Aerobic Fitness Affects Cardiovascular and Catecholamine Responses to Stressors

ELAINE M. HULL,
State University of New York at Buffalo

STEPHEN H. YOUNG,
Welborn Hospital, Evansville, IN

AND MICHAEL G. ZIEGLER
University of California at San Diego

ABSTRACT

Subjects of varying degrees of aerobic fitness were subjected to four laboratory stressors in a test of the hypothesis that aerobic fitness is associated with decreased responsiveness to stressors other than exercise. Blood pressure, heart rate, norepinephrine, epinephrine, and psychological responses to a film of industrial accidents (passive psychological stressor), the Stroop word color task (active psychological stressor), the cold pressor test (passive physical stressor), and running to exhaustion on a treadmill (active physical stressor) were measured. Baseline systolic blood pressure and relative diastolic responses to the film, Stroop task, and exercise were smaller in fit subjects over 40 than in less fit subjects of the same age group. Heart rates were lower in fit subjects at most times, except during and after maximal exercise. Norepinephrine was lower after 9 min of exercise in fit subjects, but was much higher at exhaustion, after these subjects had accomplished more work. Norepinephrine levels fell rapidly and were not different among groups 3 and 10 min after exercise. There was no preferential generalization of the "fitness effect" to the active psychological task.

DESCRIPTORS: Aerobic fitness, Exercise, Stress, Cardiovascular responses, Blood pressure, Heart rate, Norepinephrine, Mood, Type A.

The cardiovascular system responds differentially to stressors which elicit active as opposed to passive coping responses (reviewed in Obrist, 1981). Generally, an increase in heart rate (HR), mediated by the beta-adrenergic system, is more characteristic of situations requiring active coping. Passive coping, on the other hand, is associated with greater vagal and/or alpha-adrenergic control of the cardiovascular system and lower HR. Situations requiring active coping have been shown to elicit even greater HR in Type A than in Type B individuals (Glass, 1977), and in young normotensive subjects with a parental history of hypertension (Falkner, Onesti, Angelakos, Fernandes, & Langman, 1979; Hastrup, Light, & Obrist, 1982). Furthermore, it has been proposed that such enhanced cardiovascular reactivity may in some persons be a precursor to stable hypertension (Obrist, 1981). Conversely, it is possible that a reduction in lability may delay or prevent the onset of stable hypertension.

It is well known that rigorous exercise training diminishes certain cardiovascular and hormonal responses to fixed amounts of exercise. The most consistent cardiovascular effects of physical training are increased maximal oxygen consumption, reduced HR, and increased stroke volume. The pattern of lower rate and increased volume is more efficient, and, since maximal HR is not changed by training, the increased stroke volume allows for a greater cardiac output during maximal exercise.

There are contradictory findings concerning effects of training on blood pressure (BP) during rest and exercise. Some cross-sectional and longitudinal
studies have reported lower pressures at rest in trained young normotensive individuals (Cogswell, Henderson, Berryman, Harris, Ivy, & Youmans, 1946; Mellerowicz, 1966), while others have not (Ekbloom, Astrand, Saltin, Stenberg, & Wallstrom, 1966; Frick, Konttinen, & Sarajärvi, 1963; Montoye, Metzner, Keller, Johnson, & Epstein, 1972; Saltin, Blomqvist, Mitchell, Johnson, Willendahl, & Chapman, 1968; Tabakin, Hanson, & Levy, 1965). Reports of lowered resting BP and decreased responses to exercise have been more consistent when hypertensive, older, or less fit persons were subjected to a training program (Boyer & Kasch, 1970; Choquette & Ferguson, 1973; Hanson & Nedde, 1970; Kiveloff & Huber, 1971; Terjung, Baldwin, Cooksey, Samson, & Sutter, 1973; Young & Ismail, 1978). Either reduced alpha-induced vasoconstriction or potentiated beta-induced vasodilation may mediate the beneficial effects (LeBlanc, Boulay, Dulac, Jobin, Labrie, & Rousseau-Migneron, 1977; Pavlik, Hegyi, & Frenkl, 1976; Wiegman, Harris, Joshua, & Miller, 1981).

