e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022
 UGC CARE Listed (Group -I) Journal

Energy Availability and Macronutrient Intake of Elite Indian Adolescent Boxers

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Abstract:

Purpose: Energy availability (EA) has been evidenced to influence health and performance outcomes of elite athletes. However, this has not been reported sufficiently amongst Indian adolescents. Hence, this study aimed to report the daily energy availability of elite Indian adolescent boxers. Methods: This descriptive cross-sectional study recruited 32 state level boxers (females:14; males:18) aged 10–19 years using purposive, saturation sampling and assessed their energy availability. Weight, height, and skinfolds at 4 sites (biceps, triceps, subscapular and suprailiac) were taken to calculate body fat using Siri's equation & Fat free mass (FFM) calculated. Energy intake was assessed using a 24-hour recall method for one day and exercise energy expenditure by activity record method for the same day of training. Boxers were classified as moderate EA (30–45 kcal·kg−1 FFM·day−1) and low EA (< 30 kcal·kg−1 FFM·day−) and compared based on gender using Manwhitney-U test. Results: Among 32 boxers 43.75% were females and 56.25% were males. The mean energy intake of boxers was 2571 ± 609.7 (Females:2137 ± 266.9; Males: 2908 ± 592.5, p=0.0001), exercise energy expenditure was 1369 ± 251 (Females:1260 ± 106; Males: 1453 ± 299, p=0.0006) and energy availability was 24.1 ± 9.1 kcal/Kg FFM (Females: 19.5 ± 5.6; Males:27.8 ± 9.8, p=0.006) per day respectively. The mean carbohydrate intake was 371.8 ± 92.9 (Females:323.8 ± 58.4; Males:409.2 ± 98.8; p=0.013), protein was 88.8 ± 21.8 (Females: 71.3 ± 10.9; Males: 102.5 ± 18.1; p=0.00001) and total fat was 77.1 ± 22.8 (Females: 58.5 ± 6.5; Males: 91.5 ± 20.4; p=0.00001) respectively. 87.5% were categorized to have low EA and the rest 12.5% had optimal EA. No boxer consumed recovery meals within one hour of training, while the LEA group consumed meals less

frequently, with higher frequency of junk food consumption and higher frequency of skipped meals as compared to the normal EA group. It was observed that 100% of female boxers and 77.7 % of male boxers had low EA. Conclusions: Occurrence of low EA was higher amongst female boxers than males. This study reveals a need for risk assessment along with conscious food behavior change especially amongst female boxers.

Keywords: Adolescent elite athletes, boxers, energy availability.

INTRODUCTION

The human body expends a certain amount of energy for all physiological activities. Additional energy is needed to meet any increased demands brought on by changes in everyday function or physical activity to maintain homeostasis. Traditionally, energy adequacy was determined using the energy balance (EB) but more recently, the concept of energy availability (EA) has been used as an alternate way for determining energy deficit because energy balance has been criticized for its failure to recognize athletes who are chronically malnourished (Loucks, Kiens, & Wright, 2011). Energy availability is defined as "the difference between energy intake (EI) and exercise energy expenditure (EEE), expressed relative to an individual's lean body mass, representing the daily amount of energy 'available' to sustain all physiological functions outside of exercise" (Loucks, 2020). Optimal levels of EA are required to maintain body functions essential for good health and performance (Mountjoy et al., 2018). Inadequately low energy intakes are reportedly the main factor triggering unfavorable health and performance consequences predisposing athletes to Relative Energy Deficiency –Syndrome (Loucks et al., 2011; Mountjoy et al., 2018), especially the elite athletes (Mountjoy et al., 2018). EA quantifies the energy available in the body for various functions after removing the energetic cost used up in exercise (Loucks, 2004) and gives a quantitative estimate of the behavior of athletes (Loucks & Thuma, 2003). EA extends the concept of energy balance by quantifying the energy utilized during exercise and correlating the remaining available energy with essential physiological functions (Loucks, 2013)

Low energy availability indicates inadequate energy left to sustain the normal physiological functions such as metabolic, immune function, bone health, hematological factors, growth/ development, cardiovascular and gastro-intestinal factors (Mountjoy et al., 2018; Shetty, 1999). LEA also affects performance by decreasing the athletes training response, impairs judgement, decreases coordination, concentration, depression, irritability, and endurance performance (Ackerman et al., 2019).

