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Effect of Mid Anthropometric Variables and Dietary Fat Intake on Trunk Flexibility among Junior Indian Badminton Players

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Abstract: **Badminton is a fast racket sport, where anthropometric profile and nutritional intake are indispensable factors to maintain sound physique, flexible body and explosive power for successive performance. The present study concerns with impact of player's dietary fat intake & mid anthropometric variables on physical flexibility. A total of 160 badminton players from 10-12 and 13-15 age groups were selected. Specific mid body girths were measured. Trunk skeletal muscle was assessed. ∑torso skinfolds for subcutaneous fat was determined. Dietary fat was calculated by 24 hour's dietary recall method. Physical flexibility was evaluated by trunk rotation test. Statistically the data were verified and correlated. Both the genders exhibited conspicuous increment in body girths with progressive ages. Girls portrayed higher chest & hip circumferences, transverse chest breadth and torso skinfold which owe to substantial fat deposition during puberty period. On the contrary, boys displayed greater waist circumference and bi-iliac breadth. Higher trunk skeletal muscle in boys specified the musculoskeletal preeminence over girls, even though trunk rotation evidenced superior performance of girls over boys. Inverse correlations of trunk rotation with body girths, skinfold and dietary fat signified opposing impact of these parameters on flexibility, although positive correlation between trunk rotation and % trunk muscle advocated its affirmative effect on flexibility.**

Index Terms: **Badminton, Dietary fat intake, Mid body girths, Torso skinfold, Trunk flexibility, Trunk skeletal muscle.**

I. Introduction

Badminton is a racket sport for two or four people with a temporal structure characterized by actions of short duration and high intensity (Bisht et al., 2019). It requires athletes to constantly improve and progress in their physical qualities in order to maintain competitive standards (Rodriguez et al., 2015). Physical characteristics and body composition have been known to be fundamental to excellence in athletic performance (Mathur & Salokun, 1985). Dietary intake influences body composition level which effect players' strength, flexibility and agility. Additionally, skinfold thickness assesses disorders and/or diseases related to malnutrition and obesity (Cicek et al., 2014). So, right from childhood, it is essential to maintain sound anthropometric outline, decent body composition profile and sensible nutrition status for tremendous physical fitness and optimum performance of badminton players.

II. Aim and Objectives

The study concerns delineation of mid body girths (neck, chest, waist and hip regions) in terms of circumferences and breaths, total torso skinfolds from different anterior and posterior trunk specific sites (suprailiac, supraspinale, abdominal & subscapular), determination of trunk muscle mass content, assessment of dietary fat intake and evaluation of trunk specific muscle flexibility. Moreover, the study intended to apprehend the effect of all these variables on physical flexibility.

III. Relevance of Study

Successful sports performance is subjected to upright physique, healthy body composition and proper nutrition. The role of a balanced diet is well recognized for helping to maximize the physical efficiency of bodily function and hence improve the effectiveness of training (Wierniuk & Wlodarek, 2013). Longer-term adaptation to fat-rich diets, on the other hand, may induce skeletal-muscle adaptations, metabolic and/or morphological, which in turn could influence exercise performance (Gens & Helge, 2014). In globally as well as from Indian sports perspective, inadequate studies pertaining to the influences of anthropometric profile and fat specific nutritional

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status on physical flexibility are available. So in this regard, this research work was taken up to evaluate this issue.

IV. Proposed Approach

The instruments and methodology for this research work are given below.

A. Instruments

Non stretchable plastic measuring tape, portable body composition analyzer and skinfold caliper were used for performing the body measurements.

B. Methodology

The procedures of the research work are given below.

1) Selection of Subjects

Young injury free, healthy professional male and female badminton players (n=160) from 10-12 (n=80) years and 13-15 years (n=80) age groups were purposively chosen from reputed badminton academies of Nagpur, Maharashtra, India and considered as sample population for this study.

