Perspectives in Practice

Development of the Healthy Eating Index-2005

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ABSTRACT

The Healthy Eating Index (HEI) is a measure of diet quality as specified by Federal dietary guidance, and publication of the *Dietary Guidelines for Americans 2005* necessitated its revision. An interagency working group based the HEI-2005 on the food patterns found in MyPyramid. Diets that meet the least restrictive of the food-group recommendations, expressed on a per 1,000 calorie basis, receive maximum scores for the nine adequacy components of the index: total fruit (5 points), whole fruit (5 points), total vegetables (5 points), dark green and orange vegetables and legumes (5 points), total grains (5 points), whole grains (5 points), milk (10 points), meat and beans (10 points), and oils (10 points). Lesser amounts are prorated linearly. Population probability densities were examined when setting the standards for minimum and maximum scores for the three moderation components: saturated fat (10 points), sodium (10 points), and calories from solid fats, alcoholic beverages (ie, beer, wine, and distilled spirits), and added sugars (20 points). Calories from solid fats, alcoholic beverages, and added sugars is a proxy for the discretionary calorie allowance. The 2005 Dietary Guideline for saturated fat and the Adequate Intake and Tolerable Upper Intake Level for sodium, expressed per 1,000 calories, were used when setting the standards for those components. Intakes between the maximum and minimum standards are prorated. The HEI-2005 is a measure of diet quality as described by the key diet-related recommendations of the 2005 Dietary Guidelines. It has a variety of potential uses, including monitoring the diet quality of the US population and subpopulations, evaluation of interventions, and research.

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The *Dietary Guidelines for Americans 2005* are the basis of nutrition policy for the United States Government and the foundation of all Federal nutrition guidance (1). The Dietary Guidelines are revised every 5 years by the United States Departments of Agriculture (USDA) and Health and Human Services.

In 1995, the USDA Center for Nutrition Policy and Promotion released a Healthy Eating Index (HEI), which measured diet quality in terms of compliance with Federal dietary guidance (2,3). The original HEI (Table 1) and minor updates to it are described in detail elsewhere (4-7).

Publication of the 2005 Dietary Guidelines necessitated a revision of the HEI because of the increased emphasis on important aspects of diet quality, such as whole grains, various types of vegetables, specific types of fat, and the introduction of the new concept of "discretionary calories." Therefore, the goal set for this revision of the HEI was to develop a tool that measures diet quality in terms of compliance with the key diet-related recommendations of the 2005 Dietary Guidelines.

The purposes of this article are to describe the development of the revised HEI, which is called the HEI-2005, and its strengths, limitations, and potential applications. An evaluation of the validity and reliability of the HEI-2005 is presented in a companion article (8).

METHODS

An interagency working group reviewed the original HEI and its uses and decided to base the revised index on the food patterns found in USDA's food guidance system, MyPyramid. MyPyramid translates key recommendations in the 2005 Dietary Guidelines into specific, quantified dietary recommendations (9). Dietary intake data from 8,650 respondents, who had provided complete and reliable data from one 24-hour dietary recall, in the National Health and Nutrition Examination Survey, 2001-2002 were used to develop standards for several of the components (10). Children younger than the age of 2 years and breast-fed children were excluded because the 2005 Dietary Guidelines were not designed to meet their needs. Pregnant and lactating women were excluded in accordance with practices for calculating original HEI population scores (5-7).

Recommended amounts of foods to consume found in the 12 MyPyramid food patterns and the Adequate Intake (AI) and Tolerable Upper Intake Levels (UL) for sodium were converted to densities, that is, amounts per 1,000 calories. The discretionary calorie allowances were converted to calories from solid fats, alcoholic beverages, and added sugars, and, along with saturated fat, were expressed as percentages of total calories. Probability densities for 1-day intakes of sodium per 1,000 calories, percentage of calories from saturated fat, and percentage

Table 1. Original Healthy Eating Index (HEI) and Healthy Eating Index-2005 (HEI-2005) components and standards for scoring

