# The Effects of Apple Cider Vinegar on Weight, Blood Pressure, Blood Glucose Level and Heart Rate of 60 MMMC Medical Students Randomized Controlled Trial

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# Abstract

Apple cider vinegar, a sour vinegar with a seemingly sweet name is becoming trendy due to its wide variety of uses ranging from culinary uses to its speculated medicinal uses. This study is a randomised control trial aimed at investigating the effects of apple cider vinegar on the blood glucose levels, blood pressure, heart rate and weight of MMMC medical students. The side effects are also investigated. 60 Participants from batch 37 with 30 being in the control group and 30 being in the test group were assessed with a questionnaire after fulfilling certain inclusion and exclusion criteria their mood, energy levels, concentration and side effects were assessed after consuming apple cider vinegar for 5 days. Their blood glucose levels, blood pressure, heart rate and weight are also measured on the 1<sup>st</sup> and 5<sup>th</sup> day of the study and compared. The control group has no significant changes in the variables. However, for the apple cider vinegar group, there is a decrease in all the mentioned variables except the weight of the participants which showed an increase. The only significant change is that of the diastolic blood pressure of the apple cider vinegar group from a mean of 79.2mmHg to 70.3 mmHg with the paired T test and P-value testing being 3.34 and 0.002 respectively. Apple cider vinegar, if consumed will reduce the diastolic blood pressure of an individual. Its significance on other variables has to be further studied for a longer duration.

# **Keywords**

Apple Cider Vinegar, 60 MMMC Medical Students, Weight, Blood Pressure, Blood Glucose Level, Heart Rate

# **1. Introduction**

Apple cider, a seemingly sweet name for sour vinegar, but what exactly is this? Collins dictionary defined it as type of vinegar produced by the acetification of cider [1] The free dictionary by Farlex simply said its vinegar made from fermented apple cider [2] which is rich in pectin, vitamin B1, B2 and B6, biotin, folic acid, niacin, pantothenic acid and vitamin C. It also contains sodium, phosphorous, potassium, calcium, iron and magnesium and very much a significant amount of acetic acid and citric acid [3] Main ingredients used in the making are apples, sugar, yeast and last but not the least is time. This whole process will last for about 7-8 weeks before the cider is ready for use [4]. Apple cider vinegar is very much associated with the culinary world, however, for centuries people has been using it as a remedy for various kinds of illnesses such as sore throat, sunburns and even treating infections. It is also used for cosmetic purposes especially in combating the acne and dandruff problems [3, 21] Recent studies also seems to be supporting its use in reducing the blood pressure in spontaneously hypertensive rats [5], in glycaemic control amongst diabetics [6] and in lipid profile control and weight loss in obese subjects if consumed in moderation daily (1-2 tablespoons/day) over an extended period [6, 7, 22] It is said to lower blood sugar levels by changing how food absorption occurs in the gut and aids in digestion of food. It is also said

Although this cider is generally safe, consumption of it in excess over a period of time can be hazardous despite its numerous benefits if consumed too much (250ml apple cider vinegar daily for 6 years) [3]. Among its side effects is that it decreases blood potassium levels causing weak bones (osteoporosis). It can worsen the symptoms of gastroparesis among type 1 diabetics, causes nausea, erode tooth enamel and cause throat burns [9] Drug interaction in diabetics who take insulin or insulin-stimulating medications and vinegar may experience low blood sugar or potassium levels; digoxin a drug that reduces potassium levels in blood and taking it with apple cider vinegar can cause very low blood potassium levels; diuretics cause reduction in blood potassium levels and taking apple cider vinegar with it can cause dangerously low levels of blood potassium levels [10]. However, the significance of including apple cider vinegar into ones diet varies from person to person with multiple factors affecting its significance such as dietary factors, regular exercise volume, lifestyle and an individual's genetic makeup and the risk of these side effects occurring is actually low if the cider is taken in moderation. Thus it is less likely that our participants would experience severe long term damage should they volunteer in this study.

Non communicable disease (NCD), according to World Health Organization (WHO), accounts for about 71% of all deaths globally. Each year, 15 million people die from NCD between the ages of 30-69 years; over 85% of these deaths occur in low- and middle-income countries. Cardiovascular disease accounts for the most NCD deaths, followed by cancers, respiratory diseases and diabetes [11] thus it is obvious that hypertension, being one of the cardiovascular disease, and diabetes mellitus is a growing problem of late on a global scale due to modern lifestyle and diet. Consumption of high calorie, sugary and fatty foods plus a sedentary lifestyle is the main contributors for this rising problem. WHO recorded a rise of diabetics from 108 million in 1980 to 422 million in 2014 worldwide? Diabetes among adults above 18 years old has risen from 4.7% in 1980 to 8.5% in 2014 on a global scale [12] While in Malaysia itself, the prevalence of type 2 diabetes is about 2.8 million and has escalated up to 20.8% in adults above the age 30 years [13] Hypertension on the other hand is a major risk factor for stroke and coronary heart disease, a well-known complication of the same. WHO recorded the overall prevalence of increased blood pressure in adults above 25 years was 40% in 2008 with highest prevalence in Africa region (46% both sexes) and lowest in Americas (35% male>female) [14] A cross sectional study done on national levels in 2008 reveals that the prevalence of hypertension for subjects above 15 years was 27.8% with higher prevalence in males compared to females, and those above the age of 30 years has increased from 32.9% in 1996 to 40.5% in 2004

[15] and the numbers has just escalated due to the improvement of household income which tends to lead to more sedentary lifestyle changes amongst Malaysians.