The pursuit of excellence in sport predisposes an athlete to engage in excessive training loads to achieve greater levels of success (Lal PR & Balakrishnan B, 2013), which reportedly place athletes at risk of over training related health problems (Winsley & Matos, 2011), especially during adolescence (10-19 years), as it is a phase of rapid growth and development. Suboptimal

energy intake and deviations in eating behavior and disordered eating have been reported in adolescent athletes both nationally and internationally (Burrows et al., 2016; Malla et al., 2017) Screening the adolescent athletes with energy availability (EA) as it is the underlying factor of RED-S is reported by IOC as important to improve the performance and prevent or alleviate potential health related problems (Mountjoy et al., 2018). However, there is paucity of data on the EA indices of elite Indian adolescent athletes and very few studies have been reported on the prevalence of energy availability in Indian adolescent elite athletes. Hence, due to paucity of studies reported on energy availability of Indian boxers, this study was undertaken, with the objective to report the status of energy availability and macronutrient intake amongst adolescent boxers training in state training centres for national level competitions.

MATERIALS AND METHODS

2.1 Subjects/ Participants selection:

Participants of this descriptive cross-sectional study were recruited from the State training centres. They were residing in hostels and selected using purposive sampling within a predetermined inclusion criterion of athletes who were trained for more than 2 years in the sport, participated in state level competition, training for more than 5 days per week for around 5 hours per day, without any illness or injury. The study was approved by Institutional ethical committee, Lady Irwin College, Delhi University. All the participants were in the range of 10-19 years who were declared medically fit by the Sports Medicine expert and gave written consent to participate in the study. Demographic profiles, training hours per day/week and eating patterns were elicited. Also, participants were assessed for body composition, dietary intake, and exercise energy expenditure of their training.

2.2 Body Composition:

Height and body weight were measured using a standardized protocol (Marfell-Jones et al., 2012). Body weight was measured with minimal clothing using Tanita weighing scale to the nearest 0.1kg. Height was measured with bare foot by microtoise to the nearest 0.1cms. The body mass Index was calculated using Quetelet's equation (wt in kgs/ Ht in mt2). Body fat % was measured by using 4-site skin folds (SKF) at biceps, triceps, subscapular, and suprailiac as per ISAK guidelines using Holtain's skinfold caliper and computed for body density by Durnin and Wormsley equations (Durnin & Womersley, 1974) and body fat% using Siri's equation (Siri, 1956). Fat free mass was computed using the formulae given by Durnin and Rahman (Durnin & Rahaman, 1967).

2.3 Dietary Intake:

Dietary intake of 1 day was taken by 24-hour recall. The reported portion sizes were converted into grams by household measures. Dietcal (version 10) software including Indian Food

Composition Tables, (2017) (Longvah et al., 2017) data were used to compute dietary intake and nutritional analysis.

2.4Exercise Energy expenditure:

Athletes are trained to maintain activity records. The researcher took a minute-to-minute activity during their practice session of each player with the help of their coach. Exercise energy expenditure (EEE) was then computed using field-based approach by MET values (Heikura et al., 2018). The predicted resting energy expenditure (REE) was calculated using Cunningham equation which was suitable amongst Indian athletes (Cherian, Shahkar, et al., 2018) and in the Indian context (Soares et al., 1998). EEE was calculated using METs of activities given in the compendium of physical activity (Ainsworth et al., 2000, 2011).

2.5 Energy availability:

Energy availability was calculated using the methodology given by IOC consensus (Mountjoy et al., 2018). An EA of >45 kcal·kg^{-1} FFM·day^{-1} was considered optimal; EA of 30–45 kcal·kg^{-1} FFM·day^{-1} was moderate and EA of < 30 kcal·kg^{-1} FFM·day^{-1} was considered low. (Loucks et al., 2011).

2.6 Statistical Analysis:

The data collected was analyzed by using SPSS (version 17). All the data was presented in mean ±SD. Data was checked for normality by Kolmogorov-Smirnov Test of Normality. When applicable, a parametric student t test was conducted to examine gender differences. Using Pearson correlation coefficients, the relationships between EA, EI, EEE, REE, BF%, FFM and BMI body were investigated. Significance was considered at a p-value<0.05. The correlation coefficients were interpreted using the following criteria: very weak: <0.20; weak: 0.20–0.39; moderate: 0.40–0.59; strong: 0.60–0.79; and very strong: >0.80 (Evans, 1996).

RESULTS AND DISCUSSION

The mean age of adolescent boxers was 16.2 ± 2.2 years. The majority (n=32) of boxers were aged 18 or older, while the youngest boxers were aged 10 to 12 years. Both Madhya Pradesh and Uttar Pradesh contributed an identical number of athletes (43.75%) each. Most (56.25%) of the players trained for 6 hours every day.

