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Regulatory effects of low-deuterium liquor on human heart rate variability and autonomic nervous system

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Abstract: Objective To study the effects of acute intake of different doses of homemade alcoholic beverages, traditional liquor and low-deuterium liquor for 8 consecutive days on heart rate variability (HRV) and autonomic nervous system regulation in humans. Methods Eleven healthy adult male volunteers, with a body weight of (64.7 ± 4.5) kg, aged 21 to 25 years, with an average age of 23.7 years. The subjects were divided into 7 experimental groups: ÿ background (control) (CK group), no alcoholic beverages; ÿ low-dose alcohol (AL group), 50 mL 52- degree homemade alcohol + 200 mL ordinary drinking water per day ; ÿ high-dose alcohol (AH group), 100 mL 52 - degree homemade alcohol + 200 mL ordinary drinking water per day ; ÿ low-dose liquor (LL group), 50 mL 52- degree Luzhou Laojiao Tequ + 200 mL ordinary drinking water per day; ÿ high-dose liquor (LH group), 100 mL 52- degree Luzhou Laojiao Tequ + 200 mL ordinary drinking water per day; ÿ low-dose low-deuterium liquor (DDL-L group), 50 mL 52- degree Luzhou Laojiao Tequ + 200 mL low-deuterium water per day; ÿ high-dose low-deuterium liquor (DDL-H group), 100 mL 52-degree Luzhou Laojiao Tequ + 200 mL low-deuterium water per day. The treatment lasted for 8 consecutive days. The HRV of the subjects half an hour after drinking was detected using a cardiac period signal (HPS) analysis system to evaluate the activity of the sympathetic and parasympathetic nervous systems. Results Drinking homemade alcoholic beverages and traditional liquor caused changes in the sympathetic and vagus nerve activity of the autonomic nerves, with the most prominent increase in sympathetic nerve activity. No obvious changes in sympathetic and vagus nerve activity, that is, fluctuations in HRV , were observed after drinking deuterium -depleted liquor. Conclusion Compared with homemade alcoholic beverages and traditional liquor, deuterium-depleted liquor can maintain the coordination and balance of the human autonomic nervous system at a higher level.

Keywords: deuterium-depleted liquor; heart rate variability; sympathetic nerve; parasympathetic nerve.

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Effects of deuterium-depleted Chinese liquor on heart rate variability and autonomic nervous system XIA Hong- lei1a, SHI Lu1b, 2, SHEN Cai-hong3, LIU Hong-tao2, ZHOU Jun3, ZENG Na3, LIU Shi-long3, LI Yun-hui3, CONG Feng-song1a (1.a. School of Life Sciences and Biotechnology; b. Shanghai Jiao Tong University and Chiba University International Cooperative Research Center, Shanghai Jiao Tong University, Shanghai 200240, China; 2.Institute of Underwater Technology of Shanghai Jiao Tong University, Shanghai 200231, China; 3.National Engineering Research Center of Solid-State Brewing, Luzhou Lao Jiao CO., LTD, Luzhou 646000, Sichuan, China)

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Abstract： Objective To study the effect of deuterium-depleted Chinese liquor on heart rate variability(HRV), and evaluate the regulation of autonomic nervous system activity for cardiac function. Methods A total of 11 healthy adult male were enrolled, aged 21 - 25 years old with mean age of 23.7, and body weight (64.7 ± 4.5) kg. The study was divided into 7 groups: ①control group(CK), without any alcoholic beverages; ②low-dose alcohol group(A-L), every day drinking 50 mL 52 degrees self-made alcohol + 200 mL water; ③high-dose alcohol group (A-H), every day drinking 100 mL 52 degrees self-made alcohol + 200 mL water; ④low-dose ordinary Chinese liquor group (L-L), every day drinking 50 mL 52 degrees Luzhoulaojiao + 200mL water; ⑤ high dose ordinary Chinese liquor group(L-H), every day drinking 100 mL 52 degrees Luzhoulaojiao + 200 mL water; ⑥low-dose deuterium-depleted Chinese liquor group(DDL-L), every day drinking 50 mL 52 degrees Luzhoulaojiao + 200 mL deuterium-depleted water; ⑦high-dose deuterium depleted Chinese liquor group (DDL-H), every day drinking 100 mL 52 degrees Luzhoulaojiao + 200 mL deuterium -depleted water. The test was performed serial 8-day, the Biopac MP30 system was adopted to collect data of HRV 30 - 45 minutes after drinking and sympathetic and parasympathetic nervous systems were evaluated. Results The self -made alcoholic and traditional liquor made sympathetic atomic nerve activity and changed parasympathetic, the most was sympathetic nerve, but there was no significant changed in deuterium-depleted Chinese liquor. Conclusion It is demonstrated that the deuterium-depleted Chinese liquor is usefulto maintain the balance of cardiac sympathetic and parasympathetic autonomic nervous to the certain degree.

