

# The Effect of Raisins on Short-term Memory, a Pilot Randomized Controlled Trial

**Chong Zhen Xing<sup>\*</sup>, Kalaivani Maniam, Alagunathan Alagaraj, Syed Lukman, Aswin Velu Vengadeshwaran**

Faculty of Medicine, Melaka Manipal Medical College, Johor, Malaysia

## Abstract

Raisins are originate from dried grapes and are also one of the most commonly consumed dried fruits across the globe. Raisins is the highest quintile of food because of their potential to provide physiologic antioxidants to tissue cells. Golden seedless raisins contains mean total ORAC of 10450  $\mu\text{mol TE}/100\text{ g}$ . The recommended ORAC units per day is 3000-5000  $\mu\text{mol TE}$ . High level of antioxidants is believed to be beneficial in enhancing short term memory. Raisins also have beneficial effects on glycemia/insulinemia, postprandial insulin response, cardiovascular risk factors, oral health, blood pressure and satiety. The study design was randomized controlled trial. The study population was batch 39 MBBS in MMMC Muar campus comprising 146 students. The sample size was 37 in total, 18 was randomized into intervention group and 19 was randomized into control group by using block randomization. All 37 participants were asked to do the test on number, verbal and visual memory by using [www.humanbenchmark.com](http://www.humanbenchmark.com) in computer lab before the intervention starts. The memory scores were recorded in Microsoft Excel. The participants in the intervention group were given 50g of raisins everyday for 3 consecutive days whereas the participants in the control group were not given any raisin. After 3 days, all 37 participants were again tested on number, verbal and visual memory by using [www.humanbenchmark.com](http://www.humanbenchmark.com) in computer lab. The memory scores were recorded in Microsoft Excel and analysed by using [graphpad.com](http://graphpad.com) and [epiinfo](http://epiinfo.com). Based on our results from the study, there were no significant differences in visual memory, verbal memory, number memory as well as total memory between intervention and control groups. Even after adjusting the baseline memory scores, there were no significant differences in the verbal memory, number memory and visual memory between intervention and control groups. However, the participants who consumed raisins for 3 days had higher visual memory and number memory scores than participants in the control group. Since intervention (raisins) was given to intervention group only, comparison between before and after the raisin consumption in the intervention group, there were no significant differences in visual memory, verbal memory, number memory and total memory between before and after raisin consumption. In conclusion, raisins can improve visual memory and number memory since it is knons as a good source of antioxidant. They were beneficial to human's memory and cognitive performance. A regular and optimum intake of raisins was recommended for everyone

## Keywords

Raisins, Randomized Controlled Trial, Memory

Received: September 11, 2019 / Accepted: November 24, 2019 / Published online: December 27, 2019

@ 2019 The Authors. Published by American Institute of Science. This Open Access article is under the CC BY license.

<http://creativecommons.org/licenses/by/4.0/>

---

\* Corresponding author

E-mail address: [zhenxingchong@gmail.com](mailto:zhenxingchong@gmail.com) (C. Z. Xing), [anathanraja@gmail.com](mailto:anathanraja@gmail.com) (A. Alagaraj), [syedlukman69@gmail.com](mailto:syedlukman69@gmail.com) (S. Lukman), [papakalai9@gmail.com](mailto:papakalai9@gmail.com) (K. Maniam), [aswin23237@gmail.com](mailto:aswin23237@gmail.com) (A. V. Vengadeshwaran)

## 1. Introduction

Dietary guidelines across the world recommend increased consumption of fruits and vegetables. The Food-based dietary guidelines of Malaysia 2010 recommend consumption of plenty of fruits and vegetables everyday. [1] According to United States Department of Agriculture (ChooseMyPlate.gov), adults who are between 19-30 years old should consume at least 2 cups of fruits daily. [2]

Raisins are originate from dried grapes and are also one of the most commonly consumed dried fruits across the globe. [3] Raisins is the highest quintile of food because of their potential to provide physiologic antioxidants to tissue cells. [4] Raisins contain boron, omega-3, vitamin C and E, and up to 72% sugars of total weight, mostly from fructose and glucose. The high boron content is important for growth and maintenance of healthy bones. [5] They contain 3% protein and 3.7%–6.8% dietary fibres. Dietary fibre is able to improve colonic function by modulating gastrointestinal transit time, faecal acidity, faecal weight, faecal short-chain fatty acids (SCFA) as well as faecal bile acids. [6] Raisins are also high in antioxidants, but low in sodium and contain no cholesterol. [7]

Golden raisins have the highest phenolic content and oxidative capacity. [8] The antioxidant quality of phenols in raisins is nearly 10 times higher than that of vitamins. [9] Golden seedless raisins contains mean total ORAC of 10450  $\mu\text{mol TE}/100\text{ g}$ . [10] ORAC (Oxygen Radical Absorption Capacity) assays measure the capacity of antioxidants in nutrients to scavenge the peroxy radical, which is the most common reactive oxygen species (ROS) in the body. [11] ROS has beneficial effects at low/moderate concentrations because they are involved in physiological roles in cellular responses to noxia, for example in protection against infectious agents, in the function of cellular signalling pathways, and the induction of mitogenic response. [12] Oxidative stress happens when there is imbalance between the ROS production and the defense systems which are needed to detoxify them. In human, oxidative stresses are associated with diseases including cancer, Alzheimer's diseases, atherosclerosis, ocular disease, rheumatoid arthritis, diabetes mellitus and motor neuron disease. [13] Serum antioxidant capacity is significantly correlated with the intake of vegetables and fruits over the past few years. [14] Antioxidant is a substance that can delay or inhibit oxidation of that oxidised substrate. They can donate an electron to rampaging free radicals and neutralise it which in turn reduce their damage capacity. Antioxidant defenses can be made endogenously by enzymes or obtained from foods and dietary supplements (non-enzymatic). [15, 16] High level of antioxidants is believed to be beneficial in enhancing short term memory. [17]

According to Dr Ronald Prior of the US Department of Agriculture Research Service at Tufts University, Boston,

