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EVALUATION OF OBESITY INDICATORS AMONG INDIAN BADMINTON ATHLETES: NUTRITIONAL CAUSE AND IMPRESSION ON PHYSICAL FLEXIBILITY AND AGILITY

Prajakta Nande[1] and Shreyashi Saha[2]

[1] Assistant Professor, Department of Home Science, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, Maharashtra, India
prajaktanande@yahoo.co.in

[2] Research Scholar, Department of Home Science, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, Maharashtra, India
shreyashirimpi12@gmail.com

ABSTRACT:

Successive performance in badminton requires exclusive physical fitness for which sound anthropometry and adequate nutritional status are the prerequisites. Obesity indicators, like body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR), waist to height ratio (WHtR), ∑skinfold thickness (∑SF), and % body fat (%BF) are indispensable for fitness assessment, thus evaluated in the present study in search of nutritional cause and impression on physical fitness. Total 100 male and 100 female sub-elite badminton players of 13-15 years age from Nagpur, Maharashtra were purposively sampled for assessment. Anthropometries and body composition were measured by non-elastic measuring tape and skinfold calliper, Bioelectric Impedance Analyser (BIA). Nutrient intake was assessed by '24 hour dietary recalls method' for consecutive three days. Flexibility and agility were evaluated by sit and reach and Hexagonal obstacle tests. The result showed players' BMI, WC, WHR, WHtR, ∑SF and %BF were well within the range/below threshold limit of Global health and sports recommendations, considered as "good" grade, thus advocated optimum obesity indicators. Macronutrients assessment revealed significant higher intake than RDA but lesser than players of other countries. Physical fitness test exposed mannish superiority in flexibility but feminine pre-eminence in agility performance. However, no players graded "excellent". Correlation study of obesity indicators (except WHtR) vs macronutrients (-0.1069; $p>0.05$ to 0.6315; $p<0.01$) found more distinctive positive correlations in girls than boys, established augmented nutritional influence over girls. Although, for both the gender, obesity indicators have comprehensive negative impact on flexibility (-0.1848; $p>0.05$ to -0.7394; $p<0.01$) and agility (-0.3142; $0.05>p>0.01$ to -0.7751; $p<0.01$), can influence their performance.
Key Words: Obesity indicators, Macronutrients, Flexibility, Agility

Introduction

Sports performance largely depends on multifaceted variables such as anthropometry, physiology and psychology (Bompa 1994). Badminton is one of the sport which is a perfect amalgam of physical condition, mental attitude, courage, intelligence and player's technical skill and tactical efficacy with co-ordinate functioning of body and its reflexes (Singh et al. 2011). Apart from high levels of technical skills and mental acuity, sound physical outline and adequate nutritional status are

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essential for optimum physical fitness. Flexibility and agility are two imperative parameters for physical fitness (Shivalingaiah et al. 2016) in badminton in terms of feet movements and prompt in changing direction to deliver better stroke as in a smash and drop shot (Elliot et al. 1989; Chin et al. 1995). Obesity, most importantly impairs the flexibility and agility of the body. Body mass index (BMI), waist circumference (WC), Waist to Hip ratio (WHR) and Waist to Height ratio (WHtR) are simple and effective indicators of obesity (Al-Sharbatti et al. 2011; Yoo 2016). Apart from these, skinfold thickness, Bioelectric Impedance Analysis (BIA) are also equally imperative indicators of obesity.

The present study concerns with the assessment of precise obesity indicators of badminton players, its nutritional cause and its impact on physical flexibility and agility which are essentially required for successive performance.

Methods

A total of 200 sub-elite players of 13-15 years of age (Male: n=100 and Female: n=100), regularly participating in various club, school, city, district, and national level competitions were purposively chosen by random sampling method. The assessment was performed only over the players of Nagpur, considered as representative of Indian sub elite badminton players of the particular age group. The study was duly endorsed by Institutional Ethics Committee, Arneja Heart and Multispecialty Hospital, Nagpur and Research and Recognition Committee, RTM Nagpur University. Permissions were obtained from subjects and their parents and coaches for assessments.

