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Recovery Blood Pressure Patterns following Cold Pressor Test (one of the Autonomic Testing Protocol) in Relation to Aerobic Fitness Levels

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Abstract

The aim of the study was to compare the recovery blood pressure patterns following cold pressor test in relation to aerobic fitness (VO2max) of high fitness (n1=35) and low fitness (n2=35)groups of high altitude male youth. The purpose of the study was to compare between the high fitness group (HFG) and low fitness group (LFG) in regard to recovery blood pressure (RcvBP) following cold pressor test (CPT) of high altitude male youth, which will be useful for evaluation, monitoring grading, and groupingof their aerobic fitness.The high and low fitness groups were determined by VO2max ranks of 242 healthy male youth samplesof Kashmir (attitude: 6070 feet/1850 meters. The study was conducted on 70 samples among which top 35 ranks were considered in HFG and bottom 35 ranks were considered in LFG. The age of the subjects ranged from 18 to 23 years. Data was collected using a standard mercury sphygmomanometer and a stethoscope was used to record the blood pressure of the subjects at various timings of cold pressor test (one of the autonomic testing protocol) and by using insulator box and a thermometer for ensuring the temperature of cold water at 4ocentigrades. The selected variables were age in years, body weight in kilograms (B.Wt.), height in centimeters (Ht.), resting heart rate (HRrest), Basal Blood Pressure (BslBP), pulse pressure (PP), mean arterial pressure (MAP), change of systolic blood pressure at one minutes of cold pressor test (CPT1CSBP), change of diastolic blood pressure at one minutes of cold pressor test (CPT1CSBP), systolic blood pressure at one minute of cold pressor test (CPTSBP1),diastolic blood pressure at one minute of cold pressor test (CPTDBP1), systolic blood pressure at two and half minutes of cold pressor test (CPTSBP2.5), diastolic blood pressure at two and half minutes of cold pressor test (CPTDBP2.5), systolic blood pressure at five minutes of cold pressor test (CPTSBP5) and diastolic blood pressure at five minutes of cold pressor test (CPTDBP5), For statistical analysis the collected data was computed with mean, standard deviation,coefficient of variance and independent't' test. The major findings reflect significant difference between HFG and LFG in regard to VO2max (t = 47.66), (r=0.99); CPTCSBP1Min (t = 3.87), (r=0.42); and CPTCDBP1Min (t = 5.94), (r=0.58). None of the other variables showed a significant group difference in their means neither had any conclusive effect size of group differences. The study concluded that HFG having better recovery of Blood Pressure Patterns than that of LFG and The recovery of Blood Pressure Patterns Following Cold Pressor Testwas faster in HFG than that of LFG.

Key Words: Blood Pressure, Cold Pressor Test, Heart Rate, High Altitude, Kashmir.

1. Introduction

Blood pressure (BP) is the lateral pressure exerted by blood on the vessel walls while flowing through it. (Lateral pressure is that pressure when force is exerted at right angles to the direction of follow at any point within a tube filled with a circulating fluid). (Chatterjee, 1951)

Systolic Pressure (S.P) is the maximum pressure during the systole. (Contraction of heart muscle is medically called as systole). (Chatterjee, 1951). Diastolic pressure (D.P) is the minimum pressure during the diastole. (Relaxing of heart muscle is medically called as diastole). (Chatterjee, 1951).Pulse Pressure (PP) is the difference between the systolic and accepted diastolic pressure. (Chatterjee, 1951)

PP = Systolic Pressure – Diastolic Pressure

Mean Arterial Pressure (MAP) is defined as the average pressure in subject's arteries during one cardiac cycle. It is considered a better indicator of perfusion to vital organs than systolic blood pressure (Chatterjee, 1951).

$$MAP = \frac{2 \text{ x Diastolic} + \text{Systolic}}{3}$$

A very recent reviewed study concluded that high-altitude exposure has been well recognized as a hypoxia exposure that significantly affects cardiovascular function. However, the pathophysiologic adaptation of cardiovascular system to high-altitude hypoxia (HAH) varies remarkably. It may depend on the exposed time and oxygen partial pressure in the altitude place. In short-term HAH, cardiovascular adaptation is mainly characterized by functional alteration, including cardiac functional adjustments, pulmonary vascular constriction, transient pulmonary hypertension and changes in cerebral blood flow (CBF). These changes may be explained mainly by ventilatory acclimatization and variation of autonomic nervous activity. In long-term HAH, cardiovascular adaptation is mainly characterized by both functional and structural alterations. These changes include right ventricle (RV) hypertrophy, persistent pulmonary hypertension, lower CBF and reduced utero-placental/ fetal volumetric blood flows (Ke Wang et.al, 2017).

