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Comparison of various physical and body composition profiles between Indian elite male and female gymnasts

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abstract

Background The present study aimed to compare various physical and body composition profiles of Indian male and female gymnasts and also to compare the above parameters with their international/national peers.

Material/Methods The study was conducted on15 male (age = 19.2 ±3.75 years) and 16 female Indian gymnasts (age = 16.4 ±2.99 years). Various physical and body composition parameters were measured using standard methods.

Results The female gymnasts were found to have a higher amount of fat mass and volumes of extracellular water than their male and international peers while the males had a higher amount of fat free mass than females but less than their international peers. Also male gymnasts had a higher amount of body cell mass (BCM) and muscle mass (MM) than females and their international peers. The hand grip strengths, trunk flexibility, relative back strength and electrolytes were also found to be greater in male gymnasts. Significant positive correlations were observed in BCM and MM with calcium, potassium, glycogen and mineral content in both male and female gymnasts.

Conclusions These profiles of gymnasts may be used as a tool for evaluation & assessment and a future comparison for the improvement in performance.

Key words elite gymnasts, Biological Impedance Analyser, body composition, body cell mass, trunk flexibility, back strength & hand grip strength

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INTRODUCTION

Gymnastics is accepted as one of the fundamentals to attain complete physical fitness, as that concept has evolved into a broader notion of physical education. This is an anaerobic sport, and gymnasts tend to have an average level of aerobic capacity. However, they are among the strongest and the most flexible of all athletes. Cross-sectional studies indicated that college and former college (artistic) gymnasts have shown higher bone mineral density (BMD) than both non athletic controls and other athletes, such as swimmers and runners [1, 2, 3]. By and large gymnasts have a lower body mass index (BMI) and skin fold thickness. Gymnasts also have lower body fat content as compared to other sports. However, their fat-free mass (FFM) and body-cellular mass are found to be normal as reported by several researchers [3].

Gymnasts tend to be relatively short, slim, muscular individuals, with significant fast twitch fibres present in their musculoskeletal structure. Fast twitch fibres, those that respond the fastest to nerve impulses flowing from the brain, are essential to promote the speedy reaction times and powerful movements required in every gymnastic movement. Examples of fast twitch muscle activity are prominent in the run-up to the commencement of a series of floor exercises, and the approach to the vault, both of which are executed at a sprint. This is an acyclic sport, as the same movements are not repeated. Strength coupled with flexibility is the most important overall physical requirement in gymnastics [4].

Physical attributes necessary for competition success in female gymnasts have significantly changed over the past thirty years. The progressive increase in the difficulty of skills since the 1950s and 60s has increased the physical demands and the acrobatic nature of the sport. Today's elite female gymnasts are small, lean (low percent body fat), and well-muscled which results in a high power-to-weight ratio. Elite females peak before puberty and are ready for international competition at the minimum age requirement. Male gymnasts have also changed over the years and are now smaller than the gymnasts of the 1950s. Male gymnasts are lean and heavily-muscled, yet possess adequate flexibility and agility to perform the required skills at elite international competitions. Male gymnasts are ready for elite competition in their twenties when their muscle mass peaks [5]. Flexibility, which promotes the optimal range of motion in the athlete's joints, is essential to both producing the most efficient movement and to protecting the athlete from the rigors of the sport, particularly the repetitive nature of both training and competition. Some of the recent findings by Marina and Rodriguez [6] suggest that gymnastics training contributes to the development of BMD in girls undergoing bone modelling. It is further reported that body composition including speed and flexibility are prime components of success in gymnastics. As per literature very few studies have been conducted on Indian gymnasts particularly on the body composition.

Considering the above views, it was assumed that no comparative study on body composition parameters had been performed between the male and female gymnasts, at least in the Indian context. So, the aims of the present study were (i) to compare various physical and body composition profiles of elite male and female Indian gymnasts and (ii) to compare their profiles in respect to their national/international peers.

