

Reducing the Incidence of Cardiovascular Disease in North China by Healthy Dieting

Zhao Xi Lin, Ting Wen Xie, Liang Li*

School of Mathematical Sciences, University of Electronic Science and Technology of China, Chengdu, China

Email address:

plum_liliang@uestc.edu.cn (Liang Li)

*Corresponding author

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Abstract: Cardiovascular disease (CVD) is one of the most deadly diseases globally. In recent years, the incidence rate and the fatality rate of CAD has ranked first in China. CAD not only seriously damage public's health but also cause property losses to patients' family and the society. Therefore, the factors that affect the incidence of CAD are considered. Based on a research, that different eating habits and the body mass index among different regions are closely related to its incidence is proposed. The knowledge of linear algebra is then used to establish three models to get a healthy diet which helps to prevent CVD. In the first nutrient model, the purpose is to solve for a combination of food that can meet the nutrition requirement. In the second replacement model, some replacement tricks are used not only to deal with no or negative solutions problems but also to replace food which is beneficial to prevent CVD. Finally, the last energy model is used to check if the recipe satisfies the daily energy intake requirement. Eventually, a recipe which is flexible and contains various types of food is put forward. It ensures that people not only take in all kinds of nutrients and required energy daily but also prevent CVD.

Keywords: Cardiovascular Disease, North China, Diet, Projection, Column Space, Linear Dependent, Negative Solution

1. Introduction

A research which was published on The Lancet Public Health, an authoritative medical journal analyzed the incidence of cardiovascular disease (CVD) in people living in different areas of China. The research indicated that 11.4% of people in North China were likely to suffer from CVD [2]. This data was higher than most other areas in China. The high incidence of CVD in North China was related to high rate of obesity and unhealthy eating habit. In 2017, 13.5% of cardiovascular deaths were attributed to obesity and 3.1 million deaths were attributed to unhealthy eating habit [4]. Since obesity is able to solve by healthy diet, the incidence of CVD can be declined by healthy diet.

The current eating habits indicates that people in North China take in excess salt, oil, sugared beverages and alcohol. In 2015, average salt intake for home cooking was 9.3g per person per day which was higher than the recommended by the China Nutrition Society. In addition, the intake of whole grain, leaf vegetable, fruit, dairy and soy are insufficient.

According to the survey data, only 20% of adults take in more than 50g whole grain. Additionally, the consumption of traditional food soy is limited [4].

Based on the above facts, the goal of this project is to minimize the adverse effects of unhealthy diet on the incidence of cardiovascular diseases in North China by establishing some models.

2. Preparation of the Models

Figure 1 shows the percentage of various unhealthy diets in the cause of death from CVD. Based on the situation, the recommended intake of nutrients and energy are considered.

According to the recommendation, three models are set up to acquire healthy and reasonable diet. The process is as follow:

- 1) Through the analysis of the nutrients necessary for people, a diet with reasonable nutrients is established.
- 2) Establish a recipe that allows substitution of the same type of food when the recipe requires insufficient ingredients or the food is not able to avoid CVD.

3) Through the analysis and calculation of the calories of different kinds of foods, a recipe with the purpose of controlling calories is established.

In order to make the problem clear, the following five assumptions are made, which are the fundamental conditions of our three models.

- 1) People in our model weigh 60 kg and their age range from 18 to 50 years old. They have normal metabolism. They do not have any illnesses and have moderate exercise.
- 2) Standard/Required nutrient intake vector is [6]:

$$\begin{bmatrix} \text{Protein} \\ \text{Fat} \\ \text{Carbohydrate} \\ \text{Sodium} \\ \text{Calcium} \end{bmatrix} = \begin{bmatrix} 48 \\ 66.67 \\ 80 \\ 1000 \\ 1000 \end{bmatrix} \begin{matrix} g \\ g \\ g \\ mg \\ mg \end{matrix}$$

(1200mg of Sodium (Na) is taken from salt daily, 1000mg Na is needed from food.)

- 1) The food which is chosen is available and common in our lives. The nutrients' contents are per 100 grams of edible parts and the unit of energy is kilojoules per 100 grams of food.
- 2) In nutrient model, only protein, fat, carbohydrate, sodium and calcium are taken into consideration. Other nutrients are ignored since simplification.
- 3) In energy model, the transformation relationships which are considered are: fat transforms to energy and other nutrition in food does not transform to energy.

