



ANTHROPOMETRIC MEASUREMENTS, MACRONUTRIENT INTAKE AND AEROBIC WORK POWER OF GYMNASTS

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ABSTRACT

The study was carried out in the gymnastics clubs from suburbs of Mumbai. Total 400 young gymnasts including females and males from the age groups 10-12 (n=100 for females & 100 for males) & 13-15 yrs (n=100 for females & 100 for males) were purposively selected. The study included assessment of anthropometric parameters, nutritional status & physical fitness of gymnasts. Gymnasts were unable to meet the standards for mean height & weight for age & gender. With the exception of boys from age group 10-12 yrs (+2.87% excess), rests of the three groups of gymnasts showed negative energy balance. Except girls aged 13-15 years, all groups of gymnasts depicted higher intake of dietary protein. On the basis of the mean distance covered in 12 minutes, the performance of girls aged 10-12 yrs, girls aged 13-15 yrs & boys aged 13-15 yrs was rated as “above average” whereas the performance of boys aged 10-12 yrs was assessed as “average”. Gender wise comparison showed that boys possessed significantly better VO₂max than girls.

Keywords: Anthropometric measurements, Energy intake, Protein, VO₂max.

INTRODUCTION

Gymnastics is one of the most comprehensive lifestyle exercise programs available to children incorporating strength, flexibility, speed, balance, coordination, power, and discipline. Whether they are involved in recreational gymnastics or with a competition squad, skills learned in gymnastics can benefit

a child's overall development. Gymnastics helps children build a range of motor and coordination skills, and assists in developing a good sense of body awareness. A young gymnast learns using different parts of his/her body in different ways. Participation in gymnastics develops body awareness, control, and coordination, which can be



beneficial to other physical activities, sports, and in everyday life.

Gymnasts are renowned for their excellent strength-to-weight ratio. Taking part in gymnastics at a young age can help build the foundations of good all-around muscle strength, endurance, and power. According to the International Gymnastics School, gymnasts get stronger through regular training, which aid in the development of lean, toned muscles, improved balance, and better posture (Robertson, S., 2010). A well trained gymnast needs to possess certain body measurements/dimensions.

Anthropometric measurements are important criteria in achieving success in the chosen sports. It is the science of measuring size, shape and proportions of human. Standing height & body weight are the primary indices that are very helpful in assessing success in sports with required physical fitness.

Physical fitness is a state of well-being with low risk of

premature health problems and energy to participate in a variety of physical activities.

Physical fitness is classified into health related (cardiorespiratory i.e. aerobic, muscular strength and endurance, muscular flexibility, and body composition) & skill related (agility, balance, coordination, power, reaction time, and speed) (<http://www.sports-training-adviser.com/definition-of-fitness.html>). Gymnasts have to perform necessary skill on all apparatus. To complete those skills successfully it is very important for a gymnast to be physically fit. Each skill in gymnastics requires technique, precision and grace. A gymnast must possess specific physical fitness components to master required skills. Fitness components gymnast needs to possess are body composition, flexibility, muscular strength, muscular endurance and cardiorespiratory endurance (<http://healthyliving.azcentral.com>).

Gymnastics is an "anaerobic" sport and it requires short, intense



bursts of power. Thus, the goal is to maximize muscle power and strength through gymnastics specific resistance training and repetition. Generally gymnasts are in growing age so their meal plan should fulfil their requirements for both growth and development and to perform well in the sport. Ideally a high carbohydrate, moderate to high protein and normal fat diet is recommended for gymnasts. So, regular practice schedule and growing age should be important factors in meal planning. Small frequent meals which provide steady supply of energy, enhance gymnastic performance, aid recovery & at the same time maintain body weight and are advisable (Betancourt, L., 2011; Holt, B., 2011; Nall, J., 2011; Robertson, S., 2011; Pai Panandiker, D. H., et al., 2007 & Binder, A. J., 2005). Though maintaining a correct balance between power and weight is the challenge for gymnasts; meeting energy needs should be their priority. The best results can be obtained with proper refuelling and

recovery with protein and carbohydrate before and after work practice. The diet should monitored well from time to time by considering training frequency, intensity of training, and duration to keep energy balance (Nutrition and Athletic Performance-Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine 2000 & Binder, A. J., 2005).

