



ORIGINAL RESEARCH PAPER

Physiology

EVALUATION OF AEROBIC FITNESS BY VO2 MAXIMUM PREDICTION FROM QUEENS COLLEGE STEP TEST IN CRICKETERS & SEDENTARY GROUP AT S.N. MEDICAL COLLEGE JODHPUR

KEY WORDS: Cricket
Maximum O2 consumption
Fitness

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ABSTRACT

Objective - To measure ,evaluate & compare aerobic fitness by predicted VO2 maximum in age & gender matched cricketers group & sedentary lifestyle group **Methods** - Research was conducted at Dr. S.N. Medical College Jodhpur after Approval from Institutional Ethical Committee. Study design was Observational Analytic Comparative Cross Sectional Study. Written informed consent was taken from 40 Human male subjects out of which 20 Cricketers & 20 Sedentary Life style group between 20-25 years of age were included out of randomly recruited subjects ;those have answered NO to Physical Activity Readiness Questionnaires. Intervention was of Cricket sport of 20-20 overs version of 3 hours time in afternoon session with frequency 3-5 days of week ;acclimatized for one year.Maximum oxygen consumption prediction was done by Queen's College Step Test by recording recovery heart rate & applying formula. For statistical analyses microsoft office, excel sheet, graph pad software, numbers and percentages, mean and standard deviations Chi square and Fisher exact test. Unpaired t Test. Pearson's correlation coefficient, p value < 0.05 was considered as statistically significant were used. **Result** - In our study age of 20 male subjects of Cricketers group in (n = 20) in years was (Mean±SD 22.25±1.33),while age that of sedentary group (n=20) age was (Mean±SD 22.3±0.80 (p = 0.886) Resting Heart Rate in Cricketer's group (Mean±SD 73.05±4.14) was less (P = 0.086). than in Sedentary group (Mean±SD 76.15±6.7) .Queen's College step test VO2 maximum in ml/kg/min in Cricketer's group (Mean±SD 62.02±5.15) was significantly more (P = <0.0001) than in Sedentary group (Mean±SD 50.60±3.71) & Cricketers group of VO2 Max mean category was in Superior range while that of sedentary group was in Excellent range. Negative correlation was observed between Resting HR & VO2 Max in cricketers group (r=-0.064 , p = 0.785). **Conclusion** -Intervention of healthy lifestyle in form of cricket sport in group improves maximum oxygen consumption so aerobic fitness.

INTRODUCTION -

Increased Physical Activity is mentioned in NPCDS National Program for prevention and control of Cancer, Diabetes , Cardiovascular disease and Stroke (1) Aerobic Fitness can be measured by the volume of oxygen you can consume while exercising at your maximum capacity. VO2 max is the maximum amount of oxygen in milliliters, one can use in one minute per kilogram of body weight. Those who are fit have higher VO2max values and can exercise more intensely than those who are not as well conditioned. Numerous studies show that you can increase your VO2max by working out at an intensity that raises your heart rate to between 65 and 85% of its maximum for at least 20 minutes three to five times a week. A mean value of VO2max for male athletes is approx. 3.5 liters/minute and for female athletes it is about 2.7 liters/minute. Aerobic fitness is primary for most sports. Trainers must think carefully about the fitness level they believe is appropriate for peak performance and then achieve that. For example, in elite football a high aerobic capacity is important, but for volleyball, a moderate level will suffice. For most games, aerobic fitness governs how quickly one recovers between high intensity sections, and how much distance can be covered in a game. The following are examples of aerobic endurance evaluation step tests: Harvard step test ,Astrand cycle test Home step test, Three minute step test, Multistage fitness test, Queens college step test etc. (2) Aerobic training is performed to increase aerobic capacity or

fitness. The aerobic capacity of an individual is the ability to utilize the body's glycogen stores via the aerobic metabolic pathway. An individual's aerobic capacity is measured by the maximum oxygen consumption, better known as the Vo2max—the maximum amount of oxygen an individual is able to utilize in one minute per kilogram of body weight. This can be measured in the laboratory by exercising the individual to exhaustion and directly measuring the amount of oxygen consumed and carbon dioxide produced. From this procedure, the maximum amount of oxygen consumed can be determined accurately. A simpler, but less exact, method known as 'the predicted Vo2max' is estimated by measuring the heart rate at a specific workload.

