ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

Milk Tea Consumption and Short-Term Heart Rate Variability in College Students

Danhong Chai, Chunqing Tang*, Jiali Ma, Zhi Zhang, Jie Li, Ying Chen, Hui Zhang

School of Medical Imaging, Bengbu Medical College, Bengbu, 233030, Anhui, China
**Corresponding author: tangchunqing123@qq.com*

Abstract: *Background: The aim of this study was to explore the association between the frequency of milk tea consumption and HRV among college students. Methods: A total of 313 healthy college students (124 males and 189 females) participated in this cross-sectional study. The frequency of milk tea consumption was assessed using a questionnaire, and the participants were divided into three groups: <1 drink/month, 1-3 drinks/month, and >4 drinks/month. The 5-minute electrocardiogram signals of all subjects were collected in the sitting state and analysed for the HRV frequency domain parameters (VLF, LF, HF, TP, LF/HF) Results For male college students, some HRV frequency domain parameters were significantly different among the groups (P < 0.05). After adjusting for age, body mass index, and mean heart rate, the VLF, HF, and TP for male college students in the >4 drinks/month group were still significantly higher than those for male college students in the <1 drink/month group. The LF/HF in the <1 drink/month group was still significantly higher than that in the 1-3 drinks/month group. There was no significant difference in any HRV frequency domain parameter among female college students (P > 0.05) Conclusions The male students who consume more milk tea have higher HRV and female college students with different frequencies of milk tea consumption have no significant difference in HRV. There may be sex differences in the effect of milk tea consumption on HRV among college students*

Keywords: *Wireless sensor networks, Intelligent workshop products, Moving target tracking*

1. Introduction

Milk tea is currently one of the most widely consumed beverages in the world. In China, the sales volume of milk tea in 2019 exceeded 7 billion cups, of which college students are the main consumer group, with an average consumption of 1-2 drinks/week [1]. A survey by consumer protection committees in many places in China found that milk tea contains a large amount of caffeine, in addition to sugar and trans fatty acids (TFAs) [2]. Studies have shown that the habitual consumption of 3-5 cups of coffee per day can reduce the risk of cardiovascular diseases (CVDs) by 15% and that the habitual consumption of coffee may reduce the risk of atrial fibrillation [3]. However, there is a consensus that excessive sugar intake is harmful to health. Studies have shown that compared with low-sugar diets, high-sugar diets promote weight gain and obesity [4], thereby indirectly promoting the development of CVDs and type II diabetes [5]. In addition, a study by Mozaffarian et al. showed that for every 2% increase in TFAs intake, the incidence of coronary heart disease increased by 23% [6]. Furthermore, TFAs intake also increases the risk of myocardial infarction [7].

The cardiovascular system has a homeostatic regulatory function, and its activities are controlled and regulated by the autonomic nervous system [8]. Heart rate variability (HRV) is a recognized, noninvasive quantitative tool for assessing the functional status of the autonomic nervous system and the homeostasis of the cardiovascular system [9]. Within a certain range, elevated HRV is a manifestation of good cardiovascular system function, and reduced HRV indicates weakened cardiovascular system function or poor prognosis of CVDs [10]. Many previous studies have used HRV as an indicator to investigate the association between coffee, chocolate, and energy drinks and cardiac autonomic nerves. For example, de Oliveira et al. proposed that long-term coffee consumption was associated with the inhibition of the autonomic regulation of heart rate by the vagus nerve [11]. Latif et al. showed that the frequency of chocolate consumption did not change the regulation of cardiac autonomic nerves in women [12]. A randomized controlled trial conducted by Clark et al. showed that after consuming energy drinks, HRV indicators during the exercise rest period significantly increased [13]. However, to date, the effect of milk tea consumptions on HRV has not been reported. The purpose of this study was to explore whether there

ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

is an association between milk tea consumptions and HRV, so as to provide a reference for revealing the effect of milk tea on the human cardiovascular system.