Present research is an attempt to assess anthropometric indices, energy intake & aerobic work power of young female & male gymnasts.

METHODOLOGY

Young girls & boys (10-15 yrs of age) who were regularly engaged in the game of gymnasts were purposively chosen from gymnastics training clubs from suburbs of Mumbai. Subjects were engaged in artistic, aerobic, trampoline & general gymnastics. Females involved in rhythmic gymnastics were also selected for the study. Total 400 girls & boys were selected out of which 100



girls & 100 boys were chosen from the age group 10-12 yrs. Similarly, 100 girls & 100 boys were chosen from the age group 13-15 yrs.

A questionnaire-cum-interview schedule was designed for collection of data. Parents and coaches were also contacted for knowing certain information. Gymnasts were directly contacted for collecting the required data.

For most sports body size is an important factor in success, whether it is advantageous to be short, tall, heavy or light (Adhikari, A. et al., 2014; <http://pubs.sciepub.com/ajssm/2/4/1> & <http://www.topendsports.com/testing/anthropometry.htm>). Hence, anthropometric measurements are useful criteria for assessing nutritional status. For the present study, standing height (cm) & body weight (kg) of gymnasts were measured using standard heightometer & platform weighing balance (Nande, P. J. & Vali, S. A., 2010; Hall, J. G. et al., 2007; National Health and Nutrition Examination Survey (NHANES), 2004 & Jelliffe, D. B. et

al., 1989). Recorded measurements of height & weight of female & male gymnasts from age groups 10-12 yrs & 13-15 yrs were compared with reference standards for age & gender [NIN (National Institute of Nutrition)/ICMR (Indian Council of Medical Research), 2009; NIN (National Institute of Nutrition)/ICMR (Indian Council of Medical Research)/NCHS (National Center for Health & Statistics), 2004 & National Nutrition Monitoring Bureau (NNMB), 2002].

Three day's dietary recall method was used to assess macro-nutrient intake of gymnasts. Based on it, nutrient intake of subjects was calculated using food composition tables given by Gopalan, C. et al. (2007). Nutrient adequacy of the diets consumed by gymnasts was tested comparing the actual intake with recommended dietary allowances (RDAs) for age & gender.

Aerobic endurance of gymnasts was evaluated by Cooper's run-walk test. Based on



the results of Cooper's run-walk test, $VO_2\text{max}$ was calculated.

RESULTS & DISCUSSION

Height & Weight

Health and sports are closely linked and physical exercise is as important to the mind as it is to the body. Nutrition and well-being hence assumes vital role in the field of sports. Success in sports is not achieved only by practice but by the nourishment the body gets and the stamina that a sports person has.

Table 1 presents data on height, weight & BMI of subjects.

Height and weight measurements are important to monitor growth. Mean values of height of girls from the age groups 10-12 yrs & 13-15 yrs were recorded as 140.61 ± 7.03 cm & 151.98 ± 7.64 cm, respectively. Mean values of height of boys from the age groups 10-12 yrs & 13-15 yrs were recorded as 140.25 ± 6.77 cm & 157.43 ± 7.31 cm, respectively. In comparison with standard height for age & gender, female & male gymnasts from both the age groups were found to be

shorter. This difference was found to be highly significant at both 5% & 1% levels for all age groups ($z=6.49$ & 5.96 for females & $z=7.46$ & 6.39 for males from age groups 10-12 & 13-15 yrs, respectively, $p < 0.01$). In comparison with standards for age, the percentage deficit for girls from age groups 10-12 yrs & 13-15 yrs was found out to be 3.14% & 2.91%, respectively. For boys, the percentage deficit was calculated as 3.48% & 2.88% for age groups 10-12 yrs & 13-15 yrs, respectively. Being small advantageous in body rotation activities. Being shorter is advantageous to the gymnast in their balancing act. This is because shorter person has lower centre of gravity. The center of gravity is the midpoint of the body, generally one inch below the naval when a gymnast stands with her arms at her side. The lower the center of gravity is to the base of support, the better the balance will be. The base of support is the body parts & apparatus supporting the gymnast's weight (Morris, I., 2014).