Key words： deuterium-depleted liquor; heart rate variability(HRV); sympathicus; parasympathicus

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Heart rate variability (HRV) refers to the small fluctuations in the RR interval between consecutive heartbeats , reflecting the tension and balance of cardiac sympathetic and parasympathetic (cardiac vagus) nerve activities. It can quantitatively reflect the regulatory activity of the autonomic nervous system (ANS) on the heart and has become a hot topic in recent years. Heart rhythm is in a relative state of balance. Any internal or external environmental factors that can affect this balance can cause changes in heart rhythm. The effect of ethanol (commonly known as alcohol) on HRV is very complex, and there are many interfering factors, such as the length of drinking time, the amount of drinking, and whether there are other diseases. There are few studies in this area. Existing studies have shown that HRV generally decreases after drinking, sympathetic nerve activity is enhanced, and vagus nerve activity is inhibited. Moreover, the degree of HRV reduction in chronic drinkers is more obvious than that in healthy acute drinkers

[3-8]. Long-term excessive drinking can lead to impaired myocardial ANS function, enhanced sympathetic nerve function, and imbalance between the sympathetic and vagus nerves. In recent years, people have conducted extensive research on the biological effects of deuterium-depleted water. Studies have found that deuterium-depleted water has the effects of enhancing the body's immunity, lowering blood sugar, inhibiting tumor cell growth and delaying aging [9, 10]. Shen Caihong et al. [11] proposed that liquor prepared with deuterium-depleted water tastes sweet, refreshing, smooth and comfortable. The author intends to analyze the effects of different alcoholic beverages on the regulation of human HRV and ANS , explore the effects of low-deuterium liquor on the regulation of human HRV and ANS , and provide a scientific basis for healthy drinking.

1 Materials and methods

1.1 Test Materials and Test Substances

1.1.1 Test Materials

Eleven male volunteers who passed a strict physical examination were selected as test subjects, with a body weight of (64.7 ± 4.5) kg, an age of 21 to 25 years old, and an average age of 23.7 years old (standard deviation 1.3 years). All test subjects were in good health, had no mental or nervous system diseases, visual, auditory or motor dysfunction, no mental illness, and were non-smokers.

1.1.2 Test Substances 52- degree homemade alcoholic beverage, made by mixing 96-degree edible alcohol (Anhui Gujing Gongjiu Co., Ltd. provides edible alcohol for blending) and distilled water. 52- degree Luzhou Laojiao Special Liquor (Luzhou Laojiao Group Co., Ltd.). Low-deuterium water (deuterium volume fraction is 0.005 0 %) (Shanghai Chitian Super Light Water Bioengineering Co., Ltd.). 1.2 Methods 1.2.1 The test requires that the subjects do not take sedatives, do not drink stimulating beverages such as tea and coffee, do not take drugs that affect blood pressure and heart rate during the test, do not stay up late, ensure sleep, and do not engage in heavy physical labor. The test was conducted in a self-controlled manner. The subjects were informed of the purpose, methods, and physiological and psychological test contents required of them to cooperate with the study. Before the test, they were trained in the test contents and methods. During the test, the room was kept quiet and the temperature was kept at 22 ÿ ~ 26 ÿ. During the test, the subjects first sat quietly for at least 10 minutes, took a supine position, closed their eyes and relaxed, and breathed calmly.

1.2.2 Experimental Grouping and Methods

The subjects were divided into 7 experimental groups: ÿ background (control) (CK group), no alcoholic beverages were consumed; ÿ low-dose alcohol (AL group), 50 mL 52- degree homemade alcohol + 200 mL ordinary drinking water per day; ÿ high-dose alcohol (AH group), 100 mL 52- degree homemade alcohol + 200 mL ordinary drinking water per day; ÿ low-dose liquor (LL group), 50 mL 52- degree Luzhou Laojiao Tequ + 200 mL ordinary drinking water per day; ÿ high-dose liquor (LH group), 100 mL 52- degree Luzhou Laojiao Tequ + 200 mL ordinary drinking water per day; ÿ low-dose low-deuterium liquor (DDL-L group), 50 mL 52- degree Luzhou Laojiao Tequ + 200 mL low-deuterium water per day ; ÿ high-dose low-deuterium liquor (DDL-H group), 100 mL 52- degree Luzhou Laojiao Tequ + 200 mL low-deuterium water per day.