Due to the global increase in prevalence of NCDs especially in Malaysia, we intend for this study to confirm the usefulness of apple cider vinegar as a better alternative, or at least an adjuvant, for the prevention and control of high blood pressure and blood sugar levels. In other word we want to know if daily consumption of apple cider vinegar really effective in reducing the blood sugar levels and controlling blood pressure amongst Malaysians as claimed by the American Diabetes Association and others [16-20] This study is aimed at experimenting if daily consumption of 2 tablespoons of apple cider vinegar amongst medical students over a period of 5 days will indeed lower blood sugar levels, blood pressure and heart rate and its significance in weight loss.

# 2. Methodology

#### 2.1. Study Design, Setting & Population

This randomized Controlled Trial study was carried out among the MBBS students of Melaka Manipal Medical College (MMMC) [Malaysia Campus] to assess the effects of apple cider vinegar on blood pressure, heart rate, blood glucose level & weight, and its side effects. This study was conducted in Melaka Manipal Medical College [Muar Campus] over a period extending from November 2018 to December 2018.

#### 2.2. Sample Size

In this study, a sample size (n) is taken from the total population (N) of MBBS students. This study involves the comparison of means of blood pressure, heart rate, blood glucose and weight between a control group and an intervention group taking apple cider vinegar, with the following formula is applied:

$$n = \frac{2 \times K \times sd^2}{\Delta^2} \tag{1}$$

n~=~sample Size  $\alpha^2=~variance~\Delta^2=~(\mu 1-\mu 2)^2$ 

K = 7.84 (Type I error 5%, Power 80%)

$$n = \frac{2 \times 7.84 \times (1.57)^2}{(-1.02 - 0.25)^2} = 24$$
  
n(final) =  $\frac{n(calculated)}{1 - non - response\%}$  (2)

n(final) = 
$$\frac{24}{1-0.1}$$
 = 26.7 = 27

The sample size is determined as 27 respectively for the control and apple cider vinegar group, it is rounded up to 30 samples per group thus giving a total sample size of 60 students.

#### 2.2.1. Sampling

In this randomised Controlled Trial study, the study

population is all MBBS students of MMMC from both Melaka and Muar campuses, with the sampling frame being inclusive of batches 34, 35, 36, 37 and batch 38. The sampling unit being batch 37 was chosen by non-probability, convenience sampling method for the convenience of conducting the study in Muar campus itself only. 60 samples comprising of males and females of all races and ethnicity is selected from a total of 150 students from batch 37 by the systemic sampling with the sampling tool https://www.randomizer.org/. The generated random numbers are matched with the batch attendance list and the subjects are identified. From the subjects in batch 37, those who do not provide informed written consent and those who do not fulfil the inclusion criteria of and exclusion criteria are also excluded from the sampling. The criteria for participation in the study are aimed at controlling possible confounding factors by eliminating them at the start of the study and involves the following:

Inclusion criteria:

- 1. Subject does not consume alcohol containing products more than 2 times a week, with each time being more than 3 pints.
- 2. Subject does not smoke more than 1 pack cigarettes/week (20 sticks).
- 3. Subjects does not consume apple cider vinegar regularly.
- 4. Subject exercises at least once a week for more than 30 minutes a time.

5. Subject agrees to participate and give written consent Exclusion criteria:

- 1. Subject has any of the following medical conditions:
  - 1. Any form of hypertension.
  - 2. Any form of diabetes.
  - 3. Any diseases related to hypercholesterolemia.
  - 4. Any gastrointestinal or regular discomfort.
- 2. Subject is on long term medication.
- 3. Subject has food allergies related to apple cider vinegar products.
- 4. Subject is obese with BMI more than 30.

## 2.2.2. Randomisation

Out of the 60 samples, 30 random students are to be placed in the apple cider vinegar (intervention) group with the remainder being allotted in the control group at a 1: 1 ratio. The randomiser tool https://www.randomizer.org/ is used to randomise the students by block randomisation. The sampled list of students is allotted into the respective groups according to the generated block randomisation list with 1being the apple cider vinegar group and 2-being the control group irrespective of the order of the numbers.

