Changes in Orthostatic Tolerance during Short Duration Mild Hypoxia

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Abstract

A STUDY of orthostatic responses (at 60° tilt) of 20 healthy male subjects (25 to 35 years) under overnight fasting conditions (12 to 14 hours) at ground level and after half-hour exposure to hypoxia at 15,000 feet in a hypobaric chamber has been reported. Changes in blood pressure, heart rate and blood sugar and the possible implications while flying on empty stomach have been discussed.

Introduction

Short duration mild hypoxia and overnight fasting may produce an adverse reaction in orthostatic response. Hartzell et al[4] in their study have shown a significant drop in Mean Arterial pressure in sitting subjects with empty stomach after exposure to hypoxia for short duration. King[6] has compared performance of subjects who had missed one meal with those who had not and has shown that those who had missed a meal showed a reduced performance. The responsiveness of vascular reflexes to neurogenic stimuli, norepinephrine and angiotensin infusion were found to have been depressed under hypoxia; and orthostatic stress, as applied by Lower Body Negative Pressure, was not well tolerated [5, 6]. These findings are of special significance to aircrew who resort to flying on empty stomach and who may be exposed to mild hypoxia in hill flying in unpressurized transport aircraft or helicopters. A study has therefore been undertaken to look into whether missing breakfast and flying under mild hypoxia does produce adverse reactions.

Method

Twenty healthy male subjects between the age group of 25 to 35 years were taken up for the study. They were exposed to hypoxia in a decompression chamber to a simulated altitude of 15,000 ft. Orthostatic stress was given with the help of a tilt table inside the chamber. Blood pressure (B. P) was recorded by indirect method from the brachial artery and the ECG for heart rate (H. R) was monitored on a polygraph. Capillary blood sugar was estimated by King's[2] method.

Basal blood pressure and heart rate readings were obtained in supine position when 3 consecutive readings at 5 minute intervals were found to be similar. Response to orthostatic stress was obtained by noting the variations in BP and HR immediately on tilting to 60° and 5 minutes later in the tilted position. Studies were made at ground level and under hypoxia (15000 feet simulated altitude for 30 minutes) for each subject on different days after normal breakfast. Similar studies were made on the same subjects without taking breakfast on two other occasions. Blood sugar was measured before and immediately after the exposure. A direct comparison between the orthostatic response under all the four experimental conditions was obtained. Thus each subject served as his own control.

Observations and Findings

In non-fasting condition at ground level 18 subjects showed normal response (increase in HR and BP, a rise in diastolic pressure and a fall in pulse pressure[8]). Subjects 5 and 16 showed an autonomic insufficiency (AI) response (a drop in BP not associated with a significant increase in HR[7]) but both recovering to a normal response within 5 minutes. Under fasting condition, 17 subjects had a normal response. Subject 5 showed AI response where as subjects 11 and 16 showed orthostatic arterial Anaemia (OAA) response (marked increase in HR without significant change in BP). In subject 11 the response became normal within 5 minutes while subject 16 continued to show OAA response beyond 5 minutes (Table 1 & 3).

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TABLE—1

TABLE SHOWING RECORDS OBTAINED FROM 20 SUBJECTS UNDER FOUR EXPERIMENTAL CONDITIONS

	Basal at Ground Level			Response to 60° Tilt at Ground Level						Response to 60° Head up Tilt with Hypoxia of 30MNB 15000											
										Without Fasting						With Fasting					
	Non-Fast/Fast			Without Fasting 0/5 MTS			With Fasting 0/5 MTS			Before Tilt			After Tilt O MNTS/5 MTS			Before Tilt			After Tilt O MNTS/5 MTS		
	SYST	DIAST	HR	SYST	DIAST	HR	SYST	ŞDIAT	HR	SYST	DIAST	HR	SYST	DIAST	HR	SYST	DIAST	HR	SYST	DIAST	HR
1.	105 110	70 65	65 68	105 105	60 70	80 83	110 105	70 70	85 80	120	70	60	130 130	80 90	72 85	110	70	63	105 105	70 70	88 95
2.	115 110	70 60	63 55	110 110	70 70	70 80	105 105	70 70	83 75	120	70	70	130 130	75 70	88 95	125	70	65	110 110	75 65	85 90
3.	105 105	60 60	72 65	105 105	70 80	90 96	105 100	55 60	75 85	110	60	70	125 115	60 60	85 85	115	60	85	105 105	70 60	72 85
4.	110 105	70 70	58 60	115 125	80 80	68 75	110 105	75 70	75 80	105	55	73	115 105	80 80	88 80	100	60	80	100 100	65 60	85 98
5.	110 110	75 75	73 73	100 105	70 80	78 85	105 110	75 70	75 75	135	85	88	130 BP Not Recordable	85	100 66	105	70	68	BP Not Recordable		45
6.	120 110	60 60	65 53	125 120	60 60	65 73	120 110	65 75	60 63	105	65	63	105 105	50 50	68 72	110	50	63	110 110	60 50	68 80
7.	130 110	60 70	58 55	135 130	70 70	65 70	105 110	70 70	70 70	110	60	68	115 120	60 70	68 75	105	60	65	120 110	55 55	75 75
8.	115 125	70 75	80 73	110 130	80 75	85 105	120 115	80 80	95 95	105	70	98	120 130	75 80	98 108	105	65	75	125 125	80 75	96 108
9.	105 105	65 60	68 60	120 105	80 65	72 80	100 110	75 70	75 75	130	55	70	130 130	65 70	85 88	105	50	65	105 115	60 60	75 88
10.	120 105	75 60	65 60	115 120	65 80	78 72	110 110	60 60	75 78	105	60	75	105 100	60 60	75 95	110	60	78	100 110	70 70	75 93