There are some indications that aerobically fit individuals may exhibit less physiological responsiveness to other physical and/or psychological stressors than do less fit individuals. Young and Ismail (1978) interpreted their personality data as indicative of greater emotional stability in fit than in less fit subjects. However, they did not measure responsiveness to specific stressors. Cantor, Zillman, and Day (1978) reported that “high fitness” subjects exhibited smaller elevations in blood pressure and smaller decreases in skin temperature of the fingers (i.e., less vasoconstriction) in response to two arousing films (surgery and sex), and these responses were of shorter duration than in “low fitness” subjects. However, in this study the only index of fitness was a relatively low blood pressure response to exercise. Thus, these investigators found that those with a large increase in BP after exercise also exhibited a large increase in BP after the arousing films, and vice versa. They presented no data, however, on oxygen consumption during exercise, HR responses to exercise, resting BP, or exercise habits of the subjects. Thus, the difference between the “high fitness” and “low fitness” subjects in this study reflects differential responsivity of the cardiovascular system more than differential physical fitness according to the usual measures.

In a study more directly related to exercise training, rats allowed to run in activity wheels for 3 hrs/day exhibited smaller elevations in corticosterone levels in response to foot shock than did sedentary rats (Starzec, Hesse, Pytko, Dewey, & Berger, 1979). However, running wheels were available for 2 hrs after daily administration of foot shock. Gal and Lazarus (1975) have demonstrated that any type of response available during or after a stressor may diminish the perceived stressfulness of that stressor. Therefore, exercise may have contributed in a nonspecific way to a decreased responsiveness to the shock. Finally, a very recent study reported lower anxiety in fit subjects at the end of a psychosocial stress session, in addition to a more rapid decline in HR after the individual stressors (Sinyor, Schwartz, Peronnet, Brisson, & Seraganian, 1983).

The present experiment was designed to determine whether physical fitness in humans is correlated with lower amplitude and/or duration of responses to various stressors. HR, BP, and plasma norepinephrine (NE) were measured during and after a film depicting industrial accidents, a cognitive task performed under distracting conditions, a cold pressor test, and exercise on a treadmill. In addition, psychological responses were assessed after each task. The exercise and cognitive tasks were designed to elicit active coping mechanisms, while the cold pressor test and film produced passive reactions. Thus, both active and passive physical and active and passive psychological stressors were employed.

Method

Subjects

Subjects were 35 men and 20 women aged 21–64. Each subject spent at least 30 min/day on the average engaged in either exercise or a sedentary hobby. The requirement that all subjects have a hobby, either active or sedentary, was an attempt to control for personality factors leading to the willingness to commit a major amount of time to an activity unrelated to employment. The degree of aerobic fitness of each subject was operationally defined as the length of time he or she ran on the laboratory treadmill before feeling exhausted. Subjects were encouraged to continue running until their heart rate was within 90% of their theoretical maximum calculated on the basis of their age (220 bpm minus age in yrs, Astrand & Rodahl, 1977). All but 4 subjects did, in fact, reach this criterion, and most approached or exceeded 100% of their theoretical maximum. Four groups were formed based on length of time on the treadmill; mean percent theoretical maximum heart rates for the four groups were 98, 99, 99, and 99, respectively. (See Table 1.) Typical hobbies reported by group 1 (the most sedentary subjects) included woodworking, needlework, walking, calisthenics, and playing musical instruments. Group 2 subjects engaged in raquetball, tennis, jogging, swimming, and aerobic dance. Groups 3 and 4 were composed of serious runners most of whom had run one or more marathons in 3.5 hrs or less. Mean ages of the four groups were not significantly different. However, since age was found to affect BP measures, the BP data from
the 19 subjects 40 yrs of age and older were analyzed separately. For these analyses subjects were divided into fit and less fit groups based on a median split of treadmill times (median duration = 14 min). Mean ages of these two groups were not significantly different. However, gender composition of both the total groups and the older groups was unequal, with women being more frequently represented in the less fit groups. Therefore, for each measure significantly affected by fitness level, a determination of gender effects was made. In the one case in which gender was a significant factor (baseline HR), the two genders were analyzed separately.