This predicted Vo2max is commonly performed in health and fitness centers. In muscle, aerobic activity increases mitochondrial number and activity, glycogen storage, ability to use free fatty acids and vascularity. Cardiovascular effects include decreased heart rate and blood pressure with increased cardiac stroke volume and improved endothelial function.(3)(4)

Cricket is a popular sport with approximately 2.5 billion people of all ages and abilities participating. Cricket is played by 1.4 million people in Australia, nearly 300 000 people in the UK and over 5 million people in India. Further, cricket is popular among youth, many of whom continue to

play cricket into adulthood. Cricket has also become increasingly popular among women, with more than 27% of all Australian cricketers being female. Cricket is played with 11 individuals per team, over 5 days (test cricket), 1 day (50 overs) or over 4 hours (Twenty20). The 2011 Compendium of Physical Activities lists cricket as a sport that can provide moderate-intensity physical activity. Regular physical activity is an important determinant of general health, life expectancy and overall well-being. Over 31% of all adults worldwide are physically inactive, with physical inactivity levels ranging from 17% in Asia to 43% in North America. To counteract inactivity, sports participation is promoted. Sport participation provides opportunities to be physically active across the lifespan. Cricket participation can improve fitness and strength and has psychological benefits for participants, including improved self-esteem, social connections and overall well-being. Mental health and health-related quality of life (HRQoL) is higher in cricketers than in the general population. (5) The measurement of VO₂ max is the gold standard measure of cardiorespiratory fitness. VO₂ max can be estimated based on the final work rate achieved in a graded exercise test. VO₂ max can be estimated from heart rate responses to submaximal exercise by extrapolating the relationship to the subject's age adjusted estimate of maximal heart rate. Careful attention to environmental factors that can affect the heart rate response to submaximal exercise is an important aspect of the procedures for these tests. (6) The VO₂ max test represents the most often cited criterion of cardiorespiratory fitness. Current practice evaluates the VO₂ max score against criterion-referenced standards rather than norm-referenced standards. Criterion-referenced standards establish a minimum VO₂ max consistent with good health similar to blood pressure and cholesterol standards, independent of the score's percentile ranking within a particular normative data set. The accompanying table presents a five-part classification scheme for VO₂ max for men and women of different ages. The poor category for each age group represents the lower limit of cardiorespiratory fitness below which probably places the individual at increased risk for cardiovascular disease. The highest VO₂ max values are generally achieved by individuals who regularly engage in distance running, swimming, bicycling, and cross-country skiing. These individuals have almost double the VO₂ max of sedentary individuals. Cardiovascular Fitness Categories are available using VO₂ max in Age 29 Year or less in man are Poor 24.9 or below, Fair 25-33.9, Average 34-43.9, Good 44-52.9, Excellent 53 or more (7) In precollegiate students study VO₂ max (mL/kg/min) /aerobic capacity/oxygen dependent fitness: The mean & SD was 30.79 ± 5.85. The VO₂ max correlated BSA ($r = 0.297, P < 0.01$) and PFI ($r = 0.238, P < 0.02$). (8) Maximum Oxygen uptake (VO₂ max) is a good predictor of cardiopulmonary and muscle fitness. Maximum oxygen uptake is defined as the highest rate at which oxygen can be taken up and utilized by body during severe exercise. In Nepalese population; Maximum oxygen uptake was determined by using the Queen's college step-stool was used as a submaximal exercise and the result showed estimated VO₂ max in boys and girls was 48.8 ± 7.3 ml/kg/min and 37.4 ± 2.7 ml/kg/min respectively with Mc Ardle equation (9) Maximal Oxygen Consumption (VO₂ max): It is the term used to define the level of oxygen consumption beyond which no further increase in O₂ consumption occurs with further increase in the severity of exercise or the highest oxygen uptake an individual can achieve during exercise while breathing air at sea level. It is also known as aerobic capacity or aerobic power. VO₂ max of a normal individual is limited by the degree to which cardiac output can increase and not by the ventilatory capacity or oxygen diffusion capacity of the lungs. The ability of the active tissues to extract O₂ delivered by circulation or peripheral factors (muscle mass) may be other possible limiting factors for VO₂ max. VO₂ max increases by 5 to 20% by conditioning (athletic training) because of (a) Increase in cardiac output, (b) Increase in