In the background test, the subjects were tested for HRV without drinking any alcoholic beverages . In the remaining 6 groups, 11 subjects were required to drink the prescribed dose of the test substance for 8 consecutive days. On the 1st , 4th, and 8th days of each group of tests, the subjects drank the test substance about 0.5 hours after a meal and underwent HRV testing 0.5 hours later . After the end of this group of tests, all 11 subjects entered the next group of tests after resting for 7 days (without drinking any alcoholic beverages) .

1.2.3 Heart rate variability test The MP30 electrocardiograph of Biopac Company of the United States was used to collect the ECG signals of limb II leads. At the same time, the ECG signals were input into a computer equipped with an HRV test acquisition card to collect 256 cardiac cycles. The computer and the electrocardiograph were used to perform analog-to-digital conversion and R wave detection through the SMUP-PC multi-function interface. The computer obtained the RR interval and performed power spectrum density (PSD) analysis. The software can automatically remove premature beats and interference, and after manual correction, the computer directly reports the HRV frequency domain parameters. The power spectrum is a frequency domain method to describe HRV . The heart rate variability power spectrum obtained mainly includes total power (TP; 0.04 ~ 0.40 Hz), low frequency (LF; 0.04 ~ 0.15 Hz) and high frequency (HF; 0.15 ~ 0.40 Hz). LF mainly reflects the activity of the sympathetic nerves, HF mainly reflects the activity of the vagus nerves, and the LF /HF ratio reflects the coordination and balance of the sympathetic nerves and vagus nerves in regulating cardiovascular function

[12, 13]. 1.3 Statistical methods The experimental data were analyzed using SPSS 17.0 software. The data were subjected to t test, with the significance level ÿ set at 0.05. When t > t0.05/2, 20 or t < - t0.05/2, 20, the difference between the groups was considered statistically significant, where t0.05/2, 20 = 2.086. Based on this, the effects of each test substance on human HRV and 2 Results

2.1 Results of heart rate variability on the first day On the first day after drinking different alcoholic beverages, the LF values and LF / HF values of the AL and AH groups were significantly increased compared with the CK group (P < 0.05). Compared with the CK group, there was no statistically significant difference (see Table 1) .

2.2 Results of heart rate variability on day 4

After continuous drinking of the test substance for 4 days, the LF values of the AL and AH groups showed Compared with the CK group, the AL group, AH group and LL group The LF/HF values of the LH group and the LF/HF group increased, and the difference was statistically significant (P < 0.05); while the LF values and LF / HF values of the DDL-L and DDL-H groups were There was no significant difference in the CK group, and its value was significantly lower than that of the AL and AH groups and the LL and LH groups. See Table 2.

Table 1 Effects of HRV after drinking of various alcohols at 1st day

Group	LF / ms^2	$t^{\#}$	HF / ms^2	$t^{\#}$	LF / HF	$t^{\#}$
CK Group	1 857.95 ± 255.30	0.00	1 432.55 ± 252.65	0.00	1.31 ± 0.20	0.00
A–L group	2 319.31 ± 101.20*	– 5.57	1 366.03 ± 644.74	0.31	1.78 ± 0.30*	– 4.32
A–H Group	2 343.61 ± 108.03*	– 5.81	1 286.02 ± 378.60	1.06	1.86 ± 0.30*	– 5.06
L–L Group	2 133.78 ± 502.68	– 1.62	1 559.41 ± 778.12	– 0.51	1.44 ± 0.20	– 1.52
L–H Group	2 123.60 ± 791.27	– 1.06	1 640.41 ± 583.53	– 1.08	1.39 ± 0.10	– 1.18
DDL–L Group	1 983.97 ± 926.81	– 0.43	1 615.37 ± 961.82	– 0.61	1.42 ± 0.10	– 1.63
DDL–H Group	2 065.78 ± 779.39	– 0.84	1 689.44 ± 748.93	– 1.46	1.28 ± 0.10	0.44

#t value compared with the CK group. * P < 0.05 compared with the control group.

Table 2 Effects of HRV after drinking of various alcohols serial 4-day

Group	LF / ms^2	$t^{\#}$	HF / ms^2	$t^{\#}$	LF / HF	$t^{\#}$
CK Group	1 857.95 ± 255.30	0.00	1 432.55 ± 252.65	0.00	1.31 ± 0.20	0.00
A–L Group	2 258.40 ± 522.03*	– 2.28	1 271.00 ± 485.28	0.98	1.94 ± 0.30*	– 5.80
A–H Group	2 325.76 ± 423.34*	– 3.14	1 232.57 ± 905.99	0.70	1.91 ± 0.20*	– 7.03
L–L Group	2 309.31 ± 562.36*	– 2.42	1 568.54 ± 1 249.67	– 0.35	1.53 ± 0.10*	– 3.26
L–H Group	2 028.27 ± 119.82	– 2.00	1 313.41 ± 798.78	0.47	1.59 ± 0.20*	– 3.28
DDL–L Group	2 038.18 ± 398.34	– 1.26	1 510.66 ± 702.53	– 0.35	1.39 ± 0.10	– 1.18
DDL–H Group	1 946.61 ± 736.96	– 0.38	1 468.00 ± 693.26	– 0.57	1.38 ± 0.10	– 1.04

#t value compared with the CK group. * P < 0.05 compared with the control group.

