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Original Research

Dietary pattern of long-distance runners and its effect on their body composition and performance

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Abstract

Background and Aims: Evaluation of a player's dietary intake is important both for training and research. Along with body composition it provides an insight into their positive adaptation to training. This study aimed at assessing the effect of the nutritional profile of Indian long-distance runners on their body composition and performance. **Material and Method:** Dietary intake of 53 Indian long-distance runners was assessed using 24 hours dietary recall method. Body composition was analyzed using bioelectrical impedance analysis. Performance was assessed through indirect measurement of VO2 max using Astrand protocol. **Results:** BMI was correlated positively with energy and fat intake ($p < 0.05$). Sum of skinfolds was correlated positively with fat intake and energy intake (only among males) ($p < 0.05$). Fat % was correlated positively with energy intake, carbohydrate intake, fat intake (only among females) ($p < 0.05$) and negatively with VO2 max though not significant. Fat free mass % was negatively associated with energy and carbohydrate intake ($p < 0.05$). Association of VO2 max was significantly positive with protein, calcium and iron intake and negative with carbohydrate intake ($p > 0.05$). Energy intake was significantly positively correlated with carbohydrate intake for the group as a whole and with fat intake specifically in females ($p < 0.05$). Fat free mass had significant negative correlation with energy, carbohydrate intake, and fat intake in females. Inverse association of fat free mass % and VO2 max was also observed though non-significant in both males and females. **Conclusions:** Dietary intake has an impact on both body composition and VO2 max. Body weight, fat, and fat free mass distribution in long distance runners can be managed through diet and can form an important part of athletic development.

Keywords: BMI, energy balance, nutritional profile, training.

Background and Aims

Sports nutrition has an important role to play in athletic development. It helps in attainment of sports specific physique and body composition and also aids in proper and timely recovery from fatigue induced from strenuous training regimes. Hence, it is very important to include balanced dietary intake as one of the fundamental objectives of athletic training [1]. In one of its consensus statements, the International Association of Athletic Federations (IAAF) states that "Well-chosen foods will help athletes train hard, reduce risk of illness and injury, and achieve performance goals, regardless of the diversity of events, environments, nationality, and level of competitors" [2]. Long distance runners in particular require higher nutrient intake because of their longer training durations leading to an increased energy turnover and metabolic adaptations [3]. Despite this fact, it has been found that nutritional intake of athletes worldwide is subnormal [4–6]. No study has been reported on elite Indian long-distance runners related to their dietary patterns and its overall impact on their health and performance. However, among a varied group of Indian athletes, it has been found that their macronutrient and micronutrient intake is below the recommended levels [7–10]. Following this, three main objectives were set for the study: (1) to study the dietary pattern of Indian long-distance runners, (2) To find the relationship of dietary intake with their body composition, (3) To study the association of VO2 max with dietary intake and body composition.

Material and Method

Study design and participants

A cross-sectional study was conducted on 53 (27 males and 26 females) state and national level Indian long-distance runners during their preparatory phase, after informed consent.

Laboratory, anthropometric, and nutritional data collection

Nutritional intake of players was assessed using 24 hours dietary recall method and was compared against Indian Council of Medical Research (ICMR)'s Nutrient Requirements & Recommended Dietary Allowances for Indians (2010) [11]. Intake assessment and calculations were done using the software "DietSoft" (version 1.2.0; 2008–2009; Department of Dietetics; AIIMS & Invincible IDeAS Co., India). Body composition was analyzed using SECA Body Composition Analyzer. Anthropometric measurements were taken using standardize GPM anthropometric kit and Holtain skin fold caliper and followed International Society for Advancement of Kinanthropometry (ISAK) protocol [12]. The measurements included height, weight, triceps skin fold, biceps skinfold, subscapular skin fold, and suprailiac skin fold. Performance was expressed in terms of maximal oxygen uptake VO2 max calculated using bicycle ergometer test following Astrand Protocol (1954) on Monark LC7 bicycle ergometer [13].