Massachusetts, the recommended ORAC units per day is 3000-5000. Consumption of more than 5000 units per day will have no added benefit and excess is most likely excreted by the kidneys. [18] The effects of raisin intake on glycemia/insulinemia [19, 20], postprandial insulin response [21], cardiovascular risk factors [22], oral health, blood pressure [23] and satiety [24] have been investigated previously in human intervention studies [18-24]. Although there is occurrence of ochratoxin A (OTA) in raisins because of growth and contamination of ochratoxigenic fungi and humid weather during drying. The risk of toxic effect of OTA is considered to be minimal. [25]

Apart from the health benefits mentioned, can raisins improve one's short-term memory due to its antioxidant properties? The objectives of this research were to determine the effect of raisin on medical students' short-term memory, to identify the association between raisin's antioxidant properties on short-term memory and to observe and document any adverse effect due to raisin consumption. We believed that raisins consumption for 3 consecutive days can enhance short-term memory among MBBS students in MMMC.

## 2. Methodology

### 2.1. Study Design

We have conducted a randomized controlled trial parallel design in order to determine if the consumption of raisins improves short term memory, specifically on verbal, number and visual memories among the MBBS batch 39 students in Melaka Manipal Medical College (MMMC), Muar campus, Muar, Johor, Malaysia.

### 2.2. Study Setting and Study Population

This study was set in a private medical college in Muar, Johor, Malaysia, in which a student population of 146 comprising a single batch of 4th year Bachelor of Medicine & Bachelor of Surgery (MBBS) students. The study was held from August 2019 to September 2019

### 2.3. Sample Size

Pilot study was done to calculate the sample size needed. 20 participants were asked to participate. 10 participants were randomized into intervention group, who received 50g of raisins everyday for 3 consecutive days. 10 participants were randomized into control group, who were not given raisin. Data were collected and recorded by using Microsoft Excel. We proceeded by using Sample Calc apps on smartphone to calculate the sample size needed. The standard deviation was 19.3 and the size of difference was 17.2. The significance level was set to be 0.05 and the power was 80%. A sample

size of 20 in each group will be sufficient to detect a difference of 17.2 points, assuming a standard deviation of 19.3 points, a power of 80%, and a significance level of 0.05.

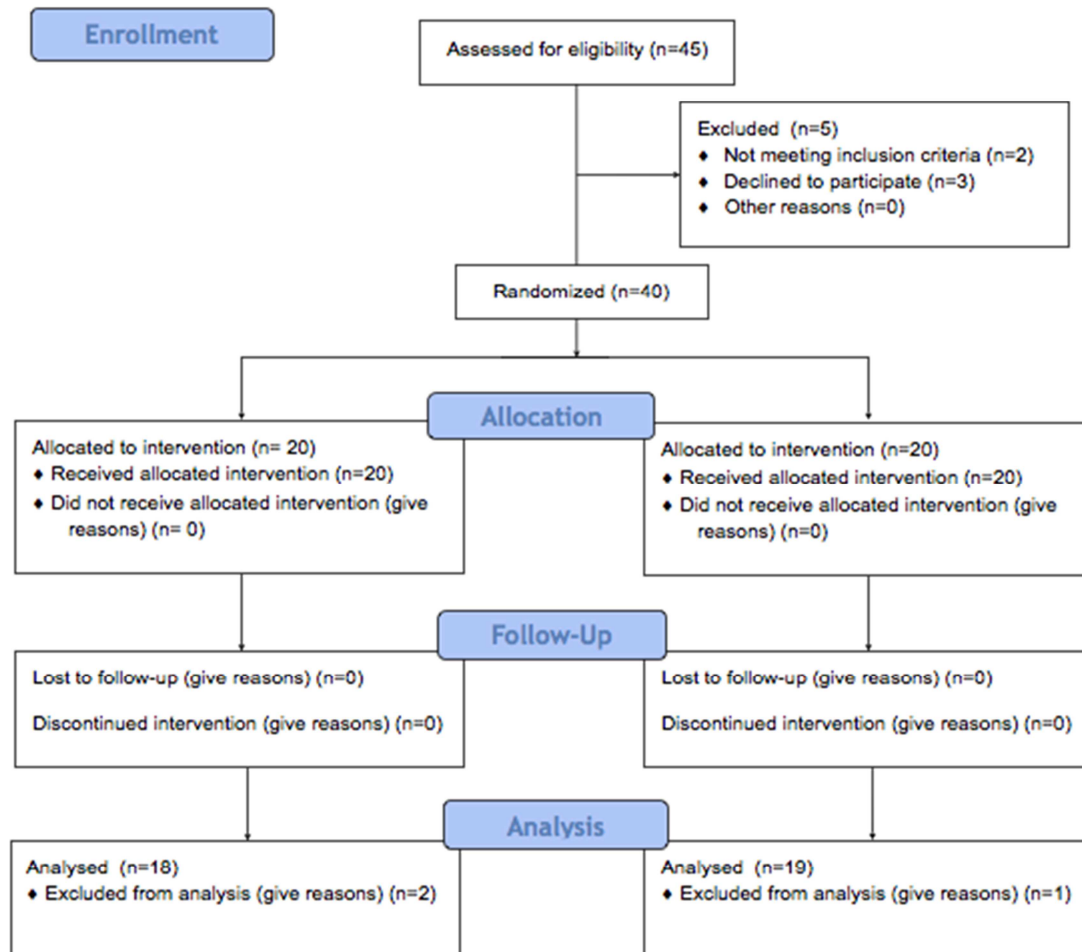
### 2.4. Sampling and Randomization

In this study, we used non-probability sampling technique to obtain sample from our study population and sample were selected according to inclusion and exclusion criteria

included in table below. Our study population consists of 146 students and 40 students volunteered to be our sample in this study. These 40 students were randomized into 2 groups, intervention and control group. We applied block randomization of block size 2 as our randomization method. 20 students were randomized into intervention group and the 20 students were randomized into control group by using the online randomizer software (randomizer.org).

