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Folic acid: Consumption and knowledge for the prevention of neural tube defects among college-aged women

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FOLIC ACID:
CONSUMPTION AND KNOWLEDGE FOR THE PREVENTION OF NEURAL TUBE DEFECTS AMONG COLLEGE-AGED WOMEN

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Folic Acid: Consumption and Knowledge for the Prevention of

Neural Tube Defects Among College-Aged Women

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Lynn M. Stahlhut

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Abstract

Over 4,000 pregnancies result in a neural tube defect (NTD) each year in the United States. However, periconceptional daily consumption of 400 µg of folic acid can prevent up to 70% of these defects. The mean folic acid intake of 47 college-aged women without and with supplements was 190±91 µg and 318±234 µg, respectively, and 31.9% consumed a multivitamin. While 83.5% of 91 college-aged women had heard of folic acid, only 3.3% knew the recommended amount. A significant positive relationship between folic acid knowledge and consumption was also established ($p < .01$). Education programs need to target college-aged women, especially those who are sexually active or of Hispanic/Latino descent, and focus on increasing folic acid consumption by promoting the importance of consuming a folic acid supplement everyday.

Dedication

I dedicate this work to God, who has greatly blessed me with the abilities to complete this project, for which I am truly thankful. "I can do all things through Him who strengthens me." Philippians 4:13.

Acknowledgements

I would like to acknowledge Dr. Erma Fernando for her time, support, and patience while guiding me through the completion of this work. I would also like to thank the other committee members, Dr. Mary Lou Hubbard and Dr. Melanie Burns, for their time and advice in completing this work. Finally, I would like to thank all of my family and friends who have encouraged, supported, and believed in me during the entire process.

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Introduction

Personal health is a valued asset in America today. Every infant deserves to start out with unblemished health so as to have every opportunity to grow into a healthy adult. Folic acid is one vitamin that may help to create this opportunity for all infants. The research on folic acid has greatly increased during the past twenty years due to findings that it may reduce the chances of neural tube defects (NTDs) in babies. Since then, extensive research has supported the claim that periconceptional folic acid consumption has a very strong correlation with decreased incidence of NTDs. The support was so strong that in 1998, the United States Food and Drug Administration (FDA) mandated that all enriched cereal grains be fortified with folic acid (McCaffree, 2001). Although this helped to reduce the incidence of NTDs, the problem still exists and needs to be addressed.

Problem

NTDs are serious birth defects that include malformations of the brain, spinal cord, or both during embryonic development (Whitney, Cataldo, & Rolfes, 2002), and affect over 4,000 newborns each year in the United States (Johnson, Stadler, Feldkamp, & Webber, 2002). Because many of these infants die or are aborted, about 2,500 infants live with an NTD (Whitney et al., 2002). The two most common NTDs are spina bifida and anencephaly, with spina bifida being the leading cause of childhood disability in the United States due to a birth defect (Mulinare, 1995). The effects of spina bifida differ among the type and severity of the defect. However, some can lead to a herniation of the brain through the

skull, protrusion of the spinal cord, lower limb paralysis, loss of bowel and bladder control (Hasenau, 2002), fluid pressure on the brain, mental retardation, and death. Those with anencephaly die within the first week of life (Mulinare, 1995). NTDs are one of the most frequent and devastating congenital abnormalities (Frey & Hauser, 2003).

One of the most exciting discoveries in nutrition in the past twenty years is that NTDs can be prevented. Folic acid and NTDs were identified as having a connection in the 1960s, and by the early 1990s, research showed that folic acid had an apparent protective effect against NTDs (Vozenilek, 1999). Studies have shown that consuming 400 µg of folic acid each day decreases the chance of NTDs by up to 70% (MRC, 1991; Czeizel & Dudas, 1992). This research spurred the 1992 United States Public Health Service (USPHS) recommendation that all women of childbearing age who were capable of becoming pregnant should consume 400 µg of folic acid per day to reach the desired level of folic acid in the body (Chacko, Anding, Kozinetz, Grover, & Smith, 2003; Stein, Keppen, & Watson, 2002). Additionally, in 1995, a new Healthy People 2000 objective was added that promoted the decrease of NTDs through increased folic acid consumption in all women of childbearing age (Kloeblen, 1999).

Since many women were not following the USPHS recommendation, in 1996, folic acid fortification of cereals and grains was approved on a voluntary basis. The FDA mandated that all cereal grains be fortified with 140 µg of folic acid per every 100 g of cereal grain by January 1, 1998 (Lawrence, Petitti, Watkins, & Umekubo, 1999). Fortification in the United States costs about one

cent per person per year, which is about $1,000 per NTD prevented (Wald, 2004). Due to the cost-effectiveness of fortification, grain products continue to be fortified in the United States (Postma, Londeman, Veenstra, De Walle, & De Jong Van Den Berg, 2002). Currently, the March of Dimes, the Institute of Medicine, the Centers for Disease Control and Prevention, and Healthy People 2010 recommend that all women of childbearing age consume 400 µg of folic acid each day (Stein et al., 2002; Gross, Caufield, Kinsman, & Ireys, 2001; Firth, Murtaugh, & Tangney, 1998; *Healthy People 2010*, 2000). This recommendation of folic acid includes all women of childbearing age because increased folate intakes are essential before neural tube closure. The neural tube closes within the first 28 days of pregnancy, often before pregnancy can be detected. Therefore, folic acid needs to be consumed periconceptionally, meaning one month prior to and during the first trimester after conception (Wild, Schorah, Maude, & Levene, 1996).

Because half of all pregnancies in the United States are unplanned, consuming the recommended amount of folic acid is very important for all women, even if pregnancy is not intended (Vozenilek, 1999). Since college-aged women are of childbearing age, and most pregnancies in women aged 18 to 24 are unplanned (Hilton, 2002), college-aged women especially need to be aware of and consume the recommended amount of folic acid each day. Research has shown that women under the age of 24 have the least amount of knowledge of folic acid compared to women older than 24 (Meyer, Wall, Morgan, Devine, & Powers, 2002) and consume much less folic acid than the recommended amount

(Wild et al., 1996). Little research has been conducted on college students and folic acid, or the characteristics and knowledge that impact folic acid consumption. Therefore, college-aged women are a high-risk group for NTDs and need to be targeted for more extensive research.

Purpose

The purpose of this study was to determine consumption and knowledge of folic acid for the prevention of neural tube defects among college-aged women.

Objectives

The research objectives for this study were to:

1. Determine folic acid consumption among college-aged women from food and supplements.
2. Determine folic acid knowledge concerning NTDs among college-aged women.
3. Determine if folic acid knowledge concerning NTDs among college-aged women varies by:
    a. Age.
    b. Grade level.
    c. Race.
    d. Completion of, or enrollment in, an introductory nutrition class.
    e. Sexual activity.
    f. Pregnancy intendedness.

4. Determine the relationship between folic acid knowledge concerning NTDs and consumption of folic acid supplements among college-aged women.

Hypotheses

The hypotheses for this study were:

1. College-aged women do not consume the recommended amount of folic acid from food and supplements.
2. College-aged women have limited folic acid knowledge concerning NTDs.
3. Folic acid knowledge concerning NTDs among college-aged women shows a significant statistical difference by:
    a. Age.
    b. Grade level.
    c. Race.
    d. Having completed, or being currently enrolled in, an introductory nutrition class.
    e. Pregnancy intendedness.
4. Folic acid knowledge concerning NTDs among college-aged women does not show a significant statistical difference by sexual activity.
5. Increased folic acid knowledge concerning NTDs is related to increased consumption of folic acid supplements among college-aged women.