Statistical analysis

Sample size was calculated using mean and standard deviation from previous studies. IBM SPSS 20 was used for statistical analysis. The data was checked for normality and homogeneity followed by calculation of descriptive statistics. Pearson's correlation coefficient and linear regression were performed to study the association between the variables under study.

Results

The participants consisted of 27 males and 26 females. Mean age of the players was 18.17 ± 2.90 years, mean height was 165.75 ± 9.75 cm, and mean weight was 53.56 ± 8.61 Kg. Descriptive statistics for anthropometric parameters and VO2 max have been represented in tables 1 and 2.

The first objective of the study was to study the dietary pattern of Indian long-distance runners. The average daily energy intake, carbohydrate, fat, protein, calcium, and iron intake was assessed for the same (tables 3 and 4). Mean percentage adequacy was also calculated using the formula:

$$\underset{(\text{Mean percentage adequacy})}{\text{MPA}} = \frac{\text{daily intake}}{\text{recommended dietary allowance by ICMR}} \times 100$$

It was seen that MPA was low for total energy and carbohydrate in both males and females. On the other hand, fat intake has been found considerably high. MPA was more than optimum for protein, calcium, andiron for both the genders.

To accomplish the second and third objective, Pearson's correlation coefficient was calculated as shown in table 5–7 and the associated variables were further analyzed through linear regression. In anthropometric parameters, a significant positive correlation of BMI was found with sum of skinfolds (SSF) and fat % and negative with fat free mass % (FFM). SSF was positively correlated with fat % and negatively with FFM (p<0.05). FFM had significant negative correlation with BMI and SSF. Among dietary intake, energy had significant positive correlation carbohydrate intake and fat intake only for females.

Table 1: General descriptive statistics (males and females).

	N		Minimum		Maximum		Mean		Std. Deviation	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Age	27	26	14	14	23	24	18.70	17.62	2.785	2.83
Years in games	27	26	1	1	4	5	2.15	3.00	.989	1.23
Height(cm)	27	26	158.90	140.80	185.80	170.70	173.24	157.97	5.38	6.64
Weight (Kg)	27	26	47.00	37.00	71.00	60.10	58.874	48.04	7.32	6.04
Triceps skinfold (mm)	27	26	2.2	2.8	5.4	5.6	4.2	4.6	0.62	0.58
Biceps skinfold (mm)	27	26	2.6	3.00	5.8	6.00	4.63	5.02	1.02	1.33
Subscapular skinfold (mm)	27	26	6.8	8.2	13.2	14.4	8.95	10.24	2.23	2.34
Suprailiac skinfold (mm)	27	26	6.2	6.8	10.2	11.4	8.81	9.02	3.02	3.33

Table 2: Descriptive statistics for anthropometric parameters and VO2 max (males and females).

	N		Minimum		Maximum		Mean		Std. Deviation	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
BMI (kg/m^2)	27	26	16.46	15.97	23.72	23.13	19.60	19.23	2.14	1.89
Sum of Skin Fold (mm)	27	26	16.60	14.50	25.00	23.20	20.34	19.04	2.30	1.97
Fat %	27	26	6.44	8.55	15.58	16.40	10.55	11.62	2.66	2.40
Fat free mass %	27	26	84.42	83.60	93.56	91.45	89.45	88.38	2.66	2.40
VO2 max (ml/kg/min)	27	26	41.80	35.10	72.69	69.26	56.08	46.96	7.78	6.58

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Table 3: Descriptive statistics for dietary intake (n = 53).