MATERIALS AND METHODS

SELECTION OF THE SUBJECTS

The present study was conducted on 15 male (n = 15, age = 19.2 ±3.75 years) and 16 female gymnasts (n = 16, age = 16.4 ±2.99 years), respectively. All the gymnasts belonged to the Center of Excellence (COE) and the SAI Training Center (STC) Schemes of Sports Authority of India (SAI), Kolkata. The gymnasts were at least of the state level performer with a minimum of 4–5 years of formal training history. They were evaluated for various physical and body composition variables at the Human Performance Laboratory of Sports Authority of India, Kolkata. They had almost the same socio-economic status with similar dietary habits and of similar training at same geographical and climatic conditions. Hence, these subjects were considered as homogenous.

Prior to initial testing, a complete explanation of the purposes, procedures, potential risks and benefits of the tests were given to the gymnasts. Clinical examinations of the participants were performed by SAI physicians who were specialized in Sports Medicine before the commencement of the various anthropometric and physiological tests [7].

TRAINING REGIMEN

The formulation and implementation of a systematic training program was made by qualified coaches with the guidance of a scientific expert from the Sport Science Department, SAI, Kolkata. The training regimen for both male and female gymnasts of the present study was held on average 4 to 5 hours every day except Sundays, which makes about 30 hours in a week. There were two sessions a day, i.e. the morning session and the evening session, both of which comprised physical training for one hour and skill training for about two hours. The physical training schedule included different strength and muscular endurance training programs along with flexibility exercises. A warm-up and cool-down session before and after the main practice were also included in the program. Beside the technical and tactical training, the athletes were also provided with a psychological or mental training session.

MEASUREMENTS

The physical characteristics of the groups including height (cm) & weight (kg) were measured by an anthropometric rod and digital scales, respectively, following a standard procedure [8]. The decimal age of all the subjects was calculated from their date of birth recorded from the original birth certificate, produced by them at the time of testing. The Body Mass Index (BMI) was calculated from body height and weight [9].

Back strength and hand grip strength (both right and left hand) were measured by a back and grip dynamometer (Senoh, Japan) following a standard procedure adopted from Johnson and Nelson [10]. The hip and back flexion as well as extension of the hamstring muscles was evaluated by a modified Sit-and-Reach Test using a ‘Flexometer’ (Lafayette Instrumental Co., USA) following a standard procedure [10].

MULTI-FREQUENCY BIOELECTRICAL IMPEDANCE ANALYSIS (BIA)

Body composition including fat mass (FM), fat free mass (FFM), total body water (TBW), extracellular water (ECW), intra cellular water (ICW), the ratio between extra and intra cellular water (ECW: ICW), body cell mass (BCM), muscle mass (MM), total body potassium (TBK), total body calcium (TBCa), glycogen and mineral were measured using Bioelectrical Impedance Analysis (BIA) (MaltronBioscan 920-2, Made in UK).Total body electrical impedance to an alternate current (0.2 mA) with four different frequencies (5, 50, 100 and 200 KHz) was measured using a multi-frequency analyser. Measurements were taken following a standard testing manual of Maltron International. A subject was in a supine position taking rest for 5 minutes on a non-conducting surface, with the arms slightly abducted from the trunk and the legs slightly apart. Before placing the surface electrodes, the sites were cleaned using isopropyl alcohol ensuring adherence and to limit the possible errors. Surface electrodes were placed on the right side of the body on the dorsal surface of the hands and feet. In the case of hands, electrodes were placed proximal to the metacarpal-phalangeal and medially between the distal prominences of the radius and ulna. In the case of feet, electrodes were placed proximal to the metatarsal-phalangeal joints, respectively, and also medially between the medial and lateral malleoli at the ankle. Before testing, the analyser was calibrated according to the manufacturer's instructions. Before taking the measurement, athletes were instructed, in consistence with Heyward and Stolarczyk [11], to follow the guidelines: 1) no heavy exercise 12h before the test; 2) no large meals 4h before the test; and 3) consumption of liquids limited to 1% of body weight, or, two 8-oz glasses of water, 2h before the test. All the tests were conducted at a room temperature varying from 23 to 25 degree centigrade with relative humidity varying between 50–60%.