11.	105	50	75	100	60	95	120	50	75	110	60	88	110	60	95	105	60	80	100	70	95
	120	50	65	115	60	85	125	60	85				105	65	100				105	60	110
12.	120	60	65	120	65	70	105	60	75	120	60	70	100	70	75	105	60	80	105	65	80
	105	50	65	120	60	75	110	60	75				110	70	80				100	65	95
13.	100	55	70	95	65	75	95	60	75	100	60	80	95	65	80	95	60	70	90	60	75
	100	50	65	105	60	75	110	50	80				75	50	70				90	50	85
14.	110	55	70	110	75	80	100	75	85	115	75	75	110	80	75	105	70	70	110	75	80
	110	60	65	110	70	85	105	70	75				110	80	75				105	60	80
15.	105	60	60	125	70	75	105	65	80	100	60	70	105	70	80	100	60	70	110	70	80
	105	60	65	120	70	75	105	70	75				105	70	80				110	75	85
16.	120	60	65	110	55	70	120	60	70	125	60	70	125	65	75	120	70	70	120	70	80
	120	60	55	110	55	75	120	60	75				120	60	85				120	60	90
17.	105	70	65	110	75	70	105	70	65	120	70	80	125	75	70	110	70	70	100	75	90
	105	65	60	105	70	70	105	65	65				125	70	80				110	70	90
18.	110	55	45	125	60	50	115	60	50	120	65	60	110	80	85	105	70	65	100	70	75
	110	50	45	120	60	55	105	60	55				120	80	70				75	Un Record-able	
19.	110	65	60	110	80	70	110	80	85	105	60	65	100	75	90	110	70	60	100	75	90
	110	60	60	105	65	75	105	75	80				100	70	80				105	75	75
20.	110	65	60	110	80	70	105	75	70	110	60	60	100	80	80	110	60	60	115	75	75
	105	60	55	115	80	75	100	75	75				110	85	85				115	75	70

Responses of the twenty subjects after 30 minutes exposure to mild hypoxia while lying supine on the tilt table are shown in Table 2. In supine subjects, fasting produced no significant change in Mean Arterial Pressure (M.A.P.) and HR in comparison to non-fasting condition.

TABLE—2

Changes in MAP & HR in fasting and non-fasting states in supine position after 30 mts. of hypoxia at 15,000 feet. Values compared to their basal records at ground level.

	Mean Arterial Pressure			Heart Rate		
	Increase	Decrease	No Change	Increase	Decrease	No Change
Non-fasting	11	8	1	18	1	1
Fasting	12	8	0	17	2	1

Under non-fasting condition with hypoxia (Table 4) 14 subjects showed normal response to tilt, whereas 6 subjects showed abnormal responses. Subjects 7 and 13 showed the heart failure type of reaction[7] (no change in BP or HR). Subjects 5, 10 and 11 showed OAA response and subject 6 showed AI response. Of the subjects showing abnormal response, subjects 5 and 13 produced typical vasovagal syncope within 5 minutes with bradycardia, hypotension and collapse. Rest of the subjects recovered to a normal reaction within 5 minutes. Out of the 6 Subjects with abnormal response at altitude, 2 subjects showed inadequate response even at ground level. In subject 5 who had an AI response at ground level, hypoxia produced an OAA response on tilt and vasovagal syncopal collapse within 5 minutes.