**Table 1.** Inclusion and exclusion criteria for the study.

Inclusion criteria	Exclusion criteria
Students of age between 18-30 years old	Students who smoke frequently
Students of any gender	Students who consume alcohol frequently
Students of any race	Students who are allergic to raisins
Students of any nationality	Students who are on sedative drugs
	Students who consume illicit drugs
	Students with diagnosed psychiatric illness
	Students with recent head trauma



**Figure 1.** Consort flow diagram.

Based on the Consort Flow Diagram, 45 participants were eligible to participant for this study. However, 5 of them were excluded, 2 of them did not meet the inclusion criteria and 3 or them refused to participate. Hence, a total of 40 participants were randomized in this study. 20 participants were randomized into intervention group, who were received

50g of raisins everyday for 3 consecutive days and 20 participants were randomized into control group, who were not receiving raisins. There were no either lost follow ups or discontinued intervention in this study. For the analysis, in the intervention group, 18 participants were analyzed as 2 smokers were excluded. Meanwhile, in the control group, 19

participants were analyzed as 1 smoker were excluded.

## 2.5. Intervention and Follow Up

Our study intervention was raisin. Raisins were actually grapes that have been dried in the sun or in a food dehydrator. It was naturally sweet and high in sugar and calories. Generally, raisins give 299 calories per 100 grams. Raisins have many nutritional benefits due to its 3.7%-6.8% dietary fiber action, mean total ORAC of 10450  $\mu\text{mol TE}/100\text{ g}$  (antioxidant properties), presence of 6% of protein, 50 grams of boron and 21% of potassium. Among different types of raisins, we chose golden raisins which is known to contain high levels of antioxidants for our studies. Golden raisins were generally dried in dehydrators with controlled temperature and humidity, which allowed them to retain a lighter color and more moisture. They were often treated with sulfur dioxide after drying.

The 18 participants in the intervention group were given 50g of golden raisins which were separated into 2 small packets consisting 25g each for 3 consecutive days in the evening. The total ORAC of 5225  $\mu\text{mol TE}$  and 25 grams of boron was received by the participants in the intervention group everyday for 3 consecutive days. The participants were required to finish 1 packet of golden raisins before sleeping at night and finish the remaining 1 packet on the next day before collecting another 50g of golden raisins. They were also told to avoid eating snacks such as chocolates, peanuts, prunes, etc. The remaining 19 participants in the control group were inactive controls. They were not given any raisins in these 3 days. They were told to continue their normal daily diets and avoid eating raisins and other additional snacks. On the first day before giving raisins to the participants in the intervention group, all the 40 participants were assessed on number, verbal and visual memory by using an online software ([www.humanbenchmark.com](http://www.humanbenchmark.com)). The total time taken to finish all 3 assessments were approximately 15 minutes. Marks of each assessment were recorded by us immediately. On the fourth day, all the 37 participants were assessed again on number, verbal and visual memory by using the same online software. The results of the assessments were recorded and compared by us. The attrition rate was 0%.

## 2.6. Data Collection

### Study procedure

Our study consists of independent and dependent variables. Independent variable was raisins consumption and dependent variable was short-term memory. Firstly, we divided the participants into 2 groups, control and intervention group. There are 18 participants in the intervention group and 19 participants in the control group. All participants were given an informed consent form before we start the study. The

participants were also informed about studies procedure and they can choose not to join or quit halfway during the study in case if they cannot tolerate raisin. We gave questionnaires to all the participants as a pre-test before the intervention start to fulfill the inclusion and exclusion criteria of the study. All the participants who fulfilled the criteria were proceeded to do Human Benchmark test, as a pre-test before the intervention starts. They were instructed to do visual, number and verbal memory test only and the scores obtained were recorded for assessment purposes. After 3 days of intervention, all the participants were proceeded to do Human Benchmark test as a post-test and the scores obtained were recorded. Both pre and post test scores were compared to observe the raisin effect on short-term memory for intervention group.

### Data collection instrument

Human benchmark was an application where an individual can measure his/her abilities and identify what were his/her strengths and weaknesses. This application test the brain based on 6 categories such as number, reaction time, verbal, visual, hearing and typing memory. For the number memory test, each number will appear for 5 seconds for the participant to memorize. The number started with 1 digit and an additional digit was added after each level. Participant was required to key in the number appeared immediately after the number disappeared. The score was the number of digits which the participant can remember. For the verbal memory test, it measured the number of words the participant can memorize at once. The number of words that were needed to remember increased continually. The participant had 3 chances until game over. The score was the number of turns white the participant lasted. For the visual memory test, number of white tiles were flashed at every level and the participant was required to pick the same tiles correctly after the tiles reset. The number of white tiles increased with level. The participant lost a life after missing 3 tiles on a level. Each participant had 3 lives in one attempt. The score was the level which the participant reached.

## 2.7. Data Processing and Analysis

For the data analysis, data collected in the questionnaires and from Human Benchmark online application. It was exported and tabulated using Microsoft Excel version 2003 and the values were double checked to prevent any errors. From Microsoft Excel, the informations were then used for statistical calculations, using analytical software Epi Info version 7.2 from Centres for disease control and prevention website (CDC) and Graph Pad.

For descriptive statistical analysis, we included mean, standard deviation (SD), frequency and percentage. Mean and standard deviation were used to analyze the score of

visual memory, number memory and verbal memory. Frequency and percentage were calculated for adverse effects of raisins consumption. A table was drawn for demographic details to describe frequency and percentage between the intervention group and control group. Measure of association was done using relative ratio. The level of significance was set at  $P < 0.05$ , in which any values more than 0.05 were considered not statistically significant. Mean plot were used to represent the numerical data of verbal, number and visual memory. Unpaired t test was used to compare the number, verbal and visual memory between control and intervention groups. Paired t test was used to compare the number, verbal and visual memory between before and after in both intervention and control groups. Multiple linear regression was used to adjust the confounding factors in both intervention and control groups.

