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Research Paper

Economical and Mathematical Impact on Planning Balanced and Nutritious Diet for Paralympic (Autistic) Athlete (100M Sprinter) Using Linear and Integer Programming Approach

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Abstract
Every athlete should maintain a balanced diet to ensure proper physical preparation before participating in any competition, as well as for recovery afterward. Dietary planning is essential for ensuring adequate nutrient intake and avoiding food allergens, which can help improve the condition of individuals with autistic (100M sprinter) athletes while also strengthening the immune system. Human dietary planning involves the use of strategies to select suitable food items that are healthy for the body and then integrate them into meals This paper seeks to use Linear programming and Integer programming to develop diet plans for autistic 100M sprinters aged 20-30 years. Linear and Integer Programming are the two scientific approaches that can be useful in reducing the costs and considering some additional constraints such as the necessary amounts of certain nutrients, as well as the allergenic products that must not be used.

Keywords
Optimization, Mathematical Modeling, Autistic Athletes, Dietary Planning, Linear Programming, Integer Programming

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1. INTRODUCTION

1.1 Menu Planning for Athletes

Menu planning can be done through various mathematical programming methods. Several previous studies have explored menu design approaches directed towards their sample respondents. Stigler (1945) first addressed the diet problem in a paper, the first of a long series of publications dealing with this and similar menu-planning problems. What became known as the "Diet Problem" was first described by Stigler as an exercise in the use of trial and error to minimize the cost of meals for the American army. Stigler's mathematical formulation of the diet problem provided the basis for the development of modern approaches to menu planning. The original mathematical model is as follows equation 1-4

$$\text{Minimize Total Cost} = \sum_{j=1}^{J} C_j X_j \tag{1}$$

Subject to

$$\sum_{j=1}^{J} n_{j,i} X_j \geq b_i \quad \text{for all } i = 1, 2, 3, \ldots, n \tag{2}$$

$$\sum_{j=1}^{J} n_{j,i} X_j \leq b_i' \quad \text{for all } i = 1, 2, 3, \ldots, n \tag{3}$$

$$X_j \geq 0 \quad \text{for all } j \tag{4}$$

Where, J is the number of foods, C_j is the cost of the j-th food, X_j is the quantity of the j-th food, η_{ij} is the i-th nutrient content of the j-th food, and b_i is the i-th nutrient requirement.

Meanwhile, Balintfy (1964) was a pioneer in the development of computerized systems for menu planning. As the science and technology of computers grew, so did this field, moving towards faster and more technical applications. Until then, Burke and Kass (1995) discovered that most athletes do not engage in proper nutritional behaviors to optimize sport performance which include variety of reasons such as general lack of nutrition knowledge, dietary extremism, poor practical skills in meal planning and food preparation, and restricted food choices due to busy schedules or frequent travel. Burke also collaborated with other researchers to investigated the issue of carbohydrate use in training and competition as related to recovery for soccer players. Then they found out that carbohydrates and fats are important for training and recovery. Hence, athletes should have sufficient amount of carbohydrates in their diet so that the energy demand of the training is fulfilled and muscle glycogen stores can be replenished between the training sessions. Recovery may further be improved by adding extra nutrient-dense carbohydrate foods and combination with protein and other nutrient-dense options in recovery meals and snacks (Burke et al., 2006, 2007, 2011; Beck et al., 2015; Kerksick et al., 2018).

Then, Burke and Manore (2020) discovered that both sport and exercise participants have distinct energy and nutrient requirements than sedentary participants. These vary with exercise intensity, duration, frequency, and type of exercise, as well as the environment. Realistic concerns also come with training and competitions, such as gaining access to appropriate foods and fluids at appropriate times and educated choices concerning supplement and sports foods. Mustafa et al. (2022) listed six key processes utilized by Malaysian sports nutritionists (SNs) in preparing meal plans for athletes. The processes are the interrelated steps of the Nutrition Care Process (NCP), yet without declaring nutrition diagnosis of the Nutrition Diagnosis step. The processes that were determined are gathering relevant information, data analysis collected, setting nutrition orders, setting up goals and planning intervention, prescribing and implementing interventions, and monitoring progress. These processes enable sports nutritionists and dietitians to create personalized meal plans that enhance athletes' nutrition status, adherence, health, and overall sporting performance. Alwadood et al. (2023) explored a well-designed diet plan is a key factor in ensuring the health of young athletes because the primary providers of energy and essential nutrients are their diets. The solution gives a plan yielding 30 servings per day, which yields a perfect quantity of 115.8 grams of protein and 69.99 grams of fat. The diet planning solution can be implemented by sports schools as a guide when preparing to make healthy diets for young athletes.

