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Acute Blood Pressure Responses to Static and Dynamic Exercise: Racial Differences

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ABSTRACT

ACUTE BLOOD PRESSURE RESPONSES TO STATIC AND DYNAMIC EXERCISE: RACIAL DIFFERENCES.

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African Americans have a higher incidence of hypertension than other racial groups. Furthermore, some research suggests that normotensive individuals who exhibit exaggerated blood pressure (BP) responses to exercise may be at risk for future hypertension. This study sought to determine if normotensive African Americans exhibited exaggerated BP responses to static exercise or dynamic exercise relative to Caucasian Americans and Asian Americans. Thirty normotensive subjects participated from each of the three racial groups (15 males and 15 females). Subjects held 30% of maximal voluntary contraction (right knee extension) for 3 minutes, and BP was recorded during the third minute. On a separate occasion, subjects cycled for 6 minutes at a power equivalent to 70% of VO_2 reserve, and BP was recorded during the sixth minute. Static exercise produced large, significant increases in both systolic and diastolic BP (35 $\pm$ 1.5 and 29 $\pm$ 1.3 mmHg, respectively). Dynamic exercise produced large,

significant increases in systolic BP (51 ± 1.6 mmHg) and moderate, yet significant increases in diastolic BP (8 ± 1.0 mmHg). There were no significant differences between racial groups in BP response to either static exercise or dynamic exercise. However, during dynamic exercise, males had a higher systolic BP response than did females. In conclusion, African Americans who are normotensive at rest do not exhibit a greater BP response to static exercise or dynamic exercise than do Caucasian Americans or Asian Americans.

Committee Members: Dr. J. David Branch
Dr. Ladd G. Colston
Dr. David W. Hunter

In loving memory of my grandmother

Ms. Viola F. Franklin (1906 - 1996)

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CHAPTER I

INTRODUCTION

Statement of Purpose

Hypertension is recognized today as a major cause of heart disease, cerebrovascular disease, kidney failure and death in our society. The adverse effects that these disease processes exert on organ systems make early detection of hypertension of foremost concern. This early detection generally means the discovery of individuals with already elevated resting blood pressure (BP) levels. Programs have been undertaken to detect and treat hypertension at an early stage. Most studies conducted on hypertension have as their basis of measurement the resting BP (Horan and Lenfant, 1990; Roccella, 1993).

Several studies have demonstrated that the increase in BP occurring during dynamic and static exercise is greater in hypertensives than in normotensives. For reference purposes, exercise is defined as the disruption of homeostasis caused by physical movements. Equally important is the awareness that *dynamic exercise* relates to patterns of muscle activation that require concentric and eccentric actions, whereas *static exercise* refers to conditions in which the muscles are acting isometrically. In most complex movements, both dynamic and static components are present (MacDougall, Tuxen, Sale, Moroz, and Sutton, 1985).

A number of studies have compared resting BPs of African Americans and Caucasian Americans, and the results have indicated that African Americans have significantly higher BPs than Caucasian Americans. There is a lack of knowledge concerning the impact of BP on cardiovascular disease in the Asian American population of the United States. For the most part, the relationship between high BP and cardiovascular disease in Caucasian Americans have been well documented (Klatsky, 1991; Roccella, 1993).

The categories of African American, Caucasian American and Asian American applied to populations are based only on the most obvious dissimilarity (i.e., phenotype) and represent a crude division of cultural and genetic differences. Clearly, within each of these populations, there may be important subgroups completely ignored due to these crude divisions of racial grouping (Corononi-Huntley, LaCroix, & Havlik, 1989; Klatsky, 1991).

Despite a marked acceleration of immigration from Asia to the United States since the 1960s, there are few reports concerning cardiovascular risk factors and disease incidence in Asian Americans. The available data suggest more coronary artery disease among United States resident

Japanese Americans versus those resident in Japan, which has been related to life-style changes (Klatsky, 1991). Two reports concerning BP among Asian Americans in California suggest Filipinos are at greater risk than other Asian American groups. This could be related to socio-cultural factors or genetic influences (Klatsky, 1991; U.S. Department of Health and Human Services, 1994).

Hypertensive populations face the prospect of heart failure, renal failure, vascular lesions in the central nervous system, brain, or kidney, and myocardial infarctions, as well as early mortality. As noted by Horan and Lenfant (1990), hypertension is a "serious public health problem."

Hypertension has been classified into two types: primary and secondary. More than 90 percent of the cases are classified as primary in nature. Primary, or essential, hypertension is an elevated resting BP that has no identifiable cause. Secondary hypertension has a clear cut initiating mechanism in which an extrinsic interference has been inflicted on one or several of the key components of the cardiovascular system. It includes such items as coarctation of the aorta and renal hypertension (Folkow, 1982; Horan and Lenfant, 1990).

In 1988, the National Center for Disease Control estimated that 58 million Americans had high BP. The exact number of individuals who are hypertensive is unknown. According to Horan and Lenfant (1990), the primary risk factors for hypertension are genetic pre-disposition, age, excessive body weight, excessive sodium intake, increased alcohol consumption, and lack of exercise (Horan and Lenfant, 1990).

The purpose of this study was to examine the relative increase in BP from rest to exercise in African Americans, Asian Americans, and Caucasian Americans.

Operational Definitions

Before any description of the BP responses to exercise in the three racial groups are discussed, the following operational definitions apply throughout this study:

Race. It is understood that defining a specific human "race" has many difficulties. This is due to the frequent migrations and the intermixing that has occurred between racial groups. For this study, race was defined as a self-identified social and biocultural group. The three racial groups were identified as African American, Asian American, and Caucasian American (Schaefer, 1984; U.S. Department of Health and Human Services, 1994).

African American. This racial group referred to those individuals who claim origins in any of the original peoples of Africa (excluding North Africa) (U.S. Department of Health and Human Services, 1994).

Asian American. This racial group referred to those individuals who claim origins in any of the original peoples of East Asia, South-East Asia or the Pacific Islands (U.S. Department of Health and Human Services, 1994).

Caucasian American. This racial group referred to those individuals who claim origins in any of the original peoples of Europe, North Africa, or West Asia (i.e. the "Middle-East")(Schaefer, 1984; U.S. Department of Health and Human Services, 1994).

Dynamic Exercise. This term was used to refer to those types of physical activity in which various larger muscle groups undergo repetitive muscle contraction involving a change in the muscle length. These contractions induce a range of motion and are carried out over a period of minutes or longer (Dlin, 1986). In this study, the dynamic exercise was bicycle ergometry.

Static Exercise. This term was used to refer to those types of physical activity which are maintained over a short period of time (usually seconds, up to a few minutes) and in which muscle groups perform non-repetitive action with a change in tension but little or no change in the muscle length (Dlin, 1986). In this study the static exercise was the knee extension.

Hypertension. The Fifth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High

Blood Pressure (JNC V, 1993) defines hypertension as a condition in which resting systolic blood pressure (BP_{sys}) is 140 mmHg or greater and/or diastolic blood pressure (BP_{dia}) is 90 mmHg or greater. Those individuals whose blood pressure falls within these ranges or who are taking antihypertensive medications are defined as hypertensive (The Fifth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure JNC V, 1993).

Normotensive Blood Pressure. The criteria for normal BP was a resting BP_{sys} that was less than 140 mmHg and BP_{dia} that was less than 90 mmHg. Diastolic BP was measured at phase 5 of the Korotkoff sound (JNC V, 1993).

Urban environment. An area that comprises one or more places and the adjacent densely settled surrounding territory that together have a minimum of 50,000 persons (U.S. Department of Health and Human Services, 1993).

Delimitations

The present study was delimited to the following:

1. All subjects were citizens or permanent residents of the United States and currently resided in the Hampton Roads metropolitan area.

2. Only subjects who indicated that all four of their natural grandparents were members of the same racial group (i.e. African American, Asian American, or Caucasian

American) were included.

3. Subjects were randomly sampled with the expectation that the three racial groups were similar regarding the extraneous variables of age, height, weight, percent of body fat, maximal voluntary contraction (MVC) and maximal oxygen consumption (VO_{2max}).

4. A total of six groups, three racial groups with two gender groups within each, were analyzed for their potential effects on the responses of BP.

Limitations

Although every effort was made to control for extraneous variables, the following were considered when developing this study:

1. Subjects did not include individuals with racial origins outside of the areas in the operational definitions of the three racial groups (i.e. India, Australia, and North and South America).

