Effects of breakfast on memory in healthy young adults

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Glucose consumption has been found to improve memory in healthy young adults.[1] The main purpose of this study was to determine the different effects of isoenergetic glucose and protein compared with sodium saccharin on memory at breakfast in healthy young adults.

Twenty healthy young adults (10 female and 10 male) were enrolled through advertisements posted at the university. The subjects were informed about the general objectives, the procedure and possible risks of the study. All subjects gave their written informed consent to the study. Subjects were not compensated for their participation. They were non-smokers, not trained athletes, aged 22±1.2 and body mass index (BMI) 21±1.3. They were not on any medication and did not take any drugs or nutritional supplements in the week before and during the experimental period. They came to the testing center on 3 separate days in a week. Only persons whose mother language was Persian were selected. The level of education was 2-3 years of university.

A repeated-measures design was used such that each subject served as his or her own control and participated in all of the 3 sessions. Subjects were told that various physiological and psychological effects of food intake were examined in the study, but they were not aware of ingesting different macronutrients. To ensure similar baseline conditions, subjects were not allowed to ingest alcohol or caffeine-containing drinks and foods. After an overnight (10-12 hour) fast with just water permitted, the subjects arrived at the testing center at 7.45 am. At 8.00 am a blood sample was taken by a lancet and then the subjects were immediately examined by 3 different memory tests (Wechsler Memory Scale-Revised).[2] Each subject was tested individually on 3 mornings, each separated by one week, and no less than 2 days, to minimize potential carryover effects. All subjects consumed their drinks in a 2-3 minute period. The blood glucose sample was collected before drink ingestion and 60 minutes after consumption of the drinks in each session. One drop of blood was used to measure plasma glucose by a blood glucose meter (One Touch Basic Meter; Lifescan Canada Ltd). This meter is accurate within 15% of laboratory results 96% of the time (One Touch Basic Test Strip package insert, 1997). The next blood sample has been taken at 9.00 am and after that, the subjects were tested with alternative versions of the same tests. One examiner was used to minimize error.

All subjects were blinded to the content of the drinks. There were 3 different drinks. The carbohydrate drink: 50gr D(+)-glucose anhydrous for biochemistry (Merck, Darmstad, Germany), 240ml water. The protein drink: 50gr casein soluble in alkali (Merck, Darmstad, Germany), 240ml water. The placebo drink: 3mg sodium saccharin (manufactured by Boots, UK), 240ml water. The glucose and protein drinks were isoenergetic.

The word recall and logical memory and association learning of Wechsler Memory Scale-Revised[2] were used as the memory tests. The Department of Clinical Psychology at the university developed the 6 tests. These tests were similar in difficulty to the Wechsler tests, but with different questions. The validity of these tests was tested by the Department of Clinical Psychology. The maximum possible score of the tests was 37, which was measured 60 minutes after drinking the allocated drink.

Statistical analysis was carried out by paired-t test, ANOVA and correlation tests for comparative analysis with the use of the Statistical Package for Social Sciences version 10. The correlation analysis was conducted to examine the relation between blood glucose levels and memory score changes.

The results indicate that no significant differences in any of these measures are evident between males and females. There are no statistically significant differences between baseline blood glucose levels and memory scores in the 3 groups. Blood glucose

Table 1 - Blood glucose and memory scores before and after each treatment and their variation.

Criteria/Group	Blood glucose before drink*	Blood glucose after drink*	Memory score before drink*	Memory score after drink*	r†	*p*-value‡
Glucose	76.8±4.9	109.7±8.3(a)	24.3±3	30±2.4(a)	0.541	0.014
Protein	75.5±6	73.9±4.8(b)	26.2±3.5	28.9±3.6(a)	-0.1	0.66
Placebo	74.45±7.1	72.2±6.7(a)	24.4±2.2	26.3±3.6(c)	-0.3	0.09

*mean ± SD, †Pearson coefficient between blood glucose and memory scores changes in each group, ‡*p*-value for r
(a) $p<0.01$, (b) $p=0.05$, (c) $p<0.01$

levels increased significantly in the glucose group (*p*<0.001) but decreased in the protein group (*p*=0.05) and placebo (*p*<0.001). However, these changes were within the normal range. All memory test scores significantly increased in each of the 3 groups **(Table 1)**. Only in the glucose group was the variation in blood glucose correlated to memory score elevation (r=0.541) (*p*=0.014).

In this study, it was found that all glucose, protein and sodium saccharin drinks significantly increased memory scores 60 minutes after ingestion. The effect of the glucose drink was greater than the protein and placebo drinks. A dependent correlation between blood glucose levels and enhancement effects of memory existed only with the glucose drink. However, it was found that enhancement of memory is independent of blood glucose levels in protein and sodium saccharin drinks and the effect of the protein drink was greater than the sodium saccharin **(Table 1)**. Kaplan et al[3] found that the provision of energy from carbohydrate, protein or fat, independent of elevations in blood glucose could improve memory. Our results support this concept. Moreover, in this study, it has been shown that even an energy-free drink (240ml water and 3mg sodium saccharin) can significantly enhance memory in healthy young adults. A minimal, non-significant, beneficial effect of saccharin compared with water alone was found in healthy young adults[4] and suggested that the effects may be due to an effect of taste stimulation on memory. Taste stimulation, notably sweet taste, is followed by cephalic-phase insulin release (CPIR) secretion.[5] However, some human studies failed to show the effect of CPIR after ingestion of nutritive and nonnutritive sweetened solutions[6] and suggested that sweet taste is not a sufficient stimulus for eliciting CPIR.[7] Such a response may require oral stimulation in the context of normal food consumption. In one study in women, it was suggested that the sensory attributes of food might play less of a role in modulating CPIR than an individual's psychological attitude towards food.[8] Thus, it is difficult to make a conclusion on the effect of sweet taste on CPIR in humans.[7] In conclusion, the effect of sodium saccharin is independent of blood glucose elevation or provision of energy, and suggests that the enhancement effect of sodium saccharin on memory may be due to taste stimulation.

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