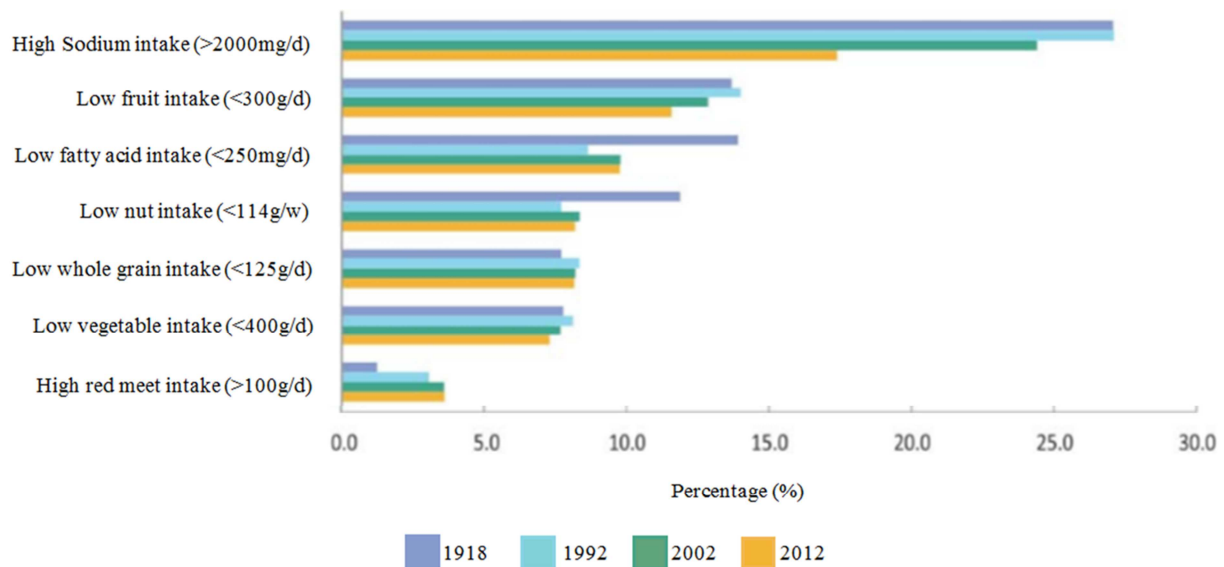


Figure 1. Percentage of CVD death attribute to inappropriate diet [5].

3. Models

Based on the main purpose of the three models mentioned above and the corresponding model assumptions, three models are established. This part will give a detailed description of the process of model establishment, and finally get a recipe that can achieve the goal of healthy diet, in order to reduce the impact of inappropriate diet on the incidence of CVD. Three dieting models are introduced in this part which help to get a result of healthy diet.

3.1. Nutrient Model - Least Square Method

This model uses the equation $Ax=b$. Meanwhile, there are some projection matrices involved. Nutrient components of each food are put in each column and combine all these columns. Then the nutrient matrix A was obtained which unit is grams or milligrams per 100 grams. b is required nutrition intake vector which unit is grams or milligrams. x is food

combination, the result which is expected. The unit of x is 100 grams. For example, if a 100g apple has 2g carbohydrate and 1.2g Calcium (Ca) and a 100g banana has 1.1g carbohydrate and 4.2g Ca. The nutrition matrix is $A = \begin{bmatrix} 2 & 1.1 \\ 1.2 & 4.2 \end{bmatrix}$ and $b = \begin{bmatrix} 5 \\ 9 \end{bmatrix}$ which means 5g of carbohydrate and 9g of Ca are needed daily. After establish the matrices, Matlab is used to obtain x which is $\begin{bmatrix} 1.5678 \\ 1.6949 \end{bmatrix}$ which means 1.5678g apple and 1.6949g banana are needed [7, 8].

Next, more data are used to get an ingredient matrix to find more information about the matrix. Two ingredients from each of the mentioned food categories are chosen as representatives. Thus, there are two ways of food combination can be gotten, where the nutrients of food are just considered as protein, fat, carbohydrate, Na and Ca. Here two kinds of diet are proposed which is healthy for human.

