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RESEARCH ARTICLE

# Comparison of effect of aspartame (artificial sweetener) and aspartame-sweetened diet drink on autonomic reactivity of volunteers

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## ABSTRACT

**Background:** Obesity is the single most important risk factor in the onset of various diseases. Dieting is considered as an important part of today's daily life; the aim of our study is to explore the effects of aspartame on autonomic reactivity and compare it with the effects of aspartame-sweetened diet drink in human volunteers. **Aim and Objectives:** To study and compare the effect of aspartame and aspartame-sweetened diet drink on autonomic reactivity. **Materials and Methods:** This is a comparative study done in the department of physiology. After getting an Institutional Ethical Committee clearance and explained informed and written consent from all the participants. The study duration was for 2 months and the study population was 120 volunteers of age 20–30 years of both genders were randomly chosen and included in the study. They were divided randomly as 80 volunteers in the study group and 40 in the control group. The study Group A in whom aspartame (artificial sweetener) diluted in water was given. Group B in whom diet drink was given and Group C as controls who was fed with plain water and tested for various parameters of autonomic reactivity. **Results:** The findings in our study showed increased sympathetic activity after consumption of aspartame diluted in water and also showed further increased sympathetic activity in subjects who consumed aspartame-sweetened diet drink than the controls. **Conclusion:** Aspartame is causing various health hazardous to humans, it is no safer to consume aspartame as a sugar substitute.

**KEY WORDS:** Aspartame; Autonomic Reactivity; Diet Drink

## INTRODUCTION

Obesity is the single most important risk factor in the onset of various diseases. Nowadays, everyone prefers taking some immediate steps to skip their calories either by doing strenuous exercise or dieting. Moreover, in dieting, consumption of diet drinks is considered as an important part of today's daily routine life.

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White granulated sugar 1 teaspoon (4 g) contains 16 calories and the complications produced by sugar intake are cardiovascular disease, nerve damage (neuropathy), kidney damage (diabetic nephropathy), or kidney failure and damage to the blood vessels of the retina (diabetic retinopathy).[1]

Aspartame packet each contains 1 g of aspartame 4 calories. 1 ounce of diet soda contains around 200 mg of aspartame. A 355 ml of diet soda will contain around 2.5 g of aspartame which is equal to 9 calories. On a weight basis, the metabolism of aspartame generates approximately 50% phenylalanine, 40% aspartic acid, and 10% methanol.[2]

"Artificial sweeteners" such as saccharin, aspartame, and sucralose are the alternatives for people who want to limit their sugar intake. Furthermore, maltitol and sorbitol are

often used, frequently in toothpaste, mouthwash, and in foods such as "no sugar added" ice creams.

Diabetics prefer sugar-substituted foods to lower the total carbohydrate in their meals and control their blood glucose level. Widely used sugar-free or diet foods include baked products, soft drinks, powdered drink mixes, candy, puddings, canned foods, jams and jellies, dairy products, beverages, instant breakfasts, breath mints, and sugar-free chewing gums.[3]

In carbonated drinks, acesulfame potassium is almost always used in conjunction with another sweetener, such as aspartame or sucralose.

All these sugar-free diets come into play with the idea of empty calories and zero fat. However, the most commonly used sugar substitute aspartame - the sweet silent killer, a major culprit of many diseases, and fatal conditions - is most commonly ignored.[4]

Methanol, a metabolite of aspartame, causes oxidative stress in the cardiovascular centers in the brain stem and/or sympathetic centers in the hypothalamus.[5,6]

Oral aspartame consumption at 40 mg/kg bodyweight/day has been found to cause oxidative stress in the brain,[7,8] liver and kidney,[9,10] and immune organs[11,12] in Wistar albino rats.

