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Study of Morning Coffee Intake in Healthy Subjects Using Pulse Rate Variability

Neelamshobha Nirala[1]
[1]*Department of Biomedical Engineering, NIT-Raipur, India*

Abstract: ***It is well known that coffee has significant affect in the functioning of autonomic nervous system (ANS). Non-invasive study of ANS by heart rate variability was well documented. We aimed to study the effect of one cup of early morning coffee ingestion in healthy adults. We included total 35 healthy college going students with a mean age of 21.628 years. 5 minutes continuous photoplethysmogram(PPG) signal was recorded in three steps: one before coffee intake and after that two readings at an interval of 30 minutes after coffee intake. 12 features defining heart rate variability were obtained using Kubios software and significant difference were computed using statistical analysis. Only high frequency power indicating parasympathetic division of ANS showed significant decrease after half an hour of coffee intake which was again neutralised after one hour.***
Keywords*:* ***Coffee, Caffeine, Heart-rate variability, Autonomic nervous system, Photoplethysmogram, Pulse rate variability***

I. INTRODUCTION

Many of us rely on a cup of coffee to overcome our boredom or laziness. Coffee contains caffeine which is a central nervous system stimulant. Caffeine is an alkaloid compound which is found especially in tea and coffee plants and is a stimulant of the central nervous system. It is one of the most widely used pharmacologically active substances[1]. Many mechanisms were known to explain the effect of caffeine but the most prominent is reversible blockage of the action of adenosine on its receptor, which eventually prevent the drowsiness caused by adenosine[2]. Both coffee and caffeine were found to be responsible for increase in muscle sympathetic activity[3]. Acute doses of caffeine was also reported to affect the autonomic nervous system (ANS) function[4]. Enhancement of parasympathetic nerve activity was reported by the consumption of caffeine containing beverages[5]. Study even reveal the improvement of autonomic functions in diabetic and healthy volunteers by consuming modest amounts of caffeine[6]. Both heart rate variability(HRV) and pulse rate variability(PRV) were used for the non-invasive assessment of ANS. Few studies suggest that PRV can be used as a surrogate for HRV analysis so that the data acquisition can be at easy[7], [8]. Many studies have demonstrated the effect of caffeine on HRV. In this study we use PRV to study the acute effect of a cup of coffee on 35 healthy young college going students as the first intake of the day.

II. MATERIAL AND METHODOLOGY

A. Subject Selection

In this study, we have included total 35 healthy adult volunteers in the age group of 21 to 24 years. All the participants are healthy college going students who were dealing with various levels of physical activity in their everyday lives and none of them were under any prescribed medication.

B. Measurement System

Data collection was done using four channel BIOPAC mp36 data acquisition system. One PPG sensor(SS4LA) working at the wavelength of 860nm were used to obtained the PPG signal from the right index finger of each participant. Each channel of mp36 has a digital programmable filter for removing power line interference and external noise. For PPG sensor one low pass filter with the cut-off frequency of 35.5 Hz and another high pass filter at the cut-off of 0.05 Hz was placed to remove very low frequency and high frequency noise. Another notch filter of 50 Hz was used to remove power line interference. Data from PPG sensor were recorded continuously for 5 minutes in each step using 24-bit analog to digital conversion at the sampling rate of 250 samples per second. Acquired data were stored in text format for later use and all pre-processing was done in MATLAB software.

C. Preparation of Coffee

One cup of coffee was prepared by adding one teaspoon (5 grams) of Bru instant coffee powder and 10 grams of sugar into 150 ml boiling water. 5 grams of coffee powder contains 1.3mg of caffeine. Intentionally milk was not added to obtain better result. Once the coffee is cool enough for drinking it was given to the participants to drink.

