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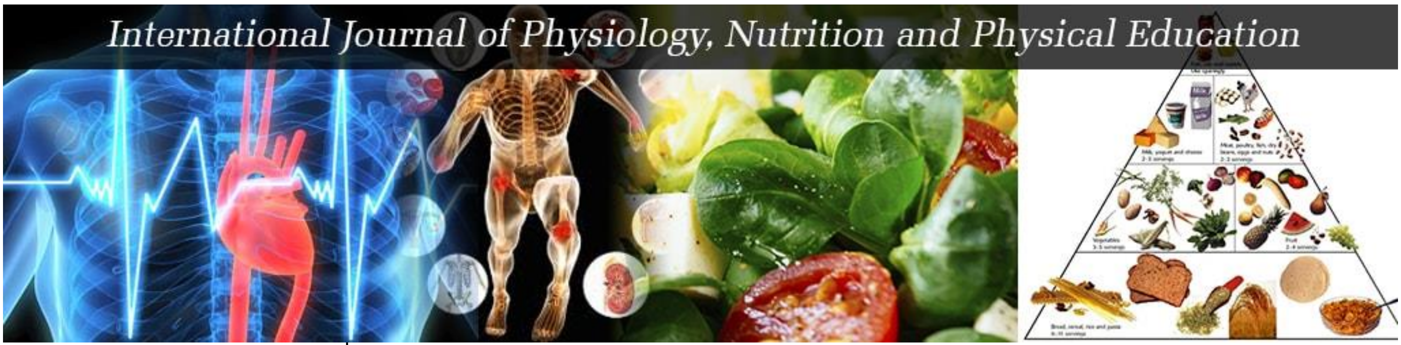

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Identifying the risk of female athlete triad in female athletes involved in aesthetic sport (Rhythmic gymnastics) and non-aesthetic sport (Football) aged between 15-25 years

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Abstract
Introduction: For a variety of causes, the athlete's diet becomes increasingly restricted; this can also be sport-specific, resulting in a condition known as Female Athlete Triad. The research aimed to identify early symptoms of the Female Athlete Triad in female athletes involved in Aesthetic Sports (Rhythmic Gymnastics) and Non-Aesthetic Sports (Football) aged between years.
Methodology: The present observational study was conducted among football athletes and rhythmic gymnastics athletes of age 15 to 25 years in Mumbai, Maharashtra. The variables investigated in the study for the research objective included the Low Energy Availability Questionnaire (LEAF-Q), quantitative measurements of body composition, and energy availability (EA). Female football players (n = 30) and gymnasts (n = 22) gave their consent. The statistical analysis was conducted using the SPSS 21.
Results: Of the 52 participants studied, 17.3% of participants (9 out of 52 women) were classified as being at-risk for the triad according to their LEAF-Q scores. Out of these 23% were from Non-aesthetic sports (footballers) and 9% from Aesthetic Sports (rhythmic gymnastics). The energy availability (EA) of the two groups was significantly different, with a p-value of 0.049, with the at-risk group having a much lower EA (8±5.1) than the non-risk group (21±16). There were no significant differences in body composition between the group of athletes.
Conclusion: Early identification of symptoms of the Female Athlete Triad by screening tools such as the LEAF questionnaire is important in protecting young athletes from long-term damage.

Keywords: Female athlete triad, aesthetic sport, non-aesthetic sport, football, rhythmic gymnastics, low energy availability

1. Introduction

The definition of the Triad was revised in 2007 to its current meaning to include one or more of the following three components: Low energy availability (LEA) (With or without DE), Menstrual dysfunction, and Low bone mineral density (BMD) (Nazem & Ackerman, 2012) [32]. Alone or in combination, the disorders of the triad can harm health and impair athletic performance.

When food intake is insufficient to provide the necessary quantity of energy for both exercise and body maintenance, low energy availability (LEA) develops and non-maintenance of the body's basic physiological functions. Values below 30 kcal/kg/FFM/day, are associated with, inter alia, functional hypothalamic amenorrhea (FHA) (Loucks, *et al.*, 2003) [22]. LEA may be intentional, due to a clinical ED and/or DE behavior. It can also occur unintentionally, due to poor awareness of appropriate sport-specific fueling or refueling requirements (Nattiv A, Loucks AB, Manore MM, *et al.* 2007) [31].