2. Methods

2.1. Subjects and data collection

The subjects of this study were 330 healthy college students at Bengbu Medical College (Bengbu, Anhui, China). All the participants met the following criteria: (1) no smoking, alcohol consumption or coffee consumption; (2) and no history of chronic diseases, such as heart disease, hypertension, diabetes, or depression. This study was approved by the Medical Research Ethics Committee of Bengbu Medical College (2021071). All participants were informed of the purpose and content of the experiment before the experiment and received remuneration after the experiment. The experimental process was performed in strict accordance with the ethical standards stipulated in the 1964 Declaration of Helsinki and its amendments.

Electrocardiogram (ECG) data were collected between 8 am and 6 pm. The participants were required to get adequate sleep the night before the measurement and to not engage in strenuous exercise, and to not consume coffee, drugs, or other substances that may cause excitement within 24 hours before the experiment. Before the ECG, the participants were required to sit still for 10 minutes to reach a relaxed state. The test environment was kept quiet, and the participants maintained a normal respiratory rate. The ECG signals were collected with the participants sitting for 5 minutes using a single-lead miniature ECG recorder (Healink-R211B, Healink Ltd., Bengbu, China). After the test, participant grouping was determined using the following 3 questions.

1) “Do you drink milk tea?”

2) “Have you been consuming milk tea > 6 months?”

3) “What is the frequency of your milk tea consumption?”

a. “Less than 1 drink per month”

b. “1-3 drinks per month”

c. “4 drinks or more per month”

2.2. Heart rate variability analysis

The Pan-Tompkins algorithm was used to extract the time series of ECG RR intervals [14]. The RR interval time series were uniformly resampled using cubic spline interpolation (4 Hz) [15]. The power spectral density of the RR interval time series was estimated using fast Fourier transforms (Welch periodogram method: 150 s window width and 50% overlap window) [16]. HRV frequency domain indicators included total-frequency power (TP), very low-frequency power (VLF), low-frequency power (LF), high-frequency power (HF), and the ratio of LF to HF (LF/HF). Among the frequency domain indicators, HF represents respiratory sinus arrhythmia, which is influenced by the parasympathetic nerve (vagus nerve), and LF is considered to be coregulated by the sympathetic and vagal nerves [17]. LF/HF is an indicator to assess the balance between the sympathetic nerves and vagus nerves. Although there is no consensus on the origin and interpretation of VLF [18], this indicator is included in this study. The above analysis was performed using Kubios HRV Premium software (version 3.1.0, https://www.kubios.com, Kubios Oy, Kuopio, Finland).

2.3. Statistical analysis

The Kolmogorov-Smirnov test and histograms were used to test the normality of the data, and nonnormal data (VLF, LF, HF, TP, LF/HF) were subjected to logarithmic transformation for subsequent analysis. One-way analysis of variance (ANOVA) was used to compare the HRV frequency domain indicators among different milk tea consumption frequency groups. When ANOVA result indicated a statistically significant difference, pairwise comparisons between the 3 groups was performed using the Bonferroni method. A multivariate linear regression model was used to exclude the effects of confounding factors, including age, body mass index (BMI), and mean heart rate (mean HR). The above analysis was performed using SPSS software (ver. 23.0, IBM Corp., USA). The significance of all tests was set to 0.05.

ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

3. Results

A total of 330 participants were recruited for this study, and those with incomplete questionnaire information (n = 2), ectopic heart beat (n = 3), and compromised ECG data (n = 6) were excluded. Ultimately, 313 participants were included. Among them, 124 subjects (39.6%) were male, and 189 subjects (60.4%) were female. The BMI, mean HR, and HRV frequency domain parameters (VLF, LF, TP, LF/HF) for males and females are provided in Table 1.

Table 1: Baseline characteristics of the study participants.