Studies also showed that long-term aspartame consumption in Wistar albino rats causes reduced cardiac parasympathetic modulation, increased low frequency (LF), decreased high frequency (HF), and decreased LF/HF ratio in heart rate (HR) variability. Total power, an index of overall heart rate variability (HRV), was also reduced in aspartame-treated animals.[13]

The inadequacy of past studies, combined with the general limited knowledge about the safety/potential toxigenic effects of substances widely present in the industrialized diet, motivated the design of this experiment. So far, no study has been done to find out the effect of aspartame on autonomic reactivity in humans. Therefore, the aim of our study is to explore the effects of aspartame on autonomic reactivity and compare it with the effects of aspartame-sweetened diet drink in human volunteers.

## MATERIALS AND METHODS

This is a comparative study done in the department of physiology. After getting an Institutional Ethical Committee clearance and explained informed and written consent from all the participants. The study duration was for 2 months and the study population was 120 volunteers of age 20–30 years of both genders were randomly chosen and included in the study. They were divided randomly as 80 volunteers in the study group and 40 in the control group. The subjects with H/o of smoking, known DM/HT, obese, and neuromuscular disorders were excluded from the study.

The study Group A ($n$ = 40) in whom aspartame (artificial sweetener) diluted in water was given. Group B ($n$ = 40) in whom diet drink was given and Group C ($n$ = 40) as controls who was fed with plain water and tested for various parameters.

All three group volunteers were instructed to take their meal 2 h prior before beginning the recordings and also were instructed to avoid caffeinated beverages on that particular day of the study, to avoid their influences.

The subjects were comfortably seated after explaining the procedure. Baseline data were recorded on day 1. Initially, resting HR and resting blood pressure were recorded for all the subjects using digitalized measuring apparatus, and their autonomic reactivity was assessed by recording when the volunteer was asked to do isometric handgrip (IHG) exercise for 5 min using handgrip dynamometer following which the HR and blood pressure were recorded. Then, the subject was asked to do deep breathing following which the HR and blood pressure were recorded and E/I ratio was calculated.

Then, the subjects were given two and a half packets of branded artificial sweetener containing 2.5 g of aspartame diluted in normal water. After ½ h, autonomic status of the subjects was measured once again using the same methods. On day 2, again baseline data were recorded for the same subjects and then aspartame-sweetened diet drink 355 ml (a can) was given. ½ h later, the autonomic status of the same subject was measured again. The same procedure was repeated individually for all the subjects in the same way for 2 consecutive days and the values were recorded. And now, the values of E/I ratio, blood pressure, and HR, before and after consumption of aspartame between the groups were assessed.

### Data Collection Method and Tools

1. IHG dynamometer was used to assess sympathetic reactivity
2. Deep breathing (E/I) ratio was used to assess the parasympathetic reactivity.

The quantitative data were checked for normality and summarized using mean/median and standard deviation; the values obtained were compared using statistical Student's $t$-test. $P < 0.05$ was the cutoff to determine statistical significance.

## RESULTS

Comparisons between the groups were using paired $t$-test and comparisons against the groups were done using unpaired $t$-test.

Table 1 summarizes the comparison of results of comparison of autonomic reactivity parameters - IHG and deep breathing (E/I) ratio in subjects before and after consumption of aspartame diluted in water.

After consumption of aspartame-sweetened water in Group A subjects, there was an increase significantly in the HR $P < 0.002$, systolic blood pressure (SBP) $P < 0.004$, and in diastolic pressure $P < 0.005$, along with reduction in parasympathetic parameter, deep breathing ratio (E/I).

Table 2 summarizes the comparison of sympathetic reactivity parameter - IHG in subjects before and after consumption of aspartame-sweetened diet drink after consumption of aspartame-sweetened diet drink in Group B subjects there was further an increase significantly in the HR $P < 0.003$, SBP $P < 0.005$, and in diastolic pressure $P < 0.005$, along with reduction in parasympathetic parameter, deep breathing ratio (E/I).

Table 3 summarizes the comparison of autonomic reactivity parameters - IHG and deep breathing (E/I) ratio in controls subjects before and after consumption of plain water. There was no significant increase in any of the autonomic reactivity parameters.