The International Olympic Committee then identified the relative energy deficit in sport (RED-S) condition in 2014, highlighting the effects of inadequate energy availability on the human body and recognized FAT as one of the outcomes of LEA in the RED-S model (Mountjoy *et al.*, 2018) [30].

Several health consequences occur in athletes with the triad. Menstrual dysfunction may lead to infertility due to a lack of ovarian follicular development, anovulation, or luteal-phase defects. Women with the triad also have decreased immune function and impaired skeletal muscle oxidative metabolism. Many athletes with low bone density and/or menstrual irregularity suffer from stress fractures. A deficiency in macronutrients can be detrimental to the body's ability to build bone, maintain muscle mass, repair damaged tissue, and recover from injury. (Nazem, *et al*., 2012) [31] With the use of qualitative instruments, such as the Low Energy Availability in Females Questionnaire (LEAF-Q), it is possible to evaluate FAT and RED-S. It is the most often employed validated screening technique for identifying LEA risk, and it does so by evaluating early signs of energy insufficiency in females. The screening of groups of athletes who are particularly at risk for this issue is crucial for the early diagnosis and prevention of LEA and the ensuing RED-S. (Melin A. *et al*. 2014) [26].

In aesthetic sports, a judge or judges of the tournament evaluate each participant's or team's performance. Thus, appearance is a major factor in judging. Examples of aesthetic sports include rhythmic gymnastics, diving, figure skating, dancing, and ballet. Non-aesthetic sports do not necessarily emphasize body weight or a lean physique.

Non-Aesthetic focused sports included ball sports (football, netball, volleyball, soccer), bat/stick sports (hockey, cricket, baseball), racquet sports, water polo, and heavyweight rowing.

Most female football players are healthy. Studies on elite female athletes from Norway also reveal that diets, eating disorders, menstrual problems, and stress fractures are common among football players. Even though menstruation disruption, dieting, and eating disorders are less frequent in sports than in many others, it is nevertheless crucial to be aware of the issue since eating disorders in female athletes are often overlooked. (Sundgot-Borgen *et al*. 2007) [41].

Prevention and early recognition of triad disorders are crucial to ensure timely intervention. Advancing research and knowledge regarding the triad will aid in the creation of more efficient prevention and treatment strategies so that all women can enjoy the physical, psychological, and social benefits of athletics participation to the fullest.

The research aimed to identify early symptoms of the Female Athlete Triad in female athletes involved in aesthetic sports (Rhythmic gymnastics) and non-aesthetic sports (football) aged 15-25 years.

2. Methodology

2.1 Participants

The study was carried out at Sports academies and gymkhanas in the Suburbs of Mumbai. The inclusion criteria were such that she should be training at least four times a week. She must have competed at the District, State, or National levels in the last 1-2 years. Participants with pre-existing chronic conditions, athletes who have had hormone therapy in the last year, and athletes who use supplements or medications that impair bone health were excluded from the study. A total of 65 participants expressed interest in signing up for the study recruitment. Out of 65 individuals, 52 athletes (15 to 25 years old) participated in the study, including 30 female football players and 22 female gymnasts. Ten of the 13 remaining participants did not match the inclusion criteria for age, two did not meet the criteria for training more than four hours per week, and one participant was using a bone supplement. Verbal and written information about the study was directed to the study participants and then they gave their informed written consent to participate in the study.

2.2 Anthropomrtric Measurements

Anthropometric measurements were taken: weight, height, and body composition analysis were done. Assessing height using a standardized stadiometer. A total of three consecutive measurements of an individual were taken, and an average value was considered for all the measurements. A body composition analyzer was used to measure the body composition of an athlete. Tanita's body (Tanita Body Fat Analyzer BC 541 Weighing Scale) composition analyzer was used to measure weight, lean muscle mass, total body water, and body fat percentages (visceral and total fat percentage).

2.3 Variables

A Low Energy Availability in Females Questionnaire (LEAF-Q) was used in the study. This is a tool used for the early screening of FAT and RED-S before significant changes occur in bone mineral density (BMD) and body composition. The questionnaire examines the physiological symptoms reported by kayakers connected with LEA and includes questions sequentially on injuries, gastrointestinal, and reproductive functions. It has been validated on endurance athletes and has 90% specificity and 78% sensitivity. A result of ≥8 out of 25 questions indicates that the competitor is at risk of LEA and, as a consequence, may be at risk of developing the FAT and RED-S group of symptoms. (Melin *et al*., 2014) [26].

