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Optimal Dietary Allocation to Reduce the Risk of Overweight and Obesity

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ABSTRACT

In this paper, we developed a transportation model for dietary allocation to reduce the risk of overweight and obesity. Our interest was on macronutrients such as carbohydrate, fat and oil and protein diets. These diets are the chief supplier of calories used by the body to perform its metabolic activities. The maximum cost method was used to determine the optimal calories per week from the intake of high fat diet and we found that the calorie required is 478.8 Kcal and average daily required intake is 68.4 Kcal. Again, the least cost method was used to determine the optimal calories per week from the intake of low carbohydrate diet and we found that the calorie required is 681.7 Kcal and average daily required intake is 97.4 Kcal. Comparing the calories from both diets, we conclude that consumption of diet with high fat produce less calories, and hence should reduce the risk of overweight and obesity compared to the consumption of carbohydrate diet even in low quantity. Since calorie is calorie irrespective of its source, we recommend taking high fat diet than taking low carbohydrate diet to reduce the risk of overweight and obesity. The determined daily calories are the minimum calories required by the body to maintain its metabolic activities, more of it will lead to excess and accumulation in the body which will lead to overweight and obesity.

***Keywords*:** Optimal dietary allocation, Obesity, Overweight, Health implications, Transportation model

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1. INTRODUCTION

The rate at which over weight; obesity; type 2 diabetes and related disease are increasing is alarming. Overweight, obesity and diabetes as a health condition cut across the globe and have a strong link with the nature of food intake by individual. Increase in carbohydrate at the expense of fat has contributed to the obesity epidemic [1]. Findings show that a lower fat, relatively higher carbohydrate diet appears to be less likely to promote excessive weight gain and be associated with a lower cardio-metabolic risk profile. Low-fat diets were advocated based on associations between dietary fat intake and cardiovascular risk but evidence based on research shows that low-fat diets might not be optimum for weight management [2]. Based on the outcome of researches, it was reported that reductions in weight favours lower carbohydrate (LoCHO) diet and against lower fat (LoFAT) diet. Comparing those on LoFAT diets, those on LoCHO diets experienced statistically significantly greater reduction in body weight.

The amount of calories people eat and drink has a direct impact on their weight [3]. This study shows that there are foods and diet patterns that protect against heart disease, stroke, diabetes, and other chronic conditions, and the foods that help prevent disease also help with weight control, and such foods are whole grains, vegetables, fruits, and nuts. Many of the foods that increase disease risk such as, refined grains and sugary drinks are factors in weight gain. The researchers found that taking a lower fat diet does not have advantage over taking a moderate or high fat diet in terms of weight loss and prevention of disease. Lower fat diets are high in carbohydrate and increase the risk of weight gain, diabetes, and heart disease. Replacing red and processed meat with nuts, beans, fish, or poultry will lower the risk of heart disease, diabetes and help with weight control.

Carbohydrate quality is much more important than its quantity. Milled, refined grains and the foods made with them, such as white rice, white bread, white pasta, processed breakfast cereals, etc are rich in rapidly digested carbohydrate. So are potatoes and sugary drinks. It is said that this type of food have a high glycemic index and glycemic load. Such foods cause fast increases in blood sugar and insulin that, in the short term, can cause hunger, which will lead to overeating. This will increase the risk of weight gain, diabetes, and heart disease. Whole grains-whole wheat, brown rice, barley, etc in their less-processed forms-are digested more slowly than refined grains. So they have a gentler effect on blood sugar and insulin, which help subside hunger and prevent weight gain. Fruits and vegetables are high in water, which may help people feel fuller on fewer calories. Hence, eating nuts does not lead to weight gain and instead help with weight control because nuts are rich in protein and fiber, both of which help people feel fuller and less hungry.

Overweight or obesity is measured by the body mass index (BMI). Body mass index is the quotient of a person's weight to height measured in kg/m^2. In other words, it is the ration of a person's weight in kilograms to the square of the person's height in meters. Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and increased health problems. People are considered obese when their body mass index (BMI) exceeds 30 kg/m^2. Obesity increases the likelihood of heart disease, diabetes, obstructive sleep apneas, cancer; osteoarthritis etc. On the other hand, over weight is a medical condition in which an individual has more body fat that is optimally healthy. It is defined as a body mass index (BMI) of 25 kg/m^2 or more but less than 30 kg/m^2. Our interest in this paper deviates a little bit from other researchers' work in the sense that we want to determine the optimal combination of diets that

will minimize the calories intake. Our aim is to develop a transportation model for optimal dietary allocation to reduce the risk of overweight and obesity. The specific objectives are:

i. To determine the combination of diets that will yield optimal calories.
ii. To determine the starting basic calories per day.

