Nutritional Analysis and Evaluation of College Students' Dietary Recipes

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Abstract. With the increasing focus on health and nutrition, university students, as a special group, have their nutritional status directly linked to their academic performance and physical health. This paper first identified 19 nutrients and 60 main components, collected relevant data, and used a collaborative filtering algorithm to preprocess missing data. Secondly, a game theory combination weighting model was employed to integrate the Analytic Hierarchy Process and entropy weighting method to obtain optimal weights for nutritional indicators. Finally, a comprehensive dietary nutrition evaluation model was established based on particle swarm optimization projection pursuit. The results show that the comprehensive dietary nutrition evaluation scores for the male and female university students' two sets of recipes are 1.26 and 1.15 respectively, indicating that the male university student's daily comprehensive dietary nutrition evaluation score is slightly higher than that of the female university student. Female university students pay more attention to nutritional intake during breakfast and lunch, but male university students have a more balanced nutritional intake throughout the day.

Keywords: Health Evaluation, College Student, Nutritional Evaluation, Dietary Recipes.

1 Introduction

With the rapid development of society and economy and the improvement of living standards, people's attention to health is increasing. In particular, college students, as a special group, have dietary nutrition status that not only affects their personal health and learning efficiency but also impacts the future development of the entire society [1]. However, due to high academic pressure and a fast-paced lifestyle, many college students have unscientific and unreasonable dietary habits, leading to nutritional imbalances and irregular eating patterns. These issues can not only cause health problems such as obesity and malnutrition but also affect their mental health and academic performance. Therefore, conducting a nutritional analysis and evaluation of college students' dietary recipes is of great significance.

Current research has conducted in-depth evaluations of dietary recipe nutritional analysis. For instance, Kılınç & Çağdaş studied 172 female medical students to assess

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the anthropometric values, body composition, nutritional knowledge, nutritional habits, food consumption frequency, and daily food consumption of healthy university students [2]. Sakai et al. conducted a cross-sectional study on the dietary habits of 333 students, evaluating the nutritional value of the canteen menu at an Indonesian university, dietary habits, and intake [3]. Medina et al. evaluated the relationship between the dietary habits and nutritional status of academic course students with nutritional knowledge and cooking methods and techniques, finding that other inherent factors in students' lives might have a greater impact on dietary habits [4]. Bernardo et al. described the research protocol and evaluation framework of a kitchen nutrition and cooking program aimed at cultivating college students' cooking skills, based on the U.S. "Cooking with Chefs" program. This approach provided new evidence on whether cooking interventions targeting college students could improve cooking skills and healthy eating habits [5]. Clerkin et al. found that food insecurity among college students is associated with poor dietary habits. They used repeated measures analysis of variance to increase fruit and vegetable consumption among college students through a campus food pantry. The results showed that female students using the food pantry increased their fruit and vegetable consumption, demonstrating that this behavior is modifiable [6].

This study systematically analyzes the nutritional components of college students' dietary recipes to evaluate their nutritional value. The aim is to identify problems in the dietary structure of college students and propose scientific dietary recommendations and improvement measures. Through this research, it is hoped that college students will pay more attention to their dietary health, improve their nutritional knowledge, and develop healthy eating habits, thereby providing strong support for their healthy growth and overall development.

2 Data Collection and Preprocessing

First, according to the basic requirements for dietary recipe analysis, evaluation, and optimization design in Attachment 4, we know that to comprehensively evaluate dietary nutrition, we select "main nutrients" from various categories as evaluation indicators. These mainly include 19 nutrients, and foods are categorized into five main classes, and combined with the main components of the major foods in a university cafeteria from Attachment 3, there are a total of 60 main components. The quantities of main nutrients per 100 grams of edible portion of food can be found in the "China Food Composition Table" volumes 1 and 2, as well as the food nutrition composition query platform (https://nlc.chinanutri.cn/fq/).

Next, due to missing data on various essential amino acids for some food components, we use a collaborative filtering algorithm to preprocess the missing data and fill in the data gaps. Collaborative filtering is an algorithm that makes predictions and recommendations by analyzing user behaviors and preferences. Its principle is mainly based on the idea of "birds of a feather flock together," assuming that similar users have similar preferences, or similar items are liked by similar users. Therefore, in cases of missing data, collaborative filtering can be used to predict and fill in these missing data

[7]. The main steps are: (1) Construct a user-item rating matrix, i.e., the original nutrient data matrix. (2) Calculate the similarity of 60 main components using cosine similarity. (3) Find similar components, for each component with missing values, find its k most similar components, here we take $k = 5$. (4) Based on the related data of the top k components, predict the relevant missing data through weighted averaging, thereby filling in the missing values.

3 Comprehensive Dietary Nutrition Evaluation Model

3.1 Game Theory Combination Weighting Model

Analytic Hierarchy Process. The Analytic Hierarchy Process (AHP) is a mathematical method for multi-criteria decision-making proposed by Thomas L. Saaty in the 1970s. AHP breaks down complex problems into levels and compares factors in pairs to determine their importance [8]. Its steps are: (1) Decompose the problem into three levels: goal, criteria, and alternatives. (2) Compare elements pairwise to construct a comparison matrix. (3) Normalize the matrices to calculate weight vectors. (4) Calculate the consistency index and ratio to evaluate consistency. (5) Aggregate weights to determine the overall ranking of alternatives.