Mean values for body weight of girls from age groups 10-12 yrs & 13-15 yrs were recorded as 32.15 ± 6.15 & 39.10 ± 5.82 kg, respectively. Mean values of body weights for 10-12 yrs & 13-15 yrs groups of boys were 36.74 ± 6.55 & 43.72 ± 7.56 kg, respectively (Table 1). Greater individual differences for body weight could be attributed to weight gain pattern which is inherited, dietary food choices, energy intake & energy expenditure pattern. Gymnastics is considered as a sport discipline for light weight category, also gymnasts want to be lighter which they feel is desirable to move & throw their bodies effectively.

Comparison of the actual body weights of gymnasts with standard body weight for age showed that with the exception of boys from age group 10-12 yrs, rests of the groups of gymnasts failed to meet the standards for body weight (Table 1). Loria, K. & Gould, S. (2016) reported that physique, talent, technique & training are important factors in achieving top position in sport.

Body type of Simone Biles, gold medallist of Rio Olympics 2016, is ideal for gymnastics. She is very short. Her height is just 142 cm & weight is 47 kg (104 lb) (Joyner, M. J. 2016).

Energy & Micronutrient Intake

Daily mean energy intake of girls aged 10-12 yrs was in the range of 1493-2435 kcal & the calculated mean was 1932 ± 239.18 kcal (Table 2). This group was unable to meet the RDA for energy (%deficit 3.88, $z=3.26$, $p<0.01$). Minimum daily energy intake by the female gymnasts from the age group 13-15 yrs was 1780 kcal whereas maximum daily intake was 2630 kcal with the mean intake as 2059 ± 213.54 kcal (11.63% lower than RDA, $z=12.69$, $p<0.01$). Mean daily energy intake of boys aged 13-15 yrs was 2418 ± 268.39 kcal & it was lacking by 12.07% in comparison with the RDA ($z=12.37$, $p<0.01$). This may be because of lesser consumption of energy dense foods by gymnasts &/or greater energy expenditure.

Cupisti, A. (2000) aimed to assess the dietary practices of 20



rhythmic gymnasts of the Italian national team, on the basis of a three-day food records collected by clinical interview. The reported energy intake was similar in gymnasts & controls (28.5+/-5.6 vs 28.2+/-7.8 kcal/kg body weight per day), but less than the recommended & the estimated requirements. Ersoy, G. (1991) found that the dietary intake of energy among child gymnasts was found to be inadequate.

Only younger group of boys (10-12 yrs) showed significantly higher daily mean energy intake (2253±258.94 kcal, z=1870-2890 kcal) & the %excess in comparison with RDA was 2.87 (z=2.43, 0.01<p<0.05, Table 2).

The mean daily carbohydrate intake was calculated as 328.97±45.89 g & 350.23±36.61 g for girls aged 10-12 yrs & 13-15, respectively (Table 2) whereas among boys aged 10-12 yrs & 13-15 yrs, it was calculated as 386.45±46.96 g & 419.96±42.93 g, respectively. Older groups of female & male gymnasts showed higher daily mean intake values of

carbohydrate than younger groups of female & male gymnasts, respectively. Michopoulou, E. et al. (2011) in their study on 40 rhythmic gymnasts (females, 10-12 yrs) found out that though gymnasts exhibited higher daily energy expenditure resulting in a daily energy deficit, they also had higher carbohydrate intake.

Mean daily intake of protein by female subjects from both age groups was found to be almost similar with a difference of 1.46 g (z=1.68, p>0.05), however, older age group subjects showed significantly less protein intake in comparison with RDAs for age (%deficit: 3.17, z=3.17, p<0.01, Table 2). In contrast to this, younger girls from age group 10-12 yrs showed significantly higher intake of protein (%excess: 20.27, z=12.72, p<0.01). Mean daily intake of protein by male subjects from both the age groups was exceeding the RDAs for age (%excess: 34.94 & 7.02 & z=11.83 & 3.25, respectively, p<0.01, Table 2). Boys from the group 13-15 yrs showed higher intake of protein



than the boys from the 10-12 yrs group ($z=2.57$, $0.01 < p < 0.05$). Lopez, S. V. et al. (2000) evaluated the nutritional status of a group of 10 young female elite gymnasts aged 13-17 yrs. These gymnasts had a higher calorie intake from dietary protein.