## 2.3. Data Collection

Upon sampling and concealed randomisation of the subjects, the subjects were identified and given the informed consent form which stated the procedure of this randomized control trial (2 tablespoons of 30ml apple cider vinegar would be given over a course of 5 days & the recording or their systolic blood pressure, heart rate, weight and blood glucose level will be performed on the 1<sup>st</sup> and the 5<sup>th</sup> day), with the assurance of anonymity and the entitlement of the participants to comply or decline their involvement in this randomized control trial. They are also entitled to enquire the study results and allowed to leave the study at any point of time.

Along with the informed consent form, the participant's information sheet comprising of the participant's sociodemographic data such as gender, age and ethnicity, followed by a simple questionnaire to be done. Section A of the questionnaire comprised of the inclusion and exclusion criteria for this trials stated. Section B of the questionnaire comprised of basic questions revolving the participants mood, energy levels & concentration, appetite & digestion, sleep quality and the experience of any adverse effects to the apple cider vinegar including throat or abdominal discomforts, gastric irritation, allergic reactions and if the participants found the apple cider vinegar palatable. Section B was only to be filled up after the consumption of the apple cider vinegar or the placebo (distilled water 30ml).

Tool	Brand	Variable measured	Units
Apple cider vinegar	Heinz Apple Cider Vinegar	-	946ml bottle x 4
Digital scale	Fitness Concept	weight	kg
Measuring tape	-	height	cm
Glucometer	Accu-Chek	Blood glucose	Mmol/L
Glucose strips	Accu-Chek	-	Pack of 50 strips
Digital B. P machine	Omron	Heart rate Blood pressure	Beats/min mmHg

Table 1. Shows the materials and apparatus used in the study along with their respective brands and their uses and units.

The study spanning over 5 days was conducted in the following manner.

The subjects were informed earlier to arrive at the venue of experiment from 5-6pm and the administration of the apple cider vinegar and distilled water on the 1<sup>st</sup> day of the study were as follows:

- 1) The participant was timed with a timer and allowed to rest for 15 minutes after arrival to the examination venue, to ensure stabilization of all the vitals.
- Then, the heart rate, blood pressure and blood glucose level were measured by 2 different trained investigators. The participant's height and weight is also taken with the appropriate tools.
- 3) The apple cider vinegar or placebo of 30ml respectively is administered accordingly and after 5 minutes the blood pressure, heart rate and blood glucose level are recorded again.
- For the subsequent 3 days, the subjects were given the

apple cider vinegar or distilled water accordingly at about 5-6pm.

On the 5<sup>th</sup> day of the study, the subjects again presented within 5-6pm and the following were conducted.

- 1) Apple cider vinegar and distilled water is given respectively upon arrival.
- 2) Subjects were timed with a timer and allowed to rest for 15 minutes after consuming apple cider vinegar or distilled water to ensure stabilization of vitals.
- 3) Then, the heart rate, blood pressure and blood glucose level were measured twice by 2 different trained investigator. The participants' height and weight is also taken with the appropriate tools.
- 4) They were then asked to fill in section B of the questionnaire.

To ensure a standardized data collection, the same investigator is to collect all relevant data of the same variable. He/she is trained to use the instruments of collection. Another trained investigator shall collect the data again and the mean value of the data obtained by both investigators is taken as appropriate. Any abnormally high or low readings are remeasured.

The tools and the variables they are used to measure with their units are as followings:

## 2.4. Data Processing & Analysis

Data collected from this study was tabulated by using Microsoft Excel and was analyse by using Epi Info 7<sup>th</sup> version from Centres for Disease Control and Prevention (CDC) website. Apple cider intervention is taken as the dependent variable and the blood pressure, blood glucose levels and weight are taken as the dependent variables.

# 3. Results

Frequency and percentage were used to represent quantitative variables such as blood pressure (systolic and diastolic), heart rate, blood sugar levels and weight. Other qualitative variables such as the presence or absence of adverse effects (gastroparesis, nausea/vomiting and ulcer of oral mucosa), alertness, appetite changes and bowel changes too, frequency and percentage were calculated and compiled. Measure of central tendency (mean) and dispersion (standard deviation) was calculated for continuous data. Paired T-test was used to compare the before and after results of the blood glucose level, blood pressure levels, heart rate as well as the weight. Chi square was used to compare the before and after results of categorical data like the presence or absence of adverse effects, the appetite, bowel changes and alertness. The level of statistical significance (P-value) was set as 0.05 and any value more than this was considered as not significant. Data then plotted into various charts such as bar chart, scatter plot and pie chart.

### 2.5. Ethical Considerations

To ensure that the study was conducted as thoroughly and as ethically as possible, the students was briefed about the purpose of the study, procedures to be done for data collections and informed consent was obtained from the participants prior to conducting the study. Participant's wellbeing and privacy was well kept at all times. Anonymity was ensured throughout the study by providing each participants with a unique ID number for study purposes. Each participants had the right to decline and drop out in the middle of the study from participating without any specific reason. Lastly this study was approved by the ethics committee of Melaka Manipal Medical College, Malaysia Campus.