Entropy Weighting Method. The entropy weight method is an objective approach used to determine the weights of indicators in multi-criteria decision-making. It is based on the concept of entropy from information theory, which measures the uncertainty of information [9]. By calculating the information entropy of each indicator, the method reflects the uncertainty of the indicator's information and determines its weight. Its steps are: (1) Construct the original data matrix. (2) Standardize the original data to eliminate the effects of different units of measurement for various indicators. (3) Calculate the proportion, information entropy, and weight of each indicator.

Game Theory Combination Weighting Model. The Game Theory Combination Weighting Method is a technique that combines subjective and objective weighting methods to determine indicator weights through the principles of game theory [10]. It leverages Nash equilibrium from game theory to balance subjective and objective weights, thereby more accurately reflecting the importance of each indicator. Its steps are: (1) Determine subjective weights using the Analytic Hierarchy Process (AHP). (2) Determine objective weights using the entropy weight method. (3) Construct a game theory combination model to minimize the weighted sum of squares between subjective and objective weights. (4) Normalize the weights.

The formula for solving Nash equilibrium is:

$$\min \sum_{i=1}^{2} (\alpha_i w_i^{\mathrm{T}} - w_i) \tag{1}$$

Where α_1, α_2 are adjustment parameters, typically with $\alpha_1 + \alpha_2 = 1$.

3.2 Particle Swarm Optimization Projection Pursuit Evaluation Model

The Particle Swarm Optimization (PSO) is an optimization technique based on swarm intelligence, which simulates the foraging behavior of bird flocks to find the optimal solution to a problem. The Projection Pursuit (PP) evaluation model is a technique used for dimensionality reduction and analysis of high-dimensional data, capable of revealing useful information in data structures. Combining PSO with the PP evaluation model forms the Particle Swarm Optimization Projection Pursuit (PSO-PP) model, which optimizes the projection direction to achieve effective evaluation of multi-criteria data [11]. Its steps are: (1) Construct the original data matrix and standardize it. (2) Define a suitable projection index function based on the evaluation objective. (3) Initialize the particle swarm and calculate the projection index function value for each particle in the current projection direction, performing particle fitness evaluation. (4) Update the particle swarm and perform iterative optimization. The objective function is

$$\begin{cases} S_Z = \sqrt{\dfrac{1}{n-1}\sum_{i=1}^{n}(z_i - \overline{z})^2} \\ D_Z = \sum_{i=1}^{n}\sum_{j=1}^{m}(R - r_{ij}) \cdot I(R - r_{ij}) \end{cases} \tag{2}$$

$$\max Q(A) = S_Z \cdot D_Z \quad s.t. \begin{cases} A > 0 \\ \sum_{j=1}^{m} a_j^2 = 1, -1 < a_j < 1 \end{cases} \tag{3}$$

Where S_Z is the standard deviation of the samples in the projection target, and D_Z is the local density of the projection target.

4 Results

We used a PSO-PPE model to conduct a comprehensive dietary nutrition evaluation of two sets of three daily meals for one male university student and one female university student (see Fig. 1).

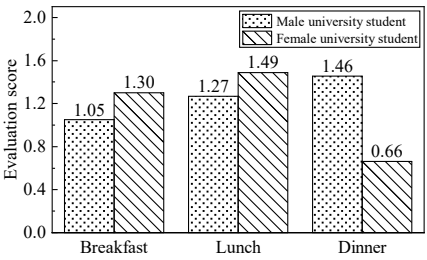

Fig. 1. Comprehensive dietary nutrition evaluation results.

From Fig. 1, we can observe significant differences in calorie intake between male and female university students at different meal times throughout the day. When we consider the comprehensive dietary nutrition evaluation scores for the entire day, the male university student's daily score is 1.26, while the female university student's is 1.15. Therefore, overall, the male university student's daily comprehensive dietary nutrition evaluation score is slightly higher than that of the female university student. This result suggests that although female university students pay more attention to nutritional intake during breakfast and lunch, male university students have a more balanced nutritional intake throughout the day.

Specifically, for breakfast and lunch, the female university student's comprehensive dietary nutrition evaluation scores are generally higher than those of the male university student. This phenomenon indicates that both males and females give sufficient importance to nutritional intake at breakfast, ensuring the quality of their morning meals. As for lunch, since the body needs more energy to support afternoon activities and maintain normal physiological functions, the nutritional evaluation scores for lunch are also relatively high. However, the situation changes at dinner time. The female university student's comprehensive dietary nutrition evaluation score is significantly lower than that of the male university student. This difference may be related to female university students' habit of consuming less at dinner to lose weight or avoid weight gain. This also indirectly explains why female university students have relatively higher dietary nutrition evaluation scores for breakfast and lunch, precisely because they eat less at dinner.

5 Conclusion

This paper conducted a comprehensive evaluation of the nutritional aspects of male and female university students' dietary recipes based on the game theory combination weighting method and the particle swarm optimization projection pursuit evaluation model. The results show that there are significant differences in calorie intake between male and female university students at different meal times throughout the day. When we consider the comprehensive dietary nutrition evaluation scores for the entire day, the male university student's daily score is 1.26, while the female university student's is 1.15. Therefore, the male university student's daily comprehensive dietary nutrition evaluation score is slightly higher than that of the female university student. This result suggests that although female university students pay more attention to nutritional intake during breakfast and lunch, male university students have a more balanced nutritional intake throughout the day.

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