For anthropometric measurement (waist circumference) non elastic plastic tape was used. Subcutaneous fat was measured by slim guide skinfold calliper (skinfold thickness) and Bio Impedance Analyser (BIA) (%Body Fat). Nutritional status of the players were assessed by 24 hour dietary recalls method' for consecutive three days (Hausswirth and Mujika 2013) along with general dietary history. Nutritive values of assessed nutrients were computed by standard food composition tables (Longvah et al. 2017; Gopalan et al. 2012). For physical fitness, flexibility test (Sit and Reach test) was performed by using 60cm scale. The subjects sat on the floor with bared flat feet and straight legs, feet slightly apart with toes pointing up and was asked to reach forward and push fingers. At the point of greatest reach, the distance from the tip of the middle finger to the toe was measured and compared with normative data (Nande and Vali 2010). Agility test (Hexagonal Obstacle Agility Test) was executed with 66 cm sided hexagon shaped cardboard cutting, stop watch and whistle. The subjects were asked to stand at the middle of hexagon and with the blow of whistle, they jumped at each face line of hexagon with both feet and jumped back to the centre. Likewise they

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completed the circuits thrice. The time of completing three circuits was compared with normative data (Nande and Vali 2010).

Results

Age of the badminton players of present study were 13.94 ± 0.84 years and 14.03 ± 0.83 for girls and boys respectively. As per parents' educational qualification, occupation, per capita monthly income and monthly food expenditure, players from both the gender came with Class-I Socio Economic Status (SES) as per Modified BG Prasad Classification for May 2021 (Majhi and Bhatnagar 2021). 44% girls and 33% boys have 2-3 years playing experience whereas 54% girls and 63% boys have >3 years sports experience. 73% boys and 70% girls were daily practicing over 2-3 hours. Most of the players are professionally aspirant for badminton.

Body anthropometry of the players (Table -1) depicted portentous higher BMI (Girls: 12.20%; z= 8.58, p<0.01and Boys: 19.68%; z= 10.01, p<0.01), WC (Girls: 7.77%; z= 8.66, p<0.01 and Boys: 14.98%; z= 9.74, p<0.01) and WHtR (Girls: 2.44%; z= 2.50, 0.05>p>0.01 and Boys: 10.26%; z= 8.00, p<0.01) than the Indian standards (Sarna et al. 2021). Moreover, the players were also found to have lower WHR (Girls: 11.76%; z= 25.00, p<0.01 and Boys: 4.71%; z= 8.00, p<0.01) than standard Indian adolescents (Sunil Kumar et al. 2015).

Table -1 Data on Obesity Indicators (Anthropometric) of subjects

S No	Parameters	Girls (n=100)	Boys (n=100)
1.	Body Mass Index (kg/m^2)		
i.	Mean ± SD (Range)	19.25 ± 2.44 (14.61 - 25.42)	19.54 ± 3.21 (13.11 - 28.29)
ii.	Standard	17.16	16.33
iii.	z values	8.58*	10.01*
iv.	% Excess	12.20	19.68
2.	Waist Circumference (cm)		
i.	Mean ± SD (Range)	66.15 ± 5.51 (54.20 – 85.00)	70.61 ± 9.45 (53.00 - 98.00)
ii.	Standard	61.38	61.41
iii.	z values	8.66*	9.74*
iv.	% Excess	7.77	14.98
3.	Waist to Hip Ratio		
i.	Mean ± SD (Range)	0.75 ± 0.04 (0.66 – 0.88)	0.81 ± 0.06 (0.72 - 1.15)
ii.	Standard	0.85	0.85
iii.	z values	25.00*	8.00*
iv.	% Deficit	11.76	4.71
4.	Waist to Height Ratio		
i.	Mean ± SD (Range)	0.42 ± 0.04 (0.35 - 0.53)	0.43 ± 0.05 (0.35 - 0.58)
ii.	Standard	0.41	0.39
iii.	z values	2.50**	8.00*
iv.	% Excess	2.44	10.26

***- Significant at both 5 % and 1% levels (p<0.01); **- Significant at 5 % level but insignificant at 1 % level (0.01<p<0.05); Values without any mark indicate insignificant difference at both 5% & 1% levels (p>0.05).**