STATISTICAL ANALYSIS

Data were analysed using the Statistical Program for the Social Sciences (SPSS) version 16.0 for Windows (SPSS Inc., Chicago, Il, USA). Differences between groups for all variables according to their gender were calculated using a one-way analysis of variance (ANOVA) and a matrix of correlation coefficient. All values were expressed as means ± standard deviation (SD). A confidence level at $p < 0.05$ was considered as significant.

RESULTS

Table 1 presents the mean, standard deviation and the level of significance of various physical and body composition profiles of both male and female Indian gymnasts. Male gymnasts were found to be significantly taller and heavier ($p < 0.001$) than their female peers. Fat mass was found to be significantly ($p < 0.001$) higher in females in comparison to males. Males possessed a significantly higher amount of fat free mass ($p < 0.001$), body cell mass ($p < 0.001$), muscle mass ($p < 0.001$), and the left hand grip strength ($p < 0.01$) than their female peers. However, no such significant differences were noted for BMI, relative back strength and trunk flexibility of both male and female gymnasts in the present study.

Table 1. Comparison and the level of significance of various physical and body composition profiles of elite Indian male and female gymnasts

Parameters	Male (n = 15)	Female (n = 16)	F value and the level of significance
Age (yrs)	19.2 ±3.75	16.4 ±2.99	1.730 NS
Height (m)	1.61 ±0.68	1.49 ±0.62	28.441**
Weight (kg)	54.6 ±7.44	44.0 ±4.67	22.549**
BMI (kg/m^2)	20.9 ±1.73	19.8 ±1.32	4.031 NS
Fat mass (kg)	6.4 ±1.76	8.6 ±2.86	26.842**
Fat free mass (kg)	48.4 ±6.92	35.4 ±4.46	33.818**
Body cell mass (kg)	26.2 ±3.48	18.8 ±1.73	58.166**
Muscle mass (kg)	23.7 ±3.50	15.2 ±1.86	72.586**
Hand grip strength (R)(kg)	37.6 ±6.36	25.5 ±4.53	2.735 NS
Hand grip strength (L)(kg)	36.2 ±6.53	24.4 ±4.33	11.391*
Relative back strength (/kg body wt)	2.3 ±0.24	1.9 ±0.30	1.943 NS
Trunk flexibility (cm)	44.4 ±4.48	44.2±3.05	0.132 NS

Values (mean ±sd), *= p < 0.01, **= P < 0.001, NS = not significant

Table 2 presents the mean, standard deviation and the level of significance of water and mineral content of both male and female gymnasts. Although the total body water content was found to be significantly ($p < 0.001$) higher in males in comparison to the female gymnasts, no significant differences were observed in extracellular water, intracellular water content and ECW/ICW between the groups. On the other hand, male gymnasts were found to have significantly higher total body potassium, calcium, glycogen ($p < 0.001$) and mineral content ($p < 0.05$) as compared to the female gymnasts.

Table 2. Comparison and the level of significance of water and mineral content of elite Indian male and female gymnasts

Parameters	Male (n = 15)	Female (n = 16)	F value and the level of significance
Total body water (lt)	35.3 ±5.12	25.4 ±2.56	47.368**
Extracellular water (%)	39.8 ±3.48	41.9 ±6.88	1.196NS
Intracellular water (%)	60.2 ±3.48	58.9 ±7.32	0.381 NS
ECW/ICW	0.7 ±0.09	0.7 ±0.20	0.918 NS
Total body potassium (gm)	125.2 ±16.79	83.1 ±7.38	83.373**
Total body calcium (gm)	976.5 ±152.04	670.7 ±91.43	46.772**
Glycogen (gm)	439.3 ±63.09	322.2 ±40.84	38.113**
Mineral (kg)	3.4 ±0.57	2.9 ±0.60	4.995*