2. The racial group of the subjects' grandparents (all four) were based upon the subjective judgment of the subjects. It was understood that the intermixing of major racial groups had occurred. Thus, it was understood that "race" here refers to social and biocultural, not genotypic, grouping.

3. The socio-economic status of the subjects was not analyzed as an independent variable.

4. Rural versus urban environment was not analyzed as an independent variable.

Statement of the Problem

African Americans have a high prevalence of hypertension. This is based on BP measurements taken when the individuals are at rest. From 18 to 64 years of age, the prevalence of hypertension increased for both men and women (8.6% to 32.8% and 11.5% to 43%, respectively) (U.S. Department of Health and Human Services, 1994). Some individuals who are normotensive at rest have larger increases in BP during exercise than others, and are characterized as "hot reactors." The research question may be stated as follows: What is the effect of exercise (static and dynamic) on normotensive African Americans' BP? And, how does this compare with the response among Caucasian and Asian Americans?

Significance of the Study

A hypertensive response in individuals during exercise is believed to be a predictor of future hypertension. Currently, the diagnosis of hypertension is based only on the values at rest. Benbassat and Froom (1986) and Tanji, Champlin, Wong, Lew, Brown, & Amsterdam, (1989) both claimed that measurement of BP during exercise stress testing provides a means of earlier detection of patients at high risk of developing resting hypertension. The researchers found that the prevalence of hypertension on follow-up examinations of cohorts who were normotensive (at rest), but had a hypertensive response to exercise was 2.06 to 3.36 times higher than among cohorts with a normotensive response (Benbassat and Froom, 1986; Tanji et al., 1989).

The Relevance to Urban Settings

African American (male and female) adults have consistently been observed to have higher levels of resting BP and more primary hypertension than Caucasian Americans. Some of this difference may be attributed to the urban environment. The 1990 census showed that 84 percent of African Americans and 76 percent of Caucasian Americans live in metropolitan areas, but 60 percent of African Americans and only 26 percent of Caucasian Americans live in central cities (U.S. Department of Health and Human Services, 1994).

There is some evidence for an effect of the urban environment on blood pressure. When African Blacks were studied in rural and urban environments, a greater blood pressure was observed for urban dwellers (Scotch, Gampel, Abramson, & Slome, 1961). Specifically, Scotch et al., 1961, examined 382 adults, 18 years or more, from a Zulu housing scheme in urban Durban, South Africa. A similar group of Zulus were examined from a rural native reserve. Mean blood pressures were significantly higher in the urban Zulu group than rural. The researchers concluded the Zulus living in the urban environment had a significantly higher incidence of hypertension and siginificantly higher blood pressure values (Scotch et al., 1961).

Sever, Peart, Gordon, Beighton (1980) conducted a blood pressure study examining the urban (64 males, 61 female) and rural (35 males, 91 females) Xhosa people of South Africa. In the urban group, mean blood pressures were significantly higher than in the rural group. Additionally, blood pressures rose with age in the urban group, but not in the rural group. The blood pressure profiles of Sever et al. were in agreement with Scotch et al. in that blood presures in urban dwellers are significantly higher than rural dwellers (Sever et al., 1980).

Kaufman, Owoaje, James, Rotimi, and Cooper (1996) sampled 598 individuals 45 years and older (190 rural men and women, 205 urban poor men, and 203 retired railway workers) in southwest Nigeria, Africa. The railway workers were chosen because they had spent their entire lives as salaried employees of the colonial and federal government. The researechers findings were in agreement with Scotch et al., 1961, and Sever et al., 1980, in that with urbanization a significantly higher prevelance of hypertension was observed (Kaufman et al., 1996).

Cooper et al., 1997, sought to examine prevalence of hypertension and associated risk factors among seven populations of West Africans. Only the urban-rural significance will be discussed. The researchers examined 612 urban men and 749 urban women in Cameroon, Nigeria. Also, the researchers examined 745 rural men and 722 rural women in Cameroon, Nigeria. The researchers found that the systolic blood pressure was significantly greater in the urban men and women compared to their rural counterparts (Cooper et al., 1997).

A study conducted in China provides further information related to the rural-urban question discussed earlier.

He et al. (1991) conducted a study to examine migration, blood pressure patterns and hypertension in the Yi people of China. The researchers wanted to examine the effects of environment and genes on blood pressure. Specifically, in 1989, blood pressures were measured in 14,505 individuals (8,241 Yi farmers, 2,575 urban Yi migrants, and 3,689 Han urban residents). The researchers found both Yi migrants (males) and Han residents (males) had significantly higher mean blood pressures than the Yi farmers, and a significantly higher prevalence of hypertension. Among the women, however, the mean systolic blood pressure was significantly higher in farmers than the migrants or urban residents. Diastolic blood pressure was not significantly different among the three groups. However, the female Yi farmers still had a significantly lower prevalence of hypertension than the migrants and urban residents. The researchers concluded that, by comparing blood pressures within the same ethnic background in different environments, environmental factors are more important determinants of blood pressure than genetic factors (He et al., 1991).

In contrast to the He et al. 1991 study, Iso et al. (1994) conducted a study to examine left ventricular mass and subsequent BP changes among middle-aged men in rural and urban Japan. Comments will be limited to changes in BPs only. Iso et al. examined 354 normotensive men (30 to 59 years) from two neighboring rural communities in Akita, Japan and urban companies in Osaka, Japan (second largest city in Japan). The data were collected at baseline between 1979 and 1983. After six to eight years, BPs were measured again. Mean age was 42 years in each population. The six to eight year follow-up revealed a significant rural-urban interaction for diastolic blood pressure only. Rural males mean diastolic blood pressure was significantly higher than urban men six to eight years later. The researchers suggest that the higher alcohol and sodium intake in the rural men may be factors attributing to the higher diastolic blood pressure recording that are not observed in the urban residence (Iso et al., 1994).

The majority of relevant studies have found that groups living in urban environments have higher BPs and a greater incidence of hypertension than similar groups in rural environments.

The Hampton Roads area is such an urban environment. The authors findings were generalized to this urban setting.

Hypotheses

1. There will be no significant difference between groups in age, height, weight, percent of body fat, VO_{2max}, or MVC in static knee extension.

2. There will be no significant difference between groups in resting BP_{sys} or BP_{dia}.

3. African Americans will have significantly greater increases in BP_{sys} during static exercise than will Caucasian Americans or Asian Americans.

4. African Americans will have significantly greater increases in BP_{dia} during static exercise than will Caucasian Americans or Asian Americans.

5. African Americans will have significantly greater increases in BP_{sys} during dynamic exercise than will Caucasian Americans or Asian Americans.

6. African Americans will have significantly greater increases in BP_{dia} during dynamic exercise than will Caucasian Americans or Asian Americans.

Chapter 2 is a review of pertinent literature regarding resting hypertension in different racial groups, normal response of BP to acute static and dynamic exercise and clinical studies on elevated BP responses to exercise. Chapter 3 is a description of the research design of the study, subjects, instrumentation, data collection procedures, statistical analysis procedures, and pilot study methodology. Chapter 4 presents the results and statistical analyses of the data. Chapter 5 contains a discussion of the findings, implications and limitations of the study's findings and recommendations for future research.

CHAPTER II

REVIEW OF LITERATURE

Resting Hypertension in Different Racial Groups

Hypertension is a clinical disease with a prevalence sufficiently high in acculturated societies to warrant its being designated a serious public health problem. In population studies, BP has been found to be a continuously distributed risk variable that is directly related to mortality. Thus, hypertension is both a disease and a risk factor. The Fifth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure (JNC V) defines hypertension as BP_{sys} of 140 mmHg or greater and/or BP_{dia} of 90 mmHg or greater, or taking hypertensive medication (JNC V, 1993). It is this definition of hypertension that will be used throughout this literature review unless otherwise noted in a specific study.

Horan and Lenfant (1990) point out with regard to gender that younger men have higher resting BPs than women of the same age; however, older men have lower pressures than older women. They also point out that regarding racial differences, African Americans have a 38 percent prevalence of hypertension as compared with a 29 percent prevalence among Caucasian Americans. Research is currently being conducted to identify subjects with a high probability for the development of hypertension in advance of the rise in BP so that appropriate interventions can be implemented as early as possible (Horan and Lenfant, 1990).