1.2 Autistic Conditions

According to Doreswamy et al. (2020), nutrition and diet are significant in total health, and they help the body and the mind. Nutritionally dense foods cleanse the body of toxins, strengthen the immune system, help control hunger, and prevent obesity. People who have autism and autism spectrum disorders (ASDs) are generally eating-challenged, and thus nutrition plays a special role in their wellness. Sathe et al. (2017) states that ensuring proper nutrition for autism is vital for their overall health and development. Therefore, essential nutrients for autistic individuals are such omega-3 fatty acids-for brain health and inflammation reduction, vitamin D-supports immune function and bone health, B vitamins-energy production and nervous system, magnesium for relaxation and sleep, zinc for immune function and sensory processing, and probiotics and prebiotics for gut health which benefited in gastrointestinal and behavioral. A proper and nutritious food intake thus affects their emotional stability. Through the years, knowledge of autism has increasingly been brought to the attention of general public, especially among parents worldwide. Similarly, Paralympic sporting performance has also gained added exposure. Autistic players form some percentage of the Paralympians. However, no earlier studies have ever been conducted on meal planning for autistic sprinter athletes.

1.3 Operational Research Method

The scientific method of operational research can be applicable in the operating systems for the best selection of alternatives, production discovery, scheduling of resources, and dietary planning. In each optimization problem, there is an objective function and constrained variables. Çetinkaya (2013), conducted a study exploring the linear programming employment for menu planning in restaurants. Her focus was on minimizing the usage of ingredients, particularly anchovies and pita, while also aiming to reduce the processing time required to prepare two menus. An example that uses integer programming is shown in Sufahani and Ismail (2014) which models the menu plans for Malaysian school children aged 13-18. When taking into account the Recommended Dietary Allowance (RDA) of Malaysian children between 13 and 18 years, the cost of menu items, the allocation of the budget by the government, and the need for variety, the problem was solved with MATLAB using the LPSolve programming language. LPSolve IDE is an Integrated Development Environment (IDE) that solves linear, integer, and mixed-integer programming problems by employing LPSolve. In addition, LPSolve IDE supports a graphical user interface (GUI) for easily modeling, solving, and analyzing optimization problems, especially diet optimization, without much coding expertise. The menu planning model was then discovered by Patil and Kasturi (2016) using an integer programming method to meet the nutritional needs of individuals aged 40-45 years and simultaneously minimizes diet costs. However, its model food combinations are limited.

Next, Sheng and Sufahani (2018) developed a model addressing the eczema patients' dietary problem in the young peer group. It utilized integer programming as a methodical to choose appropriate supplies that lessen the cost but provide desired intake of nutrients, avoid the allergens for inclusion of special products meant for reducing symptoms of eczema. In their findings, the delete-reshuffle algorithm has been implemented as an optimization technique for diet planning and menu scheduling. This algorithm serves as a tool to automatically remove food selections from the previous day, ensuring variety in menu planning. Additionally, it facilitates the utilization of all 426 food items listed in the Nutrient Composition of Malaysian Foods recipe book. Besides, Razak and Mangsor (2019) aiming to establish linear programming models for the diet problem and determine the minimum cost required to meet daily recommended nutrient intake in cafeteria at one of the Malaysian University. Due to the highly increasing cost of living, it was not easy for the undergraduate students as their financial status was badly affected, given their limited budgets in covering daily needs, with assistance from the Perbadanan Tabung Pendidikan Tinggi Nasional Study Loan. In Argentine hospitals, meal planning for lunches and dinners necessitates a great deal of detail with every dish having to comprise a starter, main course, side dish, and dessert for all the patients within the Hospital (Guala and Marenco, 2020). Employing integer programming, they conducted a study aimed at generating a weekly menu plan that minimizes overall costs while meeting the criteria for healthy eating habits, culinary variety, and local gastronomy preferences.

