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A COMPARATIVE STUDY OF CARDIOVASCULAR RESPONSE IN TWO ACUTE SUBMAXIMAL TREADMILL EXERCISE TESTS AND ITS CORRELATION WITH ANTHROPOMETRIC VARIABLES

Physiology

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ABSTRACT

Aim: (i) To assess and compare the cardiovascular response in two sub-maximal exercise tests. (ii) to see correlation between cardiovascular response and anthropometric variables.

Method: 125 males 18-25 years underwent first three stages of the original Bruce protocol in one session and exercise according to Treadmill jogging test in another session in randomised order. Heart rate, blood pressure and ECG were recorded before, during and after taking the treadmill test.

Results: During the exercise heart rate and systolic BP rose and diastolic BP fell in both the tests. Correlation analysis showed highly significant positive correlation between BMI and pre-exercise systolic BP, post-exercise heart rate and post-exercise systolic BP in both the tests. ECG showed no significant ST/T or rhythm changes during or after the exercise.

Conclusion: Heart rate and BP changes were more in Bruce submaximal exercise test as compared to treadmill jogging test. Higher BMI was found to be correlated with higher resting systolic BP, higher post-exercise heart rate as well as higher post-exercise systolic BP.

KEYWORDS

sub-maximal exercise, treadmill test, cardiovascular response, BMI.

INTRODUCTION

Dynamic exercise produces the most striking burden on cardiovascular (CV) system out of any of the various stresses encountered in normal life. One of the earliest and perhaps obvious observations about the CV system is that the heart rate (HR) and blood pressure (BP) rise during exercise. Mean and systolic blood pressure (SBP) increase with increasing exercise intensity. While during dynamic exercise total peripheral resistance falls than its value at rest which leads to decrease in the diastolic blood pressure (DBP). The study of CV response to exercise provide an excellent method to improve the understanding of the CV system operation during exercise [1-4]. The exercise stress test has several indications, among which the assessment of the levels of functional capacity to participate in vocational, leisure and sport activities, as well as to observe the arterial pressure response to exertion [5,6]. Individuals normotensive at rest but show an exaggerated BP response to exercise are at greater risk of developing hypertension in future. Exaggerated BP response to exercise may serve as an additional risk marker for hypertension [7]. Excessive amount of body fat exerts an unfavourable burden as well as hindering action towards cardiac function particularly during exhaustive exercise. A positive correlation was observed between the resting SBP and DBP and age, weight, height and BMI. Arterial BP during physical exertion has a direct relationship with age, weight, height, and BMI [8]. These facts make early identification of persons at increased risk for developing hypertension a priority so that life style modifications can be initiated at an early stage to interrupt the costly cycle of hypertension and prevent the reduction in quality of life associated with this chronic disease [9]. Maximal aerobic treadmill tests require reasonable level of fitness, longer time and are expensive. It is not recommended for recreational athletes and cardio-respiratory compromised individuals.

So, the present study was designed to assess and compare the CV response to acute submaximal treadmill exercise and to see correlation between the anthropometric variables.

MATERIAL AND METHODS

125 apparently healthy males were selected for the study after applying inclusion and exclusion criteria.

Inclusion Criteria- Male -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) [10]** Form before exercise. Subjects who had answered **NO** to all the questions were selected for the study.

Exclusion Criteria -Subjects with history suggestive of CV, 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 **[11].** For treadmill testing guidelines from American College of Sports Medicine (ACSM) were followed.

Weight was measured nearest to 0.1 kg using calibrated weighing machine in light clothing and bare feet and height nearest to 0.5 cm 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 (m^2).

The ambient temperature of the laboratory was maintained between 20-25^{0}C. All the measurements were taken at same time of the day (between 9:00-11:00 am) to avoid diurnal variation.

Pre-exercise BP Measurement: - in supine position after the rest of 10 minutes measured by both palpatory and auscultatory method in right arm using mercury manometer following the standard procedure.

Pre-exercise ECG and HR Measurement: -Instrument used: PC Based Stress Test Analysis (Stress-INVX1) system (CARDIVISION Exercise Stress Test System and Rest ECG Analysis System-*developed by MEDICAID SYSTEMS 389, Industrial Area, Phase-II, and Chandigarh, India.)*

The device is PC based which records 12 lead ECG and HR through wireless communication when connected to the subject with electrodes.