**Table 2.** Statistical test used for data analysis.

Independent variable	Dependent variable	Statistical test
Raisins group vs control group	Verbal memory	Unpaired t test
	Visual memory	Unpaired t test
	Number memory	Unpaired t test
Before vs after in intervention group	Verbal memory	Paired t test
	Visual memory	Paired t test
	Number memory	Paired t test
Before vs after in control group	Verbal memory	Paired t test
	Visual memory	Paired t test
	Number memory	Paired t test

### 2.8. Ethical Consideration

An informed consent form with all the important and relevant details of the study was given to the participants. The participants were given the option to participate in this study, and none were coerced into participating. Participants with severe allergy were avoided to participate in this study to prevent further health issues. Participants were notified that all the data and information gained through the study would be kept confidential. The form also had a concise explanation about the study and its requirements. The participants were also told that they could choose to withdraw from the study

whenever they needed to. This study was approved by Research Ethics Committee, Faculty of Medicine, Melaka Manipal Medical College.

## 3. Results

A total of 37 students participated in this study and were randomized into two groups, which was the intervention group who consumed raisins ( $n=18$ ) and control group who does not consumed raisins ( $n=19$ ). Table 3 shows baseline characteristics between the intervention group (raisins) and the control group (no raisins). The mean age of participants in the intervention group was 22.22 ( $SD=0.94$ ), while in the control group, the mean age was 22.31 ( $SD=1.00$ ). For the aspect of gender, female participants were the majority (72.22%) in the intervention group, however male participants were the majority (52.63%) in the control group. Generally, majority of the participants were Malay and Chinese, which represented by 27.78% in the intervention group and 31.58% were others in the control group. Most of the participants were Malaysians in which the intervention group and the control group were consist of 83.33% and 68.42% respectively. Based on the diet, majority of participants were non-vegetarian, 94.44% in the intervention group and 100% in the control group. The participants who sleep less than 7 hours was the majority in both group in which 83.33% in the intervention group and 57.90% in the control group. The participants in the intervention group has the majority for drinking water more than 8 cups daily (55.56%), while in the control group, they were drinking less than 8 cups daily (57.90%). Participants who does physical exercise in the intervention group and the control group were 50.00% and 57.90% respectively. As for the supplements taken, both intervention group (77.78%) and control group (57.90%) has the majority for not taking any supplements. Lastly, both intervention group (94.44%) and control group (94.73%) have not experienced any trauma to the head.

**Table 3.** Baseline characteristics between the intervention group (raisins) ( $n=18$ ) and the control group (no raisins) ( $n=19$ ).

Variables		Intervention group ( $n=18$ ) n (%)	Control group ( $n=19$ ) n (%)	Total ( $n=37$ ) n (%)
Age (years) <sup>a</sup>		22.22 (0.94)	22.31 (1.00)	22.27 (0.96)
Gender	Male	5 (27.78)	10 (52.63)	15 (40.54)
	Female	13 (72.22)	9 (47.37)	22 (59.46)
Race	Malay	5 (27.78)	5 (26.32)	10 (27.02)
	Chinese	5 (27.78)	4 (21.05)	9 (24.32)
	Indian	4 (22.22)	4 (21.95)	8 (21.62)
	Others	4 (22.22)	6 (31.58)	10 (27.02)
Nationality	Malaysian	15 (83.33)	13 (68.42)	28 (75.68)
	Non- Malaysian	3 (16.67)	6 (31.58)	9 (24.32)
Diet	Vegetarian	1 (5.56)	0 (0.00)	1 (2.70)
	Non-Vegetarian	17 (94.44)	19 (100.00)	36 (97.30)
Sleep duration	Less than 7 hours	15 (83.33)	11 (57.90)	26 (70.27)
	Between 7 to 9 hours	2 (11.11)	8 (42.10)	10 (27.03)
	More than 9 hours	1 (5.56)	0 (0.00)	1 (2.70)

Variables		Intervention group (n=18) n (%)	Control group (n=19) n (%)	Total (n=37) n (%)
Frequency of drinking water	More than 8 cups	10 (55.56)	8 (42.10)	18 (48.65)
	Less than 8 cups	8 (44.44)	11 (57.90)	19 (51.35)
Meditation or mental exercise	Yes	3 (16.67)	3 (15.79)	6 (16.21)
	No	15 (83.33)	16 (84.21)	31 (83.73)
Physical exercise	Yes	9 (50.00)	11 (57.90)	20 (54.05)
	No	9 (50.00)	8 (42.10)	17 (45.94)
Supplements taken	Yes	4 (22.22)	8 (42.10)	12 (32.43)
	No	14 (77.78)	11 (57.90)	25 (67.57)
Trauma to the head	Yes	1 (5.56)	1 (5.26)	2 (5.41)
	No	17 (94.44)	18 (94.73)	35 (94.6)

<sup>a</sup> Mean (SD)

**Table 4.** Comparison of visual memory, verbal memory, number memory and total memory between intervention group (raisins) and control group (no raisins) before the consumption of raisins.

Outcome variables	Mean (SD)		Mean differences (95%CI)	t-statistics (df)	P-value
	Intervention group (n=18)	Control group (n=19)			
Visual memory (score)	9.28 (0.87)	9.16 (0.87)	0.12 (-0.46, 0.70)	0.42 (35)	0.678
Verbal memory (score)	51.89 (29.71)	40.26 (22.95)	11.63 (-6.03, 29.29)	1.34 (35)	0.190
Number memory (score)	9.83 (1.86)	9.57 (1.57)	0.26 (-0.89, 1.41)	0.46 (35)	0.648
Total memory (score)	71 (30.21)	59 (23.50)	12.00 (-6.01, 30.01)	1.35 (35)	0.185

<sup>b</sup> Unpaired t-test

Table 4 shows the comparison of visual memory, verbal memory, number memory and total memory between interventions group (raisins) and control group (no raisins) before the consumption of raisins.