Table-1: General profile and dietary practices of boxers

Characteristics	Categories	Adolescent boxers n=32(%)
Age	10-12	2(6.25)
	13-15	10(31.25)
	16-17	8(25)
	18+	12(37.5)
Native place	Assam	2 (6.25)
	Haryana	2 (6.25)
	Madhya Pradesh	14 (43.75)
	Uttar Pradesh	14 (43.75)
Training duration (typical day)	3 hours	2(6.25)
	5 hours	4(12.5)
	5.5 hours	4(12.5)
	6 hours	18(56.25)
	6.5 hours	4(12.5)
Diet	Vegetarian	4(12.5)
	Non-vegetarian	24(75)
	Ova-vegetarian	4(12.5)
Daily Meal Pattern	3 meals per day	24 (75)
	5 meals per day	8(25)
Skipping of Meals	Yes	4(12.5)
	No	28(87.5)
Preference for Junk foods	Yes	20(62.5)
	No	12(37.5)
Nutritional supplements	Yes	2(6.25)
	No	30 (93.75)

Of the 32 boxers studied, 75% (n=24) were non-vegetarians, 12.5% (n=4) were ovo-vegetarians, and 12.5% (n=4) were vegetarians. While 75% (n=24) of athletes ate three times a day, the remaining 25% (n=8) ate five times a day. It was observed that 12.5% (n=4) of athletes skipped meals, specifically lunch, due to paucity of time. Snacks like samosas, panipuri, ice cream, and bread pakoras were popular among 62.5% (n=20) of the population. About 6.25% (n=2) of the population used nutritional supplements like BCA.

No boxers were reported with optimal EA (>45Kcal/Kg/FFM). 87.5% of boxers (n = 28) presented with low EA (LEA) (21.5 ± 6.1 kcals/kg FFM) in comparison to those with moderate EA (MEA) (n = 4; 42.4 ± 2.4 kcals/kg FFM) which is illustrated in figure1.

Figure :1 Percentage of boxers into LEA & MEA

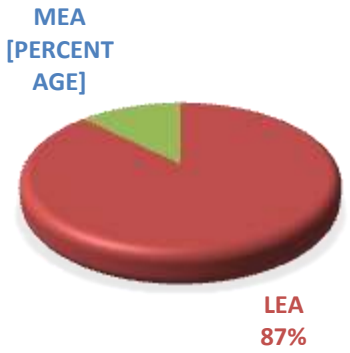
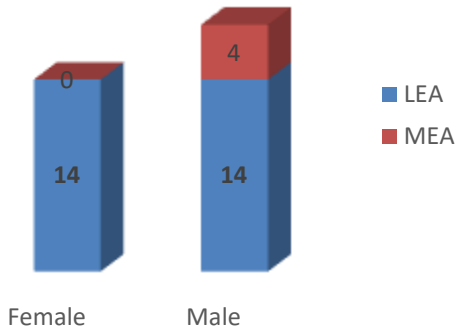


Figure: 2 LEA and MEA based on gender



It was observed that 100% (n=14) of female boxers and 77.7 % (n=14) of male boxers were in the category of low EA which is depicted in figure 2.

Figure 3 shows differences (non-significant) between LEA and MEA groups of boxers with respect to key dietary factors. The LEA group consumed junk food more frequently and had a higher frequency of skipped meals as compared to the EA group. No boxer reported meal frequency of 4 meals while a higher number of LEA group were consuming 3 meals a day as compared to moderate EA group in which a higher number of boxers were consuming five meals a day. In addition, no boxer consumed a recovery meal within one hour of training.

Figure: 3 Meal Frequency of LEA & MEA Boxers

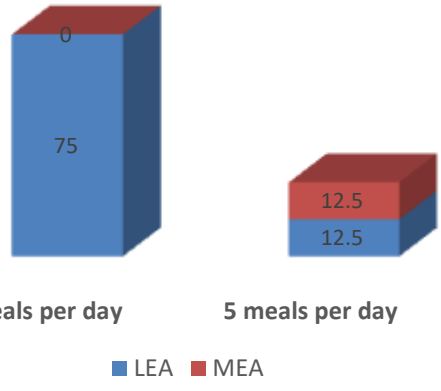


Table 2 clearly demonstrates that both male and female boxers had normal BMI, with no significant difference between the sexes. Females had a significantly higher body fat percentages than males (p=0.00001) as compared to the Indian study on junior boxers (Khanna & Manna, 2006), a marginally higher body fat percentage was reported in the present study.

