Choline: Are our University Students Eating Enough?

M Gossell-Williams[1], J Benjamin[1]

ABSTRACT

Choline is an essential nutrient; dietary deficiency of choline is associated with impaired liver function, elevated blood concentrations of alanine aminotransferase, creatinine phosphokinase and homocysteine. There is also depletion of acetylcholine concentration in the brain, leading to deficit in memory function. The authors examined the dietary intake of choline in groups of students at the Mona Campus of the University of the West Indies. Sixty-two medical students (first and second years) and biochemistry students (final year) were recruited. They were asked to (including amounts) record all foods and drinks consumed for three days (two weekdays and one weekend day). The sheets were collected and the amount of choline and betaine (a metabolite of choline) consumed were calculated. Dietary intake of folate was also evaluated. The analysis revealed that 86.2% of the females and 90.9% of the males reported diets that delivered less daily choline than the adequate intake quoted by the Institute of Medicine of the National Academy of Sciences, USA (425–550 mg/day). The betaine consumption ranged between 25 to 620 mg/day (no adequate intake documented) and the folate consumed was more than the recommended daily allowance of folate (180–200 ug/day). The dietary intake of choline in the majority of students is below adequate intake. Although folate also serves similar functions to choline, it is unlikely that it can substitute for choline in all physiological aspects and therefore the implications of low dietary choline need further investigation.

La Colina: ¿la Ingieren Nuestros Estudiantes Universitarios en Cantidades Suficientes?

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RESUMEN

La colina es un nutriente esencial. La deficiencia dietética de colina está asociada con el deterioro de la función hepática, así como con elevadas concentraciones en sangre de alanina-aminotrans-ferasa, creatinina-fosfoquinasa y homocisteína. Asimismo, se produce un agotamiento de la concentración de acetilcolina en el cerebro, lo cual conduce a un déficit en la función de la memoria. Los autores examinaron la ingestión dietética de colina en grupos de estudiantes del campus de Mona de la Universidad de West Indies. Se reclutaron sesenta y dos estudiantes de ciencias médicas (de primer y segundo año) y bioquímica (último año). Se les pidió que tomaran notas (incluyendo cantidades) de todos los alimentos y bebidas consumidos en tres días (dos días de entre semana y un día de fin de semana). Se recogieron las anotaciones y se calculó el consumo de colina y betaína (un metabolito de la colina). Se evaluó la ingestión de folato. El análisis reveló que el 86.2% de las mujeres y el 90.9% de los hombres, reportaron dietas cuyo suministro de colina por día se hallaba por debajo del consumo adecuado indicado por el Instituto de Medicina de la Academia Nacional de Ciencias de Estados Unidos (425–550 mg/día). El consumo de betaína osciló de 25 a 620 mg/día (no existe documentación sobre el consumo adecuado), en tanto que el folato consumido estuvo por encima de la ingestión diaria de folato recomendada (180 – 200 ug/día). El consumo dietético de colina de la mayoría de los estudiantes está por debajo del consumo adecuado.

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INTRODUCTION

Choline is a precursor of the phosphatidylcholine and sphingomyelin, both are major components of cell membranes and are important in the proper triglyceride turnover from the liver and blood. It is metabolized to betaine which is an

important methyl-group donor in the synthesis of methionine and the control of plasma homocysteine concentration (Fig 1). Choline is the precursor of the neurotransmitter acetylcholine which is important for the proper functioning of cholinergic neurons peripherally and in the brain (1).