Component	Score (points) 0	5	8	10	20
Original HEI					
Adequacy					
Total fruit	0 ←				→ 2-4 servings (approx. 1-2 cups[a])
Total vegetables	0 ←				→ 3-5 servings (approx. 1.5-2.5 cups[a])
Total grains	0 ←				→ 6-11 servings (approx. 6-11 oz eq[a])
Milk	0 ←				→ 2-3 servings (2-3 cups[b])
Meat (and beans)	0 ←				→ 2-3 servings (approx. 5.5-7.0 oz eq[a])
Variety	≤6 ←				→ ≥16 different foods in 3 days[c]
Moderation					
Sodium	≥4.8 ←				→ ≤2.4 g
Saturated fat	≥15 ←				→ ≤10% energy
Total fat	≥45 ←				→ ≤30% energy
Cholesterol	≥450 ←				→ ≤300 mg
HEI-2005					
Adequacy					
Total fruit[d]	0 ←				→ ≥0.8 cup eq/1,000 kcal
Whole fruit[e]	0 ←				→ ≥0.4 cup eq/1,000 kcal
Total vegetables[f]	0 ←				→ ≥1.1 cup eq/1,000 kcal
Dark green and orange vegetables and legumes[f]	0 ←				→ ≥0.4 cup eq/1,000 kcal
Total grains	0 ←				→ ≥3.0 oz eq/1,000 kcal
Whole grains	0 ←				→ ≥1.5 oz eq/1,000 kcal
Milk[g]	0 ←				→ ≥1.3 cup eq/1,000 kcal
Meat and beans[h]	0 ←				→ ≥2.5 oz eq/1,000 kcal
Oils[i]	0 ←				→ ≥12 g/1,000 kcal
Moderation					
Saturated fat	≥15 ←		10		→ 7% of energy
Sodium	≥2.0 ←		1.1		→ ≤0.7 g/1,000 kcal
Calories from solid fats, alcoholic beverages, and added sugars	≥50 ←				→ ≤20% of energy

[a]According to sex and age.
[b]According to age.
[c]In 1994-96 and 1999-2000, 8 or more different foods in 1 day.
[d]Includes 100% juice.
[e]Includes all forms except juice.
[f]Includes legumes only after meat and beans standard is met.
[g]Includes all milk products, such as fluid milk, yogurt and cheese, and soy beverages.
[h]Includes legumes only if the meat and beans standard is otherwise not met.
[i]Includes nonhydrogenated vegetable oils and oils in fish, nuts, and seeds.

of calories from solid fats, alcoholic beverages, and added sugars were estimated.

RESULTS AND DISCUSSION

Components of the Index

Because the recommendations found in MyPyramid were set to ensure adequate nutrient intake (9), the components of the HEI-2005 include all of the major food groups found in MyPyramid; that is, total fruit, total vegetables, total grains, milk, and meat and beans (Table 1). Additional components were created to represent whole fruit, because the 2005 Dietary Guidelines suggest that the majority of fruit intake should be whole fruit rather than fruit juice; dark green and orange vegetables and legumes, because those are the three subgroups of vegetables for which current intake is furthest from recommended levels; whole grains, because the 2005 Dietary Guidelines specify that at least half of grain intake should be whole; oils, because recommendations for oil are found in MyPyramid; and calories from solid fats, alcoholic beverages, and added sugars, which serves as a proxy for discretionary calories. The HEI-2005 also includes components for saturated fat and sodium to capture the 2005 Dietary Guidelines regarding them. Details and SAS code for creating HEI-2005 components are found at http://www.cnpp.usda.gov/HealthyEatingIndex-2005report.htm.

The components do not necessarily directly represent foods as eaten. For example, all components include foods that are ingredients in mixed foods. Whole grains include only the whole-grain portions of foods that contain both whole and refined grains. Only the lowest fat portions of milk and meat products are included in the milk and meat and beans components, respectively. The fatty portions of

Table 2. Recommended amounts of food groups, expressed per 1,000 kcal, and discretionary calorie allowances, expressed as a percentage of total calories, found in MyPyramid

