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RESEARCH ARTICLE

Effect of ice water ingestion on cardiac autonomic reactivity in healthy subjects

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ABSTRACT

Background: Studies have shown a significant relationship between the autonomic nervous system and cardiovascular mortality. In autonomic failure patients, water drinking has been shown to rise in blood pressure, bradycardia, and low heart rate variability (HRV). Previous studies have shown gaps in acute effects of ice water intake, in healthy subjects. This study aimed to record HRV in healthy subjects after ice water ingestion. **Aims and Objectives:** To assess frequency domain parameters of HRV before and after ingestion of water at room temperature (control group) and cold water (study group) in healthy subjects. **Material and Methods:** This cross-sectional study included total 80 healthy, both gender, subjects between the age group of 18-24 years were randomly assigned into two groups. Study group ingested ice water and control group ingested normal room temperature water. Before and after water ingestion, HRV parameters were recorded and compared. Statistically data were analyzed by student's paired and unpaired *t*-test. **Results:** High frequency power (HFP) (858.23 ± 242 vs. 964.72 ± 232.2, $P < 0.001$), total power (2280 ± 524. 64 vs. 2450.14 ± 449.4, $P = 0.01$), and very low frequency power (743.4 ± 170.12 vs. 813.2 ± 103, $P = 0.01$) were increased whereas low/high frequency power ratio (LHR) (1.374 ± 0.4 vs. 1.118 ± 0.41, $P = 0.03$), were significantly reduced after ice water ingestion in study group compared to controls. **Conclusion:** Ice water ingestion increases vagal activity in healthy subjects as indicated by high HFP and reduced LHR.

KEY WORDS: Ice Water; Heart Rate Variability; Blood Pressure; Vagal Modulation

INTRODUCTION

Ingestion of water has only recently been found to have hemodynamic effects, and it appears to have well clinical relevance. Closed chest pig models were described to hemodynamic function during surface cooling, steady state severe hypothermia and surface rewarming. The posthypothermic increase in heart rate and the reduced systemic vascular resistance were interpreted as adaptive measures.[1] Human studies have shown vagal attenuation in response to immersion of face and hand in ice water.[2-4] Literatures have investigated whether water drinking in normal subjects affected peripheral sympathetic neural discharge and its effect on vascular resistance. The last two decades have witnessed the recognition of a significant relationship between the autonomic nervous system and cardiovascular mortality, including sudden cardiac death. In patients with autonomic failure and in elderly subjects, water drinking has been shown to result in a transient increase in arterial blood pressure.[5] Ice fluid restriction was one of the standards of care in patients with acute myocardial infarction as a coronary precaution and was considered to be not evidence-based.

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Lower heart rate was actually demonstrated in the control group of nine subjects without acute myocardial infarction after ice water ingestion.[6] Thus, the effect on heart rate and the mechanisms responsible for the possible change in heart rate after cold water ingestion deserve further evaluation. Although studies have shown reduced vagal stimulation, there are lacunae regarding acute effects of ice water ingestion on cardiac autonomic reactivity in healthy subjects using HRV. Thus, the primary hypothesis was that drinking ice water decreases the low/high-frequency power ratio (LHR) through vagal enhancement in healthy subjects.

Experimental evidence for an association between a propensity for lethal arrhythmias and signs of either increased sympathetic or reduced vagal activity has encouraged the development of quantitative markers of autonomic activity.[7] Power spectrum analysis of heart rate fluctuations provides a quantitative non-invasive means of assessing the functioning of short-term cardiovascular control systems. Both sympathetic and parasympathetic nervous system makes frequency specific contribution to heart rate (HR) power spectrum. In frequency domain, high-frequency power (HFP) is a useful index of vagal activity and ratio of low to high frequency (LF/HF) is an index of sympathovagal balance.[8]

Aims and Objectives

To assess frequency domain parameters of HRV before and after ingestion of water at room temperature (control group) and of cold water (study group).