**Apparatus**

The electrocardiogram was recorded from NDM self-adhering electrodes using the standard CM5 electrode configuration. A Marquette electrocardiograph measured the interval between successive R waves and transformed each interval to bpm (HR); the latter was displayed digitally.

A standard manually operated blood pressure cuff was used to monitor systolic (SBP) and diastolic (DBP) pressures. A butterfly catheter inserted into an antecubital vein was used to draw blood periodically. A slow drip of 5% dextrose (D-5-W) solution was used to maintain patency of the catheter.

A Quinton model #18-60 automated treadmill was programmed to produce a standard Bruce protocol for graded exercise testing (Bruce, 1971). Every 3 min the grade and the rate of the treadmill were increased. Table 1 shows the rates and grades of the protocol, as well as the number of subjects who became exhausted during each stage. Stages I through III required increasingly fast walking. At stage IV most subjects began to jog. Only serious runners progressed into Stage V and beyond.

**Procedure**

Subjects were tested individually. After a detailed explanation of procedures and risks, subjects signed an informed consent form. They next answered a questionnaire concerning their health history, exercise habits and hobbies, and also filled out the Jenkins Activity Survey (JAS, a measure of Type A behavior) (Jenkins, Rosenman, & Friedman, 1967). They next reclined while the intravenous catheter was inserted and electrocardiographic electrodes were attached. The BP cuff was placed on the arm which did not have the catheter inserted. After a 15-min rest HR and BP were recorded and 10 ml of blood were withdrawn. HR was taken as the average of 5 s of displayed HR data, and was recorded immediately before BP cuff inflation and blood drawing. The subject then sat up and indicated his or her baseline mood state by checking one of five intervals between each of seven pairs of mood adjectives. After 3 min sitting, cardiovascular measures and blood were again sampled and used as baseline measures.

Four stressors were then administered consecutively: 1) a film depicting industrial accidents ("It Didn't Have To Happen"), 2) performing the Stroop word color task with conflicting auditory input for 5 min (see Frankenhsaeuser & Johansson, 1976, for description of task), 3) putting a foot in ice water for 1 min (cold pressor test or CPT), and 4) exercising on the automated treadmill until exhausted. Cardiovascular measures and blood samples were taken again near the end of the film, Stroop, and cold pressor tasks, after 9 min of exercise, and immediately after exercise was terminated. The mood checklist was also administered after each stressor. Cardiovascular measures and blood sampling were repeated 3 and 10 min after termination of each stressor, while the subject rested. The next stressor was then administered. A consistent order of stressors across all subjects was used in order to minimize variability. The present order represented increasing amplitudes of cardiovascular responses.

Plasma was analyzed for NE by the method of Lake, Ziegler, and Kopin (1976). In addition, plasma from 29 randomly selected subjects was analyzed for epi- nephrine responses during each of the four stressors and baseline.

Repeated measures analyses of variance were used to determine whether data from each time sample differed from the seated baseline. In addition, one-way analyses of variance were used to assess the effects of aerobic fitness, of age, and of Type A behavior pattern on baseline measures and relative responses to stressors (response during stressor minus response during baseline).
Results

Baseline HR was lower in aerobically fit individuals (Table 2). Since women had significantly higher HRs than men (women, 66.8 ± 3.9 bpm; men, 56.3 ± 1.7 bpm; F(1/50) = 7.7, p < .01), and were distributed in the lower fitness groups, baseline HR was analyzed separately for men and women. Higher fitness was associated with lower heart rates for men (F(3/31) = 4.5, p < .01, Table 2), but not for women. Fitness level did not influence baseline levels of any other measure when data from all subjects were analyzed together. Age was a significant factor in blood pressure measures. Subjects 40 yrs of age or older exhibited higher baseline SBP than did younger subjects (130.0 ± 4.0 mmHg and 121.1 ± 2.7 mmHg for older and younger subjects, respectively; F(1/17) = 7.34, p < .01). When BP data from subjects 40 yrs and older were analyzed separately for fitness effects, fit subjects were found to have lower baseline SBP than did less fit subjects (124.3 ± 4.5 mmHg and 139.3 ± 5.6 mmHg, respectively; F(1/ 17) = 4.5, p < .05).

