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PHYSIOLOGICAL FACTORS IN RECRUIT COMPANY COMMANDER

WORK STRESS

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PHYSIOLOGICAL FACTORS IN RECRUIT COMPANY
COMMANDER WORK STRESS*

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ABSTRACT

Three separate physiological factors from 11 measures (7 biochemical, weight, blood pressure and age) were found in 34 men undergoing their first experience in leading naval recruits. Though no relationship of these factors with the self-reported stress and work load measures while leading recruits was found, the factors did appear similar to factors found in previous studies and indicated no support for a global factor expected from Activation Theory.

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INTRODUCTION

In Selye's original paper on stress¹, he emphasized the nonspecificity of stimuli producing the "stress" response. Later research has also confirmed this generality of the stress response.² Activation theory propounds that endocrine, autonomic and central nervous systems are activated together in response to stress stimuli.³ Psychophysicologists, however, have rarely found any significant relationships between the indicators they have used to measure stress and activation.⁴ This was perhaps to be expected in that many of the processes studied by psychophysicologists are dually innervated (sympathetic and parasympathetic nerves) and both systems are operating during activation. Endocrine responses, however, are not dually affected by activation nor are they readily subjected to conditioning; therefore the study of endocrine responses may make it possible to establish whether activation or the stress response is one general response, as hypothesized by Selye, or separate endocrine measures responding differentially to stresses.

Previous factor analytic studies of physiological measures in stressful situations have indicated separate factors. In a recent study of Norwegian parachute trainees, three separate physiological factors were found--a cortisol factor, a testosterone-free fatty acid factor and a catecholamine factor.^{5,6} Relationships between these physiological factors and the psychological measures in this study indicated that defense mechanisms were related to cortisol, testosterone was related to masculine role identification, and catecholamines were related to general ability measures.

An earlier study⁷ of young men in military basic training found other separate physiological factors to be related to certain behavioral variables; 17 OHCS was again related to effective coping and defenses, catecholamines were found to be related to the expression of anger, and androgens to psychological state. Both these studies were done on small samples of young males undergoing particular stresses (parachute jumping and military basic training) and with different sets of biochemical measures.

Factor analysis, as a multivariate method, is well suited for the investigation of Activation Theory for a set of physiological variables in a study. The analysis of the intercorrelations of physiological variables by factor analysis can indicate the existence of the general "Activation" factor by the first unrotated principal component factor, or of quartimax rotation. The existence of separate factors, indicating specific sets of physiological measures contrary to Activation Theory, could be indicated by the orthogonal or oblique rotations of the principal component factor matrix. The present study used a factor analytical approach to investigate the interrelationships of several important physiological variables for American naval recruit company commanders under various levels of work stress.

The work of a company commander involves supervising 60 to 80 new recruits through seven weeks of military basic training. The early part of training is notably hectic. The recruits are undergoing medical and dental examinations, clothing is procured, and there are numerous tests, inspections, and teaching of marching drill and other aspects of military life. The Company Commanders report primarily work overload, a stress that is not uncommon in other types of jobs as well.

METHOD

Sample

The overall purpose and design of the study of company commander work stress has been described in detail elsewhere⁸. The original sample was composed of 64 men, from six successive company commander training school classes, who volunteered to be studied. From this original sample 46 graduated from the training school and successfully completed leading their first company of recruits, and 34 of these men volunteered to continue in the study for their second recruit company. The mean age of the 46 who completed their first company was 33 years (SD = 4.1).

Study Days

A pilot study of over 40% (127 of approximately 300) of the active company commanders at the Naval Training Center, San Diego, was conducted to identify various of the days of recruit training in terms of the stress and work load experienced by the company commander. Six of the training days were selected to represent the major periods of stress as well as periods of low stress for company commanders. These days selected for sampling were:

1. Two days prior to starting of a company of recruits.
2. The second day of training which involved equipment and clothing procurement, indoctrination and orientation lectures as well as getting routine barrack and military procedures established. The average number of hours worked on the previous day was 17.4 for the sample.
3. The end of the first week of training on which the first major inspection and evaluation of the company was made. The average number of hours worked on the day prior to this was 16.4 hours.
4. The end of the second week of training on which the second major evaluation was held. If the company was not performing well, the company commander could be relieved. Previous day's hours worked was 15.7.

5. A day during the fourth week of training when the recruits had peripheral duties and the company commander was not directly involved in their supervision all day long. Average hours worked on prior day was 8.7 hours.
6. A day as close as possible to the recruit company graduation from training. The previous day's average hours worked was 9.4 hours.

