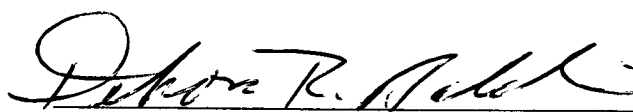
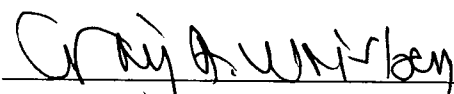
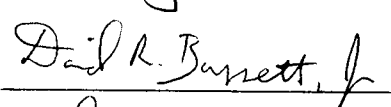
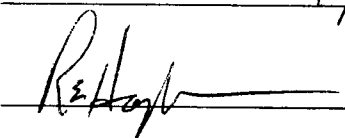


To the Graduate Council:

I am submitting herewith a dissertation written by Francis W. Craig entitled, "The Roles of Fitness, Family History of Hypertension, and Stress/Novelty Familiarity in Moderating the Cardiovascular Stress Response in College Men and Women". I have examined of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.


Debora R. Baldwin, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Associate Vice Chancellor and
Dean of the Graduate School

**The Roles of Fitness, Family History of Hypertension,
and Stressor Novelty/Familiarity
in Moderating the Cardiovascular Stress Response
in College Men and Women**

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Francis Washington Craig

August 1998

DEDICATION

This dissertation is dedicated to Kathleen Craig, my wife, and Debora Baldwin, Ph.D., my major professor.

For the past three years, Kathleen has provided a ground of selfless and unwavering love despite the figural demands of my graduate training and searches for post-graduate employment. There are few ways to I can adequately express my love for her. In noting these feelings, I am reminded that Kathleen and I share hearts, and thus, this dissertation is our accomplishment.

While Kathleen supported my soul at home, Dr. Debora Baldwin lent me hope and optimism while at the University. Deciding to work with Debora was the best decision I made in graduate school. For the last 2 years, with "kid gloves", she has pressed me, then eased off, allowing me evolve into a budding, capable young scholar. She is a bright mix of intensity and sensitivity. I am proud to be her first Ph.D. student and her friend. All doctoral students should be so fortunate.

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There are many people to whom I am grateful for their contributions toward a meaningful graduate experience.

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Other people who should be recognized include: My parents, Mr. and Mrs. Francis Craig, Sr. who have been supportive through my entire graduate career; my friends, Howard Rasey, Carl Keany, Zac Wilcox, Keith Kline, and Mike Smith, Ph.D.; my wife's mother, Eileen Lynch, and in particular my wife's father, Jim Lynch, Ph.D. Almost eight years ago I told Jim I wanted to learn more about cardiovascular behavioral medicine. A world was opened to me that few graduate students have seen. I thank him sincerely and look forward to our future efforts.

ABSTRACT

The question of whether aerobic fitness moderates the cardiovascular response to stress has been a difficult question to answer clearly. The goal of the present study was to examine conceptual and sampling issues that may have hindered past research. Specifically, in this study a cross sectional design was used to focus on the interaction of fitness with the cardiovascular stress response in three areas: Gender Differences, Family History of Hypertension, and Stressor Familiarity.

One hundred and three men and women attending the University of Tennessee-Knoxville were fitness tested and categorized into fit and less fit groups. Each completed a psychophysiological protocol in which measures of blood pressure and heart rate were collected at rest and during three periods of stress where the participant talked or read to the investigator. The data were analyzed with mixed model repeated measures analyses of variance.

It was found that for both men and women, fitness was related to decreased levels of blood pressure and rate-pressure product. Additionally fitness was associated with decreased BP responses during stress in men and women with a family history of hypertension. Fitness was not associated with cardiovascular response differences to familiar or novel stressors in men or women. Overall, the association

between fitness and the BP response to stress was stronger among males. However, it is suggested that this stronger association may have been due to larger differences in physical activity between the fit and less fit groups of males than that of females, rather than to a genetic predetermination.

The present study significantly contributes to the overall literature in this area by presenting evidence of a potential fitness interaction in both male and female groups, and in groups with a family history of hypertension. More importantly, new questions are raised for future research regarding whether the effects seen may actually have been the result of differences in physical activity levels, rather than fitness differences.

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LIST OF ABBREVIATIONS

CHD	Coronary Heart Disease
CSA	Cross Stressor Adaptation
CSAH	Cross Stressor Adaptation Hypothesis
CV	Cardiovascular
CVD	Cardiovascular Disease
DBP	Diastolic Blood Pressure
FH+	Positive Family History of Hypertension
FH-	Negative Family History of Hypertension
HR	Heart Rate
MAP	Mean Arterial Pressure
RPP	Rate Pressure Product
SBP	Systolic Blood Pressure

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CHAPTER I

INTRODUCTION

The basic question of whether aerobically fit individuals are less physiologically responsive to stress has proved to be an elusive question to answer. The contention that a relationship exists between fitness and the stress response has been termed the "Cross Stressor Adaptation Hypothesis" (CSAH) by Sothmann, Claytor, Buckworth, White-Welkey & Cox (1996). These investigators (along with many others) have proposed that the training-induced physiological adaptations which lead to decreased autonomic responsivity to an exercise stressor (e.g., decreased HR, BP etc.) may generalize in such a way that physiological responses to other, "non-exercise" or "psychological" stressors, may also be reduced. In 1997, despite the fact that in the past two decades nearly 80 studies have been conducted to test this hypothesis, there seems to be little consensus on this problem.

In 1987 Crews and Landers published a meta analysis of the CSAH based on data from 34 studies. These authors concluded that a moderate relationship exists between fitness level and the autonomic stress response to psychological stressors, such that individuals with greater fitness showed less physiological response to psychosocial stressors. These authors specifically concluded that

"regardless of the type of physiological and psychological measure used, [in the studies observed it appeared that] aerobically fit subjects had a reduced psychosocial stress response (page S118)".

Despite these promising findings, a number of problems and questions were left unaddressed by Crews and Landers' analysis. For instance, the validity of their conclusions have been questioned due to the small number and poor quality of the studies analyzed. Further, it has been pointed out that anecdotal data and poorly controlled studies represent a sizable portion of the studies used in this analysis, and this seriously weakens the generalizability of the findings (for the most recent review see, Sothmann, et al, 1996).

Another glaring problem, not pointed out in published reports involves is that Crews and Landers mixed studies that had essentially different research foci. These differences included, studies of post exercise CV hypotensive effects, CV level response ("level data"), phasic response ("reactivity") and autonomic recovery rates¹. Since the different hypotheses of these studies yield different results, it is problematic to assume that they represent shades of the same general research problem.

¹ In fairness it should be mentioned that some separate discussion was given to the effects of fitness on recovery from stress but statistically all data was combined and thus the issue of mixed hypotheses remains.

Perhaps the most serious limitation of Crews and Landers research is that their study did not clearly identify which indices of physiological functioning (e.g., BP, HR, CA, EMG) may or may not have been affected by fitness level. This omission was based on statistical choice however, not oversight. Specific conclusions regarding individuals' response measures were considered inappropriate by Crews and Landers in light of what they interpreted to be a fairly consistent trend across all variables toward decreased autonomic stress effects in fit subjects. They wrote:

...It is difficult to resist the temptation to try to glean a deeper understanding of the variables which may influence the general pattern of the aerobic fitness-psychosocial stress-reactivity² relationship. However the results of this meta analysis *clearly* indicate that it may be unproductive at this time to do this since the types of stress response measures employed do not produce a heterogeneous response that would suggest moderator variables.

[Italics added]p.S-119

This was not a precisely accurate assessment. Of the tests of homogeneity conducted, both SBP and EMG produced significant heterogeneous patterns. For other measures,

²this use of the term "reactivity" in this passage is interchangeable with "response". Crews and Landers did not differentiate the results from the reactivity literature from those of the response (or level) literature.

although not statistically significant, large χ^2 values were reported, indicative of a good deal of heterogeneity.

Perhaps, for that reason, Crews and Landers did not entirely dismiss the value of researching the individual measures of autonomic activity potentially involved in CSA. They wrote that:

[in the future] time would be better spent examining underlying mechanisms for the aerobic fitness effects. In defining these mechanisms, it may be entirely possible to determine how these changes in fitness actually reduce stress response or time spent in stress.
(p. S-119)

Thus, Crews & Landers, despite the statistical conclusion of generalized autonomic dampening with increased aerobic fitness, left the door open to examine independent response measures which index pathways and mechanisms of the systems involved in the autonomic stress response³.

In the most recent summary of research Sothmann et al (1996) proposed a number of specific directions for future study of the CSAH. For the most part, their suggestions stem from shortcomings found in Crews and Landers' paper. Sothmann's group stated that the most noteworthy deficiency in the literature is related to a lack of attention to

³For instance HR is mediated by both parasympathetic and sympathetic activation; DBP is associated with alpha adrenergic activity, given higher levels of circulating epinephrine exists (as might be found during some stressful situation).

"group differences". Foremost is the lack of research conducted in the study of fitness mediated cross stressor adaptation (CSA) in women. The authors wrote:

...one of the most relevant limitations is the lack of research on females. A high incidence of autonomic disease and the possibility that neural control of circulation during a physical or behavioral challenge may be qualitatively and quantitatively different from those in males makes this an important consideration. (p. 282)

Secondly, it is suggested that a future research progression might be best found by attending to clinical populations for whom the benefits of a cross-stressor adaptation via elevated fitness levels would have the greatest clinical meaning.

There is clearly a need for more research on the potential of exercise training for promoting health in clinical populations in which a characteristic of the medical condition includes a more chronic comprised stress capability. Research suggests that compromised stress system involvement in such medical conditions as depression, panic anxiety, hypertension, chronic fatigue syndrome, obesity etc. may fall along a continuum of hyper- and hyporeactivity. Critical issues to be addressed [include] determining whether exercise training induces a stress

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system adaptation in such clinical
groups. (p. 281)

A third area for which future study is related to qualities of the stressor presentation itself and its relationship to fitness/exercise and cross stressor adaptation. Specifically, research from the laboratories of Sothmann and his colleagues has indicated that the familiarity or novelty of a psychobehavioral stressor may determine whether fitness plays an attenuating (or exaggerating) role in the stress response. They write:

There is evidence emerging from our laboratories and others to support the need to evaluate the cross stressor hypothesis along a dimension of novelty and familiarity. (p. 281)

Given the tentative findings presented by Crews and Landers (1987), and the recent examination of the deficiencies of focus in the CSA research in past years by Sothmann, Claytor, Buckworth, White-Welkey and Dishman (1996), it appears there is an opportunity to move toward some consensus on the magnitude and parameters of association between fitness and the stress response. Despite the meta-analytical work and area reviews completed to date, it is clear that further examination of the cross stressor adaptation hypothesis is needed. Future research

must work to answer pertinent questions (such as those raised by Sothmann) which have remained relatively unaddressed for 10+ years, instead of replicating past findings.

REVIEW OF THE LITERATURE

Despite continuing shortcomings in the current CSAH research, in many ways the state of the literature can immediately shed light on the topics Sothmann and his colleagues believe were not sufficiently explored. From the findings of these explorations, future research can be designed to address questions that will expand the understanding of the field rather than contribute to its state of ambiguity.

In the following review of the literature the CSAH research is summarized with respect to the discriminating roles of sex group (male/female), hypertensive risk status, and stressor familiarity/ novelty. In particular this review concentrates on studies observing heart rate and blood pressure response since these variables (particularly BP) are of known clinical importance for groups at greater risk for CHD, a focus of this dissertation.

INTEGRATION AND SUMMARY OF GROUP RESULTS

The first sub-reviews of literature are designed to provide clarification of the issue of group sensitivities to the effects of heightened fitness on the physiological response to psychological stress. Figure II-1 lists the

amount of research completed before and after the time of Crews and Lander's meta analysis.

	N	Male Only	Female Only	Mixed**	College	Older	Clinical	Normal
1977-1986	24	11	2	8	11	8	6	17
1987-	51	30	10	10	33	20	13	41

*Studies in which group information was not reported or available were included in total but omitted from group tallies.

**These do not include studies in which sex was analyzed separately.

Figure II-1. Numerical Summary of Group Foci of Fitness Stress Response Research Before and After Crews & Landers (1987)

What can clearly be seen in Figure II-1 is that the bulk of research in the first 10 years devoted to either male or mixed-sex samples with considerably less concentration focused on women and clinical populations. Since that time, significantly more studies have focused on women and clinical populations leaving enough data to address the question of response differences between males and females as well as those among clinical populations.

THE CSA HYPOTHESIS AND SEX EFFECTS

In their meta-analytical effort, Crews & Landers tentatively concluded that indeed fitness acts to reduce the effects of the CV response to stress; however the size of effect (i.e., the magnitude of association) is roughly two-times as large for men as for women (thus the influence of

fitness appears to be more reliable and beneficial in men than in women). Perhaps uncomfortable with this precarious suggestion, the authors specifically noted that there was difficulty in addressing whether a true sex effect was present because few studies had studied sex as a separate variable. At the time of their analyses, the authors only located 4 studies that employed samples of strictly female participants.⁴ In 1997, of the 80 plus studies found⁵, only 12 were focused on females as a group while 39 were dedicated to the study of male responses (See Figure II-1). Despite the continuing disproportion between male and female oriented studies, it is clear that since publication of Crews & Landers (1987), there have been significantly more studies conducted on females than before. Additionally, the quality of these is much improved (a general criticism of many studies included in the 1987 meta analysis).

Why Study Females Separately? There are other important reasons for CSAH studies to analyze data separately for sex other than the simple lack of research attention to one group or another (although this has been the reason invoked by most investigators who have proclaimed the need to study

⁴It might be noticed that this review occasionally notes slightly different counts than Crews and Landers. This is in part due to the strict focus of this review on the stress response during stress. As mentioned previously Crews and Landers used studies of fitness and post-exercise effects; fitness, stress, and recovery data, as well as fitness and stress response data obtained during the actual stressor.

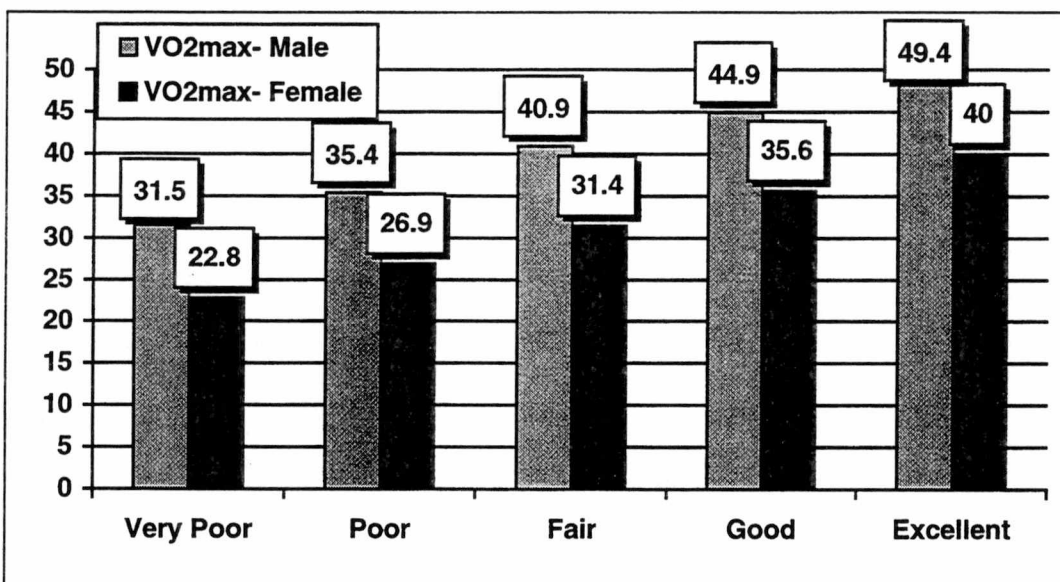
⁵This includes a number of studies using non-human animals to study the CSAH

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women separately). The most basic reason is strictly methodological. A failure to analyze fitness data separately by sex violates the statistical assumption of the independence of *independent* variables. Specifically, fitness is not independent of sex. Due to natural physiological differences (greater percentage of body fat in women than in men, thus a tendency to carry greater weight relative to size), women are more likely to show lower absolute fitness values than men despite the fact that similar adaptations may have taken place during training. This observation is born out by a review of normative fitness categories for men and women that designates aerobic capacities grouping of *poor* through *excellent* (See Figure II-2). For each grouping category the values for women at each given stage of aerobic capacity are lower in absolute terms than those for males. Thus, it appears that while males and females can exist in the same fitness group (e.g., "high fit"), they may have very different aerobic capacities. Despite this rather basic understanding, very few mixed-sex studies have split statistical analyses by sex so that the results of men and women could be considered separately (and none have grouped sample by common normative group).

A second reason for examining the fitness data of males and females separately is purely practical, and extends from

the research finding of sex differences in CSA quoted previously. The results of meta-analytic research, despite their admitted shortcomings, still suggest that fit males appear to enjoy roughly twice the reduction of autonomic response to stress with elevated fitness than do females when each is compared



Source: Cooper, K. (1977). The Aerobic Way. New York: Basic Books.

Figure II-2: Fitness Classifications for Males and Females, Age 30-39

to their less fit counterparts (Crews & Landers, 1987). Therefore, since males and females may derive different degrees of benefit from increasing their fitness levels they should be treated as different groups each worthy of independent study.

Given, (1) a clearer picture of the relationship between fitness and sex; (2) knowledge of the shaky findings for sex differences from a 10-year-old review; and (3) the benefit of significantly more data available today than in 1987, it appears that it is an appropriate time to reevaluate previous research giving each gender individual attention.

FITNESS AND THE PHYSIOLOGICAL STRESS RESPONSE IN WOMEN

Immediately, the small number of studies on females may be seen as a detriment to analyses of trends in the data. However, at least two salient points suggest that reasonable conclusions can be drawn. First, trend analysis can and has been done with fewer studies even within this area of research (Cox, 1991; Sothmann, Hart & Horn, 1991). Second, it should be pointed out that of the 12 papers reviewed, 10 studies were carried out since 1987, a point in time after which the quality of studies investigating the cross stressor adaptation hypothesis improved dramatically. Many of the methodological limitations found in earlier studies were less evident in studies published after Crews and Landers' paper. Improvements include the use of gas-collected $\text{VO}_{2\text{max}}$ to measure fitness, completion of longitudinal (training studies), and the use of a greater variety of physiological dependent measures, rather than

reliance on HR as a singular measure, by which effects of the stress protocol could be monitored. Perhaps some indication of the quality of female CSAH research conducted can be ascertained by the quality of the journals publishing the material. Publications were seen in prestigious journals such as Circulation (Buckworth, Dishman & Cureton, 1994), Health Psychology (Blumenthal, Fredrikson, Matthews, Kuhn, Schniebolck, German, Rafai, Steege & Rodin, 1991; Steptoe, Moses & Edwards, 1990) Psychosomatic Medicine (Holmes & McGilley, 1987) and Psychophysiology (Holmes & Roth, 1985). Therefore, even given the small number of studies observed, a reasonable degree of confidence can be taken from these data. In the following section these and other female focused studies are examined.

Heart Rate Level Response. Ten studies used heart rate as a dependent measure⁶. The majority of these utilized a cross sectional design. Early cross sectional research utilized primarily small samples of young college aged women, with little attention being paid to possible intervening group variables such as psychological status, family history of cardiovascular disorder, or current CV health. Garber, Sinconolfi & Carelton (1985) reported that

in a sample of 5 trained ($\text{VO}_{2\text{max}} = 39.8$ ml/kg/min) and 5 untrained ($\text{VO}_{2\text{max}} = 23.8$ ml/kg/min) women, significant differences in HR levels during a behavioral challenge (Stroop Test) were not found. A closer review of these data reveals that in fact, some modest differences did exist with fit women exhibiting lower HR during stress. However, due to the small number of subjects, statistical significance was not achieved.

In two larger studies it was found that HR levels during stress in 10 fit ($\text{VO}_{2\text{max}} = 53.5$ ml/kg/min) women were significantly lower during a 3-minute "mildly stressful stimulus" (a digits backwards task of the Wechsler Adult Intelligence Scale), than HR levels of 10 unfit ($\text{VO}_{2\text{max}} = 28.8$ ml/kg/min) women (Holmes & Roth 1985). This finding was replicated in a larger sample by McGilley & Holmes (1988) in a study of 32 college aged females. In their sample, those women classified into the higher fitness group (as determined by performance on the Cooper Run/Walk test) exhibited significantly lower HR levels during a moderate verbal performance stressor. Interestingly, the fit subjects also reported a lower level of perceived somatic arousal as well.

⁶Holmes & McGilley, 1987; Sedlock & Duda, 1994; Holmes & Roth, 1985; McGilley & Holmes, 1988; Brooke & Long, 1987; Blumenthal, Fredrikson, Matthews, Kuhn, Schniebolz, German, Rifai, Steege & Rodin, 1987; Houtmann & Bakker, 1991; Garber, Sinconolfi & Carleton, 1985; Gurley Peacock, & Hill, 1987; Steptoe, Moses & Edwards, 1990

In one of the few studies to employ a multiple regression analysis procedure, Houtmann & Bakker (1991) studied how fitness mediated the stress response of college teaching in university graduate teaching assistants. Measures were recorded early in the semester and again three months later. From the analysis of 22 female instructors, fitness was modestly predictive of HR level just prior to the second lecture ($r=-.32$), during the class in either the first or later measurement session.

Sedlock and Duda (1994) compared more (>44 ml/kg/min) and less fit (<34 ml/kg/min) groups of women with high and low trait anxiety. They concluded that no fitness effect on the stress response was present (although the statistical analysis was questionable). Although not significant, the graph of data presented by Sedlock and Duda (see their Figure 1, p.223) showed that the "High Fit/High Anxious" participants exhibited lower HR throughout the protocol while the Low Fit/Low Anxious group exhibited the highest HR during a 5 minute stressor period. In general, their data suggested that fit women, regardless of anxiety level exhibited lower HR levels during stress.

Buckworth, Dishman & Cureton (1994) studied a sample 31 women with a confirmed family history of hypertension and found that fitter females ($\bar{M}=46.2$ ml/kg/min) HRs were about

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one-third of a standard deviation ($ES_d=.30$)⁷ lower than less fit females (35.9 ml/kg/min) during mental arithmetic and .45 of a standard deviation less during a cold pressor test. For each stressor the effect sizes reported were greater than those reported by Crews and Landers research.

Three training studies have also suggested some evidence of a fitness effect on stress response in women (Blumenthal et al, 1991; Gurley & Peacock, 1987; Holmes & McGilley, 1987). Holmes & McGilley (1987), conducted a training study in which 67 females were assigned to one of four groups that were tested both before and after a training/control participation of 13 weeks. Initial assessment of fitness was made with the 12-mile walk/run test. Based on these results, women were divided into fit ($n=34$) and unfit ($n=33$) groups from which thirty were assigned to the training group (15 more fit, 15 less fit) and thirty-seven to a control group (19 more fit, 18 less fit). To obtain a training effect, subjects exercised two times weekly at 70% of maximum HR for a 20-25 minutes. At the end of thirteen weeks, HR levels to stress were less in both training groups. However, significant attenuation occurred only in the *initially* less fit group. A 40% and 33% attrition rate in the training and control groups,

⁷ ES_d = Cohen's d , an effect size used to standardize differences between group means. $ES_d = [M1 - M2 / \text{pooled SD}]$

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respectively, somewhat clouded the results of this study.

In one of the least informative studies due to poor statistical reporting, small sample size, and poor design, Gurley, Peacock & Hill (1987) found no differences in HR levels or reactivity to a moderate stressor in females. Only 8 females were included in this study of which four were assigned to a training group and four acted as controls. Training consisted of 1 hour of aerobic or interval-type exercise 5 days a week for six weeks. No mention of adherence was recorded, and more importantly, no test of fitness was completed (pre or post). Therefore while a training effect was assumed, it was not tested for. Additionally, no note was made regarding the amount of time spent in aerobic versus interval activity, or the HR training zone subjects were encouraged to maintain.

Blumenthal et al (1991) observed forty-six pre and post menopausal women who participated in a 12 week program that included training for 35 minutes three times weekly at approximately 70% of HRmax. Pre-Post VO_{2max} increased significantly from an average of 26.7 to 31.6 ml/kg/min for each group. At the end of twelve weeks, it was found that there was a main effect for aerobic training on HR across all levels of the psychophysiological protocol. That is, compared to pre-training, post-training HR response was significantly less during both stressful and non-stressful

Fitness and CV Stress Response 19 periods for both pre and post-menopausal women. The lack of significant habituation seen in a matched strength training control group suggested that differences were indeed due to aerobic training.