Lee et al. (2020), discussed menu scheduling for breast cancer patients using an integer programming method. They used integer programming in order to optimize meal costs to make them more affordable, comprehensive, and nutritious. The objective was to ensure that such breast cancer patients maintain nutritional intake without having too much expenditure every day. Next, a model of mixed-integer programming was developed by Padovan et al. (2023) to design daily menus of the institutional food service for one month. Each menu consisted of one main course, one alternative main course, two salads, one protein course, one alternative protein course, one side dish, and one dessert. The model ensured that World Food Program (WFP) guidelines are followed by providing healthy and nutritious balanced food. Later, Alwadood et al. (2023) formulated a diet plan for Malaysian adolescent athletes based on an integer goal programming model. This research will improve that model to create a healthy diet plan with the highest protein content and lowest fat content while adhering to Malaysian adolescent athletes' nutrient intake recommendations for ages 13 to 18. The formulation of the model takes into account 50 food items and their nutritional contents, including twelve basic nutrients to produce a daily meal menu for Malaysian adolescent athletes.

For this study, the Delete-Reshuffle Algorithm Sheng and Sufahani (2018) is applied on the result obtained from integer programming to design a healthy menu for the week with each day containing different foods. Cost-effective diet plans will be produced by the mathematical model that will meet the nutritional needs of autistic athletes. The problem was solved using Matlab and the LPSolve programming language. However, no study on menu planning of autistic athletes has been carried out. Therefore, the decision parameters in the model of the diet plan have been identified as the intake of foods and nutrients. Some sets and parameters such as food groups, a list of foods, requirement of nutrients, and nutrient composition are incorporated into the model for achieving the set research objectives.

2. EXPERIMENTAL SECTION

2.0.1 Description of Data

From the interviews conducted with staff at Malaysia Sport School and dietitians the actual requirements for the nutrients needed by males 20 to 30 years of age were obtained. The data involves RNI's and AI referenced nutrient amounts including energy, fats, carbohydrates, protein, calcium, vitamins A, B1, B2 and C, niacin and iron minimum and maximum values as presented in Table 1. The following nutrients composition data for this study were obtained from the Malaysian Food Nutrient Composition book produced in 2017 by Tee (2017). The meals are in serving sizes with the nutrients stated. The model employed in the research involves 426 foodstuffs chosen from Malaysian recipes enumerated in the Malaysian Food Nutrient Composition book. Here are the following nutrient that are consider in this research: Energy - EN, Fat - FAT, Carbohydrate - CHO, Protein - PRO, Calcium - Ca, Vitamin A - Vit A, Vitamin B1 (Thiamine) - Vit B1, Vitamin B2 (Riboflavin) - Vit B2, Vitamin C - Vit C, Niacin - Vit B3, Iron - Fe.

Table 1. The 11 Nutrients of Upper Bound and Lower Bound Values

Lower Bound (LB)	Nutrients	Upper Bound (UB)
1960 (kcal)	EN	2800 (kcal)
62 (g)	FAT	75 (g)
370 (g)	CHO	620 (g)
62 (g)	PRO	-
1000 (g)	Ca	2500 (g)
600 (μg)	Vit A	3000 (μg)
1.2 (mg)	Vit B1	-
1.3 (mg)	Vit B2	-
65 (mg)	Vit C	2000 (mg)
16 (mg)	Vit B3	35 (mg)
20 (mg)	Fe	45 (mg)

2.1 Description of The Model

Dietary data was collected with specific reference to food products, and this encompassed 426 foods partitioned into 10 categories according to food group. Selection ranges of each food type are as follows in Table 2: Those who have autism and who are sprinters in the 100M, a daily plan include 18 dishes in the 10 groups of food. The diet followed in Malaysian includes consumption of plain rice and water and as such the menu is arranged accordingly. The 18 food items are enumerated in Table 3 taken from Table 2, which are served in scheduled for breakfast, morning tea, lunch, afternoon tea, dinner and supper. The food groups are categorized as follows: Cereal Flour Based = CFB, Rice Flour Based = RFB, Wheat Flour Based = WFB, Miscellaneous = MI, Beverage = BEV, Cereal Meal Based = CMB, Vegetables = VEG, Fruit = FRU, Meat = MEA, Seafood = SEA .