Measures

The men had their blood drawn on these six days during each of their companies that they volunteered to be studied. Most samples were obtained between 0700 and noon in the work setting. The blood samples were analyzed for serum levels of cortisol, uric acid, cholesterol, dopamine-beta-hydroxylase (DBH), protein and pepsinogen (for assay methods and accuracy, see ref. 8). Resting blood pressures were also measured on these six days, as was the weight of the men. The men were also asked to rate the "stress" (1=none, to 5=extreme amount) and "work load" (1=not enough to do, to 5=too much to do) at this same time, and their moods were also measured with a short questionnaire.⁹

Statistical Analysis

The variability of these physiological and psychological measures between the six days sampled for the first two companies was analyzed by means of an analysis of variance. This was done to indicate if and how these measures varied across the days and companies. (See results in Table 1.)

The analysis of the interrelationships between the physiological measures was done by computing their intercorrelations at:

1. Each of the days studied, since the days were selected to represent the different aspects of work stress in this occupational setting.
2. The means of the high stress and low stress days for each company, so that the influence of general activation under stress could be tested and replicated.

The correlation matrices of the physiological variables for all these "time periods" were factor analyzed and if the unrotated principal factor or the quartimax solutions showed a majority of the variables with highly significant loadings in the first factor then support for general activation was indicated under those conditions. If, however, the varimax (using Kaiser criterion) or oblique rotations¹⁰ of the principal component solution had factors with certain sets of variables with high loadings that replicated across time periods. Then some indication of "specific activation factors" was concluded.

In order to control for the effects of extreme skewness on the correlations between the physiological variables, values greater than two standard deviations (deChauvenet's criterion) from the means were eliminated before computation of the correlations. One cortisol value greater than $30\mu/100$ ml, and one DBH value equal to zero and one greater than 80 I.U./l, and one pepsinogen value greater than 130 ng/ml were eliminated from analysis.

The correlation matrices were checked for significance by: (1) comparing the number of significant correlations ($p < .05$) to that expected from the binomial expansion (10 variables, two at a time at the .05) and (2) Bartlett's χ^2 for the significance of a correlation matrix was computed from the determinant of the correlation matrix. These tests would indicate if there were a large number of significant correlations and if the overall significance of the matrix was large. Both of these tests should reflect upon the strength and viability of any interpretation of resulting factors. By including age and weight in the matrixes analyzed, some control over the influence of these variables on the other physiological measures can be seen in the resulting factors.

Previous studies^{4,5} have related physiological and psychological variables, therefore these relationships were investigated in this study. The factor analysis of the physiological variables did not provide information about any possible relationships with the psychological measures of stress and work load perceptions or moods. Canonical correlations, which take as their basic input two such sets as physiological and psychological variables, then derive linear combinations from each of the two sets in such a way that the correlation between these two linear combinations are maximized, were computed for each time period. This provides one overall test of relationships between sets of variables, with indications as to which variables within each set contribute most to the interrelationships between the two sets.

RESULTS

Physiological Variability

There was a highly significant workload perception differences across days, representing the three high stress and three low stress days over both companies. Most physiological variables did not necessarily follow this pattern nor were they of the same significance in terms of daily mean differences. The plasma levels of cortisol and testosterone revealed only slight variations across time (see Table 1). Only on Sample Day 2 was there some evidence of the usual cortisol rise/testosterone fall phenomenon. Most of the other physiological variables showed some significant variation across time, especially cholesterol, but this variation was less than what is usually observed in laboratory or acute stress studies.

Physiological Interrelationships

The correlation matrices of the seven biochemistries and systolic BP for the 46 men who completed their first company showed few significant correlations for any of the days in the first company. Four significant correlations ($p < .05$) would be required to exceed chance; and the results indicated that less than four were found on four of the six days during the first company. Using Bartlett's test of the significance of a correlation matrix, none of these matrices for the days for the two companies reached significance ($p < .05$). The linear relationships between these variables, therefore, is not large as would be expected from the general activation theory. The matrices of the correlations between all the physiological measures means at high and low work load stress days for the first and second companies showed both a greater than chance number of significant correlations and a significantly large magnitude of correlations. This may be due to the reduction of error by using means. However, most of the resulting factors from the high and low stress means were very similar to those factors observed on the individual days analysis.

The unrotated principal factor solutions for the days or high-low mean values did not show a majority of the variables as having significant loadings which would support any "generalized physiological activation factor."