Mean values of daily total fat intake by girls from age groups 10-12 yrs & 13-15 yrs were 46.82 g & 50.90 g/day, respectively. Boys from 10-12 yrs & 13-15 yrs showed daily mean total fat intake of 54.60 ± 8.44 g & 56.24 ± 9.21 g, respectively. Wide range of individual fat consumption was observed (29.90-65.00 g for age group 10-12 yrs of girls; 38.22-68.00 g for age group 13-15 yrs of girls; 33.00-73.00 g for age group 10-12 yrs of boys & 34.00-72.00 g for age group 13-15 yrs of boys, Table 2). Variations in day to day food choices like intake of ghee, butter, fried foods, cheese, paneer, skimmed/fat milk etc. in the diet schedule resulted in difference in fat intake.

It is well known fact that even though height is genetically

inherited, it is nutritionally influenced. For this study, among all four age groups of female & male gymnasts, intake of energy, carbohydrate, protein & fat correlated significantly & positively with height ($r=0.3107$ to 0.6146 , $p < 0.01$), hence, indicating the fact that energy & energy yielding nutrients definitely play role in gaining height.

The higher the intake of energy, heavier was the gymnast, here, energy intake reflected very strong, positive & highly significant correlation ($p < 0.01$) with body weight & BMI among girls aged 10-12 yrs ($r=0.8780$ & 0.7081 , respectively), girls aged 13-15 yrs ($r=0.9191$ & 0.7681 , respectively), boys aged 10-12 yrs ($r=0.8976$ & 0.8380 , respectively) & boys aged 13-15 yrs ($r=0.9151$ & 0.7808 , respectively).

Cooper's Run-Walk Test

Gymnasts are not famous for their running ability. It was observed that mean distance covered in 12 minutes by female gymnasts aged 10-12 yrs & 13-15 yrs was recorded as



1731.69±429.51 meters & 1988.20 ±464.27 meters, respectively. For the age groups of 10-12 yrs & 13-15 yrs of male gymnasts, the mean distance covered in 12 minutes was 1960.00±332.98 meters & 2573.50±413.12 meters, respectively (Table 3).

From Figure 1, it is seen that 39% girls aged 10-12 yrs, 30% girls aged 13-15 yrs, 15% boys aged 10-12 yrs & 33% boys aged 13-15 yrs were found to be “excellent” for the results of 12 minute’s run-walk test. Many gymnasts rated “average” for the performance of this test (Figure 1). Percentage of boys who were rated “above average” was higher (18% & 28% respectively for boys aged 10-12 yrs & 13-15 yrs).

VO₂max

For the present study, on the basis of the results of Cooper’s 12 minute run-walk test, VO₂max of each gymnast was derived (Table 4).

VO₂max is generally considered the best indicator of cardiorespiratory endurance and aerobic fitness. The mean values of

VO₂max were 27.43±9.60 ml/kg/minute for girls aged 10-12 yrs, 33.16±10.38 ml/kg/minute for girls aged 13-15 yrs, 32.53±7.44 ml/kg/minute for boys aged 10-12 yrs & 46.25±9.24 ml/kg/minute for boys aged 13-15 yrs. On the basis of mean VO₂max values, younger girls were assessed with “good” VO₂max whereas older girls were rated with “fair” VO₂max. Among boys, younger group was rated as “fair” & older boys were rated as “good” for their mean VO₂max.