Resting BP differences between African Americans and Caucasian Americans in the United States are now well documented. According to the U.S. Bureau of the Census, African Americans comprise the largest minority group in the United States. In the 1990 census, African Americans numbered 30 million, or 12 percent of the total United States population (U.S. Bureau of the Census, 1993). End stage kidney failure caused by hypertension is 10 times more common in African Americans than Caucasian Americans. Stroke death rates in African Americans are twice those of Caucasian Americans. Among the 35-54 age range, deaths due to stroke are four times higher in African Americans than Caucasian Americans (U.S. Department of Health and Human Services, 1994).

According to the U.S. Department of Health and Human Services, (1994), the National Health Interview Surveys conducted between 1986 and 1990 indicated that the prevalence of hypertension increased with age. From 18 to 64 years of age, the prevalence of hypertension increased for both men and women (8.6% to 32.8% and 11.5% to 43%, respectively) (U.S. Department of Health and Human Services, 1994).

In 1978, Harburg, Gleiberman, Roeper, Schork, & Schull examined the relationship between skin color, racial group, and BP in Detroit African Americans and Caucasian Americans. The researchers decided to categorize the African Americans based upon the nationality of their father/mother: African Americans (N = 454), West Indies (N=23), African (N=8), and others (N=4). The subjects' age range was 25 to 59 years. The BP measurements were taken by skilled and trained nurse interviewers who received twenty hours of instruction prior to commencement of the study. BPs were taken via the auscultation method. Skin color was rated on a four point scale by the nurse interviewers. The area on the forehead between the eyes was the target skin area. The researchers found darker skin color for African Americans to be related to higher blood pressure (diastolic) in a linear manner. The mean diastolic BP for the lighter skinned African Americans was 80 mmHg. The mean diastolic BP for the darker skinned African Americans was 85 mmHg. Additionally, darker skin color, independently of other variables, was also related to residence in high stress areas, segregated by racial discrimination, and to lower education (Harburg et al., 1978 a).

In a similar study, Harburg et al. (1978 b) decided to examine skin color differences among American whites. The researchers examined lighter skinned American whites from Northern European heritage to see if there was a relationship between their skin color and high blood pressure. The subjects (N = 492) were grouped based on their parents' racial group in the following areas: North European (N = 172), Central Europe (N = 187), French (N = 49), and Mediterranean (N = 84). The subject's age range was 25 to 60 years. Harburg et al. found that lower blood pressures were observed in darker skinned whites, independently of other factors. The mean systolic and diastolic BP for the darker skinned whites was 120 mmHg and 77 mmHg, respectively. The mean systolic and diastolic BP for the lighter skinned whites was 127 mmHg and 81 mmHg, respectively. The researchers suggested that darker skinned whites have lower blood pressures, while the darker skinned African Americans have higher blood pressures due to the admixture of the genes of the two groups. One other reason for the differences in blood pressure for both racial groups is psycho-social stressors within the group (Harburg et al., 1978 b).

In 1989, Cornoni-Huntley et al. conducted a study based on the data from the National Health and Nutrition Examination Survey Epidemiologic follow-up study. This study analyzed changes in BP and frequency of treatment, hypertension incidence, and ten year survival of the subjects relative to hypertension status at baseline. Incidence rates for African Americans were twice the rate for Caucasian Americans for almost every age-sex group (Cornoni-Huntley et al., 1989).

Their study included 14,505 individuals (12,306 Caucasian Americans and 2,199 African Americans) who at the original time of survey were 25 to 76 years of age and at the follow up survey were 35 to 86 years of age. The base data for this study were taken from 1971 to 1975 and the follow-up survey was conducted from 1982 to 1984. The age-adjusted relative risk comparing incidence rates for African American men to Caucasian American men was 1.95, and for African American women compared with Caucasian American women, 2.33. These differences were particularly large for the younger age groups. The total incidence rate for African American women less than 35 years of age was 24 percent compared with 8 percent for Caucasian American women. For men less than 35 years of age, the rates were 28 percent for African Americans and 12 percent for Caucasian Americans (Cornoni-Huntley et al., 1989).

Burt et al. (1995) decided to conduct a study to estimate the current prevalence and distribution of hypertension in the United States adult population. Also, they wanted to analyze the awareness level, treatment, and control of hypertension in adults. Specifically, the study used a cross-sectional survey of the civilian, non-institutionalized population of the United States. This included an in-home interview and a clinic examination, each of which included BP measurement. The 9,901 subjects, from phase one of the third National Health and Nutrition Examination Survey were age 18 years and older. The survey data were collected from the time period of 1988 to 1991.

The researchers found 24 percent of the subjects had hypertension. The age-adjusted prevalence in the Caucasian American, African American, and Hispanic sub-groups were 23.3, 32.4 and 22.6 percent, respectively. African American men and women had the highest mean BP_{sys} and BP_{dia}. Caucasian American men and women had the lowest BP_{sys} and BP_{dia}. Within each racial group, 47 percent of the population had BPs in the optimal range ($BP_{sys} < 120$ mmHg and $Bp_{dia} < 80$ mmHg). The researchers found that virtually all of the differences in BP measurements were observed among subjects in the 18 to 49 year age group. Thereafter, BP_{sys} and BP_{dia} were similar.

Overall, 69 percent of the population with hypertension were aware of their condition and 53 percent were taking prescribed medications. Only 35 percent of Hispanics with hypertension were being treated and 14 percent had their hypertension in control. In comparison, 24 percent of Caucasian Americans and 25 percent of African Americans had their hypertension in control (Burt et al., 1995).

There are few studies concerning cardiovascular risk factors and disease prevalence in Asian Americans. Two such studies, however, are especially worthy of note: (a) Klatsky and Armstrong (1991) sought to investigate cardiovascular risk factors among Asian Americans living in northern California, and (b) Tanji et al. (1994) conducted a study on hypertension among recent Southeast Asian refugees to the United States (northern California).

Specifically, Klatsky and Armstrong (1991) examined 13,031 Asian Americans who voluntarily took health examinations offered by a northern California prepaid health care program between 1978 and 1985. The Chinese Americans (born in Hong Kong, Taiwan, Hawaii and the continental United States) were compared with those born in mainland China but living in the United States. The Japanese Americans (born in Hawaii and the continental United States) were compared with those born in Japan but living in the United States. For Filipino Americans, those born in the United States were compared with those born in the Philippines but living in the United States. The largest subsets of other Asian Americans were persons born in Korea, Vietnam, India, Thailand and Pakistan.

The researchers computed an odds ratio for risk factors among Asian Americans. The risk factors included body mass, hypertension, cholesterol, glucose, smoke any amount (current) and smoke more than one pack per day. Other variables were compared, but for the purposes of this study, only the odds ratios for BP results will be examined. The resting systolic BPs for Asian males were 122, 124, 121, and 120 mmHg for Chinese, Filipino, Japanese, and other Asian Americans respectively. The resting diastolic BPs for Asian males were 75, 75, 73, and 74 mmHg for Chinese, Filipino, Japanese, and other Asian Americans respectively. The resting systolic BPs for Asian American females were 116, 119, 115, and 115 mmHg for Chinese, Filipino, Japanese, and other Asian Americans, respectively. The resting diastolic BPs for Asian females were 71, 72, 70, and 70 mmHg for Chinese, Filipino, Japanese, and other Asian Americans, respectively. The odds ratios for hypertension among Asian Americans born in the United States versus Asian Americans born in China, Philippines, Japan, and other Asian countries were 1.4 and 0.9 for Chinese males and females, 0.9 and 0.6 for Filipino males and females, 1.0 and 0.7 for Japanese males and females, 3.4 and 1.5 for other Asian males and females, respectively (Klatsky and Armstrong, 1991).

Tanji et al. (1994), conducted a study to examine the prevalence of hypertension among recent southeast Asian refugees to northern California (Merced, Stanislaus, San Joaquin and Sacramento counties). The subjects for the study were men and women (N = 964), 25 to 64 years old, of

Southeast Asian descent who had immigrated from Cambodia, Laos, and Vietnam from 1988 to 1991. The mean age was 37.6 and the sex distribution was 49.2 percent men and 50.8 percent women. The incidence of hypertension among recent Southeast Asian refugees who relocated to northern California was 4.8 percent. The authors suggest the low incidence of hypertension was due to the young age of the subjects. Additionally, acculturation of these individuals from a heritage of relatively low cardiovascular risk (low body weight, low fat diets) to the United States culture might have an effect on their BP. These subjects had been in the United States from 1 to 4 years (Tanji et al., 1994).

A summary of the studies discussed showing the prevalence of hypertension in different racial groups is presented in Table 1.