A summary of the HR level data is presented in figure II-3.

Heart Rate Summary

	#	Comparisons	N	++	+	0 or --
Level	9	15	294	7	7	1
CrossSxn/Reg	6	9	173	2	6	1
Training	3	6	121	5	1	0
Reactivity	5	14	183	1	1	12
CrossSxn/Reg	3	9	129	2	0	7
Training	2	5	54	0	1	4

Key

#	Number of studies found
Comparisons	Number of group comparisons between fit and less fit participants
CrossSxn/Reg	Cross Sectional and Regression Design
Training	Studies employed longitudinal fitness training designs
N	Number of participants observed
++	Strong/significant evidence of fitness effects
+	Non significant but consistent supportive evidence
0 or --	Clear Support of Null Hypothesis (H_0)

Figure II-3. Summary of Research Results of Fitness and HR Stress Response in Females

Heart Rate Reactivity Response. Some HR research has sought to determine whether fitness decreased HR reactivity in women. Five studies provide interpretable data regarding

this question (Figure II-3).⁸ Holmes and Roth (1985) found that in a sample of undergraduate females, highly fit women (53.5 ml/kg/min) demonstrated significantly less HR reactivity than did low fit (28.8 ml/kg/min) women to the Weschler digits-backward test. Long (1991) did not find reduced HR reactivity differences to mental arithmetic and the ECG quiz stressors in 12 fit (62 ml/kg/min) vs. 13 less fit women (32 ml/kg/min) drawn from the local community (age range 18-30, $\bar{M}$ = 30). Similarly, Steptoe, Moses and Edwards (1990) did not find lower HR reactivity in fit vs. less fit samples of women who had been previously grouped into young, middle age and older sub-samples. Blumenthal et al (1991) produced the only controlled training study that observed HR reactivity with women subjects⁹. In a study of pre and post-menopausal women, no differences in HR reactivity was observed in response to a public speaking challenge or to an ice-to-forehead stressor. After review of their results these authors speculated that "HR levels during stress --but not reactivity-- may be reduced by aerobic exercise training". Thus, these results largely mirror the findings of cross sectional research on HR reactivity.

⁸Blumenthal et al, 1991; Holmes & Roth, 1985; Long, 1991; Steptoe et al, 1990.

⁹A training study by Gurley, Peacock & Hill (1987) showed some evidence for a reduced reactivity response in women. However, problems with study limit the usefulness of these findings.

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Blood Pressure Effects. To date 252 women have participated in 7 published studies involving 10 comparisons between fit and less fit women's blood pressures. Seven studies observed SBP, six utilized DBP measures and only one measured mean arterial pressure (MAP). Four studies observed changes in BP levels to stress, while another four observed BP reactivity differences.¹⁰ Of these studies, only one employed a training design (Blumenthal, Fredrikson, Kuhn, Ulmer, Walsh-Riddle, & Applebaum, 1990). Figure II-4 details the breakdown of research findings of studies observing BP response differences in fit and less fit women.

Blood Pressure Level Response. Both Garber et al (1985) and McGilley & Holmes (1988) observed BP level responses in normotensive college aged females. Garber et al (1985) found non-significant trend toward lower levels of SBP and DBP during exposure to the Stroop Color-Word Stressor. They speculated that a few extreme responses in the unfit group, as well as a small sample size (5 fit; 39.5 ml/kg/min vs. 5 unfit; 23.8 ml/kg/min) may have led to their finding of statistically unreliable differences. Using a slightly larger sample, McGilley and Holmes (1988) found significant stress response differences for SBP, and DBP for minutes 1 and 2 of a three minute stressor. In this study, women able

¹⁰One study (Blumenthal et al, 1990) analyzed both HR level and reactivity measures.

Figure 4A
Systolic BP Summary

	#	Comparisons	N	++	+	0 or --
Level	5	10	143	4	1	5
CrossSxn/Reg	4	6	97	3	1	2
Training	1	4	46	1	--	3

Reactivity	4	13	187	2	1	10
CrossSxn/Reg	3	9	141	1	1	7
Training	1	4	46	1	--	3

Diastolic BP Summary

	#	Comparisons	N	++	+	0 or --
Level	4	8	119	2	1	5
CrossSxn/Reg	3	4	73	1	1	2
Training	1	4	46	1	--	3

Reactivity	4	13	187	3	1	9
CrossSxn/Reg	3	9	141	2	--	6
Training	1	4	46	1	--	3

Key:

= Number of studies found
 Comparisons = Number of group comparisons between fit and less fit participants
 CrossSxn/Reg= Cross Sectional and Regression Design
 Training = Studies employed longitudinal fitness training designs
 N = Number of participants observed
 ++ = Strong/significant evidence of fitness effects
 + = Non significant but consistent supportive evidence
 0 or -- = Clear Support of Null Hypothesis (H_0)

Figure 4B:¹¹

Other	#	Fit > Unfit	Fit < Unfit	Fit = Unfit
Mean Arterial Pressure	1	--	--	1
Rate-Pressure Product	1	--	1	--

Figure II-4: Summary of Research Results of Fitness and BP Stress Response in Females

¹¹ Mean Arterial Pressure- Buckworth et al, 1994; RPP- Garber, Sinconolfi & Carelton, 1987

to run on average of 1.51 miles on the Cooper Run/Walk test (approximately equivalent to a VO_{2max} greater than 40ml/kg/min, cf. Howley & Franks, 1992, p.160) demonstrated lower levels of SBP and DBP during a three minute Wechsler digits backward stressor than did women who ran on average of 1.03 miles (VO_2 max less than 25 ml/kg/min; cf. Howley & Franks, 1992, p.160). This finding was significant before and after covarying out the effects of baseline BP levels.

Buckworth et al (1994) also studied college-aged women, but restricted their sample to women with a family history of hypertension. They found no differences in SBP, DBP, or MAP levels during stress in fit vs. less fit college women. All participants were tested during the follicular phase of the menstrual cycle in an attempt to control for the effects of the female hormonal cycle on cardiovascular mechanisms.

The only study to report ambulatory BP was completed by Gullette, Szczepanski, Dominick, Opiteck, Sherwood, Waugh, & Blumenthal (1996). Multiple measures of home and work place SBP were taken from 24 hypertensive women. Analysis revealed that fitter hypertensive women exhibited significantly lower levels of SBP at work and home. This finding is important as it suggests that laboratory evidence of a fitness mediated CSA response to artificial stressors may indeed be generalizable to conditions common to the

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outside world. Thus, the lab differences may not be an epiphenomenon, but a reliable index of our daily a physiological experience of stressful stimuli.

In one study examining both BP levels and reactivity, Blumenthal et al (1990) collected data from separate samples of pre and post-menopausal women who participated in either strength or aerobic training. The results of this study indicate a reduced CV response to stressful stimuli in aerobically fit women. Regarding BP level responses, it was found that, relative to pre-test stress levels, aerobically trained women exhibited lower SBP and DBP levels during cold pressor and public speaking stressors. Compared to the strength training control group (ST) were made however, aerobic training (AT) was found to be associated with lower SBP and DBP levels and decreased reactivity in the cold pressor condition for *postmenopausal women only*.

Nonsignificant reductions in BP level response was seen for both ST and AT groups to the public speaking task from pre to post stress testing. These authors note that perhaps one of the reasons for the lack of definitive findings was the greater intensity of the public speaking stressor. This stressor evoked BP and HR changes more than twice as large as those typically seen in traditional digits-backward and mental arithmetic tasks. For this reason it was proposed that fitness response differences were washed out by a more

extreme response of stress. This possibility has been forwarded by a number of other authors as well (Manuck & Garland, 1979; McCubbin et al, 1992).

Blood Pressure Reactivity Response. Steptoe, Moses and Edwards (1990) as well as Long (1991) investigated the CV reactivity responses in fit and less fit women. Steptoe et al found no reduction in BP reactivity for fit young or middle aged women using easier and more demanding Raven's Progressive Matrices tasks, a written stressor-protocol. However, fit older women (44-60 yrs) exhibited significantly lower SBP in the first 2 minutes of difficult tasks. It should be noted however that the written stressor employed in this research for the most part was ineffective at producing a significant stress response. Only in the more difficult tasks was there a marginal stress reactivity response (change from baseline levels) and only in the oldest women were HR and BP levels elevated to a level that may be indicative of some mild stress. For instance, on average during the most difficult task, for young, middle age and older subjects increased SBP by 7.94, 10.56, 13.40 mmHg, and DBP by 5.08, 6.30, 6.04 mmHg, respectively. Average stressor levels of SBP were only greater than 130 mmHg for SBP and 85 mmHg for DBP for the oldest women in the most stressful conditions. It is therefore reasonable to

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suggest that for a fitness effect to be tested, the organism must at least be moderately stressed. In the only condition (difficult task) and group (older women) where the females were clearly stressed significant differences were observed in the stress responses of fit and less fit women.

Long (1991) compared BP reactivity differences in highly trained females (max >60 ml/kg/min) and untrained females (<32 ml/kg/min) and found no reactivity differences. Unfortunately, as in Steptoe's study, the stress manipulation¹² was relatively ineffective at producing a response. Long reported that SBP levels did not significantly change from baseline levels, while DBP did increase in a statistically significant fashion ($p < .02$). Given the large sample observed ($n=54$), this may be a fairly meaningless increase which likely amounts to a difference of only 2-4 mm Hg from baseline, a number similar to the increases among the younger and middle aged women in the Steptoe study.

Summary of Female Findings & Issues of Research Concern.

From the available research a number of conclusions can be drawn. Obviously, it is clear that in the past decade investigators have paid more attention to designing

longitudinal research, and assembling samples which include women of varying ages rather than just college aged females. Although simple in nature, these changes represent a trend toward general improvement in the ecological validity of female oriented studies.

In terms of summarizing the actual data, interesting conclusions can be drawn from the HR and BP data. Analyses of CV level responses in women appear to be suggestive of fitness mediation. This is particularly true for HR level effects in which an overwhelming majority of studies reported significant main effects indicative of lower HR in fit women compared to unfit women during stress (14 of 15 comparisons revealed consistently lower HR). This finding is strengthened by the fact that the results of training studies are consistent with the findings of earlier cross-sectional research. Less clear, but suggestive, are the fitness differences in SBP levels. Only half the comparisons found lower levels during stress in fit women including ambulatory BP findings. More clearly however is the absence of consistent findings for reactivity differences for any CV measure. Less than 25% of the completed CV reactivity analyses revealed reactivity differences in the predicted direction. This was

¹² The stressors used in this study were the ECG Quiz and mental arithmetic. The approach to quantifying the stress level used during analysis is not spelled out well by the authors. It appears their approach was to combine the effects of the two stressors at

particularly clear in HR analyses, but almost equally evident in BP analyses. For all CV measures of reactivity, the clearly negative results of the training studies further support these conclusions. It should be noted however that to date, only one training study (in which effective stressor presentation was questionable) which observed BP reactivity response in fit and less fit women has been conducted (Steptoe et al, 1991). Consistent with Steptoe's et al's study, however, are other cross sectional efforts which also show no consistent trend for fit women to respond with smaller reactivity changes.

A number of problems still limiting the research on females are also noteworthy. First, as just noted, the small number of training studies somewhat decrease the power of the available findings in which cross-sectional data are still murky. Future research would be well served by training studies observing BP level. These studies, if well conducted, would go a long way toward clarifying the question of CSA in women.

A number of studies did not use a stressor of sufficient intensity to produce significant changes in CV levels or reactivity. A review of studies in which sizable, but not extreme changes were evinced, indicates that stressors which are verbal in nature reliably produce BP

increases of 10-20% over baseline levels. Tasks which are non-verbal in nature (with the exception of the cold pressor and exercise) appear to be less reliable means of obtaining a CV response. Therefore, tasks such as verbal stroop, mental arithmetic, and interview seem to be simple and reliable means of producing the required changes without also compromising results by over stimulating the system. A further benefit of the above-cited verbal tasks is that they may be reasonable analogs for the form of social stressor (i.e., dialogue) which people most commonly experience. Thus, these tasks appear to offer a greater degree of ecological validity than non-verbal tasks.

A final point is the virtual absence of attention to populations at-risk for CHD. Only a couple of studies observed hypertensives or those predisposed to develop hypertension, each of which produced results suggestive of a decreased CV stress response. Future research focusing on at risk samples may serve a greater utilitarian value in terms of establishing an avenue for dealing with the prevention or amelioration of high blood pressure.

In 1987, it was concluded, based on the review of ten studies, that the autonomic stress response of fit males was approximately one-half of a standard deviation lower than the response seen in a population of sedentary/unfit males (Crews & Landers, 1987). It must be reiterated that this conclusion cannot be taken at face value as it is based on results of studies designed to measure the stress response in different ways and under different stressor conditions.

In this section, discussion is based on 41 studies involving 1481 male participants. Thirty-six studies observed HR as a dependent measure, 21 utilized BP and 13 observed endocrine parameters. As was done with the female literature, separate discussion is devoted to physiological "level" and "reactivity" investigations, while research of post exercise response differences to stress is not considered.

Heart Rate Level Response. Currently twenty-five studies provide interpretable information regarding the relationship between fitness level and the male tonic HR response to stress (Blumenthal, Emery Walsh, Cox, Kuhn, Williams & Williams, 1988; Blumenthal, Fredrikson, Kuhn, Ulmer, Walsh-Riddle & Applebaum, 1990; Brooke & Long, 1987; Claytor, 1991; Claytor, Cox, Howley, Lawler & Lawler, 1988; Cleroux,

Peronnet & de Champlain, 1984; deGeus, van Doornen, deVisser & Orlebeke, 1990; deGeus, van Doornen & Orlebeke, 1993; Dela, Minkines, Von Linstrow & Galbo, 1992; Gurley, Peacock & Hill, 1987; Holmes & Cappel, 1987; Houtmann & Bakker, 1995; Lake, Suarez, Schneiderman & Tocci, 1985; Light, Obrist, James & Strogatz, 1987; McCubbin, Cheung, Montgomery, Bulbulian & Wilson, 1992; Plante & Karpowicz, 1987; Seraganian, Roskies, Hanley, Oseahon & Collu, 1987; Sinyor, Peronnet, Brisson, & Seraganian, 1988; Turner, Carroll, Costello & Sims, 1988; van Zijderveld, van Doornen, van Fassen, Orlebeke, van Dyck & Tilders, 1986; Sherwood, Light & Blumenthal, 1988; Sinyor, Schwartz, Peronnet, Brisson & Seraganian, 1983; Ward, Carmelli & McElroy, 1984; Zimmerman & Fulton, 1981). Thirteen of these studies were cross sectional, three employed regression designs and nine were training studies.

It is clear that the male CSAH has been examined extensively than that for females. Like the female studies of HR level during mental stress, reasonable conclusions can be drawn regarding the efficacy of fitness as a moderator of the HR level during stress. From the summary detailed in Figure II-5, it is apparent that individuals with higher levels of fitness demonstrate consistently lower heart rate levels during stress. This was found in 93% of the studies surveyed, with the majority reporting significant

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differences between higher and lower fitness groups. Adding further weight to this finding was that training and cross sectional research each produced similar fitness differences.

Heart Rate Summary

	#	Comparisons	N	++	+	0 or --
Level	25	47	947	32	12	3
CrossSxn/Reg	16	30	697	19	11	--
Training	9	17	250	13	1	3

Reactivity	23	49	755	5	14	30
CrossSxn/Reg	13	29	468	3	11	15
Training	10	20	287	2	3	15

Key:

= Number of studies found
 Comparisons = Number of group comparisons between fit and less fit participants
 CrossSxn/Reg= Cross Sectional and Regression Design
 Training = Studies employed longitudinal fitness training designs
 N = Number of participants observed
 ++ = Strong/significant evidence of fitness effects
 + = Non significant but consistent supportive evidence
 0 or -- = Clear Support of Null Hypothesis (H_0)

Figure II-5: Summary of Research Results of Fitness and HR Stress Response in Males

A good example of this research is a study by Turner et al (1988). Turner and his colleagues found, from a cross sectional sample of 12 fit and 12 less fit males, that HR was lower during a mental arithmetic and video game stressor in the fitter sample.

Brooke & Long (1987) observed HR activity to the real life stressor of rappelling. They observed that the fitter males maintained lower HR levels during rappelling, and throughout the remainder of the testing protocol.

Sinyor et al (1988) utilized a training design to produce fitness differences. After 10 weeks of aerobic exercise (3x/week ~60% of VO_{2max}), they found that the heart rate level during the stress periods of mental arithmetic and Stroop Testing (and during baseline) was lowest in the post-training sample.

In a cross sectional study of 41 normotensive men with and without a family history of hypertension, Holmes and Cappo (1987) found that independent of genetic risk for high blood pressure, those with the greatest level of fitness, showed significantly lower HR levels during a mental arithmetic and Stroop test.

Seragainian et al (1987) had 33 middle aged men participate in a 10 week aerobic training protocol. Subjects increased their fitness level by an average of 16% over pre study levels. It was found that HR levels were lower in the trained men to a variety of stressors (mental arithmetic, ECG Quiz, Stroop, Digit-Symbol Test) compared to baseline.

Lastly, Zimmerman & Fulton (1981) utilized correlational statistics to compare the relationship between fitness and the stress response. In their study a strong association ($r = -.64$) was found for a sample of 38 college aged males. Interestingly, the values were found for HR values taken at rest and recovery were virtually identical.

Heart Rate Reactivity Response. The previous summary suggests that males show lower HR levels during stress compared to unfit males. However a completely separate research question is "Are fit less reactive?" Twenty-three studies have addressed this question. Of these reactivity studies ten have employed cross sectional designs, 12 were training studies, and one utilized a regression design. Most researchers have approached this question from the point of view that fitness dampens reactivity. However, the law of initial values (Lacey & Lacey, 1962) suggests that there should be an inverse relationship between resting autonomic levels and reactivity. If this law holds true then a clear majority of these studies should have reported greater HR reactivity in fit individuals and thus fail to reject the null hypothesis.¹³ Review of Figure II-5 (p.32) reveals that this was the case in most studies. There was at least one study in which fit males were found to react more than unfit males (de Geus et al, 1993), while in a few studies (5 of 25) found evidence for reactivity reductions were found in fitter males (Blumenthal, Emery, Walsh, Cox, Kuhn, Williams & Williams, 1988; Blumenthal, Fredrikson, Kuhn, Ulmer, Walsh-Riddle & Applebaum, 1990; Czajkowski,

¹³Some studies have statistically covaried their baseline levels from their reactivity analyses. Even when this was done there was rarely a reactivity effect seen.

Hindelang, Dembroski, Mayerson, Parks & Holland, 1990; McCubblin, Cheung, Montgomery, Bulbulian & Wilson, 1992; van Doornen & de Geus, 1989)¹⁴. However for the most part there appeared to be little difference in reactivity between higher and lower male fitness groups. This conclusion is further confirmed by longitudinal research that revealed a near absence of support for presence of a relationship between fitness and HR reactivity (2 studies supportive of H_a of 20 total training studies). Thus, those investigations most able to speak of a cause-and-effect relationship between fitness level and HR reactivity speak quite loudly in their denial of a HR reactivity effect.

Blood Pressure Level Response. A review of this research suggests that indeed a relationship exists between fitness and the male BP levels during stress. Analysis of both systolic and diastolic blood pressure levels in males during stress generally reveal that fit males exhibit lower BP than less fit males (Figure II-6). The relationship appears strongest for systolic blood pressure (Blumenthal et al, 1988; Blumenthal et al, 1990; Claytor, 1991; Cleroux, Peronnet & de Champlain, 1984; deGeus et al, 1990; deGeus et al, 1993; Holmes & Cappel, 1987; Lake et al, 1985; Light et

¹⁴It is an interesting side point that the length of stressor exposure was 5 minutes or more in a number of studies reporting significant findings, whereas an estimate of typical exposure was approximately 3 minutes or less for most of the studies not finding differences

Figure 6A:

Systolic Blood Pressure Summary

	#	Comparisons	N	++	+	0 or --
Level	13	24	456	13	7	4
CrossSxn/Reg	7	12	255	10	2	--
Training	6	12	201	3	5	4*

Reactivity	15	33	907	6	2	25
CrossSxn/Reg	10	23	744	4	1	18
Training	5	10	153	2	1	7

Diastolic Blood Pressure Summary

	#	Comparisons	N	++	+	0 or --
Level	10	28	574	10	8	10
CrossSxn/Reg	3	15	373	4	8	3
Training	7	13	201	6	--	7

Reactivity	14	31	549	8	3	20
CrossSxn/Reg	8	17	334	4	3	10
Training	6	14	215	4	--	10

Key:

= Number of studies found
 Comparisons = Number of group comparisons between fit and less fit participants
 CrossSxn/Reg= Cross Sectional and Regression Design
 Training = Studies employed longitudinal fitness training designs
 N = Number of participants observed
 ++ = Strong/significant evidence of fitness effects
 + = Non significant but consistent supportive evidence
 0 or -- = Clear Support of Null Hypothesis (H_0)

Figure 6B:

Measure	#	N	Fit > Unfit	Fit < Unfit	Fit = Unfit
MAP	6	184	--	5 (1)	2 (1)

Key

Number of studies found
 N Number of participants observed
 *Data in parentheses a results of reactivity analyses.
 Data not in parentheses are results of level analyses.

Figure II-6: Summary of Research Results of Fitness and BP Stress Response in Males

in reactivity response.

al, 1987; Seraganian et al, 1987 Sherwood, Light & Blumenthal, 1989; van Doornen & deGeus, 1989; Ward et al, 1984).

For example, deGeus et al (1990) observed the association between fitness and SBP levels during stress. Significant associations were found for a tone avoidance ($r = -.46$) and reaction time stressor ($r = -.41$).

Elsewhere, Blumenthal et al (1988) conducted a training study in which 18 men exercised aerobically (3x/weekly for 35 minutes at 70% of max) for 12 weeks and observed pre-post differences in SBP levels during an extended mental arithmetic stressor. It was reported that the aerobic trained group exhibited significantly lower SBP levels than those seen during pre-training test, and lower than a control sample of weight training men.

Finally, Cleroux et al (1984) also conducted a longitudinal study in which men exercised for 20 weeks (3x/weekly for 45 min at 60%max). In this study, it was revealed that training significantly lowered SBP levels in response to a video game competition stressor.

For DBP 18 of 28 group comparisons from 10 studies showed consistent differences (Blumenthal et al, 1988; Blumenthal et al, 1990; deGeus et al, 1990; deGeus et al, 1993; Holmes & Cappel, 1987; Lake et al, 1985; Light et al,

1987; Sherwood et al, 1989; van Doornen & deGeus, 1989; Ward et al, 1984).

For example, de Geus et al (1990) found that in comparison to a matched sedentary sample, fit men exhibited significantly lower DBP levels during tone avoidance and memory search reaction time stressors.

Blumenthal et al (1990) found similar results in their training study of 35 adult males. After 12 weeks of aerobic training, DBP response to a mental arithmetic stressor was significantly lower compared to pre training levels and to that of a control group.

Sherwood et al (1989) reported similar results. In this study, after 12 weeks of aerobic training (3x/weekly for 35 minutes at ~70%max), the DBP responses during a 5 minute "head to head competitive task" were significantly lower than pre-training levels.

In addition to the research examining SBP and DBP, 4 of 6 studies found decreased mean arterial pressure (MAP) levels in fit men (Claytor, 1991; deGeus et al, 1990; McCubbin et al, 1992) (Table II-6).

A closer observation of BP differences from cross-sectional and training research reveals that the results of the latter are less clear than those of the former. For example in training studies observing systolic BP levels, 66% of training studies (8/12) found a consistent

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differences, whereas 100% of cross sectional studies observed this difference. For DBP levels, a similar trend was evident with 46% of training studies (6/13) finding observable differences, compared to 80% of cross sectional studies (12/15).