2) Ethical Clearance

The research study was carried out with the approval of Research and Recognition Committee, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, Maharashtra, India. Earlier permission was taken from subjects and their parents as well as coaches for carrying out assessments for the research. All the measurements and assessments were accomplished with Covid-19 safety protocols.

3) Anthropometric Measurements

Mid body girths specifically circumferences at neck, chest, waist, hip regions and breadths at transverse chest and bi-iliac (between either side pelvic bones) position were measured. The measurements were carried out by using non stretchable plastic tape at nearest 0.1 cm with minimal clothing.

4) Body Composition

In body composition segment, trunk specific skeletal muscle was measured through digital bio electrical impedance analyzer.

5) Dietary Fat Intake

Food records, 24 hour dietary recalls for consecutive three days and dietary history interviews were used to determine players' nutritional intake (Hausswirth & Mujika, 2013). Each and every food consumed in their daily meals was recorded. Nutritive values for dietary fat of players were calculated by using food composition tables (Longvah et al., 2017 and Gopalan et al., 2012) with some commercial food items according to company's declared nutritive values.

6) Physical Flexibility Test

Flexibility, as a component of physical fitness, is the ability of an individual to move the body and its parts through as wide a range of motion as possible without undue strain to the articulations and muscle attachments (Singh et al., 2011). Good flexibility is vital of athletes & trunk rotation test measures trunk flexibility (Nande & Vali, 2010). The subjects were asked to stand with back to the wall, just in front of a drawn vertical line with arms lengths away from the wall, extend arms out parallel to the floor and feet shoulder width apart. Then they twisted their trunk right side and touched the wall with their fingertips. The distance of touching point from central vertical line was noted. Same procedure was followed for trunk twisting to left side also.

7) Statistical Analysis

The collected data (gender and age wise) was specifically compiled and mean, standard deviation, range and percentage were taken out. The results were compared with available references (Katz et al., 2014; ICMR, 1996; Kuriyan et al., 2011; Asayama et al., 1998; Zivicnjak et al., 2008). The assessed parameters were statistically tested by z test and conclusion was drawn on the basis of 5% and 1% significance levels. Correlations were also derived.

V. Results and Discussion

1) Baseline Characteristics

The basic sports details of the assessed subjects informed that overall experienced (10-12 years: 60% and 13-15 years: 87% - >2 years of experience) female players are more in counts than male players (10-12 years: 38% and 13-15 years: 62% - >2 years of experience).

2) Anthropometric Profile

Mid anthropometric girths like neck, chest, waist and hip circumferences and transverse chest and bi-iliac breadths were measured and results are tabulated in table-1.

The mean values of neck (Girls: 27.67±1.98 cm; 30.03±1.84 cm and Boys: 28.22±2.05 cm; 32.23±3.33 cm), chest (Girls: 70.56±8.57 cm; 80.96±5.75 cm and Boys: 67.69±6.53 cm; 80.56±9.20 cm), waist (Girls: 61.11±6.73 cm; 67.04±5.54 cm and Boys: 61.31±6.86 cm; 71.23±10.19 cm) and hip (Girls: 79.33±9.47cm; 90.23±6.58 cm and Boys: 74.81±7.86 cm; 87.97±9.98 cm) circumferences and transverse chest breadth (Girls: 22.60±2.67 cm; 25.47±1.73 cm and Boys: 21.91±1.89 cm; 24.89±2.78 cm) and bi-iliac breadth (Girls: 19.55±2.15 cm; 22.79±1.88 cm and Boys: 20.23±2.26 cm; 23.51±3.36 cm) were recorded among 10-12 years and 13-15 years subjects. The differences in anthropometric measures between older subjects and their younger counterpart at neck (Girls: 2.36 cm; $z=5.52$, $p<0.01$, Boys: 4.01 cm; $z=6.49$, $p<0.01$), chest (Girls: 10.40 cm; $z=6.37$, $p<0.01$, Boys: 12.87 cm; $z=7.21$, $p<0.01$), waist (Girls:

