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Comparison of Cardiovascular Responses to Cold Stress of Summer and Winterover Members in Antarctica

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Abstract

Nine subjects each from eleventh Summer and eighth Wintering teams were studied to compare the changes in the cardiovascular reactivity to cold exposure. Cold immersion test (CT) was carried out on these subjects on three occasions and simultaneous record of pain threshold time, blood pressure, heart rate (ECG) were obtained. The results show that the normal reactivity of cardiovascular system to cold exposure gets attenuated after acclimatization in Antarctic environment. The short summer exposure was sufficient to increase the cold induced pain threshold. However, it lasted only for three weeks whereas for winter groups the acclimatization was for a longer period. This indicates different mechanism of acclimatization for the two groups.

Introduction

Adaptation to cold results in an increase in the peripheral blood flow in human subjects. The duration and intensity of cold exposure controls the responses to cold exposure. Adaptation to cold is evidenced by enhanced capacity for heat production, or by modification in the cardiovascular responses in human subjects. Cold pressor test or cold immersion test (Singh et al.,1991) is a common autonomic function test which is utilised to study cold adaptation as well as sympathetic nervous system activation in human subjects. The measurement of pain threshold time (PTT) during cold immersion test has also been used as an index of pain tolerance (Leblanc et al.,1960 and Dowling et al.,1983).

The present study was carried out in 'Maitri', the Indian station in Antarctica to determine the difference in vascular adaptability in subjects exposed for short (8 weeks of austral summer) and long (10 months of austral winter) periods. Also a correlation of pain threshold to vascular change after cold acclimatization in Antarctica was attempted.

Materials and Method

Subjects:

The study was conducted on two groups of volunteers, members of summer and winter teams. Nine male subjects in each group were studied. Group I (summer members) had a mean ± SE age of 29.2 ±4.8 years with the body mass index (BMI) of 22.75 ± 2.44. Group II (winter members) were of 29.6 ± 5.6 years with the BMI of 22.56 ± 2.72.

In case of Group I the experiments were conducted on board ship for baseline data in room temperature of 24 ± 2°C. These were repeated after eight weeks of stay in Maitri station. Members of Group II were studied only once on board ship, three weeks after the subjects left Maitri station and were on their return journey to India. The PTT was recorded in both the Groups at this time.

Procedure of cold immersion test:

Cold immersion test was elicited by immersing the right hand (upto the wrist) of the subject in a constantly stirred waterbath maintained at 4 ± 2°C. The hand was kept immersed either till the subject complained of pain or to a maximum of 5 minutes.

The heart rate (HR), galvanic skin resistance (GSR), blood pressure (BP) and pain threshold time (PTT) were also recorded. The HR was recorded by the standard limb lead II ECG tracings taken on a polygraph (Biorite manufactured by Medicare systems, India). The HR, BP and GSR were recorded 30 seconds before immersion and again 60 seconds after immersion. The heart rate calculation was done by determining the R-R interval.

The BP was recorded from the left arm using a standard aneroid sphygnomanometer and stethoscope. Korotkoff sound phase V was considered for diastolic pressure measurement.

GSR was recorded by measuring the electrical resistance with a model ME digital multimeter (MECO, India). Silver chloride button electrodes were fixed with velcro straps around the distal phalanx of the index and middle fingers of the left hand. The hand was cleaned properly by applying soap to remove the grease before placing the electrodes.

PTT was recorded by a stop watch and expressed in seconds.

The statistical analysis was done by paired 't' test for comparison of two Groups.

Results

Systolic blood pressure

The basal systolic blood pressure before and after the summer stay in Antarctica remained the same (121.55 ± 8.83 and 121.0 ± 7.78 mm of Hg, respectively). The basal systolic blood pressure in the wintering subjects was lower than that of summer subjects, though the difference was not significant. The cold immersion resulted in significant increase (P = <0.05) in the systolic BP of 6.22 ± 2.31 mm Hg after immersion test in basal condition in the ship. This response was attenuated when the same Group was subjected to the second experimental reading after a stay of eight weeks (Table I, Fig 1).

The acclimatized winter Group also showed the attenuated reflex rise of systolic blood pressure after cold immersion.

Diastolic blood pressure

The basal diastolic blood pressure was also not altered after the summer in Antarctica (80.66±6.25 vs 82.25±4.49 mm Hg).