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Body composition (Table -2) depicted that female and male players exhibit ∑skinfold thickness of 94.33 ± 23.90 mm and 82.41 ± 33.42 mm respectively measured at 8 different sites of trunk region (Subscapular, Suprailiac, Supraspinale and Abdominal) and limb extremities (Bicep, Tricep, Thigh and Calf), therefore graded in "good" category as per ISAK, 2001. Whole body fat percentage analysis by BIA ensued lower subcutaneous body fat (Girls: 2.85%; z= 1.32, p>0.05 and Boys: 7.00%; z= 2.43, 0.05>p>0.01) as compared to standards (Upper threshold value) of athletes (14-20% and 6-13% for female and male athletes respectively) by American Council of Exercise, 2009.

Table -2 Data on Obesity Indicators (Body Composition) of subjects

S No	Parameters	Girls (n=100)	Boys (n=100)
1.	**∑skinfold thickness (mm)**		
i.	**Mean ± SD (Range)**	94.33 ± 23.90 (43.00 - 146.00)	82.41 ± 33.42 (34.00 - 167.00)
2.	**Whole body fat (%)**		
i.	**Mean ± SD (Range)**	19.43 ± 4.32 (10.10 - 30.00)	12.11 ± 3.66 (5.00 - 19.70)
ii.	**Standard**	20.00	13.00
iii.	**z values**	1.32	2.43**
iv.	**% Deficit**	2.85	7.00

***- Significant at both 5 % and 1% levels (p<0.01); **- Significant at 5 % level but insignificant at 1 % level (0.01<p<0.05); Values without any mark indicate insignificant difference at both 5% & 1% levels (p>0.05).**

Badminton players, regularly engaging in strenuous practice, need adequate nutrients to fulfil metabolic requirements. Macronutrients— carbohydrates, fats, and proteins (Table -3) provide body's source of energy to fuel life processes as well as provide vital support for intense training for optimum performance. Players from both the gender far-off surpassed the recommended dietary allowance (RDA) of carbohydrates (Girls: 173.18%; z= 61.32, p<0.01 and Boys: 204.48%; z= 62.50, p<0.01), proteins (Girls: 44.53%; z= 34.27, p<0.01 and Boys: 47.38%; z= 42.94, p<0.01) and fats (Girls: 46.31%; z= 34.22, p<0.01 and Boys: 30.94%; z= 29.27, p<0.01). Nutrition Adequacy Ratio (NAR) with respect to RDA by ICMR, 2010 and 2020 also substantiate the excess intake of carbohydrate (Girls: 2.73 ± 0.28 and Boys: 3.04 ± 0.33), protein (Girls: 1.45 ± 0.13 and Boys: 1.47 ± 0.11) and fat (Girls: 1.46 ± 0.14 and Boys: 1.31 ± 0.11). Mean Adequacy Ratio (MAR) of three macro nutrient displayed 1.88 ± 0.15 and 1.94 ± 0.15 for girls and boys respectively.

Table -3 Data on Macronutrient intake of subjects

S No	Parameters	Girls (n=100)	Boys (n=100)
1.	**Carbohydrate (gm/day)**		
i.	**Mean ± SD (Range)**	355.14 ± 36.12 (274.99 - 450.86)	395.82 ± 42.53 (267.12 - 489.25)
ii.	**RDA**	130.00	130.00
iii.	**z values**	61.32*	62.50*
iv.	**% Excess**	173.18	204.48

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2.	**Protein (gm/day)**		
i.	**Mean ± SD (Range)**	62.44 ± 5.61 (48.53 - 75.88)	66.18 ± 4.95 (55.20 - 77.54)
ii.	**RDA**	43.2	44.9
iii.	**z values**	34.27*	42.94*
iv.	**% Excess**	44.53	47.38
3.	**Fat (gm/day)**		
i.	**Mean ± SD (Range)**	58.52 ± 5.41 (42.29 - 69.64)	58.92 ± 4.76 (44.51 - 68.16)
ii.	**RDA**	43.2	44.9
iii.	**z values**	34.22*	29.27*
iv.	**% Excess**	46.31	30.94