MATERIALS AND METHODS

The study was conducted in the Department of Physiology, Sri Dharmasthala Manjunatheshwara College of Medical Sciences and Hospital, Dharwad, Karnataka, from July to September 2014. For the study total 80 healthy, both male and female (equal number) students between the age group of 18-24 years were selected from the same institution. The subjects were randomly assigned into two groups. Study group made to ingest ice water (7°C ± 0.5°C), and control group made to ingest room temperature water. Sample size was 40 in each group with age, sex, and body mass index (BMI) matched. Exclusion criteria were subjects with cardiovascular, respiratory, neurological disorder, subjects taking any drug or medication, diabetes mellitus, hypertension and subjects having dental carries. Instruments used were INCO IV Channel Data Acquisition system to record HRV with personal computer to transfer the data. Before the commencement of the study, the Institutional Ethical Clearance (IEC) was obtained. After taking informed consent from the each subject, the following anthropometric parameters were recorded:

1. Age (years)
2. Height (cm)
3. Weight (in kg)
4. BMI (kg/m^2).

Parameters of frequency domain HRV recorded were:
The area under the spectral peaks within the 0.01-0.4 Hz:

1. 0.01-0.04 was defined as the very-low-frequency power (VLFP), in ms^2
2. 0.04-0.15 defined as LFP, in ms^2
3. 0.15-0.4 defined as HFP, in ms^2
4. 0.01-0.4 Hz as total power (TP), in ms^2
5. Normalized VLFP in nu
6. Normalized LHP in nu
7. Normalized HLF in nu
8. LF/HF (LHR) in ms^2.

Procedure

- Recording of basal (supine rest for 5 min) HRV parameters in all the subjects. Here electrocardiogram (ECG) signals were picked by ECG monitor and transmitted to a computer for recording for 2 min.
- To observe autonomous reactions of, water ingestion, HRV parameters were recorded in the control group for 5 min after ingestion of 250 ml of water at room temperature and after ingestion of 250 ml of ice water in the study group.

A sampling rate of 500 Hz was used. The fiducial point of the R-wave was identified by an algorithm of parabolic interpolation and a derivative plus threshold algorithm to locate a stable and noise-independent reference point. The last 512 stationary RR intervals (RRI) were obtained for HRV analysis. If the percentage of deletion was more than 5%, then the subject was excluded from the study. The power spectrum of 512 RRIs was obtained by means of fast Fourier transformation.[7]

RESULTS

Recorded data were analyzed using SPSS window version 20. All the readings were presented as a mean ± standard deviation. Paired *t*-test was used to compare the HRV data before and after water ingestion in both groups. The Student's unpaired *t*-test was used to compare the normally distributed and equal variance data age, body height, body weight, BMI and to compare values between two groups. $P < 0.05$ was considered as statistically significant.

Table 1 depicts subjects characteristics. No significant ($P > 0.2$) differences in age, body height, body weight, and BMI were found between two groups. Significant difference ($P = 0.17$) was not found between two groups before (basal) water ingestion in HRV parameters shown in Figure 1. HRV parameters did not change significantly ($P = 0.08$) in control group before and after room temperature water ingestion.