Table 2. Distribution of respondents based on Age, Gender and Ethnicity.

Variables		Apple cider Vinegar (n=29)	Control (n=25)
Mean (SD)			
Age		22.6 (1.32)	22.3 (0.90)
Frequency (%)			
	Male	14 (48.3%)	10 (40%)
Gender	Female	15 (51.7%)	10 (40%) 15 (60%) 1 (4%)
	Malay	2 (6.9%)	1 (4%)
Ethnisite.	Chinese	12 (41.4%)	7 (28%)
Ethnicity	Indians	14 (48.3%)	11 (44%)
	Others	1 (3.5%)	6 (24%)

There was a total of 60 participants at the beginning of the study with 30 of them being given apple cider vinegar (30 ml of apple cider vinegar diluted in 250 ml of plain boiled water) and 30 being controls (controls were given plain boiled water). Response rate was 90% with total non-response of 10% (6 participants in total) with 1 participant out of that being from the apple cider vinegar drinking group and 5 participants out of the 6 participants coming from the control group. The age of the participants were between 20 and 26 years old. Among the 54 participants who remained throughout the research, the mean age of those drinking apple

cider vinegar is 22.6 years old and 22.3 years old of those in the control group, with standard deviation of age of 1.32 and 0.9 respectively for the apple cider vinegar group and control group. As for gender, there was 48.3% and 40% of male participants in the apple cider vinegar group and control group respectively. There was 51.7% and 60% of female participants in the apple cider vinegar and control group respectively. Coming to ethnicity, for the apple cider vinegar group, there was 48.3% Indian participants, 41.4% Chinese participants, 6.9% Malay participants and 3.5% Others (Punjabi and Sri Lankan participants). Meanwhile, for the Durgeswari Thinathayalan *et al.*: The Effects of Apple Cider Vinegar on Weight, Blood Pressure, Blood Glucose Level and Heart Rate of 60 MMMC Medical Students Randomized Controlled Trial

control group, there was 44% Indian participants, 28% Chinese participants, 4% Malay participants and 24% Others

(Punjabi and Sri Lankan participants).

Variables		Mean (SD)		Mean Differences	t statistics (df)	D value
variables		Intervention (n=29) Control (n=25) (95% CI) t-statistics (df) P-1   57.2 (14.7) 64.5 (14.2) -2.7 (-5.51, 10.61) 0.68 (52) 0.4   79.2 (16.6) 79.1 (14.1) -0.1 (-8.39, 8.58) 0.02 (52) 0.5   119.7 (12.9) 116.6 (23.3) -3.1 (-7.03, 13.20) 0.61 (52) 0.5	r-value			
Weight (kg)		67.2 (14.7)	64.5 (14.2)	-2.7 (-5.51, 10.61)	0.68 (52)	0.497
Heart Rate (beats/min)		79.2 (16.6)	79.1 (14.1)	-0.1 (-8.39, 8.58)	0.02 (52)	0.983
Blood pressure (mmHg) SBP DBP	SBP	119.7 (12.9)	116.6 (23.3)	-3.1 (-7.03, 13.20)	0.61 (52)	0.543
	DBP	79.2 (11.6)	73.5 (8.6)	-5.7 (0.08, 11.38)	2.03 (52)	0.047*
Blood Glucose (mmol/L)		6.9 (8.9)	5.5 (1.3)	-1.4 (-0.822, 0.32)	0.89 (52)	0.377

Table 3. Pre-intervention Weight, Heart Rate, Blood Pressure and Blood Glucose between Apple Cider Vinegar (n=29) and Control (n=25).

\*Unpaired T-test

Before the start of the study, weight, heart rate, blood pressure and blood glucose of all the participants were measured. This is to compare the before and after values of the participants to see if apple cider vinegar has an effect in any of these variables. It appears that the mean (s. d.) weight, heart rate, systolic blood pressure, diastolic blood pressure and blood glucose of the apple cider vinegar group was 67.2 (14.7) kg, 79.2 (16.6) beats/min, 119.7 (12.9) mmHg, 79.2 (11.6) mmHg and 6.9 (8.9) mmol/L respectively. As for the

control group, mean (s. d.) weight, heart rate, systolic blood pressure, diastolic blood pressure and blood glucose was 64.5 (14.2) kg, 79.1 (14.1) beats/min, 116.6 (23.3) mmHg, 73.5 (8.6) mmHg and 5.5 (1.3) mmol/L respectively. The P-value for these values, calculated via unpaired T-test for weight, heart rate, systolic blood pressure, diastolic blood pressure and blood glucose is 0.497, 0.983, 0.543, 0.047, and 0.377 respectively. The P value for all the variables are not significant except for diastolic blood pressure.