arteriovenous O₂ difference due to more utilization of O₂ by exercising muscles, and (c) Increase in pulmonary capillary density. Because oxygen consumption is linearly related to energy expenditure, when oxygen consumption is measured, it indirectly measures an individual's maximal capacity to do work aerobically. It is considered to be the best indicator of cardiorespiratory endurance or aerobic fitness. VO₂ max is usually expressed relative to body weight (ml/kg/min) because oxygen and energy needs differ relative to size. It can be expressed relative to body surface area and this may be more accurate when comparing children and oxygen consumption between sexes. The physical limitations that restrict the rate at which energy can be released aerobically are dependent upon the combined ability of cardiovascular and pulmonary systems to transport the oxygen to the muscular tissue system and the chemical ability of muscle fiber system to use oxygen in breaking down fuels. (10) Factors affecting VO₂ max:

(I) Age: VO₂ max rapidly increases during the growth stages of early years and reaches its peak between 18 to 25 years. After the age of 25 yrs, the VO₂ max declines steadily, so that by the age of 55 years, it is about 27% below the values reported for the 20 years of age. The early increase is due to growth of muscles, heart and lungs and the later decline is due in large part to a gradual reduction in maximum cardiac efficiency with advancing age. (II) Sex: Before puberty there is no significant difference in maximal aerobic power between girls and boys. VO₂ max values for men typically exceed scores for women by 15-30% even among trained athletes. The apparent sex difference in VO₂ max has generally been ascribed to difference in body compositions and hemoglobin content. (III) Body size and composition: It is estimated that 69% of the difference in VO₂ max scores among individuals can be explained by differences in body weight, 4% by differences in height and 1% by difference in lean body weight (11). (IV) Genetics: Most physical fitness characteristics demonstrate high heritability. It is estimated that the genetic effect is about 25-40% for VO₂ max by the studies of Bouchard et al (12) and Perusse et al (13) (V) State of Training: A person's state of aerobic training contributes significantly to the VO₂ max. An improvement in aerobic capacity from 5% - 20% above the pre training level is observed with training. (14) The VO₂ max values were found to be higher in physical education students when compared to medical education students in a study (15) A study of maximum oxygen uptake and heart rate recovery during work and recovery as measured on cycle ergometer on national Indian sportsmen, research has reported that, the higher values of VO₂ max in sportsmen are responsible for lower heart rates during work and subsequent recovery (16). Research Question was to know how much aerobic fitness is in terms of VO₂ Max measurement in College level Cricketers group & Sedentary control group? Predictive statement about outcome of the research question as per null hypothesis is that there is no relationship between dependent & independent variables; and as per alternative hypothesis is that there is definite relationship between the dependent & independent variables means aerobic fitness (VO₂ Max) differs in cricket playing medical college students group from sedentary group of medical college students at Jodhpur India.

MATERIAL & METHODS - Our study was carried out at Dr. S.N. Medical College Jodhpur. Study period was one year in year 2021. Study design was Observational Analytic Comparative Cross Sectional Study. Ethical Institutional Committee of Dr. SNMC Jodhpur has given approval of the plan before starting this research work. Written informed consent was taken from subjects. For Sample Size - Dr. Sukanya Badami & Dr. Anita Herur's research work result showed that Aerobic fitness variable Maximum oxygen consumption in Medical Education group was in terms of Mean & SD was 47.7 ± 6.2 VO₂ max in ml/kg/min & in

Physical Education group Mean & SD was 57.5+ - 4.4 VO2 max in ml/kg/min (17) . Applying these value into following formula gave the sample size .Sample size was calculated at alpha error 0.05 and study power 90% using the formula for hypothesis testing for two population mean -

Where, n=Sample-size

$$n = \frac{2 \times (Z_{1-\alpha/2} + Z_{1-\beta})^2 \times \sigma^2}{(\mu_1 - \mu_2)^2}$$

$(Z_{1-\alpha/2})$ = Standard normal deviate for alpha error (taken as 1.96 for alpha error 0.05)

$(Z_{1-\beta})$ = Standard normal deviate for beta error (taken as 1.28 for 90% study power)

σ^2 = pooled variance of the two population. As it is not known, it is replaced by s_p^2 -

$$s_p^2 = \frac{s_1^2 + s_2^2}{2}$$

Where, s_1^2 and s_2^2 are the variances of the two samples.