This paper is divided into five sections. Section one above gives the general introduction of the work. Section two is devoted to literature review. Section three takes care of materials and methods. Section four takes care of data presentation and analysis while section five treats results and discussions.

2. LITERATURE REVIEW

Overweight and obesity is a global concern because it knows no boundary. China, which was once known to have one of the leanest populations, is fast catching up with the West in terms of the prevalence of overweight and obesity [4]. The authors observed that the transition has occurred in a remarkably short period of time and that the data from the 2002 national nutrition and health survey showed that 14.7% of Chinese were overweight (body mass index (BMI; kg/m^2) >25) and another 2.6% were obese (BMI > 30). Again, data from the China national surveys on the constitution and health in school children showed that the prevalence of overweight and obesity in children aged 7-18 years increased 28 times and obesity increased four times between 1985 and 2000 (figure), a trend that was particularly marked in boys. The explanations of China's recent epidemic of overweight and obesity include changes to the traditional diet, reduced levels of physical activity and increased sedentary lifestyles. In a similar study, some authors [5] found that Overweight and obesity are becoming increasingly prevalent in both developed and developing world and present one of the most serious public health challenges of the 21st century.

Childhood obesity in particular has increased dramatically over the past 2 decades. They observed that approximately 1 in 4 UK and Australian children and 1 in 3 US children are overweight or obese. They were of the opinion that although overweight and obesity typically have their greatest impact later in life, obesity in childhood is also associated with a range of immediate health problems. Despite the rapid increase in prevalence of childhood obesity, capacity to address the problem seems limited. We can see that overweight and obesity cut across children and adult; hence, the need to see it as emerging trend that should be dealt with before it become out of control.

It was observed that children are also experiencing complications of overweight that were recently found in adults [6]. Type 2 diabetes, hypertension, and other complications of overweight that were not seen until adulthood in years past are now emerging in children. As the prevalence of overweight among children has risen, pediatric hypertension has become more common. Hypertension and pre-hypertension have become significant issues in children's health due to the strong association of high blood pressure with overweight and the increase in the prevalence of overweight in the pediatric population.

It is now clear that primary hypertension is detectable in the young and occurs commonly. Among school-age children, the prevalence of hypertension increases as the BMI percentile increases. Studies have shown that hypertension is associated with elevated BMI in children. But overweight children were children whose BMI with respect to age and gender fell at the

95th percentile or higher, based on a national norm. At-risk-for-overweight children were children whose BMI with respect to age and gender fell between the 85th percentile and the 95th percentile, and not-at-risk-for-overweight children were children whose BMI with respect to age and gender fell below the 85th percentile. Hypertensive children were children whose systolic blood pressure and/or diastolic blood pressure were in the 95th percentile or higher relative to age, gender, and height, based on a national norm. Pre-hypertensive children were children whose systolic and/or diastolic blood pressure relative to age, gender, and height was between the 90th percentile and the 95th percentile, and normal blood pressure children were children whose systolic and diastolic blood pressure relative to age, gender, and height was less than the 90th percentile [7].

Negative evaluations of overweight are internalized as self-rejection. The attempt to fit society's norms of appearance may be more stressful than not fitting them. Constant attempt to diet and lose weight may be the distressing part of overweight, not simply being overweight per se. Overweight may be distressing for its physical implications than its social meaning [8]. Comparing people of normal weight to those of overweigh, the overweight report worse physical health, a major correlate of psychological distress. About two thirds of adults and a third of children were either overweight or obese. Overweight and obesity are associated with an increased risk of hypertension, type 2 diabetes, musculoskeletal disease, stroke, cardiovascular disease, several cancers, and other diseases [9]. Despite the risks associated with overweight, the evidence shows that many people do not recognize the condition in themselves or their children. The researchers reported that there is an association between the number of fast food restaurants per 100,000 population and area level deprivation, which may suggest that people living in deprived areas have easier access to cheap, palatable, energy dense food that lacks nutritional value. However, concern about the effect of fast food outlets is growing and there are indication that children who live near fast food restaurants are more likely to be overweight. Also geographical exposure to fast food outlets is associated with an increased body mass index and obesity in adults.