Table-1: Data on Mid Anthropometric Girths of Badminton Players

S. No.	Parameters	Girls (n=80)			Boys (n=80)		
		10-12 yrs (n=40)	13-15 yrs (n=40)	z values #	10-12 yrs (n=40)	13-15 yrs (n=40)	z values #
1	Neck Circumference (cm)						
i	Mean±SD	27.67±1.98	30.03±1.84	5.52**	28.22±2.05	32.23±3.33	6.49**
ii	Range	23.70-32.00	27.00-36.50		25.00-35.00	20.20-38.00	
iii	Standard	28.07	29.77		28.87	32.47	
iv	z values§	1.28	0.89		2.00*	0.46	
v	% Deficit/ Excess	-1.43	0.87		-2.25	-0.74	
2	Chest Circumference (cm)						
i	Mean±SD	70.56±8.57	80.96±5.75	6.37**	67.69±6.53	80.56±9.20	7.21**
ii	Range	58.00-90.00	68.00-96.50		59.00-87.00	61.50-99.00	
iii	Standard	58.93	65.23		59.43	66.17	
iv	z values§	8.58**	17.30**		8.00**	9.89**	
v	%Excess	19.74	24.11		13.90	21.75	
3	Waist Circumference (cm)						
i	Mean±SD	61.11±6.73	67.04±5.54	4.30**	61.31±6.86	71.23±10.19	5.11**
ii	Range	47.00-76.50	55.00-85.00		52.00-80.00	54.50-98.00	
iii	Standard	63.67	70.17		62.53	69.47	
iv	z values§	2.41**	3.57**		1.12	1.09	
v	%Deficit/ Excess	-4.02	-4.46		-1.95	2.53	
4	Hip Circumference (cm)						
i	Mean±SD	79.33±9.47	90.23±6.58	5.98**	74.81±7.86	87.97±9.98	6.55**
ii	Range	64.50-100.50	77.00-105.00		63.00-97.00	65.00-106.00	
iii	Standard	79.90			76.50		
iv	z values§	0.38	9.93**		1.36	7.27**	
v	%Deficit/ Excess	-0.71	12.93		-2.21	14.99	
5	Transverse Chest Breadth (cm)						
i	Mean±SD	22.60±2.67	25.47±1.73	5.71**	21.91±1.89	24.89±2.78	5.61**
ii	Range	18.60-28.90	21.80-30.00		19.40-27.70	19.30-30.80	
iii	Standard	21.81	24.27		21.97	25.25	
iv	z values§	1.87*	4.39**		0.20	0.82	
v	% Excess/ Deficit	3.62	4.94		-0.27	-1.43	
5	Bi-iliac Breadth (cm)						
i	Mean±SD	19.55±2.15	22.79±1.88	7.17**	20.23±2.26	23.51±3.36	5.12**
ii	Range	15.00-24.50	18.70-28.90		17.20-26.40	18.00-32.30	
iii	Standard	23.30	26.39		22.66	25.83	
iv	z values§	11.03**	12.11**		6.80**	4.37**	
v	% Deficit	-16.09	-13.64		-10.72	-8.98	

- z values are for between age group comparisons. § - z values are for comparison between data of subjects & standards. ** - Significant at both 5 % & 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 ($p>0.05$).

5.93 cm; $z=4.30$, $p<0.01$, Boys: 9.92 cm; $z=5.11$, $p<0.01$) and hip (Girls: 10.90 cm; $z=5.98$, $p<0.01$, Boys: 13.16 cm; $z=6.55$, $p<0.01$) circumferences along with transverse chest (Girls: 2.87cm; $z=5.71$, $p<0.01$, Boys: 2.98 cm; $z=5.61$, $p<0.01$) and bi-iliac breadths (Girls: 3.24 cm; $z=7.17$, $p<0.01$, Boys: 3.28 cm; $z=5.12$, $p<0.01$) displayed substantial growth of anthropometric profiles for both the gender with progressive age and proved significant at both 5% and 1% significance level.

