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Normative Data of $VO_{2\ max}$ Using 20 Meter Shuttle Run Test in Normal Healthy Urban Children Between the Age Group of 7 to 19 Years

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Abstract:- VO2 max is gold standard for measurement of cardio respiratory fitness(CRF). Study was done as normative data is lacking of VO2 max for Indian children which can serve as a reference range & will help in exercise prescription. Normal & healthy subjects of 7 to 19 years of both genders, from urban set up, understanding simple verbal commands were chosen by stratified random sampling from schools and junior colleges. 20 meter shuttle run test (20mSRT) was carried out on playground as per Leger's protocol. VO2 max was assessed with by Barnett's equation(b). 494 subjects showed Mean preadolescent VO2 max was 49.21±2.67ml/kg/min for boys and 44.25±2.28 ml/kg/min for girls girls age group. Mean adolescent VO2 max was 47.19±3.75 ml/kg/min for boys and 40.03±3.04 ml/kg/min for girls.

Thus styudy concludes:Mean VO2 max was more in pre adolescents than in adolescents and in boys than girls.

Keywords:- *VO2 max , Children, 20mSRT*

I. INTRODUCTION

Physical fitness is defined as a set of physical attributes that people have or achieve that relates to the ability to perform physical activity [1].

Being physically fit has been defined as "The ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies [2].

Characteristics of physical fitness are usually segregated into :A. Health Related Components that comprise of Cardio respiratory fitness (CRF) ,Body composition, Muscular strength, Muscular endurance & Flexibility

B. Skill-Related Physical Components that are Agility, Coordination, Balance, Power, Reaction time & Speed [3].

Cardio respiratory fitness (CRF) is the ability of the circulatory and respiratory system to supply oxygen during sustained dynamic activity using large muscle groups. It is important marker of both functioning ability and cardiovascular health [2].

Rowland (2001), stated that while the clinical outcomes of atherosclerotic vascular disease appear in adult years, process of atherosclerosis is lifelong one with origins in paediatric years. These findings support the existence of an association between cardio respiratory fitness and health-related outcomes in young people, and highlight the importance to include cardio respiratory fitness tests in monitoring systems from early ages [4]. High-cardio respiratory fitness during childhood and adolescence has been associated with a favourable plasma lipid profile in both overweight and non-overweight adolescents with total and central body fat, features of the metabolic syndrome, blood pressure, novel cardiovascular disease risk factors, and with arterial compliance in young people says: **David P Swain (2012)** [5]. Findings from prospective cohort studies have suggested that a low cardio respiratory fitness during childhood and adolescence is associated with later cardiovascular risk factors such as hyper lipidaemia hypertension and obesity. **J. Castero-Pineiro (2011**) found out that there is evidence indicating that the level of cardio respiratory fitness during childhood and adolescence is moderately associated with the level of fitness in adulthood [6].

As stated by **Benson et al (2006)**, high cardio respiratory fitness and muscular strength independently reduce risk of metabolic syndrome in adults, just as they do risk of cardiovascular and total mortality [7]. CRF is one of the main health-related physical fitness components used in schools, sports centres and health institutions [8].

Aerobic fitness also known as CRF refers to the ability to provide the required energy for a specific task in which the cardio respiratory system adequately supplies the needed oxygen to the working muscle cells. Aerobic activities consist of repetitive, low-resistance movements (e.g., walking or cycling) that last over a relatively

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extended period of time (generally 5 minutes or more). Most of the energy for such activities is derived from the catabolism of intracellular and adipose tissue–released free fatty acids**: Jonatan R. Ruiz et al (2008)** [9].

Ishan k. Desai et al (2015), stated that the benefits of aerobic fitness may extend beyond overall health and wellbeing. In his small but growing body of research has observed that physical fitness is positively associated with academic achievement in school-aged children and youth [10]. In addition, recent reports suggest that cardio respiratory fitness is also an important health marker in young individuals. Therefore, it becomes important to include paediatric cardiorespiratory fitness testing into consideration as an individual's strength of an aerobic system.

