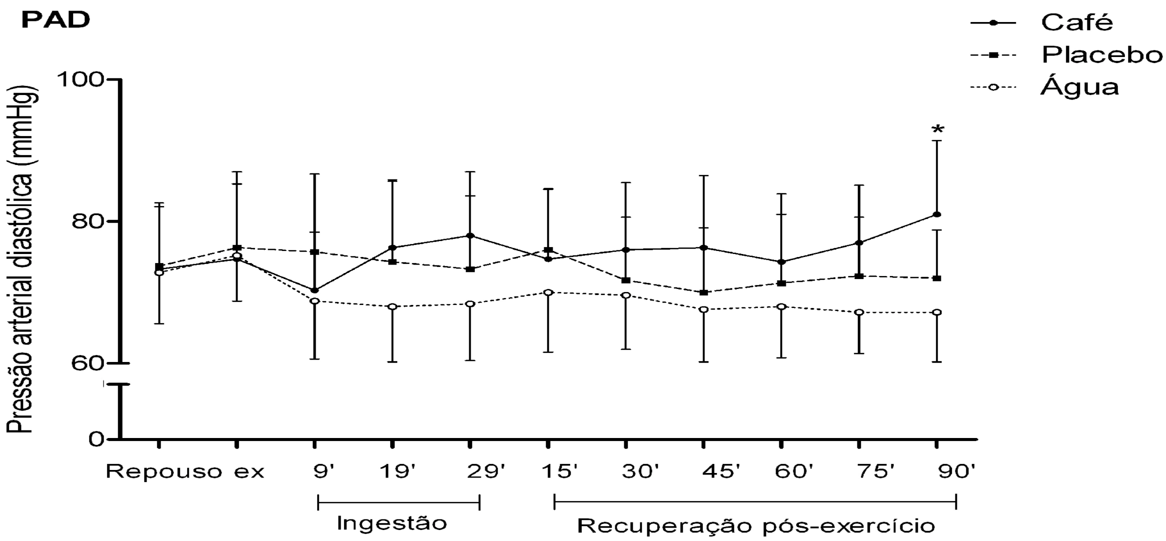

Figure 2 – Average behavior of the diastolic blood pressure at rest, immediately after the exercise, 9, 19 and 29 minutes before the intake of coffee, placebo or water, and 90 minutes after the intake of the substances. E.g.: immediately after the exercise.

* Statistic difference between Coffee and Water ($p < 0.05$).

The PEH phenomenon was calculated from the difference between the means of the last BP measure and the basal values. While the procedures with placebo and water resulted in a reduction of 7.9% and 7.3% and of 2.3%, and 7.7%, respectively for SBP and DBP, the intake of coffee promoted an increase of 3.7% and 10.5% for SBP and DBP, respectively; therefore, the intake of coffee resulted not only in PEH abolition, but in a hypertensive response in the first two hours that followed the exercise, while the procedures with intake of water and placebo did not differ between each other. Figure 3 displays the absolute values for these very same blood pressure responses.