Literature Review

Many different research studies concerning folic acid and NTDs have been conducted during the last twenty years. There are several reasons for the sudden increase of folic acid research. In the last twenty years, folic acid has been linked to the decrease in NTDs. Also, the fortification mandate in 1998 spurred more research. The severity of NTDs, and the fact that newborn infants are the victims, causes concern among researchers, as well as all people. Researching ways to decrease the incidence of NTDs is the first step in eliminating this problem.

Neural Tube Defects

NTDs are birth defects that are caused by abnormal closure of the neural tube before the 28th day after conception (Frey & Hauser, 2003; March of Dimes, 1998). The neural tube ultimately develops into the spinal cord and brain. Therefore, if the neural tube does not close properly, problems with the spinal cord and brain occur (Hasenau, 2002). There are many classifications of NTDs, depending on the abnormality of the closure. They are split into two main groups, which include defects affecting the brain and defects affecting the spine (Frey & Hauser, 2003). The NTDs affecting the brain are more obvious and are often fatal. Those NTDs affecting the spine have a variety of characteristics as the severity can differ greatly (Frey & Hauser, 2003). Studies also suggest that folic acid can prevent other birth defects, such as cleft lip and palate (March of Dimes, 2000).

Types of neural tube defects. Cranial NTDs, or those that affect the brain, include anencephaly and encephalocele (Rayburn, Stanley, & Garrett, 1996). Anencephaly occurs when the bones of the skull do not develop completely and the brain is either partially or completely absent (Mulinare, 1995). Encephalocele is characterized by a herniation of the brain and meninges through a defect in the skull (Hasenau, 2002).

NTDs affecting the spine are collectively known as spina bifida (Hasenau, 2002). Spina bifida is one of the most common birth defects and is the leading cause of childhood disability due to a birth defect in the United States (Mulinare, 1995). Spina bifida is characterized by the incomplete closure of the spinal cord and its bony encasement (Whitney et al., 2002) and can range in severity from an obvious and open defect to one that is less recognizable (Frey & Hauser, 2003).

There are three forms of spina bifida including occulta, meningocele, and myelomeningocele. Spina bifida occulta occurs when there is a small defect or gap in one or more of the vertebrae in the spine. Meningocele is the rarest form of spina bifida and involves a cyst of membranes protruding through the open part of the spine. Myelomeningocele is the most severe form in which a sack of membranes and nerve roots connected to the spinal cord protrudes through the spine and appears as a sack on the back of the individual. Instead of a sack, there may be an exposed section of the spinal cord and nerves (March of Dimes, 1998; Rayburn et al., 1996).

Effects of neural tube defects. The consequences of NTDs can be devastating to the individual as well as the parents. Although up to 42% of these pregnancies are electively terminated (Frishman, Spurrell, & Heber, 2001), many of these pregnancies with anencephaly end in miscarriage or as stillbirths. Those infants who are born with anencephaly live only for a short time and usually die within the first week of life (Mulinare, 1995), and infants with encephalocele also usually live a short life as well (Hasenau, 2002). Individuals with spina bifida usually survive into adulthood, but have many problems throughout their lifetime (Mulinare, 1995). Spina bifida occulta is usually symptomless, and causes no nerve damage or problems. The cyst in meningocele can be removed, depending on the size, which will then lead to normal development. With the open form of myelomeningocele, the back must be surgically closed, but there is usually lower limb paralysis along with bowel and bladder problems due to nerve damage (March of Dimes, 1998; Rayburn et al., 1996). Hydrocephalus, which is fluid in the brain, occurs in 70% to 90% of children with myelomeningocele spina bifida. The extra fluid causes the head to enlarge and can cause mental retardation and other neurological damage (March of Dimes, 1998). Some individuals also have problems with ambulation, spasticity, infection (Rayburn et al., 1996), clubfoot, dislocated hip, kidney disorders, muscle weaknesses, curvature of the spine, and motor and sensory losses. Some severe cases even lead to death (Whitney et al., 2002).

Another consequence of NTDs is the cost of the necessary medical care. The lifetime cost of caring for a child with spina bifida was estimated in 1985 to

be $250,000 (Rayburn et al., 1996). In 1991, the estimated medical and surgical costs of spina bifida in the United States totaled over $200 million annually (Frishman et al., 2001) and rose to $500 million in 1999 (Williamson, 2001).

Folic Acid and Neural Tube Defects

The devastation and prevalence of NTDs prompted researchers to inquire how NTDs can be prevented. Many different studies, including descriptive epidemiology, case-control studies, cohort studies, and nonrandomized and randomized intervention studies have shown a protective effect of periconceptional folic acid consumption against NTDs (Frey & Hauser, 2003). The Medical Research Council (MRC) Vitamin Study research group (1991) conducted the first randomized double-blind prevention trial that published results which showed that folic acid was the dietary component preventing NTDs. A total of 1,817 women participated in the study, all of whom had a previous pregnancy affected by an NTD, and were therefore at high risk for another NTD-affected pregnancy. All of the participants were planning another pregnancy and were not taking vitamin supplements. The women were recruited from 33 different centers in seven different countries, with the majority from the United Kingdom. Women were randomly assigned to one of four supplementation groups. Group A received only folic acid, Group B both folic acid and other vitamins (A, D, B_1, B_2, B_6, C, and nicotinamide), Group C neither folic acid or other vitamins, and Group D only other vitamins. Each center randomized the women into groups so there would be approximately equal numbers of women in each of the groups. The women consumed one capsule every day from the date

of randomization until the 12th week of pregnancy. The folic acid supplement dose was 4 mg (4,000 µg) because a lower dose may not have shown a specific result. The women stayed in the study until they had a pregnancy which could be classified as having an NTD or not, which was called an informative pregnancy, excluding miscarried pregnancies that were not classified. The study lasted from July 1983 to April 1991.

The results of the MRC study (1991) indicated that there were about the same amount of informative pregnancies in each of the four groups, which showed the randomization to be effective. The results of the groups showed that only 1.0% of those who received folic acid (Groups A and B) had an NTD-affected pregnancy, while 3.5% of those not receiving folic acid (Groups C and D) had an NTD-affected pregnancy. The relative risk of the folic acid groups was 0.28 (95% confidence interval), meaning 72% of NTDs were prevented. The results suggested that there was no indication that other vitamins other than folic acid provided any protective effect or enhanced the power of folic acid. The study established that folic acid had a specific role in the prevention of NTDs.

The MRC study (1991) researched the effect of folic acid on recurrent NTDs. However, because 95% of NTD-affected pregnancies have no family history of the defect (Geisel, 2003), the Hungarians Czeizel and Dudas (1992) conducted the first randomized controlled trial studying the prevention of first occurrence NTDs with folic acid. The researchers recruited women who were planning a pregnancy and were not currently pregnant. The study included 7,540 women, who were randomly assigned to one of two groups. One group was

given a vitamin supplement (vitamins A, B_1, B_2, B_6, B_{12}, C, D, E, nicotinamide, calcium pantothenate, biotin, 0.8 mg folic acid, calcium, phosphorus, magnesium, iron, copper, manganese, and zinc). The other group was given a supplement containing the trace-elements copper, manganese, and zinc, and vitamin C. The women continued to take these supplements until the date of the second missed menstrual period or later. Of these women 4,704 had pregnancies with confirmed results. The prevalence of congenital malformations was significantly higher in the trace-element supplement group (22.9 per 1,000) than the vitamin supplement group (13.3 per 1,000). Also, there were no NTD-affected pregnancies among the vitamin supplement group, while 6 pregnancies resulted in NTDs in the trace-element supplement group. None of the NTD-affected pregnancies had any prior family history of NTDs. The results showed that periconceptional vitamin supplementation reduces the incidence of first occurrence NTDs. The study also showed that a dose lower than 4 mg of folic acid might have a protective effect, although it may be caused by a synergistic effect with other vitamins. The results of these two randomized controlled studies, along with the results of other observational studies, caused the Public Health Service to recommend folic acid consumption in 1992 (Erickson, 2002).