➢ *Measurement of cardio respiratory fitness:*

Aerobic fitness, best measured by $VO_{2\ max}$, is a measure of oxygen transport and utilization [8]. $VO_{2\ max}$ can be defined as the highest rate at which oxygen is taken up and utilized by the body during severe exercises. It is also known as maximal oxygen uptake, maximal aerobic power, and aerobic capacity[9]. **Neil Armstrong et al (2000),** states that $VO_{2\ max}$ is a function of cardiac output and arteriovenous oxygen difference [11]. An absolute value measured in litres per minute (L/min). A relative value accounts for body mass in millilitres per kilograms of body weight per minute (ml/kg/min).

➢ *Assessment of $VO_{2\ max}$*

$VO_{2\ max}$ is usually determined by a graded exercise test1.Variety of exercise tests that active body's large muscle group can determine $VO_{2\ max}$, provided exercise intensity and duration maximize aerobic energy transfer. The $VO_{2\ max}$ tests may require single, continuous 3 to 5 minutes supra-maximal efforts. In most case, the test usually consists of progressive increments in efforts (graded exercise) until the subjects simply refuses to continue exercise that is up to level of exhaustion [8]. The "true" maximum aerobic capacity is assessed in laboratories by open circuit spirometry1.

The direct measurement of $VO_{2\ max}$ require an extensive laboratory, specialized equipment, and considerable subject's physical effort and motivation. Hence, laboratory tests remain impractical to assess large group of untrained subjects [1].

➢ *Field tests for assessment of $VO_{2\ max}$:*

In current times due to problems associated with the direct VO2 max testing, indirect measurement of $VO_{2\ max}$ in the form of field tests have become more popular. Field tests offer many benefits over other forms of laboratory testing in that, they are easy to administer, inexpensive and can be performed whenever a measured distance is available.

These tests are validated by examining either the Correlation between directly measured $VO_{2\ max}$ and estimated from physiological responses to sub maximal exercises Or The correlation between directly measured $VO_{2\ max}$ and test performance using standard graded protocol [3].

In field test $VO_{2\ max}$ can be determined by portable gas analyzer or prediction formulae based on various parameters like age, gender, BMI, height, weight, or simply distance covered or time taken for completion of the test[1].

Field tests avails more specific exercise testing according to physical activity that is more done by subjects. For example in children, running is mostly done activity , so any field test that requires running as a part of testing can be the choice of test to measure $VO_{2\ max}$ [5]. Out of all field tests, 20 Meter Shuttle Run (20m SRT) Test is most commonly used field test in children. **Daniel et al in 2015** concluded that the 20m SRT has a moderate-to-high mean criterion-related validity for estimating cardio respiratory fitness [12]. When the performance score is combined with other variables the criterion-related validity of 20m SRT increases considerably in children.

❖ *Need of the Study*

Having normative data for $VO_{2\ max}$ may help us to know the existing level of fitness in Indian paediatric population. It may also help designing specific protocol for aerobic training for paediatric age group. Hence, this study was undertaken to collect and form normative data of $VO_{2\ max}$ using 20 Meter Shuttle Run Test.

II. AIM OF THE STUDY

To estimate normal $VO_{2\ max}$ in normal healthy urban children using 20 Meter Shuttle Run Test.

III. MATERIALS AND METHODS

The study was Observational cross-sectional study performed on 494 Normal healthy students from aged between 7 to 19 years of both genders, belonging to urban schools and colleges. who can understand and respond to simple verbal commands, selected by stratified random sampling? Study was carried out at School/college playground for about 18 months. Subjects answering "yes" to any question given in Physical Activity Questionnaire Plus (PAR-Q+.) and/or suffering from any cardiovascular and respiratory disease, neurological and musculoskeletal impairment that hamper running, or having abnormal vitals before the test ,or those who are unwilling to participate in the study, were excluded from the study

ISSN No:-2456-2165

Fig 1:- Material needed for the study

IV. METHOLOGY

After approval of study design by guide, college principal and institutional ethical committee and after the approval from MUHS, study was started. After taking respective principal's permission for conducting the research, healthy urban school children, and college students were selected primarily, for the study. Subjects were screened for physical activity readiness with the help of Physical Activity Readiness Questionnaire – Plus (PAR-Q) (Annexure: 4), which is a modified version of original PAR-Q and applicable to every age group [13].

