Nutrition and Dietetic Students' Vitamin and Mineral Knowledge and Concurrent Learning and Retention Strategies

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Abstract

Background: The functions, food sources, deficiency symptoms, and toxicity symptoms are important for dietetic professionals to know and apply to community, food service, and clinical settings.
Purpose: To assess nutrition and dietetic students' knowledge of vitamins and minerals and identify students' strategies for learning and retaining vitamin and mineral information.
Methodology: Students from three universities in the western United States were invited to participate in cross-sectional study. Participants completed a brief questionnaire that included multiple choice and short answer questions to assess their knowledge of a representative list of 8 vitamins and minerals. The questionnaire also included free-response questions about strategies for retention of vitamin/mineral information. Two researchers independently reviewed responses and identified themes.
Results: Students' scores on multiple-choice vitamin/mineral questions suggested that they had difficulty remembering details regarding vitamins and minerals. Three themes were identified as common study strategies for learning vitamin and mineral content: repetition, mnemonic devices, and personal application.
Conclusions: These findings suggest that further research assessing the increased use of repetition, mnemonic devices, and especially personal application in dietetics education curriculum are warranted.
Keywords: teaching methods; learning strategies; dietetics; nutrition

1. Background

Vitamins and minerals are essential nutrients. Diets that follow the *Dietary Guidelines for Americans* (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015) provide sufficient vitamins and minerals to support health. When diets provide inappropriate amounts of vitamins and minerals adverse effects can occur. For example, a person who follows a vegan diet is at increased risk for vitamin B-12 deficiency because vitamin B-12 is found primarily in animal products. Someone with vitamin B12 deficiency may experience symptoms such as impaired nerve damage and macrocytic anemia (Lichtin, 2013).

Coordinated and Didactic Programs in Dietetics prepare students to become registered dietitians (RD). RDs work in a variety of settings ranging from clinical dietitians working on an intensive care unit, to a director of food service for a school district, to a certified diabetes educator working in a community setting. Vitamins and minerals fall under broader knowledge competencies mandated by the Accreditation Council for Education in Nutrition and Dietetics (Accreditation Council for Education in Nutrition and Dietetics [ACEND] of the Academy of Nutrition and Dietetics, 2017). The functions, food sources, deficiency symptoms and toxicity symptoms are important for dietetic professionals to know and apply in community, food service, and clinical settings (Marra & Boyar, 2009).

Instructors and/or students may employ and/or develop a variety of memorization/learning strategies to aid in retaining this information. Mnemonic devices and other strategies that tie new information to current knowledge can increase memory (Balch, 2005; Bellezza, 1996). Mnemonic devices can be especially important when students are learning new material and can serve as a scaffolding to help students remember basic information that can be built upon in later classes (Belezza, 1996). For example, DETERMINE (Disease, Eating poorly, Tooth loss/mouth pain, Economic Hardship, Reduced social contact, Multiple Medicines, Needs assistance in self care, Elder years above age 80) is commonly used to assess risk for malnutrition in older adults (Nutrition Screening Initiative, a project of the American Academy of Physicians, the American Dietetic Association, and the National Council on Aging, and funded in part by a grant from Ross Laboratories, a division of Abbott Laboratories). The use of mnemonic devices as an educational tool has been effective in educational interventions for future and current healthcare professionals. For example, the use TWED (Threat, What else, Evidence, Disposition influence) resulted in better clinical decision making among medical students during case studies (Chew, Durning, and van Merrienboer, 2016). In addition, after adopting the mnemonic device PSYCH (Patient information/background, Situation leading to the hospital visit, Your assessment, Critical Information, and Hindrance to discharge) resulted in psychiatric residents improving their communication during transitioning of patients from one treatment team to another (Mariano, Brooks, & Digiacomo, 2016). The use of mnemonic devices and other strategies to learn and remember important vitamins and minerals facts has not been previously studied among nutrition and dietetic students.

