ORIGINAL ARTICLE

Does an Asian-based Diet Sufficient to Meet the Nutritional Demands of Endurance Athletes?: A Cross-sectional Study

Zaini Bahari[1,2], Nik Shanita Safii[3], Ahmad Munir Che Muhamed[1]

[1] Department of Community Health, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Bertam, 13200 Kepala Batas, Pulau Pinang, Malaysia
[2] Department of Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[3] Centre for Community Health Studies, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia

ABSTRACT

Introduction: Limited studies have examined the dietary intake pattern of Malaysian endurance athletes. Differences in the types of foods consumed between Malaysian and Western population leads to varying nutritional intake values. This study aimed to characterise the dietary intake of Malaysian endurance athletes as compared to sports nutrition recommendations, and to determine the associations between participants' backgrounds and macronutrients intake status. **Methods:** A total of 85 endurance-trained Malaysian athletes participated in a cross-sectional study. Dietary intake for three days throughout the training season was evaluated using 24-hour dietary recall. The macronutrients and micronutrients intakes were compared to the nutritional recommendation for athletes and the Recommended Nutrient Intakes (RNI), respectively. The food serving size was compared to the Malaysian Food Pyramid 2020. **Results**: Of all participants, 51% met the minimum recommendations for carbohydrate (CHO) intake (6g/kg/day). For protein intake, 88% of participants had surpassed the lower limit of 1.2g/kg/day. The lower limit of fat intake (20% of total daily energy intake) was met by 99% of the participants. Most of the participants had a suboptimal intake of calcium, vitamin A, and vitamin E, while all had inadequate vitamin D intake. The athletes' institution was significantly associated with the CHO intake status. Also, the athletes' institution and the highest education level were significantly associated with the protein intake status. **Conclusion:** Athletes who practised Asian-based diets were able to achieve the energy, protein, and fat intake recommendations. However, there was a suboptimal intake of the CHO and micronutrients as compared to the recommendations.
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Keywords: Nutritional intake, Macronutrients, Micronutrients, Endurance athletes, Asian distance runners

Corresponding Author:
Ahmad Munir Che Muhamed, PhD
Email: ahmadmunir@usm.my
Tel: +604-562 2410

INTRODUCTION

Endurance athletes require a high-quality diet that includes a variety of foods to meet the required energy, macronutrients, and micronutrients (1,2). Published guidelines have provided valuable insights regarding the nutritional needs for athletic performance, particularly on the energy and macronutrients recommendations (3,4). A specific nutritional guideline to meet the Malaysian nutritional perspective was published by the Ministry of Health Malaysia in 2020. This publication referred to as the Malaysian Food Pyramid 2020 highlighted the recommended serving size of a particular food group (5). For moderate-to-high intensity endurance training (1-3 hours/day for 5-6 days/week), the daily recommended intake is 6-10 g/kg body weight of CHO (3), 1.2 - 2.0 g/kg body weight of protein (3,4), and 20-35% of fat from the total daily energy intake (TDEI) (3). With regard to micronutrients, special emphasis should be placed on the optimal consumption of key micronutrients that are crucial for athletic performance namely iron, calcium, vitamin D, and antioxidants (3,6).

Even though the scientific community has paid a lot of attention to the nutritional recommendations for athletes (3,4), suboptimal intakes of energy, macro-, and micronutrients were frequently reported amongst endurance athlete populations (7–11). For instance, a study among competitive trained distance runners from a National Collegiate Athletic Association in the United States showed evidence of CHO intake below the minimum recommendation of 6 g/kg/day (7). On the other hand, a few studies among Caucasian high-performance athletes from several sports indicated the protein intakes exceeded the recommendation, with an average intake of 2.1g/kg/day (8,10,12). The inadequate intake of micronutrients such as calcium, vitamin D, and iron was also reported among the endurance athletes population (10,13).

Numerous studies on the assessment of dietary intake among endurance athletes have been published involving the Western population (14–16). To date, there is a lack of published data regarding dietary intake patterns among the Asian population based on the local dietary intake. The differences between the Eastern and Western cultures are directly reflected in the types of foods consumed, which resulted in varied nutrient constituents. This will lead to variabilities in the level of nutrient adequacy in the diets depending on the population and geographical location (17).

The Asian-based diet features numerous types of rice and noodles as the daily sources of CHO. This is served together with the protein sources such as poultry, meat, and seafoods, as well as vegetables. To create distinctive flavours and tastes, Asian recipes utilise coconut milk, several herbs, and seasonings namely garlic, ginger, lemongrass, lemon basil, and holy basil. An Asian-based diet consists of the higher proportion of CHO compared to a Western diet that is high in fat and animal protein. Likewise, the typical Malaysian diet also possesses the same characteristics as described in an Asian-based diet. Despite the diversity in the ethnic group, the food culture has been homogenised to form a unique Malaysian cuisine. The ingredients used in cooking are often similar or common to each culture (18,19).

To the best of our knowledge, limited studies (14–16) had examined the dietary intake pattern of Malaysian endurance athletes who consumed mainly local Malaysian meals. This would limit the information on whether the dietary intake of Malaysian endurance athletes met the recommended intake for athletic performance. Also, the lack of scientific evidence-based in this area may limit the dietary prescriptions that are based on the local Malaysian meals among the athletes' population.

This study, therefore, aimed to investigate the dietary intake pattern of Malaysian endurance athletes and compare intakes (energy, macronutrients, and micronutrients) to sports nutrition recommendations and general population health recommendations namely Recommended Nutrient Intakes (RNI) and Malaysian Food Pyramid 2020. The secondary objective was to determine the associations between participants' backgrounds and macronutrients intake status. The findings of this study provide information about whether the nutritional requirements of the Malaysian endurance athletes who consumed an Asian-based diet met the recommended intake. This would help the sports dietitians and nutritionists to modify and plan the individual dietary prescription that utilises the local dishes for Malaysian athletes.

MATERIALS AND METHODS

Study design and setting

This cross-sectional study was carried out at the National Sports Council (n=1), State Sports Council (n=4), University Sports Centre (n=4), and several professional sports clubs. The preparation of this article was in accordance with the STROBE-nut principles (20). All participants provided their written informed consent prior to participation in the study.

Ethical clearance

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Human Research Ethics Committee of University Science Malaysia (JEPeM-USM), JEPeM code: USM/JEPeM/19010083. The institutional approval to conduct the study was obtained from each institution. A formal letter was sent to each institution prior to the data collection.