Altitude exposure is associated with major changes in cardiovascular function. The initial cardiovascular response to altitude is characterized by an increase in cardiac output with tachycardia, no change in stroke volume, whereas blood pressure may temporarily be slightly increased. After a few days of acclimatization, cardiac output returns to normal, but heart rate remains increased, so that stroke volume is decreased. Pulmonary artery pressure increases without change in pulmonary artery wedge pressure. This pattern is essentially unchanged with prolonged or lifelong altitude sojourns. Ventricular function is maintained, with initially increased, then preserved or slightly depressed indices of systolic function and an altered diastolic filling pattern. Filling pressures of the heart remain unchanged. Exercise in acute as well as in chronic high-altitude exposure is associated with a brisk increase in pulmonary artery pressure. The relationships between workload, cardiac output and oxygen uptake are preserved in all circumstances. Altitude exposure carries no identified risk of myocardial ischemia in healthy subjects but has to be considered as a potential stress in patients with previous cardiovascular conditions (Naeije, 2010).

High altitude exposure may induce important changes in blood pressure (BP) regulation, leading to significant increases in BP levels. By inducing atherosclerotic changes, stiffening of large arteries, renal dysfunction, and arterial baroreflex impairment, advancing age may induce progressive increases in systolic BP levels, promoting development and progression of arterial hypertension. It is also known, although mainly from studies in young or middle-aged subjects, that exposure to high altitude may influence different mechanisms involved in blood pressure (BP) regulation (i.e., neural central and reflex control of sympathetic activity), leading to important increases in BP levels. The evidence is less clear, however, on whether and to what extent advancing age may influence the blood pressure (BP) response to acute or chronic high altitude exposure (Parati et.al, 2015).

Another study has been conducted on 20 sojourners, between the ages of 20-30 years, to evaluate responses of the autonomic nervous system during acclimatization to high altitude. The responses measured consisted of heart rate (HR), blood pressure (BP), oral temperature (OT), mean skin temperature (SkT), cold pressor response (CPR), orthostatic tolerance to tilt and urinary catecholamines. The subjects were tested initially at Delhi (altitude 260 meters) and thereafter, on acute induction to an altitude of 3500 meters periodically for three weeks. For comparison, the same responses were studied on 10 acclimatized lowlanders (AL) who had been staying at the same altitude for more than a year and on 10 high-altitude natives (HAN). The studies showed a rise in HR, BP, OT and urinary catecholamines and a fall in SkT, CPR and orthostatic tolerance immediately on arrival at high altitude (HA), indicating a relative hyperactivity of the sympathetic system. After a stay of one week, there was a gradual recovery in all the responses, though sympathetic hyperactivity was still maintained throughout the three weeks of stay. In lowlanders (AL) also there was a preponderance of sympathetic activity, though of relatively lesser magnitude than that seen in sojourners. In High Altitude Natives (HAN), on the other hand, there was a relative parasympathetic predomination. It has been concluded that in lowlanders it takes more than a year of stay at altitude for complete recovery of autonomic balance (Malhotra et.al, 1976).A well-defined battery of five tests namely, deep breathing, valsalva manoeuvre, hand grip, cold presser and lying to standing are used to measure autonomic reflexes.

Blood pressure response test namely cold pressor test (CPT) has been used in the present study on Kashmiri male youth for sympathetic reactivity measurements. The autonomic pathways involved in these cardiovascular reflexes are extremely complex and encompass both sympathetic and parasympathetic fibers to a greater or lesser extent. Most observers now agree that the blood pressure (BP) response to cold pressor is also mediated through sympathetic pathway. It was best verified by the drugs that interfere with sympathetic transmission, inhibited the cold pressor response. (Kern et.al, 1985).