***- Significant at both 5 % and 1% levels (p<0.01); **- Significant at 5 % level but insignificant at 1 % level (0.01<p<0.05); Values without any mark indicate insignificant difference at both 5% & 1% levels (p>0.05).**

To assess the physical flexibility of the players, sit and reach test was executed for monitoring the development of player's lower back and hamstring flexibility. The test result revealed that male players (3.86 ± 5.31 cm) stretched greater distance than their counter part (3.27 ± 4.75 cm). To monitor the players' agility in terms of prompt and precise movements without losing the balance, hexagonal obstacle agility test was conducted. The test resulted mannish (17.63 ± 2.59 seconds) superiority in performance as compared to female players (20.44 ± 3.25 seconds).

Table -4 Data on Physical Fitness of subjects

S No	Parameters	Girls (n=100)	Boys (n=100)
1.	**Sit and Reach (cm) (Flexibility)**		
i.	**Mean ± SD (Range)**	3.27 ± 4.75 (-9.50 – 12.00)	3.86 ± 5.31 (-10.00 – 14.00)
2.	**Hexagonal obstacle Test (seconds) (Agility)**		
i.	**Mean ± SD (Range)**	20.44 ± 3.25 (14.00 – 27.00)	17.63 ± 2.59 (13.00 – 24.00)

The correlation study of obesity indicators with flexibility evaluation by sit and reach test acknowledged prominent negative relationship between BMI, WC, WHR, WHtR, ∑ skinfold, % Body Fat vs Flexibility (Girls: -0.1848; p>0.05 to -0.6275; p<0.01 and Boys: -0.4476; p<0.01 to -0.7394; p<0.01). Furthermore, in accordance with completion time of hexagonal obstacle agility test, all mentioned obesity indicators had inverse relationship with agility (Girls: -0.4080; p<0.01 to -0.7751; p<0.01 and Boys: -0.3142; 0.05>p>0.01 to -0.6833; p<0.01). The converse correlation indicates severe negative impact of obesity indicators on physical flexibility and agility.

Table -5 Correlation of Obesity Indicators with nutrition intake and physical fitness

Parameters		BMI	WC	WHR	WHtR	∑ skinfold	%Body Fat
1.		**Correlates of Obesity Indicators with Nutritional Intake**					
Carbohydrate	G	0.6315*	0.5464*	0.2273	-0.2488	0.4792*	0.5502*
	B	0.4295*	0.4194*	0.2390	-0.0616	0.2877**	-0.0086
Protein	G	0.4817*	0.4514*	0.2373	-0.1042	0.3223**	0.4644*
	B	0.1775	0.1973	-0.1020	-0.1280	0.1893	-0.0580

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Fat	G	0.4017*	0.3655**	-0.1069	-0.2867	0.3475**	0.3397**
	B	0.0019	0.0135	-0.0398	-0.0429	0.0363	-0.0033
2.		**Correlates of Obesity Indicators with Physical Fitness**					
Flexibility	G	-0.6275*	-0.5330*	-0.6099*	-0.1848	-0.5271*	-0.4729*
	B	-0.6301*	-0.5934*	-0.7394*	-0.4476*	-0.7283*	-0.6228*
Agility	G	-0.6462*	-0.5623*	-0.7751*	-0.4080*	-0.6094*	-0.6010*
	B	-0.5125*	-0.4076*	-0.5803*	-0.3142**	-0.6088*	-0.6833*

*- Significant at both 5 % and 1% levels (p<0.01); **- Significant at 5 % level but insignificant at 1 % level (0.01<p<0.05); Values without any mark indicate insignificant difference at both 5% & 1% levels (p>0.05).