The mean (SD) of the visual memory score in the intervention group was 9.28 (0.87) and in the control group, the mean was 9.16 (0.87). The mean differences (95% CI) and t-statistics of visual memory score between the intervention group and control group were 0.12 (-0.46, 0.70) and 0.42 respectively. The P value obtained for visual memory score was 0.678. Hence, there was no significant difference in the visual memory score between the intervention group and control group before the consumption of raisins.

The mean (SD) of the verbal memory score in the intervention group was 51.89 (29.71) and in the control group, the mean was 40.26 (22.95). The mean difference (95%CI) and t-statistics of verbal memory score between the intervention group and control group were 11.63 (-6.03, 29.29) and 1.34 respectively. The P value obtained for verbal memory score was 0.190. Hence, there was no significant difference in the

verbal memory score between the intervention group and control group before the consumption of raisins.

The mean (SD) of the number memory score in the intervention group was 9.83 (1.86) and in the control group, the mean was 9.57 (1.57). The mean differences (95% CI) and t-statistics of number memory score between the intervention group and control group were 0.26 (-0.89, 1.41) and 0.46 respectively. The P value obtained for number memory score was 0.648. Hence, there was no significant differences in the number memory score between the intervention group and control group before the consumption of raisins.

The mean (SD) of the total memory score in the intervention group was 71 (30.21) and in the control group, the mean was 59 (23.50). The mean difference (95%CI) and t-statistics of total memory score between the intervention group and control group were 12.00 (-6.01, 30.01) and 1.35 respectively. The P value obtained for total memory score was 0.185. Hence, there was no significant difference in the total memory score between the intervention group and control group before the consumption of raisins.

**Table 5.** Comparison of visual memory, verbal memory, number memory and total memory between intervention group (raisins) and control group (no raisins) after the consumption of raisins.

Outcome variables	Mean (SD)		Mean differences (95%CI)	t-statistics (df)	P-value
	Intervention group (n=18)	Control group (n=19)			
Visual memory (score)	9.50 (1.20)	9.42 (1.50)	0.80 (-0.83, 0.99)	0.18 (35)	0.860
Verbal memory (score)	48.22 (25.63)	41.89 (21.36)	6.33 (-9.38, 22.04)	0.82 (35)	0.419
Number memory (score)	9.67 (2.45)	9.16 (1.43)	0.51 (-0.82, 1.84)	0.78 (35)	0.441
Total memory (score)	67.39 (27.07)	60.47 (21.86)	6.92 (-9.46, 23.30)	0.86 (35)	0.397

<sup>b</sup> Unpaired t-test

Table 5 shows the comparison of visual memory, verbal memory, number memory and total memory between intervention group (raisins) and control group (no raisins) after the consumption of raisins.

The mean (SD) of the visual memory score in the intervention group was 9.50 (1.20) and in the control group, the mean was 9.42 (1.50). The mean difference (95% CI) and t-statistics of visual memory score between the intervention group and control group were 0.80 (-0.83, 0.99) and 0.18 respectively. The P value obtained for visual memory score was 0.860. Hence, there was no significant difference in the visual memory score between the intervention group and control group after the consumption of raisins.

The mean (SD) of the verbal memory score in the intervention group was 48.22 (25.63) and in the control group, the mean was 41.89 (21.36). The mean difference (95% CI) and t-statistics of verbal memory score between the intervention group and control group were 6.33 (-9.38, 22.04) and 0.82 respectively. The P value obtained for verbal memory score was 0.419. Hence, there was no significant difference in the

verbal memory score between the intervention group and control group after the consumption of raisins.

The mean (SD) of the number memory score in the intervention group was 9.67 (2.45) and in the control group, the mean was 9.16 (1.43). The mean difference (95% CI) and t-statistics of number memory score between the intervention group and control group were 0.51 (-0.82, 1.84) and 0.78 respectively. The P value obtained for number memory score was 0.441. Hence, there was no significant difference in the number memory score between the intervention group and control group after the consumption of raisins.

The mean (SD) of the total memory score in the intervention group was 67.39 (27.07) and in the control group, the mean was 60.47 (21.86). The mean difference (95% CI) and t-statistics of total memory score between the intervention group and control group were 6.92 (-9.46, 23.30) and 0.86 respectively. The P value obtained for total memory score was 0.397. Hence, there was no significant difference in the total memory score between the intervention group and control group after the consumption of raisins.

**Table 6.** Comparison of visual memory, verbal memory, number memory and total memory in the intervention group (raisins) (n=18) before and after consuming raisins.

Outcome variables	Mean (SD) (n=18)		Mean differences (95%CI)	t-statistics (df)	P-value
	Before	After			
Visual memory (score)	9.28 (0.89)	9.50 (1.20)	-0.22 (-0.89, 0.45)	0.70 (17)	0.495
Verbal memory (score)	51.89 (30.57)	48.22 (25.63)	3.67 (-6.54, 13.88)	0.76 (17)	0.459
Number memory (score)	9.83 (1.92)	9.67 (2.45)	0.17 (-0.90, 1.24)	0.33 (17)	0.746
Total memory (score)	71.00 (31.09)	67.39 (27.07)	3.61 (-7.39, 14.61)	0.69 (17)	0.498

\*Paired t-test

Table 6 shows the comparison of number memory, visual memory and verbal memory before and after the consumption of raisins in intervention group.

The mean (SD) of the visual memory before and after the consumption of raisins was 9.28 (0.89) and 9.50 (1.20) respectively. The mean differences (95% CI) and t-statistics of the visual memory calculated before and after the intervention was -0.22 (-0.89, 0.45) and 0.70 respectively. There was an increase in visual memory of control group with the magnitude of -0.22 mean difference. The P value of visual memory computed was 0.495. Hence, there was no significant differences in the visual memory of the participants before and after the consumption of raisins in intervention group.

The mean (SD) of the verbal memory before and after the consumption of raisins was 51.89 (30.57) and 48.22 (25.63) respectively. The mean differences (95% CI) and t-statistics of the verbal memory calculated before and after the intervention was 3.67 (-6.54, 13.88) and 0.76 respectively. There was a decrease in verbal memory of control group with the magnitude of 3.67 mean difference. The P value of verbal

memory computed was 0.459. Hence, there was no significant differences in the verbal memory of the participants before and after the consumption of raisins in intervention group.