The purpose of this study was to assess nutrition and dietetic students' knowledge of vitamins and

minerals as well as their strategies for learning and retaining information about vitamins and minerals.

2. Methodology

2.1 Participants

Junior- and Senior-level Nutrition and Dietetics students (N = 144) from three universities in the western United States were invited to participate in this study. Professors at each university contacted them by email, inviting them to complete an online questionnaire. Participants were not offered and incentive to participate in this study.

2.2 Survey Content

Participants completed an online questionnaire that assessed their knowledge of 4 vitamins and 4 minerals (Vitamin E, Vitamin K, Thiamin, Niacin, Magnesium, Chloride, Copper, and Chromium). The questionnaire included 8 (one for each vitamin/mineral) multiple choice knowledge questions, and 8 free-response questions regarding the nutrient's function, deficiency symptoms, toxicity symptoms (if applicable), food sources, and any strategies that helped them retain that information. The only demographic question was the school the participant attended.

2.*3 Survey Development*

Preliminary questionnaires were used among a subsample (n = 41) of the 144 who were invited to participate in the study to determine which vitamins and minerals were most familiar to students (unpublished data). The list had 14 vitamins and 14 minerals. The most familiar vitamins and minerals (10 of each) were excluded from the final list. This was done to both decrease the number of questions on the final survey and subsequent burden on participants, and to focus the research on determining strategies for learning/remembering the less familiar vitamins and minerals. For example, most students remember the association between vitamin A and vision, and can list several food sources of vitamin A.

The vitamins and minerals were selected for inclusion in the final questionnaire because they represented each of the following categories: water-soluble vitamins, fat-soluble vitamins, major minerals, trace minerals, nutrient involved in bone health, antioxidants, nutrients involved in nutrient metabolism, nutrients involved in blood health, and electrolytes. Vitamin K, Thiamin, and Chromium have no known toxicity symptoms (Whitney & Rolfes, 2013). The Institutional Review Board at each University reviewed all study protocol and classified this study as exempt.

2.4 Analysis

Correct answers to multiple-choice questions were assigned a score of 1, incorrect and missing answers were given a score of 0, and a score of 0.5 was given if correct and incorrect responses were given for a single questions. *Understanding Nutrition, 13th edition* (Whitney & Rolfes, 2013), *Advanced Nutrition and Human Metabolism* (Gropper & Smith, 2013), the Linus Pauling Institute Micronutrient Information Center website (Linus Pauling Institute, 2016), pubmed.org, and medlineplus.gov. were used to determine correctness of participants' answers to free-response vitamin and mineral questions (function, food

sources, deficiency symptoms, and toxicity symptoms). Two researchers independently evaluated the participants' responses related to their strategies for learning and retaining vitamin and mineral information and categorized them accordingly. This method increases reliability of the qualitative results (Mays & Pope, 1995). Once each researcher analyzed all 18 responses, they met to discuss differences and similarities in identified themes.

3. Results

Forty students completed the questionnaire in Fall 2014-Spring 2015. Overall 28% completed the study. The low response rate may be have been influenced by students being at distant locations completing dietetic internships, or for some, the study being timed near the end of the school year. The online survey did not require participants to answer each question before moving on the next question. Consequently, participants skipped questions, resulting in different n values for various questions.

3.1 Multiple Choice Results

The average multiple-choice score was a 63% percent (5/8 questions). The majority of participants (88.2%; n = 30) knew that blood clotting is the primary function of vitamin K. The lowest average number of correct responses was the result of vitamin E deficiency (38%; n = 13). See Table 1 for a summary of multiple choices questions.