In comparisons with reference standards (Katz et al., 2014), younger girls and boys as well as older boys possessed slight deficits of 1.43% ($z=1.28$, $p>0.05$), 2.25% ($z=0.89$, $p>0.05$) and 0.74% ($z=2.00$, $0.05>p>0.01$) in neck circumference except older girls with minor excess value of 0.87% ($z=0.46$, $p>0.05$). Overall, the boys exhibited greater neck circumference (10-12 yrs: 0.55 cm and 13-15 yrs 2.20 cm) than girls. While collecting reference data on Canadian children's neck circumference, Katz, et al. (2014) over large population also established that for all age and sex groups average neck circumference in boys was greater than girls. The chest circumference was found noteworthy increment of 19.74% ($z=8.58$, $p<0.01$), 24.11% ($z=17.30$, $p<0.01$) in girls and 13.90% ($z=8.00$, $p<0.01$), 21.75% ($z=9.89$, $p<0.01$) in boys for both the age groups which were

significant at 5% and 1% significance levels. Overall, the girls depicted greater chest circumference (10-12 yrs: 2.88 cm and 13-15yrs: 0.40 cm) than boys due to augmentation of fat deposition at early adolescent period. Among school going adolescents from Satara district, Maharashtra, Patil, et al. (2018) observed the same trend of greater chest circumference in female than male subjects. Furthermore, Chakrabarty & Bharati (2008) also perceived the similar results among Shabar tribal adolescents of Orissa. Comparable results were also obtained from the transverse chest breadth, where higher breadth (10-12 yrs: 0.69 cm and 13-15 yrs: 0.58 cm) were recorded in girls over boys for both the age groups. Although Zivienjak, et al. (2008) recorded greater transverse chest breadth and lesser bi-iliac breadth in boys than girls among Croatian children and youths of 2-18 years of age. As per gender comparison, there found greater waist circumference of 0.20 cm and 4.19 cm as well as bi-iliac breadth of 0.68cm and 0.72cm among older and younger boys than girls. NCHS (2016) also firmly recognized the superior waist circumferences of boys over girls in anthropometric reference data for children and adults in United States from 2011-2014. Bacopoulou et al. (2015) also delineated the same results among Greek adolescents of 12-17 age. Similar to chest, the girls also showed higher values of hip circumference (10-12 year: 4.52 cm and 13-15 year: 2.26 cm) as compared to boys for both younger and older age group substantiate the propensity of fat deposition in these regions. Asayama, et al. (1998) measured lesser waist circumference in girls and hip circumference in boys of Japanese control group. In comparison with reference (Asayama, 1998), older girls and boys displayed excess mean hip circumference of 12.93% ($z=9.93$, $p<0.01$) and 14.99% ($z=7.27$, $p<0.01$) whereas 0.71% ($z=0.38$, $p>0.05$) and 2.21% ($z=1.36$, $p>0.05$) deficit mean were noted among younger girls and boys. Transverse chest breadth reflected opposing results of 3.62% ($z=1.87$, $0.05>p>0.01$) and 4.94% ($z=4.39$, $p<0.01$) excess mean in boys and 0.27% ($z=0.20$, $p>0.05$) and 1.43% ($z=0.82$, $p>0.05$) deficit mean in girls for younger and older age group as compared with reference standard (Zivicnjak et al., 2008). On the contrary, bi-iliac breadth confirmed significant deficit of 16.09% ($z=11.03$, $p<0.01$), 13.64% ($z=12.11$, $p<0.01$), 10.72% ($z=6.80$, $p<0.01$) and 8.98% ($z=4.37$, $p<0.01$) for all four assessed age group, therefore statistically significant at 5% and 1% level of significant.

3) Skinfold Thickness

Total torso subcutaneous skinfold thickness was measured to determine the fat beneath the skin at suprailiac, supraspinale & abdominal sites at anterior part and subscapular site at posterior part of trunk region. The results are represented in table-2.

