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Determination of Aerobic Power (VO2MAX) by Bruce Submaximal Exercise Test and Assessment of Physical Fitness in Apparently Healthy Young Adults

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ABSTRACT

Background: The aim of this study was (i) to determine aerobic power (VO2max) by Bruce submaximal exercise test (ii) to assess of physical fitness in apparently healthy young adults. **Methods:** Apparently healthy males (n=125) in the age group of 18 to 25 years were included in the study. Aerobic power (VO2max) was determined following the protocol of Bruce submaximal exercise Test. Physical fitness assessment was also done. **Results:** The predicted values of VO2max ranged from 42.07 to 58.23 ml/kg/min with mean ± SD 47.06 ± 2.74 ml/kg/min. The VO2max associated Physical fitness assessment scores of the test showed (superior in 4% (n=5) excellent in 51.2% (n=64), good in 42.4% (n=53) and fair in 2.4% (n=3) amongst the participants. **Conclusion:** Thus, we conclude that Bruce submaximal exercise Test is an effective and safe method to determine the aerobic power (VO2max) in individual willing to participate in a fitness programme as well as to follow up the level of fitness in the course of training.

Keywords: VO_2max, Bruce sub-maximal exercise test, physical fitness.

INTRODUCTION

Aerobic power is the maximum capacity of an individual to transport and utilize oxygen during incremental exercise, which reflects the physical fitness (PF).[1] Fitness is the ability to maintain various internal equilibria as closely as possible to the resting state during strenuous exercise and to return back to baseline state promptly after cessation of activity.[2] Physical fitness depends upon the ability of tissues to use oxygen to breakdown metabolic fuels and the combined abilities of various systems (pulmonary, cardiac, vascular, and cellular) to transport oxygen from the air to mitochondria.[3] Technological developments & modern day commodities have driven most people into sedentary life style leading to chronic diseases like hypertension, heart disease, diabetes mellitus, metabolic syndrome, chronic low backache & obesity. Decrease in the physical activity (PA) significantly increased the risk of mortality from all causes.[4] PA and PF is inversely related to the mortality and the cardio-vascular (CV) diseases risk factors. For example, regular joggers exhibit a significantly lower mortality rate than their non-jogging counterparts.[5] Higher levels of PF appear to delay all-cause mortality primarily due to lowered rates of CV diseases and cancer.[6] Habitual PA is one of the major determinants of fitness, and fitness is improved in most individuals with appropriate exercise participation. The highly physically active subjects lived 2.1 years longer than their poorly active counterparts.[7-10]

VO2max is widely accepted as the single best measure of maximal aerobic power. Those who are more fit have higher VO2max and can exercise more intensely and longer than those who are not as well conditioned.

Direct measurement of VO2max is restricted within a well-equipped laboratory because of its exhausting, cumbersome, hazardous, complicated, expensive and the time spent to measure it and standardization. Moreover, it requires maximal exertion which is not advisable for compromised, debilitating and advancing cardio-respiratory diseased individuals.

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Therefore methods, able to predict fair degree of reliability using sub-maximal or milder grade of exercise, are employed. In Sub-maximal test, extrapolation is used to estimate maximal capacity. Although it may be efficacious to use an exercise test requiring maximal efforts in young fit and willing participants, sub-maximal exercise tests, which are relatively safer requires less time, are practical in a variety of settings.

The current study was designed to determine the aerobic power in terms of VO2max in apparently healthy young adults and to assess the physical fitness.

MATERIALS AND METHODS

One hundred twenty-five apparently healthy males were selected for the study after applying inclusion and exclusion criteria.

Inclusion Criteria- Apparently healthy male subjects between 18 to 25 years of age, pre-exercise BP <140/90 mmHg and having a normal pre-exercise ECG were included in the study.

In addition, subjects had to fill a Physical Activity Readiness (PAR-Q)11 Form before exercise. Subjects who had answered NO to all the questions were selected for the study.