Energy Availability (EA) shows the difference in energy intake (EI) and exercise energy expenditure (EEE) divided by fat-free mass (FFM), using the following formula; EA = (EI – EEE) / FFM. To calculate energy intake 24 hr diet recall was used. The 24-hour Dietary Recall (24HR) approach collects detailed, quantitative data on individual diets by asking respondents about the kind and quantity of every food and drink ingested in the preceding 24-hour period (Gibson & Ferguson, 2008).To improve the accuracy of calculating energy, a standardized kit system for measurement was developed. Exercise energy expenditure was calculated using MET values. Fat-free mass was estimated using the following method: Fat-free mass (kg) = weight [kg] × (1 - (body fat [%]/ 100)).

2.4 Statistical Analysis

The statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software SPSS 21 version. The data were presented using mean and standard deviation for normally distributed variables. The demographic analysis including age, normal amount of training (average) – number of hours per week, was done through using descriptive variables. In anthropometric analysis, the Independent T-test was used to assess anthropometric parameters. Pearson correlation was used to assess correlation With Anthropometric parameters and sports. Chi-square tests were used to determine differences in the prevalence of LEA, ED, injury, gastrointestinal dysfunction, and menstrual disturbance between groups. Pearson correlation coefficients were used to determine the presence of any significant relationship.

2.5 Ethical Considerations

All methods and procedures were carried out only after undertaking approval by the Inter System Biomedical Ethics Committee (ISBEC). The approval letter for the same has been provided. Informed consent was obtained from all participants, and parental/legislative consent was obtained from the legal person in the case of minor athletes. All necessary precautions were considered to prevent the breach of confidentiality and disregard of consent.

3. Result

The mean age of the Football players was found to be 18±2 years, whereas, for Rhythmic Gymnastics, it was 17±2 years. The average number of hours per week for normal training for Football was 6.57±3.9 hours/week, while for Rhythmic Gymnastics, it was 12.36±3.9 hours/week. In terms of weight, the mean weight for Football athletes was found to be 50.7±9 kgs, whereas, for Rhythmic Gymnastics, it was 48.18±5 kgs. Finally, the mean height for Football players was 154 cm, and for Rhythmic Gymnastics, it was 156 cm.

The Body Composition Analysis for both groups was as follows(Table 1): The mean body fat percentage was found to be higher in Football players (24.23%) compared to Rhythmic Gymnastics athletes (22.05%), although the difference was not statistically significant (p = 0.183). There were no significant differences between the two groups for TBW (%), muscle mass, resting metabolism rate, bone weight, FFM (kgs), and energy availability. However, with a p-value of 0.087, which denotes a marginal difference, it was discovered that the mean visceral fat was larger in football players (2.34) compared to Rhythmic Gymnastics athletes (1.55).

Table 1: Anthropometric Characteristics of Footballers and Rhythmic Gymnastics Athletes

Characteristics	Football (n=30)	Rhythmic Gymnastics (n=22)	p-value
Body Fat %	24.23±6.3	22.05±4.8	0.183
TBW (%)	56.17±5.0	57.32±4.2	0.392
Muscle Mass (kg)	34.83±5.3	34.09±3.1	0.562
Resting Metabolism Rate (in kcals)	1189.90±178.1	1193.86±130.4	0.930
Bone weight (in kgs)	2.17±.3	2.09±.2	0.439
Visceral Fat (%)	2.34±1.8	1.55±1.2	0.087
FFM(kgs)	37.00±5.8	37.27±3.3	0.846

All the values in the table are Mean±SD and a statistically significant weight is placed at $p \leq 0.05$

Table 2: The most important questions of LEAF-Q and the numerical answers provided by the participants in the study