	Calorie Level											
Food group	**1,000**	**1,200**	**1,400**	**1,600**	**1,800**	**2,000**	**2,200**	**2,400**	**2,600**	**2,800**	**3,000**	**3,200**
Fruits (cup eq/1,000 kcal)	1.0	0.8	1.1	0.9	0.8	1.0	0.9	0.8	0.8	0.9	0.8	0.8
Vegetables (cup eq/1,000 kcal)	1.0	1.3	1.1	1.2	1.4	1.3	1.4	1.3	1.4	1.3	1.3	1.3
Dark green vegetables	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Orange vegetables	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Legumes	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Starchy vegetables	0.2	0.3	0.3	0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4
Other vegetables	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.5	0.5
Grains (oz eq/1,000 kcal)	3.0	3.3	3.6	3.1	3.3	3.0	3.2	3.3	3.5	3.6	3.3	3.1
Whole grains	1.5	1.7	1.8	1.9	1.7	1.5	1.6	1.7	1.7	1.8	1.7	1.6
Other grains	1.5	1.7	1.8	1.3	1.7	1.5	1.6	1.7	1.7	1.8	1.7	1.6
Milk (cup eq/1,000 kcal)	2.0	1.7	1.4	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	0.9
Meat and Beans (oz eq/1,000 kcal)	2.0	2.5	2.9	3.1	2.8	2.8	2.7	2.7	2.5	2.5	2.3	2.2
Oils (g/1,000 kcal)	15.0	14.0	12.0	14.0	13.0	14.0	13.0	13.0	13.0	13.0	15.0	16.0
Discretionary calories (%)	16.5	14.3	12.2	8.3	10.8	13.4	13.2	15.1	15.8	15.2	17.1	20.3

NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

milk and meat products count as solid fat, whereas the fatty portions of fish, nuts, and seeds count as oils, as do nonhydrogenated vegetable oils. Alcoholic beverages includes beer, wine, and distilled spirits consumed as beverages, but not as ingredients in mixed dishes.

Standards for Scoring Adequacy Components

In MyPyramid, recommendations for the amounts of food groups, oils, and discretionary calories are expressed in terms of absolute amounts (9); however, on a density basis, many of the recommendations are similar across energy levels (Table 2). Therefore, in the HEI-2005, intakes of foods and nutrients are assessed on a density basis, that is, as a ratio to energy intake. The nutrient adequacy components (food groups and oils) were based on the 1,200- to 2,400-calorie patterns, which meet the recommended nutrient intakes of nearly everyone. They meet the needs of people who have higher energy requirements because the higher-calorie patterns had the same nutrient goals (9). The 1,000-calorie pattern was not used because it is aimed at only 2- to 3-year-olds, whose recommended nutrient intakes are lower than the rest of the population, even when expressed on a density basis. Among the 1,200- to 2,400-calorie patterns, the lowest amount per 1,000 calories (ie, the least restrictive or easiest to achieve) was selected as the standard for the maximum score for each of these components.

For dark green vegetables, orange vegetables, and legumes, the standard is the sum of the weekly recommendations for those three subgroups of vegetables, expressed on a per 1,000-calorie basis. Any combination of them counts toward meeting the vegetable subgroup standard, except that legumes are counted as vegetables only after the meat and beans standard has been met (11).

For all the components, intakes at the level of the standard or better are assigned the maximum number of total points allotted (5, 10, or 20 points) (Table 1). Scoring the adequacy components is straightforward because there is a logical score of zero for no intake and the scores increase as intakes increase up to the standard. Scores for amounts between zero and the standard are prorated linearly.

Standards for Scoring Moderation Components

In the 2005 Dietary Guidelines, the recommendation for saturated fat is not expressed as a single value, but rather as "*less than* 10% of energy intake." The 2005 Dietary Guidelines highlight two exemplary food guides as being consistent with its guidance, MyPyramid, developed by the USDA Center for Nutrition Policy and Promotion, and the Dietary Approaches to Stop Hypertension (DASH) Eating Plan, developed by the National Heart, Lung, and Blood Institute. The examples of these guides in the 2005 Dietary Guidelines have saturated fat levels of 7% to 8% of energy (1). Both the Dietary Guidelines Advisory Committee and the Institute of Medicine have recommended that saturated fat consumption be as low as possible, suggesting that lower is better (12,13). The DASH plan aims for 7%, and the 2006 American Heart Association guidelines call for "7% or less" (14). Based on these sources, 7% of calories was chosen as the standard for the maximum score of 10 for the saturated fat component. The 2005 Dietary Guideline is recognized by assigning a score of 8, which, by convention, had indicated a good score, to the level of 10% of calories, which does not, however, represent an optimal intake level.