	Male (n = 124)	Female (n = 189)	t	P
Age (year)	19.5 ±1.6	19.5 ±1.2	0.063	0.950
BMI (kg/m2)	22.8 ±3.1	20.5 ±2.6	-6.801	<0.001
Mean HR (bpm)	74.4 ±9.7	79.7 ±10.5	4.496	<0.001
VLF (ms2)	6.73 ±0.82	6.42 ±0.77	-3.423	0.001
LF (ms2)	6.57 ±0.81	6.05 ±0.80	-5.531	<0.001
HF (ms2)	6.36 ±1.06	6.32 ±1.10	-0.306	0.760
TP (ms2)	7.77 ±0.76	7.52 ±0.73	-3.018	0.003
LF/HF	0.21 ±0.86	-0.27 ±0.98	-4.430	<0.001

Values are expressed as the mean ±standard deviation. Bold text indicates statistical significance at P < 0.05.

Abbreviations: n, number of participants; BMI, body mass index; bpm, beats per minute; mean HR, mean heart rate; VLF, very low-frequency power; LF, low-frequency power; HF, high-frequency power; TP, total-frequency power; LF/HF, ratio of LF to HF.

The subjects were divided into groups based on the frequency of milk tea consumption, i.e., <1 drink/month, 1-3 drinks/month, and >4 drinks/month group. The HRV frequency domain parameters for males and females in the different milk tea consumption groups are shown in Figure 1 and Figure 2, respectively. There were statistically significant differences in the HRV frequency domain parameters for males in the different milk tea consumption groups (P < 0.05). The Bonferroni post-hoc test results showed that in males, VLF, HF, and TP in the <1 drink/month group were significantly lower than those in the >4 drinks/month group and that LF in the 1-3 drinks/month group was significantly lower than that in the >4 drinks/month group. Compared with that of the <1 drink/month group, the LF/HF of the 1–3 drinks/month group was lower. There was no significant difference in the HRV frequency domain parameters for females among the different milk tea consumption frequency groups (P > 0.05).

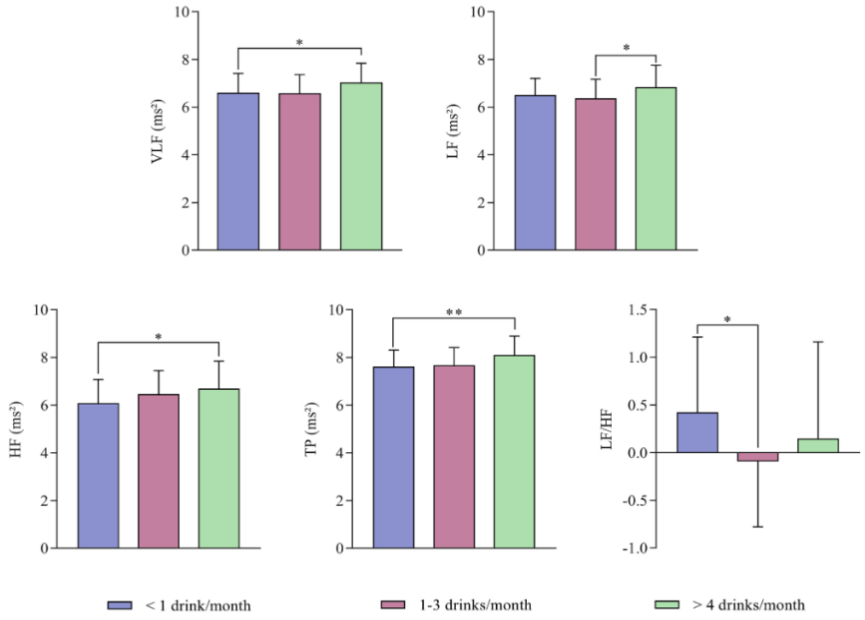

*Figure 1: HRV parameters for males in the milk tea consumption groups (<1, 1-3 and >4 drinks/month). Statistical significance was set at P < 0.05. *, P < 0.05; **, P < 0.01.*

ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

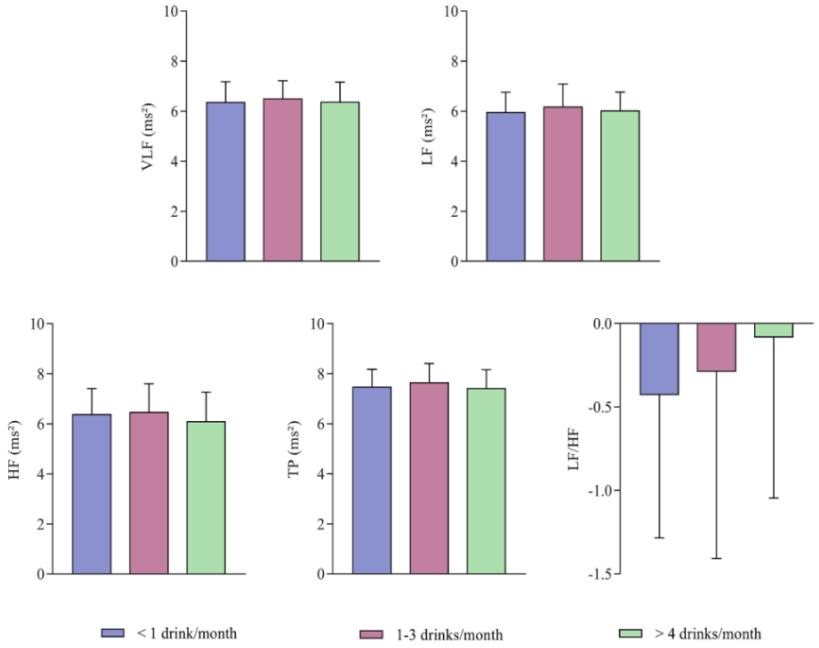

*Figure 2: HRV parameters for females in the milk tea consumption groups (<1, 1-3 and >4 drinks/month). Statistical significance was set at P < 0.05. *, P < 0.05; **, P < 0.01.*

Age, BMI, and Mean HR were controlled in the multivariate linear regression; the results are provided in Table 2. VLF, HF, TP LF/HF were still significantly correlated with milk tea consumption frequency among male participants. Specifically, the VLF, HF, and TP for males in the >4 drinks/month group were significantly higher than those of males in the <1 drink/month group (VLF: B = 0.365, 95% confidence interval (CI) = 0.038 – 0.692, P = 0.029; HF: B = 0.498, 95% CI = 0.097 – 0.899, P = 0.015; TP: B = 0.411, 95% CI = 0.125 – 0.697, P = 0.005); in contrast, the LF/HF for males in the 1-3 drinks/month group decreased compared with that for males in the <1 drink/month group (B = -0.368, 95% CI = -0.731 – -0.006, P =0.046).

Table 2: Multiple linear regression models adjusted for age, BMI and mean HR (males)

Variables	<1 drink/month (n = 56)		1-3 drinks/month (n = 32)		>4 drinks/month (n = 36)	
	B (95% CI)	*P* value	B (95% CI)	*P* value	B (95% CI)	*P* value
VLF	Reference		-0.175 (-0.503, 0.154)	0.295	0.365 (0.038, 0.692)	**0.029**
LF	Reference		-0.259 (-0.600, 0.082)	0.135	0.307 (-0.032, 0.647)	0.076
HF	Reference		0.111 (-0.292, 0.513)	0.587	0.498 (0.097, 0.899)	**0.015**
TP	Reference		-0.126 (-0.412, 0.161)	0.386	0.411 (0.125, 0.697)	**0.005**
LF/HF	Reference		-0.368 (-0.731, -0.006)	**0.046**	-0.191 (-0.551, 0.170)	0.298

Bold text indicates statistical significance at P < 0.05.
Abbreviations: n, number of participants; B, regression coefficient; BMI, body mass index; mean HR, mean heart rate; VLF, very low-frequency power; LF, low-frequency power; HF, high-frequency power; TP, total-frequency power; LF/HF, ratio of LF to HF. CI, confidence interval.