Figure 1 presents the three consistent factors across the analysis of the daily values, and Table 2 indicates the factor loadings for the mean values on the high and low stress days for the first and second companies, as well as a measure of agreement (coefficient of congruence) between these two company factor analysis results.

The first factor in many of the analysis of the daily values had cortisol as the measure with the most significant loading, often with systolic blood pressure. When the high and low stress mean values were factor analyzed, cortisol appeared as the fifth factor for the first company and with both blood pressure values in the first factor of the second company.

Testosterone appeared as a variable with high loadings in most of the daily factor analysis by itself, as it did also in the analysis of the high and low stress means (factor three in the first company and factor 5 in the second company).

Another factor that was consistent across the daily values involved cholesterol, DBH and uric acid; cholesterol and DBH appeared as the variables with the highest loadings in the fourth factor of the high and low stress means for the first and second companies.

Canonical Correlations

No significant canonical correlations were found on any of the days analyzed. It appears that the psychological measures (moods and stress and work load perceptions) formed one highly interrelated set of measures, whereas the physiological measures were much more independent with perhaps three relatively small physiological factors, and there was no association of these physiological measures with the psychological set.

DISCUSSION

The three fairly consistent factors were indicated--a cortisol factor, a testosterone factor, and a cholesterol, DBH and uric acid factor possibly related to catecholamine activity. There was no general activation factor apparent in this study.

The physiological variables analyzed in the present study consisted of hormones, metabolites, and measures of blood pressure. The aim of the original study and the selection of variables were not designed to test specifically for any general activation system. It is, therefore, striking that the linear relationships that did exist among these measures were dominated by three factors somewhat similar to those found by Ellertsen, Johnsen and Ursin⁴. The results also show some agreement with other previous multifactorial studies. Rose et al.⁶ analyzed 46 men in basic military training. They found five factors--two factors related to androgens and estrogens, one catecholamine factor, one cortisol factor, and one factor related to thyroid function. Persky, Zuckerman and Curtis¹¹ analyzed 64 male subjects--29 mental patients and 25 employees with a battery of psychological tests and measurements of pituitary hormones and adrenocortical activity. Again, they found an independence of the adrenal control activity on the one hand, and follicle-stimulating hormone, luteinizing hormone, and thyrotropic activity.

In the present material no significant linear relationships were found between the physiology and the psychology sets of variables. However, such relationships have been found in the other studies^{6,7}.

The cortisol factor was found as the first factor in four of the six analyses of the days in the first company. In four of the analyses, systolic blood pressure also loaded on this factor. The other relationships were inconsistent and will be assumed to be chance occurrences. This relationship between cortisol and systolic blood pressure may be due to the mineralcorticoids. Blood pressure is usually regarded as a sympathetic indicator, and it is particularly interesting that at low stress levels the adrenal cortex may

be more important for the variance in blood pressure. The relationship between cortisol and defense mechanisms reported by Baade et al.⁶ could not be tested directly in this material.

The testosterone factor demonstrated the independency from cortisol. The claimed "mirror image" relationship between cortisol and testosterone was not evident by correlation or in the factor analysis, and was also missing from the group mean level changes over time (Table 1). This independence of cortisol and testosterone has been seen in previous studies (4,6,10).

The third consistent factor may be interpreted as a sympathetic factor, since it has loadings from variables known to be related to the sympathetic nervous system. Cholesterol is related to free fatty acid release, which is known to be a sympathetic event (see ref. 12 for references). Cholesterol has been shown to be sensitive to psychological changes, but less so than uric acid¹³. Cholesterol has been thought to increase when loads are burdensome, depressing, and failure likely¹⁴. Uric acid, which loaded twice on this factor, is known to be dependent on norepinephrine. In pharmacological experiments where plasma levels of purine metabolites depend on the level of injected norepinephrine, the effect is mediated by beta receptors¹⁵. Also, psychological personality traits and resources in persons with high uric acid levels (see ref. 16 for references) seem fairly close to what Frankenhaeuser¹⁶ has described for persons with high sympathetic activation. DBH, which loaded on this factor three times, is believed to be directly related to catecholamine release. However, doubts have been raised as to the reliability of the present method of measuring this hormone, and whether measurement of plasma DBH is a

useful parameter for evaluation of activation for measuring sympathetic activity during prolonged stress in humans¹⁷ and calves¹⁸.

