

# Normative Data of VO<sub>2</sub> max Using 20m Shuttle Run Test in Amateur Female Cricket Players Between Age Group of 18 to 25 Years

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**ABSTRACT****BACKGROUND:**

Physical fitness refers to a set of attributes that influence an individual's ability to perform physical activity. Aerobic fitness, an important component of physical fitness, reflects the body's ability to transport and utilize oxygen during exercise and is commonly measured using  $VO_2$  max.  $VO_2$  max represents the maximum rate at which oxygen can be consumed and utilized by the body during intense physical activity and is also known as maximal aerobic capacity or maximal oxygen uptake.

Physical fitness can also be defined as the ability to perform daily tasks with vigor and alertness, without undue fatigue, and with sufficient energy to enjoy leisure activities and respond to emergencies. Evidence suggests that cardiovascular diseases such as atherosclerosis begin developing early in life, although their clinical manifestations appear in adulthood. Studies have shown a strong association between cardiorespiratory fitness and health outcomes in youth, highlighting the importance of monitoring aerobic fitness from an early age.

Cardiorespiratory fitness is best assessed through aerobic capacity, most accurately measured by  $VO_2$  max. Laboratory methods are considered the gold standard but are often expensive and require specialized equipment. Therefore, field-based tests are widely used as practical alternatives. Field tests provide exercise assessment based on activities that individuals commonly perform. Since running is a frequently performed activity, running-based field tests are appropriate for estimating aerobic capacity.

Among the various field tests, the 20 Meter Shuttle Run Test (20m SRT) is one of the most commonly used methods to estimate  $VO_2$  max. It is simple, cost-effective, and reliable for evaluating cardiorespiratory fitness in athletes and active individuals. Establishing normative  $VO_2$  max values can help in assessing the current fitness levels of specific populations and assist in designing targeted aerobic training programs.

**OBJECTIVE:**

To estimate normative  $VO_2$  max values in amateur female cricket players aged 18–25 years using the 20 Meter Shuttle Run Test.

**METHODOLOGY:**

This observational cross-sectional study was conducted over six months after approval from the Institutional Ethics Committee. A total of 40 amateur female cricket players aged 18–25 years were recruited according to the selection criteria after obtaining informed consent. Participants performed the 20 m shuttle run test to estimate their  $VO_2$  max.

Individuals with cardiovascular or respiratory diseases, neurological or musculoskeletal impairments affecting running, abnormal vital signs before testing, or those unwilling to participate were excluded from the study.

**RESULT:**

The normative  $VO_2$  max values obtained for the 40 participants ranged from 32.03 to 49.78 ml/kg/min.  $VO_2$  max showed a statistically significant association with age and BMI ( $p < 0.05$ ).

**CONCLUSION:**

The study included 40 amateur female cricket players with a mean age of  $20.5 \pm 2.14$  years and a mean BMI of  $22.6 \pm 3.9$  kg/m<sup>2</sup>. A significant association was found between  $VO_2$  max, age, and BMI. The findings indicate that  $VO_2$  max tends to decrease with increasing age and BMI.

**INTRODUCTION**

Cricket is one of the most popular team sports played worldwide and demands a high level of physical conditioning from players. During the competitive season, elite male and female cricket players engage in daily training sessions and participate in frequent matches, including international tournaments such as the ICC Champions Trophy, T20 World Cup, Ashes Series, Champions League Twenty20, and ICC Cricket

World Cup. The demanding schedule of training and competition requires well-developed physical, physiological, and mental characteristics to sustain performance throughout the season [16,17].

Physical fitness refers to the ability of an individual to perform daily tasks efficiently with Vigor and alertness, without excessive fatigue, while maintaining sufficient energy to enjoy leisure activities and respond to emergency situations [1]. It is considered a multidimensional concept and is broadly categorized into two major components: health-related fitness and skill-related fitness. Health-related fitness includes body composition, muscular strength, muscular endurance, flexibility, and cardiorespiratory fitness, while skill-related fitness includes speed, agility, balance, coordination, power, and reaction time [1,2]. These components collectively contribute to overall physical performance and quality of life.