Figure 1. Pre-intervention weight.



Figure 2. Pre-intervention heart rate.



Figure 3. Pre-intervention Systolic Blood Pressure.



Figure 4. Pre-intervention Diastolic Blood Pressure.



Figure 5. Pre-intervention Blood Glucose.



Figure 6. Post-intervention Weight.



Figure 7. Post-intervention Heart Rate.



Figure 8. Post-intervention Systolic Blood Pressure.



Figure 9. Post-intervention Diastolic Blood Pressure.



Figure 10. Pre-intervention Blood Glucose.

The post-intervention result shows that mean (s. d.) weight is higher in apple cider vinegar group at 68.9 (19.9) kg compared to control group at 64.7 (14.4) kg, p value is not significant at 0.382. Mean heart rate is higher in control group at 80.5 (10.3) beats/min compared to apple cider vinegar group at 73.7 (12.2) beats/min with significant p value of 0.032. Mean systolic and diastolic blood pressure is higher in control group at 118.9 (9.02) mmHg and 75.8 (12.4) mmHg respectively when compared to apple cider vinegar group at 115.9 (8.23) mmHg and 70.3 (9.0) mmHg respectively, the p value is non-significant at 0.215 for systolic blood pressure and 0.065 for diastolic blood pressure. The mean blood glucose level is higher in control group at 5.8 (1.3) mmol/L as compared to apple cider vinegar group at 5.6 (1.1) mmol/L, with non-significant p value of 0.514.

Table 4. Post-intervention weight, Heart Rate, Blood pressure and Blood Glucose between Apple Cider Vinegar (n=29) and Control (n=25).

Variables		Mean (SD)		Mean Differences		
variables		Intervention (n=29)	Control (n=25)	(95% CI)	t-statistics (df) 0.88 (52) 2.2 (52) 1.26 (52) 1.88 (52) 0.66 (52)	r-value
Weight (kg)		68.9 (19.9)	64.7 (14.4)	-4.2 (-5.4, 13.8)	0.88 (52)	0.382
Heart Rate (beats/min)		73.7 (12.2)	80.5 (10.3)	-6.8 (-13.1, -0.6)	2.2 (52)	0.032*
Dlasd analysis (manufact)	SBP	115.9 (8.23)	118.9 (9.02)	-2.95 (-7.66, 1.76)	1.26 (52)	0.215
Blood pressure (mmHg)	DBP	70.3 (9.0)	75.8 (12.4)	-5.49 (-11.4, 0.4)	1.88 (52)	0.065
Blood Glucose (mmol/L)		5.6 (1.1)	5.8 (1.3)	-0.2 (-0.88, 0.45)	0.66 (52)	0.514

\*Unpaired T-test

Side Effects	Intervention [frequency (%)]	Control [frequency (%)]
Allergies	0 (0%)	0 (0%)
Nausea/Vomiting	4 (13.8%)	0 (0%)
Throat Discomfort	25 (86.2%)	4 (16%)
Abdominal Discomfort	22 (75.9%)	2 (8%)
Gastric Irritation	19 (65.5%)	1 (4%)
Loose Motion	3 (10.3%)	2 (8%)
Constipation	3 (10.3%)	0 (0%)

Table 5. Post-intervention Adverse Effects of Intervention (n=29) and Control (n25).

#### \*Unpaired T-test

As mentioned in the methodology, drinking apple cider vinegar has its adverse effects. Among them are allergies (rashes, urticaria, hives), nausea/vomiting, throat discomforts, abdominal pain (cramps), gastric irritation, loose motion and constipation. Nausea/vomiting, throat discomforts, abdominal pain (cramps), gastric irritation is caused probably due to the low pH of the vinegar (pH 5.5). A feedback form was given on the fifth day to all the participants to ask them if they experienced any of these adverse effects. The outcome of the feedback was as such: there was 0% allergic reaction in both the groups, 13.8% of the participants from the apple cider vinegar group said they had nausea/vomiting after drinking the apple cider vinegar given to them, whereas 0% said they had a similar experience in the control group. As

for throat discomfort, 86.2% participants from the apple cider vinegar group experienced it, whereas only 16% from the control group experienced the same. Coming to abdominal discomforts, 75.9% from the apple cider vinegar group experienced this, whereas, only 8% of participants from the control group experienced similar symptoms. 65.5% of the participants from the apple cider vinegar group experienced irritation whereas 4% from the control experienced the same. 10.3% of participants from the apple cider vinegar group and 8% of those from the control group said they experienced loose motion and 10.3% of participants from the control group said the control group said the experienced constipation.

Table 6. Pre- and Post-intervention Weight, Heart Rate, Blood Pressure and Blood Glucose of Apple Cider Vinegar Group (n=29).

