

Research on human memory enhancement by phosphatidylserine fortified milk

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Abstract: Objective To research whether phosphatidylserine (PS) fortified milk may have beneficial effects on memory of human being. **Methods** 120students at the age of 17-18were randomized to receive either 250mL PS-milk which was added with 50%of PB to 0.08% (100mg PS) and placebo (250mL milk) for 40days.Memory assessed by clinical memory scale with computerized multimedia method (CM) before and after consumption of milk. **Results** There was no significant chagement ($P>0.05$) of MQ (memory quotation) and CM in placebo group before and after treatment. But there was significant improvement of MQ and CM in PS-milk group before and after treatment. After treatment, MQ (memory quotation) and can was significantly improved in the PS-milk group compared to the placebo group ($P<0.05$). **Conclusion** This study indicates that PS-milk treatment may improve cognitive performance in high school students.

Key words: phosphatidylserines; memory; clinical memory scale

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Phosphatidylserine(PS) is a new resource of food approved by the Ministry of Health in November, 2010, and it is mainly extracted and purified from the by-products of natural soybean oil production. As one of cytomembrane components, PS can affect the fluidity and permeability of cytomembrane and can activate the metabolism and synthesis of multiple enzymes. Also, it can improve nerve cells, regulate nerve impulse conduction and promote brain memory [1-3]. PS not only has a significant effect to the physiological cognitive ability and the cognitive ability recovery of injured population, but also can enhance the cognitive ability of non-injured population with a decreasing cognitive ability [4]. In the aspect of metabolic mechanism, after PS is absorbed by the small intestine, it can release choline. With the blood entering brain, choline is converted into acetylcholine. Namely, PS can generate phosphatidyl choline by methylation, and the later can act as the precursor of synthesizing acetylcholine to participate in the regulation of cytomembrane fluidity and play a medium role between cytomembrane receptor and the second messenger [5-7]. As acetylcholine content in brain rises, the rate of information transmission between brain nerve cells increases. It is manifested in the aspect of physiological function that brain memory is improved, intelligence is enhanced, and brain development is promoted [8].

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As the modern dietary structure changes, daily PS intake from high content of phospholipids food reduces. According to the statistics, it is estimated that current daily PS intake is less 70 to 150 mg than the normal need amount. Especially for vegetarians, it is very deficient, and its difference ranges from 200 to 250mg. Therefore, it is very necessary and significant to use PS fortified food

to reduce the memory problem caused by inadequate PS [2]. German Degussa Company has applied PS in the production of chocolates enhancing memory and continued to research the feasibility of fortifying PS in other foods such as foods of helping young people to reduce stress and concentrate attention. In addition, she also produces a water-soluble PS powder which is more suitable for the fortification of drinks and dairy products. In October, 2006, American Food and Drug Administration (FDA) generally recognized PS as safe. Afterwards, more PS fortified bread and drinks come out in succession. This study uses Holstein cow milk of Chongqing Tianyou Dairy Group as the material and adds PS to prepare the sterile PS fortified pure milk by use of UHT technique and takes senior high school students as the investigated objects to investigate the effect of PS milk on people's memory by use of ipad multimedia software CM for clinical memory scale and explore the feasibility of fortifying PS into dairy products to daily supplement phosphatidylserine for improving memory.

1 Materials and methods

1.1 General data

1.1.1 Objects selection A total of 120 senior three-grade students were selected from Chongqing Bashi Middle School, including 60 males and females.

1.1.2 Objects grouping The students were randomly divided into the control group and the intervention group, and the ratio of male to female in various groups was consistent. In the intervention group, each student administered 250ml of 100mg PS fortified pure milk daily. In the control group, each student daily administered 250ml of same milk source of pure milk.

1.2 Experiment contents (1) Investigate whether there was a significant difference for the score of clinical memory scale between the two groups after administration of PS milk (or pure milk); (2) Investigate whether there was significant difference for the score of clinical memory scale between before and after administration of PS milk in various groups.