Table 1

Prevalence of Hypertension in Different Racial Groups

Study	Race	Age	N	Incidence of HTN
Cor-Htley et al. 1989	B	25-76	2,199	28%
Cor-Htley et al. 1989	C	25-76	12,306	12%
Burt et al. 1995	B	adult	9,901	32%
Burt et al. 1995	C	adult	9,901	23%
Klatsky & Armstrong 1991	A	adult	13,031	1.4[1]% 1.0[2]% 0.9[3]% 3.4[4]%
Tanji et al. 1994	A	25-64	964	4.8%

Note: [1] Odds ratio for Chinese males born in Hong Kong, Taiwan, and the United States vs China

[2] Odds ratio for Japanese males born in the United States vs Japan

[3] Odds ratio for Filipino males born in Unites States vs Philippines

[4] Odds ratio for other Asian males born in United States vs other Asian Countries

Normal Response of BP to Acute Static or Dynamic Exercise

Tuttle and Horvath (1957) investigated the effects of static and dynamic work on BP and heart rate among a sample of 25 healthy males (age not mentioned). BPs were measured via the auscultation method. The dynamic work consisted of performing 1250 kg·m of work on a bicycle ergometer during a one minute period. BP was recorded at 15, 30, 60, and 180 seconds immediately following the work. Static work was performed by hand dynamometer at MVC for one minute. BP readings were taken the last 15 seconds of the effort, immediately following the effort, and 60 seconds after cessation. The researchers found in dynamic exercise that at 15, 30, 60, and 180 seconds after exercise, the mean systolic BPs were 173, 167, 156, and 134 mmHg, respectively. There were no significant changes in diastolic BP as a result of dynamic exercise. In the static exercise, Tuttle and Horvath found the mean systolic BP to be 161 mmHg at the last 15 seconds, 132 mmHg immediately following exercise, and 120 mmHg 60 seconds after exercise. Thus, one minute after the work period, systolic BP had returned to normal. The mean diastolic BP at the last 15 seconds was 109 mmHg, 85 mmHg immediately following exercise, and 82 mmHg 60 seconds after exercise (Tuttle and Horvath, 1957).

In 1966, Lind and McNicol examined the circulatory responses to sustained hand grip contractions performed during other exercise--both rhythmic and static. The researchers used four healthy males, aged from 29 to 39 years. The subjects walked on a treadmill continuously for 54 minutes while performing the following: (a) 5 minute hand grip at 20 percent MVC, (b) 10 minute period recovery from hand grip, (c) 2.5 minute hand grip at 30 percent MVC, (d) 10 minute period recovery from hand grip, (e) hand grip at 50 percent MVC till fatigue (usually one minute), and (f) and 10 minute period recovery from hand grip.

This protocol was performed twice by each subject at three different levels of grade on the treadmill. The second part of the investigation involved sustained contractions of the legs and arms while seated. The researchers used two hand grip dynamometers and constructed a dynamometer for the legs. BPs were measured via auscultation method. The mean resting BP for the four subjects was 120 mmHg systolic and 65 mmHg diastolic. The mean systolic BP for the subjects at the end of the 20, 30, and 50 percent MVC was 145, 180, and 185 mmHg, respectively. The mean diastolic BP for the subjects at the end of the 20, 30, and 50 percent MVC was 80, 105, and 110 mmHg, respectively. For the combined contractions of the hand grip and leg, the force was 60 and 230 kg, respectively. The mean systolic BP response for the hand and leg at 20, 30, and 50 percent MVC were increases of 35, 55, and 90 mmHg, respectively. The mean diastolic BP response for the hand and leg at 20, 30, and 50 percent MVC were increases of 15, 35, and 50 mmHg, respectively. The researchers found that when two or more muscle groups contracted simultaneously at the same proportional tension, the central cardiovascular response was not additive. Lind and McNicols' findings were similar to Tuttle and Horvath (1957) in that muscle mass and work load had an effect on BP during static and dynamic contractions (Lind and McNicol, 1967).

In 1975, McCloskey and Streatfeild investigated the muscular reflex stimuli to the cardiovascular system during isometric contractions of muscle groups of different mass. Their study was run concurrently with a study of animals. This article review will be limited to results from the human subjects' study only. The researchers' study included ten normotensive volunteers (eight males and two females). The subjects were 19 to 26 years old. The subjects were required to perform isometric contractions using the hand and fingers. Contractions were performed at 40 percent of MVC for 1 to 1.5 minutes using the hand grip and "trigger-pulling" contractions of the little finger of the same hand. Systolic BP was recorded via a catheter inserted into the radial artery of the resting arm (diastolic BP was not recorded). McCloskey and Streatfeild found in all subjects that the BP was higher after handgrip contractions than after contractions of the smaller muscle group (fingers). The mean systolic BP increase was 38.7 mmHg for the subjects during the isometric effort. The researchers concluded that muscular reflex drive in isometric exercise is related to the bulk of the contracting muscle (McCloskey and Streatfeild, 1975).

Wolthuis, Froelicher, Fisher, Triebwasser, (1977), examined the response of 704 healthy aircrewmen (United States Air Force) to treadmill exercise. The subjects' median age was 37 years. The subjects were given a maximal, submaximal, and postexertional treadmill test. BP was recorded via auscultation. In all of the subjects, heart rate and systolic BP increased with time and workload as maximum effort was approached. Diastolic BP stayed constant or fell slightly with increased effort. During the postexertional treadmill exercise, heart rates and BPs were as expected. Heart rate and BP fell at recovery minute 2 and further at minute 5. Specifically, during the last minute of the maximal treadmill test the mean heart rate was 194, the mean systolic BP was 214 mmHg, and the mean diastolic BP was 94 mmHg. The mean systolic BP at the 5, 10, and 15 percent grade was 174, 193, and 208 mmHg, respectively. The mean diastolic BP at the 5, 10, and 15 percent grade was 90 mmHg. During the postexertional treadmill exercise, measurements, at the 2 and 5 minute interval, the systolic BP was 194 and 158 mmHg, respectively. The diastolic BP for the same time period was 90 and 86 mmHg, respectively. Wolthuis et al.'s findings were in agreement with Tuttle and Horvath (1957) and Lind and McNicol (1967) in that during dynamic exercise, systolic BPs rise significantly and diastolic BP rise slightly or remain constant (Wolthuis et al., 1977).

In 1980, Buck, Amundsen, & Nielson investigated systolic BP responses during isometric contractions of large and small muscle groups. Specifically, the researchers sought to test for a difference between the systolic BP responses to large and small size muscle groups of the upper extremity at a known percentage of MVC. The study included 21 healthy male subjects between the ages of 20 and 35 years. Index finger adduction and hand grip exercise were selected to represent two different size muscle groups. After the MVC was determined, 40 percent MVC was used for the effort. The systolic BP was measured prior to the start of the fatigue contractions and approximately every 20 seconds during the contractions. The mean systolic BP of the 21 subjects for 40 percent MVC hand grip and finger adduction was 160 mmHg and 130 mmHg, respectively. The findings of Buck et al. were in agreement with those of McCloskey and Streatfeild (1975), showing that systolic BP increases in isometric exercise is related to the bulk of the contracting muscle (Buck et al., 1980).

Mitchell, Payne, Saltin, & Schibye (1980) studied the role of muscle mass in the cardiovascular response to static contractions. Their study involved eleven men who performed static contractions with the fingers (digits II and III), forearm (handgrip) and the knee extensors (knee at 90 degree angle) at 40 percent maximal voluntary contraction (MVC) for 2 minutes. In seven of the subjects, handgrip and knee extension were combined, with both contractions held at 40 percent MVC. Continuous measurements of force, heart rate and intra-arterial BP were made, before and during contraction as well as during the recovery. Heart rate and BP increased momentarily with the onset of a contraction, after which a further increase took place gradually. This pattern of response was similar for all muscle groups studied. The magnitude of the increases during the contractions were in the following ascending order: fingers, forearm, knee extensors, and combined forearm-knee extensors, with the difference between each muscle group being significant. The MVC force developed with the fingers, forearm and thigh averaged 4.2, 46.8 and 55.0 kp, respectively. After the onset of the sustained contraction at 40 percent MVC, both systolic and diastolic pressures increased immediately, gradually approaching the elevation observed at the end of the 2 minute contraction. The pattern of response was the same for all muscle groups. Although the same percentage of MVC was performed in the contractions of the different muscle groups, elevations in BPs were not the same. Both indices of cardiovascular response were lowest when the fingers contracted and the highest when the thighs contracted. When performing the handgrip, BP was lower than for knee extension, but higher than for finger contraction. The subjects performing at 40 percent MVC simultaneously with both forearm and thigh had a higher increase in BP response (mean) when compared to performance with only the thigh. The mean systolic and diastolic BPs for the maximum contractions for the finger, forearm, knee, and forearm combined with knee were 150 mmHg systolic and 110 mmHg diastolic, 180 systolic and 125 mmHg diastolic, 210 systolic and 130 diastolic mmHg, and 210 systolic and 150 mmHg diastolic, respectively. The researchers concluded that BP and heart rate responses to sustained contractions at the same percentage of MVC are muscle mass dependent (Mitchell et al., 1980).