Some authors observed that UK governments have tried to address overweight and obesity at the population level through campaigns to encourage healthier diets and increase physical activity. These campaigns are designed around discourses of individual responsibility for health and informed choice. However, obesity rates continue to rise, indicating that more radical policies may have to be developed to address the problem of overweight and obesity [10]. Indeed, while there was general disagreement with structural attributions as a cause of overweight, there was a high level of agreement that unhealthy foods were too readily available. Nevertheless, the outcome of their research indicated that agreement was highest for attributions that focused on personal responsibility for weight through lack of will power to diet and exercise. Conversely, genetic predisposition was considered the least important determinant of obesity. These findings support previous work that argues that food manufacturers have been successful in promoting a discourse of personal responsibility in relation to food consumption and obesity.

There are indications, however, that the UK public also recognizes the culpability of food retailers and manufacturers in making healthier choices more difficult. Again, the unique thing about obesity is that it does not need a scientific breakthrough to be treated successfully. Enough is known about the causes of obesity and that diet, exercise, behaviour therapy, drugs and surgery can be effective. In the long term, the cheapest and most effective strategy to improve the health of the population may be to prioritize and provide incentives for the management of

obesity [11]. The metabolic and vascular benefits of even modest reductions in weight are well described. Weight loss also enhances fertility in women, improves respiratory function and mental wellbeing, reduces risk of cancers and joint disease, and improves quality of life. Obesity management includes priority treatment of risk factors for cardiovascular disease. Primary prevention of obesity and overweight would prevent much secondary disease. And the health consequences of obesity include: diabetes, hypertension, dyslipidaemia, breathlessness, sleep apnea, gall bladder disease, coronary heart disease or heart failure, osteoarthritis, hyperuricaemia and gout, complications of pregnancy, cancer, impaired fertility/polycystic ovary syndrome, low back pain, increased risk during anaesthesia and fetal defects.

Obesity has a colossal impact on physical, mental, and social ill-health in many parts of the world. Without effective action, expanding waists in ageing populations and the associated health problems will present enormous financial burdens for future generations [12].

The prevalence of obesity is already above the critical threshold of 15% set by the World Health Organization for epidemics needing intervention. However, obesity was associated with certain behaviour among the children in the first three years of life, including watching television more than four hours a day and having only short periods of sleep, and with maternal smoking. Dietary factors related to childhood obesity, such as the consumption of sugary drinks, have been documented. Public health measures against obesity cannot ignore the increasing prevalence of obesity in childhood, but must focus on the much more increase in body fat across the whole population. New economic analyses help dispel the myth of people getting fatter but eating less. Consumption of "supersize" food portions will accelerate obesity.

Both sides of the energy balance equation must be tackled; such that people can move a little more, eat a little less. People will need better education about activity and diet, but a sustainable reduction in obesity will also require the food and exercise industries to work with consumers. Again, obesity is a well-established risk factor for many chronic health conditions, including cardiovascular disease, several types of cancer and type 2 diabetes. The treatment and consequences of obesity-related health condition impose an increased economic burden on health care system, employers, families and individuals. Obesity has been estimated to account for 2% to 7% of health care costs in developed countries: in Canada, the cost of obesity has been estimated to account for 2.2-4.1% of health care costs. The cost of excess weight represents a considerable economic and social burden to the health care system and provides further rationale for the development and implementation of comprehensive programs and policies to prevent and reduce obesity [13].

Finally, changes in the social environment over recent years could have affected weight perceptions in several ways. Increased attention to the "obesity epidemic" and publicity channeled through the media and health professionals to encourage appropriate action for weight control might be expected to promote recognition of overweight. There has also been an emphasis on positive body images for young women, which should have reduced inaccurate perceptions of overweight among normal weight women. Accuracy in self diagnosing overweight can be approached with the diagnostic concepts of sensitivity and specificity [14].

Sensitivity is the proportion of truly overweight people, who identify themselves as such, while specificity is the proportion of people who are not overweight who identify themselves correctly as not overweight.

If the combined emphasis on public awareness of the risks of obesity and promotion of a healthy body image in young women has been successful, then both sensitivity and specificity of self diagnosed overweight should have increased.