For the moderation components, it is less clear where to assign a zero score than it is for the adequacy components because *increasing* levels of intake get *decreasing* scores. This reverse scoring for the moderation components has no obvious mathematical equivalent to the zero for the adequacy components, and no scientific evidence clearly specifies how high an intake deserves a score of zero. If a standard were to be set such that a large proportion of the population would get a score of zero, it would be difficult to detect differences among individuals and groups and changes over time at the low end of the scoring range. To

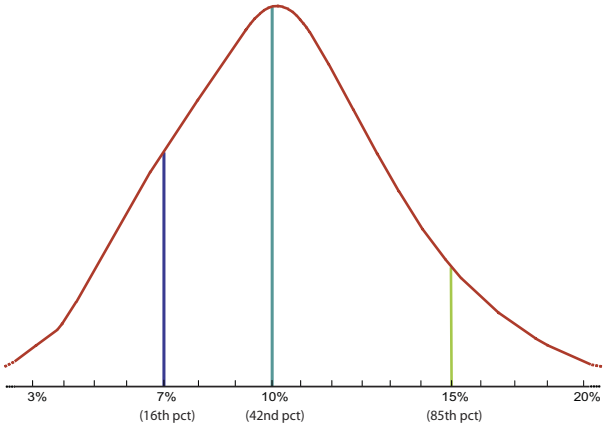

Figure 1. Distribution of 1-day saturated fat intake as a percentage of energy, United States, 2001-2002. NOTE: Information from this figure is available online at www.adajournal.org as part of a PowerPoint presentation.

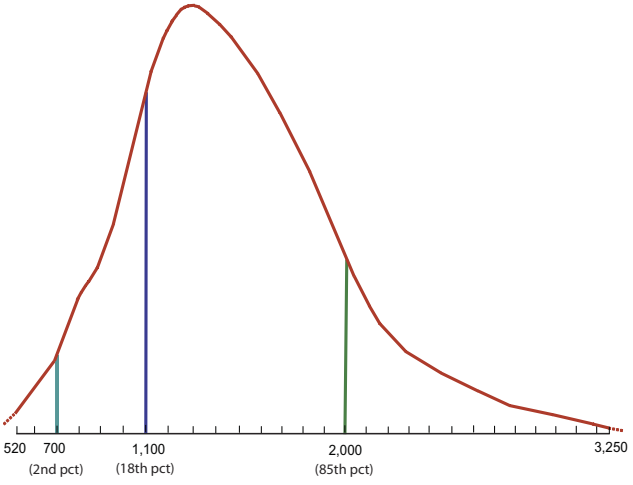

Figure 2. Distribution of 1-day sodium intake per 1,000 kcal energy, United States, 2001-2002.

mitigate this problem, a value at approximately the 85th percentile of the population distribution was selected as the standard.

Figure 1 presents the probability density of calories from saturated fat, expressed as a percentage of energy. In 2001-2002, 42% of 1-day intakes met the 2005 Dietary Guideline of 10% of calories from saturated fat or lower and 16% of intakes met the standard of 7% or lower of calories. At the other end of the distribution, 15% of intakes were at 15% of calories from saturated fat or higher. The minimum score of zero was set at that level. Amounts between 7% and 10% and between 10% and 15% are prorated linearly.

The 2005 Dietary Guidelines recommendation for sodium for most individuals is "less than 2,300 mg/day," but for individuals with hypertension, blacks, and middle-aged and older adults, the recommendation is "no more than 1,500 mg/day." These values represent the UL and AI, respectively, set by the Food and Nutrition Board (15). In light of these recommendations, 1,500 mg was chosen as the basis for the maximum score of 10, and 2,300 mg was chosen as the basis for the relatively good score of 8 for the sodium component because it does not represent an optimal intake level.

The sodium standard was set by using the approach used by the Institute of Medicine to set the Dietary Reference Intakes (DRIs) for older adults and children. The DRI panel divided the DRIs they had set for young and middle-aged adults by the estimated median energy intake for that age group (2,150 calories per day) and then used those same densities (milligrams of sodium per calorie) to set the DRIs for younger and older individuals. The density standards for the sodium component of the HEI-2005 were determined the same way. The highest possible score of 10 is assigned to diets that have <700 mg sodium per 1,000 calories (1,500 mg sodium [AI level]/2,150 calories), and a score of 8 is assigned to 1,100 mg of sodium per 1,000 calories (2,300 mg sodium [UL and 2005 Dietary Guidelines level]/2,150 calories).

The probability density of the population's 1-day intake of sodium per 1,000 calories is shown in Figure 2. The AI is the basis for the standard of 700 mg/1,000 calories for the maximum score; 2.5% of intakes are at that level or lower. The 2005 Dietary Guideline limit is recognized by giving a score of 8 to 2,300 mg, converted to a density of 1,100 mg/1,000 calories; 18% of 1-day intakes are at that level or lower. The minimum score was set at 2,000 mg of sodium per 1,000 calories because about 15% (17%) of 1-day intakes are at that level or higher. The amounts between 700 mg and 1,100 mg/1,000 calories and between 1,100 and 2,000 mg/1,000 calories are prorated linearly.