Table-2: Data on Trunk Specific Subcutaneous Skinfold Thickness of Badminton Players

S. No.	Parameters	Girls (n=80)			Boys (n=80)		
		10-12 yrs (n=40)	13-15 yrs (n=40)	z values #	10-12 yrs (n=40)	13-15 yrs (n=40)	z values #
1	∑Torso Skinfold Thickness (mm)						
i	Mean±SD	39.73±15.88	47.53±11.56	2.51**	33.85±15.29	41.78±20.48	1.96*
ii	Range	16.00-80.00	24.00-70.00		13.00-73.00	16.00-94.00	

- z values are for between age group comparisons. ** - Significant at both 5 % & 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 ($p>0.05$).

The girls from 10-12 and 13-15 age group had mean value of ∑torso skinfold as 39.73±15.88 mm and 47.53±11.56 mm accordingly. The older group was recorded significantly higher values as compared to younger group (7.80 mm; $z=2.51$, $p<0.01$). Likewise, the older boys (41.78±20.48 mm) also demonstrated remarkable increment (7.93 mm, $z=1.96$, $0.05>p>0.01$) in total torso skinfold as compared to younger one (33.85±15.29 mm).Invariably for both the age groups, the girl exposed higher skinfold thickness (10-12yrs: 5.88 mm and 13-15yrs: 5.75 mm) than boys even though they had higher playing experience as compared to the boys. This attributed the gender specific different morphological changes during pubertal transition period. Cicek, et al. (2014) also recorded akin result of higher skinfold in girls over boys among Turkish children and adolescents of 6-17 age group. Usually the girls enter puberty period earlier with instigation of menstruation along with initiation of rapid fat deposition occurred during this period.

4) Skeletal Muscle Mass

Skeletal muscle mass is the content of muscles, attached to the bones or combination of bone. For this study, trunk specific skeletal muscles mass was analysed in terms of percentage. The collected data is given in table-3.

The younger and older girls exposed mean trunk skeletal muscle mass of 24.00±2.61% and 24.26±2.52% which specified slightly higher skeletal muscle content (0.26%; $z=0.45$, $p>0.05$) in older girls than younger girls. In comparison, the boys with 10-12 and 13-15 age group had mean value of skeletal muscle mass of 26.84±3.67% and 29.73±3.86%, which revealed that the older boys had fairly higher muscle percentage (2.89%; $z=3.43$, $p<0.01$) than younger boys. With continuous practicing over the years, the older one from both the gender gained higher muscle percentage. Despite the higher playing experience similar to boys, the girls for both the age groups (2.84% and 5.47%) showed lesser muscle content than boys as at pubertal transition phase, rapid muscle development took place among boys in comparison with girls. Researchers admitted that the

increment of muscle mass for both the genders with age and the boys composing more muscle mass than the girls (https://www.fitnesss.net/everything-about-muscle-mass percentage-with-charts, 2015).

Table-3: Data on Trunk Skeletal Muscle of Badminton Players

S. No.	Parameters	Girls (n=80)			Boys (n=80)		
		10-12 yrs (n=40)	13-15 yrs (n=40)	z values #	10-12 yrs (n=40)	13-15 yrs (n=40)	z values #
1	Trunk Skeletal Muscle content (%)						
i	Mean±SD	24.00±2.61	24.26±2.52	0.45	26.84±3.67	29.73±3.86	3.43**
ii	Range	19.40-29.50	19.10-30.00		19.10-33.90	22.20-36.30	

- z values are for between age group comparisons. ** - Significant at both 5 % & 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 ($p>0.05$).

5) Dietary Fat Intake

By 24 hours dietary recall method for consecutive three days, average daily dietary fat consumption was recorded, statistically compared with reference standards and data are tabulated in table-4.