1.1 Cold Pressor Test:

Immersion of hands or feet for about 60–90 seconds in cold water (4°C) should, due to activation of afferent pain and temperature fibres from the skin as well as emotional arousal, lead to sympathetic activation and increase in blood pressure and heart rate. (Klien, 2008)A rise in diastolic blood pressure is calculated and it should normally exceed 15 mmHg. A different kind of response takes place after immersion of the face in water with breath holding (diving reflex), as regardless of water temperature it leads to bradycardia (Van den Berg et.al, 1997).Heart rate decreases by approximately 40 beats per minute, while blood pressure increases by approximately 25 mmHg. A cold face test is a modification of the latter procedure during which a cold compress (1–2°C) is applied to the subject's face for a period of 1–3 minutes. It has similar sensitivity in evaluating parasympathetic response. However, it is better tolerated by the patients/subjects. Moreover, it may be performed in subjects who are unable to cooperate with other challenge manoeuvres.

The Purpose of the study was to compare between the high fitness group (HFG) and low fitness group (LFG) in regard to recovery blood pressure patterns following cold pressor test of high altitude male youth, which will be useful for evaluation, grading, grouping and monitoring of their aerobic fitness.

2. Methodology:

2.1 Selection of Subjects:

The study included two hundred and forty two healthy male subjects of Kashmir (altitude: 6070 feet/1850 meters). The age of the subjects ranged from 17 to 23 years. The subjects performed submaximal bench step test (American College of Sports Medicine Protocol) to determine the VO_2max by plotting HR-workload combinations calculated by Karvonen heart rate reserve method. Among the total 242 subjects which were involved in the study, top 35 ranks as HFG and bottom 35 ranks as LFG on the basis of VO_2max scores have been selected for the purpose of the study.

2.2 Equipments Used:

A mercury sphygmomanometer (Omega Gold 2000), standard stethoscope, ice box (insulator in nature) and a large thermometer.

2.3 Selection of Variables

The selected variables were as follows:

Table-1
Abbreviation and Description of Selected Variables

S.No	Abbreviation	Description	S.No	Abbreviation	Description
1	AGE	Age in years	10	CPTCSBP1Min	Change of systolic blood pressure at one minute of cold pressor test
2	HGT	Height in centimeters	11	CPTCDBP1Min	Change of diastolic blood pressure at one minute of cold pressor test
3	WGT	Weight in kilograms	12	SBPCPT1Min	Systolic blood pressure at one minutes of cold pressor test
4	VO_2max	Maximal Oxygen Consumption	13	DBPCPT1Min	Diastolic blood pressure at one minutes of cold pressor test
5	BslSBP	Basal systolic blood pressure	14	SBPCPT2.5Min	Systolic blood pressure at two and half minutes of cold pressor test
6	BslDBP	Basal diastolic blood pressure	15	DBPCPT2.5Min	Diastolic blood pressure at two and half minutes of cold pressor test
7	MAP	Mean arterial pressure	16	SBPCPT5Min	Systolic blood pressure at five minute of cold pressor test
8	PP	Pulse pressure	17	DBPCPT5Min	Diastolic blood pressure at five minutes of cold pressor test
9	HRrest	Resting heart rate			

2.4 Administration of Test:

The subjects were instructed about the test called as cold pressor test (CPT). Baseline blood pressure was recorded and subject was asked to immerse right hand in cold water of four (4ºC) degree Celsius for one minute. (Low, 1984) The temperature of the water was ensured by using a large size thermometer.

2.5 Collection of Data:

The blood pressure reading were recorded at just before the hand was taken out of the cold water (i.e. at the end of one minute of right hand immersion). The BP was taken again at 2.5 minutes and 5 minutes after the hand was withdrawn from the cold water box and wrapped in a hand towel.

2.6 Statistical Analysis:

Mean, standard deviation and coefficient of variancehave been calculated for all the selected variables. Levene's test have been done for testifying the homogeneity of group variances and the variables have been compared on the basis of independent sample "t" test using SPSS.