Table 1. Multiple Choice Results (n = 34)

	Correct % (n)	Incorrect % (n)
Chloride function (component of hydrochloric acid)	84.8 (28)	15.1 (5)
Magnesium Function (DNA synthesis, energy production, bone health)	73.5 (25)	26.5 (9)
Copper Function (hemoglobin formation)	73.5 (25)	26.5 (9)
Chromium Deficiency (elevated blood glucose)	44.1 (15)	55.8 (19)
Vitamin E Deficiency (hemolytic anemia)	38.2 (13)	61.7 (21)
Vitamin K Function (blood clotting)	88.2 (30)	11.7 (4)
Thiamin Function (energy metabolism)	61.7 (21)	38.2 (13)
Niacin Deficiency (altered skin, gastro-intestinal, and nervous system health)	47 (16)	52.9 (18)

*33 participants answered this question

3.2 Free Response Results

3.2.1 Free Response Vitamins Knowledge Results

The average free-response score was a 10.75 (n = 40) (27 points possible). Participants were asked to provide the function, deficiency symptoms, toxicity symptoms, and food sources for vitamins E, K, Thiamin, and Niacin. Over half of participants provided the correct functions for Vitamin E (85%) and

Vitamin K (67.5%), while just below half were able to give the correct functions for Thiamin (42.5%) and Niacin (42.5%). Vitamin K deficiency symptoms received the most correct responses (52.5%), while Niacin received the lowest amount of correct responses (35%).

In regards to toxicity, 65% of participants provided the correct symptoms for Niacin toxicity, whereas only 22.5% provided the correct vitamin E toxicity symptoms. The majority of participants were able to provide the correct food sources for each vitamin; Vitamin E (77.5%), Vitamin K (62.5%), Thiamin (70%), and Niacin (75%). For a complete summary what participants answered correctly, incorrectly, incorrectly and correctly, did not know, or did not respond for vitamins, see Table 2.

Table 2. Free-response Vitamin Knowledge Results (N = 40)

Vitamins & Questions	Correct % (n)	Incorrect % (n)	Incorrect/ correct % (n)	Do not know % (n)	No response % (n)
Vitamin E					
Function	85 (34)	-	-	10 (4)	5 (2)
Deficiency	37.5 (15)	-	-	37.5 (15)	25 (10)
Toxicity	22.5 (9)	4 (4)	-	45 (18)	22.5 (9)
Food Sources	77.5 (31)	-	2.5 (1)	4 (4)	4 (4)
Vitamin K					
Function	67.5 (27)	5 (2)	-	4 (4)	17.5 (7)
Deficiency	52.5 (21)	7.5 (3)	-	15 (6)	25 (10)
Food Sources	62.5 (25)	5 (2)	-	17.5 (7)	15 (6)
Thiamin					
Function	42.5 (17)	7.5 (3)	2.5 (1)	15 (6)	32.5 (13)
Deficiency	40 (16)	5 (2)	-	27.5 (11)	27.5 (11)
Food sources	70 (28)	-	-	7.5 (3)	22.5 (9)
Niacin					
Function	42.5 (17)	4 (4)	7.5 (3)	4 (4)	30 (12)
Deficiency	35 (14)	2.5 (1)	2.5 (1)	25 (10)	35 (14)
Toxicity	65 (26)	2.5 (1)	-	20 (8)	12.5 (5)
Food Sources	75 (30)	2.5 (1)	-	4 (4)	12.5 (5)

3.2.2 Free Response Mineral Knowledge Results

The same question format was used regarding the minerals chloride, chromium, copper, and magnesium. The majority of participants were able to give the correct function of magnesium (45%) compared to chromium (4%). Regarding the function of chromium, the rest of participants indicated that they did not know (40%), did not respond (42.5%), gave an incorrect answer (5%), or gave a incorrect and correct answer (2.5%). Seventy percent of participants gave correct food sources for magnesium. Only 20% of participants were able to provide the correct food sources for chromium and 17.5% for copper. See Table 3. for a complete summary of mineral questions answered correctly, incorrectly, incorrectly and correctly, did not know, or did not respond.