Exclusion Criteria -Subjects with history suggestive of cardio-vascular, respiratory, metabolic, musculo-skeletal and emotional disorders were excluded.

Evaluation -Informed written consent was taken from all the subjects. The study was approved by the Institutional Ethical Committee (IEC).

Subjects were divided into small groups and then they were familiarized with the instruments. Experimental protocol was explained to them in detail. They were also given a trial run on treadmill to relieve the anxiety related to the treadmill running during actual testing and data collection.12 For treadmill testing guidelines from American College of Sports Medicine (ACSM) were followed.

Height, weight, pre-exercise blood pressure and pre-exercise ECG were measured following standard procedures.

Weight was measured using calibrated weighing machine in light clothing and bare feet and height was measured using measuring scale in centimetres which was fixed to the wall.

Body mass index was calculated using Quetlet's index: BMI=Weight (kg) / height (m2).

PC Based Stress Test Analysis (Stress-INVX1) system (CARDIVISION Exercise Stress Test System and Rest ECG Analysis System) was used for treadmill testing.

Protocol

Bruce sub-maximal exercise test13

In this test subject performs first two or three stages of the original Bruce protocol.

Table 1: stages of Bruce exercise test

STAGES	TIME [MIN]	SPEED [MPH]	GRADE [%]
I	0-3	1.7	10
II	3-6	2.5	12
III	6-9	3.4	14

Heart rate, BP and RPE were recorded for each stage.

VO_2max is then calculated by the ACSM equation utilising steady state heart rate form stage 2 and stage 3.

VO_2max [ml/kg/min] = m [HRmax-HR2] + $VO_2$2

WHERE

m = [$VO_2$2 – $VO_2$1] / [HR2-HR1]

$VO_2$1 = sub-max VO_2 [ml/kg/min] from stage 1

= [0.1×speed] + [1.8speed×%grade] + 3.5

$VO_2$2 = sub-max VO_2 [ml/kg/min] from stage 2

= [0.1×speed] + [1.8×speed×%grade] + 3.5

HR1 = HR steady state [BPM] from stage 1 that counts

HR2 = HR steady state [BPM] from stage 2 that counts

HRmax = 220-age

Speed in m/min [to convert mph to m/min multiply by 26.82]

% grade = elevation from ground in degrees divided by 100.

Statistical Analysis

The results were expressed as mean ± standard deviation (SD). A p value of < 0.05 was considered statistically significant.

Data analyses were performed on SPSS software (PSAW, Windows version 18.0).

RESULTS

Anthropometric measurements of the participants are summarized in [Table 2].

Table 2: Anthropometric Measurements of subjects

Basic characteristics	Range	Statistic (mean ± SD)
Age (years)	18- 25	21.17 ± 1.98
Height (cm)	162- 187	172.26 ± 4.62
Weight (kg)	51- 79	64.42 ± 6.19
BMI (kg/m2)	18.17- 25.06	21.70 ± 1.79

Heart rate in different stages of the test is summarized in [Table 3 & Figure 1]

Table 3: Effect of Bruce submaximal exercise on heart rate (Mean ± SD, n=125) of subjects at different stages

Clinical parameters	Pre test	Stage I	Stage II	Stage III	Net Change (pre to post exercise)	p value
HR(beats/min)	75.57 ± 3.61	112.08 ± 7.48	130.17 ± 8.58	164.31 ± 5.26	88.74 ± 5.23	<0.001

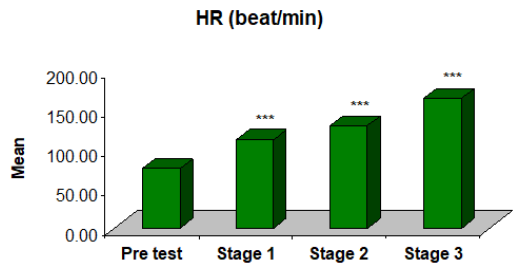

Figure 1: Pre-exercise and post-exercise mean HR of subjects during different stages of Bruce submaximal exercise test.