Variables		Mean (SD)		Mean difference	4 -4-4:-4: ( <b>16</b> )	Davalara
variables		Pre-intervention (n=29)	Post-intervention (n=29)	(95% CI)	Mean difference t-statistics (df)   95% CI) 1.13 (28)   1.7 (-5.01, 1.45) 1.13 (28)   -5.5 (-2.17, 13.2) 1.47 (28)   -3.8 (-0.41, 7.99) 1.85 (28)   -8.9 (3.45, 14.4) 3.34 (28)   -0.3 (-0.76, 0.11) 1.55 (28)	P-value
Weight (kg)		67.2 (14.7)	68.9 (19.9)	-1.7 (-5.01, 1.45)	1.13 (28)	0.268
Heart Rate (beats/min)		79.2 (16.6)	73.7 (12.2)	-5.5 (-2.17, 13.2)	1.47 (28)	0.153
Blood Pressure (mmHg)	SBP	119.7 (12.9)	115.9 (8.2)	-3.8 (-0.41, 7.99)	1.85 (28)	0.075
	DBP	79.2 (11.6)	70.3 (9.0)	-8.9 (3.45, 14.4)	3.34 (28)	0.002*
Blood Glucose (mmol/L)		5.3 (0.7)	5.6 (1.1)	-0.3 (-0.76, 0.11)	1.55 (28)	0.133

#### Paired T-test

\*Significant

Table 5 is to compare the mean and standard deviation of the participants who were given apple cider vinegar. For weight, mean and standard deviation before the study was conducted was 67.2 kg and 14.7 respectively, whereas the mean and standard deviation on the fifth day was 68.9kg and 19.9 respectively. The p value for weight is 0.268 which is not significant. For the heart rate, mean and standard deviation before the study was conducted was 79.2 beats/min and 16.6 respectively, whereas the mean and standard deviation on the fifth day was 73.7beats/min and 12.2 respectively. P value for heart rate is 0.153, which is not significant. For the blood pressure, mean systolic blood pressure before the study was conducted was 119.7 mmHg and standard deviation was 12.9, whereas mean diastolic blood pressure before the study was conducted was 79.2 with standard deviation 11.6. Mean systolic blood pressure on the fifth day was 115.9mmHg with a standard deviation of 8.2,

whereas the mean diastolic blood pressure on the fifth day was 70.3mmHg and the standard deviation was 9.0. P value for systolic blood pressure is 0.075, which is not significant, whereas for diastolic blood pressure, the p value is 0.002, which is significant. The mean blood glucose before the study was conducted was 5.3mmol/L and the standard deviation was 0.7. The mean blood glucose after the fifth day was 5.6mmol/L and the standard deviation was 1.1. The p value for blood glucose is 0.133, which is also not significant. All in all, for the group which was given apple cider vinegar, only the diastolic blood pressure seems to be significant, while there is a decrease in value for heart rate and systolic blood pressure from before the study. The study was conducted for only 5 days, which is not enough to show a significant change in weight, blood glucose and heart rate, for these things happen on the long run (probably 3 months).

Table 7. Pre- and Post-intervention Weight, Heart Rate, Blood Pressure and Blood Glucose of Control Group (n=25).

Variables	Mean (SD)		Mean difference		6 Develop
variables	Pre-control (n=25) Po	Post-control (n=25)	(95% CI)	t-statistics (df)	P-value
Weight	64.5 (14.2)	64.7 (14.4)	-0.2 (-0.82, 0.32)	0.91 (24)	0.369
Heart Rate	79.1 (14.1)	80.5 (10.3)	-1.4 (-8.03, 5.23)	0.44 (24)	0.667

Variables		Mean (SD)		Mean difference		
variables		Pre-control (n=25)	Post-control (n=25)	(95% CI)	t-statistics (df) P   1.09 (24) 0.   1.04 (24) 0.	P-value
Blood Pressure SE DI	SBP	121 (10.7)	118.9 (9.02)	-2.1 (-1.92, 6.24)	1.09 (24)	0.286
	DBP	73.4 (8.6)	75.8 (12.4)	-2.4 (-6.92, 2.28)	1.04 (24)	0.308
Blood Glucose		5.5 (1.3)	5.8 (1.3)	-0.3 (-0.61, 0.02)	1.91 (24)	0.068

