Optimization design and evaluation of balanced dietary recipes for college students

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Abstract. University is a key stage for personal growth, development and establishment of lifelong eating habits. This study focuses on the optimization and evaluation of balanced daily dietary recipes for male and female college students. In this paper, a comprehensive assessment model was built based on five dimensions, including the number of food groups, total energy, protein, fat, carbohydrates, dietary fiber, and non-energy nutrients, and the results showed that both male and female students have a more varied dietary structure, but there are deficiencies in the intake of macronutrients and non-energy- producing nutrients, and there is a significant deficit of female students at the energy level. The daily recipe optimization model was constructed to provide a dual focus on nutritional quality and cost-effectiveness. As a result, when optimizing to balance amino acid scores with economy, the recipes achieved improved performance in both aspects, effectively managing dietary costs while ensuring nutritional balance. This study provides a scientific basis and practical recommendations for improving the dietary habits and nutritional health of college students, which can help improve their overall health and academic performance.

Keywords: Comprehensive evaluation, optimization model, data analysis, diet planning.

1. Introduction

The university period is a critical stage of individual growth and development and knowledge accumulation, as well as an important period for the formation of good eating habits. At this particular age, college students not only need sufficient energy and various nutrients to meet the needs of physical development, but also need sufficient nutrition to support heavy mental labor and a large amount of physical exercise. However, the current dietary structure of college students is generally irrational, such as skipping breakfast or poor breakfast quality, frequent consumption of takeaways and fast food, and individual students reduce the accumulation of subcutaneous fat by controlling their diets, thus leading to malnutrition and other problems. Acquiring certain nutritional knowledge and forming good dietary habits are of great significance to the growth and development and health of college students.

Nutritional characteristics of college students include high energy requirements, with a daily intake of 2,400 kcal for males and 1,900 kcal for females. Dietary macronutrient ratios should be 10-15% protein, 20-30% fat, and 50-65% carbohydrates. In order to meet the various nutritional requirements, the diet should contain five major food groups, with more than 12 types per day and more than 25 types per week. The energy distribution of meals should be reasonable, with breakfast, lunch and dinner accounting for 30%, 30%-40% and 30%-40% of the total energy respectively. Nutritional requirements differ between boys and girls, with boys needing more energy, zinc, vitamin A and vitamin B1/B2, and girls needing more iron. These differences stem from differences in basal metabolic rate, physical activity levels and physiological needs.

2. A comprehensive nutritional evaluation model for college student recipes

2.1 Comprehensive evaluation indicator analysis and modeling

This study develops a comprehensive evaluation model, starting with the definition of indicators.

Table 1. Definition of indicators

N	Number of food groups
E	Total energy provided by the recipe (kcal)
P	Total protein content of the recipe (g)
F	Total fat content of the recipe (g)
C	Total carbohydrate content of recipes (g)
Df	Total dietary fiber content of the recipe (g)
Mj (j=1,2,...,11)	Total content of the jth non-capacity nutrient in the recipe, including calcium, iron, zinc, vitamin A, vitamin B1, vitamin B2 and vitamin C, etc. (11)
S	Amino acid scores of mixed food proteins

The comprehensive evaluation model can then be expressed as follows:

$$Y = f(N, E, P, F, C, D_f, M_1, M_2, \ldots, M_{11}, S)$$

Where, f is a comprehensive evaluation function, which integrates all the indicators to make an overall evaluation of the nutritional value of the recipes.

In order to quantify the evaluation, this paper normalizes the indicators so that they are on the same scale, and then assigns weights to get an evaluation score.

2.2 Model solving algorithms

Step1 Input: a daily recipe containing n food items and the amount of edible portion of each food item.

Step2 Count the number of food groups and check that the five major groups are included.