2.2 Diet Problem Formulation

To build menu planning model Integer Programming (IP) is utilized, encompassing 426 variables. For this purpose, LP-Solve IDE was used as the program.

$$\textit{Minimize the cost function: } \sum_{i=1}^{426} c_i x_i \tag{5}$$

Table 2. Food Requirement Per Day

BEV	CFB	RFB	CMB	MEA	SEA	VEG	FRU	WFB	MIS
6 (2 Plain Water)	1	1	2 (1 Plain Rice)	1	1	2	2	1	1
Total No. of Dishes = 18									

Table 3. Menu Planning of Daily Food Items

Meal	Breakfast	Morning Tea	Lunch	Evening Tea	Dinner	Supper
Type of Food Group	BEV	BEV	BEV	BEV	BEV	BEV
	CFB		CMB	WFB	CMB	
		RFB	MEA/SEA		MEA/SEA	MIS
			VEG		VEG	
			FRU		FRU	
Amount	1 from each Food Group					
No. of dishes/-day	18					

Table 4. Daily Meal Structure Using Linear Programming

Meals	Food Item	Amount
Breakfast	Malted milk drink, packet	0.9434
	Rice porridge, fish, instant	0.9434
	Tamarind fruit	0.3246
Morning tea	Pandan palm sugar rice ball	1
	Milk, UHT, low-fat,	0.7091
	recombined	1.0566
	Biscuit, cream crackers	1
Lunch	Plain water	1
	Plain Rice	1
	Fem shoots	1.7162
	Papaya only	1
	Fish, unspecified, dried, salt	0.9999
Evening tea	Sugar cane juice	1
	Prawn fritter	1
	Banana Pancake	1
Dinner	Sugar cane juice	1
	Noodle, rice	0.6754
	Peas garden, fresh	0.2838
	Tamarind fruit	1
	Chicken sate	1
	Plain water	1
Supper	Sweet fermented glutinous rice	0.2909
Total number of foods per day		18.9999 = 19
Total cost Ringgit Malaysia (RM)		16.45
Total cost United State Dolar (USD)		3.99

Subject to constraints with 11 requisite nutrients based on Table 1,

$$lower\ bound \leq \sum_{i=1}^{426} nutrient * x_i \leq upper\ bound; \quad (6)$$

And 10 requisite food group per day based on Table 2,

$$\sum_{i=1}^{10} food\ group\ of\ x_i \leq y; \quad (7)$$

Where $x_i \geq 0$ and integer y = the requirements for each food category. Based on Sufahani and Ismail (2014), it uses the Delete-Reshuffle Algorithm to make the food consumed every day different, with just two items that must be on the list each day: plain water and cooked rice. In working, the algorithm deletes the food served on the first day, then reshuffles to pick for the next day. This is a looping process for the construction of a 5-day menu. [Remaining food, x"] = [Available food, x] - [Food included in previous day, x'].

$$\begin{aligned} x'' &= x - x \\ &= [2_1 2_2 2_3 2_4 \cdots 2_{137} 2_{138} 2_{139} 2_{140} \cdots 2_{426} 2_{427}] \\ &- [1_1 0_2 0_3 0_4 \cdots 1_{137} 1_{138} 0_{139} 0_{140} \cdots 0_{426} 0_{427}] \quad (8) \\ &= [1_1 2_2 2_3 2_4 \cdots 1_{137} 1_{138} 2_{139} 2_{140} \cdots 2_{426} 2_{427}] \end{aligned}$$

Plain water = 10 (2 times in a day)
Plain rice = 5 (1 time each day)
Delete-Reshuffle Algorithm (Sufahani and Ismail, 2014).
Input:
(i) LB = $0 \times [x_1, x_{426}]$ matrix
(ii) UB = $2 \times [x_1, x_{426}]$ matrix (except for plain water = 10 and plain rice = 5)
(iii) Food(0) = LB (for Day 0)
(iv) $u(0)$ = UB (food availability for Day 0)
(v) $d = 5$ (no of days)
**Equations (5) until (7)

Output (1): Cost ($1 \rightarrow d$) and Food ($1 \rightarrow d$) (Delete Chosen Food and Reshuffle Available Food)