Low Energy Availability in Females Questionnaire	Football (n=30) n (%)	Rhythmic Gymnastics (n=22) n (%)
1. Injuries		
Absences from your training. or participation in competitions during the last year due to injuries		
No, not at all	18(60%)	17(77.3%)
Yes, once or twice	11(36.7%)	5(22.7%)
Yes, five times or more	1(3.3%)	0
Number of days of absence from training or participation in competition due to injuries. Only those participants who had an injury (n=17)		
1–7 days	5(41.7%)	5(100%)
22 days or more	7(58.3%)	
2. Gastrointestinal function		
Do you feel gaseous or bloated in the abdomen? Also, when do you not have your period?		
Yes, several times a day	1(3.0%)	2(9.1%)
Yes, several times a week	1(3.3%)	3(13.6%)
Yes, once or twice a week or more seldom	28(93.3%)	17(77.3%)
Rarely or never		
Bowel movements on average?		
Several times a day	2(6.7%)	0
Once a day	22(73.3%)	17(77.3)
Every second day	5(16.7%)	5(22.7%)
Once a week or more rarely	1(3.3%)	0
3. Menstrual function		
Do you have normal menstruation?		
Yes	26(86.7%)	17(77.3%)
No	4(13.3%)	2(9.1%)
Have you ever had problems with heavy menstrual bleeding?		
Yes	5(16.6%)	3(13.6)
No	25(83.3%)	18(86.4%)
Do you experience that your menstruation changes when you increase your exercise intensity, frequency, or duration?		
Yes	9(33.3%)	3(13.6%)
No	20(66.7%)	19(86.4%)
If yes, how? (n=12)		
I bleed less	3(33.3%)	0
No change	1(11%)	0

Table 3: LEAF-Q Score

LEAF Score	> 8 /25 then the risk of LEA		Football(n=30)	Rhythmic Gymnastics(n=22)	p-value
Injury	>	2	1.1±1.4	0.3±0.4	0.311
GI	>	2	1.1±0.7	0.9±0.6	
Menstrual	>	4	2.2±0.3	1.7±0.3	

All the values in the table are Mean±SD and a statistically significant value is placed at $p \leq 0.05$

Based on the given data, the LEAF scores for Football players and Rhythmic Gymnastics athletes were not significantly different. However, the football group has a higher risk of LEA and its associated complications, with a mean LEAF score for injury of 1.1±1.4 compared to the rhythmic gymnastics group with a mean LEAF score of 0.3±0.4. On the other hand, the mean scores for GI were similar in both groups. The study found that football players had a higher mean score for menstrual issues (2.2±0.3) than rhythmic gymnasts (1.7±0.3), but this difference was not statistically significant.

For footballers, 80% of participants had EA levels below 30 kcal/kg FFM/day, while only 20% had EA levels above 30 kcal/kg FFM/day. In rhythmic gymnastics, 86.4% of participants had EA levels below 30 kcal/kg FFM/day, while only 13.6% had EA levels above 30 kcal/kg FFM/day.

Hence, for energy availability, rhythmic gymnastics athletes had decreased energy availability as compared to footballers. (Table 4).

The data suggest that most football and rhythmic gymnastics participants had EA levels below the recommended threshold of 30 kcal/kg FFM/day, which could negatively impact their health and performance. The p-value is 0.5, which suggests that there was no significant difference in energy availability between the two groups.

Table 4: Energy Availability Comparison between Football and Rhythmic Gymnastics

Energy Availability	Less than 30 kcal/kg FFM/day	Above 30 kcal/kg FFM/day	p-value
Football (n=30)	24 (80%)	6(20%)	0.5
Rhythmic Gymnastics (n=22)	19(86.4%)	3(13.6%)	

All the values in the table are Mean±SD and a statistically significant value is placed at $p \leq 0.05$

There was a significant difference in energy availability (EA) between the two groups, with the at-risk group of LEA having a significantly lower EA (8±5.1) compared to the non-risk group (21±16). The p-value for this comparison was 0.049, which suggests that the difference was statistically significant. (Table 5)

Table 5: Football group at risk and group at no risk of LEA

	Groups with a risk of LEA (n=7)	The group not at risk of LEA(n=23)	p-value
Age (years)	19±2.3	17±2.3	0.302
Weight (kgs)	55±12.3	49±8.8	0.157
Height (CMS)	159±1.5	153±21.8	0.422
Amount of training number of hours per week	6.57±1.9	6.57±1.7	0.996
Body Fat%	26±8.1	23±5.7	0.276
TBW%	53±6.3	56±4.4	0.125
Muscle mass (kg)	35±7.2	34±4.7	0.741
RMR (kcal)	1244±209	1173±169	0.368
Bone weight(in kgs)	2±0.4	2±0.3	0.352
Visceral Fat	3.1±2.3	2±1.6	0.192
EA	8±5.1	21±16	0.049