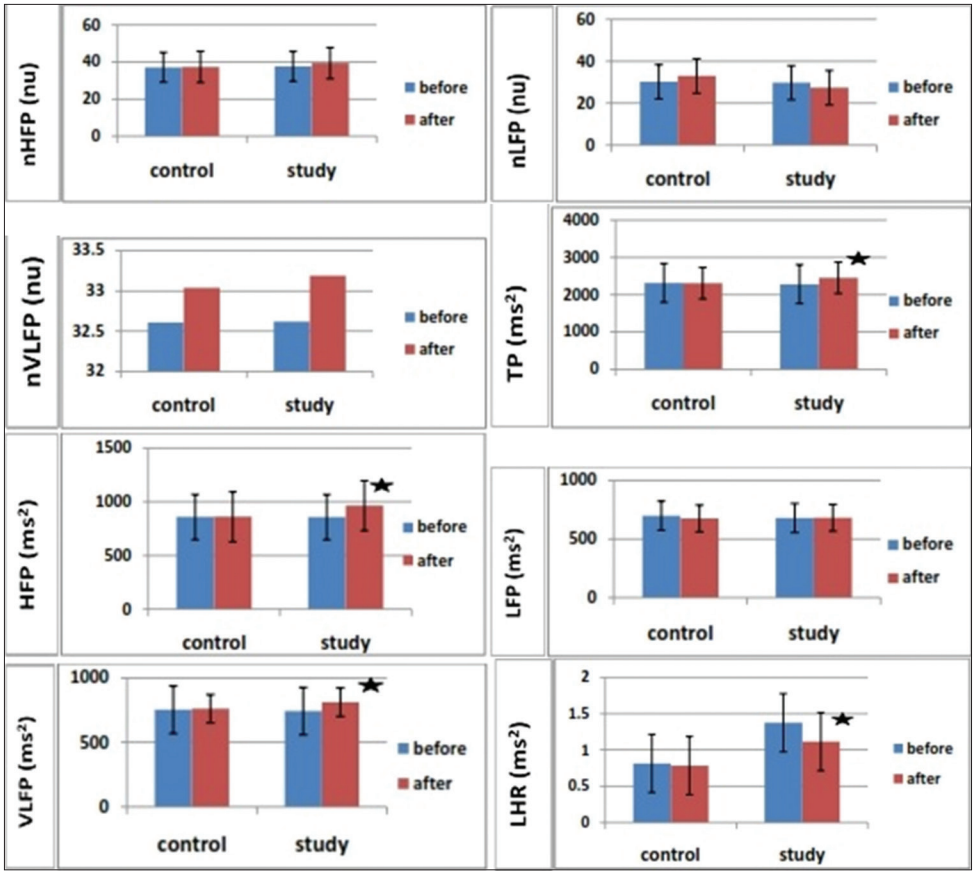

Figure 1: Heart rate variability readings of both groups before and after ingestion of water (control), ice water (study), VLFP: Very-low-frequency power, LFP: Low-frequency power, HFP: High-frequency power, TP: Total power, nVLFP: Normalized VLFP, and nLFP: Normalized LHP

Table 1: Baseline characteristics of the subjects

Features	Control group (n=40)	Study group (n=40)	P value
Age (years)	19.433±0.5040	19.84±0.78	0.718
Body height (cm)	162.70±8.101	168.58±9.91	0.167
Body weight (kg)	58.133±6.099	59.10±10.11	0.300
BMI (kg/m^2)	22.11±3.7	22.7±2.8	0.572

P<0.05 is statistically significant, values are in mean±standard deviation, BMI: Body mass index

However, after ice water ingestion there were significant changes in HRV parameters (in ms^2 unit).

VLFP (743.4 ± 170.12 vs. 813.2 ± 103, P = 0.01), HFP (858.23 ± 242 vs. 964.72 ± 232.2, P < 0.001), and TP (2280 ± 524. 64 vs. 2450.14 ± 449.4, P = 0.01) were statistically higher. LHR (1.374±0.4 vs. 1.118 ± 0.41, P = 0.03) was decreased after ice water ingestion. LFP did not change statistically after ice water ingestion.

DISCUSSION

The present study was conducted to know the effect of ice water ingestion on cardiac autonomic reactivity using standardized HRV instrument, in 40 healthy subjects (study group) compared to 40 controls who ingested room temperature water (control group). The primary findings, VLFP, HFP, and TP, were increased, and LHR was decreased after ice water ingestion when compared with those after room temperature water ingestion indicating increased vagal activity.

Our results are consistent with the previous studies. After ice water ingestion, the percentage change in HFP was higher, while percentage change in LFP, LHR was lower, when compared with those after the room temperature water ingestion.[6] We do not get any change in LFP after ice water ingestion suggesting no sympathetic modulation. Further studies have shown the increased vagal activity in response to ice water ingestion depends on position of the subject and volume of ice water. Recumbent position or larger volume up to 600 to 800ml of ice water has a greater effect than those of upright position or smaller volume in normal and myocardial infarction patients.[9,10] After normal tap water intake the HF was increased in a study[11] but in our control subjects, we did not have any significant change. VLFP rhythms are influenced by renin-angiotensin-aldosterone mechanism and a may derive from the fundamental importance of parasympathetic mechanisms in cardiovascular health.[12]

Although the mechanism of cardiovagal activation after ice water ingestion is not clear, there is an evidence for the presence of vagal receptors in esophagus in animal studies.[13]

The cold stimulation on the oral cavity and receptors in the esophagus after ice water ingestion might have the same results to that of cold test.

Limitations

As this study includes acute effects of ice water intake chronic effects can be studied with larger sample size**.** Effect of position and volume of water was not investigated. Regular Yoga or exercise practitioners and parental history of any autonomic disturbances were not addressed.

Strengths

Having established that this is a normal physiological mechanism, these findings should be considered in the design of future studies of autonomic function in cardiovascular and metabolic disorders with risk factors such as obesity, prehypertension, and genetic background. Although it is difficult to extrapolate acute responses to long-term effects, our results support the concept that ice water ingestion, a benefit to cardiovascular health.

CONCLUSION

We conclude that ice water ingestion increased VLFP, HFP, and TP and reduced LHR compared to room temperature water ingestion probably by enhanced vagal modulation. This is beneficial in term of quantitative reduction in heart rate thus acts has a cardioprotective factor in healthy subjects.

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