Included students were asked to give their assent for the study on "subject's assent form" get parental consent on the given "Parental consent form" failing to which subjects were excluded from the study. Subject's demographic data, resting vitals and anthropometric evaluation followed next.

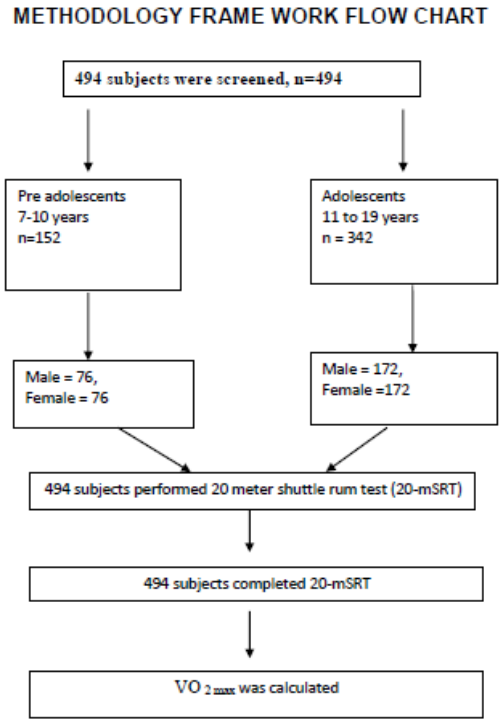

Fig 1:- Methodology flow chart

➢ *20 meter shuttle run test procedure.*

Test was been carried on the play or sports ground of respective school and colleges.The subjects performed the test as previously described by Léger et al. Subjects were instructed to run between distance of 20m marked by colourful cones, while keeping pace with audio signals emitted by audio player from speakers . The initial speed was 8.o km/h, and was increased by 0.5 km/h per minute (one minute equals one stage). The test was terminated when the participant failed to reach the end lines concurrent with the audio signals on two consecutive occasions, or when the subject stopped because of fatigue. The level at which the test was terminated was noted. However, subjects were encouraged to keep running as long as possible throughout the course of the test[9].. Speed of the test was calculated by the chart showing stagewise speed. [14].

$VO_{2\ max}$ was then calculated using Barnett's equation which is mentioned below.

$VO_{2\ max} = 24.2 – 5.0 *G –0.8*A+3.4*S$

Where, G= gender, Male= 0 & Female = 1;A= Age

S= speed of the stage[15].

Fig 3:- subject performing 20 meter Shuttle Run Test

V. DATA ANALYSIS

All the data was analysed using SPSS 20 version for windows.Mean and standard deviation was calculated for all the outcome measure.Estimation of normal values of $VO_{2\ max}$ of children from 7 to 19 years of age was done using descriptive statistics that is measure of central tendency.

Data did not pass normality test, therefore, Spearman's correlation was used to correlate Age with $VO_{2\ max}$.

Chi square test was used to associate Age groups, Gender, Mann Whitney U (Wilcoxon Rank Sum Test) was used to compare $VO_{2\ max}$ .between the Genders and between Pre-Adolescent and Adolescent Age group.

VI. RESULTS

Total 494 subjects were included in the study out of which they were primarily devided according to 2 strata having equal no. of boys =247 (50%) and girls=247 (50%) another strata was made of pre adolescents=152 (30%) and adolescents = 342 .(70%) as shown in Table 1.

Mean $VO_{2\ max}$ in The Pre Adolescent group was: 49.2±2.67 ml/kg /min for boys and 44.3± 3.75 ml/kg/min in girls and for Adolescents age group it was : 47.2 ±2.29 ml/kg/min in boys and 40.0± 3.05 in females, as shown in table 1; figure 4.