As per nutritional consideration for girls, well assenting correlation perceived between BMI, WC, WHR, ∑skinfold and % body fat with Carbohydrate (0.2273; p>0.05 to 0.6315; p<0.01), Protein (0.2373; p>0.05 to 0.4817; p<0.01) and Fat (0.3397; 0.05>p>0.01 to 0.4017; p<0.01) [except Fat vs % WHR (-0.1069; p>0.05) showing no correlation]. For boys, no to moderate affirmative correlation was obtained between BMI, WC, WHR, ∑skinfold and % body fat vs Carbohydrate (-0.0086; p>0.05 to 0.4295; p<0.01), Protein (-0.0580; p>0.05 to 0.1973; p>0.05) and Fat intake (-0.0033; p>0.05 to 0.0363; p>0.05). For both the gender, WHtR with Carbohydrate (Girls: -0.2488; p>0.05 and Boys: -0.0616; p>0.05), Protein (Girls: -0.1042; p>0.05 and Boys: -0.1280; p>0.05) and Fat (Girls: -0.2867; p>0.05 and Boys: -0.0429; p>0.05) had prominent weakly negative relationship.

Discussion

To ratify the outcome of present study, Indian and International quality literatures on badminton players and other athletes as well as standard data of adolescents of particular age group were discussed and compared with present study.

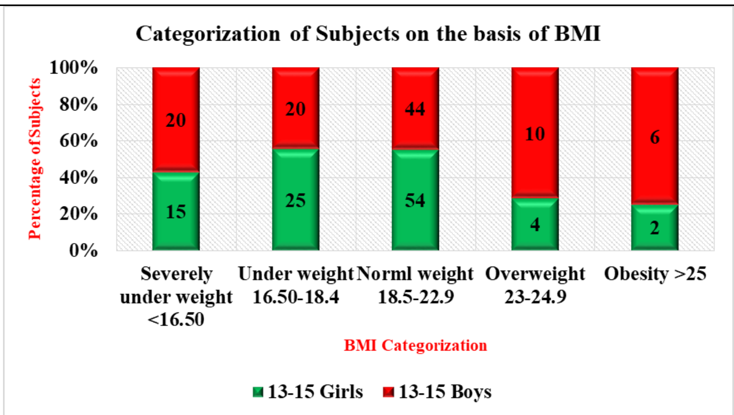

Fig 1 Subject categorization on the basis of BMI

Despite of 20%, 20% girls and 15%, 25% boys falling severely underweight (<16.50 kg/m^2) and underweight (16.50-18.40 kg/m^2) group as well as 4%, 2% girls and 10%, 6% boys falling in overweight (23-24.9 kg/m^2) and obese (>24 kg/m^2) group, 54% girls and 44% boys were falling within normal weight (18.5-22.9 kg/m^2) as per BMI categories by WHO 2008 (Fig 1). The basic