All stressors elicited significant cardiovascular, hormonal and psychological responses, the film being least effective. (See Table 3 and Figure 1.) Relative HR was lower in fit subjects only during the 9th min of exercise (Table 2). There was not a significant gender difference in relative HR.

Relative diastolic responses to maximal exercise were lower in fit than in less fit subjects (Table 2). These differences were still apparent 3 min after exercise termination, but not after 10 min. Among subjects 40 yrs of age or older, fitness was associated with lower relative DBP responses 3 and 10 min after the film and during the Stroop task. (See Figure 2.) Fitness was not associated with any differences in relative SBP. Gender differences were not apparent for any of these measures.

Relative NE levels were lower in fit subjects during the 9th min of exercise, but were higher at exhaustion, reflecting the substantially greater work done by the film subjects (Table 2). Fitness was not associated with lower NE responses to stressors other than exercise. Neither age nor gender was associated with NE differences. While all stressors elevated epinephrine levels, aerobic fitness was not associated with lower epinephrine responses to any stressor. NE responses to the various stressors correlated well among themselves, as did epinephrine

| Table 2 |
| Fitness related measures |
| Means ± SEs* |

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68.9 ± 3.4</td>
<td>63.6 ± 3.5</td>
<td>95.1 ± 4.0</td>
<td>−7 ± 3.8</td>
<td>−1.9 ± 3.0</td>
<td>1237.5 ± 340.2</td>
<td>2555.4 ± 364.0</td>
</tr>
<tr>
<td>2</td>
<td>69.6 ± 2.8</td>
<td>67.9 ± 2.9</td>
<td>82.9 ± 3.8</td>
<td>−8.4 ± 4.4</td>
<td>−5.1 ± 3.5</td>
<td>720.8 ± 108.3</td>
<td>3729.5 ± 588.0</td>
</tr>
<tr>
<td>3</td>
<td>62.0 ± 4.9</td>
<td>61.7 ± 4.0</td>
<td>71.0 ± 5.2</td>
<td>−25.9 ± 6.2</td>
<td>−17.5 ± 6.0</td>
<td>614.8 ± 50.0</td>
<td>5505.7 ± 1240.8</td>
</tr>
<tr>
<td>4</td>
<td>55.6 ± 2.5</td>
<td>54.4 ± 2.3</td>
<td>70.4 ± 3.6</td>
<td>−24.9 ± 6.8</td>
<td>−24.9 ± 6.7</td>
<td>335.9 ± 79.1</td>
<td>6249.8 ± 885.5</td>
</tr>
</tbody>
</table>

*For significant comparisons of baseline measures and relative responses to stressors.  
*p<.05, **p<.01, ***p<.001.