For $a = (1 \rightarrow d)$ do
Step 1: $u(a) = u(a-1) - \text{Food}(a-1)$
Step 2: Solve (looping until d)
Step 3: Print Cost (a)
Step 4: Print Food (a)

Equation (8)

Output (2) Scheduling Menu
For $a = (1 \rightarrow d)$ do
Step 1: Supper = MIS(a)
Step 2: Breakfast = CFB(a)
Step 3: Morning Tea = RFB(a)
Step 4: Evening Tea = WFB(a)
Step 5: Breakfast, Morning Tea, Evening Tea, Supper = BEV(a) 1 each
Step 6: Lunch, Dinner = Plain Water 1 each
Step 7: Lunch, Dinner = CMB(a), VEG(a) and FRU(a) 1 each
Step 8: Lunch, Dinner = MEAT(a) and SEA(a) 1 each randomly
Step 9: Print final schedule
End

3. RESULTS AND DISCUSSION

The mathematical model will be expanded which provides the best finding to the diets required by autism athletes who specialize in the 100M sprint. To try out the result, a linear programming approach has been used in Table 4, to see if it is a feasible result. The integer programming solutions for menu planning and nutrient intake for five consecutive days are shown in the following tables (Tables 5 – 10):

Table 4 presents the solution of a daily meal plan generated by linear programming, and the total cost of all the food items in each meal is RM 16.45 (USD 3.99). The solution, however, includes fractional values of food items, and it is difficult to determine the exact portions, as shown in Table 4. To eliminate this issue, integer programming is applied to ensure that the solutions are whole numbers so that caterers and nutritionists can obtain exact information to prepare daily meals. Linear programming was applied to verify whether this has a feasible solution or not.

Table 5 shows the meal structure for day 1. Based on day 1 meal structure, autistic 100M sprinter athletes will have a packet of malted milk drink and instant fish rice porridge during breakfast, Sugar cane juice and white bread during morning tea, and plain water, plain rice, fem shoots, papaya and unspecified dried salt fish during lunch. During evening tea, they can have sugar cane juice and banana cake. Meanwhile, during dinner and supper, they also will have plain water, rice noodle, fem shoots, papaya, and chicken sate also, recombined of low-fat UHT milk and fried peneram respectively. As a result of day 1 meal structure, it cost about RM 16.80 (USD 4.07).

Table 6 show the meal structure for day 2. Based on day 2 meal structure, autistic 100M sprinter athletes can have a packet of malted milk drink and mung bean fritter during breakfast, powder coffee mixture and cream crackers biscuit during morning tea and plain water, plain rice, tapioca shoot, tamarind fruit, and a snack of fish sate during lunch. Additionally, they also can have instant coffee powder and prawn fritter during, plain water, rice noodle, yam stalks, tamarind fruit, and chicken

Table 5. Day 1 Meal Structure Using Integer Programming

Pancake	Breakfast	Morning Tea	Lunch	Evening Tea	Dinner	Supper
Type of Food Group	Malted milk drink packet	Sugar cane juice	Plain water	Sugar cane juice	Plain water	Milk, UHT, low-fat, recombined
	Rice porridge, fish instant	Bread, white	Plain Rice	Banana Pancake	Noodle, rice	Fried peneram
			Fem shoots		Fem shoots	
			Papaya only		Papaya only	
			Fish, unspecified, dried, salt		Chicken sate	
Amount			1 from each Food Group			
No. of dishes/day			18			
Cost (RM)			16.80			
Cost (USD)			4.07			

Table 6. Day 2 Meal Structure Using Integer Programming

Meal	Breakfast	Morning Tea	Lunch	Evening Tea	Dinner	Supper
Type of Food Group	Malted, milk drink, packet	Coffee mixture, powder	Plain water	Coffee powder, instant	Plain water	Milk, UHT, low-fat, recombined
			Plain Rice		Noodle, rice	
	Mung bean fritter	Biscuit, cream crackers	Tapioca shoot	Prawn fritter	Yam stalks	Sweet fermented glutinous rice
			Tamarind fruit		Tamarind fruit	
			Fish sate snack		Chicken sate	
Amount			1 from each Food Group			
No. of dishes/day			18			
Cost (RM)				17.40		
Cost (USD)				4.22		

sate during dinner and lastly, recombined of low-fat UHT milk and sweet fermented glutinous rice during supper. For day 2 meal structure result will cost about RM 17.40 (USD 4.22) slightly higher than day 1 as is has prawn included in the meal.