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anthropometry of the badminton players depicts deficit BMI for girls (1.28%; z= 1.02, p>0.05) and excess BMI for boys (3.48%; z= 2.05, 0.05>p>0.01) than standard Indian adolescents of particular age group by Khadilkar et al. (2015). Comparing with the BMI of sub-elite young Indian badminton players (n=125) (Age: girls- 15.28 ± 2.65 years and boys- 14.60 ± 2.62 years) postulated by Koley and Srikanth (2016), players of present study were found with elevated BMI (girls: 0.52%; z= 0.41, p>0.05 and boys: 9.04%; z= 5.05, p<0.01). Although, Suseelamma (2014) quantified higher BMI (girls: 5.64%; z= 4.71, p<0.01 and boys: 3.74%; z= 2.36, 0.05>p>0.01) among professional players (Age: girls- 15.50 ± 2.06 years; n=5 and boys- 17.56 ± 1.18 years; n=20) than the present study. In the global scenario, the BMI of the present study found significantly lesser than elite Spanish players (age: 12-16 years) (Hoyo et al. 2006) (girls: 7.00%; z= 5.94, p<0.01 and boys: 6.01%; z= 3.89, p<0.01) as well as Czech players (age: Male- 17.2 ± 1.2; n=29 and Female- 17.6 ± 0.8; n=16) (Heller 2010) (girls: 10.88%; z= 9.63, p<0.01 and boys: 7.83%; z= 5.17, p<0.01) and marginally lesser (girls: 1.79%; z= 1.43, p>0.05, n=18 and boys: 2.78%; z= 1.74, p>0.05, n=20) than Korean national youth badminton players (Lee et al. 2018). The players of the present study had remarkably reduced measurement than the WC (Girls: 17.31%; z= 25.14, p<0.01 and Boys: 21.54%; z= 20.52, p<0.01) and WHR (Girls: 6.25%; z= 12.50, p<0.01 and Boys: 10.00%; z= 18.00, p<0.01) cut-off value recommended by WHO (2008) (WC and WHR: Men- 90cm and 0.90 and Women- 80cm and 0.85 respectively) as well as WC cut-off for Indian children of particular age group specified by Khandilkar et al. (2014) (Girls: 20.18%; z= 30.34, p<0.01 and Boys: 14.44%; z= 12.61, p<0.01) for any metabolic complexity. As per categorization on the basis of WC (ACSM 2005) (Fig 2) and WHR (Nande and Vali 2010) (Fig 3), 78% girls and 85% boys had "very low" WC. Also, 60% girls and 83% boys had "excellent" WHR. However, considering badminton players of Indian Subcontinent, Marwat et al. (2021) found marginally higher WC (Girls: 8.90%; z= 11.72, p<0.01 and Boys: 2.75%; z= 2.12, 0.05>p>0.01), equal WHR for boys and upraised WHR for girls (7.41%; z= 15.00, p<0.01) among Pakistani school going badminton players as compared to present study. Deficit WC (Girls: 9.31%; z= 12.32, p<0.01 and Boys: 3.19%; z= 2.47, 0.05>p>0.01) and WHR (Girls: 12.79%; z= 27.50, p<0.01 and Boys: 5.81%; z= 10.00, p<0.01) were obtained while comparing with Ghanain university athletes of 9 sports (n=129) including badminton (Male: n=12 and Female: n=9) (Moses and Duduyemi 2016). WHtR results exposed that the players of the present study also had significantly lower (Girls: 16.00%; z= 20.00, p<0.01 and Boys: 14.00%; z= 14.00, p<0.01) than global boundary value (Browning et al. 2010) of WHtR (0.05) for detecting central obesity. Comparing with other games such as netball, Indian male badminton players of present study was found to have lower WHtR (6.52%; z= 6.00, p<0.01) as compared to Indian Netball players assessed by Chaubey et al. (2018).

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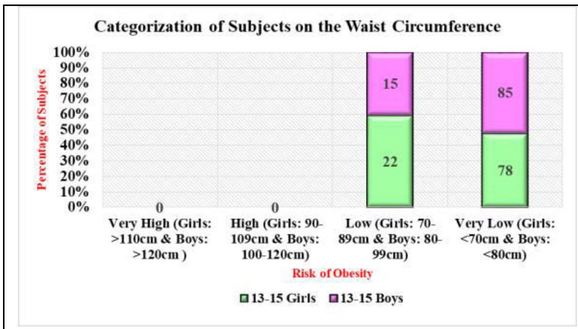

