Nutrition education on obesity and diabetes to medical students

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Abstract

It is important for medical students to understand the relationship between nutrition, obesity, and diabetes to educate their patients in the future. However, medical training does not always include nutritional education. An experiential learning project was incorporated into the medical school curriculum as an effort to implement nutrition in the physiology course. First-year medical students (n = 140) received lectures on the regulation of blood glucose levels and their relationship to carbohydrates with different glycemic indexes (GI), obesity, and diabetes. Lectures were followed by a laboratory exercise where students calculated their body mass index (BMI), percentage body fat, and percentage muscle using a Bioelectrical Impedance Commercial Scale. While 63% of students had normal BMI, 31% were overweight or obese and 5% were underweight. A subgroup of 54 students tested different types of breakfasts with varying GI and provided blood samples at 0, 30, 60, 90, and 120 min. Their glucose responses were plotted based on the breakfast GI. Pre- and posttests were conducted to assess the teaching intervention where the Wilcoxon signed ranks test indicated that posttest ranks were significantly higher than pretest ranks (Z = −6.6, P < 0.001), suggesting the intervention was beneficial to students.

blood glucose regulation; glycemic index; medical education

INTRODUCTION

It is essential for medical students to be educated on the importance of nutrition. Traditionally, students in the physiology course learn about the relationship between blood glucose concentrations and insulin secretion through lectures and in some instances a laboratory exercise of a cookbook style (1). Experiential learning would be beneficial in engaging students while teaching the physiology of the regulation of blood glucose levels (2). A laboratory report by Tarnus and Bourdon (3) serves as an example of how experiencing blood glucose measurements helped students examine the influence of food on glycemias.

Obesity is the result of an energy imbalance where calories taken in from food exceed those used; thus excess calories are stored as fat (4). Unfortunately, obesity affects people of all ages and ethnicities. A steady increase in the incidence of obesity in the last two decades is due in part to the consumption of highly processed food. Dietary patterns may provide insights into the influence of nourishment on overweight and obesity such as body mass index (BMI) changes over time (5, 6).

Diabetes is highly prevalent in Mexico where 15.2% of adults suffer from Type 2 diabetes (7). Approximately 90% of diabetes cases can be attributed to being overweight or obese (8). Due to its high prevalence, obesity is now considered an epidemic in Mexico, where 71% of the adult population and 35% of teenagers are either overweight or obese (8). Furthermore, the number of overweight and obese adults is predicted to increase to 88% by the year 2050 (9). Thus it is important for medical students to understand the relationship between obesity, nutrition, and diabetes. Guidelines from the Mexican Ministry of Health state that people with abnormal fasting glucose and/or glucose intolerance are advocated nonpharmacological interventions such as diet and exercise first where a reduction in caloric intake of refined carbohydrates and saturated fat is highly recommended (10). Although the Mexican Ministry of Health promotes a healthy diet, medical training does not always include nutritional education; this is also true in other countries such as the United States (11). Efforts are being made by educators to implement nutrition education in the medical school curriculum so that the students are self-aware and will guide patients regarding healthy dietary choices (12, 13). The goal is for healthcare providers to lead by example concerning diet, as was the case when medical professionals abandoned smoking in the 1970s (11). The purpose of this study was to educate medical students on the importance of nutrition in relation to obesity and diabetes. Students were introduced to the classification of carbohydrates using the glycemic index (GI). Carbohydrates that are quickly digested such as donuts produce large changes in blood glucose levels and thus are classified as high-GI food. On the other hand,
carbohydrates that are digested slowly, such as legumes, are classified as low-GI food. In obese subjects, high-GI food can cause hormonal and metabolic changes that, in turn, lead to overeating and promote obesity (14). This study incorporated an experiential laboratory activity where the medical students tested how low-, medium-, and high-GI food influenced plasma glucose concentrations. An increase in knowledge was anticipated through this intervention related to nutrition exercise in the physiology laboratory.

**MATERIALS AND METHODS**

**Study Design**

A quasiexperimental design with a pre- and a posttest was used to teach first-year medical students about the importance of nutrition in connection with obesity and diabetes. A laboratory exercise was incorporated as an educational intervention where the medical students tested how low-, medium-, and high-GI food influenced plasma glucose concentrations. An increase in knowledge was anticipated through this intervention related to nutrition exercise in the physiology laboratory.

**Participants**

One-hundred and forty students taking the physiology course during their first year of the medical school participated in lectures and laboratory exercises. The composition was a mix of 60 male and 80 female students who were local Mexican subjects with very little racial/ethnic diversity. This study was approved by the Southern Illinois University Edwardsville’s Institutional Research Board (Protocol No. 714).