Table 7 shows the meal structure for day 3. During breakfast and morning tea, autistic 100M sprinter athletes can have recombined of full cream UHT milk and coconut crepe roll and also instant coffee powder and cream crackers biscuit respectively. They are also can have plain water, plain rice, soya bean sprout, white mango, and unspecified salt dried fish dur-

Table 7. Day 3 Meal Structure Using Integer Programming

Meal	Breakfast	Morning Tea	Lunch	Evening Tea	Dinner	Supper
Type of Food Group	Milk, UHT, full cream, recombined Coconut crepe roll	Coffee powder, instant Biscuit, cream crackers	Plain water Plain Rice Soya bean sprout White mango Fish, unspecified, dried, salt	Coffee mixture, powder Banana Pancake	Plain water Rice, fried Peas, garden, fresh White mango Hen egg, whole	Milk, UHT, low-fat, recombined Pandan palm sugar rice ball
Amount			1 from each Food Group			
No. of dishes/day			18			
Cost (RM)				19.10		
Cost (USD)				4.63		

Table 8. Day 4 Meal Structure Using Integer Programming

Meal	Breakfast	Morning Tea	Lunch	Evening Tea	Dinner	Supper
Type of Food Group	Milk, UHT, chocolate flavoured Coconut crepe roll	Plain Syrup rose (sirap ros) Bread, white	Plain water Plain Rice Cashew leaves Langsat Beef sate	Plain Syrup rose (sirap ros) Yau car kue	Plain water Rice porridge, fish, instant Carrot Apple Indian mackerel, fried in chili	Milk, UHT, chocolate flavoured Sweet fermented glutinous rice
Amount			1 from each Food Group			
No. of dishes/day			18			
Cost (RM)				19.70		
Cost (USD)				4.78		

ing lunch, powder coffee mixture and banana pancake during evening tea, plain water, fried rice, fresh garden peas, white mango and whole hen egg during dinner, and recombined full cream UHT milk and pandan palm sugar rice ball during supper. As a result, the cost for day 3 meal is RM 19.10 (USD 4.63). The cost result of day 3 is higher than day 1 and day 2 as it has a mango in the meal structure.

Table 8 shows the meal structure for day 4. Based on day 4 meal structure, autistic 100M sprinter athletes will have a chocolate flavoured of UHT milk and coconut crepe roll during

Table 9. Day 5 Meal Structure Using Integer Programming

Meal	Breakfast	Morning Tea	Lunch	Evening Tea	Dinner	Supper
Type of Food Group	Milk, powder, skim Mung bean fritter	Orange yogurt Bread, wholemeal	Plain water Plain Rice Tapioca shoots Banana Beef sate	Tea Coconut crepe roll	Plain water Rice porridge, fish, instant Cashew leaves Langsat Indian mackerel, fried	Malted milk powder Fried peneram
Amount			1 from each Food Group			
No. of dishes/day			18			
Cost (RM)				20.50		
Cost (USD)				4.97		

Table 10. Nutrient Intake for Five Days

Nutrients	LB	Day 1	Day 2	Day 3	Day 4	Day 5	UB
EN (kcal)	1960	2686	2264	2201	2218	2417	2800
FAT (g)	62	67.30	73.80	68.3	61	73.3	75
CHO (g)	370	383	311.7	308.8	311	310.3	620
PRO (g)	62	94.20	86.1	85.40	89.3	85	-
Ca (g)	1000	915	909	912	957	902	2500
Vit A (μg)	600	1440	739	1262	948	1396	3000
Vit B1 (mg)	1.2	1.63	1.43	1.28	1.26	1.22	-
Vit B2 (mg)	1.3	3.48	3	3.57	3.16	2.13	-
Vit C (mg)	65	289.6	87.2	265.7	73.2	158	2000
Vit B3 (mg)	16	26.8	26.2	19.3	16.7	18.1	35
Fe (mg)	20	27.4	23	37.8	16.2	20.2	45

breakfast, plain syrup rose and white bread during morning tea, and plain water, plain rice, cashew leaves, langsat, and beef sate during dinner. During evening tea, they can have plain syrup rose and yau car kue. Meanwhile, during dinner and supper, they also will have plain water, instant fish rice porridge, carrot, apple, Indian mackerel fried in chili, and also chocolate flavoured of UHT milk and sweet fermented glutinous rice respectively. As a result of day 4 meal structure, it cost about RM 19.70 (USD 4.78).

