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A Preliminary Development of an Integer Goal Programming Model for the Diet Planning of Malaysian Adolescent Athletes

Zuraida Alwadood[a]*, Nur Fadhlin Husna Ayob[b], Norlenda Mohd Noor[c]

[a, b ,c]*School of Mathematical Sciences, College of Computing, Informatics and Media, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*

[a]*Email: zuraida794@uitm.edu.my*, [b]*Email: fadhlinhusna98@gmail.com*, [c]*Email: norlenda@uitm.edu.my*

Abstract

Adolescent athletes need good nutrient intake to support the high level of daily physical activity and the growth development. This paper presents the preliminary works in the development of an integer goal programming model with the objective to produce a nutritious daily diet menu plan that best satisfy the nutrient requirement intake for Malaysian adolescent athlete aged between 13 to 18 years old. To identify the required nutrition, this study put forward the analysis on the varieties of nutrition that are required by adolescent athletes. To formulate the new mathematical model, a cross analysis among past studies which employed mathematical programming techniques in diet planning problem is comprehensively presented. This analysis investigated the elements that constitutes a mathematical model, which are the model objective functions, constraints, sets and parameters. A set of model objective functions which maximize protein intake while minimizing fat consumption is the anticipated novelty of this study. The solution to the mathematical programming model is expected to be referred as a guideline for sport schools to prepare nutritious diet meals for Malaysian adolescent athletes.

Keywords: Mathematical Programming Model; Diet Planning; Adolescent Athletes.

1. Introduction

Adolescent athletes who undergo physical training and sit for academic classes are normally placed in a special training centre or sport school hostels. Since the adolescent athletes undergo extensive physical training every day, therefore the meals provided by the school must contain sufficient nutrients to support physical training and growth development of the adolescents. A good meal consumption can satisfy their daily nutritional requirement and allows them to obtain optimal nutrient levels through food intake.

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* Corresponding author.

As a result, a special designated menu for adolescent athletes is strongly needed. One of the methods to produce the best list of menus with the optimum nutrients is by using mathematical programming model approach. A mathematical programming model is a systematic tool of management science in which the operations are specified by mathematical equations. Prior to the model development, there are many aspects that need to be studied to guide the quantitative decisions on the model constructions. These include the model objective functions, constraints, sets, parameters and other restrictions. Therefore, the objective of this paper is to present a comprehensive review on the factors and details needed to formulate a mathematical programming model that will optimize the nutritional requirement for the diet plan of Malaysian adolescent athletes. The mathematical model is expected to be able to produce a daily menu containing the combination of food items that best satisfy the nutrient requirement for Malaysian adolescent athletes.

The adolescent athletes are aged between 13 to 18 years old and undergo sports training and also receive academic education at Malaysian sport boarding schools. They are assumed to have an average weight between 46.5 to 59.2 kilogram. As a result of this weight assumption, the nutrient guideline is standardized and converted to a daily requirement. All data in this study are obtained from secondary sources. The training duration is four hours every day and it is based on the routine of one sample of Malaysian sport schools. This study does not consider specific factors such as the type of sport being practised, the precise period such as pre-training, during-training or after-training or the gender of adolescent athletes. Furthermore, these adolescents are presumed to be healthy with no risk factors such as obesity, allergies or illness. In addition to this, the kind of fat included in food list is categorized as general fat due to lack of nutrient composition data specifying the types of fat with its value.

2. Th Importance of Diet Planning

Diet planning or menu planning problem is the searching of ideal combination of menu items that fulfil a fixed requirement of nutrients intake for certain days [1]. Diet planning is vital for everyone, mainly for specific groups of people such as patients with nutritional risks, the elderly, pregnant woman and athletes. These people need to be cautious on their food intake. Juraschek and his colleagues [2] stated that the lesser the sodium intake in the diet, the lower the blood pressure would be. Therefore, patients with nutritional risk such as diabetic patients must take low-sugar diet since they have higher blood glucose level than other individuals. Meanwhile, high blood pressure patients should decrease sodium intake in their diets. Stránský [3] stated that old people tend to have higher morbidity probability than any stages of life, therefore, nutrition is important for them to keep up the optimal health state and to prevent nutrient deficiency.