Fig 2 Subject categorization on the basis of WC

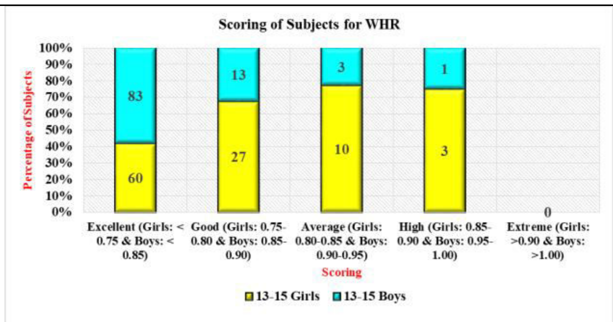

Fig 3 Subject scoring on the basis of WHR

Under body composition segment, the present study depicted that the assessed players had lesser whole body skinfold thickness than the players from other Indian subcontinent countries like Pakistan (Girls: 13.17%; z= 5.99, p<0.01 and Boys: 24.14%; z= 7.85, p<0.01) (Marwat et al. 2021) and even sub-elite female players (6.91%; z= 2.93, p<0.01) of European countries like Spain (Hoyo et al. 2006). Although, Spanish male sub-elite players found lesser skinfold thickness (2.02%; z= 0.49, p>0.05) than male players of the present study. Whole body subcutaneous fat percentage specified that the players of the present study assessed significantly lower fat percentage than Sule and More (2020) assessed Indian players (Girls: 21.34%; z= 12.20, p<0.01 and Boys: 27.47%; z= 12.54, p<0.01), Raschka and Schmidt (2013) assessed German players (Girls: 41.12%; z= 31.41, p<0.01 and Boys: 44.18%; z= 26.21, p<0.01), Moses and Duduyemi (2016) examined Ghanaian players (Girls: 29.91%; z= 19.19, p<0.01 and Boys: 56.30%; z= 42.67, p<0.01) and Hoyo et al. (2006) evaluated female Spanish players (12.00%; z= 6.13, p<0.01). However, the players of present study had noticeably higher fat percentage than Nigerian players (Girls: 30.93%; z= 10.63, p<0.01 and Boys: 103.58%; z= 16.85, p<0.01) (Akinbiola et al. 2017) and male Spanish players (23.73%; z= 6.35, p<0.01) (Hoyo et al. 2006).

Nutritional assessment ascertained that the players of present study had remarkably higher macronutrient intake in terms of Carbohydrate (Girls: 255.14%; z= 69.49, p<0.01 and Boys: 295.82%; z= 69.56, p<0.01), Protein (Girls: 79.93%; z= 49.42, p<0.01 and Boys: 81.80%; z= 60.10, p<0.01) and Fat (Girls: 67.21%; z= 43.46, p<0.01 and Boys: 17.84%; z= 18.76, p<0.01) than Estimated Average Requirement (EAR) (ICMR, 2020) of Indian 13-15 years children. Although, comparing the nutrient intake of the badminton players from other countries, except the carbohydrate intake of female players (14.40%; z= 12.18, p<0.01), present study found extraordinary lesser carbohydrate (21.71%; z= 25.80, p<0.01), protein (Girls: 42.96%; z= 83.79, p<0.01 and Boys:

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53.54%; z= 153.93, p<0.01) and fat intake (Girls: 29.70%; z= 45.68, p<0.01 and Boys: 40.72%; z= 85.12, p<0.01) than Japanese national elite players (Watnabe et al. 2006) as well as protein intake (Girls: 66.10%; z= 216.96, p<0.01 and Boys: 64.07%; z= 238.22, p<0.01) of Korean sub-elite players (Lee et al. 2018). Although, despite of higher protein intake, Nutrition Adequacy Ratio (NAR) of Protein for Korean players were lesser (Girls: 45.00%; z= 34.62, p<0.01 and Boys: 47.00%; z= 42.73, p<0.01) than Indian players, signifying that the Dietary Reference intake for Koreans (KDRI) is significantly higher than the Recommended Dietary Allowances (RDA) for India due to diverse food patterns, food habits and different food intake between Indian Subcontinent and Far East Countries.