***p<0.001- as compared to Pre test

The mean value of VO2max mean ± SD was 47.06 ± 2.74 ml/kg/min (range 42.07 to 58.23 ml/kg/min).

As VO2max is an indicator of health/fitness, a PF assessment was also done between two tests using criteria defined by The Physical Fitness Specialist Certification Manual, The Cooper Institute for Aerobics Research, Dallas TX, revised 1997 printed in Advance Fitness Assessment & Exercise Prescription, 3rd Edition, Vivian H. Heyward, 1998, p. 48. The PF assessment scores were estimated for 20-29 age groups as most of the subjects ranged between 20-29 age groups (76.8%)

The physical fitness assessment scores are summarised in [Table 4 and Figure 2]

Table 4: Frequency distribution of PF assessment of subjects by VO2max

PF assessment score	Bruce submaximal exercise (n=125) (%)
Fair	3 (2.4)
Good	53 (42.4)
Excellent	64(51.2)
Superior	5 (4.0)

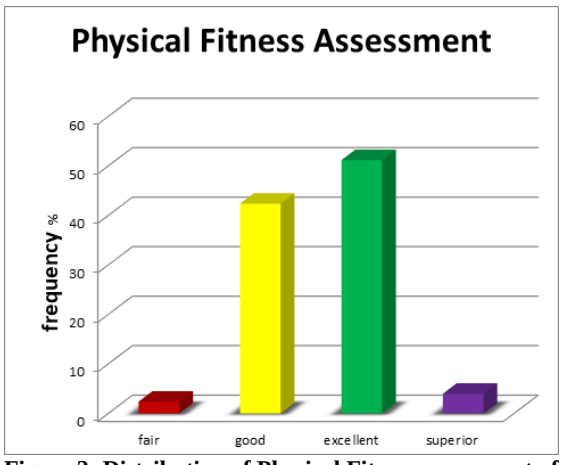

Figure 2: Distribution of Physical Fitness assessment of subjects

DISCUSSION

The importance of PF cannot be emphasized enough. The total amount of PA carried out by an individual is decreasing in amount day by day. Long standing decrease in PA is leading to more increase in the incidence and prevalence of the lifestyle diseases. Increase in the PA makes an individual more physically fit. Increase in the PF leads decrease risk of chronic disease as well as decrease in the mortality and morbidity associated with all causes. PF is not a static entity. It is in dynamic equilibrium with the PA. Those who are fit require PA to maintain their fitness and those who are currently unfit also require PA to increase their level of PF.

Various previous studies have reported accuracy and reliability of submaximal exercise tests in predicting the values of VO_2 max. Olson MS, et.al.[14] indicated that a four-minute aerobic dance test provides a valid and reliable sub-maximal protocol for estimating VO2max and providing an index of aerobic fitness in apparently healthy 18 to 40 years old females. Ebbeling CB, et.al.[15] concluded that the submaximal walking test based on a single stage of a treadmill protocol provides a valid and time-efficient method for estimating VO_2max. Kline GM, et.al.[16] in their study concluded that one-mile walk test protocol provides a valid submaximal assessment for VO_2max estimation. Minor MA, et al.[17] assessed the reliability and validity of single stage submaximal treadmill test to estimate VO_2max in women with rheumatic disease and reported its suitability for use in clinical and community settings and also that it is a reliable and valid method to safely assess the VO_2max in women with rheumatic disease. Eng JJ. et.al.[18] established the test-retest reliability and concurrent validity with VO_2max for three submaximal exercise tests in individuals with chronic stroke. The VO_2 measures of the submaximal exercise tests had excellent reliability and good concurrent validity with VO_2max. They also concluded that submaximal exercise tests may be one potential method of monitoring effects of interventions following a screening test. Eston R, et.al.[19] in their study assessed the validity of predicting the VO_2max of sedentary men from sub-maximal VO_2 values obtained during a perceptually regulated exercise test. Their results suggested that a sub-maximal, perceptually guided graded exercise test provides acceptable estimates of VO2max in young to middle-aged sedentary males. Lambrick DM, et.al.[20] in their study assessed the utility of a single, continuous exercise protocol in facilitating accurate estimates of VO2max from submaximal HR and the RPE in healthy, low-fit women, during cycle ergometry. They recommended RPE as a valuable tool that can be easily employed as an adjunct to HR, and provides supplementary clinical information that is superior to using HR alone. Klusiewicz A, et.al.[21] assessed the accuracy of prediction of VO2max from submaximal and maximal exercises on a ski ergometer. Their results demonstrated that VO2max can be predicted from the exercise test on the ski ergometer both in the submaximal exercise from the relation between HR