Among these components, cardiorespiratory fitness (CRF), also known as aerobic fitness or maximal aerobic power, has received significant attention due to its strong association with overall health and athletic performance [3,4]. Cardiorespiratory fitness refers to the ability of the cardiovascular and respiratory systems to supply oxygen to the working muscles during sustained physical activity involving large muscle groups [4]. Regular physical activity plays a crucial role in maintaining optimal physical fitness, whereas insufficient physical activity is recognized as a major risk factor for several non-communicable diseases, including cardiovascular diseases, diabetes mellitus, stroke, certain cancers, obesity, and mental health disorders [5].

Physical activity also contributes positively to mental health through neurobiological, psychological, and behavioural mechanisms. It can increase neurotrophic gene expression, improve grey matter volume, and stimulate the release of endogenous opioids, thereby enhancing mood, emotional regulation, and cognitive functioning [6]. In adults, cardiorespiratory fitness has been identified as a strong and independent predictor of cardiovascular health, with higher levels associated with reduced risk of disease, illness, and premature mortality [7]. However, recent evidence suggests that cardiorespiratory fitness levels among young individuals are gradually declining due to decreased physical activity and increasingly sedentary lifestyles [8].

Cardiorespiratory fitness is most commonly assessed by measuring maximal oxygen uptake ( $VO_2\text{max}$ ), which represents the maximum rate at which oxygen can be consumed and utilized by the body during intense physical exercise [4].  $VO_2\text{max}$  is widely considered the gold standard for evaluating aerobic capacity and endurance performance. It depends on factors such as cardiac output, oxygen transport, and the arteriovenous oxygen difference, and it can be expressed either as an absolute value (L/min) or relative to body weight (ml/kg/min) [9].

Although laboratory-based measurements of  $VO_2\text{max}$  using graded exercise testing and open-circuit spirometry provide highly accurate results, these methods require expensive equipment, trained personnel, and controlled environments, limiting their use in large populations or field settings [10,12]. Consequently, field-based fitness tests have become widely accepted as practical alternatives for estimating cardiorespiratory fitness [11,12]. These tests are simple, cost-effective, and suitable for assessing large groups of individuals.

Among the available field tests, the 20-meter shuttle run test (20m SRT) is one of the most commonly used methods to estimate  $VO_2\text{max}$ . The test requires participants to run continuously between two lines placed 20 meters apart, with the running speed progressively increasing according to audio signals until exhaustion.  $VO_2\text{max}$  is then estimated based on the final stage or number of shuttles completed [10,11]. The test is widely used in sports science, educational institutions, and health assessments due to its reliability, validity, and ease of administration.

Ethnic and population-specific differences can significantly influence  $VO_2\text{max}$  values due to variations in body composition, lifestyle, nutritional habits, and physical activity patterns [13]. Studies have shown that the  $VO_2\text{max}$  values of the Indian population are generally lower than those reported in Western populations [13]. Additionally, factors such as body mass index (BMI) and body composition are known to influence cardiorespiratory fitness levels [14,15].

Despite the growing participation of women in sports such as cricket, limited research has focused on establishing normative cardiorespiratory fitness values for amateur female cricket players, particularly within the Indian population. Cricket is an intermittent sport that involves repeated bouts of running, sprinting, and sustained low-intensity activity, making cardiorespiratory fitness an important determinant of performance [16,17]. Establishing normative VO<sub>2</sub>max values may therefore help assess the current fitness status of female athletes and guide training and conditioning programs.

Therefore, the present study aims to determine the normative VO<sub>2</sub>max values in amateur female cricket players aged 18–25 years using the 20-meter shuttle run test. Establishing such data may assist in evaluating fitness levels, designing appropriate aerobic training protocols, and promoting long-term health and athletic performance among female cricket players [18,19].