Values (mean ±sd), *= p < 0.01, **= P < 0.001, NS = not significant

Table 3 demonstrates correlation coefficients between different physical parameters and total water and mineral content in both male and female gymnasts separately. The table reveals that in the case of male gymnasts, BCM was found to be positively and significantly correlated with TBK, TBCa, glycogen, minerals ($p < 0.01$), and MM was found to be positively and significantly correlated with TBK, TBCa, glycogen, minerals ($p < 0.01$). In female gymnasts, FFM was found to be positively and significantly correlated with TBW ($p < 0.05$), glycogen ($p < 0.05$) and minerals ($p < 0.01$). Also, BCM was found to be positively and significantly correlated with TBK, TBCa, glycogen, minerals ($p < 0.01$) and MM was positively and significantly correlated with TBK ($p < 0.01$), TBCa ($p < 0.01$), glycogen ($p < 0.05$) and minerals ($p < 0.01$).

Table 3. Pearson correlations of different physical parameters and water and mineral content of elite Indian male (M; n = 15) and female (F; n = 16) gymnasts

	Total body water (lt)	Total body potassium (gm)	Total body calcium (gm)	Glycogen (gm)	Mineral (kg)
Fat free mass (kg)	M 0.37 F 0.52*	M 0.27 F 0.40	M 0.16 F 0.41	M 0.33 F 0.61*	M 0.17 F 0.69**
Fat mass (kg)	M -0.36 F -0.15	M -0.26 F 0.01	M -0.14 F 0.13	M -0.32 F -0.26	M -0.16 F -0.36
Body cell mass (kg)	M 0.38 F 0.34	M 0.1** F 0.99**	M 0.96** F 0.88**	M 0.1** F 0.91**	M 0.84** F 0.81**
Muscle mass (kg)	M 0.31 F 0.40	M 0.99** F 0.96**	M 0.96** F 0.92**	M 0.99** F 0.97*	M 0.89** F 0.92**

*Correlation is significant at the 0.05 level;**Correlation is significant at the 0.01 level

Table 4 presents the comparison of different physical characteristics of elite Indian male and female gymnasts participating in the present study with their national and international peers. The mean age of male gymnasts in the present study was higher than of their national and international peers, and in the case of females, their age group was slightly younger than one group and higher than international peers. The mean values of height, weight, BMI, fat mass, fat free mass, body cell mass, muscle mass and glycogen content were found to be higher in male gymnasts as compared to their national peers. However, mean values for BMI, fat free mass, both right and left handgrip strength and trunk flexibility were found to be lower in male gymnasts of the present study as compared to their international peers. In the case of female gymnasts, the mean values of height and weight were well comparable with their international peers. The mean values of fat mass was found to be higher, and that of fat free mass and both right and left handgrip strength to be lower in female gymnasts (present study) in comparison to their respective international peers.

Table 4. Comparison of physical characteristics of elite Indian male and female gymnasts with their national/ international peers