On cold immersion test the diastolic BP showed a steady increase on all the three occasions. The rise in dBP was highest after summer stay (82.25±4.49

Table I: The Responses of Changes in Blood Pressure, Heart Rate, Galvanic Skin Resistance and Pain Threshold Time After Cold Immersion of Summer and Winter Groups

Parameter	Summer Basal (1st)		Summer after 8 weeks (2nd)		Winter 3rd	
	Initial	Immersion	Initial	Immersion	Initial	Immersion
s.BP	121.55	127.77	121.0	120.75	116.0	118.44
mmHg mean±SD	±8.83	±8.6	±7.48	±9.10	±8.89	±11.53
d.BP	80.66	87.77	82.25	89.0	80.88	85.55
mmHg mean ±SD	±6.25	±3.82	±4.49	±10.48	±4.33	±7.16
HR	76.44	80.0	75.0	78.0	77.77	76.77
per min mean ±SD	±9.17	±15.46	±7.14	±6.40	±10.8	±9.09
GSR	637.76	512.44	535.33	503.11	876.11	938.67
k.Ohms mean ±SD	±160.64	±206.54	±277.76	±324.85	±298.83	±251.53
PTT > 5 min (n=9)		2/9		9/9		9/9

to 89.0±10.48 mmg Hg) and the rise was least in winter subjects (80.88±4.33 to 85.55±7.16 mmg Hg).

Heart rate

The basal heart rate of the summer group subjects was 76.44±9.17 per minute and that for winter group subjects was 77.77±10.8 per minute. The difference between the two groups is insignificant.

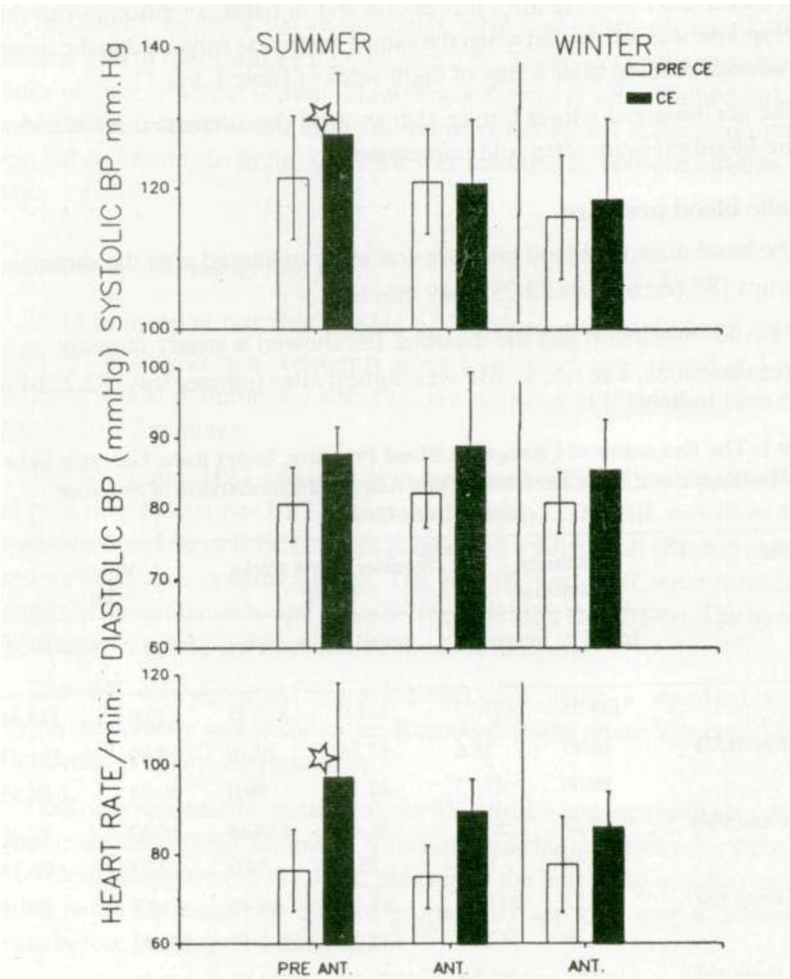

*Fig 1 : The effects of cold immersion (CI) on blood pressure and heart rate of summer and winter subjects. n=9 in each group. (mean +SD, * = p)*

The increase in HR after cold immersion test was higher in the basal study and this response was reduced after the summer stay. On the other hand, those who had wintered over showed no change in HR after cold immersion (Fig 1).

Galvanic skin resistance

The GSR which is inversely proportional to blood flow, has been measured from the hand which was not immersed in cold. This reflects the reflex systemic change in the blood flow and is different from the local changes shown by Leftheriotis et al.(1990).

A fall in the GSR is normally seen following cold exposure and this response is present in the summer group before Antarctic exposure (637.76± 160.61 to 512.44±206.54 kohms). There was inhibition of this reflex which resulted in diminished fall when the test was repeated on the subjects of summer group. The GSR response of winter group people was opposite to that of summer group. On comparison with either the baseline GSR or following cold immersion, the winter people had significantly higher values (Fig 2).

The basal GSR showed a reduction in the short stay group (637.76 vs 535.33) which is probably due to cold adaptation in Antarctica (Fig 3).