The mean (SD) of the number memory before and after the consumption of raisins was 9.83 (1.92) and 9.67 (2.45) respectively. The mean differences (95% CI) and t-statistics of the number memory calculated before and after the intervention was 0.17 (-0.90, 1.24) and 0.33 respectively. There was a decrease in number memory of control group with the magnitude of 0.17 mean differences. The P value of number memory computed was 0.746. Hence, there was no significant differences in the number memory of the participants before and after the consumption of raisins in intervention group.

The mean (SD) of the total memory before and after the intervention was 71.00 (31.09) and 67.39 (27.07) respectively. The mean differences (95% CI) and t-statistics of the total memory calculated before and after the intervention was 3.61 (-7.39, 14.61) and 0.69 respectively. There was a decrease in total memory of control group with the magnitude of 3.61

mean differences. The P value of total memory computed was 0.498. Hence, there was no significant differences in the

total memory of the participants before and after the consumption of raisins in intervention group.

**Table 7.** Comparison of visual memory, verbal memory, number memory and total memory in the control group (no raisins) (n=19) before and after the consumption of raisins.

Outcome variables	Mean (SD) (n=19)		Mean differences (95%CI)	t-statistics (df)	P-value
	Before	After			
Visual memory (score)	9.16 (0.90)	9.42 (1.50)	-0.26 (-0.98, 0.45)	0.77 (18)	0.450
Verbal memory (score)	40.26 (23.58)	41.89 (21.36)	-1.63 (-12.06, 8.79)	0.33 (18)	0.750
Number memory (score)	9.58 (1.61)	9.16 (1.42)	0.42 (-0.52, 1.36)	0.94 (18)	0.360
Total memory (score)	59.00 (24.15)	60.47 (21.86)	-1.47 (-11.80, 8.86)	0.30 (18)	0.768

<sup>c</sup> Paired t-test

Table 7 shows the comparison of visual memory, verbal memory, number memory and total memory before and after the consumption of raisins in control group.

The mean (SD) of the visual memory before and after the consumption of raisins was 9.16 (0.90) and 9.42 (1.50) respectively. The mean differences (95% CI) and t-statistics of the visual memory calculated before and after the intervention was -0.26 (-0.98, 0.45) and 0.77 respectively. There was an increase in visual memory of control group with the magnitude of -0.26 mean differences. The P value of visual memory computed was 0.450. Hence, there was no significant differences in the visual memory of the participants before and after the consumption of raisins in control group.

The mean (SD) of the verbal memory before and after the consumption of raisins was 40.26 (23.58) and 41.89 (21.36) respectively. The mean differences (95% CI) and t-statistics of the verbal memory calculated before and after the intervention was -1.63 (-12.06, 8.79) and 0.33 respectively. There was an increase in verbal memory of control group with the magnitude of -1.63 mean differences. The P value of verbal memory computed was 0.750. Hence, there was no significant differences in the verbal memory of the participants before and after the study in control group.

The mean (SD) of the number memory before and after the consumption of raisins was 9.58 (1.61) and 9.16 (1.42) respectively. The mean differences (95% CI) and t-statistics of the number memory calculated before and after the intervention was 0.42 (-0.52, 1.36) and 0.94 respectively. There was a decrease in number memory of control group with the magnitude of 0.42 mean differences. The P value of number memory computed was 0.360. Hence, there was no significant differences in the number memory of the participants before and after the study in control group.

The mean (SD) of the total memory before and after the consumption of raisins was 59.00 (24.15) and 60.47 (21.86) respectively. The mean differences (95% CI) and t-statistics of the total memory calculated before and after the intervention was -1.47 (-11.80, 8.86) and 0.30 respectively.

There was an increase in total memory of control group with the magnitude of -1.47 mean differences. The P value of total memory computed was 0.768. Hence, there was no significant differences in the total memory of the participants before and after the study in control group.

**Table 8.** Multiple linear regression analysis of visual memory, verbal memory and number memory between the intervention group (raisins) (n=18) and control group (no raisins) (n=19).

Outcome variables	Regression coefficient (b)	Standard error	P value
Visual memory <sup>b</sup>	0.031	0.440	0.944
Verbal memory <sup>c</sup>	-0.336	6.021	0.956
Number memory <sup>d</sup>	0.392	0.608	0.523

Adjusted for baseline visual memory<sup>b</sup>, baseline verbal memory<sup>c</sup>, baseline number memory<sup>d</sup>

Table 8 shows the linear regression analysis of visual memory, verbal memory and numerical memory between the intervention group (raisins) and control group (no raisins).

The interventional group who received raisins had higher visual memory score compared to the control group with regression coefficient (b) 0.031. However, this was not significant (P value = 0.944).

The interventional group who received raisins had lower verbal score compared to the control group with regression coefficient (b) -0.336. However, this was not significant (P value = 0.956).

The interventional group who received raisins had higher number score compared to the control group with regression coefficient (b) 0.392. However, this was not significant (P value = 0.523).

**Table 9.** Frequency and percentage of adverse effect experienced by participants in the intervention group (n=18) after the consumption of raisins.

Adverse effect	Frequency (%)
Allergy	0 (0)
Wheezing	0 (0)
Shortness of breath	0 (0)
Runny nose	0 (0)
Nasal blockage	0 (0)
Sore throat	0 (0)
Vomiting	0 (0)
Nausea	0 (0)



Adverse effect	Frequency (%)
Diarrhoea	0 (0)
Fever	0 (0)
Bloating	0 (0)
Indigestion	0 (0)
Abdominal pain	0 (0)
Dizziness	0 (0)
Lightheadedness	0 (0)
Blurred vision	1 (5.56)
Others	0 (0)

Table 9 shows the adverse effects experienced by participants in the intervention group after the consumption of raisins.