3. MATERIALS AND METHODS

In this paper, we develop transportation model for the optimal allocation of dietary combination that will reduce the risk of overweight and obesity. Transportation problem involve a number of shipping source and a number of destinations. Each shipping source has a certain capacity and each destination has a certain requirement associated with a certain cost of shipping from the source to the destinations. The objective is to minimize the cost of transportation while meeting the requirements at the destinations. The matrix used in the transportation models consists of squares called "cells", which when taken from "columns vertically and "rows" horizontally, the cells located at the intersection of row and a column is designated by its row and column headings. Unit costs are placed in each cell.

Transportation models deal with problems concerning as to what happens to the effectiveness function when we associate each of a number of origins (sources) with each of a possibly different number of destinations. The total movement from each origin and the total movement to each destination is given and is desired to find how the associations be made subject to the limitations on totals. In such problems, sources can be divided among the jobs or jobs may be done with a combination of sources. The distinct feature of transportation problems is that sources and jobs must be expressed in terms of only one kind of unit.

Suppose that there are m sources and n destinations, let a_i be the number of supply units available at source i (i= 1, 2, . . . , m) and let b_j be the number of demand units required at destination j (j = 1, 2, . . . , n). Let C_{ij} represent the unit transportation cost for transporting the units from sources i to destination j. The objective is to determine the number of units to be transported from source i to destination j so that total transportation cost is minimum. In addition, the supply limits at the sources and the demand requirements at the destinations must be satisfied exactly. If X_{ij} ($X_{ij} \geq 0$) is the number of units shipped from source i to destination j, then the Transportation model for the optimal dietary allocation will be

$$\text{Minimize } Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij} \tag{1}$$

Subject to

$$\sum_{j=1}^{n} X_{ij} = a_i; \qquad i = 1,..,m$$

$$\sum_{i=1}^{m} X_{ij} = b_j; \qquad j = 1,..,n$$

where $X_{ij} \geq 0$ and Z is the objective function

C_{ij} is the transportation cost associated with the calories (X_{ij}) required in each cell, a_i is the total calories available while b_j is the total calories demanded by individuals. The two sets of constraints will be consistent, that is, the system will be in a balance if

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j \tag{2}$$

See [15] and [16]. And for us to have a good understanding of the transportation model, we define the following terms, thus;

Feasible Solution to the transportation problem is a set of non-negative values that satisfies the constraints equations.

Basic feasible solution is a feasible solution to the transportation problem that contains no more than (m + n – 1) non-negative allocations.

Optimal solution is a feasible solution if it minimizes the total transportation cost.

Balanced and Unbalanced Transportation Problems occur if the total supply from all the resources equals the total demand in all the destinations and is called unbalanced if otherwise.

Thus, for a balanced problem, $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$ and for unbalanced problem, $\sum_{i=1}^{m} a_i \neq \sum_{j=1}^{n} b_j$.

Our interest is to minimize the objective function (that is the optimal dietary allocation to reduce the risk of overweight and obesity) subject to demand and supply from the available diets.

4. DATA PRESENTATION AND ANALYSIS

4. 1. Data Presentation

Table 1. Percentage of Macronutrients Available per Day.

DAYS	Percentage of Nutrients Available			Supply (Kcal)
1	30% - fat	35% - fat	20% - fat	2.9
	50% - carb	45% - carb	60% - carb	
	20% - prot	20% - prot	20% - prot	
2	23% - fat	38% - fat	18% - fat	2.8
	56% - carb	49% - carb	53% - carb	
	21% - prot	13% - prot	29% -prot	
3	40% - fat	30% - fat	25% - fat	2.7
	45% - carb	50% - carb	55% - carb	
	15% - prot	20% - prot	20% - prot	
4	20% - fat	32% - fat	35% - fat	3
	55% - carb	50% - carb	45% - carb	
	25% - prot	18% - prot	20% - prot	

5	28% - fat	36% - fat	20% - fat	2.9
	45% - carb	44% - carb	55% - carb	
	27% - prot	20% - prot	25% - prot	
6	40% - fat	32% - fat	30% - fat	3.1
	40% - carb	50% - carb	50% - carb	
	20% - prot	18% - prot	20% - prot	
7	22% - fat	25% - fat	35% - fat	2.7
	53% - carb	55% - carb	45% - carb	
	25% - prot	20% - prot	20% - prot	
Demand (Kcal)	5.5	4.2	5	

Source: Survey 2020.