In 1980, Longhurst, Kelly, Gonyea, & Mitchell also conducted a study to examine cardiovascular responses to static exercise. Longhurst et al. sought to investigate the responses in distance runners and weight lifters. The subjects in the study were sixty normotensive Caucasian American males. MVC was determined with the hand grip dynamometer after two efforts, with the stronger being recorded as the MVC. After a rest period, the subjects were asked to hold 40 percent of MVC until fatigue. BP and heart rate were recorded in 30 second intervals throughout the exercise stopping at the time of fatigue. The researchers observed that the mean hand grip time to fatigue for the weight lifters was 2.1 ± 0.1 minutes and for the distance runners 2.5 ± 0.2 minutes. Essentially, Longhurst et al. did not find any significant difference between the two groups of subjects. Additionally, the hemodynamic responses revealed the following findings: The mean systolic arterial BP for the distance runners and weight lifters at 40 percent MVC was 164 ± 3.3 and 171 ± 4.4 mmHg, respectively. The mean diastolic arterial BP for the distance runners and weight lifters at 40 percent MVC was 122 ± 2.1 and 117 ± 5.3 mmHg, respectively. The researchers findings were in agreement with Mitchell et al. (1980). Both observed systolic and diastolic BP increases with static exercise (Longhurst et al., 1980).

Bezucha, Lenser, Hanson, & Nagle (1982) conducted a study on the comparison of hemodynamic responses to static and dynamic exercise. Eight healthy males (23 to 34 years old) were examined to compare hemodynamic responses to static exercise (30 percent MVC in leg extension), static-dynamic exercise (30 percent MVC in leg extension and one arm cranking at 66 and 79 percent VO_{2peak}), and dynamic exercise (two leg cycling, 58 and 82 percent VO_{2peak}). Leg extension strength was measured by a spring scale. Cranking and cycling were performed on a Quinton bicycle ergometer. VO_2 was measured using an automated open circuit system. Heart rate was monitored through ECG, and arterial pressure was measured through an indwelling brachial artery catheter. Resting BP was determined by the auscultation method. Maximal leg extension strength was measured with the dominant leg. The one arm and two arm cycling maximal work loads and maximal one arm and two leg O_2 uptake (VO_2) values were determined with a continuous incremental test to exhaustion.

During the dynamic leg exercise, the subjects cycled at 25 percent of VO_{2peak} for 3 minutes. After a 5 minute rest, the subjects cycled at 58 and 82 percent of VO_{2peak} for 5 minutes each. During the static leg exercise, the subjects were asked to hold 30 percent of MVC for 3 minutes. During the third minute the BP was recorded. The mean arterial BP for the subjects at 30 percent MVC in leg extension was 118 $\pm$ 6 mmHg. The mean arterial BP for the subjects cycling at 58 $\pm$ 4 percent and 82 $\pm$ 3 percent $VO_{2\,peak}$ was 113 $\pm$ 3 mmHg, and 124 $\pm$ 4 mmHg, respectively. The study concluded that, during the leg extension at 30 percent MVC, both systolic and diastolic significantly increased. During the dynamic leg exercise, a significant increase was observed in systolic BP. There was not a significant increase in diastolic BP (Bezucha et al., 1982).

Seals, Washburn, Hanson, Painter, & Nagle (1983) investigated the increased cardiovascular response of larger muscle groups to static contraction. The study used 12 healthy males 20-30 years of age. The subjects performed the one-arm hand grip, two-leg extension, and the dead lift at 30 MVC for three minutes. The study revealed the following: The mean arterial BP at rest, the hand grip, leg extension, and dead lift at 30 percent MVC was 92 $\pm$ 2, 117 $\pm$ 3, 131 $\pm$ 3, and 143 $\pm$ 4 mmHg, respectively. Seals et al. observed increases in heart rates and BP throughout the exercise. The researchers concluded that the cardiovascular response to static contractions differ in large and small muscles groups with the same percent of MVC. Seals et al. found a positive relationship between the magnitude of the increase in heart rate and BP and the amount of muscle mass (Seals et al., 1983).

In 1985, MacDougall, Tuxen, Sale, Moroz, & Sutton conducted a study on the arterial BP response to heavy exercise in five healthy male volunteers (22 to 28 years of age). The purpose of their study was to record BP responses to heavy weight lifting exercise in experienced body builders. BP was directly recorded by means of a capacitance transducer connected to a catheter in the brachial artery. Intrathoracic pressure with the Valsalva maneuver was recorded as mouth pressure by having the subject maintain an open glottis while expiring against a column of mercury during the lifts. Exercises included single arm curls, overhead presses, and both double and single leg presses performed to failure at 80, 90, 95, and 100 percent of MVC. Mean resting systolic and diastolic BP was 135 $\pm$ 5 and 90 $\pm$ 3 mmHg, respectively. Systolic and diastolic BPs rose rapidly to extremely high values during the concentric phase for each lift and declined with the eccentric phase. The greatest peak pressures occurred during the double leg press, where the mean value for the group was 320 mmHg systolic and 250 mmHg diastolic. Peak pressures with the single arm curl exercise reached a mean group value of 255 mmHg systolic and 190 mmHg diastolic when repetitions were continued to exhaustion. The researchers concluded that when subjects performed weightlifting exercises, the mechanical compression of blood vessels combines with a potent pressor response and a Valsalva response to produce extreme elevations in BP. MacDougall et al. noted that BPs were extreme even when exercises were performed with relatively small muscle mass (MacDougall et al., 1985).

Table 2 summarizes the findings of the ten studies that have been just discussed in the section on "Normal Response of BPs to acute Static or Dynamic Exercise."

Table 2

Summary of Normal Response of BP_{sys} (mmHg) to Acute Static or Dynamic Exercise

Study	N[1]	Static Ex %MVC	Static Ex BP	Dynamic Ex mode	Dynamic Ex BP
Tuttle & Horvath 1957	25	100	161[2]	cycle	173
Lind & McNicol 1967	4	20	145[2]		
		30	180[2]		
		50	185[2]		
McCloskey & Streatfeild 1975	10	40	170[2]		
			165[3]		
Wolthuis et al. 1977	704			treadmill	214
Buck et al. 1980	21	40	160[2]		
			130[3]		
Mitchell et al. 1980	11	40	150[3]		
			180[4]		
			210[5]		
Longhurst et al. 1980	60	40	164[6]		
			171[7]		
Bezucha et al. 1982	8	30	118[8]	cycle	124[9]
Seals et al. 1983	12	30	117[10]		
			131[11]		
			143[12]		
MacDougall et al. 1985	5	100	320[13]		

Note: [1] all subjects normotensive

[2] hand

[3] finger

[4] forearm (handgrip)

[5] forearm (handgrip) + knee extension

[6] distance runners mean arterial BP (handgrip)

[7] weightlifters mean arterial BP (handgrip)

[8] mean arterial BP (leg extension)

[9] mean arterial BP 82% VO_{2max}

[10] mean arterial BP (handgrip)

[11] mean arterial BP (leg extension)

[12] mean arterial BP (dead lift)

[13] Peak pressures BP (double leg press)

Clinical Studies on Elevated BP Responses to Exercise

Unless otherwise noted, the racial group of the subjects was not mentioned in the articles discussed below. These clinical studies indicate that exaggerated BP response to exercise may serve as a risk indicator in the early detection of hypertension (Dlin, Hanne, Silverberg, & Bar-Or, 1983).