Girls from 10-12 years and 13-15 years showed mean fat intake of 54.79±5.12 g/day and 59.00±4.50 g/day whereas boys from 10-12 years and 13-15 years exhibit 55.07±3.91 g/day and 58.75±5.48 g/day. Mean daily intake of fat by the badminton players found remarkably excess fat consumption with 56.54% ($z=24.45$, $p<0.01$) and 57.34% ($z=32.47$, $p<0.01$) in girls and boys of 10-12 yrs and 47.50% ($z=26.71$, $p<0.01$) and 30.56% ($z=15.87$, $p<0.01$) in 13-15 yrs girls and boys as compared with recommended fat intake referred by ICMR, 2010. Due to increase in energy intake, players often exceed the dietary recommendations for fat (Berning, 2015).

It was also observed that in the younger age group, the fat intake of boys was on higher side while in the older age group the girls possessed higher fat intake. Nasreddine, et al. (2020) also assessed the higher fat intake as compared to males among Lebanese adolescents aged 12–19.9 years. Wide range of fat consumption of 43.20-62.74 g/day (girls), 47.23-64.56 g/day (boys) among younger players and 47.09-69.64 g/day (girls), 44.51-71.92 g/day (boys) among older players, could be attributed to differences in daily food habit and choices & variations in the fat quantity.

Table-4: Data on Dietary Fat Intake of Badminton Players

S. No.	Parameters	Girls (n=80)			Boys (n=80)		
		10-12 yrs (n=40)	13-15 yrs (n=40)	z values #	10-12 yrs (n=40)	13-15 yrs (n=40)	z values #
1	Dietary Fat Intake (g/day)						
i	Mean±SD	54.79±5.12	59.00±4.50		55.07±3.91	58.75±5.48	
ii	Range	43.20-62.74	47.09-69.64		47.23-64.56	44.51-71.92	
iii	Standard	35	40	3.91**	35	45	3.46**
iv	z values§	24.45**	26.71**		32.47**	15.87**	
v	% Excess	56.54	47.50		57.34	30.56	

- z values are for between gender group comparisons. § - z values are for comparison between data of subjects & standards. ** - Significant at both 5 % & 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 ($p>0.05$).

6) Physical Fitness

Trunk rotation test was conducted to evaluate the physical fitness in terms of flexibility of badminton players. The flexibility test was performed for twisting both right and left side. Results of the test are presented in table-5 and fig. 1.

By bending trunk to the right side, girls from 10-12 years and 13-15 years reached at the distance of 18.18±3.33 cm and 19.74±3.78 cm whereas twisting to the left side they were able to touch lesser distance of 16.57±3.72 cm and 17.82±3.85 cm. Therefore similar differences of 1.56 cm ($z=1.96$, $0.01<p<0.05$) and 1.25 cm ($z=1.48$, $p>0.05$) were found between two age group for right and left side rotation. Similarly, boys from 10-12 yrs and 13-15 yrs age group bent their trunk to the right side upto 16.97±3.54 cm and 18.67±3.48 cm and slightly lesser to the left side upto 15.39±4.32 cm and 16.87±3.43 cm. Like girls, boys also showed similar differences of 1.70 cm ($z=2.17$, $0.01<p<0.05$) and 1.48 cm ($z=1.70$, $0.01<p<0.05$) among two age group for right and left side. Both younger and older girls twisted their trunk at greater distance of 1.21 cm (Right), 1.18 cm (Left) and 1.07 cm (Right), 0.95 cm (Left) than boys. This may be due to higher technical, tactical, and training experiences of girls over boys. Chatterjee, et al. (2016) also assessed the same trunk flexibility test of trained young table tennis players, resulted superior performance of girls over boys.

Table-5: Data on Trunk Flexibility of Badminton Players

S. No.	Parameters		Girls (n=80)			Boys (n=80)		
			10-12 yrs (n=40)	13-15 yrs (n=40)	z values #	10-12 yrs (n=40)	13-15 yrs (n=40)	z values #
1	Trunk Rotation Test (Right and Left) (cm)							
i	Mean±SD	R	18.18±3.33	19.74±3.78	1.96*	16.97±3.54	18.67±3.48	2.17*
		L	16.57±3.72	17.82±3.85	1.48	15.39±4.32	16.87±3.43	1.70*
ii	Range	R	9.50-24.10	10.50-25.20		7.30-23.20	8.00-25.30	
		L	7.30-21.80	8.70-24.00		6.20-25.30	8.30-22.50	

- z values are for between gender group comparisons. ** - Significant at both 5 % & 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 ($p>0.05$).