Participants

This study employed purposive sampling, in which the participants who met the inclusion criteria were selected to participate in the study. The response rate in this study was 100%, in which all recruited participants managed to complete the survey. The participants were endurance athletes, consisting of road cyclists and long-distance runners. The inclusion criteria were age 18-35 years old, self-reported good health, trained and active in competition for the past 6 months. The exclusion criteria were current smoking, having chronic diseases, and being on any special diet less than three weeks before the study. For endurance runners, the trained individuals refer to those who had ≥4 sessions of training per week for 1.5–2.0 hours/session (21). As for endurance cyclists, the trained individuals refer to those who had ≥3 sessions, ≥5 hours, and ≥60 km per week of endurance road cycling training (22). The participants were recruited by direct mail through the National and State Sports Councils and the University Sports Centre. Additionally, they were recruited through advertisements, posters, and personal contact (word-of-mouth).

Sample size

The sample size was calculated using the single mean sample size formula (23). The standard deviation included in the formula was 1.1, based on the mean daily CHO intake of the Dutch endurance athletes (13). The absolute error of precision was set at 0.25. This study's calculated sample size was 74 participants. The non-response rate was set at 10%.

Data collection

Participants' backgrounds

A face-to-face interview based on the questionnaire was conducted to obtain the data on participants' backgrounds. These data included age, sex, race, current sports institution, highest education level, type of sports involved, the number of training sessions per week, the training distance per session (kilometres) and the training duration per session (minutes).

Dietary assessment

The dietary assessment was conducted at the participants' institutions or training places. The dietary assessment was performed using 24-hour diet recall for two training days and one rest day during the training season. The dietary recall for a training day was scheduled following a regular training day, while a resting day was scheduled after a day without any training session(s). The 24-hour diet recall was conducted in accordance with the USDA 5-step multiple-pass method, a recognized technique for enhancing the accuracy of dietary recall (24). The 24-h diet recall is a valid method to assess the dietary intake and has been shown to represent the dietary usual intake when repeated a number of times (3 – 7 days), in addition to a low burden to participants (11). The participants were requested to recall all the foods and beverages as well as supplements consumed within the last 24-hour, including portion size, cooking methods, brand name, time, and venue of consumption. To aid participants in estimating meal portion sizes, standard household measuring cups, glasses, bowls, and spoons were used. The participants were instructed not to alter their regular dietary habits. The assessment was conducted by a single trained researcher.

Dietary analyses

Nutritionist Pro™ (Axxya Systems LLC, Stafford, TX, USA) software was used to analyse the nutrient information for each of the food items and beverages. The sources of nutrient information were the Malaysian Food Composition Database, Singapore Energy and Nutrient Composition of Food, USDA National Nutrient Database, and food labels (25–27). When Malaysian food databases have no nutritional information for certain foods or beverages, non-Malaysian databases were referred. When any of the databases did not have nutrient information for specific food items, a standard recipe was developed using Nutritionist Pro™ (Axxya Systems LLC, Stafford, TX, USA) software. If such information was unavailable from the food composition database, commercial food product labels were referred for nutrient information. The foods that completely lacked a nutrient database or the recipe could not be established or lacked a nutrition facts label were replaced with foods of a similar type. Also, the food items and beverages obtained from the 24-hour diet recall were allocated based on the type of food groups in the Malaysian Food Pyramid 2020, in accordance with the determined serving size for each food group. The food groups comprised "rice, other cereals, whole-grain cereal-based products and tubers", "poultry, meat, egg", "fish", "legumes", "milk and milk products", "vegetables" and "fruits" (5).

Mean daily energy and macronutrients intake were assessed against recommendations for high intensities training, advocated by The American College of Sports Medicine (ACSM), Academy of Nutrition and Dietetics (AND), Dietitians of Canada (DC) (3), and International Society of Sports Nutrition (ISSN) (4). The participants' duration and frequency of training reflect the training intensities, in which they were categorised as competitive trained endurance athletes who engaged in moderate to a high volume of training to meet the performance goal. High volume intense training is characterised as having endurance training of 1-3 hour/day of moderate to high-intensity exercise, 5-6 times per week (3,4,22).

The micronutrients and food groups intake were compared against Recommended Nutrient Intake for Malaysia (28) and Malaysian Food Pyramid 2020 (5), respectively. When assessing the micronutrients intake of athletes, the recommended nutrient intake for that particular population should be referred (3). The use of the Malaysian Food Pyramid 2020 for the general population can provide data on the dietary pattern of the participants from the Malaysian context, as the endurance athletes in the present study are Malaysian population. Several previous studies conducted among athletes in other countries referred to the particular populations' food pyramid as a reference (29–31).

The commonly consumed foods were identified by the calculation of the total intake from the particular food items. The percentage of energy was computed using the Block equation (32), in which the commonly consumed foods accounted for the highest percentage of energy intake. The mean intake and the number of participants consuming each food were also quantified.

Data analyses

The data were analysed using IBM SPSS version 26 (IBM SPSS Statistics 26, NY, USA). For descriptive analysis, mean and standard deviation (SD) were used to describe continuous variables, while frequency and percentage were used to present categorical variables. The normality of data was assessed using a Shapiro-Wilk test. A one-sample t-test was used to determine whether the mean intake of macronutrients of participants was different from the minimum recommended value. A Chi-square test of independence was used to determine the associations between participants' backgrounds and macronutrients intake status. If the data did not meet the assumptions for the Chi-square test, Fisher-Freeman-Halton Exact test was employed. The statistical significance was set at $p<0.05$.

RESULTS

Backgrounds of the participants

Table I demonstrates the backgrounds of the participants in this study. A total of 85 participants were involved in this study, with the majority of them were males (84%). The participants' mean age was 24.25 ± 5.52 years old. More than half (66%) of the participants were attached to sports institutions, namely National Sports Council (17%), State Sports Council (20%), and the university sports centre (29%). On the other hand, 34% of the participants were in professional sports clubs and living freely. Of all participants, 66% of them had tertiary education as the highest education level. More than half (53%) of the participants engaged in road cycling, while 47% of them engaged in long-distance running. The participants engaged in long-distance running had about six training sessions (6 ± 3) per week, with a mean duration of 105.75 ± 22.52 minutes per session. With regards to road cycling, the participants had about seven training sessions (7 ± 3) per week, with a mean duration of 210.00 ± 62.01 minutes per session.