Age group wise comparisons revealed that older female & males were better for their mean VO₂max than younger girls & boys ($z=4.05$ & 11.60 , respectively). Adding body weight is a hindrance in running, with the exception of girls aged 13-15 yrs, among rests of three age groups of gymnasts, VO₂max correlated negatively with body weight ($r= -0.0455$ to -0.2074). Among girls & boys aged 10-12 yrs, VO₂max correlated negatively with fat intake ($r= -0.3340$ & -0.2649 , $p<0.01$, respectively). With the exception of girls aged 10-12



yrs, among rests of the groups of gymnasts VO_2max correlated negatively with energy intake ($r= -0.0371$ to -0.1968), whereas among both groups of female gymnasts VO_2max correlated positively with intake of carbohydrate ($r=0.0191$ & 0.1829 for 10-12 yrs & 13-15 yrs, respectively, $p>0.05$), in contrast to this, among both groups of male gymnasts VO_2max correlated negatively with intake of carbohydrate ($r= -0.1090$ & -0.0958 , for 10-12 yrs & 13-15 yrs, respectively, , $p>0.05$). Among all four groups of gymnasts, VO_2max depicted direct relationship with protein intake ($r=0.0116$ to 0.2576).

It is seen from Figure 2 that 32% girls aged 10-12 yrs, 20% girls aged 13-15 yrs, 8% boys aged 10-12 yrs & 24% boys aged 13-15 yrs were considered “superior” for their VO_2max . 2% girls aged 10-12 yrs, 5% girls aged 13-15 yrs, 7%

boys aged 10-12 yrs & 14% boys aged 13-15 yrs were considered “excellent” for their VO_2max .

The results clearly show the need of adequate consumption of energy along with carbohydrates & protein for the better aerobic work capacity among these young gymnasts who are in need of better nutrition for growth & development as well as for the training & performance. Gymnastics requires speed, power, and coordination. It is particularly important that young gymnasts must consume sufficient energy and macro-nutrients to meet the demands of growth, training, competition, and body tissue maintenance. Education and counselling regarding factors associated with optimal nutrition and body composition should be provided to gymnasts, their parents, coaches, team managers and health personnel.

**Table 1: Data on Height & Weight of Subjects**

Sr. No.	PARAMETERS	G I R L S (N=200)			B O Y S (N=200)		
		10-12 Yrs (n=100)	13-15 Yrs (n=100)	z Values#	10-12 Yrs (n=100)	13-15 Yrs (n=100)	z Values#
1	HEIGHT (cm)						
i	M±SD	140.61±7.03	151.98±7.64	11.0*	140.25±6.77	157.43±7.31	17.2*
ii	Range	130.00-157.00	137.00-164.00		129.00-161.00	146.00-174.00	
iii	Standard	145.17	156.53		145.30	162.10	
iv	z Values§	6.49*	5.96*		7.46*	6.39*	
v	%Deficit	-3.14	-2.91		-3.48	-2.88	
2	WEIGHT (kg)						
i	M±SD	32.15±6.15	39.10±5.82	8.21*	36.74±6.55	43.72±7.56	6.98*
ii	Range	24.00-56.00	32.00-52.60		25.00-52.00	35.00-64.00	
iii	Standard	35.0	46.63		34.30	47.60	
iv	z Values§	4.63*	12.9*		3.73*	5.13*	
v	%Excess/Deficit	-8.14	-16.15		+7.11	-8.15	

- z values are for between group comparison; § - z values are for comparison between data of subjects & standards; * - 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).

Table 2: Data on Daily Intake of Energy & Energy Giving Nutrients By Subjects

Sr. No.	PARAMETERS	G I R L S (N=200)			B O Y S (N=200)		
		10-12 Yrs (n=100)	13-15 Yrs (n=100)	z Values#	10-12 Yrs (n=100)	13-15 Yrs (n=100)	z Values#
1	ENERGY (kcal)						
i	M±SD	1932±239.18	2059±213.54	3.96*	2253±258.94	2418±268.39	4.42*
ii	Range	1493-2435	1780-2630		1870-2890	2022-2879	
iii	Standard	2010	2330		2190	2750	
iv	z Values§	3.26*	12.69*		2.43**	12.37*	
v	%Excess/Deficit	-3.88	-11.63		+2.87	-12.07	
2	CARBOHYDRATE (g)						
i	M±SD	328.97±45.89	350.23±36.61		386.45±46.96	419.96±42.93	
ii	Range	235.70-414.75	303.40-439.50		308.53-498.00	346.09-485.50	
3	PROTEIN (g)						
i	M±SD	48.59±6.44	50.05±5.83	1.68	53.84±11.78	58.11±11.72	2.57**
ii	Range	35.78-75.00	42.99-65.00		36.53-78.00	43.30-78.00	
iii	Standard	40.4	51.9		39.9	54.3	
iv	z Values§	12.72*	3.17*		11.83*	3.25*	
v	%Excess/Deficit	+20.27	-3.56		+34.94	+7.02	
4	FAT (g)						
i	M±SD	46.82±8.65	50.90±9.45		54.60±8.44	56.24±9.21	
ii	Range	29.90-65.00	38.22-68.00		33.00-73.00	34.00-72.00	

