Development of a Spanish Food Exchange List: Application of Statistical Criteria to a Rationale Procedure

THE FOOD EXCHANGE LISTS ARE groups of weighed foods that approximately contribute the same macronutrient value. Within each food list, one exchange is approximately equal to another in the three macronutrients (carbohydrates, proteins, and fats), and they can be exchanged in meal planning without significant differences in dietary intakes of patients. Food lists can be used in individualized dietetic planning or nutrition education.

The food exchange lists have been used during the last 60 years. The first edition was published in 1950; it was developed by the American Dietetic Association, the American Diabetes Association, and the United States Public Health Service.[1] They were based on carbohydrate information published previously by Olmsted's group[2] and on work done by Caso and Stare.[3] These lists were unified to similar carbohydrate values, with the objective of providing information useful for diabetic patients to control the amount of carbohydrates ingested throughout the day.[1] Since then, because of their usefulness, practitioners in nutrition and dietetics have been using them in menu planning and nutritional education of patients, especially those with metabolic diseases such as diabetes or overweight or obesity.

Since then, the American exchange lists have been updated several times. The first edition was reviewed in 1976, and groups of foods were unified to the three macronutrients and energy, to be used in menu planning and nutritional education of both healthy and diseased patients. This undocumented edition was reviewed in 1979 by Wyse in a work that compared the mean composition values of foods in each list with published values for energy, carbohydrates, proteins, and fats, showing a good adjustment in all of the groups except milk and dairy, which required a differentiation in subgroups according to their amounts of fat.[4] In 1986, the exchange lists were again updated, and a specifically prepared database with averages was published.[5] This database was updated in the 1995 exchange lists revision, establishing important statistical parameters for the use of the exchange system (average, standard deviation [SD], and range for energy and macronutrients for each group).[6] Also, this document included general recommendations to make diets by a system of exchanges, to design food exchange lists, and to convert into exchanges the nutrition facts from food labels and recipes. For the 2003 edition, the database was again updated, and new exchange lists were edited, including exchanges of raw and cooked foods, frozen and canned foods, prepared dishes, and fast foods, all expressed in grams and in household measures.[7]

After the American efforts to make and update the food exchange lists, many countries worked to design their own tables of exchanges based on traditional dishes[8,9] or to be used in the development of meal planning for healthy individuals[10] or for those with diabetes,[11-13] cardiovascular diseases,[14,15] weight problems,[12,16] or advanced chronic kidney disease.[17,18]

In Spain, some exchanges lists have been published for the intended purpose of dietetic planning in chronic diseases. They have been arranged according to one macronutrient value—carbohydrates for patients with diabetes, proteins for kidney diseases, and lipids for cardiovascular diseases[19-21]—or to energy value for obesity control.[19] Nevertheless, they could be improved. Foods on the same list contribute approximately the same amount of a macronutrient but different amounts of other macronutrients and energy, affecting the total caloric value of the diet. In Spain, exchange lists needed to be developed and arranged according to the three values of macronutrients and energy to be used in the implementation of meal plans and food education of patients. In addition, these published lists include amounts of foods that are not equivalent to household measures commonly used (eg, 70 g yogurt is not adjustable to a commercial single-serve container of 125 g). New food exchange lists needed to include, whenever possible, Spanish standard food measures.

The aim of this project was to design and validate the first Spanish food exchange lists arranged according to macronutrient and energy values, whose items correspond to common foods in Spanish meal plans expressed in amounts in grams that could be easily adjusted to Spanish household measures (ie, spoons, dishes, commercial units, cups).

METHODOLOGY BASIS

The research underpinnings of this food exchange system had four phases: (1) selection of foods to be included in Spanish lists; (2) study of the

*This article was written by **Iva Marques-Lopes***, PhD, RD, and **Susana Menal-Puey***, PhD, lecturers of nutrition and dietetics, Faculty of Health and Sport Sciences, University of Zaragoza, Huesca, Spain; **J. Alfredo Martínez,** MD, PhD, professor of food science and nutrition, Department of Nutrition, Food Science and Physiology, Faculty of Pharmacy, University of Navarra, Pamplona, Spain; and **Giuseppe Russolillo,** PhD, RD, president, Spanish Academy of Nutrition and Dietetics, Pamplona, Spain.*

**Both authors share equal authorship of this article.*

http://dx.doi.org/10.1016/j.jand.2017.04.010
Available online 2 June 2017

nutritional composition per 100 g edible portion of selected foods, to define the food groups based on the predominant nutrient; (3) definition of the amounts in grams of each food whose specific macronutrient and energy values were similar within each group, according to statistical criteria and to Spanish household measures; and (4) determination of the mean energy and macronutrients values of each exchange list, according to rounding established criteria.