$\mu_1 - \mu_2$ = The difference in between the two population (as it is not known, it is replaced by the difference in sample means $(\bar{x}_1 - \bar{x}_2)$. (18)

$$N = \frac{2 \times (1.96 + 1.28) \times \{(4.4)^2 + (6.2)^2\}}{(57.5 - 47.7)^2} \quad N = 6.31$$

Sample size was calculated to be a minimum of 6.3 subjects in each group, which was round to 20 subjects in each group. For reference or target Population - (Selection of suitable population) - Recruitment of potential human research participants were done, while taking concern of with aims & objectives and calculated sample size, by explaining recruitment materials that is covered in Participant Information Sheet. Experimental or Study Population (Selection of suitable sample) - was derived from the reference or target population. It is the actual population that participates in experimental study after giving informed consent, representative of reference population those clears qualification or eligibility criteria. (19) Total 102 Male Human Research participants between age 20 to 25 years of Dr. S.N. Medical College were recruited. Stratified Sampling was done by forming two homogenous groups/classes/strata and then sample is drawn from each stratum at random by using table of random number method (20) Group of 51 Cricketers subjects (Cricket is a bat ball game between two team of eleven players on field includes batting, bowling & fielding. (21) & Group of 51 Sedentary Life-style subjects (Limited physical activity or no regular physical activity outside work) (22) Inclusion Criteria - At least 40 Human male subjects out of which 20 Cricketers & 20 Sedentary Life stylers between 20-25 years of age were included out of Recruited Subjects ;those have answered NO to Physical Activity Readiness Questionnaires. Exclusion Criteria - Human subjects will be excluded those have answered YES to one or more questions of Physical Activity Readiness Questionnaires (23) or those having general indication for stopping the exercise test (during exercise) in low risk adult onset of angina or angina-like symptoms, Shortness of breath, wheezing, leg cramps, or claudication, Signs of poor perfusion: light-headedness, confusion, ataxia, pallor, cyanosis, nausea, or cold and clammy skin, Failure of heart rate to increase with increased exercise intensity, Noticeable change in heart rhythm, Subject requests to stop, Physical or verbal manifestations of severe fatigue, Failure of the testing equipment. (24). Their were 3 drop outs who could not able to participate or left with incomplete step test in research, were also excluded from study. Comparison were done between sedentary lifestyle students group & physically active cricketers group of Dr. S. N. Medical College students having intervention of cricket as sport of 20-20 overs of 3 hours time in afternoon session with frequency 3-5 days of week ;acclimatized for one year. To know recovery heart rate ;Radial Pulse was recorded in sitting

position as given in Hutchison's Clinical Methods (25) To know Aerobic Fitness in form of Prediction of Maximum Oxygen Consumption Queen's College Step Test was applied . Required resources are Step 16.25 inches or 41.3 cm high, Stop watch Metronome The Queens College step test is conducted as follows: Step up and down on the step for 3 minutes at the following rate: 1 Male - 24 steps per minute 1 Female - 22 steps per minute by using a metronome or have someone to help you keep to the required pace 5 seconds after finishing the test - count the heart beats for 15 seconds (PR). Calculation of VO2max is done follows: Male = 111.33 - (1.68 x PR) & for Female = 65.81 - (0.7388 x PR). (26) Normative data for the Queen's College step test. The following tables provide an assessment of an athlete's VO2max score. Queen's College Step Test For Evaluation ;categories & (related VO₂Max. values in ml/kg/min) for Age Range 20-29 for male remain in following way as given by Brian Mackenzie's Performance evaluation test - Very Poor category (VO₂Max <33.0), Poor (33.0-36.4), Fair (36.5-42.4), Good (42.5-46.4), Excellent (46.5-52.4), Superior (>52.4) (27) For statistical analysis the data was collected in Microsoft office excel sheet 2010. All statistical analyses were performed using Graph Pad software. The qualitative data were expressed in numbers and percentages for categorical variables and the quantitative data were expressed as mean and standard deviations for continuous variables. The difference in proportion was analysed by using chi square and Fisher exact test. The difference in mean among the groups was analysed using Unpaired t Test. Pearson's correlation coefficient between quantitative variables. A p value < 0.05 was considered as statistically significant. (28)(29)