Parameters	Male		Authors	Female		Authors
	Present study	National/ International counterpart		Present study	National/ International counterpart	
Age (yr)	19.2 ±3.75	15.3 ±2.92 17.7 ±1.55 15.2 ±3.4	Dey et al. [12] Dallas et al. [13] Arazi et al. [4]	16.4 ±2.99	16.9 ±3.62 13.4 ±1.62	Dallas et al. [13], Douda et al. [14]
Height (m)	1.61 ±6.44	1.53 ±9.97 1.61 ±6.96 1.62 ± 5.9	Dey et al. [12] Dallas et al.[13] Arazi et al [4]	1.49 ±6.17	1.50 ±7.06 1.52 ±8.38 1.65 ±2.0	Dallas et al. [13], Douda et al. [14], Helge et al. [15]
Weight (kg)	54.6 ±7.44	43.0 ±10.01 58.1 ± 8.21 51.35 ± 5.2	Dey et al.[12] Dallas et al. [13] Arazi et al [4]	44.0 ±4.67	46.1 ±9.26 37.1 ±5.74 53.7 ±6.0	Dallas et al. [13], Douda et al.[14] Helge et al. [15]
BMI (kg/m^2)	20.9 ±1.73	18.0 ±2.25 26.4 ± 5.1	Dey et al. [12], Massy-Westropp [16]	19.8 ±1.32	25.1 ±5.8 19.7 ±1.9	Massy-Westropp [16] Helge et al. [15]
FM (kg)	6.4 ±1.76	4.8 ±1.21 7.4 ±1.57	Dey et al. [12] Joao et al. [17]	8.6 ±2.86	7.5 ±2.73	Joao et al. [17]
FFM (kg)	48.4 ±6.92	38.1 ±9.51 57.7 ±5.78	Dey et al. [12], Joao et al. [17]	35.4 ±4.46	38.1 ±5.77 43.9 ±3.8	Joao et al. [17]Helge et al. [15]
BCM (kg)	26.2 ±3.48	20.4 ±5.17	Dey et al. [12]	18.8 ±1.73	-	-
MM (kg)	23.7 ±3.50	21.1 ±1.37	Dey et al. [12]	15.2 ±1.86	-	-
RHS (kg)	37.6 ±6.3	47 ±9.5	Massy-Westropp [16]	25.3 ±4.53	30 ±7	Massy-Westropp [16]
LHS (kg)	36.2 ±6.53	45 ±8.8	Massy-Westropp,[16]	24.4 ±4.33	28 ±6.1	Massy-Westropp [16]
TF (cm)	44.4 ±4.48	45.7 ±5.6	Arazi et al. [4]	44.2 ±3.05	-	-
GLY. (gm)	439.3 ±63.09	388.0 ±29.52	Dey et al. [12]	322.2 ±40.84	-	-

DISCUSSION

The shape, size and form of an individual play a significant role in an athlete's performance. Selected anthropometric characteristics, aerobic power, flexibility and explosive strength are important determinants of successful performance. Many sports are clearly prefer athletes who are tall and/or big in size. Gymnastics is often unique in that it provides competitive opportunities for the smallest and lightest athletes. Small stature is actually beneficial for gymnasts in performing better and avoiding injury. In gymnastics, body weight is carried; therefore, greater mass cannot be an advantage [4]. In the present study it was found that the height and weight of males are higher than females. Female gymnasts are actually shorter [18]. It has been reported that elite level or heavily involved female gymnasts may experience inadequate growth during their period of training and competition followed by catch-up growth during reduced training schedules or the months following retirement [19]. This may occur due to epiphysial closure induced by training. Our findings are also consistent with the findings of Dallas et al. [13] (Table 4). They have also reported that body weight of female gymnasts was lower than of their male peers (Table 4). It was also reported that gymnastic performance tended to decrease as stature increased [20]. Specifically, taller gymnasts struggled more with rotational movements, such as front and back rotations. Being shorter gives gymnasts an advantage in balance because the centre of gravity is placed lower. The lower the centre of gravity is to the base of support, the better the balance will be executed. The base of support is the body parts and apparatus supporting the gymnast's weight. A gymnast's strength-to-weight ratio also plays a critical role in his or her ability to perform feats of strength. So the above reason is also true for the gymnasts of the present study. The body mass index of an athlete is directly related to his/her bodyweight. In our present study, the difference in BMI was insignificant between the two groups, i.e. male and female gymnasts (Table 1). However, a higher value of BMI is a disadvantage for gymnastics movements.