Once the Patient Information Entry was over then we selected on the screen to record the 12-lead ECG. Under Record mode a data collection screen appears comprising of 12-lead real time ECG, and on the right corner of the screen current HR is displayed.

For recording of pre-exercise ECG standard 12-Lead System was followed. Subjects were asked to lie on their back *and to undress up to*

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the waist. The subjects with hairy chests were instructed to shave their chest hair before appearing for exercise testing. The places, where electrodes were to be placed, were wiped with alcohol to remove the oil and dirt. Then self-adhesive disposable electrodes were used on chest and color coded electrodes were used for arms and limbs **[12].**

Exercise ECG And HR Measurement: - Mason-Likar modification of the standard 12-Lead System was followed **[13].** HR and ECG were recorded automatically during the exercise and displayed on computer screen in real time.

Exercise BP Measurement: - BP during the exercise was measured in the right arm by ambulatory mercury manometer. SBP and DBP were measured at the end of every stage manually by mercury manometer **[14-15]**.

The exercise protocols were conducted in random order. There was a gap of at least 48 hrs between the two tests. Both the tests were performed within 10 days to avoid seasonal variation.

Bruce Submaximal Treadmill Test (BSET) [16]
Subject perform first three stages of Bruce Protocol

TABLE-1-stages of the BSET

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

CV variables were recorded at regular intervals. HR gets automatically recorded. BP recorded at the 2 minutes mark in each stage. RPE were recorded at the 2:45 minute mark of each stage. Verbal communication with the subject was maintained throughout the test. The test was terminated if the subject reached the 85%HRmax or if the subject feels fatigued. When the test was terminated, passive cool down was done in supine posture. Monitoring of the HR, BP, and RPE was continued until the subject recover. A HR below100 BPM is an arbitrary value used to gauge recovery.

TREADMILL JOGGING TEST [17]
In this test subjects were made to walk at brisk walking speed at zero level grade for three minutes. This is followed by jogging at a submaximal jogging speed between 4.3 and 7.5 mph at zero level grade until a steady state HR (two consecutive heart beats within 3 BPM 30 sec. apart) was achieved.

CV parameters were recorded at regular intervals. BP was recorded at 2:00 minute mark in walking stage and then in the jogging stage when steady state HR is achieved. HR recorded automatically every 30sec until the steady state HR was achieved. RPE recorded at 2:45 minute in walking stage and then in jogging stage when steady state HR was achieved. The test was terminated when the subject reached the steady state HR or if the subject feels fatigued or the HR reaches 180 BPM. When the test was terminated, passive cool-down in supine posture was done, continuous monitoring of the HR, BP, and RPE was done until the subject recover. A HR below 100 BPM was an arbitrary Value we used to gauge recovery

Statistical analysis: -
Data were summarized as Mean ± SD (standard deviation). Groups were compared by Student's t test. A two-tailed (α=2) p value less than 0.05 ($p<0.05$) was considered statistically significant. 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

Table 3: CV parameters pre-post exercise (Mean ± SD, n=125) of subjects between two tests

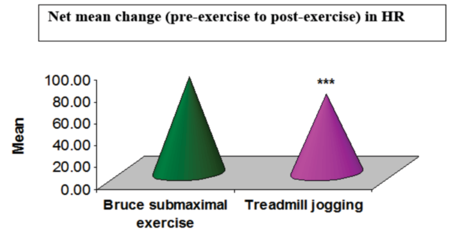
Clinical parameters	Bruce submaximal exercise test		Treadmill jogging test	
	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise
HR (beats/min)	75.57 ± 3.61	164.31 ± 5.26	75.73 ± 3.18	148.38 ± 11.16
SBP (mmHg)	122.61 ± 6.21	169.97 ± 8.72	121.81 ± 5.65	159.44 ± 7.54
DBP (mmHg)	75.42 ± 3.55	72.11 ± 4.07	74.85 ± 3.09	73.22 ± 3.35

To see the effect of two tests (BSET and TMJ) on CV parameters, net change (pre-exercise to post-exercise) in CV parameters of both BSET (post test - pre test) and TMJ (post test – pre test) were compared and summarized in Table 4 and also depicted in Fig. 1 to Fig. 3.

The net change in HR, SBP and DBP in TMJ test lowered by 18.1%, 20.5% and 50.7% respectively as compared to BSET.

