The relationship between high and low trait psychological stress, serum testosterone, and serum cortisol

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Summary. Psychological stress, as measured by the parameters of trait anxiety, hostility, and depression, was compared in the group of males age 30–55 with serum levels of testosterone. Those males who were classified as high psychological stress had significantly lower testosterone levels than did their low stress counterparts. However, comparison of their serum cortisol values revealed similar concentrations in both groups.

During the past few years, the primary focus of psychoendocrine research has focused primarily on 2 endocrine axes - the pituitary-adrenal cortical and sympathetic adrenal-medullary systems[1,2]. A much smaller amount of effort has been placed in study of psychological stress on other endocrine systems such as the pituitary-gonadal system. The lack of research in this area has been due primarily to methodological problems[3] and with the advent of specific radioimmunoassays for measuring specific hormones, this area of research is now expanding[4,5].

Initial studies in the area of stress and the pituitary-gonadal system in both humans and animals indicate that suppression of the pituitary-gonadal activity may rather commonly accompany emotional arousal or distress, as an integral part of a broad pattern of hormonal response. For example, Rose et al.[6] have studied soldiers in basic training and special force personnel anticipating imminent combat in Vietnam. These men showed lower urinary excretion of testosterone, androsterone, and eticholanolone than in a normal population of medical center personnel. Likewise, Kreuz et al.[4] in a longitudinal study of young soldiers in Officer Candidate School, reported a significant suppression of plasma testosterone levels during the 'early stressful part of the course' as compared with the latter or relaxed period.

In these and other psychoendocrine studies of the pituitary-adrenal cortical system and the pituitary-gonadal system, the relationship of psychological stress 'trait' characteristics were not considered. Therefore, the purpose of this study was to determine the relationship of 'trait' psychological stress as defined as trait anxiety, hostility, and depression on the primary male gonadal hormone testosterone and the primary adrenal cortical hormone cortisol.

Method. Subjects. 39 male subjects, 30–55 years of age, were selected from a population of faculty members from the University of Alabama in Birmingham and from businessmen belonging to local organizations in the Birmingham area. The subjects were selected from a group of 63 volunteers on the basis of their scores on 2 written psychological stress examinations. The 2 written psychological stress examinations used as a screening device were the State-Trait Anxiety Inventory (STAI) developed by Spielberger et al.[7] and the Multiple Affect Adjective Check List (MAACL) developed by Zuckerman et al.[8]. The STAI is a brief self-report that measures both state and trait anxiety. The STAI consists of 20 statements that define a continuum of increasing levels of intensity. Low scores indicate a state of calmness and serenity while high scores reflect tension, nervousness, apprehension, fearfulness, and anxiety. The MAACL like the STAI provides a measure of both state and trait levels of anxiety. In addition, the MAACL measures levels of depression and hostility. In responding to the MAACL, the subject simply checks adjectives (e.g. tense, nervous, calm) to describe how he feels. Like the STAI, the higher the scores, the higher the level of anxiety, depression, or hostility. Previous studies[9,10] have indicated that the stress parameters as measured by the MAACL are highly correlated with the stress parameters as measured by the STAI. Both the STAI and the MAACL have an extensive bibliography of research in which evidence of validity has been presented[7,8].

Because of the neoteric aspects of this study and to insure delineation between low psychological stress individuals and high stress individuals the ends of the psychological stress scales were studied. Based on scores obtained on both the STAI and the MAACL, subjects were categorized into a high psychological stress group and low psychological stress group. Subjects (n = 20) that were selected for the high psychological stress group had to score higher than 1 SD above normative scores on both the STAI trait scale[7] and the MAACL trait scales[8]. Likewise, subjects (n = 19) selected for the low psychological stress group had to score 1 SD below normative scores on the STAI and MAACL trait scales. The use of 1 SD insured assessment of individuals on the ends of the psychological scales.

A brief medical history was obtained from all subjects by use of a questionnaire seeking information concerning age, race, height, weight, personal history of coronary heart disease, alcohol consumption, dietary habits, cigarette smoking, physical activity, occupation, and physical activity associated with occupation.

Hormonal analysis. All subjects reported to the physiology laboratory at 08.00 h after a good night's sleep and at least 10-h fast and tobacco abstinence. Blood was drawn from the anticubital vein into unheparinized vacutainer tubes. They were kept chilled for no longer than 2 h. The blood was centrifuged and the plasma was withdrawn for RIA. A single blood sample was drawn from each of the 39 subjects (20 high psychological stress subjects and 19 low psychological stress subjects) for hormonal analysis. Cortisol was assayed by solid-phase radioimmunoassay according to the procedure of Rolleri et al.[11] and testosterone was assayed

Mean values (± SE) of psychological parameters and serum cortisol and serum testosterone in high and low psychological stress groups

