Relationship between Body Mass Index and Healthy Food with a Balanced Diet

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Abstract

A balanced diet provides enough energy and nutrition for optimal growth and development. It means that the diet meets all the nutritional requirements while not providing too much nutrients for human body. In order to have a balanced diet every day, people must identify the level of Body Mass Index (BMI) and recognizing the healthy foods to be taken. Fuzzy Linear Programming approach has been used to calculate the amounts of nutrients in the healthy food taken. Taking healthy food that specifies the nutritional requirements for human body will help people to have a balance diet every day.

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Keywords: Balance diet, Body Mass Index, Fuzzy Linear Programming approach, Healthy food
1. Introduction

A balanced diet means getting the right types and amounts of foods and drinks to supply nutrition and energy for maintaining body cells, tissues, and organs, and for supporting normal growth and development. A good and healthy diet plan involves eating a variety of foods to get the required nutrients while, at the same time, providing the right amount of calories to maintain a healthy weight. All healthy balanced diets should be always complete and incorporate the seven essential nutrients: protein (mostly vegetable), fats, carbohydrates, fibre, water, vitamins and minerals (Europrev-Sociedad, 2005).

In order get a balance diet, people must know their Body Mass Index (BMI). BMI is defined as ratio of weight in kilogram to square of height in metre (Onn, 2000). BMI provides a reliable indicator of body fatness for most people and is used to screen for weight categories that may lead to health problems. There are four BMI weight categories; underweight, normal, overweight and obese.

The identification of BMI helps people in choosing the healthy food to be taken. Healthy food is a food that is highly beneficial to health, especially a food grown organically and free of chemical additives. It nourishes people body with essential nutrients, namely, vitamins, minerals, trace minerals, protein, carbohydrates, fats and enzymes. These nutrients are necessary for life. Taking food that is high in calories but lack of nutrients leads people to health problems such as obesity, overweight and other diseases (Mamat et al., 2011; Mamat et al., 2012).

Therefore, in order to have a balance diet, people need to know their BMI as well as the amount of nutrients in the food taken. This can be done with the help of mathematical model.

2. Methods

This research shows the formula to calculate the BMI of a person. It also shows the calculation of nutrients in foods taken where it use the approaches of Fuzzy Linear Programming Approach (FLP). FLP is used instead of Linear Programming (LP) because the mathematical model involves the vague parameter.

2.1 BMI formula

The calculation of BMI involves the combination of weight and height of a person. The result of BMI weight is divided into four categories. It is shown as follows:
Relationship between body mass index and healthy food

BMI = weight in kilogram / (height in metre * height in metre)

BMI weight categories:
Below 18.5 : Underweight
18.5 to 24.9 : Normal
25.0 to 29.9 : Overweight
30.0 and above : Obese

2.2 Fuzzy Linear Programming Approach

Fuzzy Linear Programming (FLP) is an application of fuzzy sets theory in linear decision making problems and most of this problem is related to Linear Programming (LP) with fuzzy variables (Nasseri and Ardil, 2005). In this article, the value of nutrients in food is uncertain and it is assume as fuzzy numbers. The FLP approach is as shown below.

Minimize \[ \sum_{j=1}^{n} \bar{c}_j x_j \]
subject to \[ \sum_{j=1}^{n} a_{ij} x_j \geq b_i, \sum_{j=1}^{n} a_{ij} x_j \leq d_i, i = 1, 2, ..., m, x_j \geq 0 \] (1)

where,
\( x_j \): 100 g of food \( j \) eaten per day,
\( \bar{c}_j \): the value of nutrients in food \( j \) per 100 g,
\( a_{ij} \): the amount of nutrient \( i \) in 100 g of food \( j \)
\( b_i \): the required daily amount of nutrient \( i \)
\( d_i \): the maximum daily amount of nutrient \( i \)
\( m \): the number of nutrients
\( n \): the number of food.

Equation (2) shows the formula of multi-objective Linear Programming

\[
\begin{aligned}
\min & \sum_{j=1}^{n} c_j^- x_j, \min \sum_{j=1}^{n} c_j x_j, \text{ and } \min \sum_{j=1}^{n} c_j^+ x_j \\
\end{aligned}
\] (2)

The objectives also can be written as

\[
\begin{aligned}
\max z_1 = \sum_{j=1}^{n} (c_j - c_j^-) x_j, \min z_2 = \sum_{j=1}^{n} c_j x_j \text{ and } \min z_3 = \sum_{j=1}^{n} (c_j^+ - c_j) x_j \\
\end{aligned}
\] (3)

When there are constraints, the maximum and minimum value for each objective can be found. It is shown as below.