Since the relationship between folic acid and NTDs has been established, action has been taken to increase the consumption of folic acid through fortification and education. The statistics showing the decrease in the prevalence of NTDs since then continues to prove the relationship between folic acid and NTDs. The incidence of NTDs in the United States has decreased by almost

20% since the mandated fortification in 1998. Also, among women who had only third trimester care or no prenatal care, NTD rates have decreased by 13% (Wise, 2001). Palomaki, Williams, and Haddow (2003) found that the number of NTDs decreased from 12.3 per 10,000 pregnancies in 1993 to 1996 to 10.7 per 10,000 pregnancies in 1998 to 2000. This represented a 13% reduction and included both spina bifida and anencephaly. Later studies have shown a decrease of 20% to 30% (Erickson, 2002; Morantz & Torrey, 2003). A study of all pregnancies in Utah from 1985 to 2000 showed a significant reduction in NTDs from 1993 to 2000 as well (Feldkamp, Friedrichs, & Carey, 2002).

Potential folic acid metabolic mechanisms. Although folic acid consumption is obviously causing a decrease in NTDs, the reason is still inconclusive. The majority of NTDs are caused by both environmental and genetic factors, which in turn poses several possible explanations for how folic acid can prevent NTDs. Folic acid intake is the predominant environmental factor found to prevent NTDs (Geisel, 2003). However, decreased risk of NTDs is associated with increased serum or red blood cell folate concentrations as well as a lowered homocysteine levels. Because folate levels are inversely related to homocysteine levels, researchers do not know if NTDs are caused by low folate levels, high homocysteine levels, both, or by other downstream effects (Green, 2002).

NTDs may also be caused by the inability to absorb or transport folate, which could also result in a folate deficiency. A lack of folate in the body may cause changes in DNA formation. When folate is absorbed, folate is converted

to tetrahydrofolate. Tetrahydrofolate is able to donate single carbon units, which are used to form necessary components of DNA. A deficiency of these single carbon units may cause the formation of DNA that is unstable, which may lead to NTDs. Possible genetic factors include defects in methlyenetetrahydrofolate reductase (MTHFR), cystathionine synthase (CS), and methionine synthase (MS), which have the potential to lead to increased homocysteine levels. An alteration of a thymine for cytosine substitution at the 677 nucleotide of MTHFR may account for about 13% of NTDs. In addition, a defect in the 2756 nucleotide of MS, which substitutes an adenine for a guanine, has an association with NTDs. Any one of these factors, or those that are yet unknown, may lead to NTDs (Geisel, 2003).

Folic Acid and Folate

While there is no exact explanation of how folic acid prevents NTDs, there is substantial evidence that folic acid does prevent NTDs. Therefore, it is important that women know about folate and folic acid and their sources, bioavailability, and recommendations in order to prevent NTDs. Folic acid, or pteroylmonoglutamic acid, is a synthetic compound used in fortified foods and dietary supplements. The term folate refers to both the original form of the B vitamin, which is found naturally in foods, and the synthetic form of folic acid (American Academy of Pediatrics, 1999; McDonald, Ferguson, Tam, Lougheed, & Walker, 2002). Humans are unable to synthesize folic acid and therefore it must be obtained through the diet.

Sources of folate. Good sources of natural folate include organ meats, green leafy vegetables (McDonald et al., 2002), orange juice, whole grains, dried beans, lentils, soybeans (Hasenau, 2002), peanuts, broccoli, and asparagus (March of Dimes, 2000). Because much of natural folate is lost during the cooking process, fortified foods are also good sources of folic acid (Hasenau, 2002). Grain products, including flour, rice, pasta, cornmeal, bread, and especially cold cereals, are good fortified sources of folic acid (March of Dimes, 2000).

Bioavailability. Folate found naturally in foods is absorbed less efficiently in the gastrointestinal tract than synthetic folic acid (Geisel, 2003). Synthetic folic acid is nearly 100% bioavailable when it is consumed alone, and 85% bioavailable when consumed with food. Natural folate, however, is estimated to be only 50% bioavailable (Johnson et al., 2002; Molloy, 2002; Stein et al., 2002). This is partially due to the exposure to heat and light during cooking and storage, which causes the losses of folate (Neuhouser, Beresford, Hickok, & Monsen, 1998). Also, synthetic folic acid is a monoglutamate that can be absorbed easily by the body without being processed. Natural folate in food is a polyglutamate and must be converted to a monoglutamate in the small intestine before it can be absorbed. Once the folate is absorbed, both forms provide the same biological function (Stein et al., 2002).

Recommendations. The Dietary Reference Intakes (DRIs) recommend that 400 µg (0.4 mg) of folic acid be consumed each day (Mahan & Escott-Stump, 2004). This amount is supported by the March of Dimes, Centers for

Disease Control and Prevention, the Institute of Medicine (March of Dimes, 2000), and the United States Public Health Service (American Academy of Pediatrics, 1999) and is the amount found in most vitamin supplements (March of Dimes, 2000). Because women with a family history of NTDs are at a higher risk for an NTD-affected pregnancy, the Centers for Disease Control and Prevention recommend that these women consume 4,000 µg (4 mg) of folic acid each day (American Academy of Pediatrics, 1999). Also, because of the possibility of high folate intake masking vitamin B_{12} deficiency, the Institute of Medicine and Public Health Service set an upper limit of folic acid at 1 mg per day, even though there is no known toxicity level (Shane, 2003; American Academy of Pediatrics, 1999).

Knowledge of Folic Acid

Given that there is significant evidence provided that periconceptional consumption of folic acid reduces the risk of NTD-affected pregnancies, it is important that women of childbearing age know about these benefits. In 1995, only 52% of United States women of childbearing age knew the term "folic acid", whereas 80% knew in 2002. Nevertheless, only 20% knew that folic acid could prevent certain birth defects (Erickson, 2002) and 21% knew that folic acid should be taken before pregnancy in 2001 (Alto, 2002). These statistics show that more women are learning about folic acid, but some are learning more than others.

Knowledge among college-aged women. Much research has been conducted to determine the knowledge of women concerning folic acid and NTDs. However, little research has been directed towards college-aged women.

Wild et al. (1996) studied 150 16 to 19 year-old women and 150 first and second year undergraduate students. Of the undergraduates, 50 were medical students, 50 were studying arts subjects, and 50 were studying science subjects. The researchers reported that 51% of the 16- to 19-year-olds had heard of folic acid, 14% knew the benefits of taking folic acid before pregnancy, 17% were able to name a food or foods rich in folic acid, and only 5% were able to name a food fortified with folic acid. The undergraduates were more knowledgeable as 87% of the arts and science students and all of the medical students had heard of folic acid, 26% of arts and science students and 70% of medical students knew the benefits of taking folic acid before pregnancy, 42% were able to name a food or foods rich in folic acid, and 23% were able to name a food fortified with folic acid.