Paired T-test

\*Significant

Table 6 shows the comparison between before and after values of weight, blood pressure (systolic and diastolic), blood glucose and heart rate. Mean and standard deviation for weight before the study is 64.5kg and 14.2 respectively, whereas the mean and standard deviation for weight on the fifth day was 64.7kg and 14.4 respectively. The p value for weight is 0.369, which is not significant, although there is an increase of mean weight by 0.2kg. As for heart rate, the mean and standard deviation before the study was conducted was 79.1 beats/min and 14.1 respectively. The mean and standard deviation after the fifth day was 80.5beats/min and 10.3 respectively. The p value was 0.667 which is not significant, but there is an increase in heart rate by 1.4 beats/min. For systolic blood pressure, the mean and standard deviation before the study was conducted was 121mmHg and 10.7 respectively. The mean and standard deviation after the fifth day was 118.9mmHg and 9.02 respectively. The p value was 0.286 which is not significant, but there is an increase in systolic blood pressure by 2.1mmHg. As for diastolic blood pressure, the mean and standard deviation before the study was conducted was 73.4mmHg and 8.6 respectively. The mean and standard deviation after the fifth day was 75.8mmHg and 12.4 respectively. The p value was 0.308 which is not significant, but there is an increase in diastolic blood pressure by 2.4mmHg. As for blood glucose, the mean and standard deviation before the study was conducted was 5.5mmol/L and 1.3 respectively. The mean and standard deviation after the fifth day was 5.8mmol/L and 1.3 respectively. The p value was 0.068 which is not significant, but there is an increase in diastolic blood pressure by 0.3mmol/L. But there was an outlier in the blood glucose which is 11.2mmol/l for the pre control and 11.4mmol/L for the post control which are both bigger than the mean.

Interpretation of Mood

Intervention (Apple Cider Vinegar)

- 1. Null Hypothesis: There is no significant difference between the mood before and after the consumption of apple cider vinegar.
- 2. Alternative Hypothesis: There is a significant difference between the mood before and after the consumption of apple cider vinegar.
- 3. Two-tailed P value: 0.0023

P value is less than the level of significance of 0.05, hence there is a significant difference between the mood before and after the consumption of apple cider vinegar. Alternative hypothesis is accepted.

- 4. The difference in the means of mood before and after the intervention is -1.38.
- 5. 95% Confidence interval: -2.22 to -0.54

0 does not lie within this range, hence there is a significant difference between the mood before and after the consumption of apple cider vinegar. Alternative hypothesis is accepted.

- 6. Intermediate values used in calculations:
- i) t = 3.3601
- ii) df = 28
- iii) standard error of difference = 0.410
- Control (Water)
- 7. Null Hypothesis: There is no significant difference between the mood before and after the consumption of water.
- 8. Alternative Hypothesis: There is a significant difference between the mood before and after the consumption of water.
- 9. Two-tailed P value: 0.2894

P value is more than the level of significance of 0.05, hence there is no significant difference between the mood before and after the consumption of water. Null hypothesis is accepted

- 10. The difference in the means of mood before and after consumption of water is -0.60
- 11.95% Confidence interval: -1.74 to 0.54

0 lies within this range, hence there is no significant difference between the mood before and after the consumption of water. Null hypothesis is accepted.

- 12. Intermediate values used in calculations:
- i) t = 1.0835
- ii) df = 24
- iii) standard error of difference = 0.554

*Overall interpretation of mood in intervention and control groups:* 

Apple cider vinegar did cause a change in the mood as compared to those who didn't receive this intervention.

Interpretation of Energy Level.

Intervention (Apple Cider Vinegar)

- 13.Null Hypothesis: There is no significant difference between the energy level before and after the consumption of apple cider vinegar.
- 14. Alternative Hypothesis: There is a significant difference between the energy level before and after the consumption of apple cider vinegar.
- 15. Two-tailed P value: 0.0008

P value is less than the level of significance of 0.05, hence there is a significant difference between the energy level before and after the consumption of apple cider vinegar. Alternative hypothesis is accepted.

- 16. The difference in the means of energy level before and after the intervention is -2.00
- 17.95% Confidence interval: -3.09 to -0.91

0 does not lie within this range, hence there is a significant difference between the energy level before and after the consumption of apple cider vinegar. Alternative hypothesis is accepted.

18. Intermediate values used in calculations:

i) t = 3.7579

ii) df = 28

iii) standard error of difference = 0.532

Control (Water)

- 19.Null Hypothesis: There is no significant difference between the energy level before and after the consumption of water.
- 20. Alternative Hypothesis: There is a significant difference between the energy level before and after the consumption of water.
- 21. Two-tailed P value: 0.0071

P value is less than the level of significance of 0.05, hence there is a significant difference between the energy level before and after the consumption of water. Alternative hypothesis is accepted.

22. The difference in the means of energy level before and after the consumption of water is -1.40.

23.95% Confidence interval: -2.38 to -0.42

0 does not lie within this range, hence there is a significant difference between the energy level before and after the consumption of water. Alternative hypothesis is accepted.

24. Intermediate values used in calculations:

i) t = 2.9406

ii) df = 24

iii) standard error of difference = 0.476

*Overall interpretation of energy level in intervention and control groups:* 

Both the intervention and control groups did experience a change in their energy levels.

Interpretation of Concentration.

After Intervention (Apple Cider Vinegar)

15 out of the 29 participants who received the intervention reported an increased level of concentration. This makes up about 51.72% of the intervention group.