## METHOD AND METHODOLOGY

### Study Design:

The present study was designed as Observational cross sectional study to determine the Normative Data of VO<sub>2</sub> max Using 20m Shuttle Run Test in Amateur Female Cricket Players Between Age Group of 18 to 25 Years. Ethical approval was obtained from the Institutional Ethics Committee of Dr. APJ Abdul Kalam College of Physiotherapy, Pravara Institute of Medical Sciences (PIMS), Loni (Approval Number: DR.APJAKCOPT/BPT/UG/2025/46). All procedures were carried out in accordance with institutional and national ethical guidelines. Written informed consent was obtained from each participant in their native language prior to inclusion in the study.

The research was conducted at Dr. APJ Abdul Kalam College of Physiotherapy, PIMS, Loni, Maharashtra, India. Data collection was carried out on a standard cricket practice ground that allowed adequate space for conducting the 20-Meter Shuttle Run Test under safe and controlled conditions.

### Sample Size

A total of 40 amateur female cricket players were enrolled in the study. Participants were randomly assigned to two groups using a lottery method in an open-label manner.

### Inclusion Criteria

- Amateur cricket Players between the age of 18-25 years
- Fit to participate on the basis of SF-12 Questionnaire
- Female Cricket Players

### Exclusion Criteria

- Cardiovascular and respiratory disease.
- Neurological and musculoskeletal impairment that hamper running.
- Abnormal vitals before the test.
- Those who are unwilling to participate in the study.

### Outcome Measures:

- 1) Multi Stage 20 m Shuttle Run Test
- 2) SF12 (Short-form 12 health survey)

### Procedure

Ethical clearance for the study was obtained from the institutional ethics committee prior to the commencement of the research. A total of 40 participants aged between 18 and 25 years were recruited for the study based on the predefined inclusion and exclusion criteria. Written informed consent was obtained from all participants after explaining the purpose and procedure of the study in detail. Demographic information of each participant was recorded, and baseline assessments including resting

vital parameters and anthropometric measurements such as height, weight, and body mass index (BMI) were documented before the testing procedure.