- z values are for between group comparison; § - z values are for comparison between data of subjects & standards; * - 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).



Table 3: Data for Cooper’s 12 Minute’s Run-Walk Test for Subjects

Sr. No.	SUBJECTS	PARAMETERS	Distance Covered in 12 Minutes (Meters)		z Values#
			Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	
1	G I R L S	Mean±SD	1731.69±429.51	1988.20±464.27	4.06*
		Range	1000-3000	1390-3000	
		Performance Rating	Above Average	Above Average	
2	B O Y S	Mean±SD	1960.00±332.98	2573.50±413.12	11.60*
		Range	1210-3000	1800-3200	
		Performance Rating	Average	Above Average	
z Values■			4.20*	9.42*	-

- z values are for between group comparison; ■ - z values are for between gender comparison; * - 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).

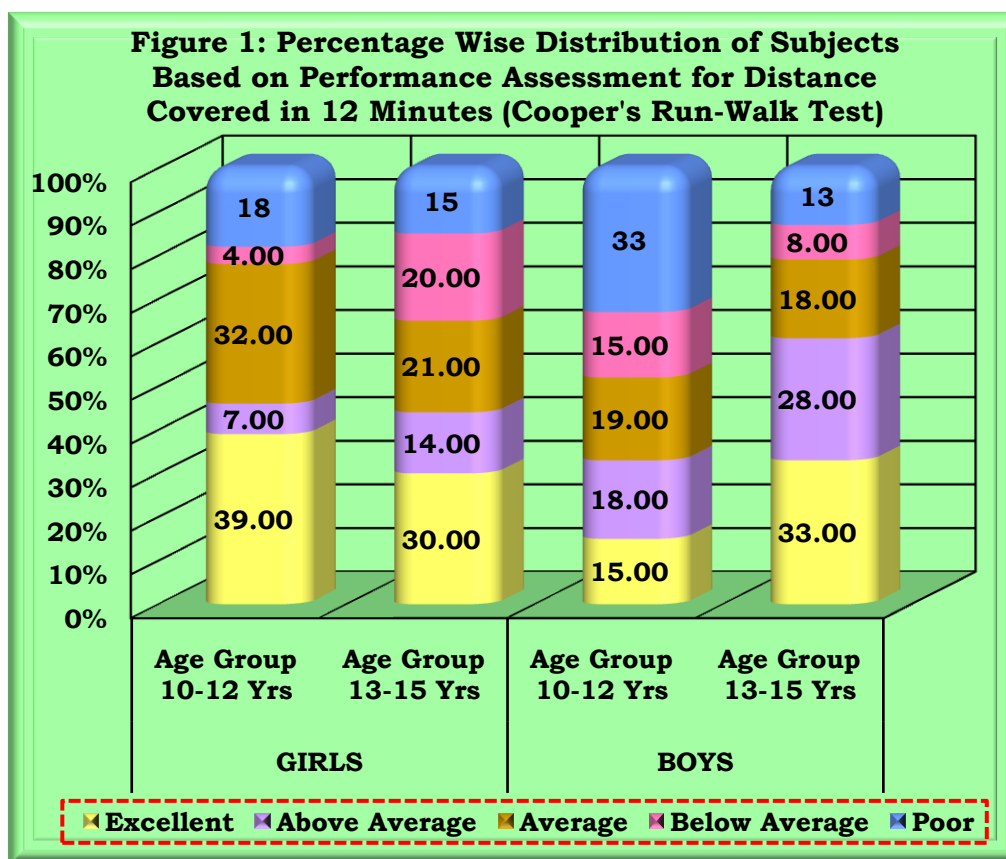
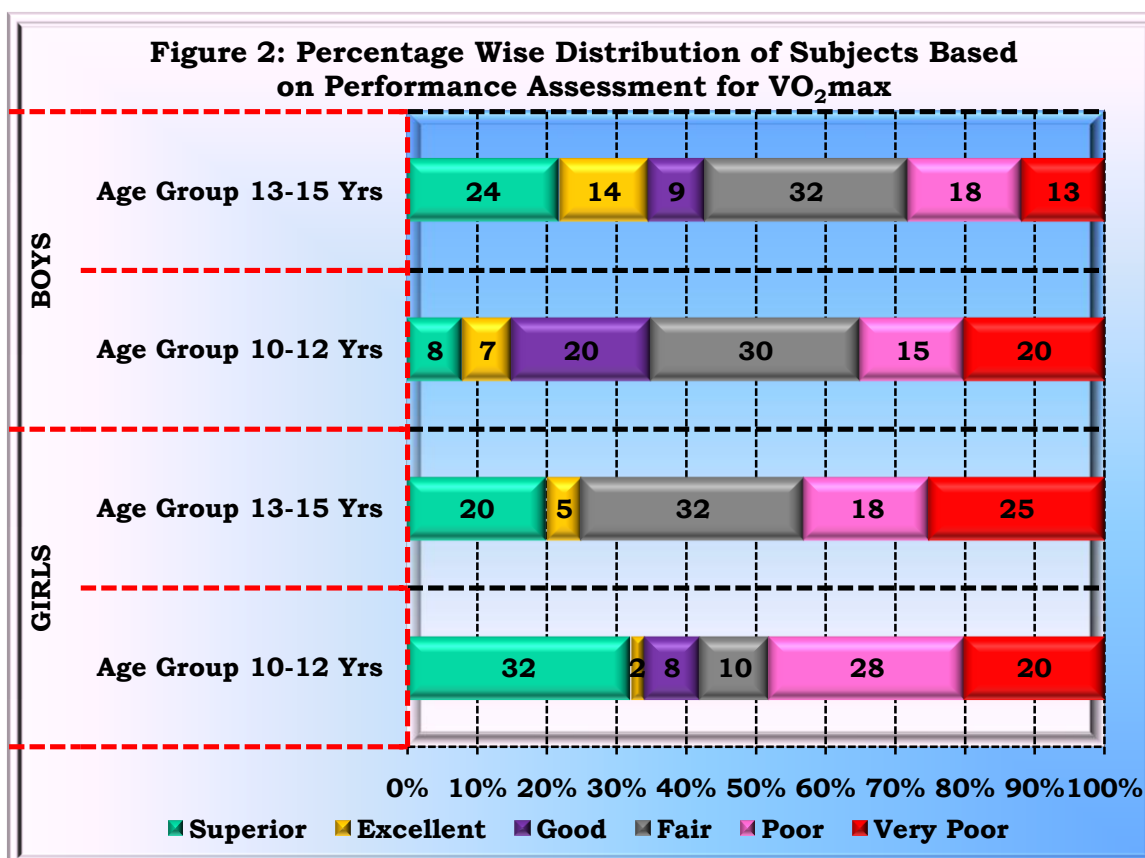




Table 4: Data for VO₂max for Subjects

Sr. No.	SUBJECTS	PARAMETERS	VO ₂ max (ml/kg/minute)		z Values#
			Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	
1	G I R L S	Mean±SD	27.43±9.60	33.16±10.38	4.05*
		Range	11.07-55.78	19.79-55.78	
		Performance Rating	Good	Fair	
2	B O Y S	Mean±SD	32.53±7.44	46.25±9.24	11.6*
		Range	15.76-55.78	28.95-60.25	
		Performance Rating	Fair	Good	
z Values■			4.20*	9.42*	

- z values are for between group comparison; ■ - z values are for between gender comparison; * - 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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