GOAL PROGRAMMING OPTIMIZATION MODEL FOR A DIABETIC PERSON

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Abstract:Diabetes is a condition in which your body cannot properly use and store food for energy. Diabetes mellitus is chronic metabolic disease characterized by higher than normal blood glucose level. To control your blood glucose (sugar), you will need to eat healthy food, be active and you may need to take pills and/or insulin. Diabetes patients need menu planning with an extra care regarding their nutrients intake (energy, protein, fat and carbohydrate) .For a diabetic person glycaemic index is a important criteria .It is very important to maintain the glycaemic index less than 70 for a diabetic person . The requirement of nutrients needs are determined from the chart gives by the World Health Organization (WHO) standards and are assimilated in the model in the form of constraints. The aim of this paper is to develop a goal programming optimization diet model subject to specific goals. Objective function in the model is designed in a way to minimize sum of the deviations percentages of the weighted goals with respect to food cost and energy density. Model is developed using goal programming for optimization to meet daily nutrients needs. Function in the model is designed in a way to minimize deviations from the defined micronutrients and macronutrients needs as well as from the food cost. As a result, the solution of the model is optimal selection of the food intake, subject to minimize deviations from the defined goals. The measures are taken by organizing nutritious dietary menu for diabetes mellitus patients. Dietary menu with appropriate amount of nutrients is prepared by considering the amount of calories, proteins, fats and carbohydrates. In this study, Goal Programming model was employed to determine optimal menu variations for diabetes mellitus patients by paying attention to optimal expenses.

Keywords: goal programming, optimization, nutrients, food cost, constraints

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Introduction

Many models are suggested for diet using linear programming problem ,but the most important draw back of L.P.P is while balancing one nutrients in diet the other nutrients over shoots their daily demand resulting in over supply Nutritional balance diet using the L.P.P is not possible because there are many goals which need to be satisfied simultaneously which are very complex relationships of constraint .Goal programming method can be used to suggest the nutritional diet with less deviation in requirement of all nutrients. Goal programming is the extension of linear programming problem.

Due to change in life style of people, fast urbanization, and food habits is leading to many chronic disease like diabetes and hypertension Diabetes is one of the major non communicable disease which is major concern to the country.

Diabetes is fast gaining the status of a potential epidemic in India with more than 62 million diabetic individuals currently diagnosed with the disease. India ranked first in diabetes .Obesity is one of the major factor for diabetes. There are many factors which are affecting diabetes in India that are making this problem so extreme. Diabetes mellitus, is a persistent condition that results from either the inability of pancreas to produce required amount of insulin needed by the human body or as a result of inability of the bodily cells to make use of the insulin produced by the pancreas. Insulin is a hormone, produced by pancreas in the human body that controls the blood glucose levels. There are three types of diabetes

i)Type I :-In this type of diabetes production of insulin reduces in human body .This diabetes usually occurs to in age group less than 40 years

ii)Type 2:- Diabetes occurs due to the inability of human body to effectively use the insulin produced by pancreas

iii)Gestational diabetes:- It develops during pregnancy. A woman with gestational diabetes has her blood glucose levels higher than the normal levels.

Diet for a diabetic person

It has been prove that there is a highly positive correlation between the components of a diet and the corresponding variations in blood sugar levels. There is a linear relation ship between Glycaemic Index and blood sugar level change.

Glycemic Index (GI), is used as a ranking measure which depicts the glycemic response of human body based on the type of carbohydrates intake. GI is measured on a scale of 1-100. The GI of pure glucose is 100 and it is used as a reference to determine the glycemic indices of other food items. Food items that have larger values of GI is observed to result in large deviations in blood glucose levels. Foods with GI less than 36 is considered to result in low variations in glucose levels while foods with GI greater than 70 have larger glucose level deviations.

The blood glucose levels variations cannot be correctly studies only on the basis of Glycemic Index. This was so because GI only considers the type of food and does not take into consideration the quantity of carbohydrates in it, which is proportional to quantity of the food item. Thus a new factor namely Glycemic Load (GL) was introduced to incorporate this information and is given by,

$$Glycemic\ Load\ GL = (GI * Net\ Carbs)/100$$

Where netcarbs is total Carbohydrates minus Dietary Fibers

Foods with GL less than 10 are considered to be safe and the ones with GL greater than 20 are considered to be very risky for diabetic patients to eat.

Literature review

The goal programming has wide range of application .It can be applied to many fields, like investment ,banks ,share market ,diet plans ,road traffic and many more. Many surveys are done on goal programming any many books are available on the survey.

In 1983 Anderson and Earle did comparative study of diet planning suggested for daily requirement of nutrients using Goal programming and linear programming problem for Thais. In today's world where many people suffering with health issue ,selection of diets by quantitative techniques become very important. The main drawback of linear programming is the ability to maintained good balance nutrients. As overdoses of some nutrients is very dangerous so balance intake of nutrient is must.