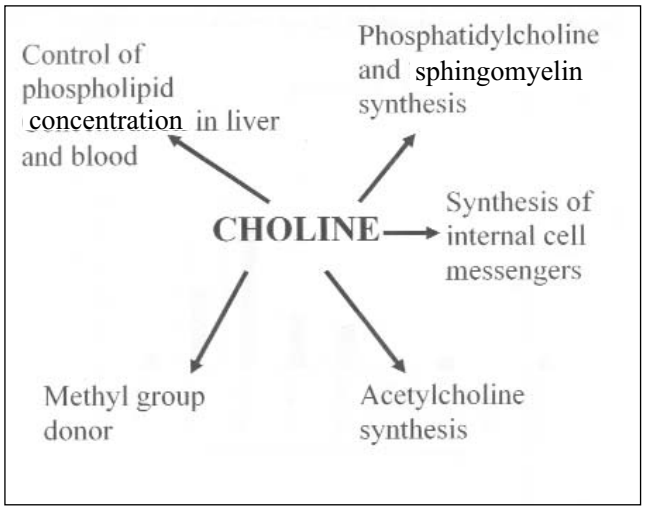

Fig 1: Diagram showing the major functions of choline in the body

It was in 1998 that choline was reclassified as an essential nutrient. Some of the richest sources of choline include eggs, liver, chicken, fish, legumes, milk and soya products. Although inadequate studies have been done to set a recommended daily allowance for choline, the Food and Nutrition Board of the Institute of Medicine of the National Academy of Sciences, USA, has set an adequate intake level for choline of 550 mg/day for men, 425 mg/day for non-pregnant women and 450 mg for pregnant women. These values are based on the amount that is likely to cause elevated plasma alanine aminotransferase (an indicator of liver damage) concentration.

Dietary deficiency of choline in humans is also associated with elevated serum creatinine phosphokinase because of increasing fragility of myocytes (2) and elevated plasma homocysteine concentration (3). Additionally, it is well established in animal studies that choline supply supports the synthesis and release of acetylcholine and that dietary deficiency of choline can lead to physiological and psychological deficits in memory functions of the brain (4–8).

Previous studies reported that students at the Mona Campus of the University of the West Indies had poor eating habits (9). The authors, therefore, examined the daily choline intake in a population of these students; namely medical and biochemistry students.

METHODS

Medical students from the classes graduating in 2008 and 2009 and the Biochemistry class that graduated in 2005 at the Mona Campus of the University of the West Indies were recruited into the study. Once informed consent was obtained, recruited subjects were asked to complete diet sheets with specific instructions to ensure detailed information (including accurate measurements) of everything consumed (except water) over three days. The three days included one weekend day and two weekdays. These food records were done outside of University's final examination period.

The choline content of foods was calculated using published data from the United States Department of Agriculture (USDA) database for choline content of common foods *(http://www.nal.usda.gov/fnic/foodcomp/Data/Choline/Choline.html)*. Choline consumed was calculated as the sum of free choline and metabolites that the body can convert to choline (phosphatidylcholine, sphingomyelin, phosphocholine, glycerophosphocholine). Betaine consumed was also calculated. For Jamaican-based foods not available in the USDA database, a nutritionally equivalent food from the database was substituted (Table 1). However, very few of the

Table 1: List of foods from the United States Department of Agriculture (USDA) database that were substituted for Jamaican-based foods. The USDA number for each food item taken from the database is also listed.

Food Ingested	Food value used in calculations	USDA number
Ginger tea, mint tea, tea bag	Iced tea	98015
Cheese cake	Cream cheese	01017
Sardine	Tuna fish	15121
Raisin bread, coco bread, hard dough bread, hamburger bun rum and raisin ice cream,	White bread	18069
Grape nut ice cream	Vanilla ice cream	19095
Kellog's special K Bar	Granola bar	19015
Curry goat	Mutton	98022
Honey roasted peanuts	Cashew nuts	12586
Fruit punch	Orange juice	09209
Cheetos	Tortilla chips	19444
Vegetable cheese	Cottage cheese	01014
Non-Dairy creamer	Cream substitute	01069
Vienna sausage	Frankfurter	07024
Vegetable soup	Tomato soup	06159
Callaloo, pak choy	Spinach	11464
Butter bean	Kidney peas	16028
Spice bun	Danish pastry, plain	98024
Easter bun	Danish pastry, enriched	18246
Beef patty, cheese patty	Flour tortilla with beef and cheese	98060
Chicken patty	Flour tortilla with chicken and cheese	98061
Pumpkin	Squash	11478
Dried mango	Peaches	09236
Pineapple juice	Orange juice	09209
Corned beef	Beef	13326
Fruit cake	Chocolate cake	18100
Lemonade, june plum juice	Orange juice	09209
Banana chips	Tortilla chips, plain	19056
Tin mackerel	Tuna fish	15121
Peanut porridge, lasco porridge	Cream of wheat	08105
Macaroni	Spagheti	20121
Mustard	Mayonnaise	04025
Pigeon peas	Pinto beans	16043
Brownie	Chocolate cake	18100
Mango juice	Orange juice	09209
Vegetable chunks	Kidney beans	16028