Table 1 :observation & Result - Comparison Of VO₂ Maximum Score By Queen's College Step Test Between Cricketers & Sedentary Group (N=20)

Queen's College step test	Cricketers Group (Mean±SD)	Sedentary Group (Mean±SD)	t value	p value
Age (yrs)	22.25±1.33	22.3±0.80	0.143	0.886
RHR (bpm)	73.05±4.14	76.15±6.7	1.761	0.086
Pulse Recovery at 15 seconds (PR)	29.35±3.07	36.15±2.21	8.051	<0.0001
Queen's College step test VO ₂ maximum in ml/kg/min	62.02±5.15	50.60±3.71	8.051	<0.0001

Table 2: Comparison Of Vo₂ Maximum Category By Queen's College Step Test Between Cricketers & Sedentary Group

VO ₂ Maximum Score in ml/kg/minute in Male	Cricketers group N(%)	Sedentary Group N(%)	Statistical test	p-value	Remarks
Superior >52.4	20 (100%)	7 (35%)	Chi square	<0.0001	Highly Significant
Excellent (46.5-52.4)	0 (0%)	11 (55%)	Chi square 15.17	<0.0001	Highly Significant
Good (42.5-46.4)	0 (0%)	2 (10%)	Fisher exact test	0.248	Not significant
Fair (36.5-42.4)	0 (0%)	0 (0%)	-	-	-
Poor (33.0-36.4)	0 (0%)	0 (0%)	-	-	-

Very Poor <33.0)	0 (0%)	0 (0%)	-	-	-
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Chi square 19.25, P value <0.0001

Table 3 -Pearson's Correlation Coefficient

Relation between	Cricketer Group		Sedentary Group	
	r value	p value	r value	p value
VO2 max and RHR	-0.064	0.785	-0.461	0.04*

DISCUSSION -

In our study age of 20 male subjects of Cricketers group in (n = 20) in years was (Mean±SD 22.25±1.33), while age that of sedentary group (n=20) age was (Mean±SD 22.3±0.80) In comparison there was no significance difference between age of these two groups was found (p = 0.886) means further comparison in following variables were done between age matched groups. In our study Resting Heart Rate in bpm in Cricketer's group (Mean±SD 73.05±4.14) was less (P = 0.086) than in Sedentary group (Mean±SD 76.15±6.7). Resting heart rate decreases after endurance training and the reasons remain enhanced intrinsic heart rate regulation, increased baroreceptor and metaboreceptor sensitivity and improved autonomic balance seen after endurance training (30)

In our study Queen's College step test VO2 maximum in ml/kg/min in Cricketer's group (Mean±SD 62.02±5.15) was significantly more (P = <0.0001) than in Sedentary group (Mean±SD 50.60±3.71) & in evaluation as per Brian Mackenzie's Book VO2max Tables; Cricketers group of VO2 Max. mean category was in Superior range while that of sedentary group was in Excellent range. (26) (27) In our study Nonsignificant negative correlation were observed between Resting HR & VO2 max in cricketers group (r=-0.064 , p = 0.785). while in sedentary group. (r=-0.461, p =0.04*) significant negative correlation were observed. It means increase in VO2 max was associated with decrease in heart rate.

Sukanya Badami research revealed that a statistically highly significant higher mean±SD, VO2 max value in Physical Education students(57.5±4.4ml/kg/min) than Medical Education students (47.7±6.24ml/kg/min). The comparison of VO2 max scores showed that most of physical education students had superior (82%) and excellent (14%) scores while most of medical education students has excellent (32%) and fair (30%) scores of VO2 max. (31)