Leslie[2] , In this paper they analysis there various factors which affect the caloric intake requirement of individuals for eg age weight ,height ,obesity ,person at rest , athlete, pregnancy or lactation ,gender etc. this model predicts their occur changes occurs in actual energy consumption of the population with respect to environment and demograpi also on activity. In this paper they showed the energy value is a function of gender ,age and activity and also show how these values differ from the recommended values by the Food Agriculture Organization

[3]Anayo Charles Iwuji, Emeka Uchendu Agwu(2017) presented a paper where they did comparison of weighted goal programming problem for dash diet with linear programming of dash diet. A daily dash diet chart for a hypertension person using linear programming was previously formulated and it satisfied minimum cost diet plan and tolerable intake of level of nutrients .The main draw back of selecting diet plan for some nutrients resulted in surplus supply of other nutrients. Anayo and Emeka developed a weighted goal programming model for dash diet. A comparsion in linear and Gp was done for sodium and calorie diet . The results proved that weighted dash diet GP has minimized the deviations from dash diet tolerable intake levels as compared to linear programming. They took dash food chart for for 1500 mg sodium level with different calories intake .They Also shown that there is very less deviation of 2.7% for fibre contained as compared to larger deviation for many nutrients in linear programming for their targeted dash diet.

[4]They proposed the goal programming model for man and woman to optimizes the required nutrients subjected to available house hold budget. There objective function was to minimize the deviation from the prescribed macro and micro nutrients and also the food cost. (WHO) world health organization has given the required nutrient needs which they incorporated in the model. Sample survey of 50 house hold in capital of Bosnia and Herzegovina was taken and studied the 55 mostly used food products as decision variables .The model gave the optimal section for food intake with minimum cost.

Assumption made for the model for the diabetic person.

The entire day meal is divided into five portions i)morning breakfast ii) mid morning snacks iii) lunch iv) evening snacks v) dinner. The main goal while preparing the diet for a diabetic person is i)blood glucose levels in the normal range or as close to normal as is safely possible ii) A lipid and lipoprotein profile that reduces the risk for vascular disease iii) Blood pressure levels in the normal range or as close to normal as is safely possible. Attain individualized glycemic, blood pressure, and lipid goals. General recommended goals from the American Diabetes Association (ADA) for these people are

i)A1C <7%
ii)Blood pressure,<140/80mmHg
iii)LDL cholesterol ,<100 mg/dL
iv)triglycerides <150 mg/dL
v)HDL cholesterol.>40 mg/dL for men
v)HDL cholesterol >50 mg/dL for women.

We have considered a menu for The calories intake depends on the height age size and physical activities of a person. Here we have considered a diet of 2000 calories intake daily with glycemic index should be less then 70 for a diabetic person

Nutrients	Units of measure	Daily values
Total carbohydrate	grams (g)	300
Total Fat	grams (g)	65
Cholesterol	milligrams (mg)	300
Sodium	milligrams (mg)	2400
Potassium	milligrams (mg)	3500
Fiber	grams (g)	25
Protein	grams (g)	50
Vitamin A	International Unit (IU)	5000
Vitamin C	milligrams (mg)	60
Calcium	milligrams (mg)	1000
Iron	milligrams (mg)	18
Vitamin D	International Unit (IU)	400

Goa-1: "Glycaemic index goal": To minimize the overachievement the tolerate level of glycaemic index G
Goal-2 "Cost goal" : Minimize the overachievement of food cost daily in Rupees C_{RS}
Goal-3 "Protein goal" : Minimize the underachievement of required intake level of protein in grams P_g
Goal -4 "Sodium" : Minimize the overachievement of the acceptable requirement for the Level of sodium in miligrams Na_{mg}
Goal-5 "Carbohydrate" :Minimize the overachievements of the acceptable amount of carbohydrate's required
Goal -6 "Fat minimize" :Minimize the overachievement of required amount of fats
Goal -7 "Cholesterol" :Minimize the overachievement of required amount of daily intake of cholesterol Col
Goal-8 "Iron Goal": Minimize the underachievement of required level for the intake of iron in grams Fe_{mg}
Goal -9 "(Potassium goal)": Minimize the underachievement of the required intake Level of potassium in mg, K
Goal -10 "VitaminA" :Minimize the underachievement of daily intake of acceptable intake of Vitamin A In IU V_A

Gaol -11 "Vitamin B": Minimize the underachievement of daily intake of acceptable intake of Vitamin B In grams V_B
Goal-12 "Vitamin C": Minimize the underachievement of daily intake of acceptable intake of Vitamin C In grams V_c
Gaol 13 "Calories" :To minimize overachievement the daily acceptable intake of Calories (cal)
Goal 14 "Fiber goal": Minimize the underachievement of the required Intake Level of fibers in grams (F
Goal-15: "Vitamin D": Minimize the underachievement of required vitamin D V_D