2.3 Results of heart rate variability on day 8

LF values of AL and AH groups on the 8th day of continuous drinking of the test substance The results showed that the expression of cytokines in the CK group was significantly higher than that in the CK group (P < 0.05), and there was no statistical difference between the other groups and the CK group. Compared with the CK group, the AL group, AH group, LL group, The LF/HF values in the LH group increased, and the difference was statistically significant (P < 0.05); while in the DDL-L group and the DDL -H group, only The LF/HF values were significantly different from those in the CK group, and the rest were significantly different from those in the CK group. There was no statistically significant difference between the two groups (see Table 3).

3 Discussions

With the improvement of people's living standards, drinking has become a common Alcohol is a common way of communication, so the impact of alcohol on human health is becoming more and more Long-term heavy drinking can cause harm to the human body, including Including damage to the central nervous system and liver damage. The most direct manifestation is often an increase in heart rate. Existing studies have shown that Drinking alcohol during sex can cause various arrhythmias, reduce HRV , and cause

Table 3 Effects of HRV after drinking of various alcohols serial 8-day

Group	LF / ms²	$t^{\#}$	HF / ms²	$t^{\#}$	LF / HF	$t^{\#}$
CK Group	1 857.95 ± 255.30	0.00	1 432.55 ± 252.60	0.00	1.31 ± 0.20	0.00
A–L Group	2 708.20 ± 282.14*	– 7.41	1 347.66 ± 768.50	0.35	1.98 ± 0.30*	– 6.16
A–H Group	2 252.91 ± 487.51*	– 2.38	1 204.69 ± 189.00	2.39	1.91 ± 0.20*	– 7.04
L–L Group	1 890.25 ± 497.98	– 0.19	1 234.52 ± 655.90	0.94	1.58 ± 0.20*	– 3.17
L–H Group	1 928.17 ± 652.17	– 0.33	1 396.66 ± 402.90	0.25	1.52 ± 0.20*	– 2.46
DDL–L Group	2 163.99 ± 763.14	– 1.26	1 528.50 ± 694.80	– 0.43	1.47 ± 0.10*	– 2.34
DDL–H Group	2 082.31 ± 536.18	– 1.25	1 504.66 ± 662.50	– 0.34	1.45 ± 0.10	– 2.07

#t value compared with the CK group. * $P < 0.05$ compared with the control group.

Changes in ANS regulatory function [14]. Koskinen P et al. [15] studied the effect of moderate drinking (1 g/kg body weight) on HRV in healthy men. The results showed that in the frequency domain analysis of HRV , high frequency spectrum power (HF, 0.15-0.50 W) was significantly reduced after drinking. Spaak J et al. [16] also showed that alcohol and red wine have similar effects on HRV , both of which can increase heart rate and reduce HRV , significantly enhance the excitability of the sympathetic nerves, inhibit the tension regulation of the vagus nerve, and cause imbalance in ANS regulation. During the 8-day acute drinking test cycle, the results of three HRV tests showed that the LF value and LF/HF value of the homemade alcohol group (AL group and AH group) were significantly higher than those of the CK group. In the three tests of the low-deuterium liquor group (DDL-L group and DDL-H group) , except for the LF/HF value of the DDL-L group on the 8th day , which was statistically different from the CK group, the other LF values, HF values and LF/HF values were not statistically different from those of the CK group. In the last two tests, the LF/HF values of the traditional liquor group (LL group and LH group) were also significantly higher than those of the CK group. The results showed that homemade alcoholic beverages can significantly enhance the excitability of the sympathetic nerves and significantly affect the regulatory function of the human ANS . LF/HF is an indicator for quantifying the coordination and balance of the sympathetic and vagus nerves. The results showed that compared with homemade alcoholic beverages and traditional liquor, low-deuterium liquor is beneficial in maintaining the coordination and balance of the cardiac sympathetic and vagus nerves, that is, the regulation of the cardiac ANS . Chinese liquor has a long history, but in recent years, excessive drinking and drinking low-quality liquor have been harmful to people's physical and mental health. Therefore, it is necessary to advocate a healthier way of drinking. Good mountains and good waters produce fine wines. As an important raw material for wine, water has received extensive attention. The biological effects of low-deuterium water are gradually

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