	N	Minimum	Maximum	Mean	Std. Deviation
Energy (kcal)/day	53	1442.64	2812.00	2104.23	312.80
Carbohydrate (gm.) /day	53	226.50	616.00	470.58	88.75
Fat (gm.) /day	53	33.70	834.30	123.15	107.67
Protein (gm.) /day	53	41.00	117.00	76.57	19.41
Calcium (mg) /day	53	337.00	1444.20	692.29	204.01
Iron (mg) /day	53	4.30	50.30	25.59	11.17
Percentage Adequacy for Energy Intake	53	51.52 %	120.69 %	83.1%	14.34
Percentage Adequacy for Carbohydrate	53	40.74 %	116.67 %	86 %	16.64
Percentage Adequacy for Fat	53	112.33 %	481.00 %	364.39 %	359.61
Percentage Adequacy for Protein	53	68.33 %	195.00 %	135.64 %	34.65
Percentage Adequacy for Calcium	53	44.25 %	180.53 %	100.66 %	30.3
Percentage Adequacy for Iron	53	13.44 %	295.88 %	114.84 %	55.66

Relationship between dietary intake and body composition

Energy intake had significant positive correlation with BMI, SSF (only males), fat %, and negative correlation with FFM. Carbohydrate intake was positively correlated with fat % and negatively with FFM. Likewise, significant positive associations of fat intake were found with BMI andSSF for the group as a whole and association of fat intake specifically in females was found to be positive with fat % and negative with FFM ($p < 0.05$).

Relationship between dietary intake and VO2 max

VO2 max had significant positive correlation with protein, calcium and iron intake. A negative non-significant association was also found with carbohydrate and fat intake.

Relationship between body composition and VO2 max

VO2 max didn't share any significant association with any body composition measure in this study, however certain weak and non-significant associations were observed with SSF in males and with fat% and FFM for the group as a whole.

The associated variables were further analyzed for linear relationship with the help of scatter plots (figure 2). Linear regression and prediction equations were formed for variables showing a linear trend (tables 8 and 9).

It can be seen from the table above that in males a variation in total daily energy intake and carbohydrate intake explains the 58.7%[a] and 58.9%[b] variation in overall body fat % respectively. Total daily protein intake explains 30.2%[c] variation in the VO2 max.While, in females the variation in daily calcium intake explains only 19.6% variation in VO2 max. No linear relationship was found when the analysis for both males and females was done together.

Discussion

Dietary pattern of Indian long-distance runners

This study assessed the variation in the dietary pattern of Indian long-distance runners against recent ICMR norms. Figure 1 shows that Indian long-distance runners did not meet up the daily requirement of total energy intake and carbohydrate. However, consumption of

Table 4: Descriptive statistics for dietary intake (males and females).

	N		Minimum		Maximum		Mean		Std. Deviation	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Energy (kcal)/day	27	26	1442.64	1565.00	2807.00	2812.00	2125.55	2082.09	344.14	281.7
Carbohydrate (gm.)/day	27	26	226.50	321.00	595.00	616.00	456.76	484.92	97.64	77.77
Protein (gm.)/day	27	26	41.00	51.00	117.00	102.30	76.52	76.62	22.98	15.32
Fat (gm.)/day	27	26	33.70	56.00	834.30	235.00	141.82	103.78	144.78	39.33
Calcium (mg)/day	27	26	546.00	337.00	1444.20	892.00	805.56	574.66	184.36	151.59
Iron (mg)/day	27	26	4.30	6.00	50.30	45.00	25.61	25.57	11.39	11.18
Percentage Adequacy for Energy Intake	27	26	51.52%	70.18%	102.82 %	120.69%	75.83%	90.67%	12.62	12.05
Percentage Adequacy for Carbohydrate	27	26	40.74%	60.80%	105.76 %	116.67%	81.93%	90.23%	17.76	14.54
Percentage Adequacy for Protein	27	26	68.33%	98.08%	195.00%	186.00%	128.45%	143.11%	38.61	28.85
Percentage Adequacy for Fat	27	26	112.33%	140.00%	781.00%	587.50%	402.65%	324.65%	491.7	119.66
Percentage Adequacy for Calcium	27	26	75.00%	44.25%	180.53%	142.17%	119.2%	101.42%	24.61	22.86
Percentage Adequacy for Iron	27	26	13.44%	23.08%	295.88%	214.29%	122.2%	107.19 %	61.26	49.22