In 1981, Wilson and Meyer investigated the early prediction of hypertension using exercise BPs. The subjects in the study consisted of 2,746 men and women. During the initial test of subjects, 2,405 were normotensive during rest and exercise. Conversely, 341 were normotensive during rest but had an exaggerated BP response during exercise. The subjects were examined two or more times between January 1971 and December 1978. Age at first visit was between 25 and 65 years, with a mean $\pm$ standard deviation of 43.7 $\pm$ 8.6 years. Average time between first and last visits was 32 months. Resting BP was measured in both arms while the subject was supine, standing, and sitting. Exercise testing was to maximum effort using a modified Balke treadmill protocol. BPs were recorded every 5 minutes during exercise and at 1, 3, 5, 7, and 10 minutes of recovery. Maximum exercise BP was the highest systolic and associated diastolic pressure achieved in the exercise period and through one minute of recovery. A normal exercise BP was defined as systolic BP of 225 mmHg or less and diastolic less than 90 mmHg. The subjects were divided into subgroups based upon their resting and exercise BP readings. Of the group that was normotensive at rest on the first visit and had an elevated (exaggerated) BP response to exercise (N = 341), 70 subjects (21%) were hypertensive at their last visit. Of the group that was normotensive at rest on their first visit and had a normal response to exercise (N = 2,405), 216 subjects (9%) developed hypertension. Thus, the risk ratio for developing later hypertension associated with an elevated BP response to exercise was 2.28. The researchers concluded that measurement of BP during stress testing provides a means of early detection of hypertension in certain subgroups of the population (Wilson and Meyer, 1981).

Davidoff et al. (1982) conducted a study to investigate postexercise BP as a predictor of hypertension. The researchers' study examined 721 healthy (initially normotensive) male aircrew (Caucasian Americans). Davidoff et al. defined exaggerated BP response to exercise as a systolic BP rise to 200 mmHg or more or any rise in diastolic BP. Hypertension was defined as a resting systolic BP of 150 mmHg or more or a diastolic BP of 90 mmHg or more. BP recordings were taken 30 seconds (supine position) after subjects completed a bicycle ergometry test at 70 percent of maximum predicted heart rate. The researchers did not state how long the subjects were at 70 percent of maximum predicted heart rate. The Davidoff et al. study was conducted to research and analyze the exaggerated systolic and diastolic BP separately. Of the group that was normotensive at rest and had an elevated systolic BP response to exercise (N = 63), 39 subjects (62%) became hypertensive. Of the group that was normotensive at rest and had a normal systolic BP response to exercise (N = 658), 197 subjects (30%) developed hypertension. Thus, the risk ratio for developing later hypertension associated with an elevated BP response to exercise was 2.07. Of the group that was normotensive at rest and had an elevated diastolic BP response to exercise (N = 96), 40 subjects (42%) became hypertensive. Of the group that was normotensive at rest and had a normal diastolic BP response to exercise (N = 625), 196 subjects (31%) developed hypertension. Thus, the risk ratio for developing later hypertension associated with an elevated BP response to exercise was 1.33. The researchers concluded that exercise related BP was a useful test in predicting the development of future essential hypertension (Davidoff et al., 1982).

Franz (1982) also conducted a study on the assessment of BP response during ergometric exercise in normotensive and hypertensive patients. The study utilized 323 healthy normotensive subjects (173 males, mean age 35.3 years) and 150 females, mean age 34.7 years). Only the results of the normotensive subjects will be discussed.

Each subject performed work in a sitting position on reclined bicycle. The subjects pedalled at 50 rpm starting at 50 watts with increments of 10 watts every minute until a maximum of 100 watts. BPs were recorded every minute during work and for 5 minutes thereafter via the auscultation method. Heart rates were recorded with an electrocardiogram during the last 10 seconds of every minute. Resting BPs were taken after three minutes in the supine position.

The mean systolic and diastolic resting BP of the normotensive group was 131 ± 11 mmHg and 80 ± 7 mmHg, respectively. The male normotensive group at 100 watts had a mean systolic and diastolic BP of 188 ± 14 mmHg and 92 ± 8 mmHg, respectively. The female normotensive group at 100 watts had a mean systolic and diastolic BP of 186 ± 15 mmHg and 93 ± 7 mmHg, respectively. Fifty two of the subjects had an elevated BP response to exercise (systolic and diastolic BP greater than or equal to 200 mmHg and 100 mmHg, respectively). That group's mean systolic and diastolic BP was 211 ± 20 mmHg and 115 ± 12 mmHg, respectively. Franz observed that the BP response to exercise was affected by the subjects size and fitness, and recommended that comparisons should be made at the same relative work intensity, rather than at the same absolute work intensity (Franz, 1982).

In 1983, Jackson, Squires, Grimes, & Beard conducted a study to determine whether exercise hypertension (exaggerated BP response) was predictive of future resting hypertension. The sample included 114 subjects who had participated in a graded exercise test in 1976 as part of an annual health examination. At the initial test, 23 subjects were found to show an exaggerated BP response to exercise (systolic and diastolic BP greater than or equal to 230 mmHg and 110 mmHg, respectively). The tests were administered on calibrated bicycle ergometers and treadmills following standard protocols; work was systematically increased by one MET every two minutes, to a target heart rate of 90 percent of age predicted maximal heart rate. Resting hypertension was defined as a systolic BP greater than 140 mmHg and/or diastolic BP greater than 90 mmHg. The researchers reviewed the records of the patients upon their return to the clinic in 1980. Jackson et al. found that, of subjects normotensive at rest but who had an elevated BP response to exercise (N = 23), 12 subjects (52%) became hypertensive. Of the group that was normotensive at rest and had a normal response to exercise, (N = 91), 14 subjects (15%) developed hypertension. Thus, the risk ratio for developing later hypertension associated with an elevated BP response to exercise was 3.46. Jackson et al. concluded that exercise hypertension enhances the identification of potential hypertensive individuals (Jackson et al., 1983).

In 1983, Dlin, Hanne, Silverberg, & Bar-Or additionally investigated exaggerated BP responses to exercise. The study included 75 health young males who were normotensive at rest but showed an exaggerated BP response (ER) to exercise (systolic BP equal to or greater than 200 mmHg and/or diastolic BP rise 10 mmHg to greater than 90 mmHg). A control group (75 subjects) who did not show an exaggerated BP response to exercise (NR) was matched with the exaggerated BP response to exercise group (ER) for comparison. Each group was given a submaximal cycle ergometer test (50 rpm). BP was measured with an electronic BP instrument. BPs and heart rates were recorded at the end of the third minute of each power level. The mean age for the ER and NR group was 24.6 $\pm$ 10.1 and 25.0 $\pm$ 10. The mean resting systolic BP for the two groups were 126.3 $\pm$ 9.7 mmHg (ER) and 122.1 $\pm$ 10.2 (NR) mmHg, and the mean resting diastolic BP was 78.3 $\pm$ 5.9 mmHg (ER) and 75.5 $\pm$ 7.3 mmHg, respectively. The mean follow up period for the two groups was 5.8 years. Dlin et al. observed of the subjects who were normotensive at rest and had an elevated BP response to exercise (N = 75), 8 subjects (11%) became hypertensive. Of the control group that was normotensive at rest and had a normal response to exercise (N = 75), none later became hypertensive. The researchers concluded that exaggerated BP to exercise may predict future hypertension (Dlin et al., 1983).

Chaney and Eyman, in 1988, concluded a 14 year study on normotensive adults who had BPs measured at rest and during maximal dynamic and isometric exercise. The subjects were 100 white males, all who had BPs less than 140 mmHg systolic BP and less than 90 mmHg diastolic BP. The mean age was 52 $\pm$ 10 years. Each patient had a resting ECG, baseline heart rate, and BP was measured by auscultation. The patient had been asked to squeeze the handgrip dynamometer maximally three times, each for three seconds, then urged to maximal effort for sixty seconds. During this minute, the heart rate and BPs were recorded repeatedly. The patient then performed a maximal treadmill test with a modified Ellestad protocol. Within the fourteen year follow-up, 16 of the 100 subjects had developed hypertension. Specifically, the mean resting BP of the 84 subjects remaining normotensive was 115 mmHg BP_{sys} and 80 mmHg BP_{dia}. The mean resting BP of the 16 subjects who later developed hypertension was 130 mmHg BP_{sys} and 90 mmHg BP_{dia}. The mean BP of the 84 subjects during the handgrip was 160 mmHg BP_{sys} and 105 mmHg BP_{dia}. The mean BP of the 16 subjects during the handgrip was 180 mmHg BP_{sys} and 120 mmHg BP_{dia}. The mean BP of the 84 subjects during the treadmill was 170 mmHg BP_{sys} and 90 mmHg BP_{dia}. The mean BP of the 16 subjects during the treadmill was 190 mmHg BP_{sys} and 100 mmHg BP_{dia}. The best single measure in differentiating later hypertension versus normotension was resting diastolic BP. This classified correctly 88 percent of later hypertensive and 69 percent of normotensive subjects. The difference between resting and handgrip diastolic BP was correlated to later hypertension ($r = 0.7$). Additionally, the difference between resting and treadmill diastolic BP also was correlated to later hypertension ($r = 0.7$) (Chaney and Eyman, 1988).