Step3 According to the Chinese Food Composition Table, find out the nutrient content of each food and calculate the total content of each nutrient in the recipe.

$$E = \sum_{i=1}^{n} q_i \times e_i$$

$$P = \sum_{i=1}^{n} q_i \times p_i$$

$$F = \sum_{i=1}^{n} q_i \times f_i$$

$$C = \sum_{i=1}^{n} q_i \times c_i$$

$$D_f = \sum_{i=1}^{n} q_i \times d_{f,i}$$

$$M_j = \sum_{i=1}^{n} q_i \times m_{j,i}, \quad j = 1,2,\ldots,11$$

where $e_i, p_i, f_i, c_i, d_{f,i}, m_{j,i}$ denote the amount of energy (kcal), protein (g), fat (g), carbohydrates (g), dietary fibers (g), and the amount of the jth non-capacity nutrient (the unit of measurement depends on the type of nutrient), per 100 g of edible portion of the ith food, respectively.

Step4 Calculate the percentage of energy supply from proteins, fats and carbohydrate:

$$\text{Protein energy supply as a percentage} = \frac{P \times 4}{E} \times 100\%$$

$$\text{Percentage of energy supply from fat} = \frac{F \times 9}{E} \times 100\%$$

$$\text{Percentage of energy supply from carbohydrates} = \frac{C \times 4}{E} \times 100\%$$

Step5 Calculation of amino acid scores of mixed food proteins S:

$$S = \min_{1 \le k \le 8} \left\{ \frac{\sum_{i=1}^{n} q_i \times a_{k,i}}{\sum_{i=1}^{n} q_i \times p_i} \times \frac{1}{r_k} \times 100 \right\}$$

Where $a_{k,i}$ denotes the amount of the kth essential amino acid per 100 g of edible portion of the ith food (g), and r_k is the reference scoring pattern value for the kth essential amino acid (mg/g protein). The minimum value in this formula corresponds to the first limiting amino acid, and its score is the amino acid score of the mixed food protein.

2.3 Analysis of evaluation results

For the students' one-day recipes for boys and girls, based on the above nutritional indicators, specific foods, their main components and main nutrients are organized and further analyzed

2.3.1 Energy analysis.

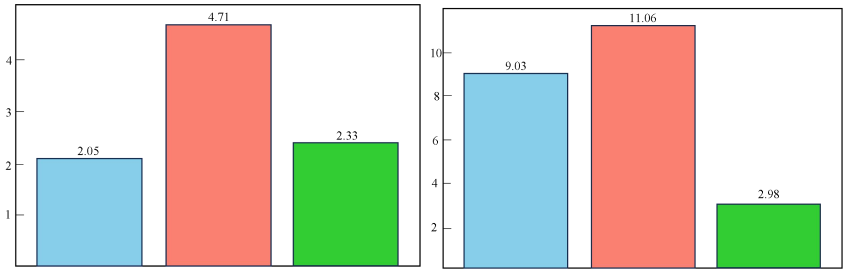

Figure 1. Figure with energy intake in three meals for boys and girls

The actual energy intake of the boys was close to the norm with a higher score of 93.88. The actual energy intake of the girls was significantly lower than the norm with a lower score of 65.96.By using the scores, this paper concludes that the boys' diets are closer to the energy requirements while the girls' diets need to increase the energy intake to meet the norm.

2.3.2 Macronutrient.

Boys' composite score: 66.15, Protein score 91.76, boys' protein intake is 13.53% which is close to the standard of 12.5% and scores higher, Fat score 32.16, boys' fat intake is 41.93% which is significantly higher than the standard of 25% and scores lower, Carbohydrate score 76.52, boys' carbohydrate intake is 43.93% which is lower than the the standard 57.5%, but still scored well.

The protein intake of boys was more reasonable, but fat intake was significantly too high and carbohydrate intake was insufficient. This suggests that the boys' dietary structure needs to be adjusted to reduce fat intake and increase carbohydrate intake to achieve a more balanced energy distribution.

Girls' overall score: 22.74, Protein score: 0. The girls' protein intake of 32.23% was much higher than the standard of 12.5%, and the score of 0 indicated a serious overload. Fat score: 26.08, the girls' fat intake of 43.48% was also significantly higher than the standard 25%, scoring low. Carbohydrate Score: 42.14. The girls' carbohydrate intake of 24.29% was well below the standard of 57.5% and also scored low.