1.3 Experimental methods There was no any difference for the external packaging between PS milk as the subject in the intervention group and the pure milk in the control group. According to the double blind test method, a special person was responsible for distributing milk to various groups of students at class break in every morning for continuous 40d, and the students administered on site. The ipad multimedia software CM prepared according to test requirements of the clinical memory scale prepared by Psychology Institute of Chinese Academy of Sciences was used to conduct scoring for the directed memory, associative learning, free memory of images, recognition of meaningless figures and portrait features-linked memory scales of the subject. The software contained two sets of test questions: A and B (two sets of questions had the same nature and similar contents).

1.4 Testing For avoid the difficulty difference of contents between test questions A and B, during testing, one half of subjects used test question A at the first time and used test question B at the second time. The other half of subjects firstly used test question B and then used test question. For each subject, two tests were conducted by the same experimenter in order to reduce system error. Also, the two tests for each subject were conducted at the same time point in order to avoid the influence of biological rhythm. According to the natural order of test questions (namely, directed memory, associative learning, free memory of images, recognition of meaningless figures, portrait features-linked memory), all subjects were tested, and the tests were completed at one time.

1.5 Statistical processing Statistics 18 software was used for comparison between before and after administration and comparison between various groups, and t test was used for statistical analysis.

2 Results

2.1 Comparisons of scores of various scales and total score between the intervention group and the control group

ipad multimedia software CM for clinical memory scale was used to assess the scores of directed memory, associative learning, free memory of images, recognition of meaningless figures, portrait features-linked memory scales for various groups of students before intervention. Before administration, there was no significant difference for the scores of various scales and total score between the intervention group and the control group ($P>0.05$), suggesting that there was no difference for memory level between two groups of students. See table 1.

Table 1 Comparisons of the scores of various scales and total score between the intervention group and the control group before administration ($\bar{x} \pm s$)

Item	intervention group	control group	<i>P</i>
directed memory	13.28±2.83	14.08±2.85	0.126
associative learning	19.08±2.84	18.98±2.83	0.954
free memory of images	21.56±3.13	21.60±4.49	0.962
recognition of meaningless figures	30.27±3.07	29.93±2.85	0.539
Portrait features-linked memory	15.38±1.88	15.60±2.12	0.555
total score	98.70±5.73	100.28±6.27	0.151

2.2 Memory evaluation results in various groups before and after administration

It was found from table 2 that there was no significant difference for the scores of various scales and total score of the control group between before and after administration ($P>0.05$), suggesting that the pure milk had no significant effect to the students' memory improvement. From table 3, it was found that compared with before administration, the scores of various scales and total score of the intervention group after administration significantly increased, and there were significant differences ($P<0.05$). Also, mean values of various scales increased by 27.6%, 9.2%, 13.2%, 7.3% and 13.5%. It was suggested that after a period of sustained PS fortified supplementation, both language and non-language memory abilities of students were significantly improved and enhanced.

Table 2 Scores of various scales and total score of the control group before and after administration ($\bar{x} \pm s$)

Item	before test-meal	after test-meal	<i>P</i>
directed memory	14.08±2.85	14.07±2.79	0.968
associative learning	18.98±2.83	18.25±3.23	0.102
free memory of images	21.60±4.49	22.82±3.44	0.067
recognition of meaningless figures	29.93±2.85	30.00±2.78	0.858
Portrait features-linked memory	15.60±2.12	15.38±1.88	0.140
total score	100.28±6.27	101.52±6.13	0.119

Table 3 Scores of various scales and total score of the intervention group before and after administration the group ($\bar{x} \pm s$)

Item	before test-meal	after test-meal	<i>P</i>
directed memory	13.28±2.83	16.95±2.55	0.000
associative learning	19.08±2.84	20.83±2.25	0.000
free memory of images	21.57±3.13	24.42±2.34	0.000
recognition of meaningless figures	30.27±3.07	32.50±3.03	0.000
Portrait features-linked memory	15.38±1.88	17.45±2.07	0.000
total score	98.70±5.73	112.15±6.77	0.000

2.3 Comparisons of the scores of various scores and total score between the intervention group and the control group after administration It was found from table 4 that there were significant differences for scores of various scores and total score after administration between the intervention group and the control group ($P < 0.05$). Compared with the control group, mean values of directed memory, associative learning, free memory of images, recognition of meaningless figures, portrait features-linked memory scales of the intervention group respectively increased by 20.5%, 14.1%, 7.0%, 8.3% and 7.6%, suggesting that the administration of PS fortified milk could significantly enhance and improve the language and non-language memory abilities of students.