There was 1 participant, which comprised 5.56% of the participants in the intervention group experienced blurred vision after consuming the raisins for three consecutive days. There was no other adverse effect experienced by the participants.

## 4. Discussion

The pilot randomized controlled study parallel design was conducted among medical students was to determine the effect of raisin on short-term memory, specifically on number, visual and verbal memory. This research was also to identify the association of raisin's antioxidant properties on short-term memory and to observe and document any adverse effect due to raisin consumption.

After 3 days of consuming raisins or not consuming raisins, we found that there were no significant differences in visual memory, verbal memory, number memory as well as total memory between intervention and control groups. However, the participants who consumed raisins for 3 days had score higher in visual, verbal and number memory than participants in the control group.

For comparison between before and after the raisin consumption in the intervention group, there were no significant differences in visual memory, verbal memory, number memory and total memory between before and after raisin consumption. The visual memory was increased but number memory, verbal memory and total memory was decreased. In control group, visual memory, verbal memory and total memory were increased but the number memory was decreased. However, there were no significant differences between the before and after the study in the control group.

After adjusting the baseline memory scores, there were no significant differences in the verbal memory, number memory and visual memory between intervention and control groups. However, the participants in the intervention group had higher visual and number memory scores than participants in the control group. Regards to verbal memory, it was shown that the participants in the intervention group had lower score as compared to the participants in the control

group. Even though there was no human trial about the effect of raisins on memory, animal study done among rats showed that antioxidant can prevent the change in oxidative stress and consequently memory impairment in diabetic rats. [17]

We found that one participant who consumed raisins had blurred vision. None of them had other adverse effects such as allergy, wheezing, shortness of breath, runny nose, nasal blockage, sore throat, vomiting, nausea, diarrhoea, fever, bloating, indigestion, abdominal pain, dizziness and lightheadedness. It was mention in the Organic Facts by Meenakashi Nagdeve, a Director Product Organic Information Services in India, that raisins might cause side effects like weight gain and allergy. [26]

The strengths of this study was that the amount of raisins we provided to the participants in the intervention group was calculated according to the recommended ORAC units per day from US Department of Agriculture Research Service at Tufts University, Boston, Massachusetts. The ORAC unit of golden raisins was obtained from USDA database. The limitations of this study was that the sample size was small and the study population was also restricted to only healthy young medical students which consequently unable to generalise the study findings to other population. The intervention was limited to 3 days only. Therefore, the benefit of raisins on memory was not observed. A more diverse study population with bigger sample size was recommended for future study on effect of raisins on memory.

## 5. Conclusion

In conclusion, raisins might improve visual and number memory although there were no significant differences in visual, number and verbal memory between the intervention and control groups. Raisins were good source of antioxidant. They were beneficial to human's memory and cognitive performance. Regular consumption of raisins can also help in glycemic control, reduce in cardiovascular disease risk, maintain good oral health and blood pressure.

## Acknowledgements

We would like to thank all the volunteers for participating in our study. We would also like to thank the Dean of MMMC Professor Dr. Adinegara Lutfi Abas, as well as our lecturers Professor Dr. Htoo Htoo Kyaw Soe, Associate Professor Dr. Sujatha Khobragade and Assistant Professor Dr. Mila Nu Nu Htay. We would also like to express our gratitude to the Research and Ethics committee, Faculty of Medicine, Melaka Manipal Medical College, Malaysia for approving our study. Last but not least, we would like to thank all the volunteers for participating in our study.