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D. Measurement Protocol

All the data were recorded in college campus. As we are solely interested in observing the effect of a cup of coffee, we took all data during early morning at an empty stomach. For these, the participants were informed one day earlier to come early morning to the data collection room. Data were collected in three steps and in each step 5 minutes PPG signal were acquired. First the PPG signal was recorded for 5 minutes in empty stomach without taking any food or drinks. Once the data were acquired participants were given a cup of coffee to drink which contains one teaspoon of coffee powder (around 5 grams of coffee powder). Second PPG signal were obtained after 30 minutes of coffee intake, in between participants were not allowed to eat or drink anything. Last 5 minute PPG signal were acquired after 30 minutes of passing the second reading. So total 3 five minutes PPG signal were obtained from each subject at an interval of 30 minutes. Above mentioned protocol was given graphically in Figure 1.

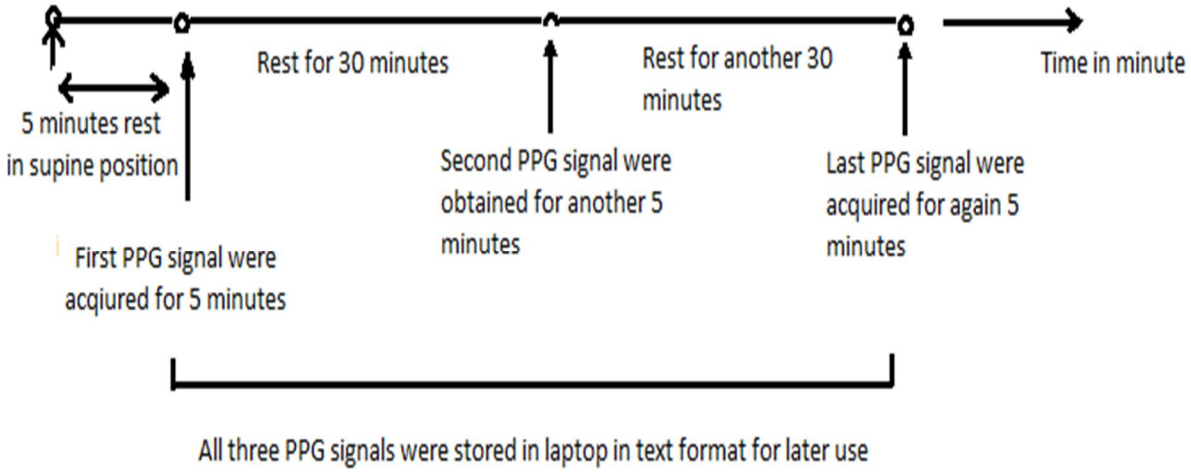

Figure 1. Schematic diagram of measurement protocol

E. Pre-Processing

All the three acquired PPG signal set from each participant were first corrected for baseline wandering using interpolation method. From the baseline corrected PPG signal peak and valley detection algorithm were applied. Based on two consecutive peaks, peak to peak interval were calculated. This peak to peak interval were then feed to the Kubios software for feature extraction.

F. Feature Extraction

Kubios is a freely distributed software for advanced Heart Rate Variability (HRV) analysis. The analysis options of the software include all the commonly used time-domain, frequency-domain and nonlinear HRV parameters, were the analysis results can be saved as any one of the following format: PDF report, ASCII text file or MATLAB file. The software is easy to use through its compact graphical user interface. From the Kubios software we have collected total 12 features 3 from time-domain, 6 from frequency domain and another 3 from nonlinear parameters.

G. Statistical Analysis

Statistical analysis was performed using paired t- test in SPSS (Statistical Package for Social Sciences) software. The values are reported as mean ± standard deviation and the P-value is calculated to know the significant change in each parameter compared.

III. RESULTS

We have taken the PPG signal from 35 subjects in three steps, first empty stomach, second after half an hour of coffee intake and last one hour after coffee intake. Complete details of the participants were given in table I. We did statistical analysis to obtain the significant difference between these three sets of PPG signal in terms of obtained features. Complete result is provided in table II. We obtained significant difference only for one feature that is ARPOWER(MS2) HF.