| Table 3 |
| Physiological effects of stressors |
| Means ±SEs |

<table>
<thead>
<tr>
<th>Measurement Periods</th>
<th>HR</th>
<th>SBP</th>
<th>DBP</th>
<th>NE</th>
<th>EPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>65.9 ± .9</td>
<td>124.9 ± 2.0</td>
<td>82.4 ± 1.4</td>
<td>264.6 ± 21.7</td>
<td>34.4 ± 5.7</td>
</tr>
<tr>
<td>Film</td>
<td>69.1 ± 1.8*</td>
<td>126.4 ± 2.0</td>
<td>80.7 ± 1.3</td>
<td>272.3 ± 19.1</td>
<td>38.5 ± 3.9</td>
</tr>
<tr>
<td>Film + 3 min</td>
<td>66.0 ± 1.6</td>
<td>123.3 ± 2.1</td>
<td>81.1 ± 1.5</td>
<td>311.4 ± 26.8*</td>
<td>310.6 ± 22.8*</td>
</tr>
<tr>
<td>Film + 10 min</td>
<td>64.6 ± 1.7</td>
<td>122.2 ± 2.1</td>
<td>80.6 ± 1.3</td>
<td>310.6 ± 22.8*</td>
<td>310.6 ± 22.8*</td>
</tr>
<tr>
<td>Stroop</td>
<td>75.4 ± 2.0***</td>
<td>133.5 ± 2.2****</td>
<td>86.8 ± 1.5***</td>
<td>306.4 ± 20.3*</td>
<td>54.2 ± 7.5*</td>
</tr>
<tr>
<td>Stroop + 3 min</td>
<td>65.1 ± 1.5</td>
<td>125.6 ± 2.1</td>
<td>83.0 ± 1.4</td>
<td>311.9 ± 20.1*</td>
<td>353.4 ± 23.6**</td>
</tr>
<tr>
<td>Stroop + 10 min</td>
<td>64.5 ± 1.5</td>
<td>123.8 ± 2.2</td>
<td>83.3 ± 1.5</td>
<td>353.4 ± 23.6**</td>
<td>353.4 ± 23.6**</td>
</tr>
<tr>
<td>CPT</td>
<td>77.1 ± 1.9****</td>
<td>141.5 ± 2.7****</td>
<td>89.4 ± 1.7****</td>
<td>369.5 ± 21.8***</td>
<td>44.0 ± 4.0**</td>
</tr>
<tr>
<td>CPT + 3 min</td>
<td>66.5 ± 1.7</td>
<td>128.5 ± 2.3</td>
<td>84.5 ± 1.5*</td>
<td>386.1 ± 24.7***</td>
<td>386.1 ± 24.7***</td>
</tr>
<tr>
<td>CPT + 10 min</td>
<td>66.0 ± 1.6</td>
<td>125.3 ± 2.2</td>
<td>83.2 ± 1.3</td>
<td>353.8 ± 22.9*</td>
<td>353.8 ± 22.9*</td>
</tr>
<tr>
<td>Exercise (9 min)</td>
<td>148.1 ± 3.0***</td>
<td>161.7 ± 2.4****</td>
<td>77.6 ± 1.5***</td>
<td>1013.6 ± 122.9***</td>
<td>671.3 ± 251.7****</td>
</tr>
<tr>
<td>Exercise (max.)</td>
<td>183.5 ± 1.9****</td>
<td>156.0 ± 4.7****</td>
<td>64.7 ± 2.8****</td>
<td>4249.0 ± 403.4****</td>
<td>4249.0 ± 403.4****</td>
</tr>
<tr>
<td>Exercise + 3 min</td>
<td>111.4 ± 2.6****</td>
<td>145.7 ± 4.5****</td>
<td>67.6 ± 2.3****</td>
<td>2100.9 ± 178.0****</td>
<td>2100.9 ± 178.0****</td>
</tr>
<tr>
<td>Exercise + 10 min</td>
<td>98.3 ± 2.0****</td>
<td>120.5 ± 1.6**</td>
<td>75.2 ± 1.4****</td>
<td>967.7 ± 74.4****</td>
<td>967.7 ± 74.4****</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001, ****p<.0001, for comparisons of baseline levels with responses to stressors.
Fitness and Stress

Figure 1. Psychological responses to stressors. B = Baseline, F = Film, S = Stroop, C = CPT, E = Exercise. Stress response differs from baseline: *p<.05; **p<.01; ***p<.001.

responses, and several NE responses correlated with epinephrine. (See Table 4.)

The only psychological responses to show fitness-related effects were depression and anger after the film. Both of these were lower in fit subjects (see Figure 3). Furthermore, Type A personality as measured by the JAS was associated only with a higher relative HR response to the Stroop task (Type A = 22.3 ± 3.2 bpm, Type X = 13.6 ± 3.1 bpm, Type B = 10.1 ± 2.8 bpm; F(2/50) = 6.93, p<.002; Type A differed from Types X and B, p<.01 and p<.001, respectively). JAS scores were not associated with significant differences in response to any other stressor or in baseline measures. Comparison of treadmill times for Types A, X and B also revealed no significant differences.

Discussion

Aerobic fitness in this experiment was associated with lower baseline HR, lower relative NE response to fixed submaximal exercise, and higher relative NE response to maximal exercise. In addition, among subjects 40 yrs of age or older, fitness was associated with lower resting SBP and lower rela-

![Graph showing relative diastolic responses to stressors](https://via.placeholder.com/150)

Figure 2. Relative diastolic responses to stressors in subjects 40 yrs and older. 0' denotes relative diastolic pressure (RDBP) during each stressor; 3' and 10' denote RDBP at 3 and 10 min post stressor. *p<.05, **p<.01.