In 1977, Tanji et al. (1989) employed the Harvard step test with 26 normotensive college men and found that 10 had exaggerated systolic BPs immediately after exercise (greater than 200 mmHg) and 9 had a normal response to exercise. The subjects were racially mixed, with 20 Caucasian Americans, 4 Asian Americans, 1 Hispanic and 1 African American. The mean age was 20.6 years. The mean resting BP of all subjects was 122 $\pm$ 6 mmHg systolic BP and 77 $\pm$ 7 mmHg diastolic BP. The exaggerated response to exercise was observed in 6 of the 20 Caucasian Americans, 3 of the 4 Asian Americans, the African American and the Hispanic. Ten years later, the follow-up subject sample size consisted of 22 individuals. Nine of the ten men (90%) who had the hypertensive response to exercise had resting hypertension, while one of the twelve subjects (8%) who demonstrated a normotensive response to exercise in 1977 became hypertensive, for a risk ratio of 11.2 (Tanji et al, 1989).

Wilson, Sung, Pincomb, & Lovallo (1990), conducted a study on normotensive males at risk for systemic hypertension who had an exaggerated BP response to exercise. This risk was estimated based on parental history of hypertension and on the person's resting BP. The subjects were thirty-five Caucasian American males aged 28 ± 0.8 years. The high-risk group, consisting of 20 subjects had a parental history of hypertension and had two resting systolic and diastolic BPs greater than 135 mmHg and 85 mmHg, respectively. The low-risk group (15 subjects) had a negative parental history and had two resting systolic and diastolic BPs less than or equal to 135 mmHg and 84 mmHg, respectively. The researchers defined exaggerated BP response systolic and diastolic BPs greater than or equal to 230 mmHg and 100 mmHg, respectively. The exercise protocol consisted of 3 minutes at 100, 200, 400, 600, 800, 1000 kpm or until exhaustion. BPs were recorded at the end of each stage. The high-risk group's mean resting systolic and diastolic BP was 130 mmHg ± 1.8 and 78 ± 1.7 mmHg, respectively. The low-risk group's mean resting systolic and diastolic BP was 118 mmHg ± 2.0 and 72 ± 2.0 mmHg, respectively. The high-risk group's mean exercise systolic and diastolic BP was 214 mmHg ± 9.9 and 94 ± 3.6 mmHg, respectively. The low-risk group's mean exercise systolic and diastolic BP was 182 mmHg ± 3.9 and 83 ± 3.0 mmHg, respectively.

Wilson et al. found all 15 low-risk subjects had a normal BP response to exercise. In the high-risk group, the researcher found 7 of the 20 subjects had an exaggerated response to exercise. The researchers examined the seven individuals' data as a separate subgroup. They found that these men had a dysregulation of vascular function during exercise. The researchers observed systolic BPs increased disproportionately with exercise work load as compared to those in the other groups. The researchers used the Jackson et al. (1983) study as the basis for predicting future hypertension. Wilson et al. (1990) concluded that, among high-risk males, there may be individuals who have poor vascular regulation to exercise and may be at greater risk for future hypertension.

Table 3 summarizes the various clinical studies discussed in this section showing the association between elevated BP responses to exercise and future hypertension.

Table 3

Summary of Clinical studies on Elevated BP Responses to Exercise

Study		Initial Test N	ER[1]	NR[2]	HTN at Follow-up ER(%)	NR(%)	RR[3]
Wilson & Meyer 1981		2,746	341	2,405	70(21)	216(9)	2.33
Davidoff et al. 1982		721					
	Sys		63	658	39(62)	197(30)	2.07
	Dia		96	625	40(42)	196(31)	1.33
Jackson et al. 1983		114	23	91	12(52)	14(15)	3.46
Dlin et al. 1983		150	75	75	8(11)	0(0)	
Tanji et al. 1989		22	10	12	9(90)	1(8)	11.20

Notes: [1] exaggerated response (ER) to exercise

[2] normal response (NR) to exercise

[3] risk ratio

Summary

In conclusion, the literature review has succinctly shown that there exists a definite difference in the resting BPs of African Americans, Asian Americans, and Caucasian Americans.

The *normal* response of BPs to acute dynamic exercise (as shown by the literature) reflects an increase in systolic BP during exercise and a slight decrease in diastolic BP. However, during static exercise systolic and diastolic BP increase. Lastly, clinical studies on elevated BP responses to exercise tend to show individuals are normotensive at rest, but hypertensive at exercise. The researchers state more research needs to be conducted in this area. Furthermore, the studies that have been done have not examined the exaggerated response to exercise based on racial group. Therefore, the author of this dissertation examined the amount of change in rest and exercise BP responses among three different racial groups: African Americans, Asian Americans, and Caucasian Americans.

CHAPTER III

METHODOLOGY

Research Design of the Study

The subjects in this study were from three racial groups (African Americans, Asian Americans, and Caucasian Americans). The manipulation of the independent variable (static and dynamic) exercise was designed to take place on the dependent variables systolic and diastolic blood pressure (a) to observe the effect of exercise on blood pressure elevation in normotensive individuals and (b) to evaluate possible differences in this effect among the racial groups. The type of research study was a quasi-experimental study--a design chosen because it provides adequate control for internal and external validity of the study (Campbell and Stanley, 1963).

Subjects

This study involved 90 subjects randomly sampled with the expectation that the three racial groups were similar in age, heght, weight, percent of body fat, MVC and VO_{2max} . Thirty subjects each participated from the three racial groups: African Americans, Asian Americans, and Caucasian Americans. An equal number of males and females were included in each group.

Subject size was determined by a power of F test based on a pilot study (see Pilot Study Methodology section). The following inclusionary criteria were utilized for participation in the study:

1. Subjects were citizens or permanent residents of the United States and currently resided in the urban population of the Hampton Roads metropolitan area.
2. Subjects were between 18 to 40 years of age.
3. Subjects were "apparently healthy" as defined by the American College of Sports Medicine (ACSM's Guidelines for Exercise Testing and Prescription, 1995) (Appendix A), meaning they (a) had no known cardiovascular, pulmonary or metabolic disease, (b) had no signs or symptoms of cardiopulmunary disease, (c) had no more than one major coronary artery disease risk factor.
4. Subjects had no musculoskeletal injuries or disorder that might be exacerbated by exercise.
5. Subjects did not currently have an acute infection, e.g. cold, flu.
6. All four grandparents of each subject were from the same racial group (to establish racial origin) (Appendix B).
7. Each subject had a resting systolic and diastolic

BP less than 140 mmHg and 90 mmHg, respectively.

The procedures and risks of the test were explained to the subjects; and, prior to participantion in the study, an informed consent (Appendix C) was obtained in accordance with university guidelines.

Instrumentation

A BMS mercurial sphygmomanometer model 12-525 with a BP cuff (appropriate to arm size) and a Littman's Cardiology II stethoscope was used to measure BPs during prescreening of subjects for participation in the study. A calibrated Health-O-Meter stand on scale with stadiometer ruler was used to measure height and weight. Lange skinfold calipers was used to measure skin folds to provide an estimate of body fat percentage. A KinCom 125AP was used for the static exercise protocol. The SensorMedics 2900c metabolic measurement system with SensorMedics computerized Ergoline 800s electrically braked bicycle ergometer was used to measure oxygen consumption for the dynamic exercise protocol. A Hans Rudolph 2700 series 2-way non-rebreathable valve, along with an appropriate size face mask and skull cap, was utilized during the dynamic exercise testing for the collection of expired air. The Suntech 4240 Exercise BP Monitor machine was used for recording BP and heart rate. Phase 5 of the Korotkoff sound was used to measure diastolic BP (Taylor and Gallen, 1994).

Data Collection Procedures

There were five phases of data collection. The "phase" names are as follows:

1. Pre-screening (telephone),
2. Screening and Lab familiarization,
3. Static Exercise - MVC and 30% MVC Test,
4. Dynamic Exercise/Anthropometrics - Maximal Test,
5. Dynamic Exercise - Submaximal Test of BP Response.