Table I: Backgrounds of the participants (*n*=85)

Variables	n (%)	Mean ± SD
Age (years)		24.25 ± 5.25
Sex		
Male	71 (83.5)	
Female	14 (16.5)	
Race		
Chinese	14 (16.5)	
Indian	2 (2.4)	
Malay	67 (78.8)	
Others (Siamese, Dusun)	2 (2.4)	
Current sports institution		
National Sports Council	14 (16.5)	
State Sports Council	17 (20.0)	
University Sports Centre	25 (29.4)	
Professional sports clubs	29 (34.1)	
Highest education level		
Secondary education	29 (34.1)	
Tertiary education	56 (65.9)	
Type of sports involve		
Road cycling	45 (52.9)	
Long-distance running	40 (47.1)	
Number of training sessions per week		
Road cycling		7.00 ± 3.00
Long-distance running		6.00 ± 3.00
Distance of training per session (km)		
Road cycling		95.78 ± 26.07
Long-distance running		11.08 ± 3.63
Duration of training per session (minutes)		
Road cycling		210.00 ± 62.01
Long-distance running		105.75 ± 22.52

Daily mean intake for total energy, macronutrients, and micronutrients of the participants

Table II describes the dietary intake of the participants assessed using 24-hour diet recall. The relative mean intake of CHO was 6.29 g/kg/day, which was within the recommended value of 6-10 g/kg/day. The mean value was not significantly higher than the minimum recommended intake of 6 g/kg/day. Out of all participants, 51% had achieved a CHO intake of more than 6 g/kg/day, while 49% had a CHO intake below the minimum recommendation of 6 g/kg/day, with a mean value of 4.54 g/kg/day. Pertaining to protein intake, the relative mean intake was 1.81 g/kg/day, which was within the recommended value of 1.2-2.0 g/kg/day. The mean value was significantly higher than the minimum recommended intake of 1.2 g/kg/day. This was evident whenever 88% (combination of meet and over recommendation) of the participants had achieved the minimum protein intake of 1.2 g/kg/day. As for fat intake, the mean intake of 32% of TDEI was within the recommended range of 20-35% of TDEI. The mean value was significantly higher than the minimum recommended intake of 20% of TDEI. This was proven whenever 99% of the participants had surpassed the minimum recommended intake of 20% of TDEI. With regards to micronutrients intake, most of the participants had intakes below the recommendation for calcium (85%), vitamin D (100%), vitamin A (95%), and vitamin E (89% men, 71% women). As for the iron, the majority (79%) of the women indicated suboptimal intake than the recommendation.

Mean intake for food group as per Malaysian Food Pyramid 2020

Table III demonstrates the mean intake for food groups based on the Malaysian Food Pyramid 2020. The majority of the participants had a suboptimal intake of recommended serves of milk and milk products (99%), legumes (93%), vegetables (92%), fish (85%), and fruits (82%).

The top 10 food sources among participants

Table IV presents the commonly consumed foods based on the diet recall data. Chicken showed the greatest contribution to overall energy intake, consumed by 97% of the participants. This was followed by flavoured rice (chicken rice, coconut milk rice, fried rice, and briyani rice) and white rice, which were consumed by 78% and 94% of the participants, respectively.

Table II: Daily mean intake for total energy, macronutrients, and micronutrients of the participants (*n*=85)

	Recommendation	Daily mean intake, Mean ± SD	*p*-value	Number and percentage of participants, n (%)		
				Meet recommendation	Under recommendation	Over recommendation
Energy intake						
kcal/day	2000-7000 kcal/day[a]	2795.84 ± 756.29		72 (84.7)	13 (15.3)	0 (0)
kcal/kg/day	40-70 kcal/kg/day[a]	46.80 ± 13.47		54 (63.5)	27 (31.0)	4 (4.7)
CHO intake						
g/kg/day	6–10 g/kg/day[b]	6.29 ± 2.22	0.237	37 (43.5) Mean intake ± SD: 7.52±1.14	42 (49.4) Mean intake ± SD: 4.54±1.04	6 (7.1) Mean intake ± SD: 10.96±1.17
% TDEI		53.19 ± 7.23				
Protein intake						
g/kg/day	1.2–2.0 g/kg/day[a,b]	1.81 ± 0.51	<0.001*	53 (62.4) Mean intake ± SD: 1.66±0.22	10 (11.8) Mean intake ± SD: 1.07±0.13	22 (25.9) Mean intake ± SD: 2.51±0.29
% TDEI		15.82 ± 3.32				
Fat intake						
g/kg/day		1.63 ± 0.50				
% TDEI	20-35% TDEI[b]	31.47 ± 5.39	<0.001*	63 (74.1) Mean intake ± SD: 29.44±3.65	1 (1.2) Mean intake ± SD: 16.81±0.00	21 (24.7) Mean intake ± SD: 38.26±2.94
Micronutrients intake						
Calcium (mg/day)	1000mg/day[c]	759.07 ± 244.36		13 (15.3)	72 (84.7)	0 (0)
Iron (mg/day)	14 mg/day (men)[c]	28.79 ± 12.48		63 (88.7)	8 (11.3)	0 (0)
	29 mg/day[c] (women)	21.14 ± 8.35		3 (21.4)	11 (78.6)	0 (0)
Vitamin D (µg/day)	15 µg/day[c]	1.31 ± 1.57		0 (0)	85 (100.0)	0 (0)
Vitamin A (µg/day)	600 µg/day[c]	169.08 ± 205.36		4 (4.7)	81 (95.3)	0 (0)
Vitamin C (mg/day)	70 mg/day[c]	91.03 ± 81.66		43 (50.6)	42 (49.4)	0 (0)
Vitamin E (mg/day)	10 mg/day (men)[c]	6.17 ± 3.05		8 (11.3)	63 (88.7)	0 (0)
	7.5 mg/day (women)[C]	4.78 ± 3.10		4 (28.6)	10 (71.4)	0 (0)

[a](4); [b](3); [c](28): a, b, and c refer to the cited references number 4, 3, and 28, respectively
**p*<0.05, the daily mean value is significantly higher than the minimum recommended value.
Abbreviation: % TDEI = percentage of total daily energy intake

Table III: Mean intake for food group as per Malaysian Food Pyramid 2020 (*n*=85)