Red Bull energy drink	Cola with caffeine	14400
Kretchmer's wheat germ	Oats	08121
Mango	Peaches, raw	09236
Lentil peas	Navy beans	16038
Ginger wine	White wine	14106
Pancake syrup	Jam	19297
Post cranberry almond cereal	Post raisin bran cereal	08337
Oreo cookies	Chocolate chip cookies	18159
Orange cream filled muffins	Blueberry muffins	18274
Kiss cupcake	Cupcake	8452
Milo, hot chocolate	Chocolate milk	01103
Jelly doughnut	Doughnut, frosted	18249
Lemon cake	Cake, yellow	18141

substituted foods were high in choline and these substitutions would not be expected to affect the results significantly.

Folate consumed by the subjects was also evaluated using published data from the USDA database for folate content of common foods *(http://www.nal.usda.gov/fnic/foodcomp/Data/SR17/wtrank/sr17a435.pdf).*

RESULTS

In total, 62 medical and biochemistry students were recruited; 29 females and 33 males. Although the sample group represented 16% of the total number of students in these groups, the results of this investigation suggest that a significant percentage of the students may have diets that do not deliver adequate choline. The majority of the recruited subjects reported daily diets that delivered less than the adequate intake of choline. For the females, 86.2% reported diets that delivered less than 425 mg/day of choline (adequate intake for non-pregnant females), with most of the females (n = 22) reporting diets that were delivering less than half of the adequate intake. For males, 90.9% reported diets that delivered less than 550 mg/day of choline (adequate intake for males), with most (n = 27) recording diets that were delivering less than half of the adequate intake (Fig 2). The betaine consumption ranged from 25 to 620 mg/day with most students (77% females and 74% males) consuming less than 200 mg/day. The diets of all the subjects delivered more than the recommended daily allowance of folate (180–200 μg) with most subjects reporting diets that delivered two to three times this amount.

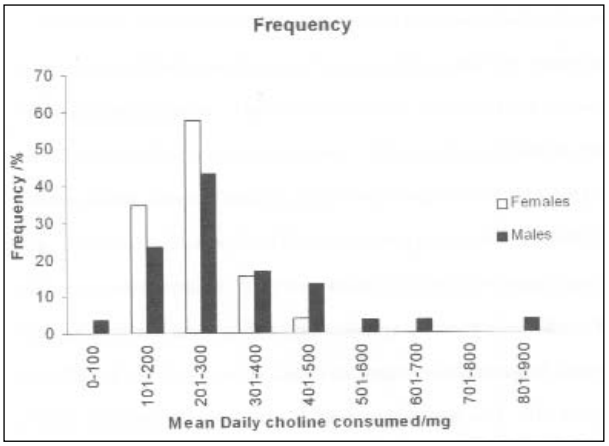

Fig. 2: Graph showing the distribution of mean daily choline consumed by sixty-two subjects. Mean choline consumed by each subject was calculated from data collected over three days. The majority of the subjects were eating diets that delivered less than half the adequate intake of 425–500 mg/day

DISCUSSION

In this study, it was found that while the diets of all the subjects delivered two to three times the recommended daily allowance of folate most of the students were not receiving adequate intake of choline. There is no adequate intake (or recommended daily allowance) documented for betaine.

Transmethylation reactions in the body are provided with methyl groups from many sources including choline (3, 10). The supply of methyl groups from sources other than choline, such as folate and betaine may therefore spare choline of this function (10). However in studies involving mice, it was shown that choline deficiency results in decrease methylation of homocysteine to form methionine, despite having adequate supply of other methyl donors (3).

Choline also plays an intergral role in several other important physiological activities, including synthesis of major cell membrane components such as phosphatidylcholine and the synthesis of acetylcholine, which is a neurotransmitter. Although folate and betaine may spare choline as methyl donor, it is unlikely that sufficient or excess intake of either can compensate for the choline deficiency in all physiological aspects. Thus the possible implications of lower that adequate intake of choline in these groups of university students warrants further investigations.

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