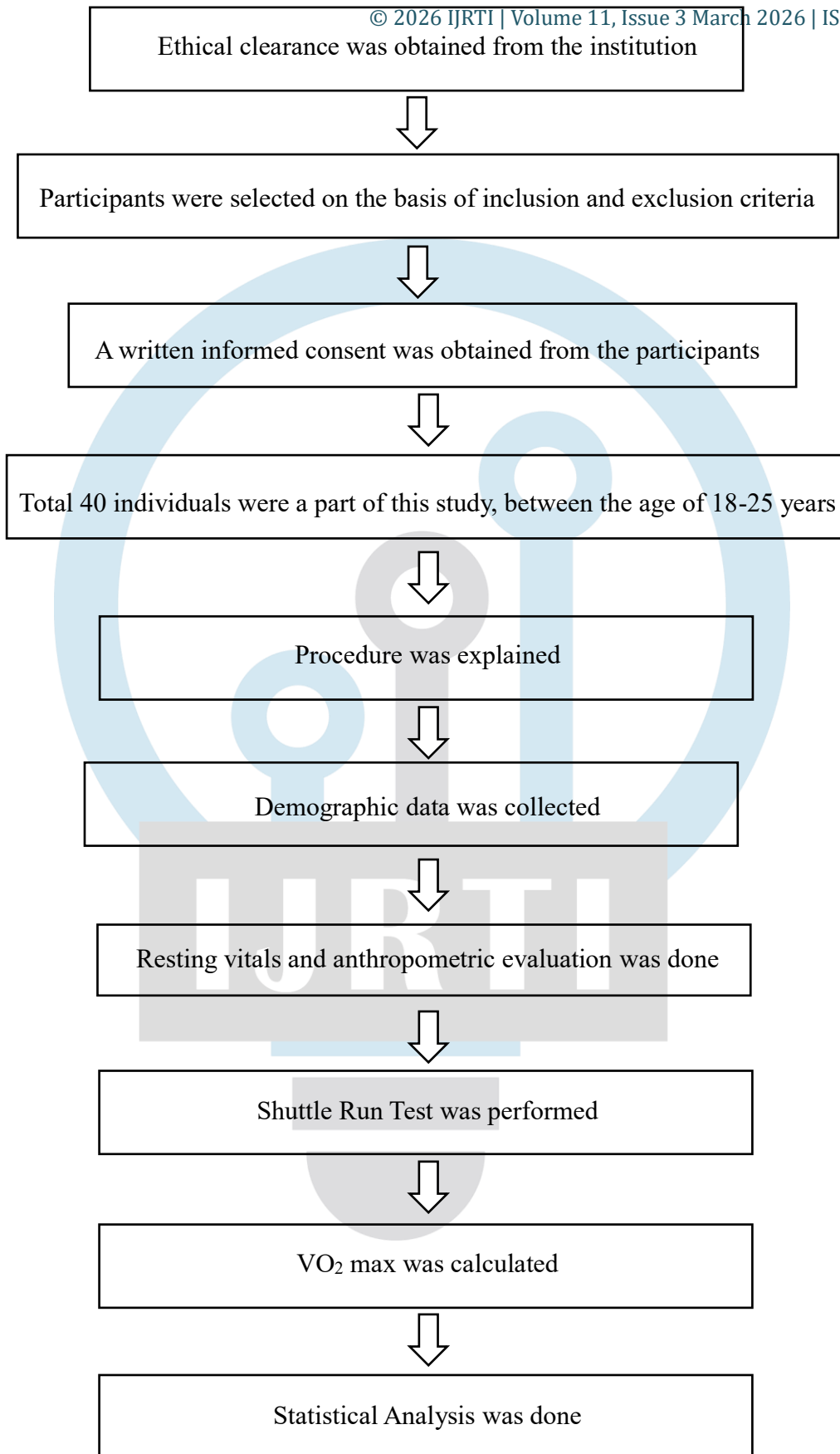
The cardiorespiratory fitness of the participants was assessed using the 20-meter shuttle run test. The test was conducted on a sports ground following the standard protocol described by Léger et al. Participants were instructed to run back and forth between two lines placed 20 meters apart, which were clearly marked using coloured cones. The running pace was controlled using pre-recorded audio signals played through speakers. Participants were required to synchronize their running speed with the beeps. The speed increased progressively at each stage of the test. The test was terminated when the participant failed to reach the end line in time with the audio signal on two consecutive occasions or when the participant voluntarily stopped due to fatigue. The final level or total number of laps completed at the point of termination was recorded. Participants were verbally encouraged to continue running for as long as possible throughout the test.

The maximal oxygen uptake ( $VO_2$  max) of the participants was estimated using the Mahar MT equation. The equation used was:  $VO_2 \text{ max} = 50.945 + (0.126 \times \text{PACER laps}) + (4.946 \times \text{gender}) - (0.655 \times \text{BMI})$ . In this equation,  $VO_2$  max represents the maximum volume of oxygen consumed during intense exercise, expressed in millilitres per kilogram per minute (mL/kg/min). The constant value used in the equation is 50.945. The value 0.126 represents the coefficient for PACER laps, which corresponds to the total number of laps completed during the shuttle run test. The coefficient for gender is 4.946, where males are assigned a value of 1 and females a value of 0. The coefficient for BMI is 0.655, where BMI is calculated as body weight in kilograms divided by the square of height in meters. Based on the calculated  $VO_2$  max values, the results were analysed and conclusions were drawn.

Statistical Analysis: Data were analysed using SPSS software. Paired and unpaired t-tests were applied. Significance was set at  $p < 0.05$ .