![Graph showing significant fitness-related psychological responses to film](https://via.placeholder.com/150)

Figure 3. Significant fitness-related psychological responses to film. *Group 1 differed from more fit groups: p<.05.

Table 4

<table>
<thead>
<tr>
<th>Measurement Periods</th>
<th>Baseline</th>
<th>Film</th>
<th>Stroop</th>
<th>CPT</th>
<th>Exercise (9 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Film</td>
<td>.78**</td>
<td></td>
<td>.67**</td>
<td>.61**</td>
<td>.43**</td>
</tr>
<tr>
<td>Stroop</td>
<td>.45*</td>
<td>.39</td>
<td>.58**</td>
<td>.84**</td>
<td>.25</td>
</tr>
<tr>
<td>CPT</td>
<td>.82**</td>
<td>.77**</td>
<td>.60**</td>
<td>.37**</td>
<td>.28</td>
</tr>
<tr>
<td>Exercise (9 min)</td>
<td>.27</td>
<td>.42*</td>
<td>.47*</td>
<td>.45*</td>
<td></td>
</tr>
</tbody>
</table>

*NE,epinephrine above diagonal, epinephrine below diagonal. In addition, the following NE/Epi. correlations were significant: Exercise (max.) NE/Exercise (max.) Epi., r = .57**; Film NE/Stroop Epi., r = .40*.

*p<.05, **p<.01.
tive DBP responses to some stressors. Only two fitness-related mood differences were observed; fit subjects were less angry and less depressed after the film than were less fit individuals. The only significant difference between Type A and Type B subjects was higher HR during the Stroop task in Type A subjects.

The fitness-related bradycardia observed in this experiment is a ubiquitous finding. The HR differences at baseline were reflected in similar differences in absolute HR at most sampling times (not reported here). An interesting point is the degree of aerobic fitness necessary to produce the observed bradycardia. Group 4 differed from Groups 1 and 2 at baseline, but the less fit groups did not differ from each other. Subjects in Group 4 were, indeed, very fit, most having completed marathons in the 2.5–3.5 hr range. Six of the 8 subjects in Group 3 were also marathon runners. A likely reason for the lack of effects of fitness level on baseline HR in women is that only one woman achieved placement in Group 4, and only one in Group 3. Thus, there were insufficient numbers of highly fit women to produce a statistically significant difference.

The significant fitness-related reduction in BP (baseline SBP and relative DBP) only in subjects over 40 is compatible with other evidence (reviewed above) that BP is lowered by training only in older and/or hypertensive individuals. None of our subjects was hypertensive; however, there is a tendency for blood pressure to increase with age. Indeed, older subjects in this experiment exhibited higher baseline SBP. One theory concerning the etiology of hypertension proposes that early labile increases in pressure lead progressively to stable hypertension, at least in some persons. Increasing aerobic fitness, and thereby reducing labile responses to stressors, may retard the progression of hypertension in predisposed individuals. However, it should be noted that fitness was associated with significantly reduced lability during only 3 of 9 non-exercise time samples. Another recent study also reported significant fitness-related reduction of DBP responses to stressors (Jacobs, Fish, Schooler, & Simpson, 1981). Furthermore, that study was conducted with college students, indicating that at least in some young people aerobic fitness may significantly lower DBP responses to stressors other than exercise.

While both NE and epinephrine were elevated by all stressors, there were no fitness-related effects except during exercise. The fitness effect during exercise, however, was dramatic. NE levels of fit persons were lower after 9 min of exercise (fixed sub-maximal load), but were much higher at exhaustion. Fit subjects had, of course, done much more work at exhaustion than less fit ones. Ziegler, Milano, and Hull (in press) found that over a range of 40 to 80% of maximum heart rate, NE levels increased exponentially with increasing heart rate, but from 80 to 100% maximum, the NE increase was even greater. As the cardiovascular system approaches the limit of its ability to deliver oxygen, tissue hypoxia elicits greater and greater NE release, which in turn increases cardiac output and distributes more blood to the exercising muscles. Repeated stress has been shown to increase the levels of catecholamines and their synthetic enzymes (Kvetnansky, Gewirtz, Weise, & Kopin, 1971). Exercise training is analogous to repeated stress, and enhances the subject's ability to synthesize and release catecholamines, thereby increasing work capacity.