Goal programming model

Minimize $Z=d_G^+ + d_C^+ + d_p^- + d_{Na}^+ + d_{carb}^+ + d_{Fat}^{\mp} + d_{col}^+ + d_{Fe}^- + d_k^- + d_{V_A}^- + d_{V_B}^- + d_{V_c}^- + d_{cal}^+ + d_{cal}^- + d_F^- + d_{V_D}^-$

Subjected to the constrains

$$c_1x_1 + c_2x_2 + \cdots \ldots . c_nx_n - d_C^+ = C$$

Cost constraints

$$a_{11}x_1 + a_{12}x_2 + \cdots \ldots \ldots . a_{1n}x_n - d_G^+ = G$$

Glycemicx index constaint

$$a_{21}x_1 + a_{22}x_2 + \cdots \ldots \ldots . a_{2n}x_n + d_p^- = P$$

Protein constraints

$$a_{31}x_1 + a_{32}x_2 + \cdots \ldots \ldots . a_{3n}x_n - d_{Na}^+ = Na$$

Sodium constraints

$$a_{41}x_1 + a_{42}x_2 + \cdots \ldots \ldots . a_{4n}x_n - d_{carb}^+ = carb$$

Constaints on carbohydrates

$$a_{51}x_1 + a_{52}x_2 + \cdots \ldots \ldots . a_{5n}x_n - d_{Fat}^+ = Fat$$

Constraints on fats

$$a_{61}x_1 + a_{62}x_2 + \cdots \ldots \ldots . a_{6n}x_n - d_{col}^+ = col$$

Constraints on cholestrols

$$a_{71}x_1 + a_{72}x_2 + \cdots \ldots \ldots . a_{7n}x_n + d_{Fe}^- = Fe$$

Constaints on Iron

$$a_{81}x_1 + a_{82}x_2 + \cdots \ldots \ldots . a_{8n}x_n + d_k^- = K$$

Constraint on potassium

$$a_{91}x_1 + a_{92}x_2 + \cdots \ldots \ldots . a_{9n}x_n + d_{V_A}^- = V_A$$

Constraint on vitamin-A

$$a_{101}x_1 + a_{102}x_2 + \cdots \ldots \ldots . a_{10n}x_n + d_{V_B}^- = V_B$$

Constraint on vitamin-B

$$a_{111}x_1 + a_{122}x_2 + \cdots \ldots \ldots . a_{912}x_n + d_{V_c}^- = V_C$$

Constraint on vitamin-C

$$a_{12\,1}x_1 + a_{12\,2}x_2 + \cdots \ldots \ldots . a_{12\,n}x_n + d_{cal}^- - d_{cal}^+ += Cal$$

Constraint on calcium

$$a_{131}x_1 + a_{13\,2}x_2 + \cdots \ldots \ldots . a_{14\,n}x_n - d_F^- = F$$

Constraint on Fibers

$$a_{91}x_1 + a_{92}x_2 + \cdots \ldots \ldots . a_{9n}x_n + d_{V_D}^- = V_D$$

Constraint on vitamin-D

$$d_G^+, d_C^+, d_p^-, d_{Na}^+, d_{carb}^+, d_{Fat}^{\mp}, d_{col}^+, d_{Fe}^-, d_k^-, d_{V_A}^-, d_{V_B}^-, d_{V_c}^-, d_{cal}^+, d_{cal}^-, d_F^-, d_{V_D}^- \geq 0$$

Where ,

$d_G^+, d_C^+, d_{Na}^+, d_{carb}^+, d_{Fat}^{\mp}, d_{col}^+, d_{cal}^+ and\ d_p^-, d_{Fe}^-, d_{V_A}^-, d_k^-, d_{V_B}^-, d_{cal}^-, d_F^-, d_{V_D}^-\ \ d_{V_c}^-$

Are the over and underachievement of glycaemicindex,cost,sodium,carbohydrates,fat,cholesterol,calories,potassium,iron,vitamin A, vitamin B, vitamin C, fibre vitamin D,vitaminC respectively.

We have considered weight of 1 to the necessary deviations and zero to the deviations which were not required.

a_{ij} = Quantity of ith nutrient in jth food

C_j , cost of 1 serving of jth food

x_j= is the number of servings of food j in the diet plan.

C is the budget cost of the diet

G, Na ,carb ,Fat, col, cal, p, Fe, V_A, k , V_B, F,V_C, V_D are impartial level of nutrients required in daily diet.

Conclusion:

Diet menu planning for diabetic person requires extra attention .The extra care for their glycemix index need to be taken care of .One needs to carefully while planning so that the proper nutients is provided and a proper balance of carbohydrates ,fat and proteins. It is very important to maintain the blood sugar level of the person.This model can be used to decide the diet for a diabetic person.one can find the deviation in the target level of nutrients .Looking at the routine diet this model can be used to suggest the changes in the daily diet .For calculation LINDO software can be used to recommend menu variations and appropriate total calories and with minimum expenses can be obtained

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