A couple of explanations for these inconsistencies are possible. The most immediate hypothesis is that the discrepancy in results is due to the fact that training samples are characterized by smaller differences between pre and post training fitness levels than those found for high and low fitness groups found in cross sectional samples. If, as Crews and Landers (1987) concluded, a mild inverse linear relationship exists between fitness and BP response to stress, then large fitness differences would be necessary to show consistent differences in CV response. It appears that in cross sectional research, large fitness differences are the norm. The absolute difference reported between fit and less fit groups in between-subjects research is rarely less than 10 ml/kg/min and often exceeds 20 ml/kg/min. This is in striking contrast to training research in which the average increase in fitness level from pre to post training measurement is approximately 16% (Craig, 1998; de Geus & van Doornen, 1993) or an average change equivalent to an average improvement of 5.5 ml/kg/min from pre (35.5) to post (41.0) (Craig, 1998). Given a linear relationship with a mild

decreasing slope, large pre-post (or fit vs. less fit) differences would be necessary to produce clearly divergent sample data (see Figure II-7, "CSAH-Traditional" for a visual model of this argument). This hypothesis of 'absolute difference' is easily tested by comparing the results of training studies producing the greatest fitness changes to those producing the least. If this first explanation is accurate then training studies producing the largest changes in fitness should be more likely to show significant results. A review of training research did not find this hypothesis to be correct. The training studies yielding the largest training effects do not seem anymore likely to produce significant pre-post stress response differences. For instance, de Geus, Van Doornen & Orlebeke (1993), Claytor (1993), and Sinyor, Peronnet, Brisson & Seraganian (1987) produced average absolute changes in VO_{2max} of approximately 7, 8, & 10 ml/kg/min in their training groups, respectively. However, their results, despite the large training effect were not any clearer than those of study producing smaller absolute changes.

A second explanation is the possibility that it is not the absolute change in fitness, but whether the change is of clinical significance relative to risk of all-cause and/or CHD mortality that is the most important consideration in this process. Respected epidemiological research conducted

Fitness and CV Response
Two Hypothetical Models of Relationship

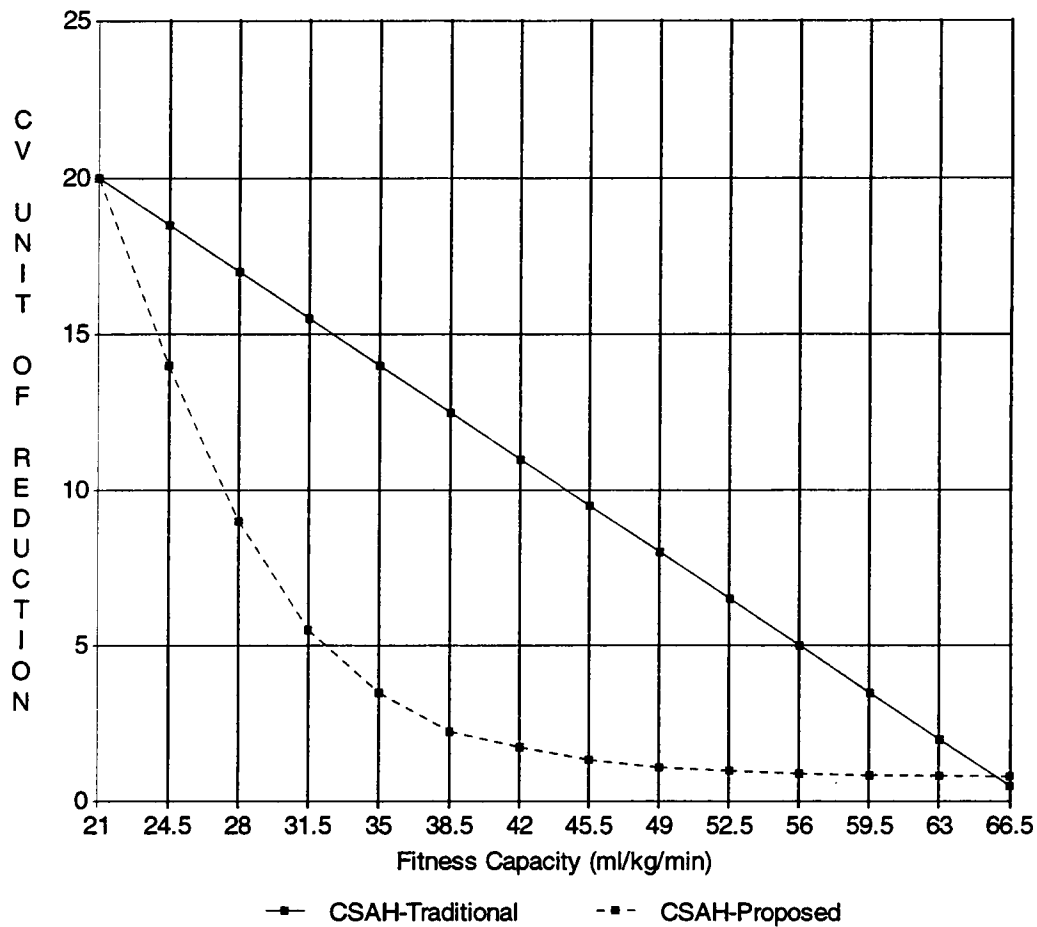


Figure II-7. Two Models of Relationship between Fitness and Stress Reduction

by Blair, Kohl, Paffenbarger, Clark, Cooper & Givens (1989) revealed that a marked decrease in risk occurs for men as their VO_{2max} nears the mid 30's ml/kg/min (and for women in their low 30's). Risk levels continue to decrease with increasing fitness, however the slope of risk flattens after achieving levels in the mid to upper 30's. It is tempting to postulate that the degree of reduction in the stress

response approximates the fitness mortality curve proposed by Blair (Figure II-7, "CSAH-Proposed"). This conceptualization leads to the prediction that at lower ends of the fitness continuum small improvements would be associated with large and meaningful reductions in the stress response. Additionally, equivalent sized improvements in groups starting at a higher initial levels of fitness would tend to produce smaller, less reliable changes in stress response. In the language of economics, the power of fitness to moderate the stress response may operate on a curve of "diminishing returns". A number of training studies which produced significant stress response differences did not have large changes in pre to post value, but were clinically meaningful (e.g, Blumenthal, Emory, Wash, Cox, Kuhn, Williams & Williams, 1988; Blumenthal et al, 1990; Rogers, Probst, Gruber, Berger & Boone, 1996). For these studies a common characteristic was the shift of their sample from a higher to a meaningfully lower level of CV risk as measured by Blair's fitness categories. In less successful training studies, participants frequently entered research at a clinically healthy (i.e., high) levels of fitness even before training. Therefore the effects of training on the CV stress response may have been muted by initially high levels of fitness (e.g., de Geus, van Doornen & Orlebeke, 1990; 1993b).

Of the two explanations for the difference between training and cross sectional research results, the second explanation seems to be the more plausible. If CV stress levels and fitness are truly related to CHD risk, it is theoretically attractive to posit that Blair's curve of fitness and mortality may also represent a curve of fitness and stress response. Additionally it is commonsensical to hypothesize that perhaps the greatest improvement in stress response will be seen when fitness changes are of clinical significance, not simply absolute changes in VO_{2max} level, regardless of initial fitness level.

Thus, whereas cross sectional research has often incorporated two tangibly different fitness risk groups, training studies have not. Those training investigations that have appeared to produce differences in the stress level response are those which reported changes in their experimental sample from a identifiably poor to a clearly improved level of fitness.

Blood Pressure Reactivity Response. A review of male blood pressure reactivity reveals a similar pattern of results (Figure II-6, p.36) to those found in the female fitness-reactivity literature. For systolic BP, 15 studies reported results on 33 separate reactivity comparisons between fit and less fit male participants. Of these 33,

only 6 demonstrated a relationship between decreased reactivity and fitness level (Albright et al, 1991; Blumenthal et al, 1990; Czajkowski et al, 1990; Lake et al, 1985; Perkins, Dubbert, Matin, Falustich & Harris, 1986) while 25 reported no relationship or a tendency toward increased reactivity in fit males (Claytor, Cox, Howley, Lawler & Lawler, 1988; de Geus, van Doornen, & Orlebeke, 1993; Dion, Gerard, Ready, & Dyck, 1992; Lake, Suarez, Schneidermann & Tocci, 1985; McCubbin et al, 1992; Nixon, Robertson & Epstein, 1986; Seraganian, Roskies, Hanley, Oseashou & Collou, 1987; van Doornen & de Geus, 1989)¹⁵. For diastolic BP reactivity, similar findings were seen. Of 31 total comparisons made over 14 studies, only 10 comparisons showed consistent results in the expected direction (Blumenthal et al, 1988, 1990; deGeus et al, 1990; Holmes & Cappel, 1987; Sherwood et al, 1989; Ward et al, 1984). A breakdown of the reactivity literature by type of study (cross sectional or training) revealed the clear majority of studies reporting a lack of relationship between fitness and reduced BP reactivity to stress. Therefore, based on this review, it may be concluded that no systematic relationship exists between blood pressure reactivity and level of aerobic fitness for males.

¹⁵Additionally, de Geus, van Doornen, de Visser & Orlebeke, 1990 reported on results from a compilation of studies in which 2 separate studies found against a BP reactivity effect.

Summary of Male Findings & Issues of Research Concern.

Approximately 41 studies have been conducted observing the male reactivity response, the majority of which incorporated BP, HR or both. These include a sizable number of training studies conducted by respected authorities in psychophysiological research. Thus the research on the effect of fitness on the male HR and BP response to stress is certainly broad enough to provide an insight into whether a cross stressor adaptation response exists.

The results of the current analysis suggest a consistent CSA for tonic HR response (44 of 47 studies showed lower HR levels during stress in fitter individuals). Not quite as powerful as the HR level data but still fairly consistent with the cross stressor adaptation hypothesis, SBP level response appeared to be typically lower for fit males during stress when compared with less fit (20 of 24 studies). There is also evidence of decreased DBP response to stress with improved fitness, although it is not as consistent as that for SBP (18 of 28 studies in direction of the alternate hypothesis).

Comparisons of trends in cross sectional vs. longitudinal data show very similar findings for HR data, but some dissimilarity for BP data. Training studies were less likely to show a BP effect than were cross sectional

studies. Despite this, appeared that the trend toward reduced SBP, and to a less extent DBP, found in cross sectional research was also evident in the training research.

Analyses of BP and HR reactivity data clearly suggest the lack of a consistent relationship between reduced CV reactivity and fitness. Even when criteria for categorizing a reduced response did not demand statistically significant differences, reduced HR, SBP and DBP reactivity in fitter males was found in only 39%, 35% and 24% of studies, respectively. In other studies, reactivity increased with elevated fitness levels, but this was not a pronounced data trend either. The suggestion that no generalized relationship exists between fitness and reactivity differences for males is further bolstered by the fact that compared to cross sectional studies there are a lower percentage of training studies reported reduced HR and BP reactivity.

The clearest need for future research efforts appear to be those observing males in "CV-At Risk" populations. Currently, a consensus on whether fitness moderates stress-related symptomology associated with development or aggravation of CHD has not been achieved. This area is undoubtedly where the greatest gains and good can be achieved from research efforts.

Conclusions of Male vs. Female Effect Differences. At

the outset of this review reasoning supportive of separate analyses by sex was conveyed. The first reason speaks simply of the appropriate design of future research based on evidence that sex and fitness are clearly not orthogonal variables. Since very few comparison studies (4) have been conducted on males and females the issue of sex differences must remain open for examination by researchers in this field of study (Sothmann et al, 1996). Fortunately, in the current review the question of sex differences (or "sameness") of cross stress adaptation benefits are, to some degree, answered. The following discussion integrates the separate findings of studies with males and females an the attempt to address whether there truly is a reliable difference in fitness-mediated cross stressor benefits between sexes.

By observing the pattern of results found from the individual reviews of male and female literature, the answer to the above question should become more distinct. A summary of the categorization method and final summary of male and female data are displayed in Figure II-8 and II-9, respectively.

General Categorization Criteria

++	+	0 or --
Statistical Significance (p<.05)	Consistent "minute means" fitness differences	Inconsistent "minute means" fitness differences
p<.10 w/ 2-tailed test	Consistent graphical evidence of fitness difference	Inconsistent graphical evidence of fitness difference
Small "N" with "notably large" fitness diffs	p <.10-.20	Fitness differences opposite of predicted direction

Figure II-8: Criteria Utilized for Categorization of CSAH Research Results

Figure II-9 summarizes the percent of comparisons finding in favor of the hypothesis of a reduced response to stress in fit men and women when compared to less fit men and women. It is clear from this table that fitness appears to be related to a reduced HR response during stress for both men and women. For both men and women 93% of the comparisons evidenced a noticeably lower HR level during stress for those in higher fitness classifications. However, it is possible that a lower HR is a more reliable function of fitness for males as 68% (32/47) of fit/less fit comparisons of male subjects showed *strong support* (++) for this hypothesis as opposed to only 47% (7/15) for female

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comparisons. This observation is further tempered when the results of training studies are considered. These findings indicate that male and female response are almost equivalent (77% and 83% of comparisons strongly supporting the association of reduced HR to fitness in men and women, respectively).

Percent of Fit/Less Fit Comparisons Finding for Response Differences		
	Male	Female
HR Level	93 %	93 %
SBP Level	83 %	50 %
DBP Level	64 %	29 %
Phasic HR	40 %	17 %
Phasic SBP	24 %	23 %
Phasic DBP	36 %	44 %

Figure II-9: Percent of Fit/Less Fit Comparisons Finding for Response Differences.

Comparisons of the male and female patterns of results for SBP level during stress indicate that, indeed, fit males when compared to less fit demonstrate decreased response. Such a trend is note as strong when fit females have been compared to less fit females. Eighty-three percent the studies on males showed decreased SBP levels in fitter males, compared to 50% of female studies. Analysis of

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training studies which measured SBP levels for male and female samples produced less information due to the small number of such studies conducted with females. It is still worthy of mention though, that the minimal training data presently available is supportive of the conclusion that fit males appear to derive a greater benefit (i.e., lower stress levels relative to their less fit comparison group) than do fit females.

Conclusions regarding tonic DBP level responses in males and females are less clear, but still consistent with the conclusions of SBP level data. In studies of male participants, 64% of the comparisons found notably lower DBP in fitter subjects, as compared to a percentage of 29% for female comparisons. Again, the training data, though limited for females, support this overall conclusion.

Figure II-9 also shows the spread of results for HR and BP reactivity data for women during psychosocial stress. One immediate observation in comparing these data is the remarkable similarity of pattern for males and females. Although some degree of variation exists, it is clear from these data that sex does not interact with fitness to produce reactivity differences. For HR reactivity, 40% of male and 17% of female analyses revealed an observable reactivity effect in fitter groups, but more importantly only 10% of male and 8% of female comparisons showed strong

support for reduced reactivity in those that were fitter.

For SBP reactivity, only 23% of the comparisons of fit females to less fit females, and 24% of the comparisons of fit males to less fit males, revealed some effect for fitness level. For DBP reactivity, this pattern of results was fairly similar. Forty-four percent of "fit females to less fit females" comparisons, and 36% of comparisons between fit males revealed some effect for fitness level.

In conclusion, it must be said that with the possible exception of BP level response, variations in the relationship between fitness level and phasic and level stress responses are generally not different for males and females. due to an interaction with sex.

THE CSAH IN AT-RISK POPULATIONS

If there is validity to the hypothesis that heightened physical fitness is related to a reduced physiological stress response, and, if it is assumed that a heightened physiological stress response has pathophysiological consequences, then the finding of a relationship between fitness and stress response would be most significant to those individuals "at risk" for disease onset and development (Rogers et al, 1996, Sherwood et al, 1989; Sothmann et al, 1996). Given that studies of stress have strongly concentrated on sympathetic mechanisms affecting

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cardiovascular disease, groups affected by the finding of an inverse relationship between fitness and autonomic response would be theorized (or demonstrated) to be at greater risk for coronary heart disease. If such a relationship exists, the discovery of a simple, cost-effective remedy to the problem of exaggerated CV level or reactivity response to daily stressors would prove of enormous clinical value. Unfortunately only a few investigators have attempted to answer the question of whether fitness level and/or training are related to dampening the stress response in certain "at risk populations". One clearly "at risk" population typically noted is those with a family history of hypertension (FH).¹⁶

Family of History of Hypertension and Stress Response.

It has been estimated that as many as 60 million Americans have essential hypertension (EH) while another 20 million have borderline hypertension (BH) (American Heart Association, 1996). Each condition is marked by elevated levels of systolic and/or diastolic blood pressure. The natural history of untreated hypertension is marked by target organ damage and eventual premature mortality (Matterson, 1987). Genetic predisposition (family history)

¹⁶ In the current literature, a conventional criterion for defining FH+ has been presence of at least one parent with diagnosed hypertension. For this reason, some authors refer to this population as having a "parental history of hypertension" or PH+.

has been shown to be an independent risk factor in the future development of hypertension (American Heart Association, 1996; World Health Organization, 1996). Specifically, risk for future development of CHD/Hypertension is significantly elevated if one or more parents have (or have had) diagnosable hypertension (Stamler et al, 1971).

Numerous studies have documented the fact that individuals with a parental history of hypertension (FH+, also frequently abbreviated as "PH+") often exhibit higher levels of BP, as well as greater reactivity, to various psychosocial stressors than do individuals with normotensive parents (e.g, Hastrup, Light & Obrist, 1980; Manuck & Proietti, 1982). This population is different from hypertensives however in that they do not have diagnosable hypertension, and will not necessarily develop it. However controlled animal research has shown that stress is more likely to act as a causal agent in the eventual development of hypertension for animals with hypertensive parents (Lawler & Cox, 1985). Thus, FH+ groups are frequently conceptualized as "middle ground" between normotension and hypertension. They therefore represent an excellent group for testing hypothetical factors thought to moderate development of future hypertension or CVD, such as exaggerated cardiovascular response to stress. Given the

known efficacy of aerobic exercise as a non-pharmacological means of decreasing resting blood pressure (Gordon, Scott, Wilkinson, Duncan, & Blair, 1990), examinations of CV stress response in fit and less fit subjects with a parental history of hypertension (FH+) has been attempted in human and animal research. The obvious goals of these studies is to clarify the question of whether improved fitness has a prophylactic influence on a number of exaggerated CV responses frequently exhibited by FH+ subjects and proposed to be related to the development of future hypertension (Shapiro, Goldstein & Jamner, 1995).

Review Results. To date only three human studies (incorporating less than 100 total subjects) have observed the relationships among fitness, indices of physiological stress response, and parental history of hypertension. A summary of the outcomes of these studies are reported in Figure II-10.

In a cross sectional study of 42 men divided in to three groups, [Fit/FH+ (50.13 ml/kg/min), Less Fit/FH+ (26.88 ml/kg/min), and FH- (38.98 ml/kg/min, No high/low grouping)], Holmes and Cappo (1987) found that the stress response of Fit/FH+ individuals was significantly lower (SBP, DBP, HR) than the Less fit/FH+, and similar that that of individuals without a family history of hypertension

(FH-). The authors concluded from these findings that aerobic fitness may be an effective means of offsetting the effects of a family history of hypertension.

PARENTAL HISTORY OF HYPERTENSION & FITNESS

Level	Measure	#	Comparisons	N	++	+	0 or --
	HR	2	3	73	3	--	--
	SBP	2	3	73	2	--	1
	DBP	2	3	73	2	--	1

Reactivity	Measure	#	Comparisons	N	++	+	0 or --
	HR	1	1	20	--	--	1
	SBP	1	1	20	--	--	1
	DBP	1	1	20	--	--	1

Key:

= Number of studies found
 Comparisons = Number of group comparisons between fit and less fit participants
 CrossSxn/Reg= Cross Sectional and Regression Design
 Training = Studies employed longitudinal fitness training designs
 N = Number of participants observed
 ++ = Strong/significant evidence of fitness effects
 + = Non significant but consistent supportive evidence
 0 or -- = Clear Support of Null Hypothesis (H_0)

Figure II-10: Summary of Research Results Comparing Fitness and the Cardiovascular Stress Response in Participants with a Parental History of Hypertension

Nixon, Robertson and Epstein (1986) used a similar design to that of Holmes and Cappo (1987) but studied reactivity differences. Twenty male subjects were divided into four groups of high or low fitness, (>50 ml/kg/min) and (<42 ml/kg/min); and by FH+ or FH-. After analysis, these authors concluded that reactivity (defined as change from baseline) was not affected by either fitness level or family history of hypertension.

Buckworth, Dishman & Cureton (1994) observed 31 females with a confirmed family history of hypertension. HR differences between fit and less fit women were observed during an active-coping stressor (mental arithmetic), however, no differences in BP were observed. Consistent with the HR effects, maximum R-R interval, indicative of greater parasympathetic tone¹⁷, was found to be greater among fit than unfit women with a family history of hypertension.

Despite this small group of studies, a number of interesting speculations can be made. First, it appears that CV response to stress may be buffered by elevated fitness levels for these groups. Although only one study (Nixon et al, 1986) addressed the issue of BP reactivity in humans, the results of this investigation are consistent with the findings of a good deal of other research showing no relationship between fitness and reduced CV change scores from baseline to stressed conditions.

Second, it appears that those at greater risk for hypertension, such as FH+ individuals, may need to maintain higher levels of fitness to offset their risk. Holmes and Cappo (1987) found similar CV responses in FH- and Fit/FH+ groups despite the large differences in aerobic capacities

¹⁷ In this study a neck suction task was used in which an airtight device fits around the carotid baroreceptors in the neck. Air is vacuumed out or blown into the device effectively lowering or raising pressure around the baroreceptors. These changes in pressure

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(Fit/FH+ being much higher). Nixon et al (1986) reported similar findings. They found that groups with and without a family history of hypertension, fit FH+ individuals exhibited a resting SBP lower than that of Unfit FH+ (122 mm Hg vs. 132 mm Hg), but similar to that of Non-Fit FH- (120 mm Hg). Further when compared to the resting SBP levels of a fit group without a family history of hypertension, the Fit FH+ levels were significantly higher (113 vs 122 mm Hg). If these findings are typical, then those at greater risk for hypertensive development such as FH+ groups must maintain higher levels of fitness to offset their risk

Finally, it appears that fitness may have a powerful reducing response on BP levels, but not BP reactivity. Lawler et al (1995) conducted a study of the SBP stress response of exercise trained rats with zero, one, and two hypertensive parents. The results of this 12 month training study clearly showed that SBP levels during stress declined markedly over time in those fit animals with a family history of hypertension and progressively became lower than the pressure seen in their unfit controls. These researchers also demonstrated that progressive elevations in fitness levels (as defined by length of training period) were accompanied by a progressive increase in SBP

result in a reflexive stimulation of the myocardium to increase or decrease heart rate. The variability of heart rate under a constant pressure is considered a measure of PSNS tone, with increased variability being indicative of a healthier PSNS response.

reactivity, rather than decreases. Lawler and others have been careful to point out that despite the possibility of enhanced reactivity, the actual CV levels maintained during the stressor remained lower in fit persons. Lawler is not alone in his de-emphasis of the importance of reactivity in this type research, others have also suggested that the danger of the stress response is less likely to be related to size of changes in BP than to tonic CV levels during a stressor (Pickering, Schnall, Schwartz & Pieper, 1991).

Conclusions. In general, the patterns of findings in FH+ samples mirror those seen in the "general population". HR level response to stress appears to be affected the most by fitness. Smaller, but noticeable differences in SBP then DBP level responses also seem to be related to fitness level.

There are two important caveats to this conclusion however. First, it appears that for the FH+ population the association between fitness and a modified stress response is stronger. It is possible that as the risk group becomes "riskier", the association becomes more pronounced (Craig, 1998). If so, the role of elevated fitness becomes increasingly powerful as one's risk status is elevated. Therefore, those who need improved fitness the most appear to benefit the most when they achieve it. This notion is consistent with the research from clinical exercise

physiology which has shown that the effects of aerobic training on decreasing resting HR and BP are heightened when an individual's initial (pre-training) blood pressure is higher (Gordon et al, 1990).