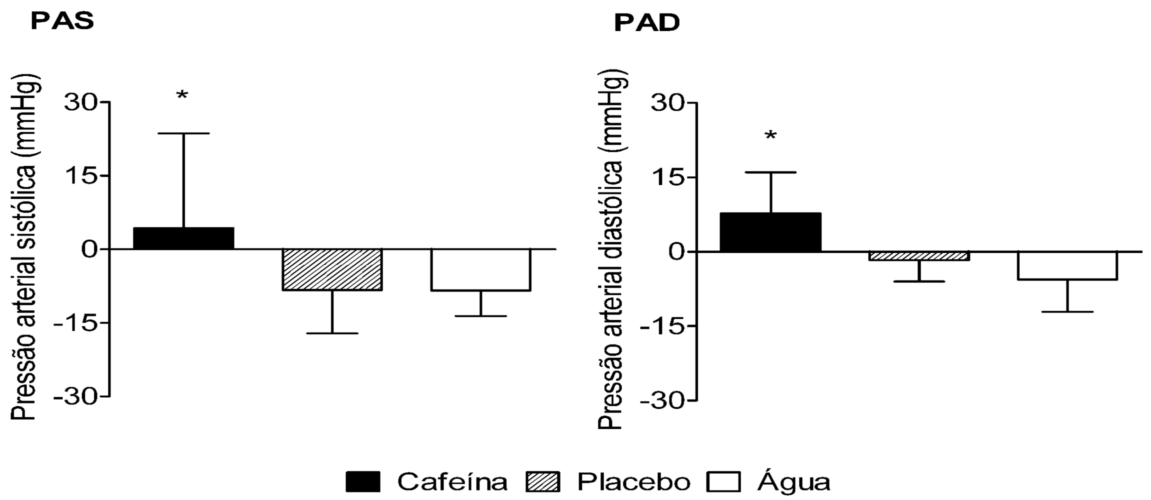

Figure 3 – Absolute delta of the systolic and diastolic blood pressure in the coffee, placebo and water procedures.

* Statistic difference between the procedures ($p < 0.05$).

DISCUSSION

The present study has demonstrated that the intake of coffee after a session of aerobic exercise not only abolished the PEH but also promoted a hypertensive response in relation to basal values. The results also indicated that this phenomenon occurred 10 minutes after the subjects ingested the first cup of coffee; however, the PEH phenomenon classically found in response to exercise remained when the subjects ingested water or placebo.

The literature has been pointing PEH values between 2 and 17 mmHg for SBP and between 2 and 7 mmHg for DBP, both for normotensive and hypertensive individuals (FORJAZ; RONDON; NEGRÃO, 2005). The range of hypotension in the PL and WT procedures corroborated these previous findings.

The substance used as placebo was decaffeinated coffee. This product still contains a concentration of caffeine, although much lower than that of the traditional coffee (120mg against 480mg, for decaffeinated and traditional coffee, respectively). In spite of that, our study has demonstrated that the blood pressure response of subjects who ingested decaffeinated coffee was much more similar to the procedure with water than when the subjects ingested coffee, although with an attenuation from the PEH to the DBP.

Regarding the traditional coffee, previous data confirm the fact that the intake of this product increases BP (LOVALLO et al., 2004; FARAG et al., 2010; GIGGEY et al., 2011), but most of these studies were conducted with subjects at rest, without considering the responses of the exercise. Corti et al. (2002) observed increase both in SBP and in DBP in response to the intake of decaffeinated coffee (250mg of caffeine). This value was much superior to that used in our study. Lane et al. (2002) analyzed the ambulatory blood pressure monitoring of individuals who habitually consumed beverages containing caffeine. They had their BP measured for three days. In the first day of study, the subjects consumed, freely, beverages with caffeine; in the second and third days, a dose of 500mg/day of caffeine or placebo was administered in two doses of 250mg each. It was observed that BP was higher with the administration of caffeine (+4 and +3 mmHg for SBP and DBP, respectively). Mort and Kruse (2008) point, in a review study, that the intake of caffeine increases blood pressure levels from 3 to 15mmHg for SBP, and from 4 to 13mmHg for DBP.

Some studies have investigated the effects of caffeine on blood pressure response to exercise. Thus, Notarius, Morris and Florais (2006), evidenced that middle-aged subjects, with high cardiovascular risk (it is not clear if they were hypertensive), who received intravenous administration of 4mg per body Kg had only an attenuation of BP and not a hypertensive response as that observed in the present study. Cavalcante et al. (2000) conducted an experiment with health youths who used the amount of 750mg of caffeine divided into three daily doses, during seven days. The behavior of BP was observed through the handgrip test, which measures, in a direct way, the isometric force. The results presented no significant increase in SBP throughout the study, showing that the subjects were tolerant to caffeine, but DBP showed significant elevation after 24 hours. It must be emphasized, as for the study aforementioned, that the handgrip exercise is very different from the dynamic aerobic exercises used in the present study. Since the handgrip is a localized exercise and activates a small muscle mass, it is expected that BP does not change very much in relation to the rest values.

