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.

1 J.W. Mason, Psychosom. Med. *30,* 565 (1968).
2 J.W. Mason, in: Emotions – Their Parameters and Measurement. Ed. L. Levi. Raven Press, New York 1975.
3 R.M. Rose, Psychosom. Med. *31,* 405 (1969).
4 L.E. Kreuz, R.M. Rose and J.R. Jennings, Archs gen. Psychiat. *26,* 479 (1972).
5 H. Persky, K.D. Smith and G.K. Basu, Psychosom. Med. *33,* 265 (1971).
6 R.M. Rose, P.G. Bourne and R.D. Poe, Psychosom. Med. *31,* 418 (1969).
7 C.D. Spielberger, R.L. Gorsuch and R.E. Lushene, Manual for the State-Trait Anxiety Inventory. Consulting Psychological Press, Pala Alto, Ca. 1970.
8 M. Zuckerman and B. Lubin, Manual for the Multiple Affect Adjective Check List. Educational and Industrial Testing Service, San Diego, Ca. 1979.
9 K.T. Francis, Psychosom. Med. *41,* 617 (1979).
10 K.T. Francis, Fedn Proc. *40,* 330 (1981).
11 E. Rolleri, M. Zinino and R. Orlandini, Clin. chim. Acta *66,* 319 (1976).
12 F.J. Auletta, B.V. Caldwell and G.L. Hamilton, in: Methods of Hormone Radioimmunoassay, chapter 21. Ed. B.M. Jaffee and H.R. Behrman. Academic Press, New York 1974.
13 J.W. Mason, Psychosom. Med. *30,* 576 (1968).
14 J.W. Mason, C.C. Kenion and D.R. Collins, Psychosom. Med. *30,* 721 (1968).
15 H. Selye, The Physiology of Exposure to Stress. Acta Inc., Montreal, Canada 1950.
16 H. Selye, Selye's Guide to Stress Research. Van Nostrand Reinhold, New York 1980.

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

R.L. Lindsay, Dorothy Chase, K.A. Dasse, D.J. Burke, A.H. Goldberg and W.C. Ullrick

Boston University School of Medicine, Department of Physiology, 80 East Concord Street, Boston (MA 02118, USA), 8 April 1981

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,

Contractile properties of muscles regenerating in bed of soleus, and innervated by nerve to soleus

	Animal weight (g)	Muscle weight (mg, wet)	DT* ($N \times 10^3$ mg^{-1})	CT* (msec)	HRT* (msec)	T:T ratio
Normal muscle						
Plantaris (7)**	296±35	242±67	19±8	62±8	55±19	1.8±0.3
EDL (10)	300±33	77±34	17±7	44±5	51±15	1.6±0.3
Soleus (7)	293±36	100±33	22±7	120±8	206±30	3.8±0.6
Regenerating muscle						
Soleus, free grafted (7)	327±56	41±20	16±10	109±21	163±34	3.5±0.7
Soleus, minced (7)	281±28	30±17	6±5	126±28	168±59	3.5±1.3
Plantaris, free grafted (6)	313±11	61±22	16±9	98±5	160±32	2.9±1.2
Plantaris, minced (7)	313±42	35±14	14±13	98±19	182±71	3.2±1.6
EDL, minced (4)	386±17	21±7	3±2	89±24	124±38	3.2±1.6

* DT = developed twitch tension, Newtons $\times 10^3$ per mg muscle; CT = contraction time; HRT = time for half relaxation; T:T = tetanic tension:twitch tension ratio. ** Muscles in each group in parenthesis. Values are means ± standard deviation.

but many of the transplantations, especially in the minced group, were anatomically or functionally unsuccessful.

3 types of muscles were studied: the fast plantaris, the faster extensor digitorum longus (EDL), and the slow soleus. The control group consisted of animals in which the soleus muscle of one leg had been removed completely from its bed, with nerves, blood vessels, and tendons severed, and then as a minced or free grafted preparation, placed back into its own bed.

The experimental groups consisted of animals in which the soleus of one leg had been removed and discarded, and the plantaris or EDL from the opposite leg transplanted either as a free grafted or minced preparation, into the vacant soleus bed.