Food groups	Recommendations	Daily mean servings	Number and percentage of participants, n (%)		
			Meet recommendation	Under recommendation	Over recommendation
Rice, other cereals, whole-grain cereal-based products, and tubers	3 – 5 servings/ day	5.92 ± 2.38	22 (25.9)	9 (10.6)	54 (63.5)
Poultry, meat, egg	1 – 2 servings/ day	3.13 ± 1.72	16 (18.8)	8 (9.4)	61 (71.8)
Fish	1 serving/ day	0.45 ± 0.50	1 (1.2)	72 (84.7)	12 (14.1)
Legumes	1 serving/ day	0.26 ± 0.39	6 (7.1)	79(92.9)	0 (0)
Milk and milk products	2 servings/day	0.22 ± 0.49	0 (0)	84 (98.8)	1(1.2)
Vegetables	$\geq$ 3 servings/day	1.04 ± 1.34	7 (8.2)	78 (91.8)	0(0)
Fruits	2 servings/day	1.04 ± 1.58	15 (17.6)	70 (82.4)	0(0)

Table IV: The top 10 food sources of energy (kcal) among participants (*n*=85)

Rank	Food item	Cons	Mean (kcal)	Contributions to energy intake (%)	Cumulative (%)
1	Chicken	82	406.80	14.04	14.04
2	Flavoured rice	66	420.59	11.68	25.72
3	White rice	80	278.87	9.39	35.11
4	Wheat noodle	48	223.96	4.52	39.63
5	Tea	59	172.77	4.29	43.92
6	Cordial syrup	42	176.59	3.12	47.04
7	Rice noodle	41	179.81	3.10	50.14
8	Bread	51	141.83	3.04	53.18
9	Malted drink	39	156.66	2.57	55.75
10	Coffee	44	137.75	2.55	58.30

Abbreviation: Cons = number of consumers

Associations between participants' background and macronutrients intake status

Table V shows the associations between participants' backgrounds and macronutrients intake status. With regards to CHO intake, athletes' institution was significantly associated with the CHO intake status. The proportion of inadequate CHO intake was higher among the participants in sports clubs (50%) than those in the national sports council (17%), state sports council (7%), and university sports centre (26%). There were no significant associations between sex, race, highest education level and type of sports involved with the CHO intake status. With regards to protein intake, athletes' institution and the highest education level were significantly associated with the protein intake status. The proportion of having an intake of more than the recommendation (>2.0 g/kg/day) was higher among those from the state sports council (46%) than those in the national sports council (23%), university sports centre (9%), and sports club (23%). Meanwhile, the proportion of meeting the recommendation was higher among those with tertiary education (74%) than those with secondary education (26%). With regards to fat intake, there were no significant associations between sex, race, athletes' institutions, highest education level and type of sports involved with the fat intake status.

DISCUSSION

The main finding of this study was that the majority of the Malaysian trained-endurance athletes who participated in this study had achieved the recommended energy, protein, and fat intakes. While more than half of the participants had achieved the recommendations for CHO when food consumed was mainly based on the Asian diet. However, the majority of the participants had a suboptimal intake of calcium, vitamin D, vitamin A, and E. Majority of female participants did not achieve

Table V: Associations between participants' background and macronutrients intake status (*n*=85)

Variables	Carbohydrates				Protein				Fat			
	Meet recommendation n (%)	Under recommendation n (%)	Over recommendation n (%)	$x^2$and *p-value*	Meet recommendation n (%)	Under recommendation n (%)	Over recommendation n (%)	$x^2$and *p-value*	Meet recommendation n (%)	Under recommendation n (%)	Over recommendation n (%)	$x^2$and *p-value*
Sex												
Male	30 (81.1)	35 (83.3)	6 (100.0)	x^2=1.345, *p*=0.734	42 (79.2)	8 (80.0)	21 (95.5)	x^2=3.208, *p*=0.208	51 (81.0)	1 (100.0)	19 (90.5)	x^2=1.374, *p*=0.583
Female	7 (18.9)	7 (16.7)	0 (0.0)		11 (20.8)	2 (20.0)	1 (4.5)		12 (19.0)	0 (0.0)	2 (9.5)	
Total	*37 (100.0)*	*42 (100.0)*	*6 (100.0)*		*53 (100.0)*	*10 (100.0)*	*22 (100.0)*		*63 (100.0)*	*1 (100.0)*	*21 (100.0)*	
Race												
Chinese	5 (13.5)	9 (21.4)	0 (0.0)	x^2=6.688, *p*=0.322	10 (18.9)	0 (0.0)	4 (18.2)	x^2=4.192, *p*=0.627	10 (15.9)	0 (0.0)	4 (19.0)	x^2=9.899, *p*=0.229
Indian	1 (2.7)	0 (0.0)	1 (16.7)		1 (1.9)	0 (0.0)	1 (4.5)		0 (0.0)	0 (0.0)	2 (9.5)	
Malay	30 (81.1)	32 (76.2)	5 (83.3)		40 (75.5)	10 (100.0)	17 (77.3)		51 (81.0)	1 (100.0)	15 (71.4)	
Others	1 (2.7)	1 (2.4)	0 (0.0)		2 (3.8)	0 (0.0)	0 (0.0)		2 (3.2)	0 (0.0)	0 (0.0)	
Total	*37 (100.0)*	*42 (100.0)*	*6 (100.0)*		*53 (100.0)*	*10 (100.0)*	*22 (100.0)*		*63 (100.0)*	*1 (100.0)*	*21 (100.0)*	
Current institution												
National Sports Council	6 (16.2)	7 (16.7)	1 (16.7)	x^2=18.115, *p*=0.002*	9 (17.0)	0 (0.0)	5 (22.7)	x^2=16.237, *p*=0.007*	9 (14.3)	0 (0.0)	5 (23.8)	x^2=7.955, *p*=0.166
State Sports Council	10 (27.0)	3 (7.1)	4 (66.7)		6 (11.3)	1 (10.0)	10 (45.5)		14 (22.2)	1 (100.0)	2 (9.5)	
University Sports Centre	14 (37.8)	11 (26.2)	0 (0.0)		19 (35.8)	4 (40.0)	2 (9.1)		21 (33.3)	0 (0.0)	4 (19.0)	
Professional sports club	7 (18.9)	21 (50.0)	1 (16.7)		19 (35.8)	5 (50.0)	5 (22.7)		19 (30.2)	0 (0.0)	10 (47.6)	
Total	*37 (100.0)*	*42 (100.0)*	*6(100.0)*		*53 (100.0)*	*10 (100.0)*	*22 (100.0)*		*63 (100.0)*	*1 (100.0)*	*21 (100.0)*	
Highest education level												
Secondary education	13 (35.1)	12 (28.6)	4 (66.7)	x^2=3.269, *p*=0.183	14 (26.4)	2 (20.0)	13 (59.1)	x^2=8.390, *p*=0.012*	21 (33.3)	1 (100.0)	7 (33.3)	x^2=1.954, *p*=0.535
Tertiary education	24 (64.9)	30 (71.4)	2 (33.3)		39 (73.6)	8 (80.0)	9 (40.9)		42 (66.7)	0 (0.0)	14 (66.7)	
Total	*37 (100.0)*	*42 (100.0)*	*6 (100.0)*		*53 (100.0)*	*10 (100.0)*	*22 (100.0)*		*63 (100.0)*	*1 (100.0)*	*21 (100.0)*	
Type of sports												
Road cycling	22 (59.5)	19 (45.2)	4 (66.7)	x^2=2.063, *p*=0.386	27 (50.9)	4 (40.0)	14 (63.6)	x^2=1.767, *p*=0.429	33 (52.4)	1 (100.0)	11 (52.4)	x^2=0.863, *p*=1.000
Long-distance running	15 (40.5)	23 (54.8)	2 (33.3)		26 (49.1)	6 (60.0)	8 (36.4)		30 (47.6)	0 (0.0)	10 (47.6)	
Total	*37 (100.0)*	*42 (100.0)*	*6 (100.0)*		*53 (100.0)*	*10 (100.0)*	*22 (100.0)*		*63 (100.0)*	*1 (100.0)*	*21 (100.0)*	