In the first diet, there have apple, cucumber, beef and egg. These ingredients are put into columns to get the ingredient matrix A . Usually the dimension of A is the number of foods

which is chosen because when these random data are extracted to form a matrix there is a high chance that each column is independent of other columns as they are different food. However, it is unavoidable that the matrix may become not invertible (the columns are dependent). When that ingredient matrix is not invertible, the column space does not span the whole space or ingredient matrix is not a square matrix and not invertible. Therefore, the solution x may not be obtained when the b is not in the column space of A . To address this problem, the idea of projection is proposed, trying to project x onto the column space of A . Actually, $Ax = \hat{b}$, where \hat{b} is the projection of b onto the column vector plane, is solved. It is worth noticing that projection does not affect the correct answer when b is in the column space, as the projection into the whole space is just the vector itself. The projection matrix is given as $A(A^T A)^{-1} A^T$. The equation we set is $Ax = \hat{b} = A(A^T A)^{-1} A^T b$. After simplify it, $x = (A^T A)^{-1} A^T b$ is obtained [9]. In Matlab the ingredients

are put into the A and $x = \begin{bmatrix} -0.4937 \\ 23.9593 \\ -4.9109 \\ 9.6343 \end{bmatrix}$ is obtained [10]. As the

amount of food to be consumed cannot be negative, the negative value is considered as zero. By doing so the amount of food to be eaten is added, so the overall nutrient intake maybe higher than the given standard nutrient intake.

After that, the second diet which includes carrot, potato, pork and corn is proposed. Solving for x , $x = \begin{bmatrix} 8.4347 \\ 87.229 \\ 3.9981 \\ -65.4588 \end{bmatrix}$ is gotten.

Two calculated recommendation diet are:

- 0g apple, 2.4kg cucumber, 0g beef, 0.97kg egg;
- 0.84kg carrot, 8.72kg pork, 0.4kg pork, 0g corn.

Notice that the magnitude of the negative component is too large [11]. If it is neglected directly, there may be an overnutrition problem. Meanwhile, not all food we take in help to avoid CVD. Therefore, a replacement model is formed to solve these problems.

3.2. Replacement Model

From the model mentioned above, a noninvertible matrix or a result of negative component of food may be encountered. If a matrix is noninvertible, the least square method is used, an invert of $(A^T A)$ which is invertible. Thus, the only problem reduces to depend columns, which means one column can be

represented as a combination of other columns. If these dependent columns are replaced by other independent columns, the solution is easy to be obtained. Inversely, when the solution of the combination of food is obtained, the food maybe simple and consumers only have a little range of choices. By replacing one food with each other a wide range of choices can be obtained. Moreover, the overnutrition issue when there are negative solutions can be automatically solved through the replacement model. Then reduce the amount of food which has too much of one particular nutrient element and replace it with others. Furthermore, the food which is not help to prevent CVD can be replaced according to the table of nutrients in food. Table 1 below shows the nutrient content of the same type but different kinds of foods, in order to facilitate the replacement between the same types of foods.

Table 1. Nutrients in food [12].

	Carbohydrate (g)	Protein (g)	Fat (g)	Ca (mg)	Na (mg)
Apple	13.5	0.2	0.2	4	1.6
Banana	22.8	1.4	0.2	7	0.8
Cucumber	2.9	0.8	0.2	24	4.9
Carrot	8.8	1	0.2	32	71.4
Rice	77.9	7.4	0.8	13	3.8
Wheat	73.6	11.2	1.5	31	3.1
Potato	17.2	2	0.2	8	2.7
Sweet	24.7	1.1	0.2	23	28.5
Pork	2.4	13.2	37	6	59.4
Beef	2	19.9	4.2	23	84.2
Chicken	1.3	19.3	9.3	9	63.3
Carb	0.5	17.6	4.1	50	53.7
Shrimp	Tr	16.4	2.4	325	133.8
Corn	22.8	4	1.2	\	1.1
Egg	2.8	13.3	8.8	56	131.5
Milk	3.4	3	3.2	104	37.2

3.3. Energy Model

In energy model only the energy (calorie) of each food ingredient is considered [13]. That is to say that each of a chosen food is only a form of energy without taking nutrition of each food into consideration. Since the energy intake can in a way determine the fat in human's body, this energy model is an indication of the fat intake. To simplify problem, the calorie of each food is considered. The model is examined and modified according to the experiments that are done with our first two models.