\( z_i^{\max} = \max z_i \) and \( z_i^{\min} = \min z_i, i = 1, 2, 3 \)
subject to $\sum_{j=1}^{n} a_{ij}x_j \geq b_i$, $\sum_{j=1}^{n} a_{ij}x_j \leq d_i$, $i = 1, 2, \ldots, m$, $x_j \geq 0$  \hfill (4)

Based on equation (4), the membership function of each objective is defined as:

$$
\mu_{z_1}(x) = \begin{cases} 
1 & , z_1 > z_1^{\text{max}} \\
(z_1 - z_1^{\text{min}})/((z_1^{\text{max}} - z_1^{\text{min}})), & z_1^{\text{min}} < z_1 \leq z_1^{\text{max}} \\
0 & , z_1 \leq z_1^{\text{min}} \\
1 & , z_2 < z_2^{\text{min}} \\
(z_2^{\text{max}} - z_2)/((z_2^{\text{max}} - z_2^{\text{min}})), & z_2^{\text{min}} \leq z_2 < z_2^{\text{max}} \\
0 & , z_2 \geq z_2^{\text{max}} \\
1 & , z_3 < z_3^{\text{min}} \\
(z_3^{\text{max}} - z_3)/((z_3^{\text{max}} - z_3^{\text{min}})), & z_3^{\text{min}} \leq z_3 < z_3^{\text{max}} \\
0 & , z_3 \geq z_3^{\text{max}} 
\end{cases}
$$  \hfill (5)

$$
\mu_{z_2}(x) = \begin{cases} 
1 & , z_2 > z_2^{\text{max}} \\
(z_2^{\text{max}} - z_2)/((z_2^{\text{max}} - z_2^{\text{min}})), & z_2^{\text{min}} \leq z_2 < z_2^{\text{max}} \\
0 & , z_2 \geq z_2^{\text{max}} \\
1 & , z_3 < z_3^{\text{min}} \\
(z_3^{\text{max}} - z_3)/((z_3^{\text{max}} - z_3^{\text{min}})), & z_3^{\text{min}} \leq z_3 < z_3^{\text{max}} \\
0 & , z_3 \geq z_3^{\text{max}} 
\end{cases}
$$  \hfill (6)

$$
\mu_{z_3}(x) = \begin{cases} 
1 & , z_3 > z_3^{\text{max}} \\
(z_3^{\text{max}} - z_3)/((z_3^{\text{max}} - z_3^{\text{min}})), & z_3^{\text{min}} \leq z_3 < z_3^{\text{max}} \\
0 & , z_3 \geq z_3^{\text{max}} 
\end{cases}
$$  \hfill (7)

Based on fuzzy decision making proposed by (Bellman and Zadeh, 1970), let

$$
\beta = \min \{ \mu_{z_1}(x), \mu_{z_2}(x), \mu_{z_3}(x) \}
$$

From equation (5), (6), and (7), the model in problem (1) becomes the following optimization problem:

maximize $\beta$

subject to 

$$
\left( \sum_{j=1}^{n} (c_j - c_j^-) x_j \right) + \beta (z_1^{\text{max}} - z_1^{\text{min}}) \leq z_1^{\text{max}}
$$

$$
\left( \sum_{j=1}^{n} c_j x_j \right) - \beta (z_2^{\text{max}} - z_2^{\text{min}}) \geq z_2^{\text{min}}
$$

$$
\left( \sum_{j=1}^{n} (c_j^+ - c_j^-) x_j \right) - \beta (z_3^{\text{max}} - z_3^{\text{min}}) \leq z_3^{\text{min}}
$$  \hfill (8)

where $x_j \geq 0$, $0 \leq \beta \leq 1$. 
3.0 Analysis and Result

The analysis for this research was done on 30 people with different BMI. The result for BMI data and average BMI data is show in Table 1 and Table 2.

Table 1. BMI data for 30 people.