Findings:

Table-2
Descriptive Statistics of the selected Variables of the subjects (High Altitude Kashmiri Male Youth)

S.NO	Variable	HFG			LFG		
		Mean	SD	CV	Mean	SD	CV
1	AGE	18.94	0.91	4.78	18.74	0.82	4.36
2	HGT	172.23	5.68	3.30	170.43	6.50	3.81
3	WGT	55.16	6.20	11.24	53.56	8.62	16.09
4	VO_2max	60.57	1.29	2.12	45.64	1.33	2.92
5	BLSBP	112.51	9.96	8.85	110.20	14.98	13.60
6	BLDBP	66.09	8.66	13.10	65.74	9.96	15.15
7	MAP	81.14	7.85	9.67	80.54	10.73	13.33
8	PP	46.43	9.70	20.89	44.46	10.06	22.63
9	HRrest	63.03	8.37	13.27	73.77	12.28	16.64
10	CPTCSBP1Min	17.26	12.31	71.30	6.37	11.19	175.60
11	CPTCDBP1Min	20.51	12.37	60.30	5.91	7.67	129.73
12	SBPCPT1Min	129.09	14.34	11.11	123.40	19.70	15.97
13	DBPCPT1Min	85.63	14.99	17.51	79.86	12.08	15.13
14	SBPCPT2.5Min	115.91	13.31	11.48	117.57	13.36	11.36
15	DBPCPT2.5Min	73.77	9.80	13.28	77.77	10.45	13.44
16	SBPCPT5Min	114.74	8.78	7.65	119.54	19.01	15.90
17	DBPCPT5Min	73.89	8.22	11.12	74.69	10.92	14.62

$N_1 = 35$; $N_2 = 35$; $N_1+N_2 = 70$;
Where N_1= Number of subjects in high fitness group (HFG); N_2= Number of subjects in low fitness group (LFG); Blood Pressure is expressed in mmhg.

Table-3
Comparison betweenHFG and LFG in regard to Recovery Blood Pressure Patterns Following Cold Pressor Test of High Altitude Male (Kashmir Youth)

S.NO	Variable Name	Levene's Test	t-test for Equality of Means				Effect size
		F	t	df	Mean Difference	Std. Error Difference	r
1	Age	0.06 NS	0.97 NS	68	0.2	0.21	0.12
2	Height	2.01 NS	1.23 NS	68	1.8	1.46	0.15
3	Weight	0.45 NS	0.89 NS	68	1.6	1.79	0.11
4	VO2max	0 NS	**47.66***	68	14.93	0.31	**0.99**
5	BLSBP	**6.73***	0.76 NS	59.13	2.31	3.04	0.10
6	BLDBP	3.09 NS	0.15 NS	68	0.34	2.23	0.02
7	MAP	**5.26***	0.27 NS	62.26	0.6	2.25	0.03
8	PP	0 NS	0.84 NS	68	1.97	2.36	0.10
9	HRrest	0.65 NS	**-4.28***	68	-10.74	2.51	0.46
10	CPTCSBP1Min	0.57 NS	**3.87***	68	10.89	2.81	0.42
11	CPTCDBP1Min	3.56 NS	**5.94***	68	14.6	2.46	**0.58**
12	SBPCPT1Min	2.75 NS	1.38 NS	68	5.69	4.12	0.17
13	DBPCPT1Min	0.05 NS	1.77 NS	68	5.77	3.26	0.21
14	SBPCPT2.5Min	0.01 NS	-0.52 NS	68	-1.66	3.19	0.06
15	DBPCPT2.5Min	0.05 NS	-1.65 NS	68	-4	2.42	0.20
16	SBPCPT5Min	**12.26***	-1.36	47.87	-4.8	3.54	0.19
17	DBPCPT5Min	1.5 NS	-0.35	68	-0.8	2.31	0.04

N_1= 35; N_2= 35; N_1+N_2 = 70; *= significant at 0.05 levels of significance;
NS =insignificant; Blood pressure is expressed in mmHg.