4. Discussion

To our knowledge, this is the first study to explore the association between milk tea consumption and HRV. This study of 313 college students found that there were significant differences in a number of HRV frequency domain parameters among male college students in different milk tea consumption frequency groups, with the differences increasing with increasing consumption frequency. The HRV frequency domain parameters for female college students were not significantly different among the different milk tea consumption frequency groups.

In general, the increase in parameters such as HF, TP, and VLF indicates enhanced parasympathetic nerve activity or sympathetic nerve inhibition, suggesting that the cardiovascular system is in a healthier and more ideal state. Therefore, from the perspective of cardiac autonomic nerve regulation, our results

ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

support the conclusion that moderate milk tea consumption (>4 drinks/month) may be beneficial to the cardiovascular system health of male college students. Caffeine is the main psychoactive substance in milk tea and can affect the regulation of cardiac autonomic nerves. Studies have shown that the cardiovascular effect of caffeine acts through adenosine receptor antagonism [19]. The binding of adenosine to the A1 receptor can reduce the heart rate and atrial contractility and attenuate the stimulating effect of catecholamines on the heart; the binding of adenosine to the A2a receptor can relax the aorta and the coronary artery [20]. Caffeine has a similar structure to adenosine and can competitively inhibit the binding of adenosine to its receptors and increase the activity of parasympathetic nerves, thereby delaying fatigue and protecting the cardiovascular system [21]. In addition, caffeine can also affect endothelial function and arterial stiffness. Shechter et al. showed that in healthy volunteers and patients with coronary artery disease, caffeine administration can lead to significant blood vessel dilation and decreased high-sensitivity C-reactive protein (hs-CRP) levels; notably, high hs-CRP levels (>3.0 mg/L) indicated coronary artery disease [22, 23].

An interesting phenomenon is that there are sex differences in the effects of milk tea consumption, and the HRV of female college students was not different among different milk tea consumption frequency groups. This finding may be related to the difference in endocrine regulation or tolerance to milk tea between males and females. Regarding caffeine, studies have confirmed that it competitively inhibits the oestrogen metabolism enzyme cytochrome P450, family 1, subfamily A, polypeptide 2 (CYP1A2), which can cause an increase in oestrogen levels in women [24]. Increases in the levels of oxytocin and oestrogen lead to the disappearance of parasympathetic nerve activity [25]. This may be one of the reasons why milk tea consumption has no significant effect on HRV in the female population. In addition, previous studies have shown that the effects of caffeine-containing beverages on the neurological activity of the cardiovascular system exhibit sex differences after puberty and that the sensitivity of women is generally significantly lower than that of men [26, 27]. Clark et al. also found that increases in HF and the root mean square of successive heartbeat interval differences (RMSSDs) in females were significantly lower than those in males after consuming energy drinks. This phenomenon can be explained by differences in steroid hormone levels and adenosine receptors [13].

Milk tea also contains substances such as TFA, milk, and tea. TFAs can increase the risk of CVDs by increasing the concentration of serum low-density lipoprotein cholesterol (LDL-C) and reducing the concentration of serum high-density lipoprotein cholesterol (HDL-C) [28]. TFAs also promote the release of inflammatory mediators, such as tumour necrosis factor-α (TNF-α), interleukin-1 beta (IL-1β), and interleukin-6 (IL-6), and concurrently promotes the synthesis of a large amount of CRP [29], thereby increasing the risk of CVDs. Milk and tea are considered to have protective effects on the cardiovascular system. For example, a cohort study published by Matsuyama et al. in an authoritative journal in the cardiovascular field suggested that green tea significantly benefited the health of cardiovascular patients [30]. Saito et al. reported that HF and RMSSD increased in healthy young people after consuming milk. Nakamura et al. found that casein hydrolysate in milk may reduce sympathetic nerve activity and increase parasympathetic nerve activity [31,32]. However, Ueno et al. found that women had reduced HF after consuming milk and dairy products [33] a finding that is consistent with the results of this study. Therefore, the effect of milk tea on the HRV of consumers may be the result of the comprehensive effects of multiple ingredients. We should fully consider that the results of this study may also be caused by multiple components in milk tea or their combined effects with the above substances.