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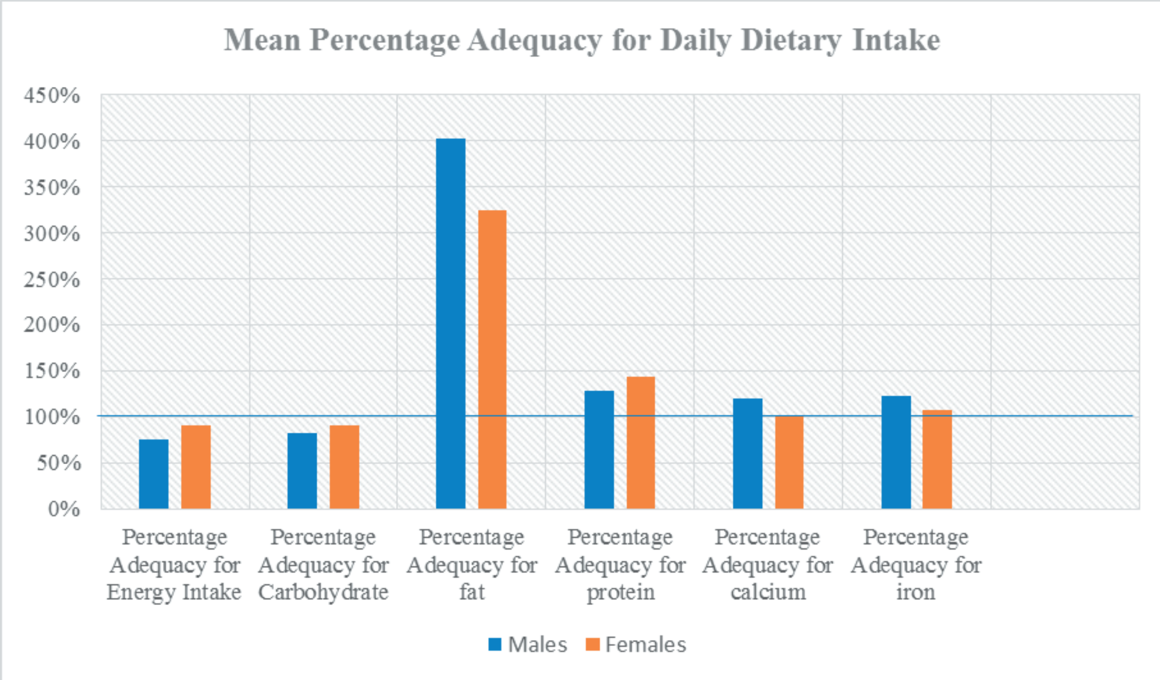

Figure 1: Percentage Adequacy for dietary intake in males and females.

protein, calcium, and iron was found to be above optimum. Fat consumption was found to be considerably high among the group. The interview during dietary recall reflected the trend of high fat low carbohydrate diet among Indian players [7–8, 10].The reasons behind such a trend can be attributed to their accustomed eating behavior as most of the players were from the northern part of the country, where consumption of buffalo's milk loaded with high fat content, homemade butter, *desi ghee* (clarified butter extracted from cow or buffalo's milk) and other saturated fats is a part of their culture. Also, the group mainly consisted of players belonging to late adolescence, the age when youth becomes prey of unhealthy nutritional behaviors and athletes are no exception to that [14]. However, it can be argued that high fat low carbohydrate diet results in metabolic adaptations which enhances oxidation of fat during long distance running when availability of carbohydrate is low [15].