According to Reference [4], malnutrition among adolescents may result in stunted growth. This will put adolescence at a risk because stunted growth can affect their mental development, academic achievement and intellectual capacity [5]. Having said this, diet plan is very essential in moulding a healthy individual. A good eating plan has several advantages, such as resulting in a healthier dietary pattern, as well as reducing expenditures on unnecessary supplementary food. The likelihood of malnutrition occurring in society can be reduced if effective meal planning is practiced in daily life.

Human life cycle has six main stages which are foetus, baby, child, adolescent, adult and elderly. Every adult has gone through adolescent stages in their life. To grow into a healthy adult, an adolescent must have appropriate growth development. Reference [6] has revealed that 16 percent of the world human population were adolescents. In addition, there exist few stages of adolescence phases and the common stages in adolescence are known as early adolescence, middle adolescence and late adolescence [7]. The Ministry of Health Malaysia has presented macronutrients recommendation in the Recommended Nutrient Intake (RNI) [8] only for general adolescents of Malaysia. In the report, the population range of age categorized as adolescent is 13 to 18 years old.

Training is vital because it helps young players in developing their athletic stamina. Furthermore, having frequent training sessions allows young athletes to enhance their skills and consequently able to boost their confident level. They will be more mentally and physically prepared when performing in tournaments and competitions. Undoubtedly, an athlete's diet is supposed to be specifically planned and distinguished as compared to the non-athletics individual [9]. The more physical exercise a person does, the more sweat is produced as a result of the body's response to lower body temperature during the exercise. Sweats are simply the excretion of water and salt. Excessive sweating causes dehydration, which happens when the amount of body fluid in the body system is reduced too drastically [10]. Dehydration can also induce muscle soreness, making the body feel weak, in some cases, causing the athlete to pass out during training or competition [11].

Medical supplements and ergogenic supplements are two of the most popular supplements associated with adolescent athletes [12]. A medical supplement, sometimes known as a nutritional supplement, is used to address clinical conditions, whereas an ergogenic supplement is meant to improve athletic performance [13]. These supplements are consumed by adolescent athletes with the goal to improve sport performances and achieve the perfect body shape, such as weightlifting athletes. However, according to a study, adolescent athletes should not rely on supplements unless they have a specific medical problem, such as iron deficiency [14]. Similarly, a recent study by Desbrow [12] stated that taking supplement for the purpose of athletic performance is improper for adolescent athletes, and that nutrient intake should be derived from food rather than supplements.

A Malaysian study focusing on eating disorders among female national athletes has discovered that moderately active and non-weight sport female athletes have a higher risk of developing an eating disorder [15]. The rationale for this statement is that the less active a teenage athlete is, the more likely he or she will develop an eating disorder as they try to avoid obesity. In general, regardless of the sort of activity that an adolescent athlete participates in, there is always a risk of developing an eating disorder. Hence, preventative measures must be taken at early stage before they fully commit to a professional sports career. One of the possible preventive measures is by having a proper diet plan which will guide them on their daily food consumption.

Injuries to adolescent athlete is frequently occurred, mainly during competition or physical training. When injuries happened, protein can speed the recovery process. Protein impairment includes protein structuring in muscle, bone, ligaments, and tendons and fast development requires high protein demand [12, 16]. Obesity, or being overweight, is, on the other hand, one of the most serious health issues. For the past few years, the

proportion of Malaysian adolescents who are overweight or obese continues to rise [17]. Past research also indicated that an overweight adolescent has a higher chance of becoming an obese adult in the future [18]. Obesity occurred due to less physical activity which leads to an increase in body fat and a loss in muscular capacity. To keep their body fit, it is critical for adolescent athletes to limit their fat intake to avoid overweight. Therefore, it is recommended that fat consumption must be reduced in the diet plan to avoid excess fat in the body.

3. The Nutrients for Adolescent Athletes

Bose and his colleagues [19] stated that adolescence is a crucial phase in human development for both genders as they will go through puberty, as well as growth and cognitive development in this phase. Reference [12] also mentioned that adolescence is a significant phase because physical growth is being developed such as changes in body composition, hormonal and metabolism shift, maturement of organ systems and initiation of nutrient deposits. The tendency for an adolescent in becoming a healthy adult is greater if they get through the phase with sufficient nutrient and exercise healthy lifestyle.