**p*<0.05, significant association between variables and macronutrient intake status the optimal iron intake. There was a suboptimal intake of several food groups namely, milk and milk products, legumes, vegetables, fish, and fruits. This means that the inadequacy of certain nutrients occurs when the participants consumed inadequate servings of foods from a variety of food groups.

This study found that the average energy intake among participants was 2796 ± 756 kcal, which corresponded to 47 ± 14 kcal/kg/day. This is slightly higher than the finding obtained from a systematic review on the energy intake during the training phase among trained endurance athletes aged 18-40 years old (43 ± 11 kcal/kg/day) (14). The finding in the present study was consistent with a study among a group of university endurance athletes in Malaysia that reported an energy intake of 2865 ± 1058 kcal and 2628 ± 840 kcal for male and female athletes, respectively (11). Likewise, a study among Spanish marathon runners reported an energy intake of 3006 ± 363 kcal/day, which corresponded to 45 ± 6 kcal/kg/day. The source of energy was contributed by 45% of CHO, 17% of protein, and 36% of fat. The contribution of fat as a source of energy was higher as compared to the present study which was 32%. The high consumption of pastries and sweets as reported in the study may explain the high percentage contribution of fat to the total energy (33). This is not surprising as the Western dietary pattern mainly consisted of red and processed meats as well as foods rich in fats and sugars (34).

Despite 51% of the participants having surpassed the minimum recommendation for CHO intake, it is worth noting that the relative mean value of CHO intake in the present study was not significantly higher than the minimum recommended intake. This means that the CHO intake of the population was not really at the optimal level in which the mean intake of CHO was very close to the minimum recommended value. This finding can be explained by the suboptimal consumption of nutrient-rich CHO foods namely fruits, vegetables, and dairy products. A study among Spanish marathon runners indicated a similar pattern of findings, in which the consumption of dairy products, vegetables, cereals, and potatoes was lower than the recommended amount of servings. This was evident when the mean intake was 5.04 ± 0.89 g/kg/day, which was lower than the present study (33). Besides, it was revealed that only 46% of endurance athletes who participated in triathlon events had an intake of CHO above 6 g/kg body weight (9). This means that the inadequacy of CHO was consistent across different populations, whenever the food servings intake was unmet.

Regarding protein intake, the majority (88%) of the participants met the lower limit of the recommended protein intake (1.2 g/kg/day). This finding was in line with a few previous studies among distance runners (7,33,35). For instance, a previous study (33) reported the mean intake within the recommended range, with a value of 1.94 ± 0.36 g/kg/day. Nevertheless, 25% of the participants in this study indicated a higher intake of protein than the recommendation (>2.0 g/kg/day), similar to other studies (8,10,12). The justification to maintain skeletal muscle mass can be a common reason for an athlete to increase protein intake. Also, the ability of the protein to enhance satiety, makes it a special interest for athletes who are targeting losing body weight (36). However, it was reported that the consumption of protein of more than 2.5g/kg body weight has no benefit (37). This indicates that an adequate protein intake was achieved among athletes in different populations. However, continuous assessment and education from sports dietitians and nutritionists are important to prevent chronic excess protein intake.

As for fat intake, the majority (99%) of the participants achieved the lower limit of the fat recommendation (20% of TDEI). Based on the previous study, most of the athletes had an intake of fat according to the recommendation, however, there was still a number of athletes who had a poor consumption of fat (8). It was advocated that endurance training on very low-fat diets (15% dietary fat) and high-fat diets (>40% dietary fat) may be detrimental to exercise performance due to compromised immune function (38). In relation to the present study, no participant had a fat intake below 15% or above 40% of TDEI. It means that the athletes in the present study and previous studies were able to consume diets that meet the optimal fat intake.

With regards to micronutrients, the present study indicated that there was an inadequacy of calcium and vitamin D. The optimal intake of vitamin D and calcium is crucial for bone health, muscle contraction, and preventing stress fractures among endurance athletes (6). The inadequate calcium and vitamin D intake in the present study was evidenced by the lower intake of milk and milk products, legumes, and vegetables by most of the participants. It was shown that the athletes who had consumed optimal dairy foods had significantly higher calcium as compared to those who did not (39). With regards to the Malaysian diet, other than milk and dairy products, the calcium-rich foods can be obtained from fish with edible bones such as canned sardines and anchovies, yellow dhal, tofu, and tempeh as well as vegetables like spinach, watercress, mustard leaves, tapioca leaves, kale and broccoli (28). The findings in the present study were in line with a few previous studies conducted among Portuguese and Dutch athletes. The Portuguese athletes showed the inadequacy of calcium and vitamin D due to low consumption of dairy products (8). While Dutch athletes showed the inadequacy of vitamin D due to low consumption of vitamin D-containing foods such as butter or margarine, and fatty fish (40). This means that an adequate serving of calcium and vitamin D rich foods is crucial to ensure nutrients adequacy.