This study, for the first time, explored the association between milk tea consumptions and HRV, providing a reference for the effect of milk tea on the cardiovascular system. However, this study also has some limitations. First, there may be a two-way relationship between milk tea consumptions and HRV. The experimental results suggested that men who rarely consumed milk tea had relatively low HRV, a finding that may be related to their learning or living habits. Second, this study used a questionnaire to determine the frequency of milk tea consumption, potentially introducing recall bias. Third, this study did not consider the differences in the types of milk tea consumed between males and females that may exist due to factors such as taste preferences. Future studies should include replication experiments with larger samples and more refined milk tea classification and population grouping.

Acknowledgments

We would like to give our heartfelt thanks to our academic supervisor Professor Bo Shi for his invaluable instruction and inspiration. This research was funded by the Anhui College Students' Innovation and Entrepreneurship Training Program (grant number S202110367006).

ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

References

[1] Shiyang Li, Yaqin Chen, Peilin Liu, Jinzhu Xu, Yuan Lin, Shaoling Lin. Analysis on the correlation between milk tea consumption and BMI of Fuzhou university students. Modern Food, 2020, (01): 224-228.

[2] Ying Li. Internet celebrity milk tea ingredients revealed. Chinese Journal of Quality, 2017, (09): 54-55.

[3] Rodríguez-Artalejo F, López-García E. Coffee Consumption and Cardiovascular Disease: A Condensed Review of Epidemiological Evidence and Mechanisms. J Agric Food Chem. 2018, 66(21): 5257-5263.

[4] Te Morenga L, Mallard S, Mann J. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. BMJ. 2012, 346: e7492.

[5] De Koning L, Malik VS, Kellogg MD, Rimm EB, Willett WC, Hu FB. Sweetened beverage consumption, incident coronary heart disease, and biomarkers of risk in men. Circulation. 2012, 125(14): 1735-1741.

[6] Mozaffarian D, Katan MB, Ascherio A, Stampfer MJ, Willett WC. Trans fatty acids and cardiovascular disease. N Engl J Med. 2006, 354(15): 1601-1613.

[7] Oh K, Hu FB, Manson JE, Stampfer MJ, Willett WC. Dietary fat intake and risk of coronary heart disease in women: 20 years of follow-up of the nurses' health study. Am J Epidemiol. 2005, 161(7): 672-679.

[8] Wake E, Brack K. Characterization of the intrinsic cardiac nervous system. Auton Neurosci. 2016, 199: 3-16.

[9] Cygankiewicz I, Zareba W. Heart rate variability. Handb Clin Neurol. 2013, 117: 379-393.

[10] Biying Hong, Sen He, Xiaoping Chen. Research progress of heart rate variability. West China Medicine,2013, 28(04): 614-618.

[11] De Oliveira RAM, Araújo LF, de Figueiredo RC et al. Coffee Consumption and Heart Rate Variability: The Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) Cohort Study. Nutrients. 2017, 9(7): 741.

[12] Latif R, Majeed F. Association between chocolate consumption frequency and heart rate variability indices. Explore (NY). 2020, 16(6): 372-375.

[13] Clark NW, Herring CH, Goldstein ER, Stout JR, Wells AJ, Fukuda DH. Heart rate variability behavior during exercise and short-Term recovery following energy drink consumption in men and women. Nutrients. 2020, 12(8): 2372.

[14] Pan J, Tompkins WJ. A real-time QRS detection algorithm. IEEE Trans Biomed Eng, 1985, 32(3): 230-236.

[15] Singh D, Vinod K, Saxena SC. Sampling frequency of the RR interval time series for spectral analysis of heart rate variability. J Med Eng Technol, 2004, 28(6): 263-272.

[16] Welch, P. The use of fast Fourier transforms for the estimation of power spectra: A method based on time averaging over short, modified periodograms. IEEE Trans Audio Electroacoust, 1967, 15: 70-73.