Adolescent athletes encounter many dietary challenges for their growth development, sport coaching or tournament and school activities. As their daily activities are also different than other adolescents, the nutrient intake must also be planned differently from general adolescent. Reference [20] mentioned that athlete's diet must be specifically planned as it is distinguished to other individuals with the same age. This is because an adolescent is in the phase of growth development which demands for greater energy and protein as compared to non-athletic adolescent [21].

In this study, 12 nutrients are considered since all these nutrients can be found in majority of Malaysian food item. These nutrients consist of macronutrients such as protein, carbohydrates, fat, fibre, as well as fluids. Fibre is included in this study since it is one of the nutrients recommended by Hannon and his colleagues [22] and human bodies require fibre to maintain proper bowel function.

3.1. Protein

Protein the most important nutrient in growth development as it is a vital components of body tissues. Protein plays important role because it constructs the major portion of lean body tissues including organs and bones [8]. Protein is constructed by building blocks of amino acids. Peptide bonds help binding the amino acids to each other to produce blocks of amino acids. Protein is important for maintenance purpose in human body and helps in the process of continual repairing to cope with the body wear and tear process. Protein also helps in constructing the regulatory compounds such as hormones and enzymes. Besides this, protein also acts as defender against diseases because when the body notice the presence of antigens, it produces antibodies to fight the antigens. When the glycogen has been used up, muscle protein will be converted to glucose by the process of gluconeogenesis [23]. Reference [24] has set the protein requirements for Flemish adolescent sprint athletes as 1.5 gkg^{-1}. To help the adolescent athletes in maintaining their muscle gain, positive nitrogen balance must be achieved [25].

3.2. Carbohydrate

Carbohydrate is the crucial source for individual's energy which takes up more than half from the total energy intake. There are three main reasons why carbohydrate is considered as the prime source. First, carbohydrates supply energy that used for oxidative metabolism. Oxidative metabolism is the process of converting carbohydrates to produce energy. Next, food containing carbohydrate plays the role as a transporter for micronutrients and phytochemicals into body system. Finally, carbohydrate preserves the glycaemic homeostasis where the stability between insulin and glucagon to maintain blood glucose in human body [8].

3.3. Fat

Fat intake is vital to encourage the fat-soluble vitamin to be absorbed to body. In addition, it helps to deliver important fatty acids that cannot be processed by the body such as Omega 3. Dietary fat can also produce energy during physical exercise. Adolescent athletes should only take minimal amount of fat because they must keep enough energy for optimal growth and maturation purposes.

3.4. Fiber

An adequate intake of fibre develops normal laxation and resulting with a good cardiovascular health [26]. The minimal intake can help to prevent adolescent from getting coronary heart disease and high blood pressure. Hannon and his colleagues [22] recommends that it is sufficient for adolescent athletes to follow the fibre requirement for normal adolescent.

3.5. Other Macronutrients

It is important to note that all these macronutrients are extracted from [8]. The main function of calcium is to support the strength of bone. Vitamin C is responsible to form collagen which is a type of protein supplying good support to bones, cartilage, muscles and blood vessels.

Other than that, haemoglobin in iron is vital for oxygen transportation in blood vessel. Besides this, vitamin B1 is associated to carbohydrate metabolism in the body. Similarly, vitamin B2 functions to convert carbohydrate into energy. Niacin is essential for electron movement in body, whereas vitamin A have plenty of functions for body such as vision and reproduction part which make vitamin A as one of the essential macronutrients.

3.6. Fluid

Malaysia is one of tropical countries where the average daily temperature is more than 30-degree Celsius. Exercising in such temperature can affects the athlete in terms of dehydration and hyperthermia [27]. Many studies have emphasized that fluid must be consumed very often, not only when thirsty. Adolescent athletes must take plenty of fluid to replenish the mineral loss during excessive sweating. Typically, fluid has the purpose to provide regular hydration and extra fuel to keep the athletes energetic and hydrate during the day.