## DISCUSSION

The findings in our study showed increased sympathetic activity (increase in systolic and diastolic blood pressure and increase in HR) while doing autonomic function test in the subjects after consumption of aspartame diluted in water and also showed further increased sympathetic activity significantly in subjects who consumed aspartame-sweetened diet drink than the controls.

which is In par with the study showing that long-term aspartame consumption in Wistar albino rats caused reduction in heart rate variability with sympathetic dominance and loss of vagal tone.[13]

Increased HR and blood pressure in our study are probably due to the aspartame changing the ratio of amino acids in the blood, blocking or lowering the levels of serotonin, tyrosine, dopamine, norepinephrine, and adrenaline. The present study deals with enforcing the toxic effects of aspartame, the artificial sweetener, and its metabolite products such as methanol and formaldehyde.

The association of hypertension with the consumption of cola beverages (Diet Coke [TM]) has been confirmed by Winkelmayer *et al*. in a large prospective study of female nurses - but not with caffeine consumption. They speculated that some other compound contained in soda-type soft drinks may be responsible for the increased risk of hypertension.[14,15] The causative role of aspartame products was indicted by (1) the striking improvement or normalization of blood pressure after stopping aspartame and (2) the prompt recurrence of hypertension following aspartame resumption. Which may be due to the conversion of phenylalanine (a molecule of aspartame)into pressor substances like dopamine, epinephrine and norepinephrine. Other aspartame reactors have evidenced peripheral vasomotor features including the Raynaud phenomenon and probable pulmonary hypertension.[16,17]

Phenylalanine being a component in aspartame when increased in the brain can elevate nor-epinephrine levels. which clinically manifest as hypertension. Nor-epinephrine increases blood pressure by increasing vascular tone through alpha-adrenergic receptors activation. So at least persons

**Table 1:** Comparison of autonomic reactivity parameters - IHG and deep breathing (E/I) ratio in subjects before and after consumption of aspartame diluted in water

| Autonomic reactivity parameters | Before aspartame (mean) | After aspartame (mean) | *P* value |
|---|---|---|---|
| HR (min) | 89.8 | 97.6 | 0.002* |
| SBP (mmHg) | 123 | 134 | 0.004* |
| DBP (mmHg) | 83 | 92 | 0.005* |
| E/I ratio | 1.19 | 1.41 | 0.005* |

**P*<0.05. IHG: Isometric handgrip, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

**Table 2:** Comparison of sympathetic reactivity parameter - IHG and deep breathing (E/I) ratio in subjects before and after consumption of aspartame-sweetened diet drink

| Autonomic reactivity parameters | Before diet drink (mean) | After diet drink (mean) | *P* value |
|---|---|---|---|
| HR (min) | 90.75 | 100.25 | 0.003* |
| SBP (mmHg) | 125.25 | 139.35 | 0.005* |
| DBP (mmHg) | 86.2 | 89.34 | 0.005* |
| E/I ratio | 1.19 | 2.45 | 0.005* |

**P*<0.05. IHG: Isometric handgrip, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

**Table 3:** Comparison of autonomic reactivity parameters - IHG and deep breathing (E/I) ratio in control subjects before and after consumption of plain water

| Autonomic reactivity parameters | Before (mean) | After (mean) |
|---|---|---|
| HR (min) | 75 | 72 |
| SBP (mmHg) | 110 | 112 |
| DBP (mmHg) | 83 | 84 |
| E/I ratio | 1.2 | 1.3 |

IHG: Isometric handgrip, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

with hypertension have to avoid aspartame products. Another component of aspartame, methanol are noted for damaging mitochondria of the myocardium and the specialized form of myocardium called the cardiac conduction system. Damage to the mitochondria of the myocardium and conducting system produces lots of free radicals which leads to susceptibility to arrhythmias (irregular heart rhythm).

Moreover, the limitations of the study are failure in the estimation of levels of catecholamines in the individuals who were showing increased sympathetic reactivity due to aspartame consumption. The study is being planned to be further continued in animals in the future.

## CONCLUSION

Since (artificial sweetener) aspartame is causing various health hazardous to humans, it is no safer to consume aspartame as a sugar substitute, either directly in the form of tabletop sweeteners or as diet products termed as "sugar free" prepared with aspartame. Diet drinks are no more a good alternative for weight reduction.

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