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IJRTI



**CONSORT FLOW DIAGRAM**

## RESULTS

Analysis of raw data was performed using SPSS software version 20 (IBM SPSS Statistics Inc., Chicago, Illinois, USA). The p-value for statistical analysis was set at  $p < 0.05$  with a confidence interval of 95%. The normality of the data was assessed using the Shapiro- Wilk test, which indicated that the data followed a normal distribution. Hence, parametric tests were applied for statistical analysis. Descriptive statistics, including mean, standard deviation, and percentiles, were used to establish normative values for  $VO_2$  max in 18-25-year-old female. Z- scores were also calculated to assess individual variability. Additionally, percentile-based classification was performed to categorize participants into different fitness levels.

**Table 1 Baseline Demographic Data**

Variables	Values
Age	20.5±2.14
Gender Female	40
Height	163.9±9.32
Weight	59±14.9
BMI	22.6±3.9

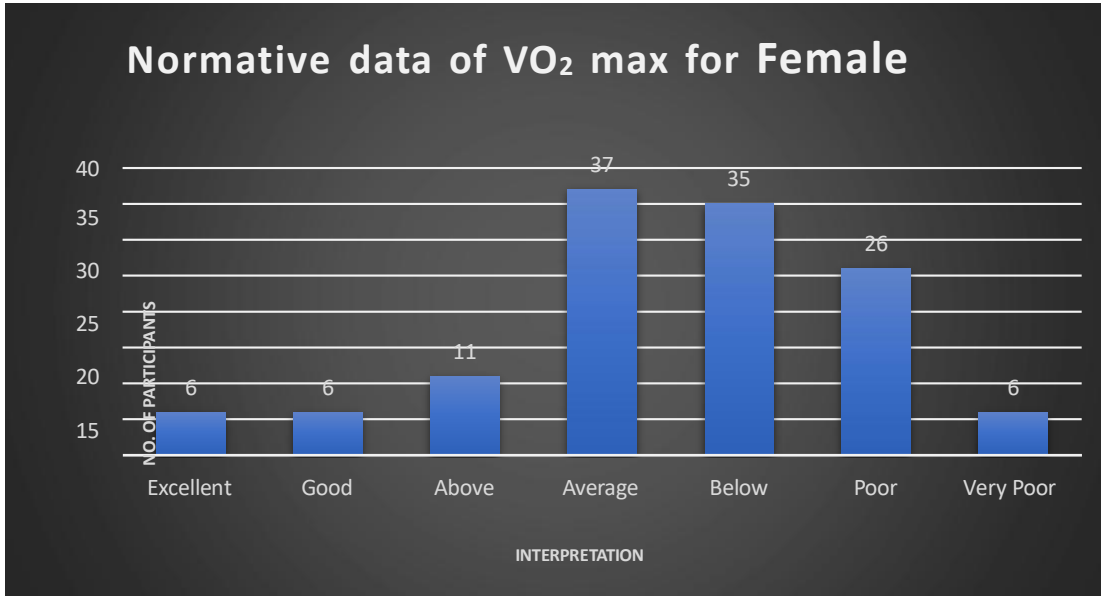
Table 1 Shows mean data of 40 participants

**Table 1.2 Normative data of  $VO_2$  max for Female**

Percentile	$VO_2$ max (ml/kg/min)	No. of Participants	% of participant	Interpretation
95th	>42.8	6	2.7 %	Excellent
90th	42.1-42.8	6	2.7 %	Good
75th	40.7-42.1	11	5 %	Above Average
50th	39.2-40.7	37	16.8 %	Average
25th	37.5-39.2	35	15.9 %	Below Average
10th	35.3-37.5	26	11.8 %	Poor
5th	<33.8	6	2.7 %	Very Poor

Table 1.2 shows the percentile values, number of female participants, interpretation and ranges for the  $VO_2$ max for female

**Graph 1.2 Normative data of VO<sub>2</sub> max for Female**



**Table 1.2 and Graph 1.2** Suggests that the normative data for VO<sub>2</sub> max categorizes participants into fitness levels based on their oxygen consumption. For females, the 95th percentile (VO<sub>2</sub> max > 42.8 ml/kg/min) represents excellent cardiovascular endurance, with the 90th and 75th percentiles indicating good and above-average fitness, respectively. The average range (50th percentile) reflects moderate endurance typical of the general female population, while below-average (25th percentile) and poor (10th percentile) categories suggest lower aerobic fitness, with room for improvement. The very poor range (5th percentile, VO<sub>2</sub> max < 33.8 ml/kg/min) highlights significantly low endurance and potential cardiovascular risks. Overall, most female participants fall within the average range, and promoting regular physical activity could enhance cardiovascular health, especially for those below average.

