RELATIVE CHANGES IN SALIVARY SODIUM AND POTASSIUM IN RELATION TO EXPOSURE TO HIGH G STRESS

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ABSTRACT

Salivary Na^+ and K^+ was studied in 16 fighter pilots who were undergoing one week of intensive training for improving their tolerance to G stress. Their saliva was collected on first, third/fourth and sixth day of training. The subjects were also administered a stress coping strategy inventory to obtain scores on their pattern of stress coping. The results showed that K^+ increased by 9.45 mEq/l ($p < 0.01$) whereas Na^+ decreased by 3.58 mEq/L ($p > 0.05$) under peak stress situation. Both K^+ and Na^+ showed a non significant decrease of 4.81 and 2.93 mEq/l respectively in third sample (post stress) compared to second sample (peak stress). K^+ concentration in saliva showed a transient phasic shift whereas Na^+ concentration showed a more persistent tonic shift in relation to G stress. Regression analysis showed significant positive correlation of baseline Na^+ with score on danger control strategy. A significant negative correlation was found between score on danger control strategy and baseline and poststress K/Na ratio.

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KEY WORDS : Stress coping strategies; Human centrifuge training.

Introduction

Normal concentration of salivary Na^+ is reported to range from 8.7 to 24 mEq/l (average 17.4 mEq/l). On the other hand salivary K^+ has normal narrower range of 13 to 16 mEq/l with an average of 14.1 mEq/l. The ionic content of saliva during low flow rate is of utmost interest in assessing the effect of psychological stress. In this range K^+ concentration in saliva exceeds Na^+ and increases steeply as a linear function of decreasing flow while Na^+ concentration remains at low level [1]. It has been reported that transient alarm reactions result in release whereas slower and long lasting stresses increase the rate of Na^+ reabsorption in salivary glands (2-5).

Fighter aircrew are given training in use of anti - G straining manoeuvres (AGSM) to counteract the effects of G stress on circulatory system. The training is considered very demanding and strenuous [6]. It has been

brought out in an earlier study that stress adaptation can be studied scientifically with the help of a 51 item "coping strategy inventory" [7].

It is felt that serial levels of salivary Na^+ and K^+ concentration during exposure to high G stress will provide a predictive physiological index of stress coping. It is also proposed to study the preponderant orientation of our subjects in terms of coping strategies and its correlation with salivary ionic content.

Material and Methods

Subjects : 16 fighter pilots who underwent centrifuge indoctrination course at Institute of Aerospace Medicine, were taken up for this study. They were all young (age : 25 to 32 years) aviators who were well motivated.

Centrifuge indoctrination training : Centrifuge indoctrination training is designed to teach aircrew correct timing and technique for performing AGSM for protection against

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high G stress (acceleration stress) which they encounter during combat manoeuvres in fighter flying. This is practiced by raising intra-thoracic pressure and exhaling through closed and semi-closed glottis forcibly on ground and then during rapid onset G runs in human centrifuge. They are progressively introduced to higher G stress, up to a level of 9G. Thereafter they are continuously exposed to G stress alternating between 4.0 and 8.0 G in what is called as simulated air combat manoeuvre (SACM) for a duration which they can tolerate.

Psychological questionnaire [7] : "Stress coping strategies inventory" was given to all the subjects on the first day of the course. The inventory provided scores on danger control, anxiety control, anxiety repression and situation control. It is a 51 item inventory with 16 statements on danger control, 17 on anxiety repression, 12 statements on anxiety control and 6 statements on situational control. The statements are scored on 0 to 4 scales. For obtaining comparable values the absolute score is divided by maximum possible score on the respective scale.

Salivary Na^+ and K^+ estimation : Flame photometric method was used for estimation of salivary Na^+ and K^+ concentration.

Methodology : All the trainees reported to the department of Neuropsychiatry on the first day before the start of centrifuge runs. They were explained the aims of the study and were administered stress coping strategy inventory. Before collection of the salivary sample, the subjects washed their mouth with water. Explicit instructions were given that the saliva present in mouth only is to be

brought out and no attempt is to be made to produce more. Pre-test demonstration and practice were given. The first and third samples were collected in the biochemistry laboratory before and after the centrifuge training respectively. The second sample of saliva was collected from the subjects while in the cockpit of the centrifuge. This was done just after simulated aerial combat manoeuvre (SACM). Due to unavoidable circumstances, the post-stress sample of saliva could be taken only in 7 out of 16 subjects.

Analysis : The descriptive as well as correlational analysis was carried out with the help of computer software known as Statistical Package for Social Sciences (SPSS).

Results

Table 1 shows the results of coping strategy questionnaire. The mean percentage scores on various scales were calculated by dividing raw score by the maximum possible score and multiplying the sum by 100. The scores showed a narrower dispersion in case of danger control and anxiety control, and greater individual variability in case of anxiety repression.

Table 2 presents the results of salivary ionic concentration during various phases of centrifuge training and their comparative analysis respectively. The baseline salivary content of Na^+ and K^+ in our subjects showed that K^+ was slightly higher compared to the normal range and Na^+ was well within this range. The baseline K/Na ratio was also slightly higher at 1.29. The peak stress values showed significant rise ($p < 0.01$) of 9.45 mEq/l in K^+ , nonsignificant fall of 3.58 mEq/l

TABLE 1
Scores on stress coping strategies inventory

Coping strategies	Mean		SD	Minimum		Maximum	
	Raw	(%)		Raw	(%)	Raw	(%)
Danger control	38.0	59.4	4.39	29.0	45.3	45.0	70.3
Anxiety repression	32.3	47.5	9.99	18.0	26.5	53.0	77.9
Anxiety control	28.9	60.2	5.19	20.0	41.7	37.0	77.1
Situation control	2.8	11.7	2.81	0.0	0.0	11.0	45.8

in Na^+ and increase ($p < 0.004$) in K/Na ratio to 2.42 compared to the baseline values. The comparison of peak-stress and post-stress ionic concentration showed that none of the parameters were found to have any significant difference except K^+ which showed a sizable decline (NS) of 4.81 mEq/l in post-stress condition. The comparison of post-stress values with baseline values showed that the post-stress saliva was lower (NS) by 2.76 mEq/l in K^+ , there was decline ($p < 0.006$) of 11.61 mEq/l in Na^+ and rise ($p > 0.05$) of K/Na ratio to 3.71.