4. Mathematical Models in Diet Planning

Several research have presented the study on diet planning for various groups of people and several mathematical and non-mathematical approaches have been utilized in in the studies. A mathematical programming model approach is widely used to produce the best list of menus with the optimum nutrients. A mathematical programming model is a systematic tool of management science in which the operations are specified by mathematical equations and constraints. Numerous types of menu planning model have been developed using mathematical model and one of the most common menu planning models is optimization model. Optimization model consists of three elements which are objective function, decision variables and constraints. Examples of optimization model are linear programming, binary programming, integer programming and goal programming.

A fuzzy mathematical programming approach is used by Kashima and his colleagues [28] to address the diet planning problem. The goal was to create a well-balanced nutrient diet plan for Japanese citizens while fulfilling their taste preferences. To reflect individual taste, they employed rough set theory as a determinant. Other study by Oruç and his colleagues [29] used a fuzzy binary integer programming approach to design a 20-day dietary plan for firm employees aged 19 to 30 years old. A menu planning model was designed with 1280 decision variables and 752 constraints. An evolutionary approach using Genetic Algorithm was put forward by Moreira and his colleagues [30] to generate dietary menu for Brazilian school. Reference [31] stated that linear programming (LP) model was widely used since it is able to produce the best optimal results. Hreţcanu and Hreţcanu [32] have established the combination of foods that optimize the need for a person based on daily nutritional requirements. The objective function of the LP model was to minimize the calorie intake while being constrained by 16 nutrients restrictions. Nilu and his colleagues [33] have adopted a LP model to develop menu planning for three age-levels which are below 12 years, 12 to 40 years and above 60 years. Having the objective function to minimize the meal cost, they utilized a coding system called A Mathematical Programming Language (AMPL) to generate the minimum cost for the diet menu. Binary Integer Programming (BIP) is an optimization model where the decision variables being restricted to value of 0 or 1. A BIP model is also known as zero-one programming. A study done by Sufahani and Ismail [34] aimed to formulate the meal plan for Malaysian secondary schools' pupils by using BIP. In this study, they enforced constraints to ensure that a food is not served for more than twice in a day. Using this constraint, the study managed to produce a meal plan without having repetition of foods. Ali and his colleagues [35] adopted similar model and successfully generated a diet plan for a Malaysian boarding school with optimal amount of nutrient content, within the government allocated budget.

Due to the current trend of eating lifestyles, chronic diseases such as diabetes mellitus has increased among the community. Reference [36] used integer programming (IP) in formulating diet plan for diabetic patients. Theoretically, the IP model proposed can reduce the intake of sodium-rich and sugar-high food among diabetic patients. An IP model approach has also been adopted by Lee and his colleagues [37] to generate a weekly menu plan for breast cancer patients. Practicing a healthy diet is important for breast cancer patients and good diet plan can lead to healthy lifestyle and consequently reduce the morbidity risk among them [38]. The study has produced a minimal-cost diet plan that have optimal nutrient intake for the breast cancer patients.

Jridi and his colleagues [39] has solved diet planning problem for haemodialysis patients using Goal Programming (GP) model, whereby each goal function satisfies four types of nutrients which are protein, energy, sodium and potassium. The meal plan formulated by this study was verified by the haemodialysis experts. Besides this, Pasic and his colleagues [40] has also developed a GP model to produce a diet plan for 25-years-old females and males person with average weight of 55 kg and 65 kg, respectively. The GP model has minimized the sum of deviations for daily micronutrients and macronutrients intake in the diet plan and the menu plan generated has successfully satisfy the household's financial budget.

5. The Gap Analysis for Models Construction

In the process of formulating a new mathematical model, a comprehensive analysis across various past studies which employed mathematical programming techniques in diet planning problem must be implemented. The purpose of this analysis is to investigate all the important elements that will constitute the new mathematical model. To conduct the analysis, eight research papers which employed mathematical programming model in solving diet planning problem are selected. The studies are research done by Hui and his colleagues [41], Nilu and his colleagues [33], Eghbali [20], Fauzi and his colleagues [42], Sheng and Sufahani [43], Sufahani and his colleagues [44], Dhoruri and his colleagues [45] and Rajikan and his colleagues [46]. The elements of the mathematical model which are the objective functions, constraints, sets and parameters are closely analyzed among these eight selected studies.