Since human needs 2100 to 2600 kilocalories each day [14], vector v is set as requirement calories each day which unit is kilocalories. Set x as linear combination of food.

Table 2. Energy in food [12].

	egg	Sweet potato	cucumber	carrot	beef	corn	banana	grape	cabbage	almond	rice
Energy kJ/100g	599	446	70	174	528	500	405	191	111	2469	1480

Table 2 above shows the foods in the final recipe got and their calories. Data above was used to calculate the required energy daily:

$$1[599] + 1[446] + 3[70] + 2.5[174] + 3[528] + 2[500]$$

$$+ 2[405] + 2[191] + 3[111] + 0.5[2469] + 2[1480] \\ = 9993.5\text{kJ} = 2387.44715\text{kcal}$$

the combination $x = [1 \ 1 \ 3 \ 2.5 \ 3 \ 2 \ 2 \ 3 \ 0.5 \ 2]^T$ which means 100g of egg, 100g of sweet potato, 300g of cucumber, 250g of carrot, 300g of beef, 200g of corn, 200g of banana,

200g of grape, 300g of cabbage, 50g of almond, 200g of rice is a feasible combination. It is worth noticing that the result of this matrix multiplication is nothing but just a dot product of a row vector (each food's energy content) and a column vector (the right combination of food x). And because the row vector just has one row, that means the dimension of the row vector is only one. Supposed that the row vector has n components, then the dimension of the null space which is orthogonal to the row space is $[(n-1)!]$. The number $n-1$ is large, thus given that the dimension of the null space is too high, the solution can be got is also multi-dimensional (many solutions as the solution is composed of the null space and the particular solution). Instead of computing all these combinations of food to get a healthy food, this model is chosen as a verifying method to check if the calculations in other models satisfy the energy requirement.

4. Conclusion

By applying the three models (nutrient model, replacement model and energy model) which are proposed a healthy diet then is obtained: 100g of egg, 100g of sweet potato, 300g of cucumber, 250g of carrot, 300g of beef, 200g of corn, 200g of banana, 200g of grape, 300g of cabbage, 50g of almond, 200g of rice. After obtain the diet, several suggestions which are utilized to replace the food are given. First, increase the intake of whole grain, vegetation, fruit, soy, nut and fish. It can be seen from the final result that a combination of cereals and cereals in terms of staple food is chosen. This can reduce the risk of CVD while avoiding the increased risk of diabetes due to excessive intake of cereals. In the diet obtained, the intake of fruits and vegetables accounted for the majority, because increasing the intake of these two would effectively reduce the risk of CVD. In a Meta survey study, every increase of 80g/d of vegetable or fruit intake reduces the risk of CVD by about 13% [15]. In addition, fruits and vegetables also play a good role in preventing various cancers. The diet also pays attention to the intake of nuts, which may be a type of food that will be overlooked. A moderate increase in nut intake can improve blood lipids and reduce the risk of all-cause death. The intake of meat such as beef is also controlled to prevent excessive intake of meat from causing obesity and increasing the risk of disease. To sum up, the healthy recipes obtained through the establishment of three models have taken into account the intake of essential nutrients for the human body, and a reasonable combination of various substances. Increase the intake of foods that can reduce the incidence of CVD, and control the intake of foods that cause the risk of disease. This reasonable nutritional combination also has a good effect in preventing other diseases. Taking into account the eating habits of various places and the types of foods available, the replacement model is used to allow people to flexibly replace similar things based on the recipes given, in order to increase the breadth of the recipe audience.

In addition to the daily diet, the following suggestions are also useful to help reduce the incidence and mortality of cardiovascular diseases. Drinking tea is able to reduce the risk of CVD. A cup of tea (236.6ml) daily helps to decrease the incidence and death of CVD. Furthermore, total physical activity 3000 to 4000MET-min/w dramatically reduces the risk of CVD [4, 16]. Besides, taking in excess salt, alcohol and

trans-fat do not prevent CVD.

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