Pain threshold time

PTT is the maximum time for which the hand could be immersed before cold induced pain was experienced. The PTT was 134.5±122.66 sec. in Group I subjects on board ship. When the team reached Maitri PTT increased to 322.25±99.88 sec after 8 weeks of stay. Only 22% (two out of nine) of summer subjects could tolerate cold immersion of 6 minutes in the basal conditions but after 8 weeks this figure rose to 100% (Fig 3). This reading was comparable to the same of 331.87±74.41 sec for the winter team after 15 months of stay in Antarctica.

The PTT when recorded after three weeks of departure from Antarctica, showed that the value for summer members had returned to average value of 149.33 sec whereas for the winter team members it still maintained the high PTT average value of 336 sec (Fig 3).

Discussion

The present study confirms that a rapid cold adaptation within 8 weeks of exposure to Antarctic environment occurs during austral summer and this is due to a decreased sympathetic reactivity of vascular smooth muscles. This vascular adaptation in the short stay group is reversible within 2 to 3 weeks of

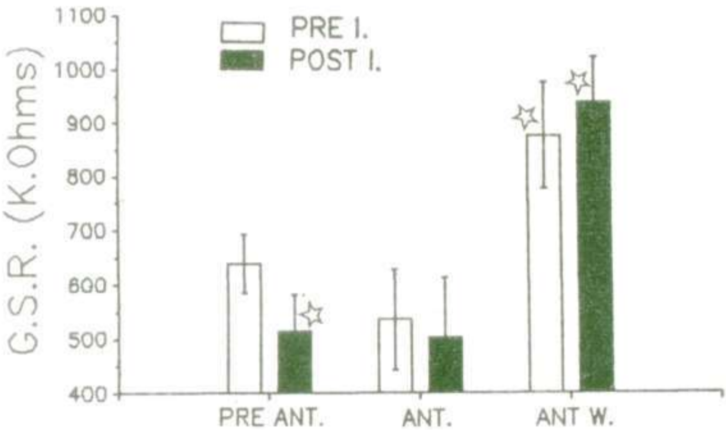

*Fig 2 : The effect of cold immersion (CI) on galvanic skin resistance (GSR) of summer and winter subjects. n=9 in each group. The graph shows significant reduction of GSR with CI only in summer subjects whereas winter subjects show an increase in GSR. (mean +SD * = p)*

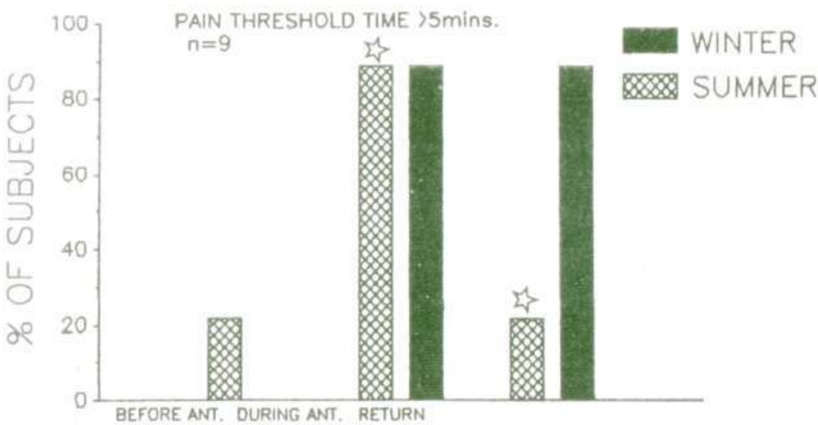

*Fig 3 : The pain threshold time (PTT) of summer and winter subjects. n=9 in each group. See text for explanation. (* = p)*

exposure to warm environment. The prolonged stay group (winterover group), who are exposed to Antarctic environment over a longer period, do not lose this cold acclimatization till 3 weeks of return to warm environment. This clearly indicates that duration of cold exposure is an essential factor for sympathetic cardio-vascular sensitivity.

In the present study the galvanic skin resistance, which is inversely proportional to flow of blood, has been measured from the other hand which is

not immersed in cold. This reflects the systematic change in blood flow and the local changes are different as shown by Leftheriotis et al.(1990).

Cold immersion test measures the autonomic reactivity of an individual. The cardio-vascular reflexes lead to an increase in blood pressure and heart rate during cold immersion due to sympathetic stimulation (Tipton, 1989). The experiments carried out in the present study indicate gradual attenuation of sympathetic reactivity to cardio-vascular responses after short stay in Antarctica and is short lasting. The winterover personnel showed a long lasting alteration of sympathetic reactivity indicating down regulation of adrenergic receptors on vascular smooth muscle after adaptation to Antarctic cold.

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