Table 3. Free-Response Mineral Knowledge Results (N = 40)

Minerals & Questions	Correct % (n)	Incorrect % (n)	Incorrect and correct % (n)	Do not know % (n)	No response % (n)
Chlorine					
Function	42.5 (17)	10 (4)	2.5 (1)	12.5 (5)	32.5 (13)
Food Sources	40 (16)	2.5 (1)	5 (2)	17.5 (7)	35 (14)
Chromium					
Function	4 (4)	5 (2)	2.5 (1)	40 (16)	42.5 (17)
Deficiency	5 (2)	7.5 (3)	-	40 (16)	47.5 (19)
Food Sources	20 (8)	-	-	35 (14)	45 (18)
Copper					
Function	17.5 (7)	5 (2)	2.5 (1)	33.3 (15)	33.3 (15)
Deficiency	5 (2)	5 (2)	2.5 (1)	42.5 (17)	45 (18)
Toxicity	17.5 (7)	2.5 (1)	2.5 (1)	32.5 (13)	45 (18)
Food sources	17.5 (7)	7.5 (3)	15 (6)	20 (8)	40 (16)
Magnesium					
Function	45 (18)	5 (2)	12.5 (5)	15 (6)	22.5 (9)
Deficiency	17.5 (7)	15 (6)	2.5 (1)	35 (14)	30 (12)
Toxicity	12.5 (5)	5 (2)	-	47.5 (19)	35 (14)
Food Sources	70 (28)	2.5 (1)	2.5 (1)	7.5 (3)	17.5 (7)

3.3 Vitamins and Minerals Learning and Retention Strategies

Overall, 18 strategies were reported for vitamins and/or minerals. After independent scorers identified themes and engaged in discussion, the result was three themes. The final themes included were "repetition," "mnemonic devices," and "personal application." These are discussed in greater detail below.

3.3.1 Repetition

Arriving at this theme involved grouping the researcher's ideas that had the same underlying meaning, together. The responses that researcher one grouped under "repetition," matched the responses researcher 2 grouped under "practice" and "repeated exposure" in the classroom. Collaboration resulted in theme one, "repetition. " Responses placed under this theme indicated that the student practiced, studied, or had classroom exposure. This strategy was used for vitamins E and K. For example, a response regarding vitamin E stated, "I look it up [vitamin E] in my textbook, write down the symptoms of deficiency, excess, and therapeutic uses."

3.3.2 Mnemonic devices

"Mnemonic devices," was chosen because the responses both researchers one and two grouped under "mnemonic devices" and "acronyms" matched and "mnemonic devices" is a more comprehensive term compared to "acronyms." "Mnemonic devices," was defined as using a mnemonic device to remember a

vitamin or mineral. Acronyms were a common mnemonic device used for vitamins E and K. For example, the acronym ADEK or KADE for fat-soluble vitamins was used for vitamins E and K. Another mnemonic device reported was remembering the function of vitamin K as "K for klotting."

3.3.3 Personal application

Researchers one and two separately identified the theme "personal application," and grouped the responses identically. "Personal application," was defined as associating a vitamin with an individual's daily activity and experiences. Using personal experience as a memory technique was used for vitamins E, K, thiamin, Niacin, and for minerals chlorine and magnesium. For example, one participant responded, "I take a vitamin E supplement daily." Another participant responded with, "I learned through a friend who had cancer and had vitamin K restrictions." For an inclusive summary of themes and responses, see Figure 1.