A study by Cavalcante et al. (2000) observed that the acute increase in DBP disappears with chronic caffeine intake by subjects used to consume coffee in their diet. Our study only counted with the participation of subjects who were already hypertensive and used to ingest coffee at least once a day, but even so, they responded to the intake of coffee with hypertensive activity after exercise. In face of these conflicts, it is possible to see the need for a greater deepening into this question in further studies, particularly because, as far as we know, our study is the first one in which the influence of coffee on PEH was investigated in hypertensive individuals. More studies with this population are important because many hypertensive people exercise and ingest coffee in meals that occur in the first hours after practicing physical training.

The PEH phenomenon is well clarified and occurs both in response to aerobic exercise and after sessions of resistance exercises (FAGARD, 2001; POLITO; FARINATTI, 2009). The mechanisms listed so far to explain PEH are of hemodynamic, metabolic and neural nature. The hemodynamic alterations occurred after the exercises are increase in cardiac output and reduction in plasmatic volume. Among the metabolic mechanisms, the increase in shear stress during the exercise is directly related to the release of vasodilator substances, like prostaglandin, hyperpolarizing factors derived from the endothelium and, mainly, nitric oxide (HALLIWILL et al., 1996; O'SULLIVAN; BELL, 2000; HALLIWILL; MORGAN; CHARKOUDINA, 2003, 2003). The neural mechanisms involved are better balance between sympathetic and parasympathetic discharges, besides improvement in the baroreflex function. Thus, a reduction in the release of P substances into the solitary nucleus after the performance of exercise results in a lower transmission of *gamma*-Amino butyric acid neurotransmitters (GABA) to its gabaergic interneurons, greater excitation of the neurons in the caudal ventrolateral medulla, inhibition of the neurons in the rostral-ventrolateral area of the bulb and, consequently, reduction in the sympathetic nervous activity (CHEN; BONHAM, 2010).

Of all these mechanisms, the main candidate to vasodilation that relates to caffeine is the adenosine. During exercise, the hydrolysis of the adenosine triphosphate (ATP) originates the adenosine that, in turn, remains accumulated in the interstice in post exercise moments. The adenosine attaches to its specific receptors $_{(A2a}$ ^{and} $_{A2b)}$ and promotes a cascade of reactions that result in the relaxation of the vascular smooth muscle (LATINI; PEDATA, 2001; MUBAGWA; FLAMENG, 2001; RAMKUMAR; HALLAM; NIE, 2001; NOTARIUS et al., 2001). Caffeine, administered orally or intravenously, acts in the organism competing with the adenosine for its receptors. Thereby, the attachment of caffeine inhibits all the cascade of reactions produced by the adenosine and generates a vasoconstrictor response (MUBAGWA; FLAMENG, 2001; RIKSEN; RONGEN; SMITS, 2009). Besides, the vasoconstriction provoked by caffeine may occur after the release of Ca^{2+}, through activation of ryanodine receptors into the sarcoplasmic reticulum, since these receptors are sensitive to this substance (OSTROVSKAYA et al., 2007; UREÑA; VALLE-RODRÍGUEZ; LÓPES-BARNEO, 2007). Gómez-Viquez et al. (2005) observed that, even in the presence of ryanodine, caffeine does not have its function reduced in the sarcoplasmic release of Ca^{2+} into the cells of the smooth muscle of the urinary bladder. In the same way, Ostrovskava et al. (2007) showed that, in the cells of the smooth muscle of the pulmonary artery, caffeine increased the release of Ca^{2+} by the sarcoplasmic reticulum. In opposition to the ryanodine - Ca^{2+} hypothesis, Fredholm et al. (1999) state that doses 100 times higher than the caffeine contained in one cup of coffee are necessary for these receptors to be activated; but it is worth stressing that these findings come from experiments conducted at a level of cerebral arterial bed.