Table-2: Anthropometry of adolescent Boxers

Variables	Male (n=18)	Female (n=14)	Total (n=32)	p value
Weight (kgs)	59.7 ±6.2	53.1±6.4	56.8±7.1	0.0053**
Height (cms)	170.4±6.0	157.3±7	164.7±9.1	0.00012***
BMI (kg/m2)	20.5±2	21.3±2.9	20.9±2.4	0.509^{NS}
Body Fat%	11±1.4	15.7±1.4	13.1±2.8	0.00001***
NS- Not significant; **P<0.01				

There was a significant difference between male and female boxers' calorie intake (P= 0.0001), exercise energy expenditure (P=.0006), fat-free mass (P=.0004), and EA (P= 0.006), as shown in Table 3.

Table-3: Energy availability (EA) variables based on gender (n=32) (Mean ± SD)

Variables	Male (n=18)	Female (n=14)	Total (n=32)	p-value
Energy availability (EA) (kcal/kg/FFM/day)	27.8±9.8	19.5±5.6	17±7.8	0.006*
Energy intake (EI) (Kcal/day)	2908 ±575	2137±256	2571±599.7	0.0001***
Exercise energy expenditure (EEE)(Kcal/day)	1453±299	1260±106	1722.8±324.8	.0006***
Estimated RMR (Kcal/day)	1668±124	1482.4±104.7	1586.8±147.6	.00044***
FFM	53.1±5.6	44.7±4.8	49.4±6.7	.0004***

*P<0.05, **P<0.01; ***P<0.001

Table: 4 depicts there is a significant difference between male and female boxers with respect to carbohydrate intake (p= 0.013*), protein intake (p=0.00001***) and fat intake (0.00001***).

Table: 4 Macro nutrient intake of adolescent boxers

Macronutrients	Male (n=18)	Female (n=14)	Total (n=32)	p- value
Energy (Kcal)	2908 ±575	2137±256	2571±599.7	0.0001***
Carbohydrate (g)	409.2 ±98.8	323.8 ± 58.4	371.8 ± 92.9	0.013*
Protein (g)	102.5 ± 18.1	71.3 ± 10.9	88.8 ± 21.8	0.00001***
Fat (g)	91.5 ± 20.4	58.5 ± 6.5	77.1 ±22.8	0.00001***

*P<0.05, ***P<0.001

Table 5: Relationships between body composition parameters and energy availability

	BMI	BF%	FFM	EEE	EI	EA	REE
BMI	1	.351*	.475**	.121	-.106	-.389*	.475**
BF%		1	-.472**	-.471**	-.555**	-.333	-.473**
FFM			1	.696**	.697**	.204	1.000**
EEE				1	.707**	.000	.696**
EI					1	.695**	.697**
EA						1	.203
REE							1

Moderate inverse relationships were observed between the body fat% and energy intake (r = −0.555) as presented in Table 5.

DISCUSSION

The objective of the present study was to evaluate the energy availability of boxers and report the LEA percentage in boxers. A secondary objective was to analyze the variations in EA values between males and females, as well as the relationship between the factors of energy availability. According to the study findings, The LEA was reported amongst 87.5% of boxers and the rest 12.5% were in moderate EA category (Figure-1). With respect to gender, 100% females and 77.7% males had LEA (Figure -2). There are no studies reported with respect to energy availability of Indian boxers, however, the occurrence of 87.5% LEA in the present study was higher than previous findings reported in Indian studies, on junior national level male and female soccer players (24% and 58%) (Cherian et al., 2018); other studies on elite soccer players (53%)(Braun et al., 2018), and competitive male endurance athletes (47.2%)(Lane et al., 2019). The mean energy availability of boxers observed in the current study was 24.1 ± 9.1 kcal/Kg FFM which is below the threshold of <30 kcals/kg FFM/day. The average energy intake reported amongst boxers was lower than the energy intake reported by another Indian study (Tyagi &

Bhushanam, 2021). An inverse relationship between bodyfat% and energy intake observed in our study, has not been reported in Indian athletes thus far.

CONCLUSION

Occurrence of low EA was higher amongst female boxers than males. This group also reported a higher intake of junk food & skipping meals; with the majority consuming 3 meals per day as compared to MEA group that reported a majority consuming five meals. No boxer consumed a recovery meal within one hour of training. study reveals a need for risk assessment along with conscious food behavior change especially amongst female boxers.

LIMITATIONS

In the present study, EA was computed using estimates of energy intake based on food recall, energy expenditure based on activity logs, MET values, and estimated RMR based on FFM measurements of skin folds. Thus, it largely relied upon self-reporting of the athletes which can lead to errors due to underreporting or overreporting**.**

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