CSA & STRESSOR PRESENTATION: The Dimension of Stressor
Novelty-Familiarity

The fitness-stress response hypothesis has evolved beyond the simple conclusion of a generalized attenuation of physiological activity during stress by those who are more fit (Sothmann et al, 1996). Greater clarification of the parameters which influence cross stressor adaptation (CSA) and the those physiological measures most likely to show an effect has enhanced scientific understanding of the ways in which improving one's fitness may have on our response to daily stressors. Recent cross-stressor investigations of fitness mediated CSA has resulted in a modified hypothesis suggesting that stress response differences are more likely to be seen between fit and less fit given certain conditions of stressor presentation. It has been hypothesized that the relationship between fitness and physiological stress response may be a function of the degree to which a stressor falls within a dimension of "novelty versus familiarity"

(Sothmann et al, 1996). Essentially this hypothesis stated that trained individuals would exhibit an attenuated or lower physiological response to a familiar stressor than to a novel stressor. Given what is known from Selye's research of the effects of chronic stress on disease state (Selye, 1974), this hypothesis, if true, would be a finding of significant clinical importance. Faster habituation of fit groups to extended or repeated stressors suggests that fitness may buffer the individual against the constant "day-to-day" sort of stressors which may subtly act over time to compromise healthy functioning. Given the research with animal models (a rat with 1 parent with hypertension) which showed that repeated stress application over results in the development of hypertension (Lawler et al, 1985). A demonstration of a "familiarity effect" in fit individuals would be of particular importance for those with a genetic predisposition toward hypertension.

Although the role of stressor familiarity in CSA was first mentioned 10 years ago (Sothmann, 1987), only recently has this modification to the CSAH been authoritatively advanced as a significant avenue for future study (Sothmann, Buckworth, Claytor, Cox & White-Welkey, 1996). The initial empirical basis for the existence of a familiarity effect

was largely based on a small body of research emphasizing catecholamine changes to a familiar stressor in fit and unfit subjects (Sothmann, Hart & Horn, 1991; Sothmann, Hart, Horn, & Gustafson, 1985; Sothmann, Hart, Horn & Gustufson, 1987). Specifically, Sothmann and his colleagues have documented that a lower level of norepinephrine (NE) is seen in fit individuals engaged in a moderate psychobehavioral challenge. However, these fitness differences have typically not been apparent until the 6th minute of stressor presentation, and not statistically significant until after the 12th minute. Thus, as the moderate stressor becomes more "familiar" the NE response is more likely to differentiate fit from less fit individuals.

Recently, evidence supporting the role of stressor familiarization and the buffering of cardiovascular stress has also been reported (Claytor, 1991; Claytor et al 1988). Claytor (1991) explained his findings of blood pressure and hemodynamic differences in fit and less fit populations in terms of the degree of stressor familiarity. It was reported that gradually reduced levels of MAP, TPR, and Q (heart rate x stroke volume) were exhibited in fit, but not unfit groups, after repeated exposure to the same stressor. Claytor noted that, given stress familiarity, fit individuals are likely to exhibit a "more economical

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response pattern in that the increase in metabolic demand is minimal during behavioral challenge and thus large increases in blood flow [and pressure response] are not required by the muscle".

Claytor's speculation of a familiarity effect is based upon the hypothesis that a physiological habituation occurs more quickly in fit individuals when prior exposure to the moderate stressor has occurred. Examples of such conditions are found in CSA research in which the participants were exposed to the experimental stressor prior to the actual experimental conditions (e.g, practice conditions); or, were part of a research design in which he/she was exposed to the same stressor on multiple occasions in fairly close temporal proximity.

Senkfor and Williams (1995) examined the HR responses of 41 college students to stress. All subjects were allowed to familiarize themselves with the stressor by practicing on the Video Stroop stressor prior to its research presentation. The results revealed that compared to low fit individuals, those in the high fitness group were found to have significantly lower HR levels, but not reactivity, during the stressor presentations and subsequent recovery.

Shulhan, Scher & Furedy (1986) found non-significant differences in the heart rate levels of fit and less fit

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male participants during stress, even though practice trials were given "to familiarize the subject with the procedure". A glaring shortcoming of this study however was its failure to compare groups of even meaningfully different fitness levels. The less fit group in Shulhan's study had an aerobic capacity of 44 ml/kg/min, a value that is not characterized as low fit at any age.

Rogers et al (1996) conducted a training study of 18 male hypertensives. All participants were given practice of familiarize themselves with the tasks. Subjects were observed during Stroop presentation at baseline, 4 and 8 weeks. Significant and progressive decreases in MAP, SBP and DBP levels were found for both fitness groups (high and low intensities) observed. This is consistent with Claytor's contention that, with practice and/or with repeated stressor presentation, familiarity may interact with fitness level.

Compelling support for Claytor's hypothesis is found in the research of Houtmann and Bakker (1991). In this study, the fitness levels of 52 graduate student teachers (GTAs) were assessed. Following this assessment, twice during the semester, heart rate was measured at a baseline period, just prior to lecturing (called "Anticipatory HR") and twice

during the class they taught. The first measurement was taken on the first day of class while the second was taken near the end of the semester. The investigators formulated an index of the "habituation response" by assessing the change between HR levels at the two measurement periods. Analysis of the habituated responses of these GTAs to the chronic repetitive stressor of college teaching revealed a strong linear relationship between fitness and habituation for males, but not females. These results are congruent with the hypothesis that as a stressor becomes more familiar, those who are fitter will respond in an increasingly "economical" (less exaggerated) fashion.

Finally, Blumenthal and his colleagues (1988, 1990) utilized a stressor which may be characterized as a "hybrid", capturing separate elements of familiarity, extended length of presentation, and successive presentation of the same stressor. Blumenthal's subjects engaged in three successive verbal arithmetic tasks of 5 minutes each with a short 1-minute rest period inserted at the end of the first and second task series. The 1-minute break in Blumenthal's stressor served simply as a chance for the participant to catch his or her breath momentarily, not as

an opportunity to relax. Thus, the participants were exposed to both repeated task presentation and presentation of an extended stressor. Interestingly, in both of the studies incorporating this stressor protocol, Blumenthal found that fitness was associated with significantly decreased SBP, DBP, RPP and HR levels.

Conclusions. Based on the available research it appears that increased fitness is associated with a more "economical response pattern" to stress. Given the results of Lawler's (1985) research showing that repeated stress may cause hypertension in rats with one parent with high blood pressure, it is suggested that an examination of familiarity effects in individuals with a family history of hypertension is warranted.

DIRECTION FOR FUTURE RESEARCH

The purpose of this literature review was in part to further the initial area review of the fitness mediated cross stressor adaptations hypothesis started by Crews and Landers in 1987 and guide the construction of a meaningful research design and hypotheses. This was done by focusing a

greater attention on individual measures of cardiovascular functioning, by examining potential sex effects, and by reviewing varying effects on populations with a social and genetic background related to added risk for CHD.

In the following pages relevant problems for dissertation research are stated. These are followed by the dissertation hypotheses.

Statement of the Problems. Insufficient research attention has been given to populations most likely to benefit the most from findings of a fitness mediated CSA, those with hypertension and a family history of hypertension. Some of the most promising results were found from studies that focused on FH+ and hypertensive populations. Therefore, in this research CSA will be examined in a population defined by a family history of hypertension.

Secondly, clinically relevant criteria to must be used to separate high and low fit groups. Recent epidemiological evidence suggests that the salubrious effects of fitness operate in an inverse curvilinear fashion rather than in an inverse linear fashion (Blair et al, 1989). Thus, the greatest improvements in health would be expected as an

individual moves from a low to "moderate" level of fitness, rather than from a moderate to high level of fitness. Based on the rudimentary analysis completed in this paper, it appears that greater CSA is found in studies that compare unusually low groups to moderate groups, or when fitness is raised from particularly low pre-trained levels. In this study, fitness level is determined by YMCA tests. These data were split data creating statistically different groups that also belonged to different clinical normative categories (as defined by Cooper, 1977).

Third, stressors used in previous research were frequently too strong or not strong enough (particularly as noted in studies with females). The stressor intensity that appears to be "just right" is that of speech stressors. An extensive research program by Lynch and his colleagues has suggested that for most people, a simple speech stressor increases BP and HR approximately 10-50% within one minute (Lynch, 1985). This magnitude of change has been reported by Blumenthal (1991) Manuck and Garland (1979) and McCubbin (1992) who suggest the need for a moderate but not overly exciting stressor stimuli. In addition to being an effective stressor, speech represents the single greatest chronic stressor (in the sense of physiological response) in most peoples lives'.

Fourth, while the effects of the novelty or familiarity of a stimulus in the adaptive response appear to be promising, to date no study has included a test of the novelty/familiarity issue as an integral part of its design. In the present study the effects of novel and familiar stressor will be assessed according to *a priori* hypotheses.

Fifth, comparisons of fitness levels in male and female mixed-sample research often leads a disproportionate number of females in the low group and males in the higher fitness group. The aerobic capacity to be categorized as "good" for females would place a male in the "low" category. In order to circumvent this problem, data were analyzed separately by sex.

Finally, the study of CSA is concerned with differences that occur during a stressor, thus baseline measures are typically not attended to by CSAH investigators. However it is important to note that frequently what is reported as a reduced stress response in fitter individuals may be a carryover effect from fit subjects exhibiting lower baseline physiological levels. Thus what may be hypothesized is that the cross stressor adaptation to stress may be dependent on producing a reduction in baseline values. Practically speaking, it should be inconsequential whether the stress levels only differ during a stress period. What is

important is that the fitness adaptations that led to baseline levels remain intact also lowering responses during stress. If the fitness adaptations which lead to reduced CV levels at rest remain proportionally lower during the stressor in fit compared to less fit individuals, this is what is most important in terms of fulfilling the goal of decreasing the overall stress response. This issue will be examined in this dissertation.

STATEMENT OF DISSERTATION HYPOTHESES

The following hypotheses were tested in this dissertation:

General Hypotheses.

1. There would be significantly higher level of estimated VO_{2max} in males than in females.
2. a-e. There would be significantly greater CV levels of HR, MAP, SBP, DBP, & RPP during periods of talking (stressor) than during silent baseline.

Hypotheses for Male Participants.

- 3 a-e. There would be significantly lower levels of HR, MAP, SBP, DBP, & RPP in fit men during stressor periods than compared to less fit men during stressor periods.
- 4 a-e. There would be significantly greater levels of HR, MAP, SBP, DBP, & RPP during stressor periods in men with a

family history of hypertension than in men with no family history of hypertension.

5 a-e. There would be significantly lower levels of HR, MAP, SBP, DBP, & RPP during stressor periods in fit men with a family history of hypertension than in less fit men with a family history of hypertension.

6 a-e. There would be significantly lower levels of HR, MAP, SBP, DBP, & RPP in fit males with a family history of hypertension to familiar, but not novel stressors.

Hypotheses for Female Participants.

7a-e. There would be significantly lower levels of HR, MAP, SBP, DBP, & RPP in fit women during periods of stress than compared to less fit women during stressor periods.

8a-e. There would be significantly greater levels of HR, MAP, SBP, DBP, & RPP in women with a family history of hypertension during stressor periods than in women with no family history of hypertension.

9 a-e. There would be significantly lower levels of HR, MAP, SBP, DBP, & RPP during stressors in fit women with a family history of hypertension than in less fit women with a family history of hypertension.

10 a-e. There would be significantly lower levels HR, MAP, SBP, DBP, & RPP in fit females with a family history of hypertension to familiar, but not novel stressors.

METHODS

PARTICIPANTS

A total of 103 undergraduate college students participated in this study. This sample included 46 males and 57 females between the ages of 18 and 45 years ($M = 22.84$; $SD = 4.71$). Due to equipment and measurement problems, data from four participants were not included analysis. Of the remaining students, 50 were confirmed to have a parental history of hypertension (22 males/28 females) and 49 were confirmed to have no parental history of hypertension (22 males/27 females).

To confirm family history of hypertension all parents were contacted by telephone at which time they were asked about their blood pressure status. A positive confirmation of parental hypertension was made if the parent answered "Yes" to the following question: "Has your doctor at any point told you that you have high blood pressure?". The only exception to this occurred in the case of students who reported a parent with high blood pressure and could name the medication(s) used for treatment of their parent's hypertension. This information was taken as sufficient confirmation. If parents were married, one parent could answer for both individuals. If parents were divorced, each parent was contacted and questioned separately.

This sample of participants was solicited from psychology classes conducted at the University of Tennessee. All participation was strictly voluntary. Actual participation in the research commenced only after informed consent was given. Permission to conduct this study was granted by the University of Tennessee IRB (Appendix A-1).

APPARATUS AND MATERIALS

Informed Consent. Prior to involvement in the research all students were provided an informed consent statement approved by the UT IRB which clearly explained the risks and benefits of study participation. Student questions regarding the informed consent or the study were encouraged and answered (See Appendix A-2).

Health Status Questionnaire. This brief questionnaire assessed potential risk of engaging the student in the exercise protocol. For example, any student with orthopedic problems impeding cycling would be discovered by this questionnaire and thus excluded after being given credit. No students were excluded as a result of their response to the HSQ (See Appendix A-3).

Demographic Inventory. The demographic inventory was used to collect information such as age, sex, race and education

level of participants. In addition, questions tailored to this project were also asked such to estimate physical activity level, whether the individual regularly exercised, and whether they were currently medicated (See Appendix A-4).

The Twenty Statements Test (TST). The TST is a measurement of self-concept devised by Kuhn and McPartland (1954). Subjects were asked to respond to the question "Who are you?" in twenty statements or less. These statements were used by the investigator to aid in an interpersonal interview conducted later in the experimental protocol (Appendix A-5).

Physiological Measurement.

Dinamap BP Monitor. The Critikon Dinamap 845 XT Automatic Occlimetric Blood Pressure Computer and occluding arm cuff was used to assess the dependent measures of HR, SBP, DBP and MAP. SBP, DBP, and MAP were assessed by measuring pressure waves within the brachial artery. HR was assessed by measuring pressure at maximum oscillation amplitude. Yelderman and Ream (1979) obtained high reliability measurements for the Dinamap. Ramsey (1979) found that the average difference between simultaneous direct intraarterial and indirect measurements of MAP was -

.23mmHg (SD=.0421), with a correlation of .984 between these two measures. Venus, Mathru, Smith and Phan (1985) found correlations between direct and indirect reading of DBP $\bar{r}=.76$, SBP $\bar{r}=.86$, and MAP $\bar{r}=.80$. This device has the advantage of automatic inflation, adjustable time intervals, digital readout, and is relatively unaffected by environmental noise or limb movement.

Monark cycle ergometer. The Monark cycle ergometer was utilized in order to carry out the YMCA test of estimated aerobic capacity. Specifically, the Monark is a stationary exercise cycle which allows accurate measurement of the amount of work performed. It allows measurable levels of pedal resistance to be applied by the investigator by simple adjustment of the tension on a belt wrapped around the flywheel. This tension, a measure of subject "work", is measured in kiloponds (kp). A subject's work rate (or "power") can be calculated using "work" (kp) by distance (m) over time (min) or, specifically "kilopond-meters*min⁻¹" (kpm/min). Distance traveled is also measurable, as the cycle flywheel is exactly 6 meters (m) in circumference. [There at 50 revolutions per min (rpm), the flywheel travels 300 meters (50rpm x 6m/rev = 300 meter/min)].

Polar Heart Rate Monitor.

The Polar Heart Rate Monitor

(HRM) consists of a chest strap with electrodes sensitive to ventricular depolarization. Depolarizations are transmitted to a wrist receiver where an algorithm converts the second by second rate of ventricular depolarization into an average heart rate in "beats per minute" (bpm). These are displayed in an easily readable LCD display. This monitor was used in order to accurately measure and record HR at given amounts of cycle ergometry work. The plot of HR by workload was used to estimate VO_{2max} .

PSYCHOPHYSIOLOGICAL RESEARCH DESIGN

A mixed model repeated measures design was employed to test the hypotheses of this study. A schematic of this protocol is presented in Table III-1.

Table III-1: Outline of Experimental Protocol

ACTIVITY:	TIME (min)	TOTAL (min)
baseline rest	5	5
novel stress	3	8
rest #2	3	11
novel/familiar stressor	3	14
rest #3	3	17
novel/familiar stressor	3	21
recovery	3	24

PROCEDURE

Recruiting and Set-up. Upon obtaining permission to conduct research by the University of Tennessee Internal

Review Board (IRB), instructors of psychology classes at UT were contacted and asked if they would distribute a sign-up sheet on which their students indicated whether or not they were interested in participating in the project. If interested, the student was asked to note their phone number, parental history of high blood pressure, and an estimate of weekly exercise activity, and a time to contact them by phone.

If interest was indicated, students were called by the primary investigator. Upon initial phone contact, in order to assure full student compliance during the research, it was explained to the student that they could expect to spend approximately 1.5 hours participating in the study protocol. It was explained that during this time, approximately 20 minutes would consist of filling out informed consent and survey information, approximately 40 minutes would consist of multiple blood pressure measurements, mostly while the student was sitting quietly but occasionally while engaged in conversation, and 20 minutes would consist of riding an exercise cycle at a low and moderate intensity while their heart rate response was monitored. If the student remained interested after this information was provided, s/he was scheduled for a research time slot.

The evening prior to testing each participant was contacted a second time to remind him/her of their appointment and to request that they:

- 1) refrain from consuming any products with stimulatory effects such as coffee, tea, caffeinated colas or chocolate at least 2-3 hours prior to their appointment.
- 2) refrain from smoking or using chewing tobacco at least 2-3 hours prior to their appointment.
- 3) refrain from engaging in any form of prolonged exercise/physical activity for at least 2-3 hours prior to their appointment.
- 4) wear a T-shirt so that blood pressure readings could be taken more easily.
- 5) bring tennis shoes and clothing in which they would be comfortable riding an exercise cycle.

After these instructions were given all students were asked if they had any further questions or concerns. If there were questions, they were fielded at that time. Once the student was informed, they were thanked and given the phone number and directions to the laboratory.

When students arrived for their appointment, they were warmly greeted and immediately brought to a private desk where an informed consent statement was completed. After this health status questionnaire consisting of questions, that if answered positively, would select the student out of

the study due to potential health problems with the exercise portion of the research. Assistance in putting together a list of the most relevant questions to assure participant safety was given by Professor Edward Howley, Ph.D. of the Exercise Science Unit at the University of Tennessee. After this safeguard was completed the participant was given the research packet to fill out completely. There were no participants who did not qualify.

Upon completion of the research survey packet the participant was escorted to a separate room which was 9 x 13 foot in area which was well lit, relatively free from noise disturbance and constant in temperature. In the near corner of this room was the interviewing area. In this space were two chairs facing one another at a distance of approximately 3 feet. The chair closest to the front wall was used by the primary investigator. The chair further from front was a comfortable padded chair in which the participant was seated. In back of the participant's chair, was a 5 foot high partition which separated the "interviewing area", from the "recording area. In the recording area was a 5 foot desk on which resting blood pressure and biofeedback monitoring equipment with a visual monitor was located. In the far corner was a printer.

Upon entry into this research area, the participant was seated. An appropriate sized BP cuff was fitted to the non-

dominant arm. This fitting was used to minimize any artifact that may be associated with excess arm movement.

Once measurement equipment was attached, the equipment was checked for proper operation. The participant was asked how the BP cuff felt and if it needed to be adjusted. Once all equipment was found to be in working order, and subject discomfort was minimized, the experimental protocol was initiated.

Experimental Protocol and Stress Manipulation. As seen in the Table III-1 (p.76), the protocol consisted of 4 separate rest periods, between which were the presentation of 3 psychosocial stressors. BP and HR were sampled once a minute for every subsection of the protocol, with the exception of the baseline rest condition (minutes 3,4 and 5). All participants experienced the novel stressor first. This stressor consisted of an interview in which the student was asked to speak generally about his or her life at Tennessee. Common topics included a description of their apartment/dorm, favorite activities, friends, and classes. During this interview, an effort was made by the primary investigator to steer away from topics that were potentially explosive or painful, and to engage the student in a common sort of dialogue without a "therapeutic" edge. The second and third stressor periods consisted of randomly ordered

presentations of a second interview in which the participant simply talked about himself or herself in a general way or read aloud a typed passage from Michael Crichton's, The Great Train Robbery (Appendix A-6). For the second interview-type stressor (see familiar stressor) the investigator used student responses on the Twenty Statements Test (Kuhn & McPartland, 1954) to lend structure to the dialogue and to assure that the stressor period consisted of 3 continuous minutes of dialogue. Similar to the initial interview, the student was engaged in dialogue by the primary investigator and asked to speak generally about himself or herself. In the reading stressor, the student was asked to read the passage at a fast pace. It was explained that it was critical to the research that they read quickly and attempt to complete approximately one page per minute. After the last stressor, a final 3-minute rest period was completed. After this final rest, the monitoring equipment was removed from the participant and he/she was escorted into an adjacent room to prepare for fitness testing.

Fitness Testing. Once in the fitness testing room, participants were fitted with a heart rate monitor and

placed on the Monark cycle ergometer (All female participants were fitted by a female research assistant). The pedal distance was then adjusted to an appropriate leg length. Once properly adjusted, the student was told to pedal in time to an electronic metronome which produced a pulsing tone of 100 beats per minute. Each pedal stroke was to be in unison with a new tone producing a steady rate of 50 revolutions per minute (2 pedals/100 tones/minute). The cycle flywheel was then set at a resistance of .5 kiloponds (kps) and the student was asked to begin pedaling to the sound of the metronome.

Once the participant was synchronized to the metronome, the timer was started and the YMCA fitness test was carried out (Appendix A-7). If the two HR levels recorded during Minutes 2 and 3 of the protocol were within 5 beats of one another, the student was assumed to have reached steady state. If two measures were more than 5 bpm apart, a 4th minute was added in order to allow additional time to reach a steady state. Once a steady state was achieved, the resistance on the cycle ergometer was adjusted upward to a preset level depending on the student's HR level at the initial testing resistance of .5 kps. The test was

concluded after two successive stages of resistance resulting in steady state heart rates greater than 110 bpm.

Immediately following the YMCA test, measurements of participant height, weight, and circumference of waist and hips were collected. Then it was explained to the student that their parent(s) would be contacted directly by the primary investigator to confirm presence of a parental history of hypertension existed. All students were asked to contact their parent and let them know that a University of Tennessee researcher would be calling within 1-2 weeks. Once this communication was completed the participant was thanked and given a "proof of extra credit participation" page and told that his/her instructor would be contacted and advised of their successful completion of the research.

RESEARCH VARIABLES

Blood Pressure/Heart Rate. Heart rate and mean arterial, systolic, and diastolic blood pressures were taken directly from the Dinamap display and recorded on a data sheet (Appendix A-8). A measure of CV level response during each part of the psychophysiological protocol was completed by

taking the individual mean of each three minute recording segment which characterized the differing protocol activities (baseline, stress1, rest, stress2, rest, stress3, rest).

Fitness. A plot of the heart rates over 110 against the amount of resistance at each stage which produced these heart rates was made on a standardized graph which illustrates the relationship between oxygen consumed and physical work completed. A line connecting these two points was extending the participants age predicted maximum HR ($220 - \text{age}$). Aerobic fitness can then be estimated by observing the point on the line indicative of maximal HR and dropping a perpendicular tangent to the x-axis which estimates oxygen consumption of the individual at that maximum HR ($\text{VO}_{2\text{max}}$).

Once $\text{VO}_{2\text{max}}$ estimates were determined, median splits of data were conducted. Analyses were then completed separately for males and females. Before making this separation, statistical testing was completed to assure its validity (see Hypothesis 1, Chapter IV). These data were also compared to assure that groups were not just

statistically different but were different as defined by Cooper's 1977) normative categories.

Family History of Hypertension. Designation of a parental history of hypertension was made based on phone confirmations with the participant's parent as described at the beginning of this dissertation section. Based on this conversation, student participants were assigned into the categories of: FH+: positive parental history of hypertension; or, FH-: negative parental history of hypertension.

Stressor Novelty/Familiarity.

Within the psychophysiological protocol three stressor condition were presented. Two of these three stressors were similar (dialogue in which the individual speaks of him or her self and life). The first of these stressors was assumed to be a "novel" presentation, since it was the first stressor presented and the student did not have prior experience with this stressor situation. The second dialogue stressor, was assumed to be a "familiar" presentation as it was similar to the previous stressor presentation. Any reduction in response between the novel

and familiar stressor was assumed to be due to habituation.

RESULTS

STATISTICAL ANALYSIS

All raw data were entered into a text file. A program was written to decrypt and convert the raw data into a SPSS 6.1 for Windows (Nourisis, 1994). All t-tests and descriptive statistical tests were run from the syntax window of SPSS 6.1. Mixed model repeated measures analyses and subsequent least square means *post hoc* tests were run using the SAS system for Unix.

Descriptive statistics were calculated in order to show the demographic make up of the groups under consideration (Males: Fit/Less Fit; Females: Fit/Less Fit). Independent t-tests and χ^2 tests were completed to test for group differences in demographic and anthropometric data after the median split by fitness was performed.