In the fasting hypoxic condition (Table 1 & 4), 15 subjects showed normal response to tilt while 5 had altered reaction. Subject 5 produced vasovagal syncope immediately on tilt after hypoxia whereas he collapsed after 5 minutes of tilt in the non-fasting state. Subject 18 showed OAA reaction immediately on tilting, leading to a vasovagal syncope within 5 minutes. This subject demonstrated normal reaction in the other 3 experimental conditions. Subject 12 showed Heart Failure (HF) reaction on tilt, later developing into an OAA reaction. Subject 13 had an AI reaction immediately on tilting while after 5 minutes his reaction was of the OAA type. Subject 16 had on OAA response, changing into an AI response after 5 minutes. The blood sugar levels before and after exposure to hypoxia in fasting and non-fasting conditions did not show any significant differences.

From the Tables 3 and 4, it may be observed that hypoxia affects Orthostatic tolerance adversely. This inadequacy becomes more pronounced under fasting conditions.

TABLE—3

Ground Level Response of 20 Subjects to Tilt

SUBJECT STATE		Normal	Heart failure	Orthostatic Arterial Anaemia	Vaso vagal	Autonomic Insufficiency
NON FASTING	Immediate Response	18	NIL	NIL	NIL	2(No. 5 & 16)
	After 5 mts	20	NIL	NIL	NIL	NORMAL
FASTING	Immediate Response	17	NIL	2(No. 11 & 16)	NIL	1 (No. 5)
	After 5 mts	18	NIL	1(No. 16) Normal in 11	NIL	1 (No. 5)

TABLE—4

Response to Tilt in 20 Hypoxic Subjects

SUBJECT STATE		Normal	Heart failure	Orthostatic Arterial Anaemia	Vaso vagal	Autonomic Insufficiency
NON FASTING	Immediate Response	14	2(No. 7&13)	3(No. 5, 10) & 11)	NIL	1 (No. 6)
	After 5 mts	18	1(No. 13) Normal in 7	Normal in 10 & 11	1 (No. 5)	Normal in 6
FASTING	Immediate Response	15	1 (No. 12)	2(No. 16 & 18)	1 (No. 5)	1 (No. 13)
	After 5 mts	15	NIL	3(No. 12, 13 & 16)	2 (No. 5 & 18)	NIL

Discussion

Hartzell[4] has exposed sitting human subjects to a short duration (45 minutes) hypoxia (17,000 feet) and has shown a significant reduction in the MAP under fasting conditions. He concluded that under such conditions some pooling of blood occurs in the lower limbs due to vasodilatation effects of hypoxia. His group contends that fasting reduces the Respiratory Quotient and as a result the Pulmonary Alveolar Oxygen tension falls. This fall would be enhanced by exposure to altitude leading to a disturbance of homeostatic mechanisms mediated by chemoreceptors and baroreceptors. Heistad and Wheeler[6] on exposing hypoxia subjects to Lower Body Negative Pressure have found an inadequate response in that there was a reduction in MAP and an inadequate rise in heart rate. The changes were corrected on breathing normoxic air. Their duration of exposure to hypoxia was 36 hours. The fasting condition was not included.

Nair[10] has reported a study of 20 control subjects acutely exposed to 13,500 feet of which 60 percent showed OAA reaction. He classifies this as the standard Orthostatic response of healthy subjects to hypoxia and attributes it to a failure in adjustments of the autonomic nervous system in causing an increase in venomotor tone. Of his control subjects, 10 percent showed vasovagal reaction which he explained to be due to autonomic system maladjustment in producing a peripheral arteriolar constriction or a reduced response of the peripheral vascular receptors to norepinephrine. Lamb[9] has reported a deconditioning in peripheral arteriolar constriction mechanism in hypoxia.

In our series of 20 subjects, a majority showed normal orthostatic response after half hour exposure to hypoxia. A number of subjects demonstrated inadequacy of orthostatic response under hypoxia and the degree of inadequacy increased under fasting conditions. The exact mechanism as to how fasting aggravates the inadequacy of vascular responses after hypoxia is not clear and requires further investigations.

Conclusion

Our stuy shows that acute short duration hypoxia does alter normal orthostatic response to tilt. Missing of a meal seems to aggravate this inadequate response. A pilot who may show normal orthostatic tolerance at ground level, may have a fainting type of reaction in the hypoxic fasting condition. These findings are of significance to aircrew who may resort to flying on an empty stomach and thus jeopardise flight safety.

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