5.1. Model Objective Function

The most common goal in diet planning problem is to minimize costs while optimizing nutrient intake. Nilu and his colleagues [33] presented a diet plan for three distinct groups of people, each of which was distinguished by age. The study's goal was to reduce total costs while meeting the nutritional needs of the target groups. Sufahani and his colleagues [43] solved the menu planning challenge for secondary school students aged 13 to 18. The study was able to propose a diet plan that met the dietary requirements of secondary school students while also minimizing the cost and preparation time. In addition to this, Rajikan and his colleagues [46] developed a weekly diet plan for low socioeconomic female adults. They are able to provide a weekly meal plan with sufficient nutrition at a reasonable cost in a diet plan for low socioeconomic female adults. Hui and his colleagues [41] developed a diet plan for two hypertension patient groups, which are 54 and 82 years old. The results revealed that IP model produces a better diet plan with optimal dietary requirements and is less expensive than LP. Dhoruri and his colleagues [45] aimed to develop diet plan for diabetic patients that low in cost, at the same time supply optimal nutrient intake to the patients. They solved the diet planning problem by minimizing deviations of three types of nutrients which are fat, protein and carbohydrate. Fauzi and his colleagues [42] developed a meal planning for undergraduate students using a GP model approach which minimized the sum deviations of price. It was found that the GP technique produced a better meal plan than the LP method in terms of the meal cost. Adult athletes' diet planning problem was solved by Eghbali [20] who set the model objective function as maximizing calorie intake and minimizing fat intake. Table 1 shows the summary on the model objective functions in models of previous research on diet planning. From the gap analysis, a set of model objective functions which maximize protein intake while minimizing fat consumption is anticipated as the

novelty of this study. This decision is shown in the rightmost column of Table 1.

Table 1: Cross Analysis of Objective Function Used in Model of Related Works.

	Authors								
Objective Functions	[41]	[33]	[20]	[42]	[43]	[44]	[45]	[46]	[**]
To minimize the cost	√	√		√	√	√	√	√	
To minimize deviation				√			√		
To minimize the fat intake			√						√
To minimize the calorie intake			√						
To maximize the protein intake									√

[41] Hui and his colleagues (2021); [33] Nilu and his colleagues, 2020; [20] Eghbali, (2020); [42] Fauzi and his colleagues (2019); [43] Sheng and Sufahani (2018); [44] Sufahani and his colleagues (2018); [45] Dhoruri and his colleagues (2017); [46] Rajikan and his colleagues (2017); [**] This study

5.2. Model Decision Variables

In mathematical programming, a decision variable is a variable whose value can varies within the feasible solution. Decision variables are the numerical outcomes or the result obtained when solving mathematical programming model. Price of food, food intake, nutrient intake, lower and upper deviation were commonly set as decision variables in past research of diet planning studies. Among these five decision variables, price of food and food intake were most frequently selected as the variables in past studies.

Among the selected studies, all except Dhoruri and his colleagues.

[45] and Eghbali [20] has taken price of food as the decision variables. The setting of food price as the decision variables is mainly due to the model objective function which is aimed to minimize the cost of meal. Lower deviation and upper deviation are the decision variables in the model by Dhoruri and his colleagues.

[45] and Fauzi and his colleagues [42] because their models were utilizing GP model. In addition to this, Eghbali [20] has regarded food and nutrient intake as decision variables in his model. From the gap analysis done, it has been determined that this study will develop a diet plan model with decision variables of food and nutrient intakes. Table 2 shows the cross analysis of decision variable used in previous studies, with the rightmost column showing the intention of this study.

Table 2: Cross Analysis of Decision Variables Used in Model of Related Works.