Phases 1 and 2

Foods chosen to be in the exchange lists are those typical of the culinary and gastronomic customs, both those of Spanish origin and those coming from other countries, that are included in the eating habits of the Spanish population.

The selection of foods and the study of their nutritional composition were made from a national food composition database,[22] and preliminary food groups were defined on the basis of the main nutrient (carbohydrates, fats, proteins, sugars, or vitamins and minerals).

Phase 3

Once preliminary groups were defined, the amount of each food that could be exchanged with any other food in the same group, without significant differences in nutritive values, was determined. In this way, different amounts of each food were introduced in calibration software,[22] and main macronutrient values of each one were compared, to verify the most appropriate amount for matching lists. After this unification, secondary macronutrients and energy contents were matched. In all of the cases, the amounts in grams tested were established according to the Spanish culinary and dietetic practices, which corresponded to food portions recommended in Spanish dietary guidelines[23] (eg, 200 to 250 g milk) or, absent such portion values, to habitual food portions of consumption (eg, 10 g sugar), or to small amounts deliberately established to be easily convertible into small or large recommended portions (eg, 30 g meat). Also, whenever possible, the amounts in grams tested should be convertible into Spanish household measures. Figure 1 shows the criteria to select the weight portions introduced in the calibration software.

The amounts of foods that satisfied statistical criteria for all of the macronutrients were incorporated in the exchange lists. We considered the recommended values of SD used by Wheeler and colleagues[6] in exchanges lists. If values of SD were outside the limits, foods with greater deviation were removed from the list and located in another appropriate group to match groups. Once the SD was adjusted, the coefficient of variation (CV) was also studied, aiming for values less than 30%. For groups with higher values of CV, the z-value for each food was calculated, establishing as criteria z-values between ± 2, to eliminate foods with high variations. Statistical criteria proposed to match values within each group are shown in Table 1.

Phase 4

The macronutrient values of each exchange group corresponded to the mean amount in grams of the foods listed in each group and were subjected to rounding. Values were rounded down for decimals less than 0.49 and rounded up for decimals higher than or equal to 0.5, as long as the z-value of the exchange value against the mean value was between ± 1. If the z-value was outside the limits, a new rounding was necessary until the established criteria were met.

The energy value of each exchange group was calculated by multiplying the content of proteins, fats, and carbohydrates assigned to each exchange list by the Atwater factors.

FINDINGS

Selection of Foods and Recompilation of Nutritional Composition

A total of 299 foods were selected. After a study of centesimal composition, they were classified in groups according to the predominant nutrient: (1) grains, potatoes, and legumes as foods containing primarily carbohydrates; (2) meat, fish, eggs, and meat products as the rich protein group; (3) oils, butters, and nuts as foods with mainly lipids; (4) milk and dairy products as calcium-rich products; (5) fruits and vegetables as important sources of vitamins and minerals; and (6) added sugars as the sugars group.

Establishment of Food Exchanges and Definition of Food Groups According to Statistical Criteria

After studying the content of other nutrients in the amounts of foods tested, the general food groupings were divided into subgroups, according to the different content in secondary nutrients of foods. In this way, legumes were considered as a subgroup of the carbohydrate group because of the extra protein contribution (4.4 g more per exchange) instead of rice, pasta, or bread. The incorporation of confectionary into the carbohydrate group provided large SD in fats values, so a subgroup of pastries and other sweet desserts was defined. The protein foods list was divided into five groups (very lean products, lean products, medium-fat products, high-fat products, and very-high-fat products) based on the different amount of fats observed in the food amounts tested (0.08 to 16.08 g). In relation to fatty foods, although all of the amounts tested contributed about the same amount of fat (5 g), some subgroups were defined by the different lipid profiles (rich in polyunsaturated fatty acids, monounsaturated fatty acids, saturated fatty acids, and others) to recommend the presence of those rich in unsaturated fats. Also, milk and dairy were classified into fat, low-fat, nonfat, sweetened desserts, and dairy desserts, because of the different sugar and fat content in the amounts tested (7.5 to 23 g sugars, 0.25 to 9.45 g fats). Cheeses were removed from this group and located in the protein group because of the similar content of protein (4.8 to 9.7 g) and fat (0.16 to 11.9 g) per exchange. Because of the different carbohydrate contents of fruits (10.8 to 21.1 g) and vegetables (0.75 to 7.35 g), they were considered separately.

The definitive food groups and subgroups and a summary of the exchanges proposed for the more representative foods of each are presented in Table 2. The food exchanges were defined in grams and in household measures and were referred to as raw and net weight, and, when