The introduction of concepts concerning blood glucose regulation, insulin secretion, GI, and disease mechanisms of obesity and diabetes occurred using a combination of online and in-class activities and a laboratory exercise. Students’ knowledge of the topics introduced was assessed using pre- and posttests as well as a laboratory report.

**Laboratory Protocol**

The laboratory protocol was adapted from a laboratory report by Tarnus and Bourdon (3). Fifty-four students were divided into three groups (see Table 1). Each group was served a different breakfast. Each student was served only one portion (size of the portion included in Table 2). The breakfasts tested were representative of classic meals these students would have eaten at home or at the university cafeteria.

The portion size, the GI values obtained from the published international tables (15), and approximate caloric intake are shown in Table 2. The breakfast GI was calculated by dividing the grams of carbohydrate (CHO) in each food by the total grams of CHO and multiplying this by the GI value. The sum of all components gives the breakfast GI. For example: for cereal and milk, GI = [(26/38 × 69) + (12/38 × 27) = 47.2 + 8.5 = 56.

All 140 students participated in the laboratory by obtaining their body measurements such as height, weight, percentage body fat, and percentage muscle. These measurements were estimated using a Bioelectrical Impedance Commercial Scale (WS 90; Microlife, Inc., Clearwater, FL). In addition, a group of 54 volunteers completed a survey that gathered information such as their age, gender, eating habits, and exercise habits on a weekly basis. The survey also collected information regarding any family members with diabetes. Students who volunteered were asked to fast for 8 h before the experiment. After blood sampling at time 0, the participants were given breakfast and blood sampling continued every 30 min for 2 h. Thus there were a total of five blood samples per participant at

| Table 1. Study timeline |
|------------------------|
| **Length of Intervention** | **Activity** | **Number of Students** |
| Day 1 | Pretest | 136 |
| Day 2 | Lecture | 140 |
| Day 3 | Lecture | 140 |
| Day 4 | Lab: High-GI breakfast, Health questionnaire, BMI calculations, Blood samples | 18 students |
| Day 5 | Laboratory: Medium-GI breakfast, Health questionnaire, BMI calculations, Blood samples | 18 students |
| Day 6 | Laboratory: Low-GI breakfast, Health questionnaire, BMI calculations, Blood samples | 18 students |
| Day 7 | Lab: No breakfast, Blood glucose measurements | 29 students |
| Day 7 | Lab: No breakfast, Blood glucose measurements | 29 students |
| Day 7 | Lab: No breakfast, Blood glucose measurements | 28 students |

BMI, body mass index; GI, glycemic index.

| Table 2. Types of breakfasts, portion sizes, caloric intake, and calculated GI of the meals |
|---------------------------------|
| **Available CHO** | **Food GI** | **Breakfast GI** | **Total Calories** |
| Baguette | 22.5 | 95 | 61 | 411 |
| Black beans | 12.5 | 20 | 7 | 35 |
| Total | 35 | 68 | |
| Cereal | 26 | 69 | 47.2 | 252 |
| Milk | 12 | 27 | 8.5 | |
| Total | 38 | 56 | |
| Yogurt | 5 | 36 | 11.2 | 150 |
| Apple | 8 | 39 | 19.5 | |
| Cantaloupe | 3 | 65 | 12.2 | |
| Total | 16 | 43 | |

GI, glycemic index; CHO, carbohydrates.
RESULTS

Health Awareness

Students calculated their BMI using the data collected in the laboratory. Although 63% of the student population \( n = 140 \) had a BMI within the normal range, a large percentage of the students were overweight or obese with BMI values \( >25 \) (Fig. 1).

Data from the health questionnaire were completed by 54 volunteers (Table 3). A large percentage (78%) of the students had relatives with diabetes. Also, the large majority had poor health habits and 65% of the students reported weight gain within 1 yr.

Blood Glucose Monitoring

Blood samples from 54 volunteers were collected immediately before and after eating breakfasts with different glycemic loads to assess the impact of diet on blood glucose. Students were informed to plot their results and contrast the curves obtained on days 4, 5, and 6 from each group of volunteers. Their results are shown in Fig. 2. Figure 2A shows average glucose tolerance curves from three breakfast groups. Contingency analysis was performed to show that neither the gender, nor the BMI, nor the interactions between groups, gender, and BMI were factors. Therefore, modeling suggested that the only factor at 30, 60, and 90 min defining glucose levels was the breakfast type. Figure 2B shows that the area under the curve (AUC) correlates with the GI calculated for each breakfast type.

Student Responses

At the end of the study, the results were shared with the students and a few of their responses as recorded in their laboratory reports are shown in Table 4.