In normal weight females (n=30) VO2 max values obtained by Treadmill exercise test following Bruce protocol was 32.74 ± 12.82 ml/kg/min while in overweight female (n=20) it was 28.67 ± 9.78. VO2 max in normal weight males (n=15) was 39.50 ± 11.28 ml/kg/min while in overweight males (n=35) it was 35.17 ± 8.87 ml/kg/min. VO2 max was best correlated with total body fat percentage in males (r = -39) and females (r = -33) than total body mass in our study so in interpretation VO2 max was significantly less in overweight adults in comparison to normal weight adults. High body fat rather than high body weight played main role for reduction of VO2 max in Indians. (32) Maximum oxygen uptake (VO2 max) is internationally accepted parameter to evaluate the cardiorespiratory fitness. But determination of VO2 max. is restricted within well equipped laboratory because of its exhausting, hazardous and complicated experimental protocol. Department of Physiology University of Calcutta study results suggest that Queen's College Step Test in its original form cannot be applied due to its poor agreement with the direct method but can be applied with the modified equation in this population to evaluate maximum oxygen uptake, especially when large numbers of participants are to be tested in absence of a well equipped laboratory. (33) VO2

max values in ml/kg/min in health & disease in males remain in following way Cross-country skiers 84 ,Distance runners 83 , Sedentary: young 45 Sedentary: middle aged adults 35 , Post myocardial infarction patients 22, Severe pulmonary disease patients 13 ml/kg/min. In physiological basis Endurance training programs that increase VO2 max involve a large muscle mass in dynamic activity for twenty to sixty minutes per session, three to five times per week, at an intensity of 50% to 85% VO2 max .Although VO2 max increases an average of about 15% as a result of an endurance training program, the largest increases are associated with deconditioned or patient populations having very low pretraining VO2 max values. Genetic predisposition accounts for 40% to 66% of one's VO2 max value. Very strenuous and/or prolonged training can increase VO2 max in normal sedentary individuals by more than 40%. In young sedentary subjects, approximately 50% of the increase in VO2 max due to training is related to an increase in maximal stroke volume (maximal heart rate remains the same), and 50% is due to an increase in the a-v O2 Difference The large differences in VO2 max in the population (2 versus 6 liters/min) are due to differences in maximal stroke volume.(34) VO2 Max of Kerala cricket players had a score of 46.48 ml.kg-1.min-1 at the 50th percentiles and the mean score was 46.982 ml.kg-1.min-1, while compared to Australian cricket players they had a mean score of 51.293 ml.kg-1.min-1 which was better than the Kerala players. (35) The genetic predisposition to elite athletic performance has been a controversial subject due to the underpowered studies and the small effect size of identified genetic variants. The research investigated that the association of common single-nucleotide polymorphisms (SNPs) with endurance athlete status in a large cohort of elite European athletes using GWAS approach, followed by replication studies in Russian and Japanese elite athletes and functional validation using metabolomics analysis .It was concluded that the first report of genome-wide significant SNP and related metabolites associated with elite athlete status. Further investigations of the functional relevance of the identified SNPs and metabolites in relation to enhanced athletic performance are warranted. (36) The physically active population group which attends fitness clubs demonstrated the presence of such cardiovascular risk factors as high blood pressure, overweight and obesity, and affective disorders. Fitness club members should receive regular compulsory consultations of the sports medicine specialist, in order to individualise the training programme, to identify people with low exercise capacity and pathological stress reaction ("risk group"), and to increase the safety of the fitness training process. To identify potential additional measures of cardiovascular prevention in physically active population groups, further research is warranted on physical and mental health of fitness club members. (37) National Programme for Development of Sports, branded as Khelo India (Play India), aims at improving India's sports culture at the grass-root level through organized talent identification, structured sporting competitions and infrastructure development.(38) Narendra Modi Stadium Ahmedabad in India is World's largest (as per capacity crowd 132000) followed by Melbourne cricket ground Australia (capacity crowd 100024) , Eden gardens Kolkata India (capacity crowd 68000) etc.(39)

CONCLUSION -

In cricketer's group of medical students , aerobic capacity variable VO2 Max. was significantly more & associated with decrease in heart rate in comparison with sedentary lifestyle group of medical college students. Further in cricketers group mean VO2 Max. range as per standard classification was in Superior category while in that of sedentary group these range was in Excellent category. So intervention of healthy lifestyle in form of cricket sport improves fitness standard of group & for public ; various physical fitness related programmes are launched in country India.

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