Data on percentage wise distribution of players based on their performance for trunk rotation test are displayed in fig. 1.

The distribution demonstrated decent result of male and female subjects' performance as none of the subjects rated under poor category as well as very few subjects and that to younger subjects under fair category. Majority of the older and younger subjects rated either "very good" (Right- Girls: 52.5% and 30%, Boys: 52.5% and 52.5%; Left- Girls: 57.5% and 40%, Boys: 47.5% and 47.5%) or "excellent category" (Right- Girls: 35% and 60%, Boys: 25% and 37.5%; Left- Girls: 20% and 40%, Boys: 15% and 32.5%).

So the uprated gradation of performances had led to recognize player's hard and intense effort in practice over long duration. Unlike the higher muscle content as well as less skinfold fat found among boys, percentage wise the girls for both the age groups graded superior over boys.

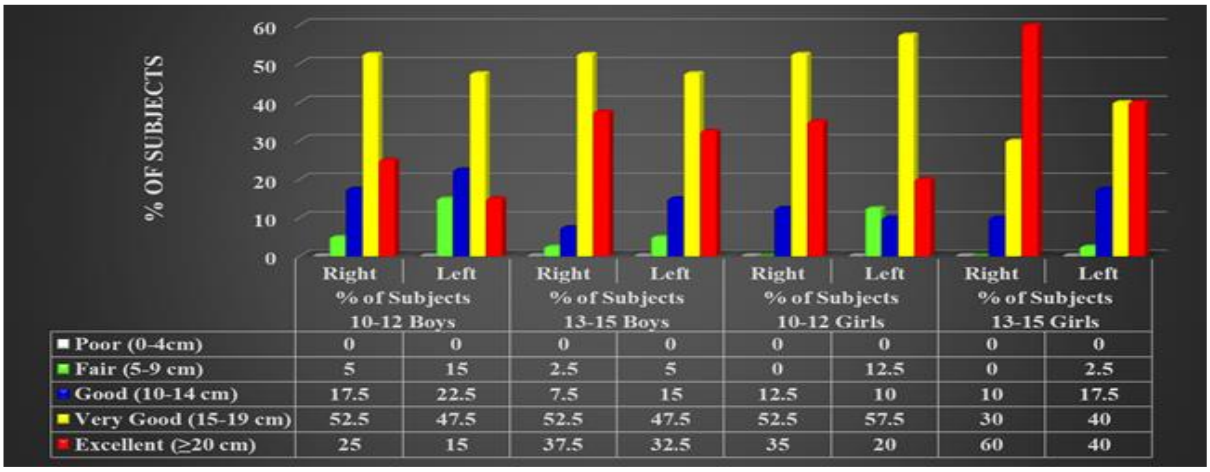

Fig. 1 Trunk Rotation Test (Right and Left) Performance Evaluation of Subjects

7) Correlation Studies

In table-6, all the variables of mid anthropometric profiles of girls and boys for both the age groups signified negative correlations with performance of trunk rotation for right side (r= -0.0599 to -0.6016) and left side (r= -0.1239 to -0.6874) trunk twisting. Likewise inverse relationships (Right: r= -0.4343 to -0.6310 and Left: r= -0.4810 to -0.6898) for all the groups of both genders were also delineated for trunk flexibility with ∑torso skinfold thickness. Additionally considering nutritional status of all the age groups from both the genders, dietary fat intake also found negative correlations with trunk flexibility in terms of trunk rotation test for both the sides (Right: r= -0.0803 to -0.4910 and Left: r= -0.1652 to -0.5480). Solitary positive relation only record between trunk specific skeletal muscle mass and trunk rotation test (Right: r= 0.4067 to 0.5668 and Left: r= 0.2976 to 0.5794) supported the constructive effect of muscle content on flexibility test.