Table 1 presents the percentage of macronutrient available for individuals on a daily bases. Cab represents carbohydrate; prot represent protein and Kcal represent Kilo calories

4. 2. Data Analysis

We observed from Table one that equation (2) was not satisfied, hence the need to create a dummy supply with zero calories to balance it, see Table 2.

Table 2. Nutritional matrix indicating the demand and supply.

DAYS	1	2	3	4	Supply (Kcal)
1	30% - fat	35% - fat	20% - fat	0	2.9
	50% - carb	45% - carb	60% - carb		
	20% - prot	20% - prot	20% - prot		
2	23% - fat	38% - fat	18% - fat	0	2.8
	56% - carb	49% - carb	53% - carb		
	21% - prot	13% - prot	29% -prot		
3	40% - fat	30% - fat	25% - fat	0	2.7
	45% - carb	50% - carb	55% - carb		

	15% - prot	20% - prot	20% - prot		
4	20% - fat	32% - fat	35% - fat	0	3
	55% - carb	50% - carb	45% - carb		
	25% - prot	18% - prot	20% - prot		
5	28% - fat	36% - fat	20% - fat	0	2.9
	45% - carb	44% - carb	55% - carb		
	27% - prot	20% - prot	25% - prot		
6	40% - fat	32% - fat	30% - fat	0	3.1
	40% - carb	50% - carb	50% - carb		
	20% - prot	18% - prot	20% - prot		
7	22% - fat	25% - fat	35% - fat	0	2.7
	53% - carb	55% - carb	45% - carb		
	25% - prot	20% - prot	20% - prot		
Demand (Kcal)	5.5	4.2	5	5.4	

Table 2 presents the nutritional matrix indicating the proportion of nutrients available; the demand and supply in kilo calories. We have noted in the short run that protein does not increase body weight, and therefore we should not bother about the percentage of protein required on daily calories.

Formulation of the Model:

Step 1: the variables X_{ij} in Table 3 below represent the percentage macronutrients available in a combination of diets per day and measured in kilo calories (KCal). We seek to minimize the calories present in these diets. Supply represent the proportion of the calories made available to the individual while the Demand represents the calories the individual takes per day. These can be represented in the matrix shown in Table 3 below.

Table 3. Distribution of the macronutrients.

Sources	Cost Matrix				Supply
1	X_{11}	X_{12}	X_{13}	X_{14}	S1
2	X_{21}	X_{22}	X_{23}	X_{24}	S2

…	…	…	…	…	…
7	X_{71}	X_{72}	…	X_{74}	S7
Demand	D1	D2	D3	D4	XXX

The sum of demand (D1, …, D4) must be equal to the sum of supply (S1, . . ., S7) for the problem be feasible.

Step 2: feasible alternatives are sets of values of X_{ij} ; $X_{ij} \geq 0$.

Step 3: objective is to minimize the daily calories to reduce the risk of overweight and obesity

$$\text{Max (Min) } Z = C_{1j}X_{1j} + \ldots + C_{5j}X_{5j} + \ldots + C_{74}X_{74}$$

We can either maximize fat consumption by taking nutrients high in fat or minimize carbohydrate consumption by taking nutrient low in carbohydrate. Each of these will reduce the calorie intake per day; and hence, reduce overweight and obesity.

In general, if C_{ij} is the percentage nutrient shipped from ith source to jth destination, the objective is to:

$$\text{Max (Min) } Z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$$

Subject to the following constraints:

Step 4: constraints due to supply:

$X_{11} + X_{12} + \ldots + X_{14} = S1$
$X_{21} + X_{22} + \ldots + X_{24} = S2$
$\ldots + \ldots + \ldots + \ldots = \ldots$
$X_{71} + X_{72} + \ldots + X_{72} = S7$

$$\sum_{j=1}^{n} X_{ij} = a_i; \qquad i = 1, .., m.$$

because of requirement or demand:

$X_{11} + X_{21} + \ldots + X_{71} = D1$
$X_{12} + X_{22} + \ldots + X_{72} = D2$
$X_{13} + X_{23} + \ldots + X_{73} = D3$
$X_{14} + X_{24} + \ldots + X_{74} = D4$

In general, there are n constraints if the number of destination is n, which can be expressed as

$$\sum_{i=1}^{m} X_{ij} = b_j; \qquad j = 1, .., n.$$

Solution of the Transportation Model

The Maximum (Least) Cost Method:

We adopted the least cost method of solution because our interest is to minimize the calorie intake per day in order to reduce the risk of overweight and obesity.