**Table 1.3** Shows the correlation analysis suggests that the vo2 max shows negative correlation with Age and BMI which suggest as AGE increases VO2 max tends to decreases. Same as BMI increases V02 max decreases

**Table 1.3 Correlation between VO2 Max with Age and BMI**

Variable	Person’s correlation	P value
VO2 Max with Age	-.055	.418
VO2 Max with BMI	-.227	.001

**Table 1.4 regression between VO2 max with Age and BMI**

Variable	B (Unstandardized Coefficient)	Standard Error (SE)	B (standardized Coefficient)	T value	P value
VO2 max (constant)	46.23	2.48		18.7	<b>0.0001</b>
AGE	-.057	.107	-.035	-.531	<b>0.59</b>
BMI	-.198	.058	-.224	-3.382	<b>0.001</b>

Intercept (Constant): The intercept value of 46.23 represents the predicted VO<sub>2</sub> max when both Age and BMI are zero. This value is statistically significant ( $p = 0.0001$ ), suggesting the baseline VO<sub>2</sub> max is reliable.

Age: The coefficient for Age is -0.057, indicating that as Age increases by 1 year, VO<sub>2</sub> max is expected to decrease by 0.057 units. However, the p-value for Age (0.59) is greater than 0.05, indicating that Age does not significantly predict VO<sub>2</sub> max in this sample.

BMI: The coefficient for BMI is -0.198, meaning for each 1-unit increase in BMI, VO<sub>2</sub> max is predicted to decrease by 0.198 units. The p-value for BMI (0.001) is less than 0.05, indicating that BMI has a statistically significant negative effect on VO<sub>2</sub> max. The Beta coefficient (-0.224) suggests a moderate strength of the relationship between BMI and VO<sub>2</sub> max.

This analysis suggests that BMI is a significant predictor of VO<sub>2</sub> max, with higher BMI associated with lower aerobic capacity. Age, however, does not have a significant impact on VO<sub>2</sub> max in this study. These findings emphasize the importance of considering BMI when assessing or improving VO<sub>2</sub> max levels.<sup>[25]</sup>

**Table 1.5 Association of Age with VO<sub>2</sub> max category**

	Value	Df	P Value
Pearson Chi-Square	1670.45	1611	.148

**Table 1.5** shows Association of age with VO<sub>2</sub> max shown by Chi-Square test in which value is 1670.45 with Df 1611 which is not significant because it is more than P Value of 0.05.

## DISCUSSION

The present study was conducted to determine the normative values of VO<sub>2</sub> max in amateur female cricket players aged 18–25 years using the 20-meter shuttle run test. A total of 40 female participants were included in the study, with a mean age of  $20.5 \pm 2.14$  years and a mean BMI of  $22.6 \pm 3.9$  kg/m<sup>2</sup>. The mean VO<sub>2</sub> max observed in the participants was  $40.7 \pm 3.4$  ml/kg/min, with values ranging from 32.03 ml/kg/min to 49.78 ml/kg/min. These findings suggest a moderate to good level of aerobic fitness among young adult females in the studied population.

VO<sub>2</sub> max represents the maximum amount of oxygen that an individual can utilize during intense physical activity and is considered one of the most important indicators of cardiorespiratory fitness. It reflects the integrated efficiency of the respiratory, cardiovascular, and neuromuscular systems, including pulmonary ventilation, cardiac output, oxygen transport through the blood, and oxygen utilization by skeletal muscles. Because of its strong relationship with endurance capacity, VO<sub>2</sub> max is widely used to evaluate aerobic fitness and cardiorespiratory endurance in both athletes and healthy individuals [7,8].