[17] Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Circulation, 1996, 93(5): 1043-1065.

[18] Akselrod S, Gordon D, Ubel FA, et al. Power spectrum analysis of heart rate fluctuation: a quantitative probe of beat-to-beat cardiovascular control. Science, 1981, 213(4504): 220-222.

[19] Riksen NP, Smits P, Rongen GA. The cardiovascular effects of methylxanthines. Handb Exp Pharmacol. 2011, (200): 413-437.

[20] Jacobson KA, Gao ZG. Adenosine receptors as therapeutic targets. Nat Rev Drug Discov. 2006, 5(3): 247-264.

[21] Davis JM, Zhao Z, Stock HS, Mehl KA, Buggy J, Hand GA. Central nervous system effects of caffeine and adenosine on fatigue. Am J Physiol Regul Integr Comp Physiol. 2003, 284(2): R399-404.

[22] Shechter M, Shalmon G, Scheinowitz M et al. Impact of acute caffeine ingestion on endothelial function in subjects with and without coronary artery disease. Am J Cardiol. 2011, 107(9): 1255-1261.

[23] Peng X, Peng D, Hu Y, Gang H, Yu Y, Tang S. Correlation of heart rate and blood pressure variability as well as hs-CRP with the burden of stable coronary artery disease. Minerva Cardioangiol. 2020, 68(5): 376-382.

[24] Kolahdouzan M, Hamadeh MJ. The neuroprotective effects of caffeine in neurodegenerative diseases. CNS Neurosci Ther. 2017, 23(4): 272-290.

[25] Tracy LM, Gibson SJ, Labuschagne I, Georgiou-Karistianis N, Giummarra MJ. Intranasal oxytocin reduces heart rate variability during a mental arithmetic task: A randomised, double-blind, placebo-

ISSN 2618-1584 Vol. 4, Issue 10: 34-40, DOI: 10.25236/FMSR.2022.041007

controlled cross-over study. Prog Neuropsychopharmacol Biol Psychiatry. 2018, 81: 408-415.
[26] Butler TR, Smith KJ, Berry JN, Sharrett-Field LJ, Prendergast MA. Sex differences in caffeine neurotoxicity following chronic ethanol exposure and withdrawal. Alcohol Alcohol. 2009, 44(6): 567-574.
[27] Nehlig A. Interindividual differences in caffeine metabolism and factors driving caffeine consumption. Pharmacol Rev. 2018, 70(2): 384-411.
[28] De Roos N, Schouten E, Katan M. Consumption of a solid fat rich in lauric acid results in a more favorable serum lipid profile in healthy men and women than consumption of a solid fat rich in trans-fatty acids. J Nutr. 2001, 131(2): 242-245.
[29] Judd JT, Baer DJ, Clevidence BA, Kris-Etherton P, Muesing RA, Iwane M. Dietary cis and trans monounsaturated and saturated FA and plasma lipids and lipoproteins in men. Lipids. 2002, 37(2): 123-131.
[30] Matsuyama S, Sawada N, Tomata Y et al. Japan Public Health Center-based Prospective Study Group. Association between adherence to the Japanese diet and all-cause and cause-specific mortality: the Japan Public Health Center-based Prospective Study. Eur J Nutr. 2021, 60(3): 1327-1336.
[31] Saito Y, Murata N, Noma T et al. Relationship of a special acidified milk protein drink with cognitive performance: a randomized, double-blind, placebo-controlled, crossover study in healthy young adults. Nutrients. 2018, 10(5): 574.
[32] Nakamura H, Iwamoto M, Washida K et al. Influences of casein hydrolysate ingestion on cerebral activity, autonomic nerve activity, and anxiety. J Physiol Anthropol. 2010, 29(3): 103-108.
[33] Ueno HM, Yoshise RE, Sugino T, Kajimoto O, Kobayashi T. Effects of a bovine lactoferrin formulation from cow's milk on menstrual distress in volunteers: a randomized, crossover study. Int J Mol Sci. 2016, 17(6): 845.