Effect of dietary pattern on body composition

Number of calories consumed and the relative distribution of various nutrients in diet directly affect body mass and composition [16–18]. Tables 6-8 show that BMI is related to daily energy intake and fat intake, skinfolds were related to fat intake and fat% was related to daily energy and carbohydrate intake in both males and females ($p < 0.05$). Additionally, fat intake has been found to be associated with fat% in females (table 8, $p < 0.05$). An increase in energy intake leads to a linear increase in fat% of male players and more than half of the variation in fat content can be explained by the daily energy intake ($R^2 = 0.587$). Aforementioned relationship of body composition parameters with total energy intake, dietary carbohydrate, and fat intake favor the fact that these macronutrients can contribute to a negative energy balance to achieve a lean and slender athletic body for long distance running [19]. BMI and skinfolds are interchangeably used methods of estimating relative obesity and adiposity as reported by various studies [17, 18]. Present study also suggests the association of BMI and skinfolds with obesity and body composition.

Carbohydrates are needed as substrates for metabolic pathways leading to glycogen synthesis which is essential for improved endurance and effective recovery [15]. However, carbohydrates of moderate to high glycemic index are recommended for athletes. Meanwhile, the present study suggests

Table 5: Pearson's correlation coefficient for variables under study (n = 53).

	Weight (Kg)	BMI (kg/m²)	Sum of skinfolds (cm)	Fat %	Fat free mass	VO2max (ml/kg/min)	Energy (Kcal/day)	Carbs (gm/day)	Protein (gm/day)	Fat (gm/day)	Calcium (mg/day)	Iron (mg/day)
Weight (kg)	1	.682**	.417**	.090	−.090	.275	.203	.046	.219	.277*	.414	.216
BMI (kg/m²)		1	.440*	.388**	−.388**	.018	.333*	.198	.221	.315*	.037	.374
Sum of skinfolds (cm)			1	.330*	−.330*	.100	.344	.131	.110	.325*	.166	.040
Fat %				1	−1.000**	−.213	.556**	.585**	.125	.108	-.078	.230
Fat free mass					1	.213	−.556**	-.585**	-.125	−.108	.078	−.230
VO2max (ml/kg/min)						1	.266	-.115	.532**	.283	.631**	.367*
Energy (Kcal)/ day							1	.729**	.082	.365	.148	.019

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 6: Pearson's correlation coefficient for variables under study (males, n = 27).

	Weight (Kg)	BMI (kg/m²)	Sum of skinfolds (cm)	Fat %	Fat free mass	VO2 max (ml/kg/min)	Energy (Kcal/day)	Carbs (gm/day)	Protein (gm/day)	Fat (gm/day)	Calcium (mg/day)	Iron (mg/day)
Weight (kg)	1	.866**	.201*	.257	−.257	.015	.294	.230	.237	.351*	.142	.388
BMI (kg/m²)		1	.365*	.327*	−.327*	.078	.361*	.245	.256	.399*	.009	.386
Sum of skinfolds (cm)			1	.531**	−.531**	−.072	.491**	.327	.003	.439*	−.031	.069
Fat %				1	−1.000**	−.050	.766**	.778**	.247	.163	.006	.098
Fat free mass					1	.050	−.766**	−.778**	−.247	−.163	−.006	−.098
VO2max (ml/kg/min)						1	.209	.097	.550**	.246	.483*	.383*
Energy (Kcal)/day							1	.796	.132	.370	−.026	.024

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

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Table 7: Pearson's correlation coefficient for variables under study (females, n = 27).

	Weight (Kg)	BMI (kg/m²)	Sum of skinfolds (cm)	Fat %	Fat free mass	VO2max (ml/kg/min)	Energy (Kcal/day)	Carbs (gm/day)	Protein (gm/day)	Fat (gm/day)	Calcium (mg/day)	Iron (mg/day)
Weight (kg)	1	729**	472*	.350	–.350	.285	.070	.134	.382	.297	–.010	.139
BMI (kg/m²)		1	.528**	.539**	–.539**	.202	.283**	.177	.169	.275**	–.061	.365
Sum of skinfolds (cm)			1	.272**	–.272**	.080	.113	.019	.324	.215	.034	.006
Fat %				1	–1.000**	–.219	.331**	.275**	–.077	.291**	.115	.397
Fat free mass					1	.219	–.331**	–.275**	.077	–.291**	–.115	–.397
VO2max (ml/kg/min)						1	.368	.236	.449**	.258	.443*	.425**
Energy (Kcal)/day							1	.680**	–.011	.499**	.375	.011

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 8: Regression analysis for variables having linear relationship (males and females).