Gymnasts demonstrate their strength by being able to move their bodies through a myriad of positions. Their strength is high when expressed relative to their body weight. Strength is one of the major redeeming characteristics of gymnastics. Improvement in strength has an influence on speed and power, and also provides the basis for strength endurance. Gymnasts tend to develop upper body strength more than in many other sports [4]. In the present study hand grip strength (left hand) in male gymnasts was found to be significantly higher ($P < 0.01$) than in the female ones, which corroborates with Massy-Westroppe's findings [16]. On the other hand, trunk flexibility was found to be insignificant when compared with the two groups. Our findings, although seem to yield a lower result, are consistent with the findings regarding international peers in both sexes. Most gymnastic coaches would agree that flexibility is an essential aspect of gymnastics training and performance. Flexibility is frequently included in talent identification and screening measures for gymnasts. Gymnastics emphasizes flexibility due to the need for gymnasts to adopt certain specific positions in order to perform skills. The flexibility demands of gymnastics are the most significant and unique aspects of gymnastics that serve to separate gymnastics from most other sports [4]. There is scientific evidence that the incidence of injury decreases when gymnasts include flexibility training in their routines due to the enhanced ability to move unimpeded through a wider ROM. The only exception to this would be when there is an excessive or unstable ROM, which may increase the likelihood of injury [21]. It may be stated from the present study that better strength and flexibility in male gymnasts is advantageous and enables them to perform better than the female gymnasts. So, it may be further suggested that more emphasis should to be given to improve the strength and flexibility in female as well.

Regular gymnastic training leads to a reduction in body fat percentage and an increase in muscle mass [4]. Body fat percentage was found to be higher in female gymnasts in comparison to their male peers in the present study as well as to their male and female international peers [17]. This general acceleration in body fat accumulation, particularly sex-specific fat, is mostly attributed to changes in female hormone levels. After adolescence, the accumulation of sex-specific fat more or less stops, or decreases dramatically in healthy-weight women, and there is usually no further increase in the number of fat cells. Fat cells in males also do not tend to multiply after adolescence. Typical values for elite athletes are 6% to 12% for men and 12% to 20% for women [22]. On the other hand, lean body mass is slightly higher in males. Mercier et al. [23] have also reported that a lower proportion of fat mass and more muscle mass are preferred, while a high proportion of FFM relates to a high volume of TBW and its ICW component.

Hydration is one of the most important nutritional concerns for an athlete. Approximately 60 percent of body weight is water. Research has shown that losing as little as 2% of total body weight can negatively affect athletic performance. For example, if a 150-pound athlete loses 3 pounds during a workout or competition, their ability to perform at peak performance due to dehydration is reduced. Proper fluid replenishment is the key for preventing dehydration and reducing the risk of heat injury in athletes engaged in training and competition. In a study conducted by Matias et al. [24], the ICW compartment is determined as the difference between the TBW and ECW compartments. As per literature the relationship between hydration and cognitive or exercise performance, intracellular water should be an indicator of choice, as functional impairment should be more related to cell volume than to the cell environment [25]. It has recently been shown that reductions in the ICW compartment decrease strength and power in elite judo athletes and leg strength and jumping height over a season in basketball, handball and volleyball players. These findings further support the important role of effective monitoring of the water distribution volumes (TBW, ECW, and ICW) in physical performance. The content of total body water, body cell mass and muscle mass was significantly higher in males in the present study, which also provides distribution of body water spaces in both male and female gymnasts, which has been found to be influenced by gender, body composition and age. The possible explanation of the above facts might be due to the gender difference in body fluid spaces occurring from the teenage years onwards due to their differing fat levels, muscle mass is replaced with fat [25]. Since women contain a greater amount of fat mass than men, their water reserve is lower as compared to men. An association of gender with the body fluid level has been well demonstrated by Ritz et al. [25] and Aloia et al. [26], whose research corroborates with the findings of the present study, and there might be the same reasons for such a difference.