Theme 1 Repetition	1. "My micro teacher made us repeat the TCA cycle over and over to her and that niacin and riboflavin were used in the cycle" (Niacin) 2. "Just review of notes from class" 3. "Look up in text book/write down symptoms of deficiency excess, therapeutic uses" (Vitamin E) 4. "My micro teacher kept reiterating this for weeks" (Thiamin) 5. "The way I remembered this was by reviewing my notes before a nutrition exam" (Vitamin K)
Theme 2 Mnemonic Devices	1. "Fat Soluble vitamins are ADEK" (Vitamins E (1) & K (2)) 2. "Realizing that NADP starts with an N helped me remember that niacin was a part of this electron carrier" (Niacin) 3. "K for "Klotting" (Vitamin K)
Theme 3 Personal Experience	1. "A dietitian told me this and I have a child and they give all babies a vitamin K shot at birth so their blood clots and that info just stuck with me" (Vitamin K) 2. "Remembered that vitamin E was an antioxidant since I used to read ingredients lists which say they used vitamin E to maintain freshness, thus reminding me that it functions as an antioxidant" (Vitamin E) 3. "I take a vitamin E supplement daily" (Vitamin E) 4. "Babies need a vitamin k shot at birth to help with bleeding" (Vitamin K) 5. "People on blood thinners need to be aware of vit k intake" (Vitamin K) 6. "Learned via a friend with cancer who had restrictions" (Vitamin K) 7. "Remember it with Coumadin" (Vitamin K) 8. "I remembered that it was in grains by reading nutrition fact labels during my shopping" (Thiamin) 9. "Presentation I did on Wernicke's Encephalopathy" (Thiamin)

Figure 1. Vitamin and Mineral Learning and Retention Strategies

4. Discussion

The purpose of this study was to assess nutrition and dietetic students' vitamin and mineral knowledge as well as learning and retention strategies. Overall, the average score for participants that completed both the free response questions and multiple-choice questions (n = 34) was a 16.5/ 35 (47%). Including all participants (N = 40) and giving a score of 0 points on unanswered free response questions; the average score was a 14.1/35 (40%) (35 points total). As this has not been previously studied, the results are unable to be compared to other studies or students.

Participant scores indicate that without studying or referring to references, their overall vitamin and mineral knowledge among participants was low. Most participants did not report any strategies for remembering. Maybe this is because it is just part of their knowledge and understanding and they can't pinpoint how they remember. It could have been that they were fatigued from taking the survey. Or, it could have been that they didn't remember the information and therefore didn't have an effective strategy for remembering.

The highest percent of participants (85%) correctly indicated that vitamin E serves as an antioxidant. Perhaps that is related to the mnemonic device: ACE, which signifies vitamins A, C, and E are antioxidants. Many were also able to provide a correct food source of vitamin E (77%). Perhaps this is because they remembered that vitamin E is a fat-soluble nutrient, and is therefore present in oils and other fat-containing foods. Seventy percent of participants correctly indicated that an important function of vitamin K is coagulation. Reported strategies for remembering this information included a mnemonic device, "K for klotting", and personal application, routine vitamin K injections for newborns (who consume breast milk, which is low in vitamin K, and do not have gut bacteria and therefore cannot synthesize vitamin K in the colon) to prevent bleeding. Participant responses highlighted that a personal experience strengthens their ability to remember. This provides justification for the use of experiential learning activities within dietetics curriculum. Dietetic students may gain further understanding and retention of vitamin/mineral information when applying these principles in a clinical setting with real patients/clients.

Repetition was also identified as an important strategy for learning and remembering information. It is not surprising that many students did not list a strategy, or listed something vague such as "school." Participants' mention of studying for nutrition exams and "my micro teacher kept reiterating this for weeks" provide further support for this notion.

Limitations to this study include small sample size, low response rate, and the inability to verify that participants did not search the internet when completing the survey. However, participant selection of "I don't know" suggests that students relied on their own current knowledge.

5. Conclusion

This study provided a foundation for future research regarding vitamin and mineral educational strategies

for nutrition and dietetic students. These results indicate that vitamin and mineral knowledge may be low and that repetition, mnemonic devices, and personal experience may aid in learning and retention of this information. Controlled evaluation of these learning/retention strategies are warranted. Studies that specifically assess students' learning before and after clinical supervised practice experiences may be especially useful. Knowledge about vitamins and minerals is important for nutrition and dietetic students because it will improve the quality of care they provide in community, foodservice, and clinical settings.

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