Table 4 Comparisons of scores of various scores and total score after administration between the intervention group and the control group (parallel control) ($\bar{x} \pm s$)

Item	before test-meal	after test-meal	<i>P</i>
directed memory	16.95±2.55	14.07±2.79	0.000
associative learning	20.83±2.25	18.25±3.23	0.000
free memory of images	24.42±2.34	22.82±3.44	0.003
recognition of meaningless figures	32.50±3.03	30.00±2.78	0.000
Portrait features-linked memory	17.45±2.07	16.22±2.28	0.002
total score	112.15±6.77	101.52±6.13	0.000

3 Discussion

There are many factors of influencing memory ability, such as heredity, interest, fatigue, mood, mental state and nutritional status so on. Among them, dietary nutrition is closely related to memory. Studies show that the foods helping to improve memory include fruits and vegetables, high fat content fish, beans, nuts, meat, etc. Natural PS is mainly from animal brain, soybean and other foods [9]. The results of this study suggested that after a senior high school student daily administered 250ml of 100mg PS (soybean extract) fortified milk for 40 d , the memory ability was significantly improved.

Animal experiments show that PS can apparently improve and enhance memory. The research of PS improving momentary memory and delayed memory by use of Morris Water maze test suggested that after rats orally administered 15mg/kg PS daily for a period of time, the learning ability and memory ability were significantly enhanced [10]. In the two-way active avoidance test, the emotional behavior and cognitive ability of adult mice administering PS were enhanced somewhat [11]. In the study of Hellha Mmer (Swedish expert) et al. the mixture of soybean phospholipid and PS (PAS) was used to conduct the social stress test (TSST) for 20 subjects. It was found that after 400mg PAS was administered daily for 3 week, adrenocorticotrophic hormone (ACTH) and cortisone levels in serum of subjects were obviously inhibited by PAS and body's emotional tension was relieved. Also, heart rate wasn't influenced [12]. Therefore, PS can obviously reduce the excessive stress hormone level in the bodies of persons with working stress, relive stress and alleviate brain fatigue. Also, it can promote attention concentration, improve alertness and memory and alleviate undesirable moods [13]. In this study, the investigated objects are students with the same education level, belonging to the same age period (17 to 18 years old), and they don't receive similar tests and don't administer drugs or health foods improving memory. Therefore, the influences of education level, age, psychological test, drugs or health foods improving memory and other factors on the experimental result are deleted. In addition, before the experiment, memory evaluation is conducted for randomly-grouped students between groups, which deletes the difference between groups and ensures the fairness and objectivity of the process of PS improving memory. According to the statistical analyses of various groups before and after administration, it is found that there is no significant difference for the scores of various scales of the control group between before and after administration, which deletes the influences of learning transfer and psychological suggestion on evaluation of PS improving memory. So, according to the result that the scores of various scales of the PS milk intervention group after administration increased, it can be speculated that PS fortified milk can improve and enhance students' memory ability.

The experiment programs the evaluation criteria method of clinical memory scale into the special multimedia software by use of program language of Apple Corp, America by combining learning and life rules and cooperation enthusiasm of students and installs the software in an ipad panel computer to use the multimedia test evaluation method to conduct professional evaluation of clinical memory scale scores of students. This method has a stronger maneuverability in the experimental process. For the multimedia evaluation method and manual method of clinical memory scale, some reports confirm that both have a high consistency, and the multimedia evaluation method can improve the standardization degree and efficiency of the scale [14]. As a result, it is safe to by supplement PS by drinking the milk fortified with PS extracted from soybean

in the daily milk drinking habit, and the milk has rich nutrition and can apparently improve memory.

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