S.No.	Dependent Variable (y)	Independent Variable (x)	Simple Correlation(R)	Coefficient of Determination(R^2)	Constant (a)	Slope (β)	Significance (*p*)
1.	Fat% (males)	Energy (kcal)/day	0.766	0.587[a]	–2.058	0.006	0.00
2.	Fat% (males)	Carbohydrate (g)/day	0.778	0.589[b]	0.861	0.021	0.00
3.	VO2 max (ml/kg/min) (males)	Protein (g)/day	0.550	0.302[c]	41.849	0.186	0.00
4.	VO2 max (ml/kg/min) (females)	Calcium (g)/day	0.443	0.196	35.917	0.019	0.02

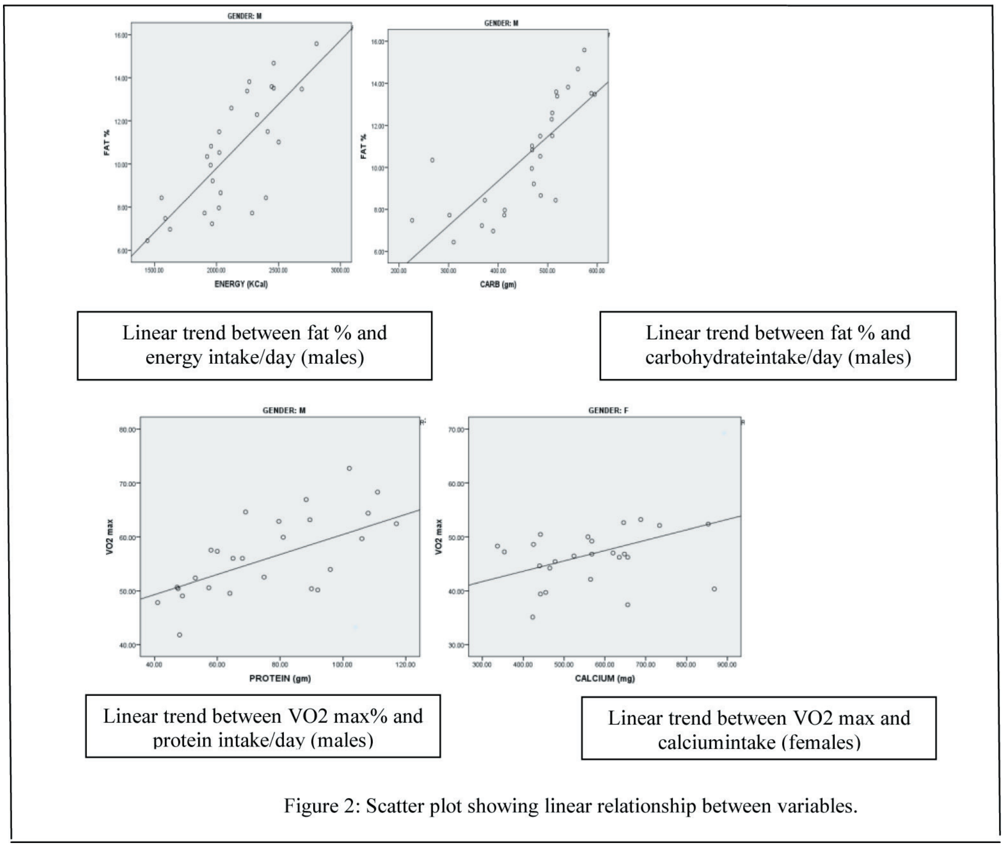

Figure 2: Scatter plot showing linear relationship between variables.

that undesirable carbohydrate intake can lead to an increase in fat content in the body [$R^2 = 0.589$].