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Table I. Demographic Details of Participants

Features		Values
Number of participants		35
Male: Female		16:9
Usual preferred beverage in daily routine	Coffee (number of subject)	1
	Tea(number of subject)	6
	Both coffee and tea(number of subject)	17
	Nothing (number of subject)	11
Age (in years)		21.628±2.289
Height (in meters)		1.665±0.083

Table II. Result of Statistical Analysis of the Features

FEATURES	EMPTY STOMACH	AFTER HALF AN HOUR	AFTER ONE HOUR	P VALUE	
				(B-H)	(B-O)
SDNN	66.287±33.187	64.069±28.711	63.085±23.296	0.73	0.565
RMSSD	62.712±28.289	61.835±23.225	60.025±25.313	0.854	0.452
HRVTRI	8.846±2.322	8.916±2.8	8.772±2.244	0.9	0.891
VLF(ms2)	2679.797±4770.449	1608.9312±3954.85	3108.197±1243.252	0.345	0.859
LF(ms2)	2159.074±2522.475	2333.146±2263.905	2595.057±4888.625	0.745	0.613
HF(ms2)	2974.477±3589.427	1661.05±1449.062	2063.334±1973.284	0.043*	0.143
LF NORM	47.596±21.162	52.281±19.841	50.361±18.88	0.313	0.548
HF NORM	52.254±21.152	47.518±19.783	49.384±18.961	0.306	0.536
LF/HF (ms2)	1.403±1.397	1.947±3.056	2.246±6.008	0.301	0.409
NLSD1	44.82±20.193	44.265±16.653	42.932±18.083	0.871	0.461
NLSD2	80.958±44.603	78.01±37.572	76.623±29.784	0.733	0.592
NLSD2/SD1	1.834±0.646	1.756±0.454	1.883±0.673	0.566	0.763

Data are written as mean ± standard deviation, * indicate significant difference with p-value less than 0.05
SDNN-SD of NN interval
RMSSD- Root of the mean of the sum of the squared differences of adjacent NN intervals
HRV triangular index (HRVTRI)
Very low frequency (VLF) power
Low frequency (LF) power
High frequency (HF) power
LF normalized power (LF NORM)
HF normalized power (HF NORM)
In Poincare plot, Standard deviation of the points perpendicular to the line of identity (NLSD1)
In Poincare plot, Standard deviation along the line of identity (NLSD2)

IV. DISCUSSION

Effect of caffeine on autonomic nervous system is well known. Even though many articles have discussed the effect of coffee or caffeine consumption using HRV, results were contradictory[9]. Some studies support that coffee intake can increase the high frequency (HF) power indicating an increase in parasympathetic activity while others assert no significant effect on HRV. In one

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study, a cup of espresso coffee containing 75mg of caffeine showed increase in HF at supine positon but no change in seated position[10]. In another study a transient and significant increase in HF power was noted after the consumption of 240mg of caffeine containing beverage[5]. Similarly, intravenous infusion of 4mg/kg caffeine was shown to increase the vagal heart rate modulation in healthy subjects[11]. However, another study on 30 habitual caffeine consumers showed no perceptible change in HRV within 90 minutes of 200mg of caffeine intake. Similar results were demonstrated on 50 healthy South Indian usual coffee consumer male adults. That study obtained a significant increase in heart rate and blood pressure but no significant change in HRV[12]. In our study, out of 12 features indicating HRV analysis we obtained a significant difference only in terms of HF power that also only after 30 minutes of coffee intake. This significant difference again neutralizes after one hour of coffee ingestion. There were a few limitations in our study like, the amount of caffeine given to the subject is very low in content, less number of subjects were taken into consideration, and the time gap considered between each measurement should have been decreased. Our study includes only 2 reading after coffee intake at an interval of 30 minutes. We have not included any other physiological parameters like blood pressure, heart rate and respiration rate.

V. CONCLUSION

In our study we observed that intake of a cup of coffee in early morning has indeed has the capability to alter the parasympathetic division of autonomic nervous system. This changes can be seen by pulse rate variability in healthy adults.