	Cortisol (μg%)	Testosterone (ng%)	STAI* Anxiety	MAACL* Anxiety	Depression	Hostility
High psychological stress (n = 20)	12.1 ± 1.2	4.23 ± 0.35[a]	46.8 ± 2.0[a]	10.3 ± 0.6[a]	17.3 ± 1.2[a]	9.6 ± 0.7[a]
Low psychological stress (n = 19)	12.0 ± 0.9	5.65 ± 0.44[b]	27.3 ± 0.7[b]	2.2 ± 0.6[b]	6.2 ± 0.7[b]	3.9 ± 0.5[b]
Normative psychological parameters**			38.1 ± 0.5[c]	5.8 ± 0.3[c]	10.0 ± 0.5[c]	6.3 ± 0.3[c]

[a,b,c] Those values in each column with unlike superscript are significantly different from each other at the $p \leq 0.01$ level. * Values represent arbitrary units characteristic of each test. ** Normative values taken from Spielberger et al.[7] and Zuckerman and Lubin[8].

according to the method of Auletta et al.[12]. RIA Kit for both analysis were purchased from New England Nuclear (Boston, Massachusetts). All changes were assayed for statistical significance by analysis of variance.

Results. The medical history questionnaire indicated that the 2 groups of subjects were similar in all categories except trait anxiety, hostility, and depression. The table presents the mean STAI anxiety and MAACL scores of the total high and low psychological stress groups for the 3 highly interrelated mood and feeling parameters of trait anxiety, hostility, and depression. The data revealed that the goal of attaining 2 distinctly different psychological stress groups was obtained.

Serum cortisol values in the high psychological stress group (12.1 ± 1.2 µg%) was not significantly different from the low psychological stress group (12.0 ± 0.9 µg%). However, serum testosterone levels in the high psychological stress group was significantly ($p \leq 0.01$) different in comparison to the low psychological stress group. High psychological stress serum testosterone levels were 4.23 ± 0.35 ng% in comparison to 5.65 ± 0.44 ng% in the low psychological stress group.

Discussion. Previous studies[2,4,13,14] have indicated that a common observed hormonal response to emotional stimuli is a pattern of suppressed urinary 17 ketosteroid secretion or serum testosterone with a concurrent elevation of urinary 17 hydroxycorticosteroids or serum cortisol. It should be noted, however, that these investigations did not delineate 'trait' behavior or personality characteristics.

The present study suggests that depressed testosterone levels and urinary 17 ketosteroid secretion reported in these previous studies might possibly be reflective of the inherent trait stress variables of elevated anxiety, hostility, and depression in the subjects selected. It should be noted that this is speculative and can only be verified by reassessment of these previous data in light of trait psychological characteristics.

The nearly identical cortisol values in both the high and low psychological stress groups (table) lends credence to a growing body of data which cast serious doubts upon the concept of absolute 'non-specificity' of the pituitary-adrenal cortical response to diverse 'stressors', a basic premise of 'stress' theory formulated by Selye[15,16]. It appears that the pituitary-adrenal cortical system does not respond indiscriminately to the comprehensive range of psychological stimuli or 'stressors', encountered in every-day living, as originally assumed in the formulation of the 'non-specificity' concept by Selye[15]. It would be logical to assume that if it did, this would be reflected in alterations in the serum cortisol values in the high trait psychological stress group.

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Contractile properties of fast muscle preparations regenerating in slow muscle beds[1]

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Summary. Mechanical evidence is presented to show that fast muscle tissue regenerating in the bed of a slow muscle, and innervated by the slow muscle nerve, has contractile properties identical to those of a slow muscle regenerating in its own bed. The results do not support the idea that regenerating fast muscles are partially resistant to the transforming effects of a slow nerve.

When minced slow muscles are transplanted into beds formerly occupied by fast muscles, and vice versa, essentially complete conversion of contractile characteristics has been reported[2]. A similar conversion of slow to fast muscle properties has also been observed for whole muscle free grafted preparations[3,4]. However, when data for the conversion of regenerating fast free grafted preparations to slow tissue were examined, the conversion was interpreted as being incomplete[3,4]. The investigators considered that perhaps the incomplete conversion might be due to an intrinsic myogenic component of fast muscle which is partially resistant to the transformation effects of a slow nerve[3,4].

In these 'incomplete conversion' experiments the contractile characteristics of the transplanted regenerating muscles were compared to the properties of normal (non-transplanted, non-regenerating) muscles. A more appropriate control group for comparison however would seem to be muscles removed from and then replaced for regeneration into their own beds. In other words, a fast muscle regenerating in a slow muscle bed, and innervated by the slow muscle nerve, should have its properties compared to a slow muscle regenerating in its own bed, and innervated by its own nerve. This is the essence of the experimental design of the work now described.

Material and methods. Data are reported on the contractile characteristics of muscles from 55 male Sprague-Dawley rats. The animals were 5 weeks old at time of operation. The original number of animals was considerably larger,