	Authors								
Decision Variables	[41]	[33]	[20]	[42]	[43]	[44]	[45]	[46]	[**]
Food price	√	√		√	√	√		√	
Food intake	√	√	√	√	√	√		√	√
Nutrient intake			√						√
Lower deviation				√			√		
Upper deviation				√			√		

[41] Hui and his colleagues (2021); [33] Nilu and his colleagues, 2020; [20] Eghbali, (2020); [42] Fauzi and his

colleagues (2019); [43] Sheng and Sufahani (2018); [44] Sufahani and his colleagues (2018); [45] Dhoruri and his colleagues (2017); [46] Rajikan and his colleagues (2017); [**] This study

5.3. Model Set

To develop diet planning for any individuals, many sets of information are needed. From the selected past studies, there were five commonly used sets that have been used in diet planning problem. The most important set is the nutritional requirement. A good diet plan must be able to provide the optimal nutrient to individuals. Hence, nutritional requirements' set are the most important set in diet planning problem. The other commonly used set is nutritional value in food. A food that satisfies the nutritional requirement of the targeted group will definitely be chosen in the diet plan. The cost of food data is important when the studies aimed to develop diet plan with limited financial budget. All past studies except Eghbali [20] have cost of food set in the data for their model. Besides this, the studies by Nilu and his colleagues [33], Dhoruri and his colleagues [45], Fauzi and his colleagues [42] and Eghbali [20] prepared a list of food without categorizing into any food groups. This type of study usually does not categorize food into session meals because they only consider limited number of food items. On the other hand, the model developed by Sufahani and his colleagues [44], Sheng and Sufahani [43], Rajikan and his colleagues [46] and Hui and his colleagues [41] used these food group requirements in formulating the diet plan model. As for this study, four sets of information are identified to be included as the model set, namely the nutrient requirement, nutrients composition in food, food group and list of food items. Table 3 shows the cross analysis on sets used in models of previous studies.

Table 3: Cross Analysis of Sets Used in Model of Related Works.

	Authors								
Sets	[41]	[33]	[20]	[42]	[43]	[44]	[45]	[46]	[**]
Nutrient requirement in related people	√	√	√	√	√	√	√	√	√
Nutrient composition in food	√	√	√	√	√	√	√	√	√
Cost of Foods	√	√		√	√	√	√	√	
Food Group	√				√	√		√	√
List of specific food	√	√	√	√	√	√	√	√	√

[41] Hui and his colleagues (2021); [33] Nilu and his colleagues, 2020; [20] Eghbali, (2020); [42] Fauzi and his colleagues (2019); [43] Sheng and Sufahani (2018); [44] Sufahani and his colleagues (2018); [45] Dhoruri and his colleagues (2017); [46] Rajikan and his colleagues (2017); [**] This study

5.4. Model Parameter

Lower and upper boundaries for nutrient requirement are important parameters because the bounds ensure that the model will produce a diet plan with within the tolerable values of nutrient intake. Different group of individuals need different level of nutrient requirements in their diet plan. Hence, nutrient requirements have been used as the model parameters in all past studies. Price of food has been used as parameter in all past studies too, except in the model by Eghbali [20]. Price of food is an important parameter if the study aimed to develop a cost-saving diet plan. Apart from that, all past studies have used the list of food as one of the parameters. The studies by Sufahani and his colleagues [44], Sheng and Sufahani [43], Rajikan and his

colleagues [46] and Hui and his colleagues [41] used other parameter which is the list of food groups. Other parameter being utilized is the nutrient value in each food. There are 26 types of nutrients in foods used in the past studies which are energy, carbohydrate, protein, fat, calcium, cholesterol, fatty acid, potassium, magnesium, sodium, vitamin A, vitamin B12, vitamin B6, vitamin B1, vitamin C, vitamin B2, vitamin E, vitamin D, vitamin K, water, zinc, iron, phosphorus, fibre, niacin and sugarloaf. The common macronutrient such as carbohydrates, fats and protein are normally included in the list of food in the past studies.

Table 4: Cross Analysis of Parameters Used in Model of Related Works.