The only psychological responses to be affected by fitness were depression and anger after the film, both of which were lower in fit subjects. There might well have been fitness-related differences following exercise if the mood assessment had been given after 9 min of exercise rather than, or in addition to, after exhaustion. However, it was logistically impossible to do this. The paucity of fitness-related mood differences was not due to lack of psychological responses to the stressors, since each stressor elicited significant mood changes relative to baseline. Thus, the popularly reported decline in "stressfulness" may be felt more in terms of long term coping rather than in immediate psychological responsiveness, or may be at least partially a result of expectation. On the other hand, the recent study by Sinyor et al. (1983) reported lower anxiety at the end of a psychosocial stress session, in addition to a more rapid decline in HR after the individual stressors.

The only response which showed a relationship to Type A behavior, as measured by the JAS, was HR during the Stroop task. That Type A subjects were more-responsive than Type B persons on the Stroop task is not surprising, since it required active mental effort. Type A persons have been shown to be more responsive than Type B subjects on tasks which required active coping, but to be less reactive to tasks which were either very easy or impossible (Glass, 1977). It is, however, interesting that Type A responsiveness was characteristic of HR rather than BP measures. The lack of influence of Type A on BP responses was not due to the ineffectiveness of the stressors in evoking BP responses; all stressors elicited both HR and BP increases. This same pattern of Type A influence on HR but not on BP responses, even in the face of significant increases in BP, was seen in recent studies by Morrell (1982) and Reed and Katkin (1983).
The lack of relationship between Type A behavior pattern and aerobic fitness contrasts with the reduction in JAS scores reported by Blumenthal, Williams, Williams, and Wallace (1980). However, the present study utilized a cross-sectional design, with a wide range of fitness levels and with controls for time spent in non-occupational pursuits. The former study reported differences in JAS scores before and after a modest program of group exercise training, and utilized no control group. Thus, it is difficult to make meaningful comparisons between the two findings. We suggest that aerobic fitness is not directly associated with lower JAS scores, and that exercise training can be pursued with as much competitiveness as can one's occupation. The reduction in JAS scores reported by Blumenthal et al. may have been related to social factors and/or an implicit emphasis on moderation in training.

There was no preferential generalization of the fitness effect to the active psychological task, the Stroop word color test. The reduction in diastolic responses of fit subjects over 40 was distributed across the stressors, and the reduction in psychological responses was seen only after the film. Furthermore, while absolute HRs of fit subjects were generally lower, relative HR responses showed a reduction only to exercise. Thus, the training related reduction in cardiovascular lability is neither all-pervasive nor specific to tasks which elicit cardiovascular responses similar to those of exercise.

In summary, we have shown that aerobically fit subjects over 40 exhibit reduced lability in DBP responses to stressors as well as lower resting SBP compared with less fit subjects of similar age. We have also reaffirmed the common finding of bradycardia in aerobically fit persons, both at rest and in response to stressors. This bradycardia was statistically significant, however, only in very fit subjects. Aerobic fitness was associated with lower NE output at a fixed load of exercise, but greatly elevated NE at exhaustion. The lower NE at fixed loads and the rapid decline in levels after cessation of exercise signify greater metabolic efficiency in response to exercise in aerobically fit persons. Aerobic fitness, however, facilitates catecholamine release at near-maximal HR. Among mood measures, only depression and anger after the film showed fitness-related decreases. Type A behavior pattern was associated only with increased HR during the active psychological task (Stroop task). There was no preferential generalization of fitness effects to the active psychological task.

REFERENCES


Development of an objective psychological test for the determination of the coronary-prone behavior pattern in employed men. *Journal of Chronic Diseases*, 20, 371–379.


(Manuscript received August 19, 1982; accepted for publication January 12, 1984)