All surgery was done under sodium pentobarbital anesthesia, and was based on techniques as described by Carlson[5]. The mincing procedure involved slicing the muscle longitudinally and laterally into 1-mm^3 fragments; 80% of the mince was used for implantation. The previously sectioned soleus nerve (and associated vessels) was placed into the minced mass or on the free grafted preparation.

After 35 days the animals were sacrificed, and the transplanted regenerating muscles removed. The proximal end of each muscle was fastened by way of a spring clamp to a force transducer. The distal end was placed in a clamp containing platinum electrodes, and the preparation immersed into Ringer's solution containing 154 mM NaCl, 5.6 mM KCl, 5.6 mM $CaCl_2$, 7 mM $NaHCO_3$ and 5.5 mM dextrose. The solution was bubbled with 95% O_2 and 5% CO_2, and maintained at 20 °C.

The preparations were then stretched automatically to L_{max} (length of maximum tension development) and twitch and tetanic tension responses to square wave pulses recorded. Records were analyzed for twitch and tetanic developed tension, in N (newtons) per mg muscle tissue between the holding clamps, and for contraction time (CT, time to peak tension) and half relaxation time (HRT) in msec. The data were subjected to analysis of variance and tested for all possible comparisons between groups.

Results. All results are presented in the table. In the normal (unoperated) muscles, the contraction time of the EDL was significantly faster than the plantaris, and the plantaris significantly faster than the soleus. The developed twitch tension was the same for all 3 types, but, as expected, the tetanic-twitch tension ratio (T:T) was significantly greater for the slow muscle than for either fast muscle. The soleus was, as expected, slower to relax than either the EDL or plantaris.

Among the regenerating muscles, the developed twitch tensions of the minced EDL and minced soleus preparations were lower than those of the other 3 groups (see table). This is probably best explained on the basis of the high adipose and connective tissue content in regenerating minced preparations, as discussed and illustrated by Salfsky et al.[2], and by Batalin and Allrook[6], rather than being a characteristic of the tissue per se. The T:T ratios were the same for all 5 groups, and there were no differences among the 5 groups in CTs or HRTs. Hence, the contraction characteristics of the fast and slow preparations are considered indistinguishable.

When regenerating and normal muscle groups are compared, an assortment of differences appear. For example, normal unoperated plantaris muscles are faster (CT, HRT) than minced or free-grafted plantaris preparations; the minced or free-grafted plantaris T:T ratios are higher than in the normal plantaris; normal soleus muscles are slower to relax (HRT) than free grafted soleus preparations; the normal EDL is faster (CT, HRT) than the minced EDL; and the normal EDL T:T ratio is lower than that of the minced EDL preparations. All of the above stated differences are based on statistical tests between groups with $p < 0.05$.

Discussion. The results of the experiment are clear. First, significant differences between the contractile properties of the different types of muscles exist. Second, when compared to normal muscle, regenerating muscle of a given type displays various departures from normal values. Third, fast muscles regenerating in the slow soleus muscle bed show contractile characteristics no different from those of the slow muscle regenerating in its own bed, under conditions whereby both types of muscles are regenerating under the influence of the slow muscle nerve.

It is concluded that there is no basis for believing that properties of a fast muscle resist in some way complete mechanical transformation to a slow muscle. The data show the transformation to be as complete as the properties displayed by the regenerating slow muscle itself.

The differences between the contractile properties of a regenerating muscle and its normal counterpart probably reflect the presence of abnormal amounts of connective tissue in the regenerating preparations, rather than the influence of any possible residual and surviving transplanted muscle fibers.

1 This investigation was supported in part by NIH grants 1-RO1-NS-14033 and 1-T32-07224.

2 B. Salfsky, P. Akbarzadeh and K. Sahid-Sales, in: Basic Research in Myology, p.405. Excerpta Medica Foundation, Amsterdam 1973.
3 B.M. Carlson and E. Gutmann, Experientia *30,* 1292 (1974).
4 E. Gutmann and B.M. Carlson, Pflügers Arch. *353,* 227 (1975).
5 B.M. Carlson, J. Morph. *125,* 447 (1968).
6 N.J. Batalin and D.B. Albrook, in: Basic Research in Myology, p.396. Excerpta Medica Foundation, Amsterdam 1973.