This rule may be stated as follows:

(i). start from the first row and compare the supply of nutrient by source 1 (call it S_1) with the requirement for nutrient from demand (call it D_1).

(a). if $D_1 < S_1$, set X_{ij} equal to D_1 and proceed to row 2.

(b). if $D_1 = S_1$, set X_{ij} equal to D_1 and proceed to row 3.

(c). if $D_1 > S_1$, set X_{ij} equal to S_1 and proceed to row 4.

(ii). continue in this manner, row by row until the last row (row 7).

Table 4 presents the maximum allocation of fat to produce the amount of calories that will reduce obesity and overweight, while Table 5 presents the minimum allocation of carbohydrate to produce the amount of calories that will reduce obesity and overweight.

Solution 1: By maximizing the fat intake

Table 4. Solution Table.

DAYS	1	2	3	4	Supply (Kcal)
1	30% - fat	35 (2.9)	20% - fat	0	2.9 – 2.9 = 0
	50% - carb	45% - carb	60% - carb		
	20% - prot	20% - prot	20% - prot		
2	23 (1.5)	38 (1.3)	18% - fat	0 (1.5)	2.8 - 1.3 = 1.5 – 15 = 0
	56% - carb	49% - carb	53% - carb		
	21% - prot	13% - prot	29% -prot		
3	40 (2.7)	30% - fat	25% - fat	0	2.7 – 2.7 = 0
	45% - carb	50% - carb	55% - carb		
	15% - prot	20% - prot	20% - prot		
4	20% - fat	32% - fat	35 (3)	0	3 – 3 = 0
	55% - carb	50% - carb	45% - carb		
	25% - prot	18% - prot	20% - prot		

5	28 (1.3)	36% - fat	20(1.6)	0	2.9 - 1.3 = 1.6 1.6 -1.6 = 0
	45% - carb	44% - carb	55% - carb		
	27% - prot	20% - prot	25% - prot		
6	40% - fat	32% - fat	30 (0.4)	0 (2.7)	3.1 – 0.4 =2.7 2.7-2.7 = 0
	40% - carb	50% - carb	50% - carb		
	20% - prot	18% - prot	20% - prot		
7	22% - fat	25% - fat	35% - fat	0 (2.7)	2.7 - 2.7 = 0
	53% - carb	55% - carb	45% - carb		
	25% - prot	20% - prot	20% - prot		
Demand (Kcal)	5.5 -1.5= 4.0 -2.7=1.3- 1.3=0	4.2–2.9 = 1.3 -1.3=0	5 – 3=2-1.6 = 0.4 - 0.4 = 0	5.4-2.7 =2.7 -2.7=0	20.1

The starting basic dietary allocations are: $X_{12} = 2.9$; $X_{21} = 1.5$; $X_{22} = 1.3$; $X_{24} = 1.5$; $X_{31} = 2.7$; $X_{43} = 3$; $X_{51} = 1.3$; $X_{53} = 1.6$; $X_{63} = 0.4$; $X_{64} = 2.7$; $X_{74} = 2.7$

The maximum calories required for reducing the risk of overweight and obesity per week from the data is:

Maximum calories = 35 (2.9) + 23(1.5) + 38(1.3) + 0(1.5) + 40(2.7) + 35(3) + 28 (1.3) + 20(1.6) + 30(0.4) + 0(2.7) + 0(2.7) = 478.8 Kcal

Daily calories required for reducing the risk of overweight and obesity is: 68.4 Kcal.