The abolition of the PEH by caffeine may occur also by an increase in the plasmatic concentration of cathecolamines. Notarius, Morris and Floras (2006) reported that this may occur through a greater release of cathecolamines by the adrenal glands or by the inactivation of one of the functions of the adenosine, which is to limit presynaptic release of neural noradrenaline. Norager et al (2006) corroborate this finding, observing that health elderly who ingested 6mg per Kg of body weight of caffeine responded to an exercise test with increase of 49% in the concentration of adrenaline, and 29% of noradrenaline. Fortes and Whitham (2011) also associated caffeine intake with increase in the production of cathecolamines in health men after exercise on treadmill to explain the increase in the activity of the heat shock protein 72 (Hsp72), a substance involved in the response to the elevation in body temperature during exercise, and in psychological stress.

Altogether, these pieces of information reinforce the hypothesis that coffee intake abolishes post exercise hypotension, mainly via activation of specific alpha-adrenergic receptors and increase in the secretion of cathecolamines, with an arguable possibility of the participation of ryanodine receptors.

The main aspect that differs the present study from others that have investigated this relationship between caffeine and blood pressure response to exercise is that, while most of all previous studies have used pure caffeine with intravenous application to investigate its effects on the blood pressure response, the present study used the traditional coffee, of a brand consumed among the subjects of the study. This methodology is very close to the reality of the subjects who used exercise as a non-medication treatment to arterial hypertension and who, at the same time, are coffee consumers.

Because the procedures are closer to the daily routine of these subjects, the data of this study indicate that they may be limiting or cancelling the classic PEH obtained with the exercise. This points that physical educators and nutritionists need to work together, adjusting the ideal moments for physical exercise and intake of foods rich in caffeine so that both professional conducts may not mutually cancel their therapeutic purposes referring to arterial hypertension.

In addition, aiming the preparation of adequate procedures for the practice of physical exercises, the present study brings to light two questions that deserve to be investigated in the future. The first of them is that, as coffee was ingested only a few minutes after the exercise, in order to prevent the PEH phenomenon, there should be also an investigation on the effect of the administration of coffee only after the PEH process is installed; and the second is that, because we were concerned about conducting this study with a group of subjects with homogenous characteristics (all controlled hypertensive, practitioners of exercises and responsive to the training with post exercise hypotension), the number of subjects involved in the study reduced and restricted to a very small age group. In face of that, a further study in which coffee is administered only after one or two hours after the end of the exercise is recommended, contemplating other age groups and a larger number of subjects, in order to allow for the inference of data for the hypertensive population.

The amount of three cups of coffee we used and the time interval in which they were ingested may not reflect the reality of the population (three cups of 140mL each, within an interval of only 30 minutes). Besides, this study has not allowed diagnosing the maximum amount of coffee that could be used without negatively interfering with the PEH response. To clarify this question, new studies should be conducted by using the intake of varied amounts of coffee, in order to establish the minimum concentration of caffeine that would cause important alterations in BP.

Moreover, other factor that can be considered determinant in the final concentration of caffeine is the boiling time. It prevents us from determining the exact concentration of caffeine after the preparation of the coffee (BELL; WETZEL; GRAND, 1996). This characterizes a methodological difficulty in the conduction of studies with the beverage coffee; for this reason, further studies are necessary to analyze the caffeine content at the end of the preparation of the coffee.

After solving these questions in future studies, physical educators and nutritionists will have more efficient tools to better instruct hypertensive individuals regarding the attitude to adopt, in order to harmonize diet habits and physical exercise towards the control of arterial hypertension.

CONCLUSION

The results of this study evidenced that the intake of three cups of coffee not only abolishes PEH, but also causes a hypertensive reaction in response to a session of aerobic physical exercise.

This result is of great importance to hypertensive individuals who have the habit of consuming coffee in their diet and use physical exercise as a form of treatment to hypertension. Since small amounts of coffee are habitually used by these subjects and may not negatively interfere with the PEH, further studies are necessary to better define the safe volume of this beverage, as well as to maintain the effects of the exercise, to better assist physical educators and nutritionists when dealing with arterial hypertension.

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