Table-3 documents the F- statistic of Levene's Test for checking the homogeneity of group variances. On the basic of Levene's test appropriate t-statistic (t-statistic with Equal variance assumed when Levene's test is not significant and t-statistic with equal variance not assumed when Levene's test is significant) has been selected and it was found to be statistically significant between HFG and LFG in regard to VO_2max (t = 47.66), (r=0.99); CPTCSBP1Min(t = 3.87), (r=0.42); and CPTCDBP1Min(t = 5.94), (r=0.58). None of the other variables showed a significant group difference in their means neither had any conclusive effect size of groups.

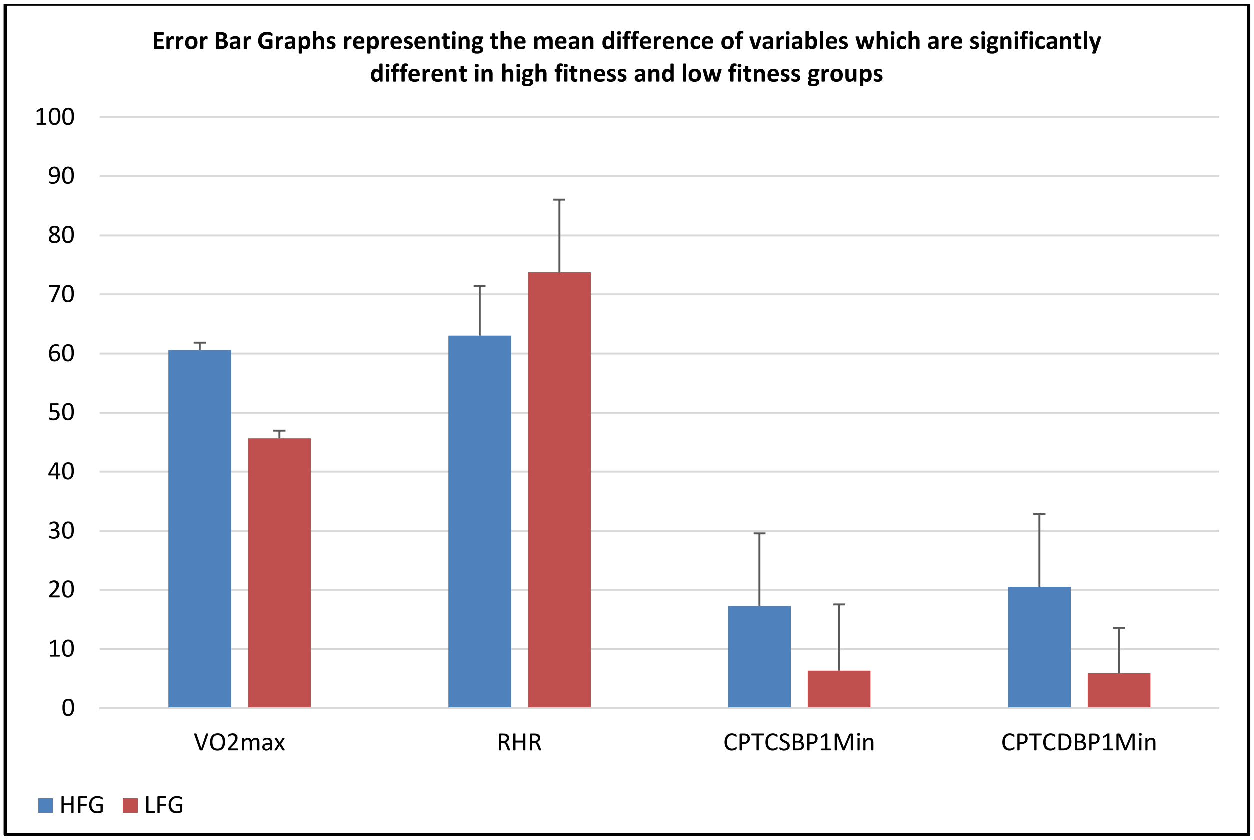

Figure 1. Showing the Difference in mean scores of HFG and LFG

4. Discussion of Findings:

The analysis of the table-2 reveals that the recovery blood pressure patterns following cold pressure test was faster in HFG than that of LFG.

5. Conclusion:

It is concluded that HFG having better recovery blood pressure patterns than that of LFG following cold pressure test which corroborates with existing theories.

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