Effect of dietary pattern on performance

Studies are there on dietary pattern, body composition, and performance of Indian athletes [7]. However, no study has been done to study the impact of dietary pattern on VO2 max of Indian long-distance runners. The results of the study suggest a linear relationship of VO2 max with protein, iron, and calcium but not with other nutritional components.

Table 9: Prediction equations.

S. No.	Prediction equations y = a + β x
1.	Fat%= –2.058+0.006 [Energy (kcal)] **(males)**
2.	Fat%= 0.861+0.021 [Carbohydrate (g)] **(males)**
3.	VO2 max (ml/kg/min) = 41.849+0.186 [Protein (g)] (**males)**
4.	VO2 max (ml/kg/min) = 35.917+0.019 [Calcium (mg)] (**females)**

Protein

Protein is considered as a key element of athletic success and players consume it in their diet as well as in supplements. Endurance athletes require it to maintain lean body mass, muscle repair, and synthesis of mitochondrial enzymes for muscle protein metabolism [15]. The findings of the study don't support a large explanation of variation in the VO2 max caused due to protein levels in diet ($r=0.550$, $R^2=0.302$, $p<0.01$).

Iron

Iron requirement of athletes is more than that of the sedentary population reaching up to even 70% above the recommended daily allowance [15, 16]. The reason behind it can be that long-distance runners suffer from iron deficiency anemia (IDA). A phenomenon called foot

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strike hemolysis occurs in which RBCs keep on getting ruptured when long distance runners hit the track during running [16]. Also, in general terms iron has been known as a carrier of oxygen and running players require continuous and elevated supply of oxygen for a long duration. However, iron consumption alone doesn't contribute much to variation in VO2 max.

Calcium

Calcium has been reported to be associated with VO2 max and bone mineral density [20], however, the exact mechanism is not known. A similar trend has also been observed in the current study (r = 0.443, $R^2 = 0.196$, $p < 0.01$).

Role of total energy intake, carbohydrate, and fat intake

Energy balance is a determining factor for athletic performance. An excess of calories leads to undesirable weight and fat gain and a deficit in energy leads to fatigue, injuries, delayed recovery, and muscle loss. Carbohydrates are required for maintenance of glycogen stores in the muscles. Any unfavorable change in glycogen levels can negatively impact muscle strength, aerobic, and anaerobic components of athletic performance. The lipid component in diet helps in maintenance of cell membrane integrity and in the absorption of liposoluble vitamins required in synthesis of various hormones involved in vital body functions [21]. Though, during specific training phases such as just before competition it is advisable to cut down calories coming from carbohydrates and fats.

Significant difference was found between males and females in terms of sum of skinfolds, VO2 max, and calcium intake. Higher sum of skinfolds in females under study is consistent with the findings of other studies reporting such observations in general due to hormonal differences [22]. Males possess a higher oxygen carrying capacity due to lesser body fat than females- another gender specific physiological difference like maximum heart rate, stroke volume, etc [22]. Consumption of calcium among female runners is higher to combat low bone mineral density due to estrogen dominance in females and altered menstrual cycle resulting out of strenuous physical training [23].

Conclusion

Dietary intake has an impact on both body composition and VO2 max (performance). Good diet is important for training, to fight against diseases, and to recover fast from fatigue and injuries. Availability of substrates for proper functioning of metabolic pathways requires an adequate distribution of nutrients in diet. Nutritional recommendations derived from latest scientific knowledge on peculiarities of each sport and phase of training do exist but have not been incorporated by trainers as part of athletic development. It is highly recommended to conduct similar grass root level studies on Indian athletes to identify their nutritional requirements based upon the sporting discipline they belong to and phases of training they undergo.

Conflict of Interest

The authors declare no conflict of interest.

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