Meyer et al. (2002) obtained data from the 1999 North Carolina Pregnancy Risk Assessment Monitoring System (PRAMS), which randomly surveyed 200 women who had recently given birth each month. In 1999, 1,780 women responded to the PRAMS survey. The researchers found that women who had heard or read about folic acid varied by age with the youngest women having the lowest percentage of those who had. Of the women aged 25 to 34 and 35 and over, 86.1% and 82.9% had heard or read about folic acid, respectively. Of the women aged less than 20 and 20 to 24, 60.9% and 66.4% had heard or read about folic acid, respectively.

Quillin, Silberg, Board, Pratt, & Bodurtha (2000) studied 71 female psychology students enrolled at Virginia Commonwealth University. The students completed a pretest questionnaire, listened to a 5-minute educational

slide presentation about folic acid, completed a posttest questionnaire, and were debriefed. The results of the pretest showed that 64% had heard of folic acid, but only 5% knew the recommended amount. In addition, 69% reported that they had heard of NTDs. Based on t-tests comparing pretest and posttest questions, the results of the posttest showed a significant increase in both knowledge of folic acid (p = .0001) and of NTDs (p = .0002).

Wojick & Glanville (1999) surveyed a conveniently selected sample of 72 undergraduate students in which 93% were female. The survey included 21 closed-ended questions. The researchers reported that 42% of the students had previous information about folic acid. However, when asked specifically where they received information about folic acid, 20% reported that they received information from popular media, including television and magazines, 5% had heard from policy information, 4% from a nutrition class, and 1% from word of mouth. These studies demonstrate the trend that young women know less about folic acid than the average woman in the United States.

Consumption of Folic Acid

Many women may know about folic acid and the benefits it provides for the prevention of NTDs. More importantly, women need to be consuming folic acid to receive the benefits. Several studies have shown that consumption rates in the United States have changed since the implementation of folic acid fortification. The expected increase of folic acid consumption due to fortification was 100 µg per day (Cuskelly, McNulty, & Scott, 1999). However, Quinlivan and Gregory (2003) showed an increase of 215 to 240 µg per day. Another study

used data from the fifth and sixth examinations of the Framingham Offspring Cohort Study to determine the change in folic acid and total folate consumption due to fortification (Choumenkovitch, Selhub, Wilson, Rader, Rosenberg, & Jacques, 2002). Of those who did not consume supplements, total folate intake increased by a mean of 323 µg per day after fortification. Also, those who did not meet the estimated average requirement (EAR) of total folate (320 µg per day) dropped from 48.6% to 7.0% due to fortification. Lawrence et al. (1999) clinically evaluated data from 1994 to 1998 and found that the median serum folate values have increased from 12.6 mg per liter in 1994 to 18.7 mg per liter in 1998. Although folate consumption is increasing, many women are still not consuming the recommended amount of 400 µg per day.

Consumption among college-aged women. Wild et al. (1996) studied consumption of folic acid in young women as well. Based on a food frequency questionnaire, the median folate intake for women aged 16 to 19 was 235 µg per day and 248.5 µg per day for female undergraduate students. Wojick and Glanville (1999) conducted a food frequency assessing the diet of 72 undergraduate students (93% female). The results revealed a mean folate intake of 192±114 µg per day. The estimated intake increased by 30% when grains and cereals were assumed to be fortified with 140 µg of folic acid per 100 g of cereal grain.

Meyer et al. (2002) obtained consumption information from the 1999 North Carolina PRAMS survey. The results showed that consumption of multivitamins on a daily basis prior to pregnancy increased with age. While 7.6% of women

under 20 and 13.7% of women aged 20 to 24 consumed multivitamins on a daily basis prior to pregnancy, 35.4% and 40.5% of women aged 25 to 34 and 35 and over consumed multivitamins on a daily basis prior to pregnancy, respectively.

Quillin et al. (2000), in a study of 71 female psychology students, found that about one-third (32%) of the students consumed multivitamin supplements. Hilton (2002) found similar results in another study of college students. Hilton studied 42 conveniently selected female college students from a small liberal arts college aged 18 to 24. One-third (33.3%) of the students reported intake of multivitamins containing folic acid to be once a day, while 7% took a multivitamin 4 to 6 times per week, 11.9% took a multivitamin 1 to 3 times per week, and 38.1% never took a multivitamin. In addition, Hilton reported that most of the participants did not meet the recommended number of servings of oranges, orange juice, dark green leafy vegetables, fortified cereals and grains, and legumes, showing that their dietary intake of folate was inadequate. These young women are at risk for NTDs because of their poor dietary folate intake and lack of supplementation.

The literature reviewed demonstrates that NTDs are a devastating disorder that can impact the lives of the individuals, as well as those around them. Much research has shown that periconceptional consumption of folic acid can prevent these defects, although the exact reason is unknown. Because college-aged women are of childbearing age, have a lack of knowledge about folic acid, and have low dietary consumption of folic acid, they are at high risk for

an NTD-affected pregnancy. Further research regarding this group of women is needed to increase folic acid consumption and decrease the risk for NTDs.

Methodology

This study assessed consumption and knowledge of folic acid for the prevention of NTDs among college-aged women. A three-day dietary record database was utilized to determine folic acid consumption and a questionnaire was utilized to determine folic acid knowledge concerning NTDs and how knowledge differs by characteristics. From this information, folic acid consumption and knowledge among college-aged women was determined.

Pilot Study

A pilot study was conducted to determine the impact of characteristics and knowledge on folic acid consumption among college-aged women. The pilot study included a sample of 31 college-aged women conveniently selected at Eastern Illinois University. Each participant completed a survey, which included a questionnaire and a dietary recall. The questionnaire consisted of 15 multiple-choice questions that assessed characteristics including sex, age, grade level, race, number of previous pregnancies, source of school finances, smoking habits, exercise habits, dieting, sexual activity, and folic acid supplement usage. The questionnaire also assessed the knowledge of folic acid concerning NTDs by asking if the participants had heard of folic acid, spina bifida, and anencephaly, and if they knew the benefits of folic acid concerning birth defects. The dietary recall was a 24-hour dietary recall, which asked each participant to list all foods, drinks, and supplements that were consumed in the previous 24 hours and to include approximate amounts of each food. Based on the results from the pilot study, conclusions were made that providing information about folic acid and the

benefits it offers, as well as promoting folic acid supplement usage, may increase folic acid consumption among college-aged women.

Design of the Study

The design of this study was non-experimental and utilized an established food record database as well as a questionnaire format. The database included three-day food records from students who participated in a nutritional assessment program. The questionnaire assessed demographic information as well as folic acid knowledge concerning NTDs using multiple-choice questions.

Sample

The sample included 138 college-aged females. The sample was selected conveniently and purposively from a food record database as well as certain classes in the School of Family and Consumer Sciences at Eastern Illinois University.

Selection of the sample. The sample was selected from two different groups. The first sample group, the database sample, included all females aged 18 to 25 who had participated in the Health Education Resource Center's (HERC) nutritional assessment program during the 2003-2004 school year at Eastern Illinois University. The second sample group, the questionnaire sample, included all females aged 18 to 25 in two class sections of Foundations in Family and Consumer Sciences, one class section of Orientation to Internship, one class section of Directions in Family and Consumer Sciences, and one class section of Nutrition Dilemmas. All of the classes were conducted during the spring 2004 semester at Eastern Illinois University. The specific section of each class was

chosen randomly so as to decrease bias. The selection was convenient in that it included readily available participants. The selection was also purposive in that the classes that were chosen to survey included a predominantly female population as well as a wide range of grade levels.

Description of the sample. The database sample group included 47 college-aged females who were assumed to be attending Eastern Illinois University, ranging from the ages of 18 to 24. The questionnaire sample group included 91 college-aged females attending Eastern Illinois University aged 18 to 25. The sample included students from freshman through senior grade levels and the majority were White.