Initial tests of all hypotheses were completed using a 2 x 2 x 2 x 4 repeated measures ANOVAs in which fitness group (fit/less fit), parental history of hypertension (FH+/FH-) and order of stressor presentation (familiar presented 2st or 3rd) were between-subjects factors, while CV measures taken during baseline-quiet vs. stressor-talking (3 stressors) served as within-subjects factor.

Significant effects found during repeated measures analyses were further examined up using a program written for the SAS system. This program allowed for univariate and pre-planned least square means post hoc analyses of all effects while controlling for the typically inflated error rate found when testing multiple contrasts. The criterion for rejection of the null hypothesis was set at $p < .05$.

GENERAL HYPOTHESIS TESTING

The first hypothesis was that the male group would evidence a higher VO_{2max} value than the female group. An independent T-test confirmed this hypothesis. The VO_{2max} of the male sample ($N = 44$; $M = 37.98$ ml/kg/min, $sem = .988$) was significantly higher $t(97) = 3.44$, $p < .001$ than that of the female sample ($N = 55$; $M = 32.96$ ml/kg/min, $sem = 1.04$). Given these differences the overall sample was split into male and female groups.

Each group was further split into fit and less fit subgroups by way of a median split. Independent-t tests revealed that for both males and females the median split was successful at creating significantly different groups based on estimated fitness level (males: $t(42) = 9.61$, $p < .0001$; females: $t(53) = 9.99$; $p < .0001$). In terms of the Cooper categories (Cooper, 1977), the aerobic capacity of fit male and female groups were classified in the "Good" and

"Excellent" categories for the 20-29 age group, respectively. The aerobic capacity of the less fit male and female groups were classified as "Very Poor" and "Poor" for 20-29 year old participants, respectively. The means and standard errors for aerobic capacity, demographic, and anthropometric data displayed in Tables IV-1 and IV-2.

The second set of hypotheses addressed the efficacy of the stressors employed to create differences between baseline and stressor periods. MAP, SBP, DBP, RPP and HR were hypothesized to be greater during the stressor periods than at baseline. This hypothesis was confirmed. Repeated measures ANOVAs of the male sample (Appendix A-9) revealed that all CV measures during the stressor periods were significantly greater than during baseline rest (MAP, $F(3,40) = p < .0001$; SBP, $F(3,40) = p < .0001$; DBP, $F(3,40) = p < .0001$; RPP $F(3,40) = p < .0001$ and HR $F(3,40) = p < .0001$) (see Figures IV-1). Similarly repeated measures ANOVAs of the female sample (Appendix A-10) revealed that all CV measures during the stressor periods were significantly greater than during baseline rest (MAP, $F(3,51) = p < .0001$; SBP, $F(3,51) = p < .0001$; DBP, $F(3,51) = p < .0001$; RPP $F(3,51) = p < .0001$ and HR $F(3,51) = p < .0001$ (Figures IV-2).

Table IV-1

Demographic and Physiological Comparisons of Fit and Less Fit Male Research Groups (Mean $\pm$ SD)

Variable:	Male Fitness Grouping		p <
	Fit(N = 22)	Less Fit(N = 22)	
VO _{2max} (ml/kg/min)	43.49(3.65)	32.50(3.93)	.001*
Age (years)	22.05(3.09)	23.55(5.60)	.28
Height (in)	70.75(3.01)	70.23(3.59)	.60
Weight (lbs)	163.09(26.91)	170.32(29.09)	.39
Waist (cm)	82.09(6.98)	87.81(9.89)	.03*
Hips (cm)	99.86(6.38)	103.76(6.50)	.05*
W/H Ratio	.82(.05)	.84(.05)	.16
BMI	22.88(3.18)	24.21(3.12)	.16
Baseline CVs (mmHg) ¹⁸			
MAP	84.36(9.55)	87.89(7.46)	.03*
SBP	118.47(10.50)	122.36(9.37)	.04*
DBP	67.71(9.75)	72.45(6.94)	.002*
RPP	75.96(14.15)	81.07(11.15)	.08
HR	64.12(9.94)	66.31(8.18)	.31
FH+ (Y/N)	10/12	12/10	.65
Act Level(0-4)	3.55(.91)	2.57(1.21)	.005*
Reg.Exer?(Y/N)	16/6	14/8	.53
Words Total	500.41(80.07)	538.27(80.39)	.13

¹⁸ tests of difference taken from analyses of overall model, not independent-t tests

Table IV-2

Demographic and Physiological Comparisons of Fit and Less Fit Female Research Groups (Mean $\pm$ SD).

<u>Female Fitness Grouping</u>			
<u>Variable:</u>	<u>Fit(N = 28)</u>	<u>Less Fit(N = 27)</u>	<u>p <</u>
VO _{2max} (ml/kg/min)	39.01(5.56)	26.68(3.36)	.001*
Age (years)	21.21(2.83)	23.11(6.23)	.15
Height (in)	65.30(1.98)	66.11(2.96)	.24
Weight (lbs)	127.11(15.59)	157.56(35.23)	.001*
Waist (cm)	74.42(9.31)	85.56(12.95)	.006*
Hips (cm)	96.29(6.62)	105.55(11.58)	.002*
W/H Ratio	.77(.07)	.81(.13)	.20
BMI	20.94(2.10)	25.36(5.36)	.002*
Baseline CVs (mmHg) ¹⁹			
MAP	79.77(7.04)	83.12(9.16)	.02*
SBP	108.24(7.95)	111.94(9.70)	.009*
DBP	66.29(7.15)	69.56(8.71)	.04*
RPP	73.61(15.62)	82.29(16.86)	.004*
HR	67.75(11.32)	73.23(11.79)	.005*
FHH(Y/N)	15/13	13/14	.90
Act Level(0-4)	2.96(1.05)	2.53(.86)	.11
Reg.Exer?(Y/N)	18/10	16/11	.71
Words Total	546.68(79.77)	517.27(98.29)	.23

¹⁹ tests of difference taken from analyses of overall model, not independent-t tests

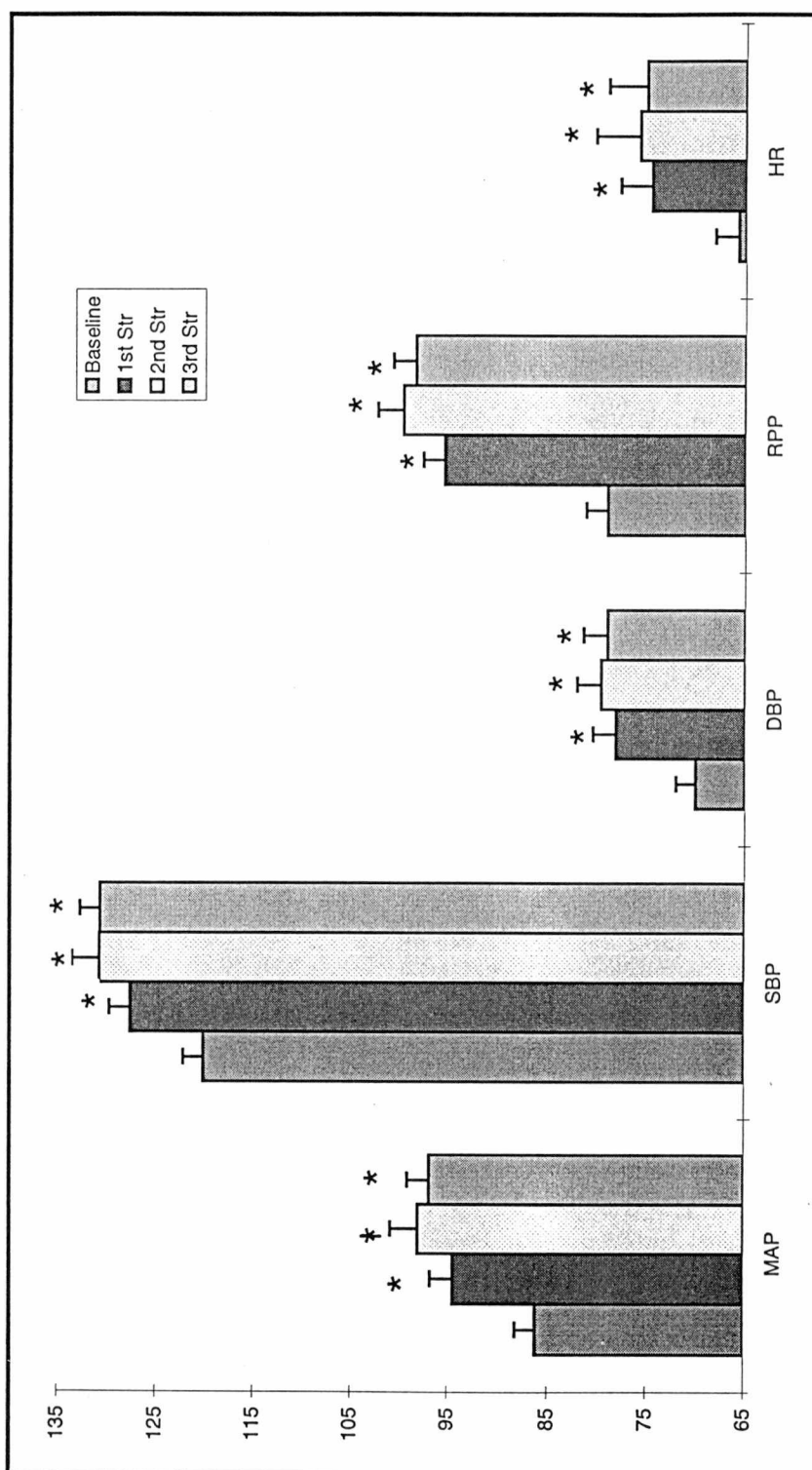
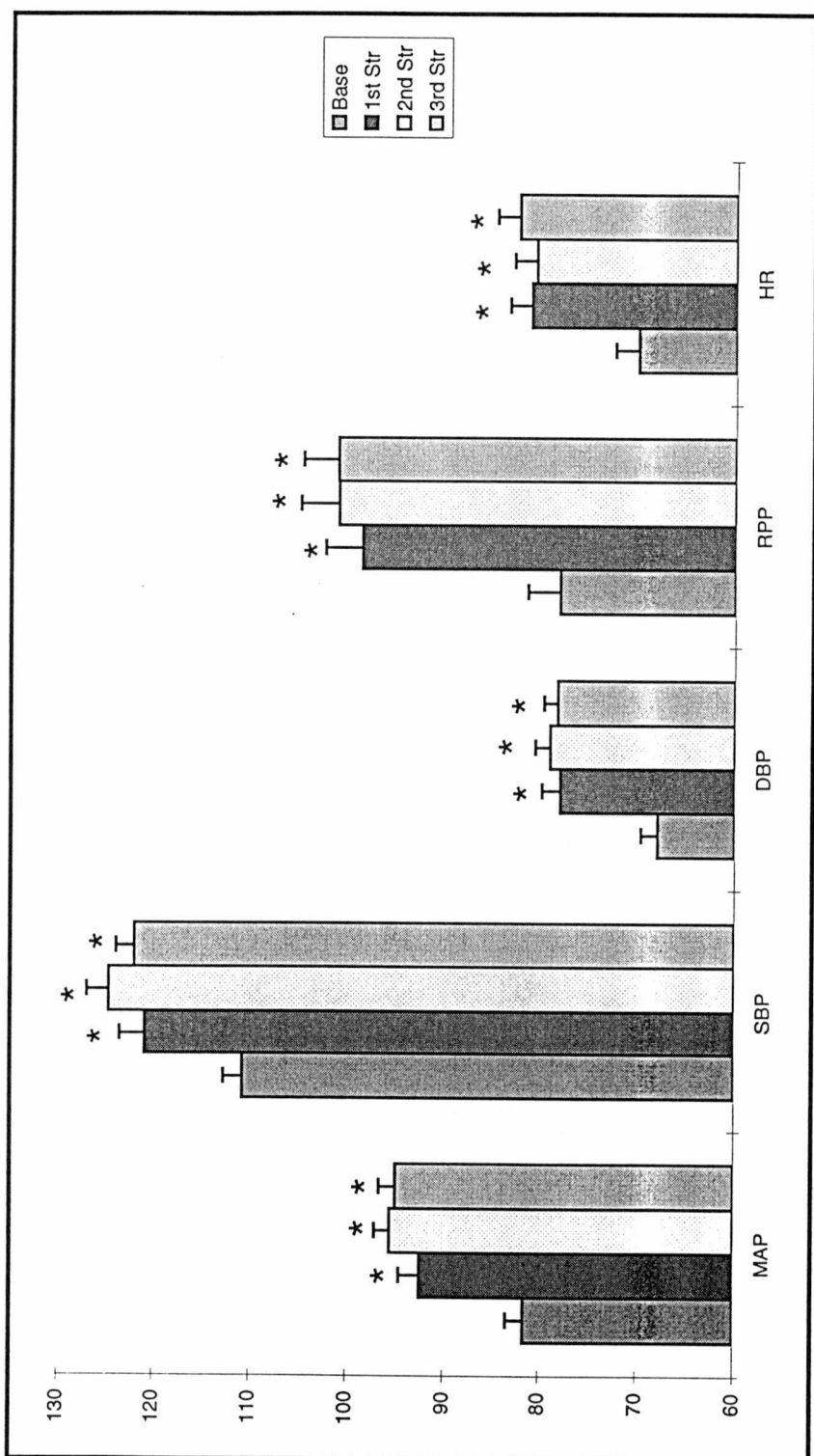


Figure IV-1: Comparison Of Baseline To Stressor Periods In Male Participants



*stressor period greater than baseline, $p < .0001$

Figure IV-2: Comparison Of Baseline To Stressor Periods In Female Participants

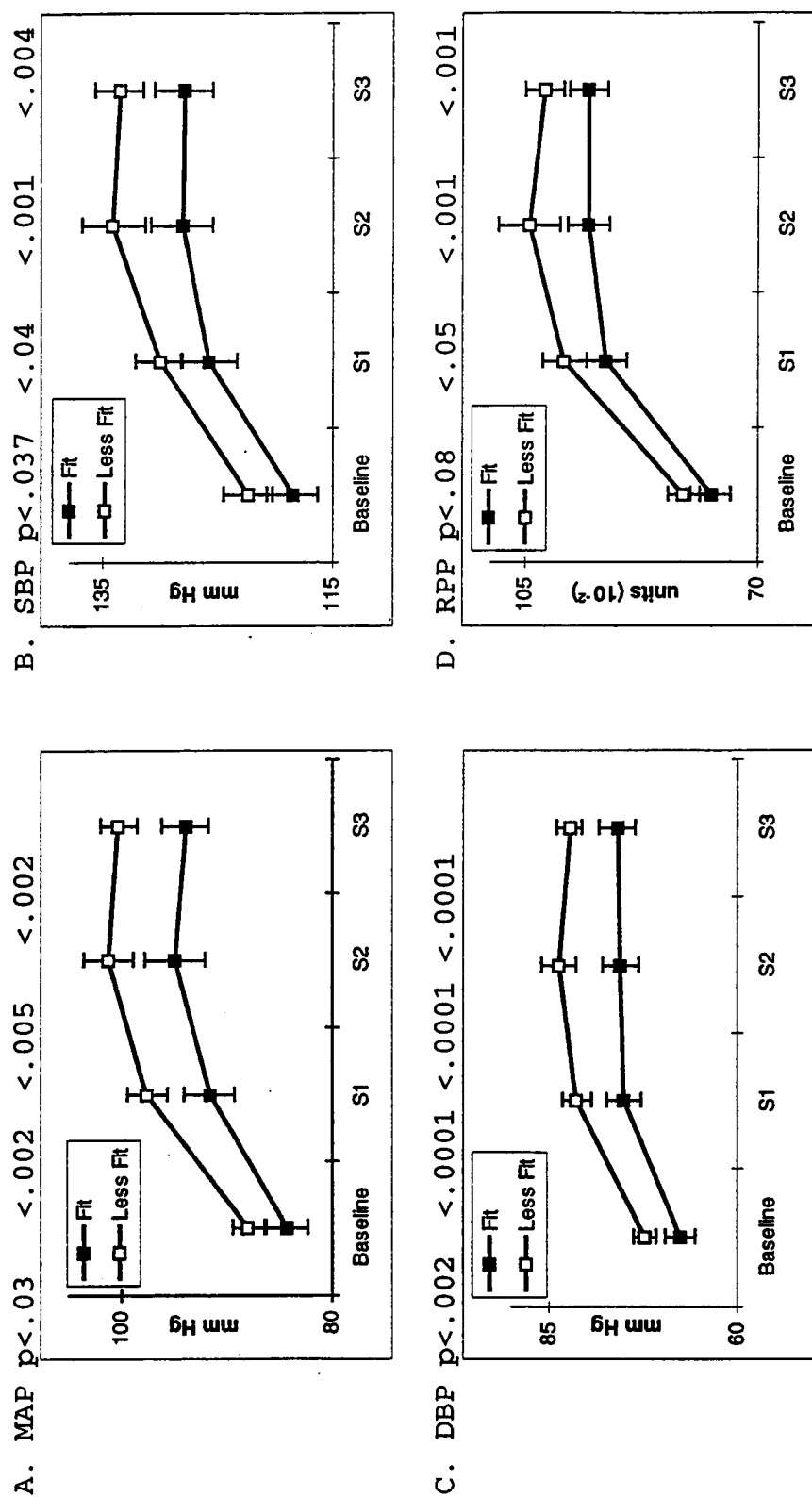
RESULTS- MALE GROUP

There were four main hypotheses tested for the male sample in this study. Each of the main hypotheses was further divided into five tests of sub-hypotheses representing an analysis of each of the individual dependent measures (MAP, SBP, DBP, RPP and HR).

The first set of male hypotheses addressed the question of whether fit males exhibited significantly lower levels of MAP, SBP, DBP, RPP and HR than did unfit men during periods of stress. Mixed model repeated measures analyses of variance with one-tailed tests of significance revealed a significant main effect of fitness group was found for MAP ($F(1,37)= 3.15$, $p<.042$) and DBP ($F(1,37)=4.98$, $p<.016$). A non-significant trend toward significance was found for SBP ($F(1,37)= 1.90$, $p<.088$) and RPP ($F(1,37)= 1.41$, $p<.12$).

In addition to these main effects, a non-significant trend toward the interaction of Fitness X Time was found for DBP ($F(3,111)=1.20$, $p<.155$) and RPP ($F(3,111)=1.05$, $p<.174$). No main effect of fitness grouping or interaction of Fitness Group X Time were found for HR ($F(3,111)=.43$, $p<.26$).

Least square means post hoc tests revealed that fit males had significantly lower MAP, SBP, DBP and RPP than less fit males during baseline and during each stressor (Figure IV-3a-d). Additionally, for all measures of BP there was a trend observed for the differences between fit



Figures IV-3: Comparisons of Cardiovascular Response of Fit and Less Fit Males

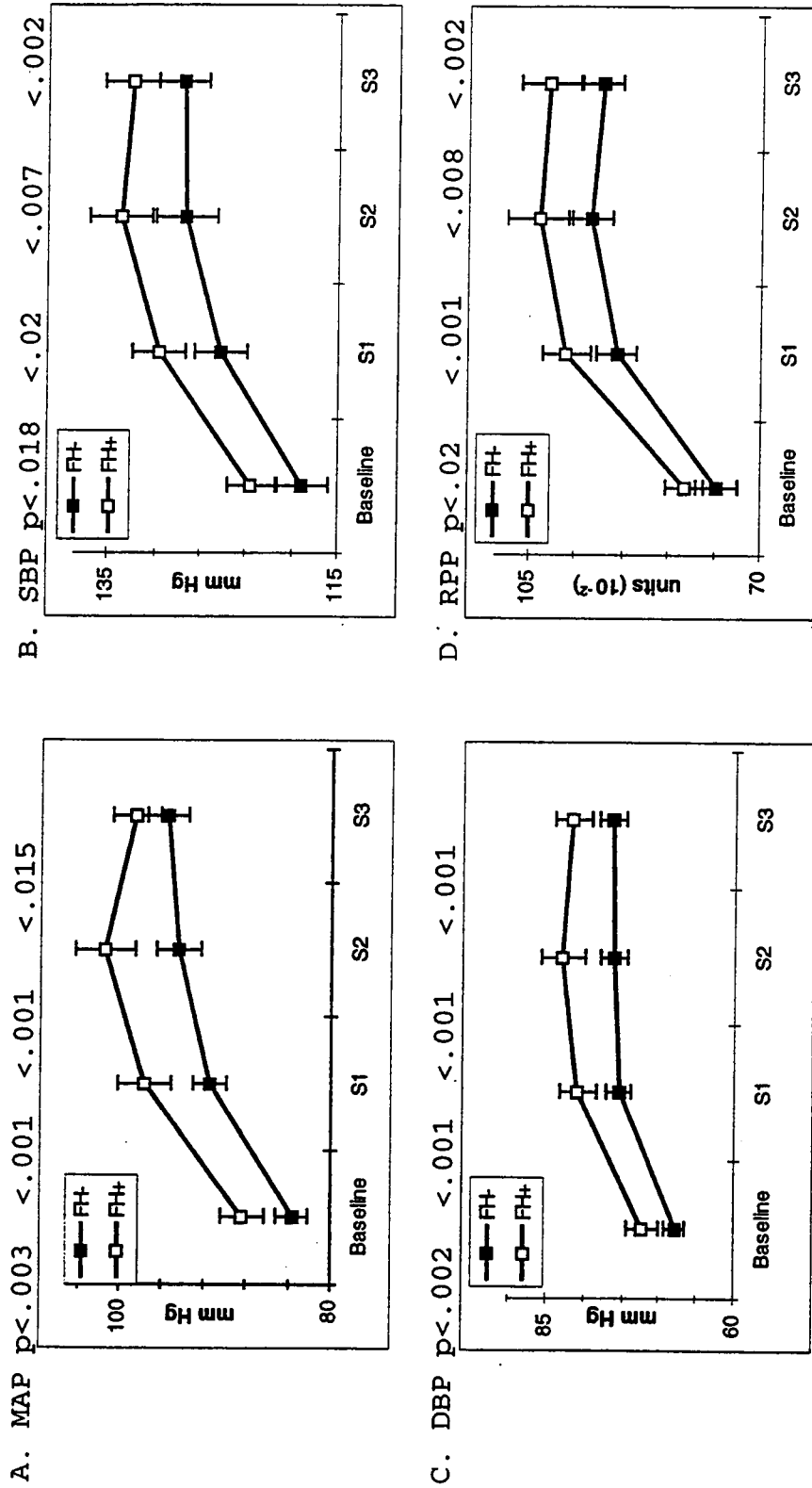
and less fit males to be greatest during the stress periods. This trend was strongest with DBP and RPP, but still non-significant ($p < .15$ and $.18$, respectively) (Figures IV-3c and 3d).

The second set of hypotheses addressed the question of whether males with a family history of hypertension exhibited greater levels of MAP, SBP, DBP, RPP and HR during periods of stress than did males without a family history of hypertension. Mixed model repeated measures analyses of variance with one-tailed tests of significance revealed a significant main effect of family history of hypertension (FH) for MAP, $F(1,37) = 4.98$, $p < .016$, SBP $F(1,37) = 3.01$, $p < .045$, and DBP $F(1,37) = 5.48$, $p < .012$. A non-significant trend was found for RPP $F(1,37) = 1.84$, $p < .091$.

Post hoc analyses of these effects revealed that for MAP, SBP, and DBP males without a family history of hypertension (FH-) had significantly lower levels than males with a family history of hypertension (FH+) in the baseline condition and during each stressor (Figure IV-4a-d).

A non-significant interaction of FH X Time was found for MAP, $F(3,111) = 1.40$, $p < .123$.

No main effect for FH, $F(1,37) = .43$, $p < .26$, or interaction of FH X Time, $F(3,111) = .14$, $p < .94$, was found for HR levels.