and oxygen uptake or power output and from the relation between VO2max and maximal power output without oxygen uptake measurement. GRANT JA, et.al.[22] compared the results of 7 commonly used indirect VO2max tests to those of a direct VO2max test in a constant subject group. Their study found 6 of the 7 predictive tests to be valid for women 18 to 35 years old. Validity coefficients were low for the data from the men's group, rendering it inconclusive. Marsh CE,[23] assessed the validity of the American College of Sports Medicine's (ACSM's) submaximal treadmill running test in predicting VO2max. They concluded that the ACSM equation provides a reasonably good estimation of VO2max. However, they recommended direct measurement of VO2max if a precise knowledge of is required. Koutlianos N, et.al.[24] assessed the indirect calculation of VO2max using ACSM's equation for Bruce protocol in athletes of different sports and compared it with the directly measured VO2max values. They also developed regression model for predicting VO2max in athletes. They concluded that ACSM's equation was not capable of accurately predicting VO2max in athletes aged 18-37 years using Bruce protocol. Only the regression models were correlated moderately with the actually measured values of VO2max.

Koley S.[25] determined the values of VO2max from college going boys by Queen's college step test and reported VO2max values 48.74±8.74 ml/kg/min. Smilee JS, et al,[26] predicted the value of VO2max using Astrand-Rhyming normogram in north Indian and south Indian male subjects exercising at submaximal workload on bicycle ergograph. VO2max values were 51.21 ± 7.20 ml/kg/min in north Indian vs. 49.19 ± 7.86 ml/kg/min in south Indian subjects were found. Setty P, et. al,[27] determined the VO2max in young healthy male subjects by treadmill jogging test. The VO2max values were 48.90 ± 4.24 ml/kg/min. Comparing the VO2max values from our study 47.06 ± 2.74 ml/kg/min the small differences in values of VO2max may be apparent because all the tests are indirect and a small difference can be there due small error in prediction. They may be actual due to difference in fitness or genetic or socioeconomic or multi-factorial in nature.

Dasgupta PK, et.al.[28] determined VO2max in runners by maximal exercise test on treadmill. Values VO2max were 46.24±5.18 ml/kg/min short distance runners, 52.26 ± 2.8 ml/kg/min in medium distance runners and 51.03 ± 1.96 ml/kg/min in long distance runners. When compared to VO2max values from our study 47.06 ± 2.74 ml/kg/min. The higher values of VO2max in long and medium distance runners are due to effect of training. Lower values of VO2max in short distance runners because short distance runners utilize greater amount of energy from anaerobic than aerobic sources. So, their VO2max may not be high as compared to long and medium distance runners.

Looking at the VO2max prediction studies we conclude that the Bruce submaximal exercise test used in our study gave values of VO2max that were not having a large difference for their matching counterpart studies.

CONCLUSION

1. Bruce submaximal exercise Test is a valid, safe and reasonably accurate method for the estimation of Aerobic power (VO2max) in young adults.
2. Jogging is a popular form of exercise and treadmills are readily available in laboratories, can be employed for exercise prescription.
3. Assessment of physical fitness can be done using the submaximal exercise test that can be used as a baseline value in future training programme.
4. Health promotion policies & physical activity programs should be designed to improve physical fitness.

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