The 2005 Dietary Guidelines Advisory Committee introduced the concept of "discretionary calories," defined as the "difference between total energy requirements and the energy consumed to meet recommended nutrient intakes" (12). The 2005 Dietary Guidelines further explain that added fats or sugars per se are not directly limited. Rather, the discretionary calories allowance is a defined number of calories that may come from any mix of solid fat, added sugar, alcohol, or additional amounts of nutrient-rich foods beyond the recommended levels (1).

Nonetheless, the population generally consumes more calories from solid fats, added sugars, and/or alcoholic beverages than the allowance permits (16), so a component that specifically captured the calories from solid fats, alcoholic beverages, and added sugars was developed. This component is not intended to be a measure of solid fat, alcohol, and/or added sugar per se, but rather a measure of the calories in the diet that are obtained from dietary constituents other than nutrient-dense foods. The standard for the maximum score is the least restrictive, or easiest to achieve, of all the discretionary calorie allowances found in MyPyramid, 20% of calories (Table 2). For calories from solid fats, alcoholic beverages, and added sugars, about 10% of 1-day intakes were below the standard of 20% of calories, and 14% were above 50% of calories. The maximum score of 20 and the minimum of 0 were set at these levels, respectively. The amounts in between are prorated linearly.

Weighting of the HEI-2005 Total Score

The HEI-2005 components should be considered to be a set of scores that measure compliance with the many

different aspects of the 2005 Dietary Guidelines. When a single summation score is also needed, the HEI-2005 component scores can be weighted to derive a total HEI-2005 score. The maximum value of each component effectively serves as the weight; that is, the total score can be considered to be a weighted sum of the component scores.

Although the HEI-2005 weighting may seem arbitrary, it reflects the directive found in the 2005 Dietary Guidelines to take all the guidance as a whole. Therefore, most components of the HEI-2005 are weighted equally. Fruit, vegetables, and grains each have two components (total and a subgroup) that get 5 points each, so these three food groups effectively are allotted 10 points each. The one exception is calories from solid fats, alcoholic beverages, and added sugars, which is weighted twice as heavily as any other component (20 points), because 1) the 2005 Dietary Guidelines encourage the selection of "low-fat forms of foods in each food group and forms free of added sugar," and 2) solid fats, alcoholic beverages, and added sugars may displace nutrient-dense foods in the diet, add energy without adding nutrients, and are currently consumed in amounts that far exceed the discretionary calorie allowances (16).

Implications of Truncated Scores

The ability to detect meaningful changes over time or differences among groups at one point in time in the score is especially important when scores are truncated as they are in the HEI. Truncated scores may result in undesirable floor effects, when scores bunch at the low end (0) of the scale, or ceiling effects, when they bunch at the high end (5, 10, or 20, depending on the component). This point was addressed in two ways. First, the minimum score for saturated fat; sodium; and calories from solid fats, alcoholic beverages, and added sugars, was set at about the 85th percentile of the intake distribution. The scoring system was designed so that a large proportion of the population would not get a zero so that future changes in diets, however subtle, could be detected. Second, because the range of scores applied to each component is relatively large, each 1-point change or difference is indicative of a small change in intake. The ability of the HEI to detect changes and differences is determined not only by the scoring system, but also by the study sample size, the precision of the dietary assessment instrument, and the ability of the coding system to capture the dietary components of interest.

If the HEI were to be used with dietary data that represent observation periods longer than 1 day, such as might be collected with multiday food records or a food frequency questionnaire, the floor and ceiling effects would be mitigated. More days of intake data or estimates of usual intake would reduce within-person variance and result in fewer component scores at the minimum and maximum levels. However, the greater accuracy and precision of 24-hour recall data compared to, for example, what can be expected from a food frequency questionnaire, may well be of greater value than any concomitant loss of precision that may be attributable to a floor or ceiling effect in the distribution of the scores.

Strengths

The major strengths of the HEI-2005 are that it: 1) assesses diets on a per 1,000 calorie basis in order to characterize diet quality while controlling for diet quantity; 2) addresses the consumption of energy-dense, nutrient-poor foods and ingredients; and 3) emphasizes those aspects of the American diet that are furthest from current recommendations (1). The reliance on food-group rather than nutrient standards reflects a basic premise of the 2005 Dietary Guidelines, which is that nutrient needs should be met primarily through consuming foods. The HEI-2005 also is consistent with the assertion that the 2005 Dietary Guidelines are interrelated and mutually dependent and should be used together.