Learning Assessment

Out of a total of 140 students, 136 students completed the pretest and 114 students completed the posttest (76%). Some of the surveys were incomplete, and therefore, the total of completed surveys were 107 which were paired to assess the impact of the educational intervention.

The number of students that answered each question correctly during their pre- and posttests was plotted (Fig. 3). There was a total of 21 questions in both the pre- and posttests. Positive gains were calculated using the following formula: \( G = (\text{postassessment} - \text{preassessment})/(100\% - \text{preassessment}) \), where preassessment was the percent correct on pretest and postassessment was the percent correct on the posttest. These numbers reflected the possible percentage points the whole group could have gained from the pre- to postassessment. Overall, 18 questions showed a learning gain with 12 questions having a significant gain (0.21–0.66). For questions about metabolism, the students showed significant gains in all except one question (0.27–0.57). Questions related to diabetes showed gains (0.21–0.4) in all but one
The dispersion was similar in both sets of data. To determine the increase in student learning (Fig. 4, bottom right) the posttest showed a greater number of correct answers. Wilcoxon signed ranks test, a nonparametric alternative to the paired sample t test was used. The analysis indicated that posttest ranks were significantly higher than the pretest ranks (W = 494.5, Z = –6.60, P < 0.001). A nontreatment control group is not incorporated in this study because we could not exclude students from lectures and the physiology laboratory.

**DISCUSSION**

A sedentary lifestyle, a high intake of energy-dense food, and a large intake of soft drinks promote weight gain and the development of Type 2 diabetes (18, 19). To sustain a healthy lifestyle, a person should maintain a BMI in the range of 18.5 to 24.9 and avoid gaining more than 5 kg during adulthood (19). Thus the knowledge of healthy eating and exercise is crucial to achieving a healthy lifestyle.

It is important for medical students to recognize the association between lifestyle and chronic diseases since physicians should discuss these topics with their patients (20). However, in this study, 31% of medical students were overweight or obese and as many as 61% did not exercise and reported gaining an average of 2 kg within the past year. Moreover, 78% had a family history of diabetes. This is a major concern since a BMI equal to or >30 represents a risk factor for Type 2 diabetes. Individuals with a BMI >35 are 20 times more likely to develop diabetes within the next 10 yr.

**Table 4. Samples of student responses from the laboratory reports**

| Questions                                                                 | Notes                                                                 |
|---------------------------------------------------------------------------|----------------------------------------------------------------------|
| Question about complications of diabetes.                                | This value (GI) is very important since it tells us how much blood glucose increases and how long it takes to do so after digesting food. The higher the glycemic index, the greater the ability to increase the level of glycemia in the blood. The GI is of great importance for people with diabetes since we must avoid rapid rises in blood glucose. With the observed data, we can conclude that the intake of foods with a lower glycemic index presents notable benefits over those with a high GI since it generates less drastic metabolic and hormonal changes, which makes it easier for glucose levels to return to basal levels, generating a greater feeling of satiety and in turn makes the absorption of nutrients faster; this could be of great clinical importance in diets for populations with obesity problems.
| Question about obesity had positive gains (0.39–0.5).                     | This value (IG) is very important since it tells us how much blood glucose increases and how long it takes to do so after digesting food. The higher the glycemic index, the greater the ability to increase the level of glycemia in the blood. The GI is of great importance for people with diabetes since we must avoid rapid rises in blood glucose. With the observed data, we can conclude that the intake of foods with a lower glycemic index presents notable benefits over those with a high GI since it generates less drastic metabolic and hormonal changes, which makes it easier for glucose levels to return to basal levels, generating a greater feeling of satiety and in turn makes the absorption of nutrients faster; this could be of great clinical importance in diets for populations with obesity problems.
| Questions about GI, the largest gain (0.66) observed was about the definition of GI. Only three questions showed a negative gain. | Question about weight maintenance and GI showed a positive gain in the posttest but was answered by very few students. |
| Questions about obesity had positive gains (0.39–0.5).                     | Question about weight maintenance and GI showed a positive gain in the posttest but was answered by very few students. |

**Figure 2.** Blood glucose levels of 3 groups of 18 student volunteers at 0, 30, 60, 90, and 120 min after ingesting a breakfast of high-, medium-, and low-glycemic index (GI); n = 54. A: glucose tolerance curves using means ± SD values. B: area under the curve (AUC) was calculated for each group and plotted against the calculated GI for each breakfast.
A genome-wide association study has found that ~25% of Mexicans carry a haplotype that increases the risk of Type 2 diabetes at lower BMI values (22, 23). More recently, it has been shown that obesity and diabetes increase mortality in Mexican COVID-19 patients (24). Thus it is important to help medical students become aware of their health, level of fitness, and nutritional choices. At the University of Cambridge, the School of Clinical Medicine has introduced nutrition teaching within the preclinical and clinical years through the medical nutrition education initiative. According to this initiative, some nutrition concepts can be added to the biochemistry and physiology courses (25).