Data Collection Instruments

The data collection instruments included a three-day food record database and a questionnaire. The questionnaire was revised from the questionnaire used in the pilot study by eliminating questions that were deemed irrelevant to the purpose of the study.

Food record database. The food record database was provided by the HERC at Eastern Illinois University. The HERC provided nutritional assessment to inquiring students. The inquiring students recorded three days of dietary intake, including supplements, which were then analyzed for nutritional content by trained staff members. All food records from females aged 18 to 25 who participated in the nutritional assessment program at the HERC during the 2003-2004 school year were used in the study. Information used from the food records

included age, average folic acid intake over the three-day period, and multivitamin consumption.

Questionnaire. The questionnaire (Appendix A), which was adapted from Gates and Holmes (1999), Leininger (1998), and the pilot study, included 16 multiple-choice questions that assessed demographic information, other characteristics, and folic acid knowledge concerning NTDs. The demographic information assessed included age, grade level, and race. The questionnaire addressed other characteristics including completion of, or enrollment in, an introductory nutrition class, sexual activity, pregnancy intendedness, and frequency of folic acid supplement consumption. The knowledge questions assessed if the participants had heard of folic acid, NTDs, spina bifida, and anencephaly, and if they knew the benefits of folic acid concerning birth defects, the time folic acid should be consumed, the recommended daily amount of folic acid, and concentrated sources of folic acid.

Procedure for Data Collection

Folic acid consumption data was collected from the three-day food record database provided by the HERC at Eastern Illinois University. Due to confidentiality at the HERC, a trained staff member compiled the data from the database using the records of all female participants from the 2003-2004 school year. The data compiled included age, average folic acid intake over a three-day period, and any supplements that were consumed. The data was compiled two weeks prior to the end of the spring semester.

Questionnaire data was collected by the researcher. The researcher attended each of the five classes during the same week to administer the questionnaire. Every female in each of the classes was informed about the purpose of the questionnaire and signed a consent form (Appendix B) to participate. Each female was asked to answer all of the questions honestly and to the best of her ability. When finished, the participants were asked to place the questionnaire in a folder, blinded from the researcher, to maintain anonymity.

Both the food record database and questionnaire were valid sources for data collection. Content validity was established for the food record database, which utilized the Diet Analysis Plus software program. Experts in the field of dietetics approved the software program, which was based on the Elizabeth Stuart Hands and Associates (ESHA) Research. The ESHA Nutrient Database utilized nutrient information from over 1,300 scientific sources and included over 26,000 food items (*ESHA Research*, 2004) Also, experts in the field of dietetics who were employed at Eastern Illinois University approved and recommended the Diet Analysis Plus software program as a quality program for dietary analyses. The questionnaire also had established content validity as it was utilized previously in the pilot study, and three expert judges in the field of Family and Consumer Sciences approved that it was an accurate tool to measure for the information desired. Questionnaires were also, in general, practical and concrete assessment tools which were very common among researchers.

Both data collection instruments were reliable sources as well. The food record database had established internal consistency as each of the HERC staff

members utilizing the software program were trained in the same manner. That training confirmed standardization for the data received from the HERC food record database. Reliability was established for the questionnaire as it was used previously in the pilot study, and questionnaires have shown over time to be reliable tools for data collection. Also, beyond validity and reliability, this study was deemed ethical as the Protocol for Research Involving Human Subjects for this study was approved by the Institutional Review Board at Eastern Illinois University.

Data Analyses

Folic acid consumption among college-aged women was determined using the food record database information. The three-day food records were analyzed by trained staff members at the HERC using the Diet Analysis Plus software program. All reported foods and amounts for the three days were entered into the program for each participant. A trained staff member analyzed each of the females' food records for the average folic acid intake for the three-day period. The trained staff member also reported any supplements that were consumed. If a multivitamin was consumed, it was assumed that it contained 400 µg of folic acid, as that was the usual amount in many multivitamins, and was added to the average dietary folic acid to determine total folic acid consumption. This information was analyzed using the Statistical Package for Social Sciences (SPSS) version 12.0 software program. Frequencies were used to describe the database sample group and to determine consumption among college-aged women from food and supplements.

Folic acid knowledge concerning NTDs among college-aged women was determined by creating a knowledge score from the nine questions assessing folic acid knowledge contained in the questionnaire (Appendix A, Questions 8 to 16). The participants received one point for each question in which they expressed that they had knowledge about folic acid by answering "Yes" (Appendix A, Questions 8 to 14) or by providing the correct answer (Appendix A, Questions 14 to 16). Participants were only considered to know the recommended daily amount of folic acid (Appendix A, Question 14) if "Yes" was circled and the correct amount (400 µg) was written in the blank. The total number of points from the nine questions determined the folic acid knowledge score for each of the participants.

The questionnaire data and folic acid knowledge scores were analyzed using the SPSS software program as well. Frequencies were used to describe the sample and determine folic acid knowledge among the participants. Independent t-tests were used to determine differences in mean folic acid knowledge scores between those who had completed, or were currently enrolled in, an introductory nutrition class and those who were never enrolled, between those who did engage in sexual intercourse and those who did not, and between those who were planning a pregnancy and those who were not. Independent t-tests were chosen because they were used to compare the means of two independent groups. One-way analysis of variance (ANOVA) tests were used to determine differences in mean folic acid knowledge scores among the different ages, grade levels, and races because one-way ANOVAs were used to compare

means of three or more groups. Crosstabs and Spearman's nonparametric correlation were used to determine the relationship between of folic acid knowledge concerning NTDs and the consumption of folic acid supplements by comparing the folic acid knowledge scores and the frequency folic acid supplement consumption. Spearman's correlation was chosen because the ordinal values for the frequency of folic acid supplement consumption necessitated a nonparametric correlation.

Results

Two different sample groups were used in the analyses of this study. The database sample group participated in the HERC's nutritional assessment program, which provided the average amount of folic acid consumed over a three-day period. The questionnaire sample group completed a questionnaire which assessed folic acid knowledge concerning NTDs as well as demographic information.

Folic Acid Consumption

Fifty-two females participated in the HERC's nutritional assessment program during the 2003-2004 school year at Eastern Illinois University. Of these participants, five were not used in the analysis due to being outside the age range of 18 to 25 years old. Therefore, 47 participants were included in the database sample group for the analysis of folic acid consumption.

Table 1 displays the age, multivitamin consumption, and folic acid intake with and without supplements among the database sample group. The mean age of the participants was 19.32±1.76 years old and the majority (68.1%) of the sample did not consume a multivitamin. Before supplementation, only one participant (2.1%) met the daily recommended amount of 400 µg of folic acid, and a majority (57.4%) consumed 200 µg or less. When supplements were included in the total folic acid intake, nearly one-third (31.9%) of the participants met the daily recommended amount and 42.6% consumed less than 200 µg. Folic acid intake without supplementation ranged from 56 to 442 µg and had a

Table 1

Age and Folic Acid Consumption Among College-Aged Females in Database Sample Group

Category	n	%
Age		
18	21	44.7
19	13	27.7
20	3	6.4
21	4	8.5
22	1	2.1
23	3	6.4
24	2	4.3
Multivitamin[a]		
Consumed a multivitamin	15	31.9
Did not consume a multivitamin	32	68.1
Folic Acid Intake Without Supplements[b]		
0 – 200µg	27	57.4
200 – 400µg	19	40.5
>400µg	1	2.1
Folic Acid Intake With Supplements[c]		
0 – 200µg	20	42.6
200 – 400µg	12	25.5
>400µg	15	31.9

Note. N = 47.
[a]Assumed to contain 400µg of folic acid. [b]Average of folic acid intake from a three-day food record. [c]Sum of supplemental folic acid and average folic acid intake from a three-day food record.

mean of 190±91 µg. Folic acid intake with supplementation included ranged from 56 to 842 µg and had a mean of 318±234 µg.