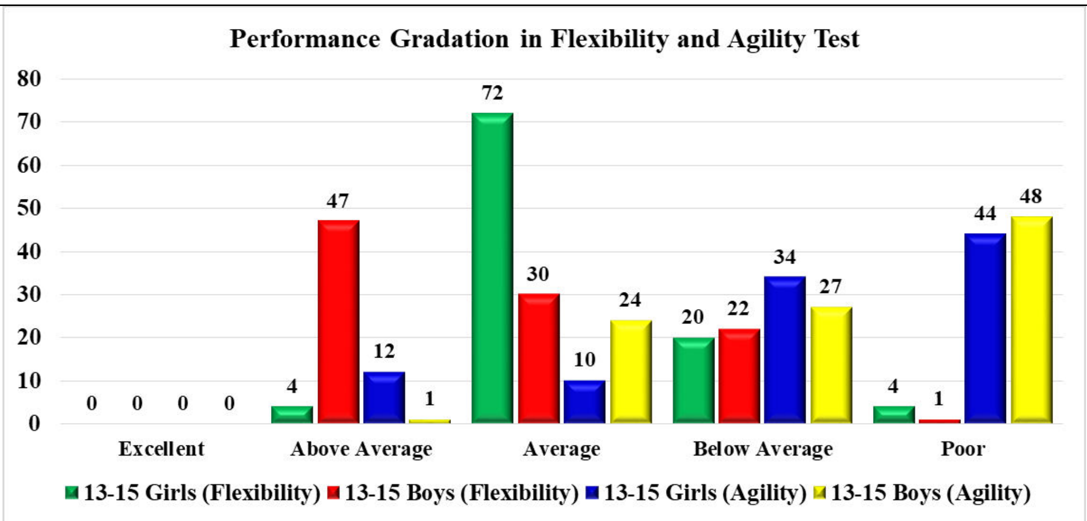

Fig 4 Performance gradation of players in Flexibility and Agility Test

Physical fitness assessment (Fig 4) articulates that in flexibility evaluation, sit and reach test result graded 72% girls in “average” category and 47% boys in “above average” category. No such players performed the flexibility test under “excellent” grade. Although, the male players of the present study touched greater distance than Indian university level male badminton players with (84.80%; z= 3.33, p<0.01; n=15) or without (85.34%; z= 3.34, p<0.01; n=15) eight weeks resistance training as evaluated by Pathak and Aasi (2016). Under agility appraisal, hexagonal obstacle agility test confirmed 44%, 28% girls and 48%, 27% boys performed under “poor” and “below average” categories respectively. 12% girls and only 1% boys performed under “above average” grade. Also, no player was found under “excellent” performance. However, the agility performance of present study was superior (Girls: 19.59%; z= 15.35, p<0.01 and Boys: 30.65%; z= 30.10, p<0.01) to the performance of Hong Kong players (Girls: n=12 and Boys: n=18) evaluated by Towel et al. 2018.

Conclusion

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From the assessed data, it was perceived that players from both the gender were belonged to Class-I Socio-Economic Status. Most of them were professional aspirant players, practicing daily 2-3 hours since >3 years.

Anthropometric assessment depicted significant difference obesity indicators (BMI, WC and WHtR) between present study and Indian standard for both the genders. However, WHR was found to be lesser than Indian standard. Mean BMI of both male and female players were under Normal BMI range as per WHO 2008 with only 54% girls and 44% boys were falling in it. WC, WHR and WHtR were well below the threshold value of Global standards advocating optimum obesity indicators of the players.

Evaluation of body composition ensured that the players of present study had substantial lower ∑ skinfold thickness at 8 fat deposition sites and % body fat (BIA) as compared to few Asian, African and European countries, thus graded "good" skinfold thickness as per ISAK, 2001 and well within the range of ideal %body fat of Athletes as per American Council of Exercise 2009. All these had proven the adequate subcutaneous body fat deposition of the players of present study.

The dietary assessment specified that although the consumption of macronutrient of the players far exceeded the Indian RDA, but well below the intake of Far East badminton playing countries. However, Indian players had better NAR as compare to those countries, evidencing adequate nutrition intake as per Indian climate, ethnicity, food habit as well as physical and physiological demand of Indian players.

In physical fitness test, as per performance gradation, mannish superiority in flexibility and feminine supremacy in agility test was perceived. No players from both the gender performed the tests with excellence. However, the players of the present study showed better results as compared to Indian university level players even after obtaining resistance training as well as players from South-East Asian counties like Hong Kong.

As far as correlation concerned, for girls, apart from WHtR, obesity indicators had well positive correlation with all macro nutrients except weak negative correlation in Fat vs WHR, owing to the higher fat depositional tendency in gluteal-femoral region of the girls due to hormonal changes in body during puberty period. For boys, nutritional intake had no to abstemiously affirmative correlations with obesity indicators except weak negative correlation between Protein vs WHR due to rapid skeletal muscle growth in adolescent ages. In addition, for both the genders, WHtR vs nutrient intake had negative correlation revealed indirect nutritional effect on faster skeletal development in terms of height increment. All these had endorsed the eloquently higher nutritional influence on obesity indicators in female players as compared to male players.

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Furthermore, from momentous inverse relationship between obesity indicators with players' flexibility and agility status, it was also firmly established that the obesity indicators have direct negative impact on fitness level of the players which may effect in their performance.

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