As per Figure 5, Age showed significant negative correlation with $VO_{2\ max}$, which suggests that $VO_{2\ max}$ decreases with increasing age Referring to Table 2 and figure 6 ,There was significant association found between $VO_{2\ max}$ and gender. Girls showed Maximum number of subjects having $VO_{2\ max}$ in category "Superior" compared to boys who showed maximum number of subjects having $VO_{2\ max}$ in category "Good".

Parameters	Strata	BOYS			GIRLS		
		N	Mean	SD	N	Mean	SD
Age	Preadolescent	76	8.50	1.13	76	8.50	1.13
	Adolescent	171	15.00	2.59	171	15.00	2.59
$VO_{2\ max}$	Preadolescent	76	49.21	2.67	76	44.25	2.28
	Adolescent	171	47.19	3.75	171	40.03	3.04

Table 1:- Mean value of $VO_{2\ max}$ for gender and age group

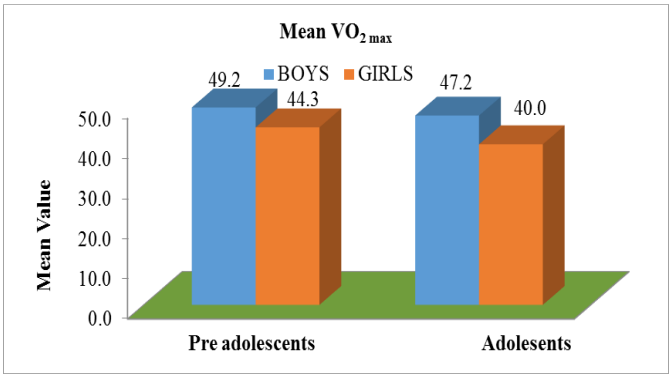

Fig 4:- Graph showing Mean $VO_{2\ max}$

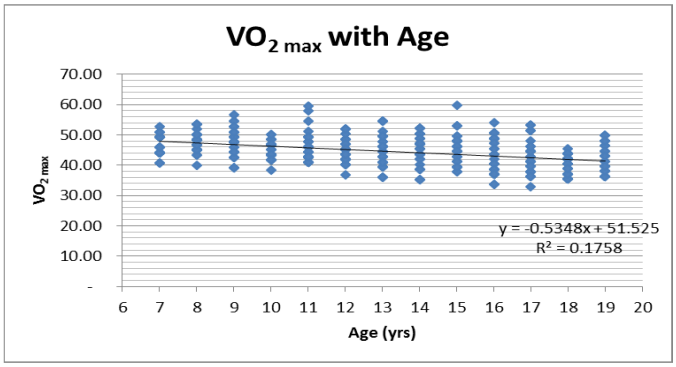

Fig 5:- Graph showing correlation of $VO_{2\ max}$ with Age

Variables	Sex				Chi square test	-value
VO2 max	Boys	%	Girls	%		
Very Poor	0	0	0	0	191.184	<0.001
Poor	3	1.2	0	0.0		
Fair	51	20.6	3	1.2		
Good	153	61.9	64	25.9		
Excellent	36	14.6	71	28.7		
Superior	4	1.6	109	44.1		
Total	247	100.0	247	100.0		