Table 3 shows the results of regression analysis between scores on various scales of

coping strategy inventory (independent variable). The results are shown in the form of standard SPSS output which includes strength of correlation in the form of R square value along with respective F value and significance of F value. It also contains the direction of correlation in the form of beta regression coefficient. The results showed that score on danger control scale of the inventory was significantly positively correlated with baseline Na^+ concentration and negatively correlated with baseline and post-stress K/Na ratio.

Discussion

Selye (2) has reported that hyperkalemia

TABLE 2

Comparative analysis of salivary ionic concentration in different phases of exposure to G stress

Phase	K ⁺ (mEq/l)		Na ⁺ (mEq/l)		K/Na ratio	
	Mean	SD	Mean	SD	Mean	SD
Baseline Vs Peak Stress (N=18)						
Baseline	119.29	8.69	18.39	6.53	1.29	0.88
Peak stress	28.73	12.15	14.8	6.53	2.42	1.85
Mean difference	+ 9.45		-3.58		+ 1.14	
p value	< 0.01		NS		< 0.004	
Peak Stress Vs Post Stress (N=7)						
Peak stress	27.17	9.48	13.37	6.75	2.83	2.13
Post stress	22.36	3.79	10.43	8.48	3.71	3.01
Mean difference	- 4.81		- 2.93		+ 0.88	
p value	NS		NS		NS	
Baseline Vs Post Stress						
Baseline	25.11	7.62	22.06	10.67	1.67	1.11
Post stress	22.36	3.79	10.45	8.48	3.71	3.01
Mean difference	- 2.76		- 11.01		+ 2.14	
p value	NS		< 0.006		NS	

TABLE 3

Regression analysis between psychological attributes and salivary ionic concentration

Independent variable	Dependent variable	R Square	F Value	Sign of F	Beta
Danger control	Baseline Na	0.69	8.82	$p < 0.05$	0.83
Danger control	Baseline K/Na	0.81	17.51	$p < 0.001$	-0.90
Danger control	Post stress K/Na	0.93	51.67	$p < 0.002$	-0.96

occurs in transient alarm phase of the stress reaction. Rigby and Templeton (5) have demonstrated direct sympathetic control of K^+ secretion, and slower and longer lasting stress increase in the rate of Na^+ reabsorption in salivary glands in rats. Human studies have shown predictable decrease in salivary Na^+ concentration with increasing stress of university work in students and during lectures preparatory to final examinations (4). High academic work has also been related to lowered Na^+ concentration (3). Hinton (8) has found significant increase in K/Na ratio with stress induction in the form of obligatory time wasting and mental IQ test. His study on extempore speech delivery (another type of stress) resulted in significant rise of K/Na ratio after the stressor period.

Measurement of pilot reaction in simulator (9) shows that anticipation and uncertainty provide strong stimuli to norepinephrine secretion. Further norepinephrine levels begin to decrease after the emergency and continued to do so until reaching their lowest level at shutdown. This is contrasted with cortisol levels which are highest at shutdown, thus reflecting its role in assisting the subject to cope with stress or once the existence of stressor is recognized.

Our findings provide evidence of phasic shift in salivary K^+ concentration in the form of anticipatory stress in the higher baseline values as well as its abrupt rise with the onset of stress as shown in the peak stress values. Further K^+ values show sudden sizable decline at the post stress phase. These findings indicate close association with the expected sympathetic response to stress. Although we have not carried out concurrent measurement of catecholamines in our study, the trend of salivary K^+ estimation is in conformity with other workers, findings in relation to exposure to subtle stress. We have also observed tonic shift in salivary Na^+ with marginally lower values at baseline and its reduction at peak and post-stress phase. This shows a close association with the expected cortisol response under stress as discussed above and is in conformity with the findings of other

workers. Our findings on K /Na ratio are also similar to other reported observations (9). The ratio provides an integrated index of stress. It is felt that salivary estimation is reliable field measure of sympatho-adrenal response to stress.

Stress coping inventory provides scores under danger control, anxiety repression, anxiety control and situational control. Subjects in this study obtained a pattern with high scores on danger control and anxiety control and low score on situation control. Their response on anxiety repression shows a wider dispersion which shows a greater individual variability on this score. This pattern implies that there was greater consistency in adaptation to stress in these subjects. This finding is in conformity with the general attitude of high performance pilots and also with the successful culmination of the highly stressful training. There was very little individual variation in the highly selected high performance aviators who underwent the high G centrifuge indoctrination course. Hence no grading was given to subjects as far as their tolerance to G stress was concerned.

The results of regression analysis between scores on stress coping inventory and salivary ionic concentration provide evidence of predictability of stress adaptation with the help of salivary ionic concentration alone. Theoretically high score on danger control indicates better stress adaptation. This study provides an unmistakable evidence that higher the baseline sodium and lower the baseline and post stress K/Na ratio better is the stress adaptation. This is rather interesting finding which can have far reaching importance in prediction of the outcome of stress situation. However, this kind of correlation has not been attempted earlier. It is felt that replication studies should be conducted on similar lines in a larger population to validate this correlation.

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