	Author								
Parameter	[41]	[33]	[20]	[42]	[43]	[44]	[45]	[46]	[**]
Lower bound of nutrients requirement	√	√	√	√	√	√	√	√	√
Upper bound of nutrients requirement	√	√	√		√	√	√	√	√
Average price/cost for food	√	√		√	√	√	√	√	
List of specific foods		√	√	√			√		√
Bounds for specific food intake		√							
List of food groups	√				√	√		√	√
Requirement for food groups	√				√	√		√	√
Energy content		√	√	√	√	√	√	√	√
Carbohydrate content		√	√		√	√	√	√	√
Protein content	√	√	√	√	√	√	√	√	√
Fat content			√	√	√	√	√	√	√
Calcium content	√	√		√	√	√		√	√
Cholesterol content		√							
Fatty acid content		√							
Potassium content	√	√		√					
Magnesium content				√					
Sodium content	√	√		√					
Vitamin A content		√		√	√	√		√	√
Vitamin B6 and Vitamin B12 content		√							
Vitamin B1 content				√	√	√			√
Vitamin B2 content	√			√		√			√
Vitamin C content	√	√			√	√		√	√
Vitamin E content		√							
Vitamin D and Vitamin K content				√					
Water content		√							
Zinc content		√		√					
Iron content				√	√	√		√	√
Phosphorus content				√					
Fibre content			√					√	√
Niacin content					√	√			√
Sugarloaf content			√						

[41] Hui and his colleagues (2021); [33] Nilu and his colleagues, 2020; [20] Eghbali, (2020); [42] Fauzi and his colleagues (2019); [43] Sheng and Sufahani (2018); [44] Sufahani and his colleagues (2018); [45] Dhoruri and his colleagues (2017); [46] Rajikan and his colleagues (2017); [**] This study

Vitamins such as vitamin A and vitamin C are the common vitamins that have been used in the past studies model. The food list in Nilu and his colleagues [33] and Fauzi and his colleagues [42] studies have the highest number of nutrients being listed which are 15 types of nutrients. Food that has cholesterol and fatty acids can be found in Nilu and his colleagues [33]. Meanwhile, Fauzi and his colleagues [42] have included extra micronutrients such as magnesium, vitamin D, vitamin K and phosphorus nutrient in their diet model. The

model by Dhoruri and his colleagues [45] have another additional parameter which is the value target for four nutrients which are energy, carbohydrate, protein and fat. In their model constraint, the food in the diet plan have been set to a target value of energy. Table 4 shows the cross analysis of parameters used in past studies.

6. The Expected Result of Model

This study will utilize a reference model from Reference [20]. The model was chosen as the reference model because it has successfully developed a diet plan that maximized and minimized certain nutrient intakes, which are maximizing calories and minimizing fat. Similarly, the expected model to be developed in this study is aimed to maximize protein while limiting fat in the diet of Malaysian adolescent athletes.

The model constraints presented by [20] have posed certain restrictions on the nutrient requirements. Among them are the limitations on the nutrient composition of food item, the upper bound value of nutrients, as well as the non- negativity values of serving number. They used the technique of pre-emptive goal programming to solve the LP model to find optimum food combination. On the other hand, this study is intended to develop an IGP model due to the feature of the decision variable, which is the number of foods serving.

There are three novelties that will be introduced in this study. First, a milk requirement constraint is added to ensure that milk must be taken once during breakfast and once during supper. Second, a plain water requirement constraint is being introduced as young athletes need more water intake to support the fluid loss during physical training. Third, this study will be using a new set of data on daily food requirement's constraint, specifically taken from the list of Malaysian food. Table 5 shows the differences between the expected model and the reference model.

Table 5: The Expected Model in contrast to the Reference Model.

	Expected Model	**Reference Model**
1.	Integer goal programming model is used	Linear programming model is used
2.	Objective function maximizes protein	Objective function maximizes calories
3.	Specific constraint for plain water and milk	No specific constraint for plain water and milk
4.	50 types of Malaysian food in diet plan	14 types of food in the diet plan

7. Conclusion

This paper has presented the preliminary works in the development of a mathematical model that will produce a daily meal menu containing the combination of food items that best satisfy the nutritional requirement for Malaysian adolescent athletes aged between 13 to 18 years old. An integer goal programming model is chosen to be the tool in finding the optimal solution to the diet plan. The main elements supporting the model construction are discussed in detail, with the novelty of model are to maximize protein and minimize fat while fulfilling the nutrient recommendation intake.

In this sense, the paper is expected to assist researchers to formulate structured models by means of the clear definition of model variables and parameters. The work is part of the study that will be conducted to solve diet planning problem among adolescent athletes. Upon developing a new integer goal programming model that

could produce diet meal with optimum nutrition intakes, the optimal solution to the mathematical model will then be proposed. These new model and solution approaches will be presented in next research papers of our study.

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