The other 14 participants (48.28%) of the intervention group did not experience any increase in concentration level. *Discussion* 

There are currently many up and coming research on the many benefits of apple cider vinegar on improving health for there are many benefits indeed. Humans have been consuming and topically applying apple cider vinegar for decades now, believing that it can cure certain illness and promote better overall health. Among the health benefits that apple cider vinegar is claimed to have an effect on are, aiding in weight loss (suppressing hunger and decreasing appetite are among the ways apple cider vinegar aids in weight loss) [1]. Therefore, due to curiosity, this study was conducted to learn if apple cider vinegar has a positive effect on reducing weight, blood pressure (systolic and diastolic blood pressure), blood glucose level and decreasing heart rate. Many of the trials evaluating the effectiveness of vinegar and glycemic control were small in scale, and the amount of vinegar, type of vinegar, its acidity, timing of consumption, and composition of the meal varied [2]. So, we decided to keep our study group small too.

A study was conducted on 60 participants, although there were 6 drop outs, so results from only 54 participants (29 participants in the test group and 25 participants in the control group) could be recorded and interpreted. The study revolved around segregating these participants into control and test group and giving the control group 250ml of plain boiled water and giving the test group 30ml of apple cider vinegar diluted in 250ml of water for a period of 5 days. Every participant's weight, blood pressure, blood glucose level and heart rate are measured and recorded on the first and fifth day. The outcomes were then compared and interpreted. The reason water was given to the control group is simply an appropriate placebo couldn't be found just because if something like apple juice or some other sour was given, it would have implications on the dependent variable and will affect the overall outcome of the study, as juices will increase blood glucose levels. Hence, to keep things neutral, water is given. Water is also used to dilute the apple cider vinegar for it is very sour and slightly corrosive to the esophagus due to its low pH value, therefore water is used to make it more palatable at the same time not affecting the dependent variables of the study. The full procedure of the study is mentioned in the methodology along with the method of collecting, analyzing and interpreting data.

Implication

The objective of this study is to confirm the consumption of 30ml of apple cider vinegar daily will reduce body weight, decrease blood pressure, blood glucose levels and heart rate. In this modern world, people are becoming more weight conscious and are always in the lookout for new, permanent and effective weight loss method. People are also more health conscious and would like to improve their quality of life by being disease free. On a global scale, the number of people with diabetes has risen from 108 million in 1980 to 422 million in 2014 [4]. An effective intervention is on the lookout and we were hoping that apple cider vinegar would do the trick. Apple cider vinegar is cheap and easily accessible with minimum side effects as compared to medication. Organic Apple cider vinegar is also available for those who are extra particular on their diet and eating 'clean'. An improvement in fasting blood glucose was observed in one pilot study, yet no significant favorable effect was noted on 2-hour postprandial glucose, insulin concentration, or glycated hemoglobin [3].

After five days of giving the apple cider vinegar group apple cider vinegar and the control group water, their weight, blood pressure, blood glucose and heart rate were measured. The results are as such: there was a decrease in heart rate, systolic and diastolic blood pressure, although the p value of only the diastolic blood pressure showed a significant decrease in value. All the other values were not significant and there was an increase in body weight and blood glucose. Although this does not say much as random blood glucose was taken and it takes a minimum of 3 months to see actual change.

#### Limitation

This study involves invasive procedure to collect data (pricking the finger to draw blood to test blood glucose level which poses as an issue for there are participants who are needle shy and are reluctant to take part in the study due to this. The five participants from the control group dropped out of the study due to this very reason. Moreover, apple cider vinegar is extremely unpalatable and corrosive to the esophagus and stomach mucosa, leading to gastritis and stomach pains and discomforts, which makes it all the more difficult for the participants to come back the next day for a second, third, fourth and fifth dose of apple cider vinegar. But after much persuasion and convincing, we were able to secure 29 out of the 30 participants who were initially in the test group, although one participant dropped out due to gastritis. We did not force any of the participants though. We made it very clear to the participants at the beginning that participants are free to pull out of the study whenever they want. What was mildly startling is that most of the participants stayed just to look at the outcome for personal reason. This shows that people are indeed aware of the many benefits of apple cider vinegar and are routing for it to have a positive outcome.

# 4. Conclusion

The objective of this study is to find out if consuming 30 ml of apple cider vinegar everyday has a positive effect reducing body weight, reducing blood pressure, blood glucose level and heart rate. After five days of conducting the study and measuring and comparing the before and after of weight, blood pressure, blood glucose and heart rate of each of the participants, it was found that only the diastolic blood pressure showed a significant change. Although there is a decrease in heart rate, systolic and diastolic blood pressure, only the p value of diastolic blood pressure showed a significant decrease. All in all, the study was conducted in a very short time frame due to time constraints and if it were to be conducted for a longer duration, say one year, the results would probably show a greater significance for weight loss takes at least 3 months to notice any significant change, and the results may be positive and in favor of our objective. Despite the outcome, the results look promising.

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100