## References

- [1] Malaysia [Internet]. Food and Agriculture Organization of the United Nations. [cited 2019 Aug 1]. Available from: <http://www.fao.org/nutrition/education/food-dietary-guidelines/regions/countries/malaysia/en/>
- [2] All About the Fruit Group [Internet]. Choose MyPlate. 2019 [cited 2019 Aug 1]. Available from: <https://www.choosemyplate.gov/fruit>
- [3] Association of raisin consumption with nutrient intake, diet quality, and health risk factors in US adults: National Health and Nutrition Examination Survey 2001–2012 [Internet]. Taylor & Francis. [cited 2019 Aug 1]. Available from: <https://www.tandfonline.com/doi/full/10.1080/16546628.2017.1378567>
- [4] Anderson JW, Waters AR. Raisin Consumption by Humans: Effects on Glycemia and Insulinemia and Cardiovascular Risk Factors-Anderson-2013-Journal of Food Science-Wiley Online Library [Internet]. Journal of Food Science. John Wiley & Sons, Ltd (10.1111); 2013 [cited 2019 Aug 1]. Available from: <https://onlinelibrary.wiley.com/doi/full/10.1111/1750-3841.12071>
- [5] Vasilopoulou, Effie, Trichopoulou, Antonia. Greek raisins: A traditional nutritious delicacy [Internet]. Journal of Berry Research. IOS Press; 2014 [cited 2019 Aug 1]. Available from: <https://content.iospress.com/articles/journal-of-berry-research/jbr074>
- [6] Spiller GA, Story JA, Furumoto EJ, Chezem JC, Spiller M. Effect of tartaric acid and dietary fibre from sun-dried raisins on colonic function and on bile acid and volatile fatty acid excretion in healthy adults: British Journal of Nutrition [Internet]. Cambridge Core. Cambridge University Press; 2007 [cited 2019 Aug 1]. Available from: <https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/effect-of-tartaric-acid-and-dietary-fibre-from-sundried-raisins-on-colonic-function-and-on-bile-acid-and-volatile-fatty-acid-excretion-in-healthy-adults/03841E6F1C28D92219217437F94E68BB>
- [7] Jamela J, Ban E-haboby, Waleed J, Enas A. The Effect of Iraqi Yellow Raisin on the Brain regions and the Blood Cells Count [Internet]. Research Gate. 2016. Available from: [https://www.researchgate.net/publication/309477594\\_The\\_Effect\\_of\\_Iraqi\\_Yellow\\_Raisin\\_on\\_the\\_Brain\\_regions\\_and\\_the\\_Blood\\_Cells\\_Count](https://www.researchgate.net/publication/309477594_The_Effect_of_Iraqi_Yellow_Raisin_on_the_Brain_regions_and_the_Blood_Cells_Count)
- [8] Antioxidant Capacity and Phenolic Content of Grapes, Sun-Dried Raisins, and Golden Raisins and Their Effect on ex Vivo Serum Antioxidant Capacity [Internet]. Journal of Agricultural and Food Chemistry. [cited 2019 Aug 1]. Available from: <https://pubs.acs.org/doi/abs/10.1021/jf071468p>
- [9] Arianna C, Thea L, Dalia P. Health Benefits of Sun-Dried Raisins [Internet]. 2012. Available from: <https://pdfs.semanticscholar.org/4f46/cbcf6d8a17eb793b0675873e977dce58657d.pdf>
- [10] David HB, Seems B. USDA Database for the Oxygen Radical Absorbance Capacity (ORAC) of Selected Foods, Release 2 [Internet]. 2010. Available from: <http://www.drmarcofranzreb.com/wp-content/uploads/2013/04/ORAC-de-alimentos-2.pdf>
- [11] Alexander SG. Antioxidant testing: an ORAC update [Internet]. Research Gate. 2004. Available from: [https://www.researchgate.net/publication/236834981\\_Antioxidant\\_testing\\_an\\_ORAC\\_update](https://www.researchgate.net/publication/236834981_Antioxidant_testing_an_ORAC_update)
- [12] Valko M, Leibfritz D, Moncol J, Cronin MTD, Mazur M, Telser J. Free radicals and antioxidants in normal physiological functions and human disease [Internet]. The international journal of biochemistry & cell biology. U.S. National Library of Medicine; 2007 [cited 2019 Aug 1]. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/16978905>
- [13] Hajhashemi V, Vaseghi G, Pourfarzam M, Abdollahi A. Are antioxidants helpful for disease prevention? [Internet]. Research in pharmaceutical sciences. Medknow Publications & Media Pvt Ltd; 2010 [cited 2019 Aug 1]. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3093095/>
- [14] Mancini, F. R., Affret, A., Dow, C., Balkau, B., Fabrice Bonnet, M.-C. B.-R., & Fagherazzi, G. (2017, November 9). Dietary antioxidant capacity and risk of type 2 diabetes in the large prospective E3N-EPIC cohort. Retrieved from <https://link.springer.com/article/10.1007/s00125-017-4489-7>.
- [15] Bell SJ. Overview Of Antioxidants: Emphasis On Raisins [Internet]. The Internet Journal of Nutrition and Wellness. Internet Scientific Publications; 2009 [cited 2019 Aug 1]. Available from: <http://ispub.com/IJNW/10/1/6985>
- [16] Free radicals and antioxidants in health and disease: a review [Internet]. World Health Organization. World Health Organization; 1998 [cited 2019 Aug 1]. Available from: <http://apps.who.int/iris/handle/10665/118217>
- [17] Protection of cholinergic and antioxidant system contributes to the effect of berberine ameliorating memory dysfunction in rat model of streptozotocin-induced diabetes [Internet]. Behavioural Brain Research. Elsevier; 2011 [cited 2019 Aug 1]. Available from: <https://www.sciencedirect.com/science/article/pii/S0166432811000489>
- [18] How do we know levels of antioxidants in foods? The ORAC system. [cited 2019 Aug 1]. Available from: <https://www.naturalbalancefoods.co.uk/community/healthy-living/the-orac-system/>
- [19] A pilot, randomized controlled trial to examine the health outcomes of raisin consumption in patients with diabetes [Internet]. Nutrition. Elsevier; 2013 [cited 2019 Aug 1]. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0899900713003730>
- [20] Esfahani A, Lam J, Kendall CWC. Acute effects of raisin consumption on glucose and insulin responses in healthy individuals: Journal of Nutritional Science [Internet]. Cambridge Core. Cambridge University Press; 2014 [cited 2019 Aug 1]. Available from: <https://www.cambridge.org/core/journals/journal-of-nutritional-science/article/acute-effects-of-raisin-consumption-on-glucose-and-insulin-reponses-in-healthy-individuals/CED06211EA29FE22E7BEADEC52694DD>
- [21] Polyphenol content and health benefits of raisins [Internet]. Nutrition Research. Elsevier; 2010 [cited 2019 Aug 1]. Available from: <https://www.sciencedirect.com/science/article/pii/S0271531710001375>

- [22] Puglisi MJ, Torres-Gonzalez M, Wood RJ, Volek JS, Fernandez ML. Raisins and additional walking have distinct effects on plasma lipids and inflammatory cytokines [Internet]. *Lipids in Health and Disease*. BioMed Central; 2008 [cited 2019 Aug 1]. Available from: <https://lipidworld.biomedcentral.com/articles/10.1186/1476-511X-7-14>
- [23] Wong A, Young DA, Emmanouil DE, Wong LM, Waters AR, Booth MT. Raisins and oral health [Internet]. *Journal of food science*. U.S. National Library of Medicine; 2013 [cited 2019 Aug 1]. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/23789933>
- [24] Painter JE, Waters AR. A Review of the Health Benefits of Raisins-Painter-2013-Journal of Food Science-Wiley Online Library [Internet]. *Journal of Food Science*. John Wiley & Sons, Ltd (10.1111); 2013 [cited 2019 Aug 1]. Available from: <https://onlinelibrary.wiley.com/doi/full/10.1111/1750-3841.12139>
- [25] Ostry V, Ruprich J, Skarkova J. Raisins, ochratoxin A and human health [Internet]. SpringerLink. Springer-Verlag; [cited 2019 Aug 1]. Available from: <https://link.springer.com/article/10.1007/BF02946091>
- [26] Nutritional Benefits Of Eating Raisins Every Day [Internet]. Organic Facts. 2019 [cited 2019 Sep 5]. Available from: <https://www.organicfacts.net/health-benefits/fruit/health-benefits-of-raisins.html>