Cholesterol levels dropped about 40 mg/l while the work load and subjective stress estimation remained high (days 2 to 3, and 4). This puzzling finding is perhaps explained in the multifactorial analysis. The loadings on the catecholamine factor are in the same direction as uric acid and DBH. This indicates that the later cholesterol increase (from days 4, 5, and 6) rather than the decrease is the relevant variation for the study of activational stress factors. The decrease evident in the data may be related to other irrelevant factors like diet or physical work load. Retrospective investigations suggested indeed that during the early recruit company high work loads, these men did not eat properly and very often missed meals, switched to a carbohydrate-high diet--like cookies, chocolate bars, soft drinks, etc., worked over 17 hours a day average, and did much more walking than usual for them.

This analysis demonstrates the usefulness of multivariate analysis of this type of complex matrix. There are few linear relationships in the material, but those that are present may be revealed by this type of analysis. Multivariate analysis is a powerful way of reducing complex interactions which may otherwise be missed, especially where no a priori sets of variables exist. This study supports previous analyses suggesting independent endocrine activation factors. The study also suggests three such factors--a cortisol factor, a testosterone factor, and a catecholamine factor. This last factor was only indirectly indicated in this study. No significant relationships between these factors and psychosocial variables were found in this study, but such connections have been indicated in previous studies^{6,7}

This paper presents the relationships of the between-persons' differences on physiological measures at particular points of time in this work situation. The within-person analysis of these and other data representing the individual patterns of responses over time in this work are the subjects of other reports^{19,20,21}.

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Table 1

Physiological Variables† and Work Load Means
for Six Days Over Two Companies

Variable	Company	Days						F* Days	F*Co.
		1	2	3	4	5	6		
Cholesterol mg/l	1st Co.	202	202	172	161	184	195	42.16	8.11
	2nd Co.	204	201	178	175	192	202		
Cortisol μ/100 ml	1st Co.	11.2	12.4	10.9	9.7	11.5	10.1	3.12	1.35
	2nd Co.	10.2	11.9	10.0	9.8	10.8	9.6		
DβH I.U./l	1st Co.	26.1	23.4	25.7	26.6	26.9	27.7	12.10	23.92
	2nd Co.	28.2	27.0	27.6	28.1	28.4	29.3		
Pepsinogen ng/ml	1st Co.	73.8	63.1	65.7	66.4	69.9	70.3	3.12	.00
	2nd Co.	70.4	64.9	67.1	67.3	69.4	70.0		
Protein mg/l	1st Co.	8.0	8.2	8.0	7.7	7.7	7.8	15.73	5.56
	2nd Co.	7.9	7.8	7.9	7.7	7.7	7.8		
Systolic B/P ml Hg	1st Co.	123.0	123.6	119.7	118.9	119.3	120.9	5.17	.01
	2nd Co.	123.5	123.5	119.8	120.8	119.8	122.4		
Diastol. B/P ml Hg	1st Co.	81.2	80.2	75.7	75.4	76.4	81.9	7.88	4.55
	2nd Co.	81.0	84.4	79.9	79.6	80.3	79.3		
Testosterone μ/100 ml	1st Co.	6.9	5.9	6.9	5.8	7.6	7.4	12.60	4.41
	2nd Co.	6.4	5.7	6.4	6.4	7.3	6.6		
Uric Acid mg/l	1st Co.	5.5	5.7	5.1	5.1	5.0	5.1	7.22	6.25
	2nd Co.	5.2	5.2	4.9	4.9	4.9	5.2		
Weight Kg	1st Co.	81.1	81.0	79.4	79.5	79.1	77.9	21.89	5.02
	2nd Co.	81.2	80.5	79.9	79.3	79.7	80.7		
Workload	1st Co.	2.3	3.9	3.6	3.7	2.0	1.9	89.34	1.20
	2nd Co.	1.9	3.6	3.7	3.6	1.8	1.9		

*The conservative degrees of freedom (Geisser-Greenhouse) for Companies or Days equals 1,32; therefore, An $F > 4.15$ would be significant at $p < .05$; $F > 7.51$, $p < .01$; $F > 13.16$, $p < .001$. No interactions between Companies by Days were found to be significant.

†Extreme cases not omitted because of use of harmonic mean analysis.