Next, a large inadequacy of iron was seen among female participants in the present study. The inadequate intake of dietary iron was identified as among the common factors for cases of iron deficiency among athletes (41,42). The prevalence of iron inadequacy among endurance athletes was about 3-11% and 20-40% among male and female athletes, respectively (6). The key roles of iron are for oxygen delivery, energy metabolism, and immune function. These roles are important for the optimal function of the aerobic energy system, which is the main energy fuel in endurance athletes (41). The inadequate iron level will therefore impair endurance performance. As evidenced in this study, one of the possible reasons for the inadequate iron intake was due to the higher number of participants who did not meet the serving size for high iron-containing foods namely vegetables (leafy green vegetables) and legumes (lentils, beans, nuts). Although the majority of the participants had achieved the recommended servings of meat, poultry, and egg, it was not adequate to achieve the recommended iron intake. The amount of iron in meat and poultry was 2.2 and 2.8 mg/100g edible portion, respectively. These amounts were lower than the several high-iron foods such as swamp cabbage (kangkung) (5.2 mg/100g edible portion), spinach (5.0 mg/100g edible portion), and chickpeas (6.9mg/100g edible portion). From the Malaysian context, among the foods that are high in iron are chickpea, fried soya bean curd, spinach, swamp cabbage (kangkung), liver, dried anchovies, and boiled cockles (28). With the suboptimal intake of iron-containing foods, it is not surprising that a few review studies revealed a high prevalence of iron deficiency in female athletes of different sports (41,42). The intention to lose weight and/or improve performance which leads to severe energy restriction makes it a possible cause for female athletes being more prone to micronutrient deficiency (3).

The consumption of antioxidants was found to be inadequate in this study, particularly vitamin A, and vitamin E. This finding was in line with the previous studies among trained endurance athletes in the Western populations (40,43). This may link to the lack of antioxidant-rich foods such as fruits and vegetables as evidenced in this study. The optimal intake of antioxidants is crucial to protect the cell membranes from oxidative damage due to chronic training (3).

The types of foods consumed by participants in the present study were not similar to the previously published study based on a Western diet due to differences between the two distinct cultures (17). Asian-based diet shares many important features with the Mediterranean-like dietary pattern which emphasized whole grains, fresh fruits, vegetables, good quality proteins (i.e., pulses, fish, poultry, dairy products, eggs, and a moderate amount of red meat), little to no processed and packaged foods, sweets and sweetened beverage (18,44). In contrast, a Western-based diet is characterized by being high in red meat and pastries, but lacking in fruits and vegetables (19,45,46). In the present study, the foods consumed mainly consisted of white rice and noodles as sources of CHO together with chicken as a source of protein. This combination of meals reflects the typical Asian diet that was able to meet the energy, protein, and fat requirement for the athletic performance of endurance athletes. This was in line with the previous study conducted among a group of university endurance athletes in Malaysia that reported white rice and wheat noodle as the preferred sources of CHO (11). A study by Fujita et al. (29) reported that Japanese athletes' daily food intake consisted of CHO in the form of rice, noodles, and bread, together with protein sources of fish and meat as well as vegetables. This balanced and optimal diet intake is essential for health and enhancing exercise performance.

With regards to the association between participants' backgrounds and macronutrients intake status, the participants from the sports club indicated the highest proportion of inadequate CHO intake. It was evident that low CHO intake in relation to training sessions was often in the diets of free-living athletes (9,43,47). The nature of free-living in which the participants were responsible for their meals may lead to the inadequacy of the CHO intake. This can be related to the skills to purchase and prepare foods, which were indicated as the determinants of the food intake among athletes (48). Next, the participants with tertiary education had a higher proportion of fulfilling protein intake than those with secondary education. Those who had tertiary education had been shown to have wider exposure to nutritional information from reputable personnel such as academicians, medical officers, dietitians, or nutritionists and online resources from the internet (49). This may imply a good quality of knowledge obtained, which can be translated into good nutrition practice.

On the other hand, the present study highlighted that the participants from the state sports council had the highest proportion of having more than the recommendations for protein intake. This may be due to the situational factors in which the foods were readily provided at the dining hall for each meal time. The freedom to choose foods based on the quantity they preferred may lead to overconsumption of protein. It was reported previously that the abundance of foods available led to overeating in dining rooms (48). A systematic scoping review highlighted that the accessibility and convenience of getting food were among the determinants of food choices of the athletes (50).

The strength of this study was the identification of the dietary pattern of Malaysian endurance athletes which was not widely reported previously. A previous local study limit the investigation to university athletes only and reported no data on the micronutrients intakes (11). The present study used 24-hour diet recall based on the USDA 5-step multiple-pass, which serves as the "gold standard" method that can provide detailed dietary data on the method of preparation, portion size, and location of the consumption. The repeated number of days for dietary assessment can adequately reflect the dietary pattern of the participants. However, some limitations should be acknowledged. There are inherent issues when using self-reported dietary data, such as recall error, inaccurate estimation of portion size, and systematic error in dietary reporting to produce socially desirable answers.

CONCLUSION

It was evident from this study that an Asian-based diet was sufficient in providing the energy, protein, and fat intake of Malaysian endurance athletes. While the CHO intake was fulfilled by slightly more than half of the endurance athletes. However, the present study observed key micronutrients intake of calcium, vitamin D, vitamin A, vitamin E and iron were not fulfilled. In addition, several food groups namely fruits, vegetables, and dairy products were also not fulfilled. Therefore, the findings of this study highlight the need for endurance athletes to modify their individualized nutrition needs based on their respective local diets. This can be achieved through sports nutrition educational talks and individualized counseling sessions with sports dietitians or nutritionists.