In this study, the students learned to calculate the BMI to estimate the rate of overweight and obesity among themselves as well as the risks associated with those conditions and Type 2 diabetes. Our results suggest that experiential learning in the laboratory can contextualize carbohydrate metabolism and help students learn about metabolic diseases like obesity and diabetes. Since carbohydrates are the macronutrients with the greatest impact on glucose levels, we used this particular nutrient to demonstrate how low GI carbohydrates can help limit hyperglycemia (Fig. 2A). The amount of carbohydrate together with GI accounts for ~90% of the variability in glucose and insulin responses (26). However, this is true for single foods. For mixed meals that vary in energy from 1,650 up to 2,550 kJ, the amount of carbohydrate alone is not significantly related to glucose and insulin responses (27). Furthermore, in mixed meals, the type of carbohydrate rather than protein or fat is the primary determinant of postprandial glucose levels. Our analysis showed a direct correlation between the glucose response (measured by AUC) and the calculated GI of the meal (Fig. 2B) although the caloric intake was not the same for the different breakfasts. In an accompanying laboratory report, some of the students correctly concluded that low-GI meals could help prevent complications of diabetes. Such knowledge is important for medical students since a meta-analysis of 14 randomized controlled trials suggested that carbohydrates with low GI decrease hemoglobin A1c (HbA1c test) in patients with diabetes (28). In addition, the Diabetes Canada Clinical Practice Guidelines Expert Committee recommends replacing high GI carbohydrates with low GI carbohydrates in meals for people with Type 1 and Type 2 diabetes (29). Thus we believe that nutrition education intervention will aid the students when they start their clinical courses and learn about the management of patients with diabetes and obesity.
Our results, where 12 out of 21 questions showed learning gains between 21 to 66% in the posttest, suggest that an experiential laboratory exercise combined with traditional lectures were successful. Furthermore, the average grade of the class increased from 6.0 to 6.9, almost 1 point (in the Mexican system the scale goes from 0–10, with 6 being a passing grade). Taken together, our data suggest that this teaching intervention was beneficial to students.

**Limitations of the Study**

The current study is a one-group quasiexperimental pre-and posttest design. The study was designed in this manner because it was conducted at a public university where there is only one group per academic year and we could not exclude students from this intervention. While planning the laboratory exercise, convenient sampling was used because students were allowed to volunteer for glycaemia measurements. Such an approach introduces volunteer bias. We recognize that a better experimental design should be a randomized control-group pretest, posttest design that can account for pretest sensitization and eliminate volunteer bias. However, given our teaching settings and the university rules, we were not able to implement such a design.

When the same test is taken by students the second time, recall of information could promote retention of information (30) and students may score higher on posttest questions (31) and students may score higher on posttest questions that appeared in the pretest (31). These results have been attributed to effects on memory and the subject focusing on questions that he or she does not know, which helps remedy these deficiencies in the pretest. Thus using the same questionnaire as pre- and posttest could make our intervention appear more effective than it is. However, a recent study shows that posttesting is better compared with pretesting on promoting retention after 7 days (32). Higher learning gains were observed when a pretest was used in combination with an educational intervention aimed to promote the acquisition of science concepts (33). In that study, the authors argue that “the sensitizing effect of a pretest concern the activation of prior knowledge that facilitates the next learning of new knowledge. From an educational perspective, pretesting is not a problem but an opportunity…” (33). Here, the number of correct answers in the posttest increased by 78 students, did not change in 13 students, and decreased among 16 students. Based on these results, we presume that our intervention was successful for most students and that pretest sensitization is possible but was not determined due to the quasiexperimental nature of the study. Therefore, it is likely that the pretest helped students retain information and prompted them about material to be learned, potentiating perhaps their experiential learning. More research is needed to collect evidence in favor of this idea.

In conclusion, this study serves as an example in educating medical students learn the relationship between nutrition and blood glucose levels while engaging in active learning of the basic concepts. The hands-on experience and knowledge are expected to help students connect the adverse effects of nutrition with the development of obesity and Type 2 diabetes.

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**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the authors.

**AUTHOR CONTRIBUTIONS**

P.P.-C and C.G. conceived and designed research; P.P.-C, N.E., C.-F., and M.L.G.-H. performed experiments; P.P.-C. analyzed data; P.P.-C and C.G. interpreted results of experiments; P.P.-C prepared figures; P.P.-C and C.G. drafted manuscript; P.P.-C and C.G. edited and revised manuscript; P.P.-C and C.G. approved final version of manuscript.

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