Table 2:- Association of $VO_{2\ max}$ with Gender

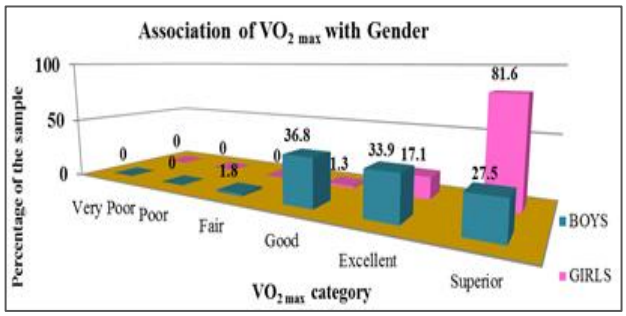

Fig 6:- Graph showing association of $VO_{2\ max}$ with Gnder

VII. DISCUSSION

As per the Aim of the study, the mean value of $VO_{2\ max}$ in pre-adolescent age group mean $VO_{2\ max}$ was found to be 46.73 ± 3.52 ml/kg/min ranging from 38.4 ml/kg/min to 56.61 ml/kg/min and in adolescent age group mean $VO_{2\ max}$ was 43.61± 4.95 ml/kg/min ranging from 32.8 to 59.8 ml/kg/min **(Table 1;Figure 4)**. $VO_{2\ max}$ was found to be significantly higher in pre adolescents than adolescents when compared between 2 **groups** $VO_{2\ max}$ had shown significant negative correlation with the age suggesting that, as the age increases $VO_{2\ max}$ decreases **(Figure 5).**

The reason for preadolescents showing more cardiorespiratory fitness may be because preadolescents have high resting Heart rate. The resting heart rate declines very slowly during pre pubertal and pubertal years than post pubertal years. It is known that maximal heart rate (HR_{max}) is age dependant therefore preadolescents have more HR_{max} than adolescents. Resting $VO_{2\ max}$ is high in children which may directly correlate with heart rate. Preadolescent children have diminished thermoregulatory control under extremes of physical exercise compared to older youths or young men. Because of this they can sustain the temperature changes occurring during exercises and persist with the physical activity even in hot or cold climate.

Children have flexible muscles which allow them to continue physical activity without any sence of tiredness or discomfort. Skeletal muscle blood flow increases from 15% to as high as 80% of the cardiac output during heavy exercise [16]. The increase in skeletal muscle flow comes from reduction of local vascular resistance. Humoral vasodilator mechanisms and neurogenic dilatation can be responsible for this. Increased sympathetic tone with exercise presumably creates constriction in other vascular beds to cause redistribution of flow to the muscle. Also, children have low anaerobic capacity which can be because of diminished glycolytic enzymes in children. On this basis, it can be assumed that pre adolecsents can tolerate endurance type of exercise rather than short burst high energy events [17].

$VO_{2\ max}$ was found to be significantly more in boys than in girls **(figure 4; Table 2;Figure 6).** Most of the boys had $VO_{2\ max}$ in category 'GOOD' according to Heywords classification of $VO_{2\ max}$[41] and had $VO_{2\ max}$ between 45.2 - 50.9 ml/kg/min. Where as most of the girls had $VO_{2\ max}$ in 'SUPERIOR' category according to Heywords classification of $VO_{2\ max}$ [18]. but had $VO_{2\ max}$ only >41.9 ml/kg/min. $VO_{2\ max}$ showed a decline in the adolescent age group for both boys and girls.

It is known fact that post pubertal girls have less $VO_{2\ max}$ than pre pubertal girls can be due to change in body composition in girls at puberty with more fat and less lean body mass . Boys on the other hand, have an increase in muscles mass after puberty which could account for the increase in $VO_{2\ max}$ [19]. Over the age range 8-16 years, boys' values increase by about 150% and girls' by about 80% :The statement by neil Armstrong corroborating findings of present study

M. A. Jones et al(2000) beleives that sexual maturity has a significant independent role in proving inequal levels of VO2 max Since the increase in testosterone production in adolescent children is markedly higher in boys than girls, boys become stronger faster and to a higher degree In general, boys develop greater strength and thus surpass girls in the performance of most sport-related skills. Early maturing girls undergo a socialization process which does not motivate them any more to excel in physical exercise. On the other hand, late-maturing girls tend to be socialized into sports participation.During adolescence; males show a steady increase in performance and endurance that extends into early adulthood. There are dissimilarities among the girls [20].

Gender differences can also be present due to physical activity level differences that exist between boys and girls after puberty. **Telema et al(2005)**in their 20 years physical fitness tracking study observed clear gender difference between fitness levels [21].

VIII. CONCLUSION

From the present study we conclude that urban children of 7 to 19 years show declining pattern of $VO_{2\ max}$ values with the advancing age. Mean $VO_{2\ max}$ was found to be more in pre adolescents than in adolescents. Also, boys show higher $VO_{2\ max}$ than girls at any stage of the age.

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