All the values in the table are Mean±SD and a statistically significant value is placed at $p \leq 0.05$

The group with a risk of LEA had a significantly higher age compared to the non-at-risk group (23 vs. 17±2.3, p=0.002). Additionally, the group with a risk of LEA had a significantly higher RMR (resting metabolic rate) compared to the non-at-risk group (1481±165 vs. 1165±88, p=0.00). Also, the group at risk had low EA as compared to the group not at risk. (Table 6)

Table 6: Rhythmic Gymnastics group at risk and not at risk of LEA

	Groups with a risk of LEA (n=2)	The group not at risk of LEA(n=20)	p-value
Age (Years)	23	17±2.3	0.002
Weight (kgs)	49±2.8	48±5.7	0.832
Height (cms)	157±4.9	155±4.1	0.514
Amount of training number of hours per week	10	12±4.0	0.386
Body Fat%	20±2.1	22±5	0.545
TBW%	58±7.7	57±4.8	0.690
Muscle mass (kg)	31.±2.2	34±3.1	0.230
RMR (kcal)	1481±165	1165±88	0.00
Bone weight(in kgs)	3	2±1.2	0.415
Visceral Fat	1±1.3	1±1.3	0.535
EA	16±4	25±11	0.289

All the values in the table are mean±SD and a statistically significant value is placed at $p \leq 0.05$

4. Discussion

In this study, an assessment of the Female Athlete Triad using the LEAF questionnaire showed the risk of low energy availability 17.3% of participants. Additionally, 5 of the women in the study did not have a normal monthly cycle at the time. Out of which 4 were footballers and 1 was from rhythmic gymnastics who did not know about her menstrual cycle. Therefore, there is a high degree of assurance that these women have LEA.

Footballers scored more in injury and also in the menstrual function section. Some possible reasons for the higher risk of menstrual dysfunction in football players may include higher levels of physical activity, higher levels of stress, and different nutritional habits compared to rhythmic gymnasts. Rhythmic gymnastics, on the other hand, is a non-contact sport that calls for more controlled motions and less force on the body. The size and strength of the players are other aspects that can contribute to football's increased injury risk. Furthermore, football matches involve a lot of physical contact with other players, which increases the risk of collision and injury. Finally, the type of playing surface may also contribute to the higher injury risk in football.

In a study by Jesus *et al*., 2021 [55] conducted among elite runners, it was found that over the past year, stress fractures were the third-most reported injury among these athletes and that these affected 2.25% of women. It was also noted that athletes of both sexes who reported stress fractures, usually associated with reduced BMD, were identified as being at risk of LEA. A study by (Condo *et al*. 2019) [50] discovered that female football players who were deemed to be at risk for LEA disclosed sports-related injuries that had occurred during the previous year. For example, the percentage of training days lost due to injuries lasting 15 to 21 days was 11%, with a similar percentage for those injuries more than 22 days.

However, a higher percentage of lost training days was reported by (Łuszczki *et al*. 2021) [23], who also studied football players. The number of lost training days due to injury of 15 to 21 days was 14.7%, and above 22 days, it reached 20.6%. (Folsher *et al*. 2015) [16], studying ultra-marathon athletes, reported an incidence of stress fractures in 3.4% of female participants. On the other hand, the number of days lost due to injury treatment was 7.8% for recovery lasting 15 to 21 days and 10.5% for recovery lasting more than 22 days.

Meng *et al*. 2020 investigated the risk of LEA among competitive and amateur female athletes. They found that female athletes, who were at risk of LEA, were more likely to have sports injuries compared to those female athletes who were not at risk of LEA, 62.5% vs. 16.7% respectively.