Questionnaire Sample Group Characteristics

Ninety-seven females completed the folic acid questionnaire at Eastern Illinois University. Six questionnaires were not used in the analysis due to being outside the age range of 18 to 25 years old. Therefore, 91 participants were included in the questionnaire sample group for the analysis of folic acid knowledge concerning NTDs.

Table 2 presents the characteristics of the questionnaire sample group. The mean age of the sample was 20.84±1.38 years old. Most of the participants were White (89.0%), had completed, or were currently enrolled in, an introductory nutrition class (74.7%), did engage in sexual intercourse (74.7%), and were not planning a pregnancy (98.9%). Of the participants, 41.8% never consumed folic acid supplements and only 6.6% consumed supplements once a day.

Folic Acid Knowledge Concerning Neural Tube Defects

Table 3 shows the responses to questions assessing folic acid knowledge concerning NTDs among the questionnaire sample group. Most of the participants had heard of folic acid (83.5%) and had heard of spina bifida (89.0%). More than half of the participants responded that they knew folic acid can prevent birth defects (60.4%) and that folic acid should be taken before pregnancy (57.1%). However, only 3.3% knew the daily recommended amount of folic acid. Orange juice was recognized as a concentrated source of folic acid

Table 2

Characteristics of College-Aged Females in Questionnaire Sample Group

Characteristic	n	%
Age		
18	3	3.3
19	11	12.1
20	23	25.3
21	29	31.9
22	15	16.5
23	8	8.8
25	2	2.2
Grade Level		
Freshman	12	13.2
Sophomore	12	13.2
Junior	35	38.5
Senior	32	35.2
Race		
White	81	89.0
African American	7	7.7
Hispanic/Latino	3	3.3
Introductory Nutrition Class		
Completed or enrolled	68	74.7
Never enrolled	23	25.3
Sexual Intercourse		
Did engage in sexual intercourse	68	74.7
Did not engage in sexual intercourse	23	25.3
Pregnancy Intendedness		
Planning a pregnancy	1	1.1
Not planning a pregnancy	90	98.9
Frequency of Folic Acid Supplement Intake		
Once a day	6	6.6
4-6 times per week	4	4.4
1-3 times per week	8	8.8
Never	38	41.8
Don't know	35	38.5

Note. N = 91.

Table 3

Folic Acid Knowledge Concerning Neural Tube Defects Among College-Aged Females

	Knowledge		No Knowledge	
Knowledge Question	n	%	n	%
Have you heard of folic acid?[a]	76	83.5	15	16.5
Have you heard of neural tube defects (NTDs)?[a]	52	57.1	39	42.9
Have you heard of spina bifida?[a]	81	89.0	10	11.0
Have you heard of anencephaly?[a]	21	23.1	70	76.9
Do you know folic acid can prevent birth defects?[a]	55	60.4	36	39.6
Do you know folic acid should be taken before pregnancy?[a]	52	57.1	39	42.9
Do you know the recommended daily amount of folic acid?[b]	3	3.3	88	96.7
Of the foods listed, which one is the most concentrated source of folic acid? (Cold breakfast cereal)[c]	15	16.5	76	83.5
Of the foods listed, which one is the most concentrated source of folic acid? (Orange juice)[d]	35	38.5	56	61.5

Note. N = 91.
[a]Participants were considered to have knowledge if they chose "Yes" and no knowledge if they chose "No". [b]Participants were considered to have knowledge if they chose "Yes" and wrote the correct amount of 400µg. All other responses were considered to have no knowledge. [c]Participants were considered to have knowledge if they chose "Cold breakfast cereal" and no knowledge if they chose "Banana", "Milk", "Chicken", or "Don't know". [d]Participants were considered to have knowledge if they chose "Orange juice" and no knowledge if they chose "Potato", "Beef", "Tomato", or "Don't know".

more than cold breakfast cereal, yet the questions were only answered correctly by 38.5% and 16.5%, respectively.

One point was given when the participants expressed knowledge about folic acid concerning NTDs for each of the nine knowledge questions. The points were added to create a folic acid knowledge score. The folic acid knowledge scores of the sample are presented in Table 4. Knowledge scores ranged from 0 to 8 with a mean score of 4.29±2.10 points. Of the participants, 2.2% expressed no knowledge of folic acid. Most of the participants received 6 points (20.9%), and no participants received all 9 points.

Folic Acid Knowledge and Characteristics

The folic acid knowledge scores were analyzed to determine the mean difference among participants with different characteristics. Table 5 displays the mean knowledge scores for each of the characteristics assessed in the questionnaire. The mean scores for each of the age groups generally increased as age increased, but not significantly. One-way analysis of variance (ANOVA) at the .05 alpha level showed a significant difference in mean knowledge scores among the different races (F (2, 88) = 3.21, p = .045). The Scheffe post hoc test showed that the White females had mean knowledge scores of 3.062 points higher than that of the mean scores of Hispanic/Latino females, which was significant at the .05 level. Only 3.3% of the sample was of Hispanic/Latino descent, which was representative of the larger population on campus. The participants who had completed, or were currently enrolled in, an introductory nutrition class had slightly higher mean scores than participants who had never

Table 4

Folic Acid Knowledge Scores Among College-Aged Females

Knowledge Score[a]	n	%
0	2	2.2
1	12	13.2
2	8	8.8
3	7	7.7
4	16	17.6
5	15	16.5
6	19	20.9
7	8	8.8
8	4	4.4
9	0	0.0

Note. N = 91.
[a]Knowledge score is the number of questions in which the participants expressed knowledge about folic acid out of a total of nine knowledge questions.

Table 5

Comparison of Folic Acid Knowledge Concerning Neural Tube Defects Among College-Aged Females with Different Characteristics

Characteristic	n	Mean±*SD* Knowledge Score
Age		
18	3	3.00±1.73
19	11	4.36±2.77
20	23	4.35±1.99
21	29	4.31±2.09
22	15	4.20±2.40
23	8	4.50±1.51
25	2	4.50±2.12
Grade Level		
Freshman	12	4.00±2.80
Sophomore	12	4.67±1.50
Junior	35	4.20±2.23
Senior	32	4.34±1.93
Race		
White	81	4.40±2.03*
African American	7	4.29±2.63
Hispanic/Latino	3	1.33±0.58*
Introductory Nutrition Class		
Completed or enrolled	68	4.43±2.11
Never enrolled	23	3.87±2.07
Sexual Intercourse		
Did engage	68	3.93±2.14**
Did not engage	23	5.35±1.61**
Pregnancy Intendedness		
Planning a pregnancy	1	4.00
Not planning a pregnancy	90	4.29±2.12

Note. N = 91. All tests were assumed to have equal variance.
[a]Knowledge score is the number of questions in which the participants expressed knowledge about folic acid out of a total of nine knowledge questions.
*The mean difference is significant, one-way ANOVA, $p < .05$. **The mean difference is significant, independent t-test, $p < .01$(two-tailed).

enrolled, but not significantly higher. An independent t-test analysis showed that participants who did not engage in sexual intercourse had significantly higher mean knowledge scores than those who did engage in sexual intercourse (t (89) = 2.91, p = .005). The difference in mean knowledge scores among women planning and not planning a pregnancy was not significantly different. However, the one participant who was planning a pregnancy had a knowledge score of 4 points. In summary, there were significant differences in mean knowledge scores by race and sexual activity, but no significant differences by age, grade level, nutrition class, or pregnancy intendedness.