<table>
<thead>
<tr>
<th>Weight (KG)</th>
<th>HEIGHT (M)</th>
<th>BMI</th>
<th>BMI Weight Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>1.55</td>
<td>17.48</td>
<td>Underweight</td>
</tr>
<tr>
<td>40</td>
<td>1.58</td>
<td>16.02</td>
<td>Underweight</td>
</tr>
<tr>
<td>43</td>
<td>1.60</td>
<td>16.80</td>
<td>Underweight</td>
</tr>
<tr>
<td>39</td>
<td>1.54</td>
<td>16.44</td>
<td>Underweight</td>
</tr>
<tr>
<td>45</td>
<td>1.62</td>
<td>17.15</td>
<td>Underweight</td>
</tr>
<tr>
<td>51</td>
<td>1.67</td>
<td>1.670</td>
<td>Underweight</td>
</tr>
<tr>
<td>53</td>
<td>1.70</td>
<td>18.34</td>
<td>Underweight</td>
</tr>
<tr>
<td>44</td>
<td>1.53</td>
<td>18.80</td>
<td>Normal</td>
</tr>
<tr>
<td>47</td>
<td>1.56</td>
<td>19.31</td>
<td>Normal</td>
</tr>
<tr>
<td>57</td>
<td>1.69</td>
<td>19.96</td>
<td>Normal</td>
</tr>
<tr>
<td>61</td>
<td>1.72</td>
<td>20.62</td>
<td>Normal</td>
</tr>
<tr>
<td>45</td>
<td>1.53</td>
<td>19.22</td>
<td>Normal</td>
</tr>
<tr>
<td>57</td>
<td>1.69</td>
<td>19.96</td>
<td>Normal</td>
</tr>
<tr>
<td>55</td>
<td>1.60</td>
<td>21.48</td>
<td>Normal</td>
</tr>
<tr>
<td>42</td>
<td>1.50</td>
<td>18.67</td>
<td>Normal</td>
</tr>
<tr>
<td>46</td>
<td>1.54</td>
<td>19.40</td>
<td>Normal</td>
</tr>
<tr>
<td>60</td>
<td>1.63</td>
<td>22.58</td>
<td>Normal</td>
</tr>
<tr>
<td>78</td>
<td>1.76</td>
<td>25.18</td>
<td>Overweight</td>
</tr>
<tr>
<td>63</td>
<td>1.55</td>
<td>26.22</td>
<td>Overweight</td>
</tr>
<tr>
<td>70</td>
<td>1.64</td>
<td>26.03</td>
<td>Overweight</td>
</tr>
<tr>
<td>63</td>
<td>1.56</td>
<td>25.89</td>
<td>Overweight</td>
</tr>
<tr>
<td>76</td>
<td>1.68</td>
<td>26.93</td>
<td>Overweight</td>
</tr>
<tr>
<td>73</td>
<td>1.65</td>
<td>26.81</td>
<td>Overweight</td>
</tr>
<tr>
<td>66</td>
<td>1.57</td>
<td>27.99</td>
<td>Overweight</td>
</tr>
<tr>
<td>76</td>
<td>1.67</td>
<td>27.25</td>
<td>Overweight</td>
</tr>
<tr>
<td>70</td>
<td>1.53</td>
<td>29.90</td>
<td>Overweight</td>
</tr>
<tr>
<td>66</td>
<td>1.62</td>
<td>25.15</td>
<td>Overweight</td>
</tr>
<tr>
<td>69</td>
<td>1.58</td>
<td>27.64</td>
<td>Overweight</td>
</tr>
<tr>
<td>80</td>
<td>1.71</td>
<td>27.36</td>
<td>Overweight</td>
</tr>
<tr>
<td>94</td>
<td>1.73</td>
<td>31.41</td>
<td>Obese</td>
</tr>
</tbody>
</table>

Table 2. Average BMI data for 30 people.

<table>
<thead>
<tr>
<th>BMI Weight Category</th>
<th>Average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>23.3</td>
</tr>
<tr>
<td>Normal</td>
<td>33.3</td>
</tr>
<tr>
<td>Overweight</td>
<td>40.0</td>
</tr>
<tr>
<td>Obese</td>
<td>3.30</td>
</tr>
</tbody>
</table>
Table 3 shows the suggested food with different BMI weight category. The FLP approach has been used to calculate the amount of nutrients in the suggested food for each BMI weight category. The food suggested is based on the nutrient composition of Malaysian foods (Siong et al., 1997).

Table 3. Suggested food for people with different BMI weight category

<table>
<thead>
<tr>
<th>BMI Weight Category</th>
<th>Suggested Food (Healthy food with required nutritional requirements for human body)</th>
</tr>
</thead>
</table>
| Underweight         | Starchy vegetables, dense whole grains, proteins low in saturated fat and low-fat dairy.  
|                     | Example: carrot, tomato, barley, rice porridge, milk, yogurt, cheese, bread, wheat flour, noodle, rice flour |
| Normal              | Fruits, vegetables, whole-grains, legumes, nuts and seeds, meat, poultry and fish  
|                     | Example: apple, banana, grapes, bread, soya bean curd, soya bean milk, dhal, anchovy, fish ball, crab, cuttlefish |
| Overweight          | Whole grains, fresh produce, beans and nuts, fish, fruits and vegetables  
|                     | Example: oat, barley, coconut water, peanut, almond, fish ball, grilled fish, green apple, banana, orange, mango, carrot, papaya |
| Obese               | Vegetables, high fibre food, whole grains, lean proteins and fruits  
|                     | Example: brown rice, whole-wheat pasta, wheat bread, broccoli, legumes and spinach, tofu, fish, shellfish |

The result in Table 3 shows a few list of food for people with different weight categories. The diet plan for people is differ according to the BMI weight category. To get the normal BMI, people should choose the right and healthy food with the right nutrient requirements.

4.0 Conclusion

Healthy food provides nutrients to help the human body work properly. No single food contains them in the amounts needed, so a mixture of foods has to be eaten. By identifying the BMI weight categories, people can choose the right and healthy food to be taken. Encouraging people to choose a variety of foods that specify the nutritional requirements every day will help ensure that they can get a balance diet as well as obtain the wide range of nutrients that their bodies need to remain healthy, function properly and have a healthy body.
References


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