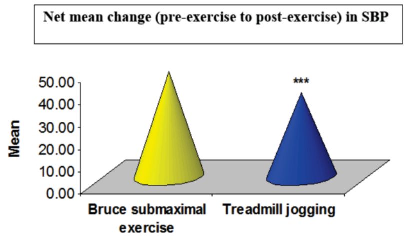
Table 4: Comparison of change (pre-exercise to post exercise) in CV parameters (Mean ± SD, n=125) of subjects between two tests

Clinical parameters	Bruce submaximal exercise test	Treadmill jogging test	t value	p value
HR (beats/min)	88.74 ± 5.23	72.66 ± 10.64	15.17	<0.001
SBP (mmHg)	47.36 ± 7.21	37.63 ± 6.17	11.46	<0.001
DBP (mmHg)	-3.31 ± 2.05	-1.63 ± 1.42	7.53	<0.001



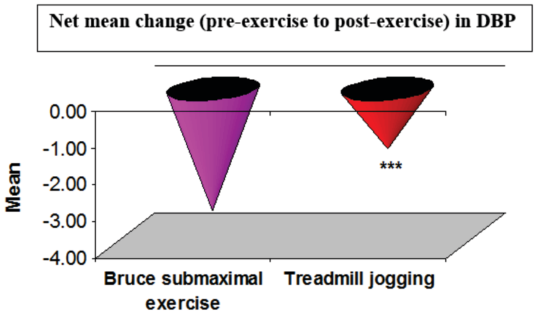
***p<0.001- as compared to Bruce submaximal exercise test

Fig. 1. Net mean change (pre-exercise to post-exercise) in HR of subjects during two tests.



***p<0.001- as compared to Bruce submaximal exercise

Fig. 2. Net mean change (pre-exercise to post-exercise) in SBP of subjects during two tests.



***p<0.001- as compared to Bruce submaximal exercise

Fig. 3. Net mean change (pre-exercise to post-exercise) in DBP of subjects during two tests.

Highly significant positive correlation was found between BMI and pre-exercise SBP as well as between BMI post-exercise SBP and post-exercise HR in both the tests

Table 5-Correlation of BMI with CV parameters (Mean ± SD, n=125) of the subjects between two tests.

Clinical parameters	Bruce submaximal exercise test		Treadmill jogging test	
	r	P	r	P
Pre-exercise SBP	0.58	0.001	0.52	0.001
Post-exercise SBP	0.49	0.001	0.45	0.001
Post-exercise HR	0.44	0.001	0.43	0.001

DISCUSSION

CV parameters change in our present study in both the tests i.e. rise in HR and SBP and fall in DBP with increasing severity of exercise were in agreement with the changes described by ***Bassett DR Jr et al [1], Krogh & lindhard [2], Harold M [3], fletcher GF et al [4], Pande SS et al [18]*** *in their respective studies and also* ***Dabade SK et al [19]*** *in their sample of subjects without family history of hypertension. None of the abnormal CV responses as described by* ***Dlin RA et al [7]*** *and* ***Dabade SK et al [19]*** *were found in our study.*

The amount of change in parameters compared between the two tests in terms of net change (pre-exercise to post-exercise) were not equal. This was due to difference in the workload between the two tests when calculated by ACSM equation **[22]** for walking and running.

Reddy et al [20**]** and **Balogun et al [**21**]** have found that BMI and triceps skin fold thickness are strong determinants and positively correlated with SBP and DBP. In our study we found BMI to be positively correlated with pre-exercise SBP only and not with DBP. ***Pande SS et al [18]*** *also reported positive correlation between BMI and DBP which was not found in our study. This correlation in our study indicates inhibitory action of increasing BMI on CV system at rest and also during exercise indicated by more work done by heart for same amount of workload.*

According to ***Becker MDE M et al [8]*** *there is a positive correlation between resting SBP and resting DBP with height, weight, age and BMI. And arterial BP response to physical exertion also has a direct relationship with* age, weight, height, and BMI while the DBP has a direct relationship with individual's age. In our present study we only found significant positive correlation between BMI and pre-exercise SBP and between BMI and post-exercise SBP and post exercise HR only and not with other anthropometric variables.

CONCLUSION-

1. Submaximal treadmill exercise tests are reliable, safe and valid methods to assess CV response to exercise.
2. Exercise testing provides an opportunity for early identification of future risk of CV morbidity.
3. Abnormal CV response to exercise should be followed by lifestyle modification and pharmacological intervention if required.

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