Solution 2: By minimizing the carbohydrate intake

Table 5. Solution Table

DAYS	1	2	3	4	Supply (Kcal)
1	30% - fat	35% - fat	20% - fat	0	2.9 - 2.9 = 0
	50% - carb	45(2.9)	60% - carb		
	20% - prot	20% - prot	20% - prot		
2	23% - fat	38% - fat	18% - fat	0	2.8-1.3 = 1.5-1.5 = 0
	56% - carb	49(1.3)	53(1.5)		

	21% - prot	13% - prot	29% -prot		
3	40% - fat	30% - fat	25% - fat	0	2.7-2.7 = 0
	45(2.7)	50% - carb	55% - carb		
	15% - prot	20% - prot	20% - prot		
4	20% - fat	32% - fat	35% - fat	0	3-3 = 0
	55% - carb	50% - carb	45(3)		
	25% - prot	18% - prot	20% - prot		
5	28% - fat	36% - fat	20% - fat	0	2.9-2.8 = 0.1-0.1 = 0
	45(2.8)	44% - carb	55(0.1)		
	27% - prot	20% - prot	25% - prot		
6	40% - fat	32% - fat	30% - fat	0(2.7)	3.1-0.4 = 2.7-2.7 = 0
	40% - carb	50% - carb	50(0.4)		
	20% - prot	18% - prot	20% - prot		
7	22% - fat	25% - fat	35% - fat	0(2.7)	2.7-2.7 = 0
	53% - carb	55% - carb	45% - carb		
	25% - prot	20% - prot	20% - prot		
Demand (Kcal)	5.5-2.7 = 2.8 -2.8 = 0	4.2 - 2.9 = 1.3 -1.3 = 0	5 -1.5 = 3.5 - 3 = 0.5 - 0.1 = 0.4 - 0.4 = 0	5.4-2.7 = 2.7-2.7 = 0	20.1

The starting basic dietary allocations are: $X_{12} = 2.9$; $X_{22} = 1.3$; $X_{23} = 1.5$; $X_{31} = 2.7$; $X_{43} = 3$; $X_{51} = 2.8$; $X_{53} = 0.1$; $X_{63} = 0.4$; $X_{64} = 2.7$; $X_{74} = 2.7$

Maximum calories = 45(2.9) + 49(1.3) + 53(1.5) + 45(2.7) + 45(3) + 45(2.8) + 55(0.1) + 50(0.4) + 0(2.7) + 0(2.7) = 681.7 Kcal

Daily calories required to reducing the risk of overweight and obesity is: 97.4 Kcal.

5. DISCUSSIONS

The maximum cost method was used to determine the optimal calories per week from the intake of high fat diet and we observed that the calorie required is 478.8 Kcal and average daily

required intake is 68.4 Kcal. From the data analysis, these are the calories required to reduce the risk of overweight and obesity per week and per day respectively on individuals. On the other hand, the least cost method was used to determine the optimal calories per week from the intake of low carbohydrate diet and we found that the calorie required is 681.7 Kcal and average daily required intake is 97.4 Kcal.

Comparing the calories from both diet, we conclude that consumption of diet with high fat produce less calories, and hence should reduce the risk of overweight and obesity than the consumption of carbohydrate diet even in low quantity, since calories is calories irrespective of the source. This determined daily calories are the minimum calories required by the body to maintain its metabolic activities, more of it will lead to excess and accumulation which will lead to overweight and finally to obesity.

6. CONCLUSIONS

Overweight and obesity are health conditions that pose a lot of threat to human lives. From the literature in this paper, we saw different terminal diseases that are linked to them, such as diabetes, heart failure, osteoarthritis, etc. We have learnt that overweight and obesity are on the increase and many factors are responsible for it. The type and nature of diet intake is the chief cause of obesity, which ultimately result into so many health challenges. Type 2 diabetes is caused by obesity. Since this can be reduced or eradicated by being careful over the type and nature of diet intake, we embark on this study to contribute our own quota to the eradication of overweight and obesity. We developed a transportation model for dietary allocation. Our interest was on macronutrients such as carbohydrate, fat and oil and protein diets. These diets are the chief supplier of calories used by the body to perform its metabolic activities. From the literature, the consumption of protein diet does not pose danger to health with respect to its storage in the body in the short run.

The two major diets that causes overweight and obesity are fat and carbohydrate. This is the reason we concentrated on them. Researches favour high fat intake than low carbohydrate intake in weight reduction. We use the maximum and least cost method to determine the diet that yields more calories per day and over a period of one week. We discovered that high fat diet yield lower calories compared to even low carbohydrate diet. Since calorie is calorie no matter its source, we recommend taking of more fatty food than taking starchy food to reduce the risk of overweight and obesity.

This finding is in line with other researches that favour the intake of high fat diet than taking even low carbohydrate diets. Carbohydrate, refined food, sugary drinks, etc are the culprit and major cause of obesity.

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