Density standards are useful not only because they allow common standards to be used, but also because they are independent of an individual's energy requirement, which is difficult to measure precisely. In effect, the density approach to setting standards uncouples diet quality from diet quantity by allowing the assessment of the quality of the mix of foods consumed, rather than the absolute amounts of foods consumed.

Limitations

The HEI-2005 does not apply to children younger than 2 years of age; its validity for specific ethnic and cultural groups whose dietary patterns are markedly different from the US norm remains to be determined (17); and it does not directly capture excess intake of the major food groups, oils, total fat, cholesterol, or *trans* fat. To reflect the 2005 Dietary Guidelines related to fat, the HEI-2005 has one component for saturated fat and one for oils from fish, nuts, and nonhydrogenated vegetable oils. Although several types of fat are mentioned in the 2005 Dietary Guidelines (total fat, saturated fat, *trans* fat, and cholesterol), limiting saturated fat is considered the most important because current intake is more excessive than that of *trans* fat or cholesterol (1). Separate components for total fat and cholesterol were considered to be unnecessary in the HEI-2005 because intakes of both are significantly correlated with saturated fat (0.92 and 0.59, respectively). The HEI-2005 also captures solid fats, which include hydrogenated vegetable oils. Solid fats are important sources of both *trans*-fatty acids and cholesterol. It would be very difficult to monitor intake of *trans* fats because the food industry is working to reduce their levels in the US food supply (18).

Because the food patterns in MyPyramid did not meet Recommended Dietary Allowances (RDAs) for vitamin E or AIs for potassium, a perfect score on the HEI may not ensure adequate intake of these nutrients to the same degree it does other nutrients. The recommendations in MyPyramid were set to meet the RDAs and AIs established by the Institute of Medicine. The RDAs are appropriate standards for MyPyramid because the patterns provide plans for individuals to follow to ensure nutrient adequacy (19). However, the RDAs are too high for assessment purposes, and standards analogous to the Estimated Average Requirements (EARs) would be more appropriate for use in the HEI. We cannot, however, set food-group–based standards that would provide average nutrient requirements until EARs are available for all nutrients of interest. Lacking EAR-based standards, we set the standards at the lowest level among the MyPyramid recommendations for sedentary individuals.

The density standards have limitations. The meat and beans and the milk recommendations in MyPyramid,

when expressed per 1,000 calories, vary more than the other food groups. Iron and calcium requirements are much higher for some age/sex groups who have relatively low energy requirements; therefore, iron and calcium requirements are generally inversely correlated with energy requirements. The discretionary calorie allowances also vary more than the food-group recommendations because energy and nutrient requirements are not well-correlated. For example, the lowest discretionary calorie allowance is found in the 1,600-calorie MyPyramid pattern and reflects the low energy but high nutrient needs of women. In contrast, the highest allowance, found at 3,200 calories, reflects the high energy needs and, in comparison to their energy needs, the relatively lower nutrient requirements of active teenage boys.

The choice of the least restrictive of the various MyPyramid food intake recommendations as the basis for the density standards led to the scores being higher than they might be otherwise. This means the scores are more specific, and less sensitive, when identifying intakes that do not meet recommendations. Nonetheless, except for total grains and meat and beans, very high component and total scores are quite rare. This suggests that, as a practical matter, choosing the least restrictive standard did not limit the range of scores appreciably.

CONCLUSIONS

The objectives for revision of the HEI have been met. The HEI-2005 is a tool that was designed to assess diet quality as described in the 2005 Dietary Guidelines and has a variety of potential uses. It is used by the USDA for population monitoring (20). Other potential uses include evaluation of menus and other diet plans, evaluation of nutrition interventions, epidemiologic research, economic research, and other types of research. HEI-2005 scores might also serve as a measure of nutrient density of diets as defined by the 2005 Dietary Guidelines because the food group components are all in their most nutrient-dense form—without added sugar or fat—and the calories from the solid fats, alcoholic beverages, and added sugars component of the HEI-2005 captures the foods and ingredients of foods that decrease the nutrient density of diets.

Possibilities for further research include adaptations of the HEI-2005 for specific subpopulations, such as Alaska Natives (17). Research is needed to determine the best statistical method for estimating HEI-2005 scores at the population level for nutrition-monitoring purposes.

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