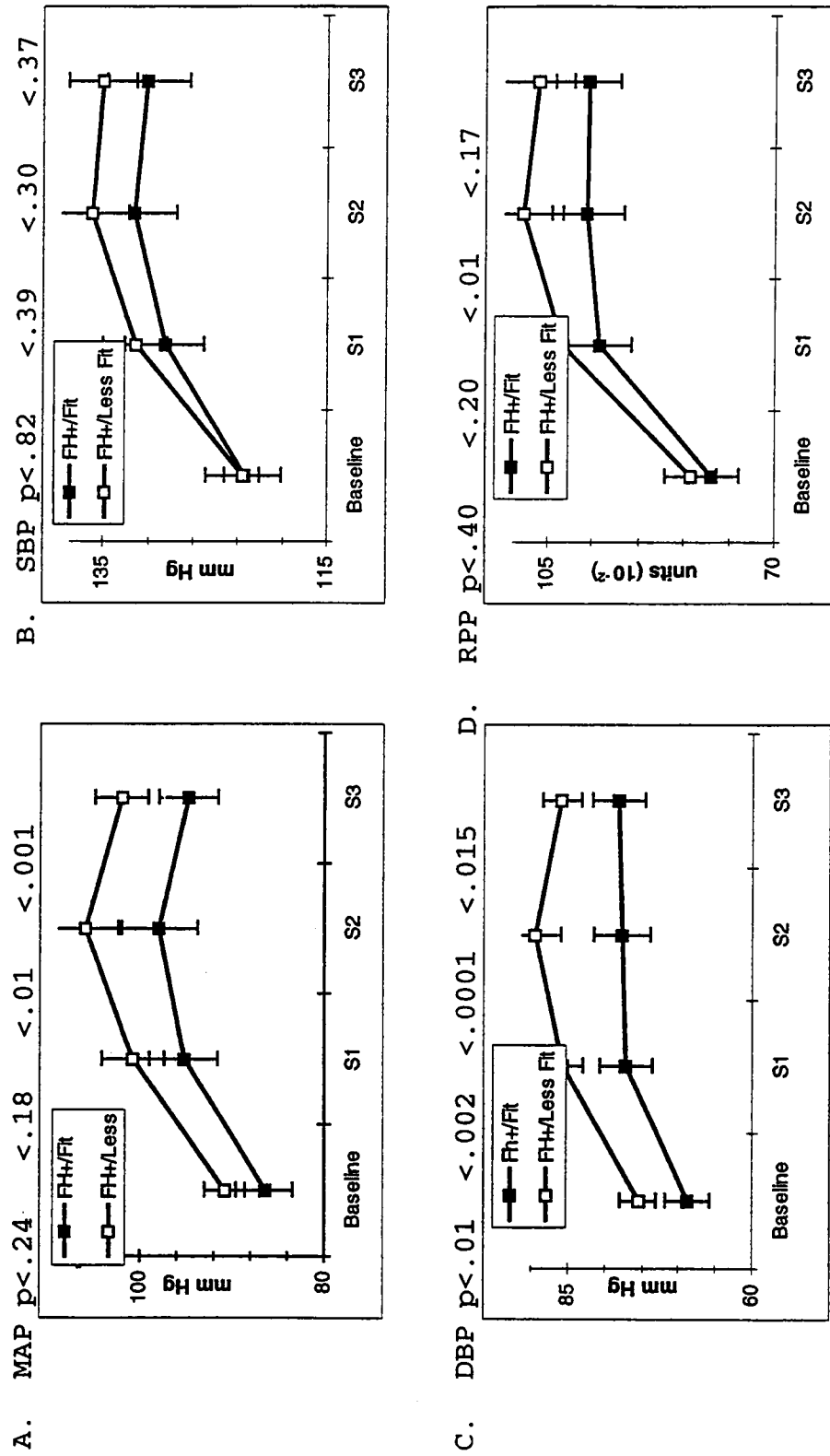


Figures IV-4: Comparisons of Cardiovascular Response of Males with and without a Family History of Hypertension

The third set of hypotheses addressed the question of whether fitness acted to moderate the stress response of males with a family history of hypertension. It was proposed that fit individuals with a FH+ would exhibit significantly lower levels of MAP, SBP, DBP, RPP & HR during stress than would less fit men with a family history of hypertension. In order to isolate just the groups with a family history of hypertension, while using the same statistical methods of previous hypotheses, a mixed model repeated measures analyses of variance were run from which least square means contrasts between fit and less fit FH+ males were examined. The results revealed that fit FH+ males exhibited several significantly lower levels during stress than did less fit FH+ males. Specifically, fit FH+ males exhibited significantly lower MAP during the second, $F(1,20) = 2.65$, $p < .01$, and third, $F(1,20) = 4.11$, $p < .001$, stress period; lower DBP during, the first, $F(1,20) = 4.02$, $p < .002$, second $F(1,20) = 5.37$ $p < .0001$ and third $F(1,20) = 2.63$, $p < .015$, stress periods, and RPP during the second stress period, $F(1,20) = 2.62$, $p < .01$ (Figures IV-5 a,c,d).

No effect of fitness, or interaction of Fitness X Time was found on HR in FH+ males ($p > .05$).

The fourth set of hypotheses addressed the question of whether fitness, family history of hypertension and stressor familiarity interacted in such a way that FH+ fit males



Figures IV-5: Comparisons of Cardiovascular Response of Fit and Less Fit Males with a Family History of Hypertension

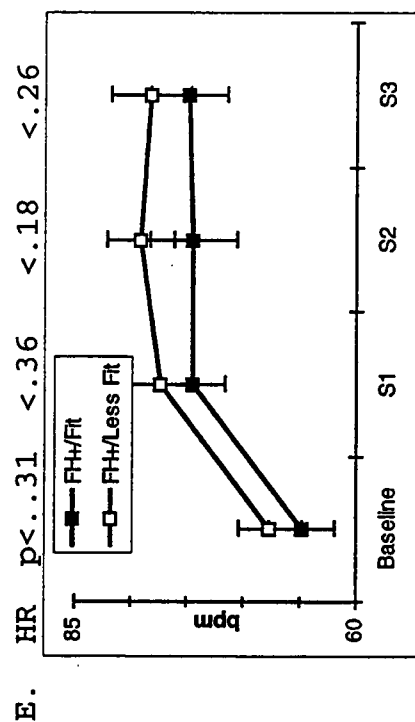


Figure IV-5: (continued)

Fitness and CV Stress Response 101

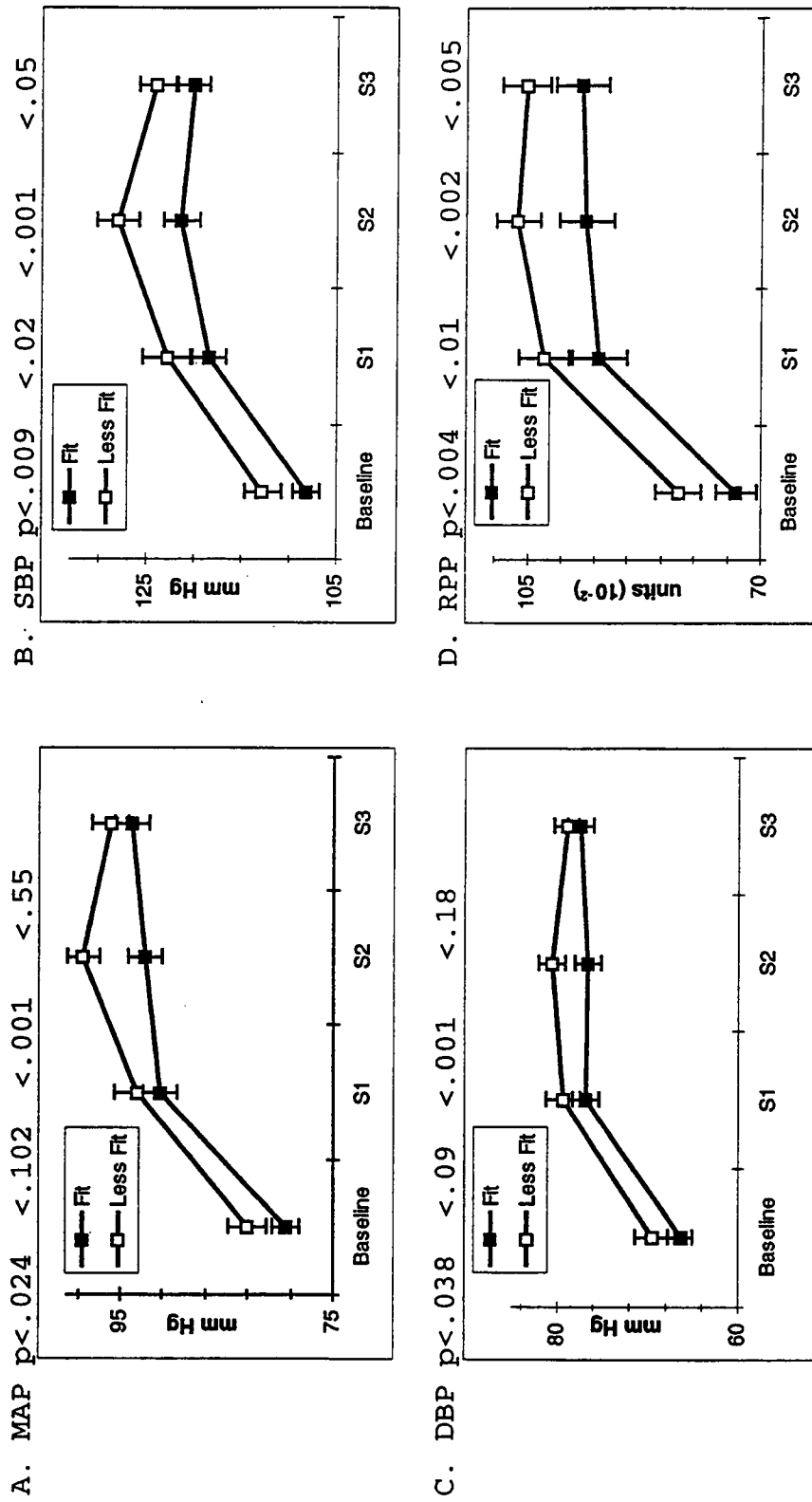
compared to FH+ less fit males would exhibit lower levels of MAP, SBP, DBP, RPP and HR to familiar, but not to a novel stressor. The results revealed no significant evidence of this interaction (Appendix A-13).

RESULTS- FEMALE GROUP

There were four main hypotheses tested for the female sample in this study. Each of the main hypotheses was further divided into five tests of sub-hypotheses representing analysis of each of the individual dependent measures (MAP, SBP, DBP, RPP and HR).

The first set of female hypotheses addressed the question of whether fit females exhibited significantly lower levels of MAP, SBP, DBP, RPP and HR than did unfit females during periods of stress. Mixed model repeated measures analyses of variance revealed a non-significant effect of fitness group for MAP, $F(1,46) = 2.17$, $p < .075$, SBP, $F(1,46) = 2.45$, $p < .062$, DBP, $F(1,46) = p < .097$, and RPP, $F(1,46) = p < .101$) and for the interaction of Fitness X Time for MAP $F(3,138) = 1.40$, $p < .122$) and SBP $F(3,138) = 1.00$, $p < .199$) (Figure IV-6 e).

The second set of hypotheses addressed the question of whether females with a family history of hypertension exhibited greater levels of MAP, SBP, DBP, RPP and HR during



Figures IV-6: Comparisons of Cardiovascular Response of Fit and Less Fit Females

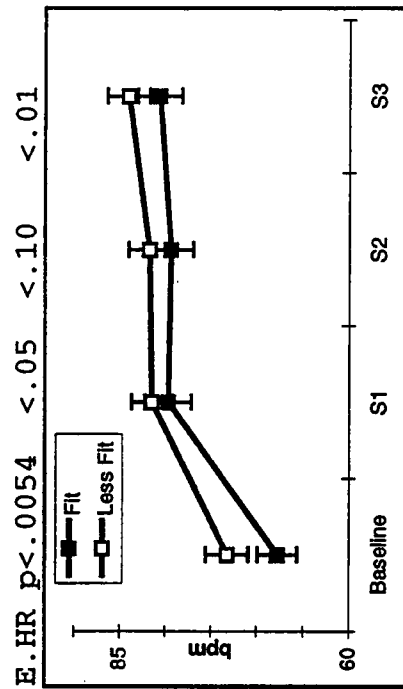
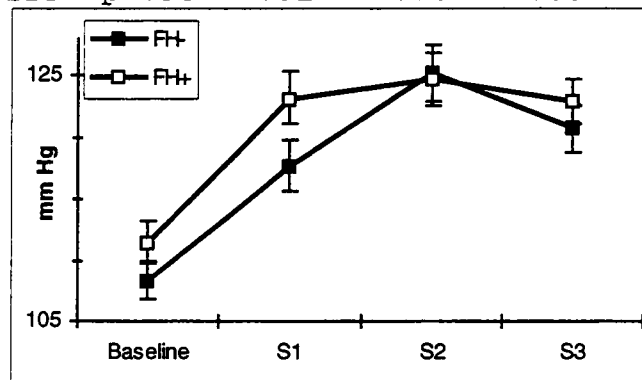


Figure IV-6: (continued)

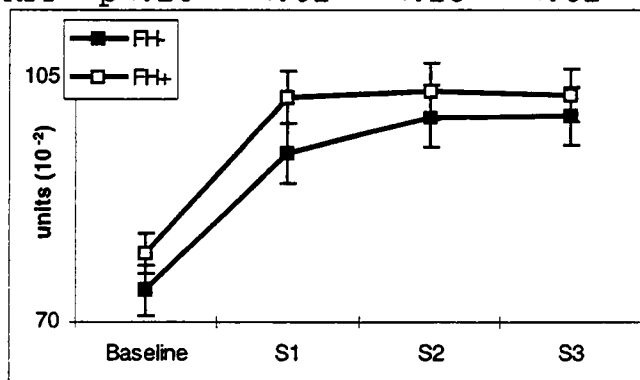
periods of stress than did women without a family history of hypertension. Analyses revealed no significant main effects for family history of hypertension on any of the dependent variables ($p > .05$).

Although a trend was found for the interaction of FH X Time was found for SBP, $F(3,138)=1.82$, $p < .073$, no interaction achieved significance. (Figure IV-7a-b). Therefore this set of hypotheses were rejected.

A. SBP $p < .35$ $< .01$ $< .76$ $< .66$



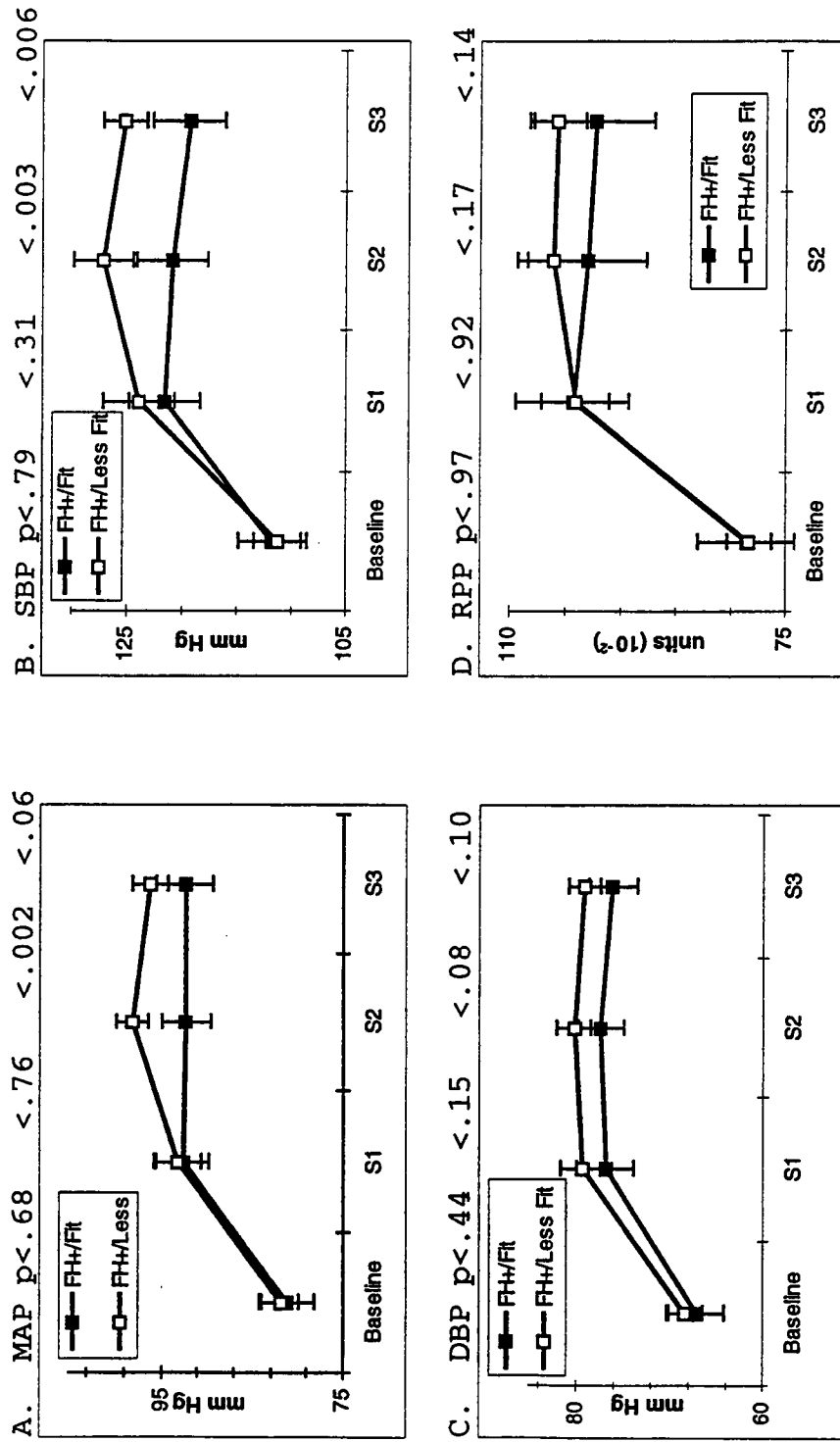
B. RPP $p < .20$ $< .01$ $< .28$ $< .61$



Figures IV-7. Comparison of SBP and RPP Response of Females with and without a Family History of Hypertension

The third set of hypotheses addressed the question of whether fitness acted to moderate the stress response of individuals with a family history of hypertension. It was proposed that fit females with a FH+ would exhibit significantly lower levels of MAP, SBP, DBP, RPP & HR during stress than would less fit women with a family history of hypertension. As with the male group, to isolate just the groups with a family history of hypertension a mixed model repeated measures analyses of variance were run from which least square means contrasts between fit and less fit FH+ males were examined. Analysis of these tests revealed a significant interaction for FH X fitness X time for SBP, $F(3,138)=2.44$, $p<.033$. Post hoc analyses revealed points of significant difference for SBP such that Fit FH+ women exhibited lower levels during the second and third stressor, but not the initial habituation stressor or baseline (Figure IV-8a & b).

The fourth set of hypotheses addressed the question of whether fitness, family history of hypertension and stressor familiarity interacted in such a way that FH+ fit females compared to FH+ less fit females would exhibit lower levels of MAP, SBP, DBP, RPP and HR to familiar, but not to a novel



Figures IV-8: Comparisons of Cardiovascular Responses of Fit and Less Fit Females with a Family History of Hypertension

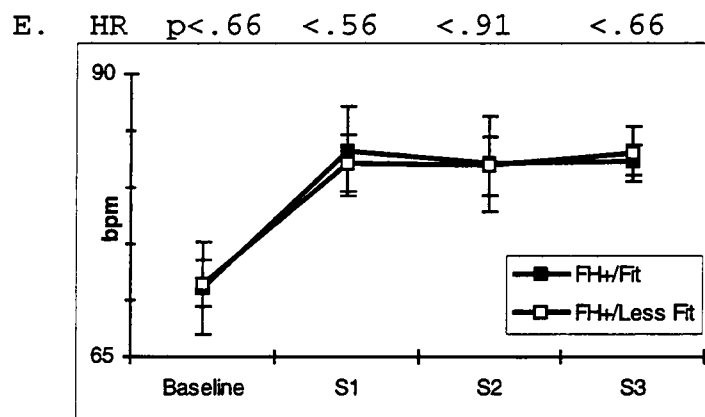


Figure IV-8: (continued)

stressor. However, once again no significant interactions supporting for this hypothesis were found. Therefore this hypothesis was rejected (Figure A-2a-e).

DISCUSSION

The results of this research add to a growing body of literature demonstrating a relationship between aerobic fitness and response to psychological stress. This research adds not only in the traditional sense of producing data which fill a niche, but also in the more practical sense of addressing methodological and conceptual issues which have clouded research asking similar questions in the past. Additionally this study extends previous CSAH research by testing *a priori* hypotheses (familiarity/novelty) on specific sub-samples (FH+) of individuals that have been proposed to be particularly sensitive to the stress reducing qualities associated with elevated fitness (Sothmann et al, 1996). In pushing this envelope this is the first to test a theory which posits that fitness effects on stress are partially related to the nature of the stressing condition (Sothmann et al, 1996).

The first two hypotheses tested were termed "general hypotheses". To meaningfully test later hypotheses it was necessary to confirm that certain preconditions existed. Specifically, in this dissertation it was argued that males and females represented different "fitness" groups as determined by aerobic capacity, thus their data should not be mixed and analyzed together. Second, it was argued that

a basic validity check of all CSAH research should include whether the stressor employed was successful at raising physiological levels.

In the first hypothesis it was proposed that males would exhibit significantly greater VO_{2max} levels than did females. Statistical testing confirmed this hypothesis in that the average aerobic capacity of males was 15.16% greater than that of females. With this pre-condition met, the separate analyses of research hypotheses by sex were warranted.

The second hypothesis addressed the effectiveness of the stress conditions in evoking an experimentally and statistically meaningful change in CV levels over baseline cardiovascular conditions. As was noted in the review of literature, a number of studies were compromised because of an inability to evoke a meaningful stress response (Steptoe et al, 1990; Long, 1991). By the same token, Blumenthal et al (1990) and others (Manuck & Garland, 1979; McCubbin et al, 1992) have contended that the use of a overly powerful stressor (and typically ecologically invalid e.g., shock or large audience public speaking) may evoke too great a response which could mask the contributions that fitness may have on the stress response. After an extensive review of the CSAH literature it was reasoned that simple speech stressor would likely evoke the most reliable response.

Analyses of the data of males and females separately revealed that each of the stressor periods evoked highly significant increases in heart rate and blood pressure. For all measures of men and women, the 3-minute talking stressor evoked a response between 10-20% over baseline levels, as hypothesized.

In addition to fulfilling the necessary preconditions to confidently test for cross stressor adaptation, the finding that even simple non-affective dialogue is "stressful" is a significant finding in and of itself. Typically psychophysiological research has employed verbal arithmetic ("mental arithmetic") or the Stroop tasks to evoke similar CV response in participants. The pressor responses found in conjunction with these tasks have been associated with "mental stress" as opposed to the act of communicating with the attending investigator. However in the present study, the dialogue and reading tasks were not designed to evoke "mental stress", but rather to require research participants communicate in slightly different ways (reading aloud and dialogue) under novel and familiar conditions. No manipulations of dialogue content or expression characteristics were made to "distress" the participants in any way. In fact, when sensitive personal topics did arise, they were subtly steered away from. This study is in concert with the growing body of research

evidence that contends that the simple act of communicating drives a powerful pressor response (Lynch 1985; Malinow, Lynch, Thomas & Friedman, 1986).

The first set of CSA hypotheses for both male and female samples proposed that those participants in the "fit" groups would exhibit significantly lower CV levels during stress than those in the "less fit" groups. For both male and female samples this hypothesis was partially supported. In the male sample significant main effects for fitness were seen for MAP and DBP and trends found for SBP and RPP illustrate the potentiality of fitness level to affect pressure and the work of the heart. These findings are quite similar to Blumenthal's (1988, 1991) and van Doornen & De Geus' (1987) research findings in which fit males showed reduced RPP and/or BP relative to less fit males across a series of verbal stressor tasks. Interestingly, unlike these studies, in the present study, fit males did not show any difference in resting heart rate compared to less fit males.

The findings of overall fitness effects for females were quite similar to those of the males. Like the males the strongest differences between fit and less fit groups occurred for BP measures and RPP, while HR differences were not as readily apparent during stress. However unlike the males, fitness grouping did not differentiate the group in a

statistically significant way on any measure. This finding resurrects a concluding point made tentatively by Crews and Landers (1987) more than 10 years ago. These authors wrote that the magnitude of association between fitness level and autonomic stress response appears greater for males than females. Interestingly, in reworking the F-values found for the female results (D.STAT 1.11, Johnson, 1989), the r-values for the effects found in the female sample ranged from .17-.21, numbers strikingly close to those suggested by Crews and Landers in 1987 ($\underline{r}=.22$).