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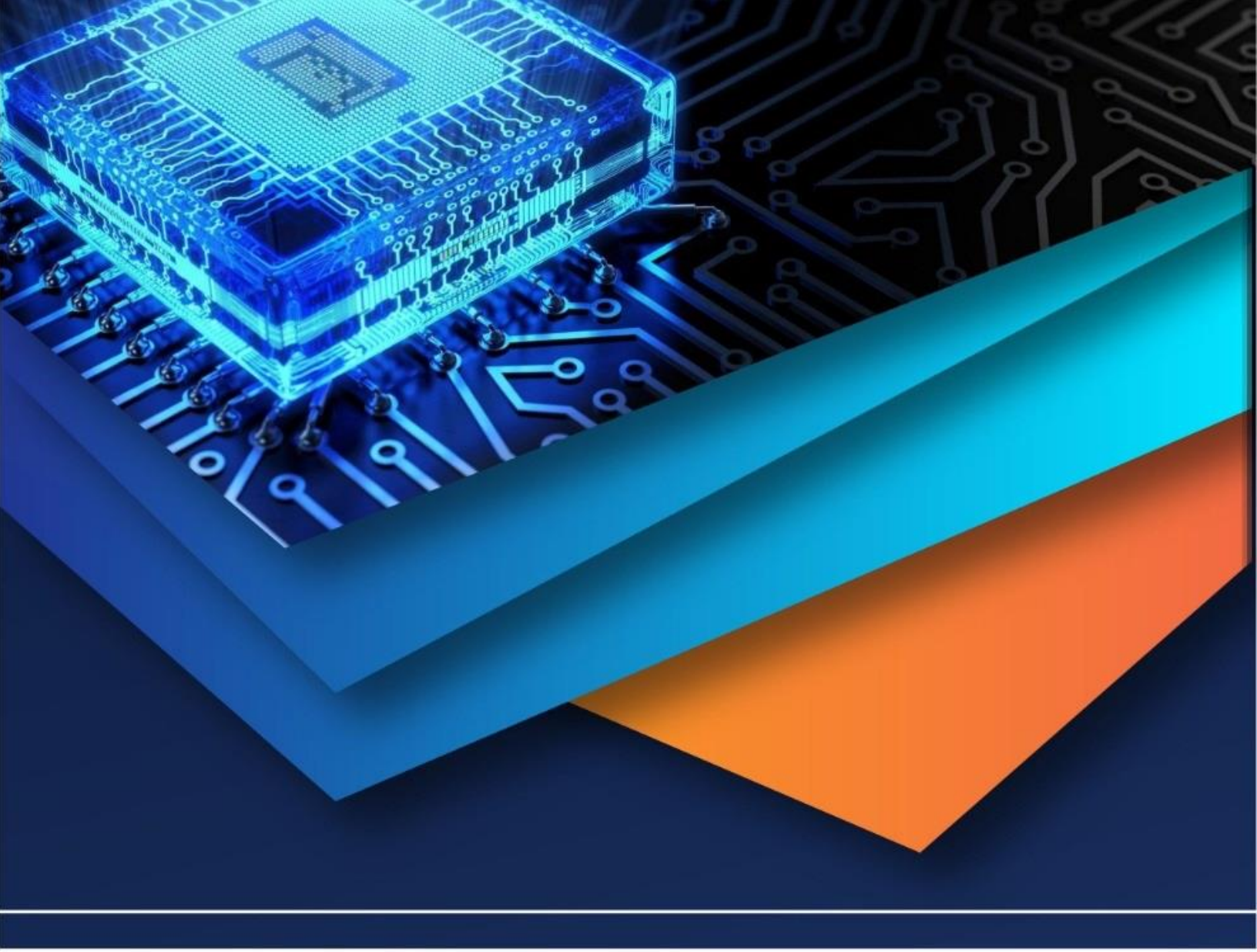

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