Table-6 Correlation studies of Different Variables with Physical Fitness

S. No.	Parameters		Correlation Coefficient Values (r)			
			Girls (n=80)		Boys (n=80)	
			10-12 yrs (n=40)	13-15 yrs (n=40)	10-12 yrs (n=40)	13-15 yrs (n=40)
I	Correlates of Trunk Flexibility with Mid Anthropometric Profile					
1.	Performance of Trunk Rotation vs. Neck Circumference	R	-0.3992**	-0.1522	-0.3309**	-0.0599
		L	-0.4096**	-0.2212	-0.1723	-0.1239
2.	Performance of Trunk Rotation vs. Chest Circumference	R	-0.5441*	-0.3308**	-0.4187*	-0.2081
		L	-0.6209*	-0.3965**	-0.3498**	-0.3315**
3.	Performance of Trunk Rotation vs. Waist Circumference	R	-0.6016*	-0.4109**	-0.4031**	-0.4402*
		L	-0.6874*	-0.4400*	-0.3785**	-0.4864*
4.	Performance of Trunk Rotation vs. Hip Circumference	R	-0.5426*	-0.4952*	-0.3994**	-0.2985
		L	-0.6657*	-0.5118*	-0.2542	-0.4133**
5.	Performance of Trunk Rotation vs. Transverse Chest Breadth	R	-0.3895**	-0.3519**	-0.4105**	-0.2027
		L	-0.4672*	-0.4194*	-0.3499**	-0.3059
6.	Performance of Trunk Rotation vs. Bi-iliac Breadth	R	-0.6016*	-0.4109**	-0.4031**	-0.4402*
		L	-0.6874*	-0.4400*	-0.3785**	-0.4864*
II	Correlates of Trunk Flexibility with Skinfold Thicknesses					
1	Performance of Trunk Rotation vs. ∑Torso Skinfold Thickness	R	-0.6310*	-0.5776*	-0.4343*	-0.4904*
		L	-0.6898*	-0.5626*	-0.4810*	-0.5685*
III	Correlates of Trunk Flexibility with Nutrition Status					
1.	Performance of Trunk Rotation vs. Dietary Intake	R	-0.3333**	-0.4910*	-0.1286	-0.0803
		L	-0.4779*	-0.5480*	-0.1954	-0.1652
IV	Correlates of Trunk Flexibility with Body Composition					
1.	Performance of Trunk Rotation vs. Skeletal Muscle Content	R	0.5668*	0.4067**	0.4176**	0.4068**
		L	0.5794*	0.5140*	0.5476*	0.2976

*- 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 ($p>0.05$).

CONCLUSION

From the collected data, it was found that invariably for both the genders, all measured parameters increased with progressive ages. Overall boys for both the age groups showed greater neck as well as waist circumferences and bi-iliac breadth than girls. On the contrary, the girls exposed superior chest as well as hip circumferences and transverse chest breadth over boys.

Therefore, gender wise different body morphological changes along with different fat prone sites emerged during pubertal transition. Likewise, higher total torso skinfold thickness among girls over boys, also signified hasty fat deposition in girls at this puberty period. Although higher dietary fat intake of girls compared to boys also catalyzed the fat deposition at susceptible sites of trunk.

From the results of the study, it can be concluded that, despite of positive effects of consistent badminton practice and fitness training, the physical flexibility was highly compromised collectively with mid anthropometric variables, trunk skinfold fat and dietary fat intake, as evidenced from deterioration in trunk rotation test performance with increment of these factors. On the contrary, skeletal muscle mass have optimistic effect on flexibility as the physical flexibility significantly enhanced with collective muscle mass development.

Moreover by this research, it was also established that with technical & tactical knowledge along with durative practicing experience over the years, the fitness result could be enhanced as proven from notable performance of girls. So besides intense practice and exercise, successive performance with sound body flexibility may be improved by maintaining adequate muscle mass, optimum body fat together with healthy dietary intake.

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