This observation is probably somewhat misleading however, as given the state of the literature in 1987, it is likely that the values reported were found by tabulating single degree of freedom tests of difference between fit and less fit female groups. Therefore, it should be clarified that these main effect F-values are pre-corrected for multiple comparisons, therefore, not completely reflective of the frequently large differences which were present at times between fit and less fit females at specific points in the experimental protocol. For example, for every dependent measure assessed (HR, BP, RPP), at some point within the protocol (baseline or stress periods) significantly lower levels were found for fit females than for less fit females with an associated p-value of at least $=.0054$. This value when converted to an r-value (to assess magnitude of

association) is equal to .34 in our female group, a number clearly greater than the $r = .22$ posed by Crews and Landers. Thus, while the association between fitness and CV levels is greater in males than females, it may not be true that the magnitude of association is as low as that originally reported in their 1987 meta-analysis (Complete tables of correlations between fitness and CV levels for male and female groups are presented in Appendix A-13).

The second set of hypotheses for males and females proposed that those with a family history of hypertension would exhibit greater CV during stress than those without a family history of hypertension. This hypothesis was supported for the male group, but only partially for the female group.

In the female group, significant differences were found for SBP and DBP during stressor presentation but not during baseline. The findings of larger, but statistically non-significant, levels during stressor for females has been noted in a number of previous studies (Lawler, Kline, Seabrook, Krishnamoorthy, Anderson, Wilcox, Craig, Adlin & Thomas, 1998; Ravogli, Trazzi, Villani, Mutti, Cuspidi, Sampieri, DeAmroggi, Parati, Zanchetti, & Mancia, 1990). Moreover, family history of hypertension is typically a reliable predictor of higher resting and stressor pressure levels (Kannel, 1974, 1996; Lawler et al, 1998). Given that

resting BP is the strongest predictor of hypertension (Julius, 1977; Lamensdorf & Linden, 1995, Shapiro, Goldstein & Jamner, 1995), the lack of significant differences between female FH groups at baseline calls into question whether the sample of women truly in the present study truly represent different risk groups.

Consistent with past findings it was found that, FH+ males exhibited significantly greater levels than FH- males (Fahrenberg, Foerster & Willlliams, 1995; Lawler et al, 1998). These highly significant differences were seen during both baseline and stressor presentations. This finding suggests that the sample used in this study consisted of groups that were not only different in genetic background, but also for whom this genetic risk may already be manifesting itself with higher levels of resting pressure (albeit within "normotensive ranges"; there were no male or female participants who met the criterion for the diagnosis of even borderline hypertension, 140/90). This is particularly interesting given the findings of Thomas and Duzyncki (1982), who reported that in young normotensive men with a parental history of hypertension, those with resting systolic pressures of 125 and above had 12.5 times the risk of developing hypertension in the future. In our sample, FH+ males who fell just below this level (122.5 mm Hg at

rest) might be considered to be clearly in an "at risk" group.

The third set of hypotheses specific to the male and female samples proposed that elevated fitness would be associated with significantly lower levels during stress in those individuals with a family history of hypertension. These hypotheses were partially supported for both males and females. Compared to the less fit FH+ group, significantly lower levels were found in the fit FH+ male group during stress for MAP, DBP and RPP. Although HR and SBP failed to show significant group differences, the differences seen in both measures were in the hypothesized direction. In the only previous study to observe CV level responses to stress in fit and less fit FH+ males, significant group differences were found for HR, SBP and DBP (Holmes & Cappo, 1987). Similar to our study, Holmes and Cappo used just over 21 male participants with a family history of hypertension (22 in this study). However, in contrast to the present study, their fit and less fit groups were characterized by larger differences in aerobic capacity. In the present study the average aerobic capacity of fit and less fit males with FH+ was 43.3 and 30.77 ml/kg/min, respectively, whereas in Holmes and Cappo's groups the averages were 50.13 and 26.8 ml/kg/min, respectively. Perhaps if a slightly more discrepant sample in terms of aerobic capacity had been

obtained in the present study, the groups might have measured differently for SBP and HR as well. Regardless, it is important to note that the mean differences within the SBP and HR data, although not statistically significant, were in line with the *a priori* hypothesis.

In the female analyses, a slightly different pattern of significant differences emerged such that fitter FH+ women exhibited lower MAP and SBP, but not DBP, RPP and HR, during stress than did less fit FH+ women. The only other study to observe cardiovascular responses to stress in fit and less fit FH+ women was conducted by Buckworth et al (1994). In this study of 31 women HR differences were seen during stress, but no differences were found for MAP, SBP or DBP. The most obvious explanation for finding BP differences in our study, but not Buckworth et al's is related to the respective success in creating two groups with clinically different levels of fitness for comparison. As was discussed in the review of the literature (see Figure I-1), clinical differences between groups (or within-groups, in pre-post studies) may be essential to the power of a study and the probability of producing significant differences. When both fit and less fit groups are characterized by "good" and "excellent" levels of fitness (using Cooper criteria), as was the case with Buckworth et al, it may be less likely that a fitness difference will be observed.

However in the present study, the groups were characterized as "poor" and "excellent" in level of fitness, a difference that was not just statistically but clinically significant.

The fourth set of hypotheses was proposed to test the "familiarity/novelty" dimension of the cross stressor adaptation hypothesis proposed by Sothmann, Claytor and their colleagues (1996). It was proposed that for individuals with a family history of hypertension, fitness would be associated with significant difference in CV levels during familiar but not novel stressors. To test this, participants were exposed to two similar stressors (interpersonal dialogue) over the course of the psychophysiological protocol. It was assumed that the first stressor presentation would be novel and thus yield little difference between fit and less fit groups, but the second similar stressor would be familiar, and would therefore produce significant differences. This hypothesis was not confirmed for either male or female samples, however some interesting patterns in the data did emerge. For males, significant differences between groups were apparent for DBP, but overall there was no clear tendency for the differences to be greater during the familiar stressor than during novel stressor.

Generally, a review of data and figures reveal a tendency during stressor periods to be largely a

continuation of the differences that existed at baseline.

Interestingly for the female sample, some data for SBP were in the hypothesized direction, but did not approach statistical significance.

The issue of different response patterns for males and females is an interesting one addressed directly in one previous CSAH study. Houtman and Bakker (1995) found that in females fitness was not associated with a greater habituated response to a college teaching stressor, but generally was for males.

The result of Houtman and Bakker's and the present study raises the question of why this difference may exist. Perhaps, fit females do not habituate to the repeated stressors, but fit males typically do (but did not in our study). Perhaps, each stressor utilized in the present study was familiar for females, but novel to males (but the second stressor was familiar to males in Houtmann & Bakker's research).

Regarding the first suggestion, it seems unlikely that some adaptive mechanism may be present in males that is not present in females. What has been found is a generally congruent pattern of findings between males and females across numerous studies of the CSAH (Table II-7), including the findings of this study.

The second suggestion seems more plausible. Thus it is reasonable to think that the dialogue stressor utilized was simply not novel for females, while it may have remained quite novel for males. It seems likely that the dialogue format in which the participant is asked to share information about him/herself was more likely to be a normal or comfortable occurrence in most females' lives, but not those of males. This explanation enjoys considerable support by a long history of social psychological research. Based on his research, Wright (1982) thought it most accurate to characterize male and female orientations toward relationships as "side to side" and "face to face" respectively, an analogy of how each gender tends to engage others in dialogue.

In addition to being more comfortable in a one-on-one interview situation, women may be less likely to feel vulnerable in a situation requiring self disclosure (Speiler, 1986). A recent meta-analysis of 205 studies clearly indicated that females were significantly more comfortable and more likely to reveal personal aspects of their lives to others than were males (Dindia & Allen, 1992). Thus, the pattern of results for males and females in the present study should not be surprising.

Therefore the fitness differences that existed at baseline remained through the stressor, but because females

were presented with two "familiar" or "comfortable" situations rather than a "novel" then "familiar" stressor, no familiarity effect could be observed. It is perhaps for this same reason, that Houtman and Bakker failed to find habituation in the HR of female GTAs when teaching class. The female GTAs may have found teaching a class stressful, but not novel, so further habituation could not have occurred. Further, in Houtmann and Bakker's study, and other research from which evidence of a habituating response in males can be extrapolated (Blumental et al, 1990, 1991), participants were presented with a stressor more than two times. If, indeed, the conversational stressor is initially quite novel for males, then it should require a number of stressor presentations before some level of habituation occurs.

This explanation which considers both the nature of the organism and the stressor presentation characteristics is consistent with Groves and Thompson's (1970) "Dual Process Theory" which states that repetition of an effective stimulus results in a response decrement of the slope whose decline is a function of the stimulus (frequency, intensity) and state of organism (level of arousal).

Another factor that may have contributed to differences in perception of novelty or familiarity of the stressor/research environment is the sex of the interviewer.

Previous psychophysiological research has found that the BP responses of college students to dialogue can be significantly different depending on the sex of the interviewer (Lynch, 1994; Lynch, Lynch, & Friedman, 1992). When males interviewed females, DBP and SBP were significantly lower during neutral vs. affective talking. However when females interviewed females, there was no difference in the BP levels during the two conditions. Given that all interviewing of females in the present research was done by a male interviewer, Lynch et al's finding points, again, to the possibility that the females may have experienced the neutral-type interviews used in this study as being quite familiar, rather than novel.

Other research on the comfort with self-disclosure to opposite or same-sex friends has found that females tend to be more comfortable than males in either type friendship (Block, 1980). It is therefore possible that, in addition to possible differences in a general willingness to self disclose between male and female participants, the male-only interviewer design may have further created an atmosphere of greater novelty for males, and more familiarity for females.

While the exact role of interviewer sex in blood pressure response to familiar and unfamiliar stressor presentations remains unclear, it is certainly possible that

these factors may have contributed to the ambiguous results in this particular research focus.

Future research of this question should attempt to engage fit and less fit females and males in equally stressful situations (similar intensities) that are equally novel (similar stimulus characteristics) and present the stressor at least three times or more (increase frequency). Further, the use of both male and female interviewers in future research will allow examination of this factor's influence on the familiarity or novelty of the communicative environment.

An important final point to address in this discussion is the relative absence of HR level differences (at rest or during stress) between the various contrasts of fit and less fit groups were found in this study. Lower resting HR is a traditional marker of aerobic condition, thus it was expected that this would be the measure that would demonstrate the most consistent differences between fitness groupings, particularly given the wide differences in aerobic capacity of the fitness groups. Thus, given the inconsistency of a strong HR effect, yet reliable findings of BP differences for both male and female fitness groups, it is tempting to conclude that it was not an "aerobic fitness" adaptation, but rather a "physical activity" effect behind confirmation of many hypotheses. This conclusion is

strongly supported by a review of Table IV-1 that shows not surprisingly, that fitness differences among males covaried with highly significant differences in activity level. For females however, the activity differences between fit and less fit groups were less exaggerated (Table IV-2) and not statistically different. Given this covariation of fitness level with physical activity level for males along with the greater association between "fitness and stress response", it is interesting that in females, where insignificant differences were present in physical activity between fit and less fit groups, the magnitude of association between fitness and the stress response was less strong. This discrepancy hints at the possibility that the reduced BP response may be more a function of physical activity level than fitness level, particularly for women. This alternative explanation is congruent with the thinking of a leading psychophysiological researcher who has stated that, for women in particular, physical activity may be a better indicator of the autonomic stress response than is aerobic capacity (Blumenthal et al, 1991).

Clear differences in physical activity and BP levels between our fit and less fit groups, but no apparent HR training effect, is consistent with previous research by Hagberg (e.g., Hagberg, Montain & Martin, 1987). These investigators have conclusively demonstrated that light to

moderate physical activity (exercise ~45% of max), does not appreciably change aerobic fitness but is associated with the largest reductions in resting BP (but not HR) for clinical populations. In the present study the strongest series of statistical findings were main effects for distinguishing fit vs less fit males. These revealed that the differences found during in resting BP measurement between our fitness group tended to hold steady during stressor periods. As mentioned elsewhere in the dissertation, baseline is a strong influence on BP levels during stress. Rogers et al (1996), exercised a hypertensive population at moderate (~45% VO_{2max}) and vigorous levels of activity (~70% VO_{2max}) to observe changes in resting and stressed BP response pre and post training. After twelve weeks of training the moderate group had only raised their aerobic capacity by 1% (27.3 to 28.5 ml/kg/min), whereas the vigorous group raised capacity by 28% (24.7 to 31.7 ml/kg/min). Despite clear differences in improvement of fitness, the moderate group showed significantly greater decreases from pre-to-post training BP levels (MAP, SBP & DBP) during baseline and stress, whereas the vigorously exercised group only showed significant decreases in DBP. These findings led the authors to conclude that low intensity exercise may be more effective than high intensity exercise in altering BP stress response.

This speculation naturally leads to the general hypothesis that the best way to alter BP levels to stress is to focus on modifying baseline BP. Therefore, while highly fit individuals can be expected to have lower BP than less fit individuals, what may be important is to be physically active, a characteristic which appears to have a more powerful effect of lowering pressures in at-risk samples.

SUMMARY AND CONCLUSIONS

One hundred and three college students from the University of Tennessee, without cardiovascular disease or hypertension, participated in this study of the relationship of fitness to the psychophysiological stress response. Of particular interest was the degree to which the stress response could be modified by fitness in participants with a parental history of hypertension. All participants completed survey information, completed a test of estimated aerobic capacity and had measures of BP and HR taken during baseline and three verbal stressor periods.

Analysis of data supported the existence of the CSAH. Elevated fitness was associated with decreased BP and RPP, but not decreased HR, at baseline and during a commonplace dialogue stressor. Analysis of groups with a family history of hypertension revealed that, for males, fitness was associated with decreased BP and RPP levels during stress, and for females fitness was associated with lower MAP and SBP levels during stress. Analyses of interactions of fitness and stressor familiarity did not reveal any significant patterns for either males or females with a family history of hypertension.

There was a relative absence of resting HR differences between fit and less fit groups. Differences in BP response

observed in this study may have been related physical activity differences rather than fitness differences. This is supported by the fact that in overall analyses of fit and less fit female groups showed the presence of significantly different resting heart rates as well as significant differences in aerobic capacity. However a weaker relationship was seen between fitness and BP response than that found in males. This is interesting, as unlike the male groups, for females no differences were apparent in physical activity.

Support was also obtained for the notion that baseline level is a particularly meaningful indicator of the subsequent stress response. It is posited that many of the previous findings supporting a "fitness mediated cross stressor adaptation" may actually have been a reflection of the generalized adaptations at rest which occur with improved fitness.

The most important finding of this research is finding of a relationship between fitness and reduced BP during stress in a group with a family history of hypertension. This finding is consistent with three previous studies and suggests that those individuals with FH+ are particularly sensitive to fitness effects on BP during stress.

Future research in this area should continue to focus on clinically meaningful populations. Prior research with

these groups has been inexplicably absent. Ideally future research should include longitudinal case-control designs to best identify the role of fitness level (or physical activity level) on the stress response.

Additional investigation of the role of an improved habituated response in fit individuals should also be addressed. Although, the present study failed to find a difference in habituated response in fit individuals with a family history of hypertension, a number of factors may have contributed to this.

Finally, and perhaps most importantly, the findings of this and as well as one previous study (Rogers et al, 1996) demand that the role of physical activity in affecting the CV stress response be addressed. In this research the data from groups that showed a high covariation of fitness with physical activity tended to be more strongly consistent with the hypotheses, and vice versa. Given the high covariation of physical activity level with fitness level, past studies which have claimed fitness mediated CSA, may have been showing a physical activity CSA instead. This distinction may be more than a semantic one. Improved fitness typically requires exercising at moderate-to-intense levels over an extended period. Physical activity represents a type of exercise that is typically less intense and more accessible to a broader range of individuals than is aerobic training.

If this finding can be confirmed its impact could be much further felt than the finding of a relationship between the fitness level and the cardiovascular stress response.

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APPENDICES

THE UNIVERSITY OF TENNESSEE
KNOXVILLE



06/10/97

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IRB # : 5330 B

Title : The Role of Fitness and Family History of Hypertension in
Cardiovascular Response to Psychological Stress

Craig, Francis W.
Psychology
301C Austin Peay Bldg.
Campus - 0900

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Psychology
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Your project listed above was reviewed. It qualified for expedited review and has been approved.

This approval is for a period ending one year from the date of this letter. Please make timely submission of renewal or prompt notification of project termination (see item #3 below).

Responsibilities of the investigator during the conduct of this project include the following:

1. To obtain prior approval from the Committee before instituting any changes in the project.
2. To retain signed consent forms from subjects for at least three years following completion of the project.
3. To submit a Form D to report changes in the project or to report termination at 12-month or less intervals.

The Committee wishes you every success in your research endeavor. This office will send you a renewal notice on the anniversary of your approval date.

Sincerely,

A handwritten signature in cursive script that reads "Brenda Lawson".

Brenda Lawson
Compliances

cc: Warren Jones

Informed Consent for Research Protocol

Explanation

I hereby voluntarily consent to participate in this research protocol. During the first part of the research I will be asked to rest, and talk about myself and read a familiar passage. During this time blood pressure and heart rate will be periodically taken. After this first part, I shall perform a graded submaximal exercise test by riding a cycle ergometer. The exercise test is the YMCA submax test which is widely used. Exercise will begin at a low level and be advanced in stages. Once two consecutive stages with a heart rate greater than 110 beats per minute is found then the test will be completed. The exercise test may be stopped at any time because of feelings of fatigue or discomfort or for any other personal reason.

Benefits to be Expected

Blood pressure, heart rate and an estimate of maximal oxygen uptake (VO_{2max}) will be collected and explained to me should I wish. Blood pressure and Heart Rate are indices of cardiovascular health, while VO_{2max} is an index of aerobic power. These measures are important determinants in healthy functioning.

Risks and Discomforts

I understand that some discomfort may be experienced from the blood pressure cuff. I also understand that the risks of the exercise testing procedure may include a disordered or accelerated heart beat, an abnormal blood pressure response, fainting, and shortening of breath. It is extremely unlikely for someone of my age and condition to experience a heart attack under these experimental conditions (No cases in over a million tests last year).

Freedom of Consent

I have read the information above and have had all my questions answered to my satisfaction. In addition I am aware that:

1. My name will remain confidential
2. I am entitled to further inquiries to be answered regarding this research.
3. I am free to withdraw from this research at anytime without penalty or prejudice.
4. In the event of physical injury because of study participation, financial compensation is not available and medical treatment will not be provided free of charge.
5. My signature indicates that I have received and have carefully read this consent form.

Date: _____ Signed: _____

Date: _____ Witness: _____

Any question regarding the research protocol, or aspects of it, are welcomed by the investigators of this research. For questions or comments Francis Craig or Debora Baldwin can be reached at 974-2770 or 974-3357 or WLS A308.

HEALTH STATUS QUESTIONNAIRE

Personal Physician: _____

Physician Phone (if known): _____

_____ Yes _____ No Have, or had, cardiovascular disease. (e.g., heart problems)

_____ Yes _____ No Has your doctor ever said you have heart trouble?***

_____ Yes _____ No Do you frequently have pains or pressure in the left or midchest area, neck, left shoulder or arm at rest or in response to exertion.

_____ Yes _____ No Do you often feel faint or have spells of severe dizziness.**

_____ Yes _____ No Have high blood pressure.

_____ Yes _____ No Has a doctor ever said your blood pressure is too high?***

_____ Yes _____ No Am over 65 and not accustomed to vigorous exercise.**

_____ Yes _____ No Smoke more than a pack of cigarettes a day.

_____ Yes _____ No Have bone or joint problems that would interfere with or be aggravated by exercise.**

_____ Yes _____ No Have been told by the physician not to exercise, or to limit the level of physical exertion.

_____ Yes _____ No Have symptoms of back pain that might limit you in flexibility, calisthenic or aerobic exercises.

_____ Yes _____ No Have a medical condition not mentioned here that might need special attention in an exercise program.

_____ Yes _____ No Taking medications for blood pressure, heart disease, diabetes or asthma. (if yes, please list: _____)

If you answered **yes** to any of the question above, please explain:



After completing these questions, please hand these papers to the investigator.

DEMOGRAPHIC FORM

Participant Number: _____

The information you give below will be coded and kept confidential.
Please do NOT give your name!

1. Sex: Male _____ Female _____
2. Age _____
3. Grade level: Fr. _____ So. _____ Jr. _____ Sr. _____ Grad. _____ N/A _____
4. Race: African-American (Black) _____ Hispanic American _____
Euro-American (White) _____ Native American _____ Other _____
5. Marital Status: Single _____ Married _____ Divorced _____
6. Have you consumed any of the below products or exercised in the last 2 hours? (Please circle)
- Caffeinated drinks: Coffee Tea Soda
- Tobacco products: Cigar/Cigarette Dip Chewing tobacco
7. Are you currently taking any medication? Yes _____ No _____
If yes, please list: _____
8. Do you exercise regularly? Yes _____ No _____

If "YES", Please note the **type** and **length of time** and/or **distances** involved below:

9. Do either (or Both) of your parents have high blood pressure? YES _____ NO _____
If "YES", please list their phone number and medication (if known)
Phone: _____ Meds: _____

10. Answer the following by circling "0" (rarely), "1" (sometimes), "2" (often)			
a.	In conversation, how frequently do you interrupt?	0	1 2
b.	How often do you joke, saying in a funny way something that is actually important to you?	0	1 2
c.	Do you think that if a partner or friend really cared about you she/he would understand your needs without your having to explain everything?	0	1 2
d.	When you don't understand something, do you dislike having to ask questions?	0	1 2
e.	How often do you hint about things you want rather than asking directly?	0	1 2
f.	How frequently do you say "Yes", when you really want to say "No"?	0	1 2

11. Exercise Profile:

Indicate the level of your participation in any of the listed activities by circling the appropriate numbers below.

AEROBIC =	four or more times a week
FREQUENTLY =	two or more times a week
WEEKLY =	about once per week
MONTHLY =	about once per month
NEVER =	almost never

How often do you participate in:	NEVER	MONTHLY	WEEKLY	FREQUENTLY	AEROBIC
Swimming	0	1	2	3	4
Walking (2 miles/day)	0	1	2	3	4
Hiking/Backpacking	0	1	2	3	4
Bicycling	0	1	2	3	4
Aerobics/Dance Exer	0	1	2	3	4
Raquetball/Tennis	0	1	2	3	4
Golfing	0	1	2	3	4
Team Sports	0	1	2	3	4
Other (list):	0	1	2	3	4

What are your answers when you ask yourself: "Who am I?"

Describe those "parts" which **MOST** make up how you think about yourself.

To answer as *accurately as possible*, treat this question as if you were responding to yourself.

Write only 1 answer per line.

Example Answers: I am intelligent ..moody ...a church member ...an athlete ...fun

...strong

1. **I am...**
 2. **I am...**
 3. **I am...**
 4. **I am...**
 5. **I am...**
 6. **I am...**
 7. **I am...**
 8. **I am...**
 9. **I am...**
 10. **I am...**
 11. **I am...**
 12. **I am...**
 13. **I am...**
 14. **I am...**
 15. **I am...**
 16. **I am...**
 17. **I am...**
 18. **I am...**
 19. **I am...**
 20. **I am...**
-

It is difficult, after the passage of more than a century, to understand the extent to which the train robbery of 1855 shocked the sensibilities of Victorian England. At first glance the crime hardly seems noteworthy. The sum of money stolen- 12,000 pounds in gold bullion- was large, but not unprecedented. There had been a dozen more lucrative robberies in the same period. And the meticulous organization and planning of the crime, involving many people and extending over a year, was similarly not unusual. All major crimes at the mid-century called for a high degree of preparation and coordination.

Yet the Victorians always referred to this crime in capital letters as The Great Train Robbery. Contemporary observers labeled it "The Crime of the Century" and "The Most Sensational Exploit of the Modern Era". The adjectives applied to it were all strong: it was "unspeakable", "appalling", and "heinous". Even in an age given to some moral overstatement, these terms suggest some profound impact upon everyday consciousness.

To understand why the Victorians were so shocked by the theft, one must understand something about the meaning of the railroads. Victorian England was the first urbanized industrialized society on earth, and it evolved with stunning rapidity. At the time of Napoleon's defeat at Waterloo, Georgian England was a predominantly rural nation of thirteen million people. By the middle of the nineteenth century, the population had nearly doubled to twenty-four million, and half the people lived in urban centers. Victorian England was a nation of cities. The conversion from agrarian life seemed to have occurred overnight; indeed the process was so swift that no one really understood it.