The relative proportion of ICW and ECW fraction appears to be an important marker of gender difference. Slightly greater volumes of ECW in female athletes were observed, whereas ICW was found to be higher in men in the present study. The explanation might be due to the fact that women contain higher fat mass than men. The relationship between fatness and ECW is that little water is contained in fat mass (5–10%), as extra-cellular water. It is logical that the greater the fat mass, the greater the extra-cellular compartment. This fact has also been shown in obese persons in comparison to lean ones [27]. At a similar BMI, women have more fat than men; hence they should have a greater proportion of extra-cellular water. Associations of age & gender with both ECW & ICW have been demonstrated by Ellis [28] & Tuuri et al. [29] respectively in earlier studies which corroborate with the findings our study.

Body composition plays an important role in athletic performance, as exercise has an ability to alter body composition, where body cell mass (BCM) is an important factor. Gymnastics is a type of strength-power sport, demanding high levels of both flexibility and anaerobic capacities for successful performance. As female gymnasts develop into elite senior competitors, they may receive regular assessment of body weight and body fat levels in order to maintain a lean, muscled physique. BCM is the functional mass of the body, where work is done and all metabolic activity takes place within the body cell mass. It has been reported that for a normal individual the muscle tissue accounts for approximately 60% of the BCM, the organ tissue accounts for 20% of BCM, with the remaining 20% made up of red cells and tissue cells. The BCM also contains the vast majority (98–99%) of the body's potassium. The normal range of BCM is set at 40% of the ideal healthy body weight. BCM is a strong predictor of athletic performance as well as muscular efficiency. High levels of FFM and BCM are related to increases in muscular efficiency, and a lower BCM signifies a decrease in muscular efficiency [30]. In the present study, it has been found that male gymnasts have higher body cell mass and muscle mass than their female peers. Significant positive correlations were observed for body cell mass (BCM) and muscle mass (MM) with body calcium, potassium, glycogen and mineral content in both male and female gymnasts. A high level of BCM in male gymnastics, which is a non-endurance sport, signifies the type of strength-power sport demanding high levels of both anaerobic explosiveness and flexibility for successful performance, with which leanness is associated [12].

Proper hydration and electrolyte balance is important for cellular metabolism, blood flow and hence physical and athletic performance. The maintenance of precise osmotic gradients of electrolytes is important. Such gradients affect and regulate the hydration of the body as well as blood pH, and are critical for nerve and muscle function. Electrolytes are molecules capable of conducting electrical impulses and include sodium (Na^+), potassium (K^+), calcium (Ca_2^+), magnesium (Mg), and chloride (Cl). Without sufficient levels of these key electrolytes, muscle weakness or severe muscle contractions may occur. The male gymnasts in the present study had a higher significantly amount of potassium, calcium, glycogen and mineral content compared to the females. Apart from genetic factors, the proper increase in bone mass in the period of intense development is affected by environmental factors linked with lifestyle, the most significant of which include physical activity [31] and eating habits, appropriate intakes of calcium and phosphorus with diet in particular. Physical activity has been shown to have a positive effect on bone metabolism among adolescents. A comparison with international peers, as cited in Table 4, reveals that the gymnasts in the present study possess more fat mass (FM) but lower hand grip strength. However, the measures of all the remaining parameters are more or less consistent with the peers. Despite training indoors, gymnasts need to keep their fluids up during training to prevent dehydration that can lead to poor performances. During training sessions water should be the main fluid but sports drinks may be helpful during long or very intense training sessions and competition, as they also provides carbohydrates for active muscles.

CONCLUSION

In the present study, some novel physical and body composition data about the leading Indian male and female gymnasts were presented. The anthropometric and physical profiles are phenotypic and are, therefore, susceptible to change with growth, training, nutrition and ageing. The current study provides various baseline anthropometric and body composition data that could be used in the prescription of individual training programs for gymnastics athletes of both the genders. The result of the present study may become a guideline for future assessment and comparison. In addition, the evaluation and assessment of the present status reveals strengths and relative weaknesses and can become the basis for coaches/trainers to formulate a systematic training programme for improvement in gymnasts' performance.

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