Cardiorespiratory fitness plays an important role not only in sports performance but also in maintaining overall health. Reduced levels of cardiorespiratory fitness have been associated with an increased risk of cardiovascular diseases and other degenerative conditions, which are becoming more prevalent worldwide due to sedentary lifestyles and reduced physical activity. Regular physical activity is essential for maintaining optimal physical fitness and reducing the risk of non-communicable diseases such as cardiovascular disease, diabetes mellitus, stroke, obesity, and mental health disorders. Exercise also has

positive neurobiological and psychological effects, including increased expression of neurotrophic factors, improved brain structure, enhanced mood, and better sleep quality and coping abilities [8].

The importance of  $VO_2$  max extends beyond athletic performance and serves as a key indicator of cardiovascular health. Previous studies have demonstrated that individuals with higher  $VO_2$  max levels have a significantly lower risk of cardiovascular disease, metabolic disorders, and overall mortality, whereas lower  $VO_2$  max values are associated with poorer health outcomes [7].

In the present study,  $VO_2$  max values were estimated using a standardized predictive equation based on performance in the 20-meter shuttle run test. The results indicate that the participants possessed an acceptable level of aerobic fitness. However, several factors such as ethnicity, lifestyle, and body composition may influence  $VO_2$  max values. A study conducted by Neethu John et al. [7,11] reported that  $VO_2$  max values among the Indian population are generally lower compared to Western populations. Differences in lifestyle habits, dietary patterns, physical activity levels, and body composition were identified as contributing factors influencing aerobic capacity [13].

Correlation analysis in the present study showed a negative association between  $VO_2$  max and both age and BMI. This indicates that  $VO_2$  max tends to decrease with increasing age and body mass index even within a young adult population. These findings are consistent with previous studies that have demonstrated that increased body mass and adiposity reduce the efficiency of oxygen transport and utilization during exercise. According to Betik et al., age-related decline in  $VO_2$  max occurs due to reduced cardiac output, decreased oxygen delivery to skeletal muscles, and reduced mitochondrial oxidative capacity [9].

The 20-meter shuttle run test used in this study is widely recognized as a reliable and practical field method for estimating  $VO_2$  max when direct laboratory measurements are not feasible. Previous meta-analyses have reported a strong correlation between measured  $VO_2$  max and performance in the shuttle run test, supporting its validity as a field-based assessment of cardiorespiratory fitness [11].

Furthermore, research has shown that aerobic capacity is influenced by factors such as training status, body composition, and lifestyle habits. Individuals who engage in regular physical training generally demonstrate higher  $VO_2$  max values compared to sedentary individuals. Body composition, particularly BMI and fat mass, also plays a significant role in determining aerobic fitness, with higher BMI often associated with lower  $VO_2$  max values [12,15].

Overall, the findings of the present study support the use of the 20-meter shuttle run test as a valid and practical field-based method for estimating  $VO_2$  max. Establishing normative  $VO_2$  max values for amateur female cricket players may help in assessing their current fitness status, guiding training and conditioning programs, and promoting long-term health and athletic performance in this population [12].

## CONCLUSION

Normative  $VO_2$  max values were assessed in 40 female individuals with a mean age of  $20.5 \pm 2.14$  years and a mean BMI of  $22.6 \pm 3.9$  kg/m<sup>2</sup>. A significant relationship was observed between  $VO_2$  max and both age and BMI. The findings indicated that  $VO_2$  max showed a declining trend with increasing age among females. Similarly, higher BMI values were associated with lower  $VO_2$  max levels. These results suggest that aerobic capacity in young adult females is influenced by age-related and body composition factors, with reductions in maximal oxygen uptake evident as age and BMI increase, and these associations were found to be statistically significant.

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