Table 9 shows the meal structure for day 5. During breakfast and morning tea, autistic 100M sprinter athletes can have skim milk powder and mung bean fritter, and also orange yogurt and wholemeal bread respectively. They are also can have plain water, plain rice, tapioca shoots, banana, and beef sate during lunch, tea and coconut crepe roll during evening tea, plain water, instant fish rice porridge, cashew leaves, langsat, and fried Indian mackerel during dinner, and malted milk powder and fried peneram during supper. As a result, the cost for day 5 meal is RM 20.50 (USD 4.97). The cost result of day 5 slightly higher than day 4 because it consisted of orange yogurt in the meal.

By using integer programming, Tables 5 - 9 shows the result of 5-day with a complete 6 times of meal including breakfast, morning tea, lunch, evening tea, dinner and supper. It also shows provide the recommended food distribution per meal session, providing optimal diet plan to Malaysian autistic 100M sprinter athletes under the modified mathematical model from Tables 5 – 9. Breakfast must be the most calorie-dense meal following lunch and dinner to offer adequate energy for the day. Morning tea and evening tea act as pre-lunch and pre-dinner snacks, respectively, to sustain nutrient levels and suppress hunger. Lunch and dinner are the two major meals, which are typically made up of rice, protein foods, vegetables, fruits, and beverages. For supper, it is recommended for autistic athletes to take milk as it can contribute to bone development, which is optimized when there is a positive nitrogen balance during sleep as shown in Tables 5 – 9 (Alwadood et al., 2023). Besides, especially for autistic athletes, the consumption of milk in the morning can ease digestion and pain from stomach issues. It can also help reduce the risk of cardiovascular disease. On the other hand, the 5-day meal structure in Table 5 – 9 also show that consuming plain water at least twice a day will reduce the risk of dehydration during training and competition.

Table 10 indicates the nutrients provided under the diet plan of this research, i.e., energy (EN), fat (FAT), carbohydrates (CHO), protein (PRO), calcium (Ca), vitamin A (Vit A), B vitamins (Vit B1, Vit B2, and Vit B3), vitamin C (Vit C), and iron (Fe). The ideal values for macronutrients (energy, fat, carbohydrates, and protein) required by autistic 100M sprinter athletes are high in this research. On the contrary, the contents of micronutrients (vitamin A, B vitamins, calcium, vitamin C, and iron) also reached an optimum value, which is sufficient in providing adequate nutrients to provide enough nourishment for autistic 100M sprinter athletes.

4. CONCLUSIONS

This initial finding of the study shall be helpful to understand the nutrient needs of autistic athletes specializing in 100M sprint and further applying the principle of integer programming to an optimal and palatable menu plan. This will involve autistic athletes in the study who are within the age of 20 to 30 years. The total cost for the diet can be as low as RM 16.80 to more than RM 20.50, depending on what food item is selected for each menu. The future research could also be done on the preparation of menus for a balanced diet that fulfils all the nutritional needs, with other modifying variables included, such as the frequency of the training sessions that could interact with the total intake of food taken per day in a week.

There are some applied implications when planning menus for autistic sprinters focusing the context of Asian businesses. These concern sports nutrition for performance, and the food selectivity related to AS. This comprises nutrient density, area sensitivity, cultural acceptability and profitability. Sprinter athletes require macronutrients such as carbohydrates for energy source, proteins for muscle rebuilding, and fats and also micronutrients because the body requires vitamins and minerals in order to support neurological and muscular functionality. Besides, some of the autistic athletes may have a rigid eating pattern which makes them refrain from taking new foods. Hence, providing them routine and consistent meals can prevent distraction and stress to them as they can alter the type of food group without shifting nutrient intakes daily.

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