The girls were significantly overweight in both protein and fat intake and grossly underweight in carbohydrate intake. This suggests that the girls' diets are severely imbalanced and that there is a need for a significant reduction in protein and fat intake, as well as a significant increase in carbohydrate intake in order to achieve a balanced energy distribution.

2.3.3 Non-capacity nutrients.

The data and criteria were analyzed to obtain control results Table 2.

Table 2. Non-capacity nutrient results vs. standards

original proposal	Recipe of the Day for Male College Students	Reference value (me	Recipe of the Day for Female College Students	Reference value (female)
calcium	755.46 mg	800 mg	209.15 mg	800 mg
Iron	22.898 mg	12 mg	8.055 mg	20 mg
Zinc	10.3103 mg	12.5 mg	4.944 mg	7.5 mg
Vitamin A	213.55 μg	800 μg	174.35 μg	700 μg
Vitamin B1	1.002 mg	1.4 mg	0.7905 mg	1.2 mg
Vitamin B2	0.7825 mg	1.4 mg	0.5135 mg	1.2 mg
Vitamin C	29.6 mg	100 mg	39.6 mg	100 mg

Calculated and obtained, male college students have a composite score: 52.34 and female college students have a composite score: 43.52, both male and female students have lower scores in this item, with male students having higher scores than female students.

For male students, increase your intake of calcium, zinc, vitamin A, vitamin B2, and vitamin C. For example, eat more dairy products, shellfish, green leafy vegetables, and citrus fruits. Female college students, increase intake of calcium, iron, vitamin A, vitamin B2 and vitamin C, e.g. eat more dairy products, red meat, green leafy vegetables and citrus fruits.

2.3.4 amino acid score.

Amino acid scores were calculated for the boys' and girls' recipes for three meals and for the whole day, resulting in Figure 2.

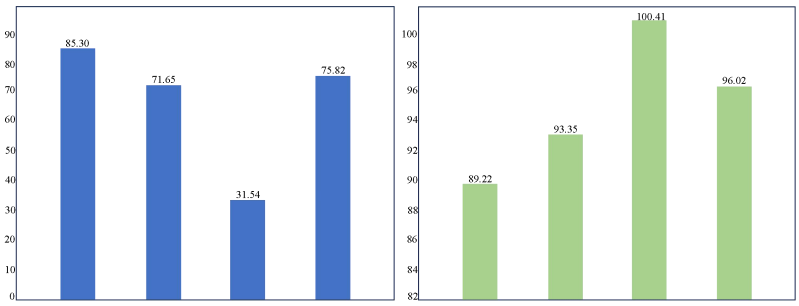

Figure 2. Figure with amino acid score of three meals for boys and girls

The average amino acid score of the boys for the whole day was 75.82 indicating an overall imbalance in intake and the low score for dinner brought down the average for the whole day. Amino acid scores for boys were higher at breakfast 85.30, decreased at lunch 71.65, and lowest at dinner 31.54, which indicates that the boys did not consume enough amino acids at dinner.

The average amino acid score of the girls for the whole day was 96.02, the overall intake was balanced and all were at a high level. The girls' amino acid scores were higher at breakfast 89.22 and lunch 93.35, and the highest dinner score of 100.41 was above 100, indicating a more adequate amino acid intake.

Boys, to improve amino acid intake at dinner, can increase amino acid-rich foods, such as lean meat, fish, beans, and so on. Balance the amino acid intake of each meal to ensure that the intake throughout the day meets the recommended standard. For girls, continue to maintain a good amino acid intake habit. While maintaining a balanced intake, be careful not to over-consume certain amino acid-rich foods to avoid nutritional imbalance.

3. Summary

This study presents a comprehensive evaluation and optimization model for the daily dietary intake of male and female college students.A model based on five dimensions—food groups, total

energy, protein, fat, carbohydrates, dietary fiber, and non-energy nutrients—evaluates students' daily diet nutritional value. Male students scored higher, suggesting their diets align more closely with nutritional requirements, yet with excessive fat and insufficient carbohydrates. Female students showed significant overconsumption of protein and fat, alongside inadequate carbohydrates, highlighting a severe dietary imbalance.

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