There was a considerable variation in energy intake amongst footballers and rhythmic gymnasts in our study. Compared to the non-risk group, girls in the risk group consumed considerably fewer calories. There was a significant difference in energy availability (EA) between the two groups, with the at-risk group having a significantly lower EA (8±5.1) compared to the non-risk group (21±16). The p-value for this comparison was 0.049, which suggests that the difference was statistically significant, However, if energy intake remains low over a prolonged period, the body begins to conserve energy by reducing metabolic rate and suppressing non-essential bodily functions, such as reproductive and immune system functions. This leads to a condition known as low energy availability, which can have negative effects on overall health and performance. Female Australian rules football players were the subject of research (Condo *et al*., 2019) [50]. Low energy availability (LEA), which is highly frequent among sports, and eating problems may both have their roots in this. Instead of measuring genuine LEA behaviors-eating disorders-LEAF-Q measures symptoms associated with LEA. Large cohorts are frequently used to estimate LEA risk. Nearly 40% of Irish active females were found to be at risk of LEA (Logue *et al*., 2019) [21].

Our findings indicate that females who did not consume enough calories were equally likely to belong to the Triad/Red-S risk category. This agrees with findings from other researchers. According to Kwiatkowska-Pamula *et al*. (2017) [53], 93% of female judokas participate in excessive body mass reduction and consume between 40 and 60 percent of their daily caloric demands. Football players' energy needs are challenging to estimate since they vary with age, degree of daily exercise, and body composition (Mielgo-Ayuso *et al*., 2015) [51].

Low energy availability may affect physiological function, menstrual function, BMD, and energy balance, according to the literature (Mielgo-Ayuso *et al*., 2015) [51]. Among these athletes who lack energy may also have a normal weight as a result of physiological adjustments. Athletes can maintain stable body mass while yet being energy deficient due to several factors, one of which is lower resting energy expenditure (De Souza *et al*., 2014) [36].

In the rhythmic Gymnasts athletes, the group with a risk of LEA had a significantly higher RMR (resting metabolic rate) compared to the non-at-risk group (1481±165 vs. 1165±88) kcals, p=0.00. If the risk of Low Energy Availability (LEA) was associated with a significantly higher Resting Metabolic Rate (RMR) in a group of athletes, it could suggest that the body is trying to compensate for the lower energy availability by increasing its metabolic rate to maintain basic physiological functions. This is because a negative energy balance caused by low energy availability can lead to metabolic adaptations that can reduce energy expenditure and promote energy conservation in the body. An increased RMR may be the body's way of trying to overcome this adaptation and maintain metabolic homeostasis.

With regards to body composition differences between Footballers and rhythmic gymnastics, there were no significant differences between the two groups for TBW (%), muscle mass, resting metabolism rate, bone weight, FFM (kgs), and energy availability. Overall, the study suggests that Football players tend to have slightly higher body fat and visceral fat levels than Rhythmic Gymnastics athletes, but the difference is not significant. Popović *et al*. (2014) [54] also found similar results where rhythmic gymnasts had significantly lower body fat percentage and higher fat-free mass compared to soccer players. Similar results were found in Bayios *et al*. (2006) [52] study.

The strength of the study is that it identified risk factors of FAT in Indian Female Athletes. The study specifically focused on Aesthetic and Non-Aesthetic sports. The results of the study are not only useful for nutritionists but also for athletes, and coaches. This relatively small sample size is one of the limitations of our study and reflects the difficulty and challenge of recruiting athletes, particularly those preparing for major events which happened in the case of rhythmic gymnastics athletes. As a result, bigger sample sizes should be used in studies of this kind that are undertaken with populations of athletes from different sports. Unequal distribution of females involved in aesthetic and non-aesthetic sports.

5. Conclusion

In this study, according to the LEAF-Q, the prevalence of FAT in young female football (Non-Aesthetic Sport) players is on a very high level as compared to rhythmic gymnastics(Aesthetic sport). In both groups, there are no significant changes in the body composition, the data suggest that a majority of participants in both football and rhythmic gymnastics had EA levels below the recommended threshold of 30 kcal/kg FFM/day. Between the two sports, the body fat percentage and visceral fat are on the higher side in footballers than in rhythmic gymnasts. It has also been noticed that there are significant changes in the energy intake between the group at risk and not at risk among the footballers and rhythmic gymnasts. Nutrition in sports is a priority. It is the basis for maintaining optimal health and a prerequisite for the high performance necessary for competitions. However, when it comes to successful performance and health, not only is good nutrition significant but also energy availability and the importance of energy intake matching the energy expenditure.

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