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REFERENCES

1. Vitale K, Getzin A. Nutrition and Supplement Update for the Endurance Athlete : Review and Recommendations. Nutrients. 2019;11(6):1289. doi: 10.3390/nu11061289.
2. Ravindra P, Janhavi P, Divyashree S, Muthukumar S. Nutritional interventions for improving the endurance performance in athletes. Arch Physiol Biochem. 2022;128(4):851–8. doi: 10.1080/13813455.2020.1733025.
3. Thomas DT, Erdman KA, Burke LM. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. J Acad Nutr Diet. 2016;116(3):501–28. doi: 10.1016/j.jand.2015.12.006.
4. Kerksick CM, Wilborn CD, Roberts MD, Smith-ryan A, Kleiner SM, J∆ger R, et al. ISSN exercise & sports nutrition review update : research & recommendations. J Int Soc Sports Nutr. 2018;15(1):1–57. doi: 10.1186/s12970-018-0242-y.
5. National Coordinating Committee on Food and Nutrition. Malaysian Dietary Guidelines 2020. Malaysia: National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia; 2021. Available from: https://hq.moh.gov.my/nutrition/wp-content/uploads/2021/07/Web%20MDG.pdf.
6. Beck KL, Hurst PR Von, Brien WJO, Badenhorst CE. Micronutrients and athletic performance : A review. Food Chem Toxicol. 2021;158:112618. doi: 10.1016/j.fct.2021.112618.
7. Beermann BL, Lee DG, Almstedt HC, McCormack WP. Nutritional Intake and Energy Availability of Collegiate Distance Runners. J Am Coll Nutr. 2020;39(8):747–55. doi: 10.1080/07315724.2020.1735570.
8. Nunes CL, Matias CN, Santos DA, Morgado JP, Monteiro CP, Sousa M, et al. Characterization and Comparison of Nutritional Intake between Preparatory and Competitive Phase of Highly Trained Athletes. Medicina (B Aires). 2018;54(3):41. doi: 10.3390/medicina54030041.
9. Masson G, Lamarche B. Many non-elite multisport endurance athletes do not meet sports nutrition recommendations for carbohydrates. Appl Physiol Nutr Metab. 2016;41(7):728–34. doi: 10.1139/apnm-2015-0599.
10. Baranauskas M, Stukas R, Tubelis L, Zagminas K, Surkiene G, Svedas E, et al. Nutritional habits among high-performance endurance athletes. Medicina (B Aires). 2015;51(6):351–62. doi: 10.1016/j.medici.2015.11.004.
11. Noh NM, Shuhaimi FA, Nor NM. Carbohydrate Intakes and Preferences among Endurance Athletes in Universiti Teknologi MARA Selangor. J Phys Conf Ser. 2020;1496(1):012010. doi: 10.1088/1742-6596/1496/1/012010.
12. Mielgo-Ayuso J, Zourdos MC, Calleja-Gonz6lez J, Urdampilleta A, Ostojic SM. Dietary intake habits and controlled training on body composition and strength in elite female volleyball players during the season. Appl Physiol Nutr Metab. 2015;40(8):827–34. doi: 10.1139/apnm-2015-0100.
13. Wardenaar F, Brinkmans N, Ceelen I, Van Rooij B, Mensink M, Witkamp R, et al. Macronutrient intakes in 553 Dutch elite and sub-elite endurance, team, and strength athletes: Does intake differ between sport disciplines? Nutrients. 2017;9(2):119. doi: 10.3390/nu9020119.
14. Heydenreich J, Kayser B, Schutz Y, Melzer K. Total Energy Expenditure, Energy Intake, and Body Composition in Endurance Athletes Across the Training Season : A Systematic Review. Sport Med. 2017;3(1):1–24. doi: 10.1186/s40798-017-0076-1.

15. McGuire A, Warrington G, Doyle L. Low energy availability in male athletes : A systematic review of incidence, associations, and effects. Transl Sport Med. 2020;3(3):173–87. doi: 10.1002/tsm2.140.
16. Capling L, Beck KL, Gifford JA, Slater G, Flood VM, Connor HO. Validity of Dietary Assessment in Athletes : A Systematic Review. Nutrients. 2017;9(12):1313. doi: 10.3390/nu9121313.
17. Hsu FC, Agyeiwaah E, Scott N. Understanding tourists' perceived food consumption values: Do different cultures share similar food values? Int J Gastron Food Sci. 2022;28:100533. doi: 10.1016/j.ijgfs.2022.100533.
18. Cena H, Calder PC. Defining a Healthy Diet : Evidence for the Role of Contemporary Dietary Patterns in Health and Disease. Nutrients. 2020;12(2):334. doi: 10.3390/nu12020334.
19. Zainal Abidin MR, Che Ishak FA, Ismail IA, Juhari NH. Modern Malaysian Cuisine: Identity, culture, or modern-day fad? Int J Gastron Food Sci. 2020;21:100220. doi: 10.1016/j.ijgfs.2020.100220.
20. Lachat C, Hawwash D, Ockй MC, Berg C, Forsum E, Hurnell A, et al. Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology (STROBE-nut): An Extension of the STROBE Statement. PLoS Med. 2016;13(6):1–15. doi: 10.1371/journal.pmed.1002036.
21. Durkalec-Michalski K, Zawieja EE, Zawieja BE, Jurkowska D, Buchowski MS, Jeszka J. Effects of low versus moderate glycemic index diets on aerobic capacity in endurance runners: Three-week randomized controlled crossover trial. Nutrients. 2018;10(3):370. doi: 10.3390/nu10030370.
22. Pauw K De, Roelands B, Cheung SS, Geus B De, Rietjens G, Meeusen R. Guidelines to Classify Subject Groups in Sport- Science Research. Int J Sports Physiol Perform. 2013;8(2):111–22. doi: 10.1123/ijspp.8.2.111.
23. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med. 2013;35(2):121–6. doi: 10.4103/0253-7176.116232.
24. Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler W V., et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. Am J Clin Nutr. 2008;88(2):324–32. doi: 10.1093/ajcn/88.2.324.
25. Singapore Health Promotion Board. Energy and Nutrient Composition of Food [Internet]. 2011 [cited 2021 Oct 15]. Available from: https://focos.hpb.gov.sg/eservices/ENCF/.
26. United States Department of Agriculture. USDA Nutrient Database for Standard Reference. Riverdale, Md: Nutrient Data Laboratory, Agricultural Research Service; 2011. Available from:https://data.nal.usda.gov/dataset/usda-national-nutrient-database-standard-reference-legacy-release.
27. Institute for Medical Research. Malaysian Food Composition Database [Internet]. 2015 [cited 2021 Oct 15]. Available from: https://myfcd.moh.gov.my/index.html.
28. National Coordinating Committee on Food and Nutrition. Recommended Nutrient Intakes for Malaysia. A Report of the Technical Working Group on Nutritional Guidelines. Putrajaya: Ministry of Health Malaysia; 2017. Available from: https://nutrition.moh.gov.my/wp-content/uploads/2017/05/FA-Buku-RNI.pdf.
29. Fujita D, Yanagisawa K, Mekata Y, Sasaki K, Kawano Y. Typical Japanese dietary pattern of meal consumption is positively related to healthy eating in university athletes. J Phys Fit Sport Med. 2020;9(3):95–104. doi: 10.7600/jpfsm.9.95.
30. Jenner SL, Devlin BL, Forsyth AK, Belski R. Dietary intakes of professional Australian football league women's (AFLW) athletes during a preseason training week. J Sci Med Sport. 2019;22(11):1266–71. doi: 10.1016/j.jsams.2019.06.014.
31. Pelly FE, Thurecht R. Evaluation of Athletes' Food Choices during Competition with Use of Digital Images. Nutrients. 2019;11(7):1627. doi: 10.3390/nu11071627.
32. Block G, Dresser C, Hartman A, Carroll M. Nutrient sources in the American diet: quantitative data from the NHANES II survey. II. Macronutrients and fats. Am J Epidemiol. 1985;122(1):27–40. doi: 10.1093/oxfordjournals.aje.a114084.
33. Mielgo-Ayuso J, Calleja-Gonzalez J, Refoyo I, Leon-Guereno P, Cordova A, Coso J Del. Exercise-Induced Muscle Damage and Cardiac Stress During a Marathon Could be Associated with Dietary Intake During the Week Before the Race. Nutrients. 2020;12(2):316. doi: 10.3390/nu12020316.
34. Flores-Garcia MK, Merida-Ortega A, Denova-Gutierrez E, Rothenberg SJ, Lopez-Carrillo L. 'Western' and 'Prudent' dietary patterns are associated with breast cancer among Mexican pre- and post-menopausal women. Nutr Res. 2022;105:138–46. doi: 10.1016/j.nutres.2022.06.007.
35. Gillen JB, Trommelen J, Wardenaar FC, Brinkmans NYJ, Versteegen JJ, Jonvik KL, et al. Dietary protein intake and distribution patterns of well-trained Dutch athletes. Int J Sport Nutr Exerc Metab. 2017;27(2):105–14. doi: 10.1123/ijsnem.2016-0154.
36. Manore MM. Weight Management for Athletes and Active Individuals: A Brief Review. Sport Med. 2015;45(1):83–92. doi: 10.1007/s40279-015-0401-0.
37. Burke LM, Castell LM, Casa DJ, Close GL, Costa RJS, Desbrow B, et al. International Association of Athletics Federations Consensus Statement 2019 : Nutrition for Athletics Recognizing the Special

