Development of a Screening Tool to Identify Patients at Risk of Magnesium Deficiency

Emily A. Young[1], Andrea Rosanoff, PhD[2], Rebecca B. Costello, PhD[2], Kristen B. Johnson, PhD[3], & Bernadette P. Marriott, PhD[1]

[1]Medical University of South Carolina, Charleston, SC; [2]Center for Magnesium Education & Research LLC, Pahoa, HI; [3]University of Tennessee; Knoxville, TN

Background

Magnesium is a cofactor in over 300 enzymatic reactions and has been implicated in the pathogenesis of diseases such as hypertension and diabetes[1]. The 2010 Dietary Guidelines Advisory Committee found magnesium (Mg) to be under-consumed relative to the Estimated Average Requirement and characterized it as a shortfall nutrient of public health concern[2]. Given the combination of the prevalence of the under-consumption of Mg and its role in biochemical processes in multiple organ systems, deficiency potentially contributes to the pathogenesis of a wide variety of chronic conditions currently taxing the healthcare system[4]. Yet few physicians in clinical practice have extensive training in nutrition[5] and understand the breadth of the medical implications of the national shortfall of Mg intake among the US population.

We report on the development of a novel computerized, self-scoring tool (MagQuest) that can be used to help clinicians identify patients at risk of Mg deficiency. The 67-item questionnaire includes an abbreviated 30-day food frequency questionnaire (FFQ), based on the National Cancer Institute's Diet History Questionnaire (DHQ-II)[3], which measures the intake of 60 foods and supplements that are good sources of Mg, an assessment of medical conditions associated with Mg deficiency, and validated assessments for alcohol intake, depression, anxiety, and eating disorders (Table 1).

Methods

Based on a questionnaire by Seelig and Rosanoff[6], we built an evidence-based, computerized, self-scoring instrument called MagQuest in REDCap[7] that was designed to estimate dietary Mg intake and capture medical conditions associated with Mg deficiency. MagQuest contains 4 Sections (Table 1). The dietary portion is based on the NCI DHQ-II with a focus on diet items that contain higher levels of Mg plus all dietary supplements. MagQuest includes information on alcohol use, medications, body weight, and medical diagnoses as factors known to impact Mg status. Similarly, anxiety, depression and disordered eating have been shown to impact Mg status and are measured with embedded, well-validated, brief instruments[8,9].

The initial instrument was tested in focus groups of medical students and clinical practitioners from 4 disciplines (Table 2). Based on anonymous focus group feedback, qualitative and quantitative adjustments were made to MagQuest. Twenty-three volunteers participated in a validation study to compare reported Mg intake on both the revised MagQuest and the DHQ-II. Participants were randomized to complete either the DHQ first (n = 14) or MagQuest first (n = 9). DHQ-II nutrient analysis was obtained using DietCalc version 1.5[10]. MagQuest's daily Mg intake estimate is based on Mg values retrieved from the USDA Standard Reference Nutrient Database[11]. All values assigned to magnesium supplements were subtracted from daily intake estimates before Pearson's correlation coefficients were calculated.

Table 1. Description of information collected by MagQuest

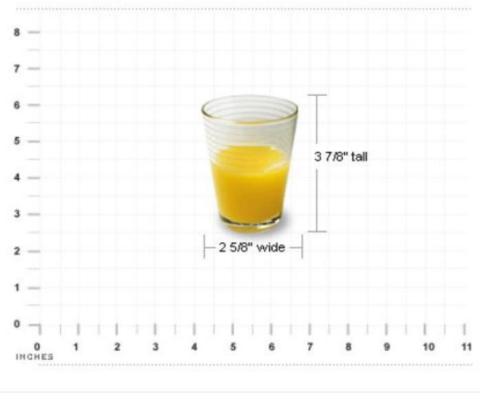| Composition of MagQuest |
| --- |
| **30 Day FFQ** (39 questions) |
| Fruits and Vegetables |
| Whole grains |
| Meat and Dairy |
| Nuts and Beans |
| Miscellaneous and Supplements |
| **Alcohol Intake** (4 questions) |
| **Mental Health** (13 questions) |
| PROMIS Anxiety[9] |
| PROMIS Depression[9] |
| SCOFF Questionnaire (disordered eating)[8] |
| **Medications** (3 questions) |
| **Medical Diagnoses** (8 questions) |

Figure 1. Sample portion size images were added to the questionnaire based on focus group feedback.

Results

Table 2. Description of focus group composition and feedback.

Professional Role	Number of Participants	% Responded Survey Too Long	% Indicated Would Use
Registered Dietitian	9	44% (n = 4)	78% (n = 7)
Nurse	8	12.5% (n = 1)	50% (n= 4)
MD (OB/GYN)	8	75% (n = 6)	0% (n = 0)
WMC[a] Faculty	7	14% (n = 1)	57% (n = 4)
Medical Students	6	17% (n = 1)	83% (n = 5)
Totals	**38**	**34% (n = 13)**	**53% (n = 20)**

[a]Weight Management Center

a. Focus Groups. Questionnaire length and the time burden required to complete the survey were the most consistent concerns cited across focus groups. Prior to dietary validation, we reduced questionnaire length by 10 items and reduced the average time required to take the questionnaire from approximately 20 minutes to 10-15 minutes. Sample portion size images also were added to MagQuest based on focus group feedback. (See Figure 1.) Question order also was revised for better clarity based on feedback.

b. Dietary Validation. Estimated Mg intake based on the dietary MagQuest questions and the DHQ-II were significantly positively correlated (Pearson's r = 0.617,p < 0.01), indicating a good correlation. Examination of the individual data indicated that 4 volunteers were estimated to have a low MagQuest estimate relative to their DHQ-II estimate, while 4 different volunteers had a low DHQ-II estimate relative to their MagQuest estimate. When comparing their responses to corresponding food items on both surveys, differences were consistently noted in responses to "greens" consumption for the relatively low MagQuest cohort, while consistent differences in responses to "nut" consumption were noteworthy for the low DHQ cohort. Adjustments were made to the MagQuest estimates, based on the amount of Mg that would have been added to the daily intake estimate if all of the corresponding MagQuest and DHQ-II food items had been answered identically. After substituting in these corrections, Pearson's correlation coefficient for the entire sample rose to r = 0.766 (p < 0.01), a strong correlation.

Discussion

In the focus group that reported least likelihood to use this instrument in practice, a primary concern was the desire to see scientific evidence supporting the need for clinical screening for Mg status, and whether a serum Mg test would provide more useful information. Serum Mg, unfortunately, is an imperfect marker of total Mg status and current reference ranges are rooted in outdated information[12]. To allay this concern, the text introduction for MagQuest is being expanded to provide information on the national shortfall status of Mg as well as a short overview of the medical reasons for concern about Mg status. Clinicians also will receive information about next steps if Mg status for a given patient is below threshold.

This tool has been designed to assist clinicians providing primary care in identifying patients who might be at risk of Mg deficiency. Next steps include updating the FFQ prior to any further data collection and validating the non-dietary items against a biochemical measure of Mg status. We hope this tool will be used to raise awareness of Mg's overlooked role in health and assist in collecting data that is currently lacking with regard to the role that Mg plays in disease pathogenesis.

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