Folic Acid Knowledge and Consumption

Folic acid knowledge scores and folic acid supplement frequency were compared to determine if folic acid knowledge concerning NTDs and the frequency of folic acid supplement consumption were related. Table 6 shows the crosstabs between folic acid knowledge scores and the frequency of folic acid supplement consumption. The mean knowledge scores of those who consumed folic acid supplements once a day and 4 to 6 times per week were 4.83 points and 7.00, respectively, whereas the mean knowledge score of those who never consumed folic acid supplements was 4.34 points. Spearman's nonparametric correlation analysis showed a positive and significant relationship between knowledge scores and supplement consumption at the .01 level (r_s = .304). This showed that as the folic acid knowledge scores increased, the frequency of folic acid supplement consumption increased as well.

Table 6

Relationship Between Folic Acid Knowledge Concerning Neural Tube Defects and Folic Acid Supplement Consumption Among College-Aged Females

Folic Acid Knowledge Score	Frequency of Folic Acid Supplement Consumption				
	Once a Day	4-6 times/wk	1-3 times/wk	Never	Don't Know
0	0	0	0	0	2
1	0	0	0	7	5
2	0	0	0	3	5
3	1	0	1	1	4
4	1	0	1	6	8
5	2	0	2	9	2
6	2	1	4	6	6
7	0	2	0	4	2
8	0	1	0	2	1
9	0	0	0	0	0

Note. N = 91. Correlation is significant, $r_s = .304$, $p < .01$(two-tailed).

Discussion

The purpose of this study was to determine consumption and knowledge of folic acid for the prevention of NTDs among college-aged women. The results that were found provide data to determine this main objective by supporting or rejecting the hypotheses of the study.

Folic Acid Consumption

The hypothesis that college-aged women do not consume the recommended amount of folic acid from food and supplements is supported by the data from this study. The daily recommended amount of folic acid is 400 µg, and only one participant from the database sample group met this requirement through diet alone. The mean intake of folic acid without supplements for this study was 190±91 µg. These results are similar to those of Wojick and Glanville (1999), who reported a mean intake of 192±114 µg among 72 undergraduate students in which 93% were female. However, these findings are lower than the results from Wild et al. (1996), who found a mean intake of 248.5 µg among 150 female undergraduate students. The difference may be due to the different sampling procedures. The sample in the study by Wild et al. was a larger size than of this study and of the study by Wojick and Glanville, and one-third of the sample consisted of medical students. Even so, all three of the studies show that college-aged females are not meeting the requirements of folic acid through diet alone.

Multivitamin consumption was found to be low as well. About one-third (31.9%) of the database sample group consumed a multivitamin, which is similar

to the results of the studies by Quillin et al. (2000) and Hilton (2001). Quillin et al. found that 32% of 71 female psychology students consumed multivitamins. Hilton studied 42 female college students and found exactly one-third (33.3%) consumed multivitamins once a day. When supplements were included in the mean folic acid intake of this study, folic acid intake levels increased. The results also showed that 15 participants consumed a multivitamin and 15 participants met the daily recommended amount of folic acid through diet and supplements combined, demonstrating that only the participants who took a supplement met the requirement. Nevertheless, only about one-third of the participants met the daily recommended amount with supplements included. This also shows that college-aged females are not consuming the recommended amount of folic acid from food and supplements combined.

Folic Acid Knowledge Concerning Neural Tube Defects

The hypothesis that college-aged women have limited folic acid knowledge concerning NTDs is also supported by the results of this study. Many participants (83.5%) had heard of folic acid, which is consistent with other studies of college females. Wild et al. (1996) found that 87% of 100 arts and science students had heard of folic acid. The results from these two studies were higher than the results of Meyer et al. (2002), Quillin et al. (2000), and Wojick and Glanville (1999). Meyer et al. studied 1780 women who had recently given birth. Of the women aged 20 to 24, 66.4% had heard of folic acid. This result was similar to Quillin et al., who reported that 64% of 71 female psychology students had heard of folic acid. However, Wojick and Glanville found that only 42% of 72

undergraduate students (93% female) had previous knowledge of folic acid, which is much lower than the results of this study. The increased knowledge among this sample as compared to others may be due to the recent increase in promotion of folic acid in the United States.

Although the results show that a vast majority of the participants had heard of folic acid, the results also show that they have limited knowledge about certain aspects of folic acid concerning NTDs. Slightly over half of the participants knew that folic acid can prevent birth defects (60.4%) and should be taken before pregnancy (57.1%). These rates are higher than that of Wild et al. (1996) who reported that 26% of arts and science students and 70% of medical students knew folic acid should be taken before pregnancy. Again, this may be due to the recent increase in promotion of folic acid in the United States.

While some participants may have known how folic acid is beneficial, very few knew what to consume, or how much to consume, to receive the benefits. Only 16.5% and 38.5% recognized cold breakfast cereal and orange juice as concentrated sources of folic acid, respectively, and 3.3% knew the recommended amount of folic acid. This is similar to the results from Quillin et al. (2000) who reported that 5% of 71 female psychology students knew the recommended amount of folic acid.

The folic acid knowledge scores of the participants in this study were low also. The mean knowledge score was 4.29±2.10 points, showing that the average participant expressed knowledge of folic acid for less than half of the nine knowledge questions. The results show that these females knew more

about some areas of folic acid than other areas, but in general, had limited knowledge of folic acid concerning NTDs.

Folic Acid Knowledge and Characteristics

The hypotheses that folic acid knowledge concerning NTDs among college-aged women shows a significant statistical difference by age, grade level, having completed, or being currently enrolled in, an introductory nutrition class, and pregnancy intendedness are not supported by the results of this study. None of these characteristics showed a significant difference in mean folic acid knowledge scores among the different counterpart groups. Although some studies show a difference in folic acid knowledge among different ages (Wild et al., 1996; Meyer et al., 2002), they show a difference among different age groups, where college-aged women are considered to be in one age group. The reason this study does not show a difference in folic acid knowledge among different ages may be because only one age group was assessed. Enrolling in an introductory nutrition class also does not show to increase folic acid knowledge. This may be due to participants not retaining the information, regarding the information as irrelevant to themselves, or not being taught about folic acid. The one participant who reported planning a pregnancy expressed knowledge for less than half of the knowledge questions. Her lack of knowledge about folic acid may be problematic during her pregnancy.

The hypothesis that folic acid knowledge concerning NTDs among college-aged women shows a significant statistical difference among different races is supported. The results suggest that White females know slightly more

about folic acid than African American females, but know significantly more about folic acid than Hispanic/Latino females. In fact, White females had an average of 3 points higher on the folic acid knowledge score than Hispanic/Latino females. However, these results are limited due to the small percentage of Hispanic/Latino females in the study.

The hypothesis that folic acid knowledge concerning NTDs among college-aged women does not show a significant statistical difference by sexual activity was not supported by this study. The results show that there is a significant difference among those who did engage in sexual intercourse and those who did not. Those who did not engage in sexual intercourse had higher mean knowledge scores than those who did engage in sexual intercourse. While it is hoped that females engaging in sexual intercourse would know about the risks of pregnancy, and therefore the risks of NTDs, more than females who do not engage in sexual intercourse, that is not shown to be true in this study. The females who do not engage in sexual intercourse may be more aware of the risks of pregnancy and NTDs, and therefore decide not to engage in sexual intercourse.