Table 2

Factor Analysis of High and Low Stress Means of the First and Second Companies

Company Factor	Varimax Factor Loadings ^a											
	1st		2nd		1st		2nd		1st			
	1	2	1	2	3	4	5	4	4	5b		
Age	22	-01	44	74	01	19	15	06	19	06	-33	16
Cholesterol	24	15	-19	-03	42	52	44	57	52	57	-19	14
Uric Acid	60	24	-11	-01	-13	25	-02	16	25	16	07	63
DBH	-08	00	02	01	-04	62	-02	55	62	55	12	-04
Protein	22	21	-19	-11	-01	13	10	12	13	12	19	21
Pepsinogen	-01	19	74	63	06	-11	-15	-15	-11	-15	08	-22
Weight	60	07	-03	09	-18	-21	-14	-25	-21	-25	-05	77
Cortisol	13	46	01	-31	-00	07	-04	33	07	33	55	-11
Testosterone	-32	00	-41	-53	62	-18	70	-28	-18	-28	21	-19
Systolic B/P	53	79	16	12	05	02	-07	-03	02	-03	18	19
Diastolic B/P	71	75	25	33	45	-6	13	00	-6	00	01	41
Stress ^c	01	01	-10	-04	-40	-04	-20	-04	-04	-04	03	01
Coef. Cong.		.60		.90		.85		.93				
Eigenvalue	2.38	2.65	1.65	1.93	1.44	1.31	1.14	1.17	1.31	1.17	1.12	1.41
Percent σ^2	19.9	22.1	13.8	16.1	12.0	11.0	9.5	9.8	11.0	9.8	9.4	11.8

^aDecimals omitted, significant loadings $\geq .48$. Ns = 32 to 34
 not matching factors

^cHigh stress means = 1; Low stress means = 0

TOTAL MATERIAL
SIX TEST DAYS - FIRST COMPANY

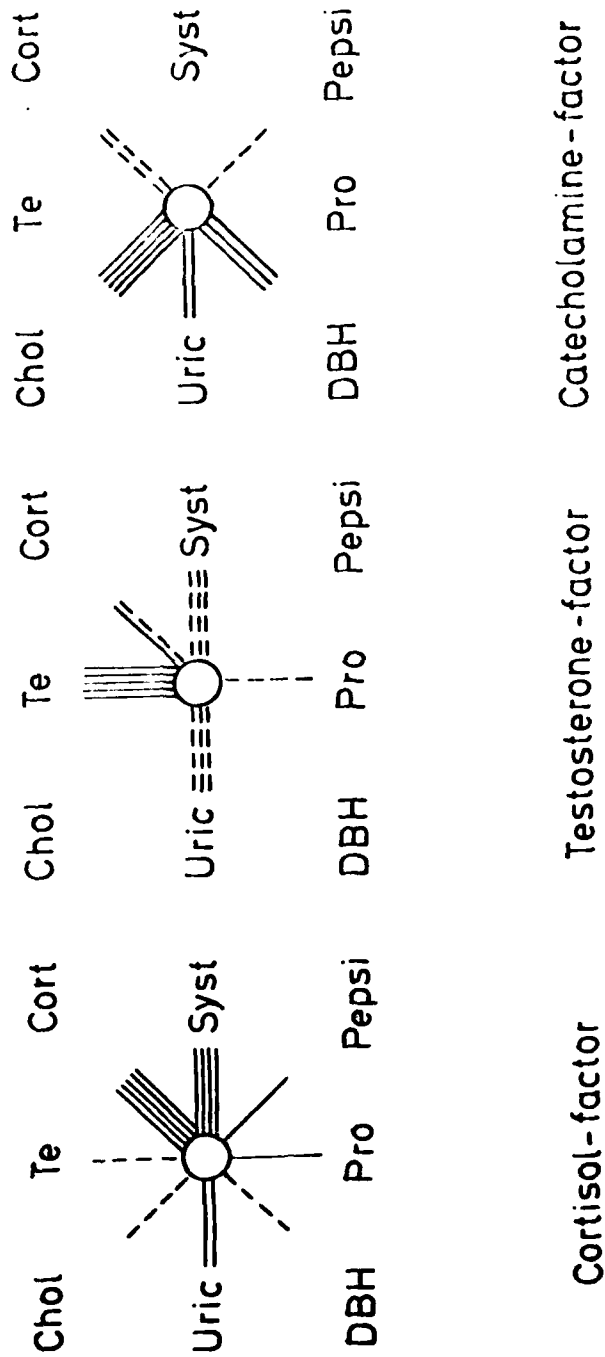


Fig. 1 - Review of the three consistent factors. Each line represents one significant (>.40) loading for one of the six sampling days.

--- = Significant negative loadings, Ns between 43 and 50.

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