Victorian novelists, with the exception of Dickens and Gissing, did not write about the cities; Victorian painters for the most part did not portray urban subjects. There were conceptual problems as well- during much of the century, industrial production was viewed as a kind of particularly valuable harvest, and not as something new and unprecedented. Even the language fell behind. For most of the 1800's, "slum" meant a room of low repute, and "urbanized" meant to become urbane and genteel. There were no accepted terms to describe the growth of cities, or the decay of portions of them.

This is not to say that Victorians were unaware of the changes taking place in their society, or that these changes were not widely- and often fiercely- debated. But the processes were still too new to be readily understood. The Victorians were pioneers of the urban, industrial life that has since become commonplace throughout the Western world. And if we find their attitudes quaint, we must nonetheless recognize our debt to them.

The new Victorian cities that grew so fast glittered with more wealth than any society had ever known-- and they stank of poverty as abject as any society had ever suffered. The inequities and glaring contrast within urban centers provoked many calls for reform. Yet there was also widespread public complacency, for the fundamental assumption of Victorians was that progress- progress in the sense of better conditions for all mankind- was inevitable. We may find that complacency particularly laughable today, but in the 1850's it was a reasonable attitude to adopt.

During the first half of the nineteenth century, the price of bread, meat, coffee, and tea had fallen; the price of coal was almost halved; the cost of cloth was reduced 80 percent; and the per-capita consumption of everything had increased. Criminal law had been reformed; personal liberties were better

protected; Parliament was, at least to a degree, more representative; and one man in seven had the right to vote. Per-capita taxation had been reduced by half. The first blessings of technology were evident: gaslights glowed throughout the cities; steamships made the crossing to America in ten days instead of eight weeks; the new telegraph and postal service provided astonishing speed in communications.

Living conditions for all classes of Englishmen had improved. The reduced cost of food meant that everyone ate better. Factory working hours had been reduced from 74 to 60 hours a week for adults and 72 to 40 for children; the custom of working half-days on Saturdays was increasingly prevalent. Average life span had increased five years.

Guide to YMCA Submaximal Bicycle Ergometer Test

General Rules:

1. Follow "YMCA Work Rate Diagram Below"
2. Three minutes at each work rate
(Add a 4th minute if HR changes > 5bpm from minute 2 to 3).
3. Measure HR @ minute #2 & 3.
4. On plotting sheet, plot 3rd minute values (need 2 values over 110 bpm)
5. On plotting sheet, draw a line through HR values ≥ 110 bpm.
6. Extrapolate to age-predicted HR_{max}.
7. Drop line to X-axis to estimate VO₂ Max.

YMCA Work Rate Diagram

First Work Load	150 0.5 kp 50 rpm			
	HR < 80	HR 80-89	HR 90-100	HR > 100
Second Work Load	750 kgm 2.5 kp	600 kgm 2.0 kp	450 kgm 1.5 kp	300 kpm 1.0 kp
Third Work Load	900 kgm 3.0 kp	750 kgm 2.5 kp	600 kgm 2.0 kp	450 kpm 1.5 kp
Fourth Work Load	1050 kgm 3.5 kp	900 kgm 3.0 kp	750 kgm 2.5 kp	600 kpm 2.0 kp

Age _____ Est HR_{Max} _____
(220-Age)
Work Load (kg) Heart Rate (bpm)

1. 0.5 _____
2. _____
3. _____
4. _____

Est. VO_{2max} = _____ L/min x 1000ml/_____ kg = _____ ml/kg/min

Experimental Data Sheet

Participant# _____

Date/Day# _____

Sex: M F AGE: _____ HT: _____ in. WT: _____ lbs Waist: _____ Hips: _____
 HT: _____ cm. WT: _____ kg
inches * 2.54 lbs * .454

Est. VO_{2max}: _____ ml/kg/min**Blood Pressures & HR:**

	Min	MAP	SBP	DBP	HR
Rest	1				
	2				
	3				
	4				
	5				
Neutral	1				
	2				
	3				
Rest	1				
	2				
	3				
S1:	1				
	2				
	3				
Rest1	1				
	2				
	3				
S2:	1				
	2				
	1				
Rest2	1				
	2				
	3				

ANOVA TABLES FOR MALES

MAP Males:

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	901.918	901.918	3.15	0.0840
FHH	1	1423.830	1423.830	4.98	0.0318
ORDER	1	728.479	728.479	2.55	0.1190
FIT*FHH	1	116.779	116.779	0.41	0.5268
FIT*ORDER	1	162.133	162.133	0.57	0.4563
FHH*ORDER	1	1575.665	1575.665	5.51	0.0244
FIT*FHH*ORDER	1	0.955	0.955	0.00	0.9542
TIME	3	3674.893	1224.964	47.73	0.0001
FIT*TIME	3	43.789	14.596	0.57	0.6367
FHH*TIME	3	108.039	36.013	1.40	0.2457
ORDER*TIME	3	97.201	32.400	1.26	0.2908
FIT*FHH*TIME	3	35.567	11.855	0.46	0.7094
FIT*ORDER*TIME	3	29.952	9.984	0.39	0.7611
FHH*ORDER*TIME	3	33.286	11.095	0.43	0.7303
FIT*FHH*ORDER*TIME	3	105.032	35.010	1.36	0.2575

SBP Males:

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	756.817	756.817	1.90	0.1768
FHH	1	1201.241	1201.241	3.01	0.0911
ORDER	1	196.543	196.543	0.49	0.4872
FIT*FHH	1	797.116	797.116	2.00	0.1660
FIT*ORDER	1	60.827	60.827	0.15	0.6985
FHH*ORDER	1	1773.838	1773.838	4.44	0.0419
FIT*FHH*ORDER	1	16.580	16.580	0.04	0.8396
TIME	3	3164.986	1054.995	37.80	0.0001
FIT*TIME	3	31.333	10.444	0.37	0.7718
FHH*TIME	3	8.664	2.888	0.10	0.9579
ORDER*TIME	3	171.665	57.221	2.05	0.1110
FIT*FHH*TIME	3	15.546	5.182	0.19	0.9059
FIT*ORDER*TIME	3	15.439	5.146	0.18	0.9068
FHH*ORDER*TIME	3	28.431	9.477	0.34	0.7968
FIT*FHH*ORDER*TIME	3	50.308	16.769	0.60	0.6158

DBP- Males					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	1393.322	1393.322	4.98	0.0317
FHH	1	1532.847	1532.847	5.48	0.0247
ORDER	1	650.465	650.465	2.33	0.1357
FIT*FHH	1	8.228	8.228	0.03	0.8647
FIT*ORDER	1	118.770	118.770	0.42	0.5186
FHH*ORDER	1	828.021	828.021	2.96	0.0936
FIT*FHH*ORDER	1	18.777	18.777	0.07	0.7970
TIME	3	2596.998	865.666	39.96	0.0001
FIT*TIME	3	77.669	25.889	1.20	0.3150
FHH*TIME	3	64.843	21.614	1.00	0.3967
ORDER*TIME	3	46.124	15.374	0.71	0.5482
FIT*FHH*TIME	3	45.410	15.136	0.70	0.5547
FIT*ORDER*TIME	3	29.450	9.816	0.45	0.7156
FHH*ORDER*TIME	3	5.403	1.801	0.08	0.9691
FIT*FHH*ORDER*TIME	3	64.425	21.475	0.99	0.3997

RPP Males:

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	14883661.664	14883661.664	1.41	0.2422
FHH	1	19405452.309	19405452.309	1.84	0.1829
ORDER	1	45649.811	45649.811	0.00	0.9479
FIT*FHH	1	1794706.552	1794706.552	0.17	0.6822
FIT*ORDER	1	402967.403	402967.403	0.04	0.8460
FHH*ORDER	1	26306325.332	26306325.332	2.50	0.1226
FIT*FHH*ORDER	1	86993.264	86993.264	0.01	0.9281
TIME	3	116916101.315	38972033.771	67.22	0.0001
FIT*TIME	3	1820625.759	606875.253	1.05	0.3749
FHH*TIME	3	514181.495	171393.831	0.30	0.8285
ORDER*TIME	3	7117894.095	2372631.365	4.09	0.0085
FIT*FHH*TIME	3	307772.360	102590.786	0.18	0.9118
FIT*ORDER*TIME	3	130051.306	43350.435	0.07	0.9734
FHH*ORDER*TIME	3	566678.128	188892.709	0.33	0.8067
FIT*FHH*ORDER*TIME	3	1911722.773	637240.924	1.10	0.3527

HR Males					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	479.510	479.510	0.87	0.3554
FHH	1	181.471	181.471	0.33	0.5685
ORDER	1	106.851	106.851	0.19	0.6615
FIT*FHH	1	435.992	435.992	0.79	0.3780
FIT*ORDER	1	797.701	797.701	1.45	0.2347
FHH*ORDER	1	936.900	936.900	1.70	0.1984
FIT*FHH*ORDER	1	655.202	655.202	1.19	0.2808
TIME	3	4272.582	1424.194	68.02	0.0001
FIT*TIME	3	16.456	5.485	0.26	0.8527
FHH*TIME	3	47.068	15.689	0.75	0.5245
ORDER*TIME	3	77.271	25.757	1.23	0.3012
FIT*FHH*TIME	3	10.830	3.610	0.17	0.9149
FIT*ORDER*TIME	3	11.621	3.873	0.19	0.9064
FHH*ORDER*TIME	3	104.155	34.718	1.66	0.1789
FIT*FHH*ORDER*TIME	3	36.5180	12.172	0.58	0.6282

ANOVA TABLES FOR FEMALES

MAP Females					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	530.997	530.997	2.17	0.1479
FHH	1	4.475	4.475	0.02	0.8931
ORDER	1	0.341	0.341	0.00	0.9704
FIT*FHH	1	18.122	18.122	0.07	0.7869
FIT*ORDER	1	70.973	70.973	0.29	0.5931
FHH*ORDER	1	0.152	0.152	0.00	0.9802
FIT*FHH*ORDER	1	20.474	20.474	0.08	0.7739
TIME	3	5680.095	1893.365	70.90	0.0001
FIT*TIME	3	112.354	37.451	1.40	0.2448
FHH*TIME	3	24.357	8.119	0.30	0.8224
ORDER*TIME	3	40.378	13.459	0.50	0.6802
FIT*FHH*TIME	3	79.943	26.647	1.00	0.3959
FIT*ORDER*TIME	3	64.522	21.507	0.81	0.4929
FHH*ORDER*TIME	3	25.772	8.590	0.32	0.8097
FIT*FHH*ORDER*TIME	3	107.092	35.697	1.34	0.2650

SBP Females					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	892.006	892.006	2.45	0.1247
FHH	1	73.427	73.427	0.20	0.6557
ORDER	1	4.720	4.720	0.01	0.9099
FIT*FHH	1	59.213	59.213	0.16	0.6888
FIT*ORDER	1	89.014	89.014	0.24	0.6236
FHH*ORDER	1	40.759	40.759	0.11	0.7397
FIT*FHH*ORDER	1	0.137	0.137	0.00	0.9846
TIME	3	4991.535	1663.845	58.05	0.0001
FIT*TIME	3	85.158	28.386	0.99	0.3994
FHH*TIME	3	156.357	52.119	1.82	0.1467
ORDER*TIME	3	122.183	40.727	1.42	0.2393
FIT*FHH*TIME	3	210.170	70.056	2.44	0.0667
FIT*ORDER*TIME	3	51.163	17.054	0.59	0.6193
FHH*ORDER*TIME	3	59.972	19.990	0.70	0.5552
FIT*FHH*ORDER*TIME	3	14.892	4.964	0.17	0.9144

DBP Females					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	346.369	346.369	1.69	0.1994
FHH	1	2.185	2.185	0.01	0.9181
ORDER	1	0.016	0.016	0.00	0.9928
FIT*FHH	1	2.144	2.144	0.01	0.9189
FIT*ORDER	1	181.188	181.188	0.89	0.3513
FHH*ORDER	1	74.068	74.068	0.36	0.5501
FIT*FHH*ORDER	1	25.424	25.424	0.12	0.7259
TIME	3	3517.494	1172.498	50.73	0.0001
FIT*TIME	3	16.926	5.642	0.24	0.8654
FHH*TIME	3	19.091	6.363	0.28	0.8431
ORDER*TIME	3	65.498	21.832	0.94	0.4210
FIT*FHH* TIME	3	41.655	13.885	0.60	0.6156
FIT*ORDER*TIME	3	135.172	45.057	1.95	0.1245
FHH*ORDER*TIME	3	47.262	15.754	0.68	0.5648
FIT*FHH*ORDER*TIME	3	26.497	8.832	0.38	0.7660

RPP Females:

Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	23063778.737	23063778.737	1.67	0.2025
FHH	1	5018414.480	5018414.480	0.36	0.5494
ORDER	1	1825461.651	1825461.651	0.13	0.7177
FIT*FHH	1	10783041.710	10783041.710	0.78	0.3812
FIT*ORDER	1	8186677.339	8186677.339	0.59	0.4450
FHH*ORDER	1	9868484.481	9868484.481	0.72	0.4020
FIT*FHH*ORDER	1	9583687.323	9583687.323	0.69	0.4089
TIME	3	166951396.675	55650465.558	78.47	0.0001
FIT*TIME	3	315426.222	105142.074	0.15	0.9307
FHH*TIME	3	1843092.086	614364.028	0.87	0.4603
ORDER*TIME	3	4109593.540	1369864.513	1.93	0.1273
FIT*FHH*TIME	3	1301075.506	433691.835	0.61	0.6086
FIT*ORDER*TIME	3	769975.334	256658.444	0.36	0.7806
FHH*ORDER*TIME	3	1845799.796	615266.598	0.87	0.4597
FIT*FHH*ORDER*TIME	3	864532.076	288177.358	0.41	0.7487

HR Females					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
FIT	1	180.446	180.446	0.43	0.5169
FHH	1	151.217	151.217	0.36	0.5528
ORDER	1	24.231	24.231	0.06	0.8118
FIT*FHH	1	21.234	21.234	0.05	0.8236
FIT*ORDER	1	0.273	0.273	0.00	0.9798
FHH*ORDER	1	304.310	304.310	0.72	0.4009
FIT*FHH*ORDER	1	2.031	2.031	0.00	0.9450
TIME	3	2865.348	955.116	59.27	0.0001
FIT*TIME	3	31.485	10.495	0.65	0.5838
FHH*TIME	3	6.790	2.263	0.14	0.9356
ORDER*TIME	3	251.720	83.906	5.21	0.0021
FIT*FHH*TIME	3	16.522	5.507	0.34	0.7952
FIT*ORDER*TIME	3	11.185	3.728	0.23	0.8744
FHH*ORDER*TIME	3	24.965	8.321	0.52	0.6718
FIT*FHH*ORDER*TIME	3	55.032	18.344	1.14	0.3369

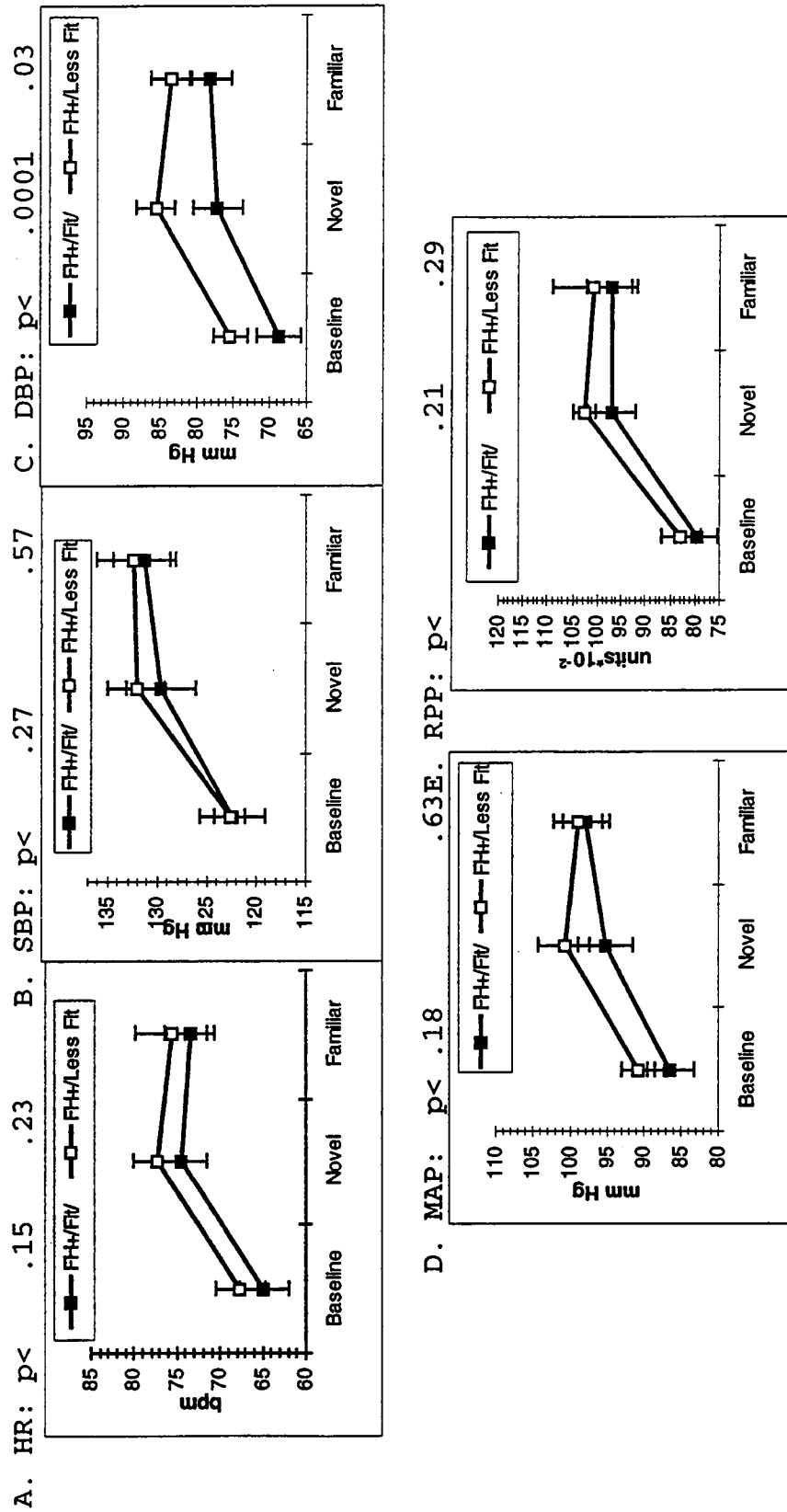


Figure A-1: Comparisons of Cardiovascular Response of Fit and Less Fit Males with a Family History of Hypertension to Novel and Familiar Stimuli

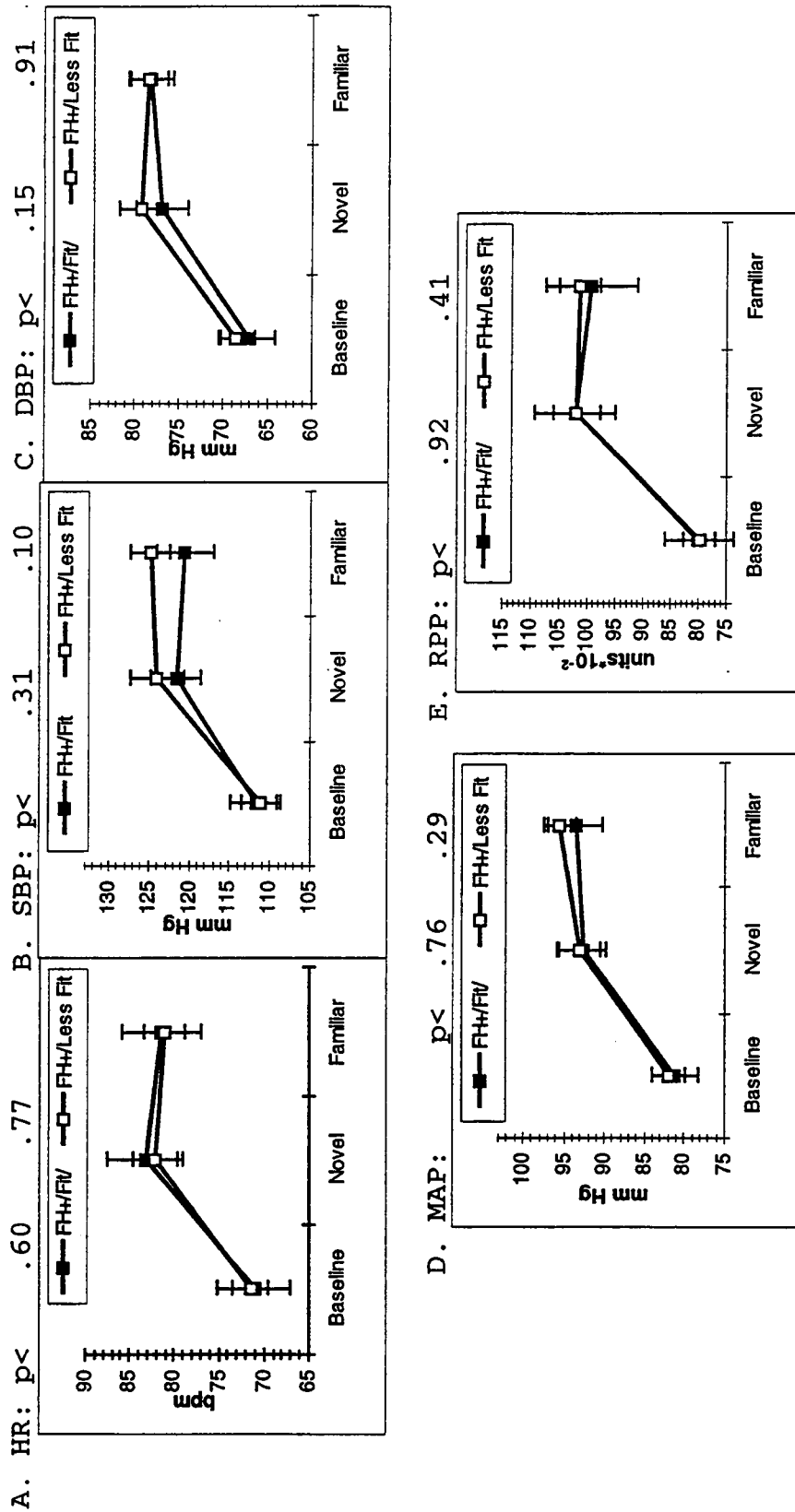


Figure A-2: Comparisons of Cardiovascular Response of Fit and Less Fit Females with a Family History of Hypertension to Novel and Familiar Stimuli

Appendix A-13: Correlations Between Fitness and CV Levels in Male and Female Samples

Males	Baseline	Stress 1	Stress 2	Stress 3
MAP	$r = .28$	.43	.38	.43
SBP	.27	.26	.47	.40
DBP	.43	.56	.56	.56
RPP	.21	.25	.47	.47
HR	.16	.30	.36	.15

Females	Baseline	Stress 1	Stress 2	Stress 3
MAP	$r = .27$	.17	.50	.01
SBP	.32	.28	.42	.22
DBP	.24	.18	.42	.12
RPP	.36	.31	.39	.35
HR	.34	.26	.34	.21

VITA

Francis W. Craig was born in Philadelphia, Pennsylvania on August 2, 1967. After elementary education in Northern Virginia, Hawaii, and Germany, he moved to St. Louis, Missouri. In June 1985, he graduated from St. Louis University High School. He graduated with a Bachelor of Arts degree in History from the University of Richmond in May 1989. In August 1990, he entered the Master's program in clinical psychology at Loyola-Maryland College, Baltimore, Maryland where an interest in cardiovascular behavioral medicine developed. He received a Master of Arts in January 1994. Doctoral training at the University of Tennessee-Knoxville began in August 1994. He continued to focus on behavioral medicine focusing on cardiac rehabilitation and became the first psychology student to complete the cardiac rehabilitation internship at Baptist Hospital of Knoxville, Tennessee offered by the exercise physiology unit at UT. A doctorate in experimental psychology with a health psychology concentration was awarded August 1998. In August 1998, Dr. Craig began a tenure track assignment at Mansfield University in Mansfield, Pennsylvania as an Assistant Professor of Health Psychology.