Folic Acid Knowledge and Consumption

The hypothesis that increased folic acid knowledge concerning NTDs is related to increased consumption of folic acid supplements is supported by this study. There was a positive correlation between folic acid knowledge scores and the frequency of folic acid supplement consumption. Therefore, the females that

know more about folic acid concerning NTDs consume folic acid supplements more frequently.

Limitations

There are limitations to this study. First, the sample is not a true random sample and is a relatively small sample size. In addition, the food records that were used for the database sample group may have overestimated or underestimated folic acid intake as some participants may have forgotten foods that were eaten, reported erroneous amounts of food, or changed their eating habits due to the recording. The dietary analysis program used for the database sample group may overestimate or underestimate folic acid results, as not every food is listed in the database and the foods most similar to those reported were chosen. Also, the students who participated in the HERC nutritional assessment program may be more health conscious than the average college female.

Conclusions and Implications

The purpose of this study was to determine consumption and knowledge of folic acid for the prevention of NTDs among college-aged women. Two different sample groups were used in the study. The database sample group included 47 college-aged females who submitted three-day food records for a nutritional assessment program. The questionnaire sample group included 91 college-aged females who completed a questionnaire assessing demographic information, certain characteristics, and folic acid knowledge concerning NTDs. The results were analyzed and determined that college-aged women do not consume the recommended amount of folic acid from food and supplements and have limited knowledge about folic acid concerning NTDs. Also, White females and those who did not engage in sexual intercourse knew significantly more about folic acid than Hispanic/Latino females and those who did engage in sexual intercourse. Additionally, the results showed a significant relationship between increased folic acid knowledge concerning NTDs and increased folic acid supplement consumption.

Conclusions

The results of this study, as well as other studies, suggest that college-aged women do not consume enough folic acid through food alone. In fact, the results show that these women need to double the amount of folic acid they consume from food to meet the recommended amount. Taking folic acid supplements daily would be an easier alternative for these women to ensure that the recommended amount is being consumed. However, three different studies

show that only about one-third of college-aged females consume folic acid supplements. This study suggests that the only way for college-aged women to meet the recommended amount of folic acid is to consume a folic acid supplement. Therefore, supplemental folic acid is very important for college-aged women, and all of these women need to consume a folic acid supplement every day to meet the recommended amount. This is also very important considering a majority of college-aged women are sexually active and have the potential to become pregnant.

The results of this study also suggest that college-aged women have limited knowledge of folic acid concerning NTDs. Four different studies, including this one, report that the majority of college-aged women have heard of folic acid. However, only some know that it needs to be consumed before pregnancy, and even fewer know sources rich in folic acid. Very few college-aged women know the recommended amount of folic acid as well. All college-aged women need more education about folic acid and NTDs.

Certain groups of college-aged women know less about folic acid and NTDs than others. This study indicates that those who are sexually active and those who are of Hispanic/Latino descent have less knowledge about folic acid than their counterparts. Therefore, these groups of women need to be targeted among college-aged women for education about folic acid and NTDs. Education especially needs to be directed towards those who are sexually active because of their potential to become pregnant, and in turn, their potential to have an NTD-affected pregnancy.

Education for college-aged women about folic acid and NTDs is also justified by the relationship between increased folic acid knowledge and increased folic acid supplement consumption that this study shows exists. This study suggests that college-aged women who know more about folic acid and NTDs consume folic acid supplements more frequently and in turn, reduce their chances of having an NTD-affected pregnancy.

Implications

Based on the conclusions of this study, college-aged women are not consuming enough folic acid and need more education about folic acid and NTDs. The United States currently has programs promoting this knowledge. However, this education needs to be targeted towards college-aged women, especially those who are sexually active because of their potential to become pregnant and have an NTD-affected pregnancy. Many of these women have heard of folic acid, and some know the benefits of taking folic acid, but very few are actually consuming it. Therefore, education programs need to focus on ways to increase folic acid consumption. College-aged women need to be informed about food sources rich in folic acid as well as the importance of consuming a folic acid supplement every day to be nutritionally prepared for pregnancy, even if pregnancy is not intended.

There are several intervention methods that can be used to increase folic acid knowledge and consumption among college-aged women. First, implementing folic acid educational programs within campus residence halls could provide knowledge to large audiences. Also, sororities are required to

attend a certain number of educational programs each semester. Organizing a folic acid informational for sorority women to attend would provide knowledge to an accessible audience. Options to target Hispanic/Latino women include providing educational sessions on folic acid for Latino sororities, as well as for entire campuses during Latino heritage month. To target college-aged women who are sexually active, informational handouts about folic acid could be included with birth control and condoms sold on campuses.

There is a great need for more research on this topic. More research on the consumption and knowledge of folic acid among college-aged women is needed because of the limited amount. A better understanding of this group of women may help increase consumption and prevention of NTDs among these women. Also, more research needs to be conducted on the causes of NTDs, as well as the biological mechanism of how folic acid prevents NTDs. Knowing more about the function of folic acid can only help college-aged women, and all women of childbearing age, to prevent and eventually eliminate NTDs, which is the ultimate goal.

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Appendix A

Folic Acid Questionnaire

Please circle one answer for each question and answer honestly and to the best of your ability. Thank you for your participation.

1. What is your age? (Please write in) _____

2. What is your grade level?
   a) Freshman b) Sophomore c) Junior d) Senior e) Graduate

3. What is your race?
   a) White b) African American c) Hispanic/Latino d) Asian e) Pacific Islander f) American Indian
   g) Other (Please write in)_____

4. Have you completed, or are you currently enrolled in, an introductory nutrition class? (Example: FCS 2100 – Nutrition in a Global Society)
   a) Yes b) No

5. Do you engage in sexual intercourse?
   a) Yes b) No

6. Are you planning a pregnancy?
   a) Yes b) No

7. How often do you take supplements containing folic acid?
   a) Once a day b) 4-6 times/wk c) 1-3 times/wk d) Never e) Don't know

8. Have you heard of folic acid?
   a) Yes b) No

9. Have you heard of neural tube defects (NTDs)?
   a) Yes b) No

10. Have you heard of spina bifida?
    a) Yes b) No

11. Have you heard of anencephaly?
    a) Yes b) No

12. Do you know folic acid can prevent birth defects?
    a) Yes b) No

13. Do you know folic acid should be taken before pregnancy?
    a) Yes b) No

14. Do you know the recommended daily amount of folic acid? (If yes, write in amount)
    a) Yes _____ b) No

15. Of the foods listed, which one is the most concentrated source of folic acid?
    a) Banana b) Milk c) Cold breakfast cereal d) Chicken e) Don't know

16. Of the foods listed, which one is the most concentrated source of folic acid?
    a) Orange juice b) Potato c) Beef d) Tomato e) Don't know

Appendix B

Consent Form

This questionnaire is part of a study assessing the knowledge and consumption of folic acid among college-aged women. The results of this study will be used for a Master's thesis project in the School of Family and Consumer Sciences at Eastern Illinois University. The duration of your participation in this study includes only completing this questionnaire. There are no risks or benefits involved in this study. Your participation in this study is voluntary and you can withdraw from this study at any time during the questionnaire without prejudice. Your responses will be confidential and anonymous.

If you have any questions pertaining to the study, please contact Lynn Stahlhut (348-6497) or Dr. Erma Fernando (581-6352).

I, _____, hereby consent to participate in this study.
(Print Name)

_____ _____
(Signature) (Date)