Issues of Event Groups in Athletes. Int J Sport Nutr Exerc Metab. 2019;29(2):73–84. doi: 10.1123/ijsnem.2019-0065.
38. Gunzer W, Konrad M, Pail E. Exercise-Induced Immunodepression in Endurance Athletes and Nutritional Intervention with Carbohydrate, Protein and Fat—What Is Possible, What Is Not? Nutrients. 2012;4(9):1187–212. doi: 10.3390/nu4091187.
39. Capling L, Tam R, Beck KL, Slater GJ, Flood VM, Connor HTO, et al. Diet Quality of Elite Australian Athletes Evaluated Using the Athlete Diet Index. Nutrients. 2021;13(1):126. doi: 10.3390/nu13010126.
40. Wardenaar F, Brinkmans N, Ceelen I, Van Rooij B, Mensink M, Witkamp R, et al. Micronutrient intakes in 553 Dutch Elite and Sub-Elite Athletes: Prevalence of Low and High Intakes in Users and Non-Users of Nutritional Supplements. Nutrients. 2017;9(2):142. doi: 10.3390/nu9020142.
41. Castell LM, Nieman DC, Bermon S, Peeling P. Exercise-Induced Illness and Inflammation: Can Immunonutrition and Iron Help? Int J Sport Nutr Exerc Metab. 2019;29(2):181–8. doi: 10.1123/ijsnem.2018-0288.
42. Pal S, Rishi P, Pawaria S, Das J, Relayach N. Prevalence of Iron Deficiency with Or Without Anemia In Female Athletes- A Review. Eur J Mol Clin Med. 2021;7(11):2586–95. Available from: https://www.ejmcm.com/article_6147.html
43. Moss K, Kreutzer A, Graybeal AJ, Zhang Y, Braun-Trocchio R, Porter RR, et al. Nutrient Adequacy in Endurance Athletes. Int J Environ Res Public Health. 2023;20(8):5469. doi: 10.3390/ijerph20085469.
44. Caprara G. Mediterranean-type dietary pattern and physical activity: The winning combination to counteract the rising burden of non-communicable diseases (NCDS). Nutrients. 2021;13(2):429. doi: 10.3390/nu13020429.
45. Zeng L, Ruan M, Liu J, Wilde P, Naumova EN, Mozaffarian D, et al. Trends in Processed Meat, Unprocessed Red Meat, Poultry, and Fish Consumption in the United States, 1999-2016. J Acad Nutr Diet. 2019;119(7):1085–98. doi: 10.1016/j.jand.2019.04.004.
46. Agarwal S, Fulgoni VL. Contribution of beef to key nutrient intakes in American adults: an updated analysis with NHANES 2011-2018. Nutr Res. 2022;105:105–12. doi: 10.1016/j.nutres.2022.06.009.
47. Burke LM, Lundy B, Fahrenholtz IL, Melin AK. Pitfalls of conducting and interpreting estimates of energy availability in free-living athletes. Int J Sport Nutr Exerc Metab. 2018;28(4):350–63. doi: 10.1123/ijsnem.2018-0142.
48. Malsagova KA, Kopylov AT, Sinitsyna AA, Stepanov AA, Izotov AA, Butkova T V., et al. Sports nutrition: Diets, Selection Factors, Recommendations. Nutrients. 2021;13(11):3771. doi: 10.3390/nu13113771.
49. Nor Azizam NS, Yusof SN, Amon JJ, Ahmad A, Safii NS, Jamil NA. Sports Nutrition and Food Knowledge among Malaysian University Athletes. Nutrients. 2022;14(3):572. doi: 10.3390/nu14030572.
50. Pelly FE, Thurecht RL, Slater G. Determinants of Food Choice in Athletes : A Systematic Scoping Review. Sport Med - Open. 2022;8(1):1–22. doi: 10.1186/s40798-022-00461-8.