Phase 1: Pre-screening Procedures (telephone) Prospective subjects were identified through telephone interview to determine their health status and racial origin. If the prospective subject favorably met all inclusionary criteria (with the exception of measured resting BP), he or she was scheduled for phase 2 of data collection. Additionally, the prospective subjects were asked to (a) abstain from alcohol, caffeine and other drugs for 24 hours, (b) not to eat for at least one hour prior to each scheduled test, and (c) to come to the testing dressed in shorts, exercise shoes, and a light shirt.

Phase 2: Screening and Lab Familiarization The subjects were directed to take a seat with both feet flat on the floor and legs uncrossed for a period of five minutes. At the end of the five minutes, a resting sitting BP was measured through the auscultation method. If the subject's

BP was less than 140 mmHg BP_{sys} and less than 90 mmHg BP_{dia}, having previously met all other inclusionary criteria, he or she was entered into the study. The procedures and risks of all phases of testing were explained to the subject and informed consent was obtained. The subject was introduced to the various pieces of test equipment utilized. Then, the subject was immediately entered into phase 3.

Phase 3: Static Exercise - MVC and 30% MVC Test

In Phase 3, the static portion of data collection, the Suntech 4240 exercise BP monitor was attached to the subject as follows:

1. The ECG Patient Cable was attached to V2, V6, and the epigastrium area.

2. The appropriate size cuff for the diameter of the subject's arm was selected.

3. The Suntech 4240 microphone (using adhesive pad) was placed over the brachial artery of the left arm (the brachial artery was palpated to ensure proper placement).

4. The BP cuff was snugly placed one inch above the antecubital crease on the medial aspect of the elbow.

Then the subject was told to sit as motionless as possible for 5 minutes to record the resting BP. The BP was recorded at the end of each minute, with the average of the last minute used for later statistical analysis. Following this, each subject performed a knee extension exercise test using the KinCom 125AP to determine MVC. The knee of the subject's dominant leg was placed at a 90 degree angle. The KinCom 125AP was programmed to prohibit any movement beyond the 90 degree angle. The subject was allowed to do a practice test (5 seconds) of the knee extension exercise. After the practice test, the subject was allowed to rest 3 minutes before attempting MVC. The subject was instructed to exert as much force as possible during the MVC determination. Each subject was given two chances to exert as much force as possible. The KinCom 125AP recorded the highest "peak force" from the two efforts. The subject was then given 5 minutes rest after MVC is determined before conducting the test at 30% of MVC. For the 30% MVC test, the subject was required to hold 30% MVC for 3 minutes. Subjects were instructed to breathe normally during the 30% MVC effort. At the end of each minute, BP and heart rate were recorded using the Suntech 4240. The BP recorded during the third minute was used for later statistical analysis. The subject was now scheduled for Phase 4 of data collection.

Phase 4: Dynamic Exercise/Anthropometrics - Maximal Test

Phase 4 of the data collection was scheduled no sooner than 2 days after completion of Phase 3. During the fourth phase of data collection, each subject's height, weight, and skinfold measurements were taken (chest, abdomen, and thigh for men; triceps, suprailiac, and thigh for women), to determine percent of body fat (Pollock et al., 1980).

In Phase 4, the dynamic maximal exercise portion of data collection, a maximal oxygen consumption test was performed utilizing the computerized Ergoline 800s electrically braked and calibrated bicycle ergometer and the SensorMedics 2900c metabolic measurement system. The SensorMedics 2900c metabolic measurement system ventilation meter was calibrated at least once per day against a 3.0 liter syringe, and the oxygen and carbon dioxide analyzers were calibrated against known gas concentrations prior to each test. The preparation procedures for recording BP (Suntech 4240) of the subject was the same as utilized in the static data collection (phase 3). After the subject was connected to the Suntech 4240, the subject was instructed to sit on the computerized Ergoline 800s bike to determine correct seat height. The seat was adjusted to provide a slight bend (approximately 5 degrees) in the knee at full extension of the leg on the down pedal of the bike. The handlebar was adjusted to a comfortable height for the subject. Pedal straps were used. The subject was fitted with a Hans Rudolph 2700 series 2-way non-rebreathable valve and appropriate size mask and skull cap. The dynamic maximal exercise test was performed at 50 rpm.

The protocol for the dynamic maximal exercise test was the following:

1. The subject was asked to remain motionless for 5 minutes while resting BP, heart rate, and resting VO_2 (two consecutive minutes) were recorded.

2. Next, the subject was allowed to warm-up by cycling for one minute without resistance.

3. The maximal test was then performed in 1 minute stages. The power output was 15 watts for the first minute, and increased 15 watts each minute thereafter.

All subjects were exercised till they had reached exhaustion and under their own volition decided to stop, or until they could no longer maintain the prescribed cadence, or if the test was terminated due to signs or symptoms in accordance with ACSM guidelines (ACSM's Guidelines for Exercise Testing and Prescription, 1995).

4. A 2-3 minute cool down was allowed at the end of the maximal test.

The subject was then scheduled for Phase 5 of data collection. Phase 5, the dynamic submaximal exercise trial, was scheduled no earlier than 2 days after completion of Phase 4.

<u>Phase 5: Dynamic Exercise - Submaximal Test</u>

In Phase 5, the dynamic submaximal exercise portion of data collection, the preparation procedures were the same as for the maximal exercise test. The subject cycled for 6 minutes at a power equivalent to 70% of VO_2 reserve determined from the maximal test. VO_2 reserve was determined by subtracting resting VO_2 from maximal VO_2. Then, VO_2 rest was added to 70% of VO_2 reserve. This equalled the target VO_2. Next, a review of the maximal test data was conducted to determine the corresponding power.

The protocol for the submaximal exercise test was the following:

1. The subject sat on the bike with the BP monitoring equipment attached.
2. The subject was asked to remain motionless for 5 minutes while resting BP and heart rate were recorded.
3. Following step two, the subject was allowed to warm-up by cycling for 1 minute at 15 watts.
4. The subject was then required to cycle at a power equivalent to 70% of VO_2 reserve for 6 minutes to allow steady state (heart rate) to be achieved. BPs were recorded each minute. The BP recorded during the 6th minute was used for later statistical analysis.
5. A 2-to-3-minute cooldown was allowed at the end of the submaximal test.

The data for each subject's phase of testing were recorded on a data collection sheet for later analysis (Appendix D).

Statistical Analysis Procedures

A two-way analysis of variance (ANOVA) was utilized to analyze hypothesis number 1 for possible differences in subject characteristics (age, height, weight, percent of body fat, MVC, VO_{2max}) among the three racial groups and gender.

A multivariate analysis of variance (MANOVA) was utilized to examine the remaining five hypotheses (2 through 6).

Hypotheses

1. There will be no significant difference between groups in age, height, weight, percent of body fat, VO_{2max}, or MVC in static knee extension.

2. There will be no significant difference between groups in resting BP_{sys} or BP_{dia}.

3. African Americans will have significantly greater increases in BP_{sys} during static exercise than will Caucasian Americans or Asian Americans.

4. African Americans will have significantly greater increases in BP_{dia} during static exercise than will Caucasian Americans or Asian Americans.

5. African Americans will have significantly greater increases in BP_{sys} during dynamic exercise than will Caucasian Americans or Asian Americans.

6. African Americans will have significantly greater increases in BP_{dia} during dynamic exercise than will Caucasian Americans or Asian Americans.

Data Collection

Data designed to test hypotheses 1 and 2, were collected in phases 3 and 4. Data designed to test hypotheses 3 and 4 were collected in phase 3. Data designed to test hypotheses 5 and 6 were collected in phase 5. Significance for all statistical tests was judged at the 0.05 alpha level. If a statistical significance was observed, a Bonferroni post hoc analysis was utilized.

Pilot Study Methodology

With certain exceptions, the data collection procedures in the pilot study were the same as discussed in describing the final study. The exceptions are indicated below.

Subjects

The subject size for the pilot study consisted of twelve volunteers (two males and two females from each of the three racial groups being investigated). The subjects in the pilot study met the same inclusionary criteria as previously discussed.

Instrumentation

A calibrated Monark 818 Ergomedic bike was used to test subjects during the dynamic portion of the pilot study, instead of the SensorMedics 2900c metabolic measurement system with SensorMedics computerized Ergoline 800s electrically braked bicycle. Skin fold measurements were not taken. The subjects' expired air was not analyzed.

Data Collection Procedures

A maximal test was not conducted. A submaximal cycle ergometer test was conducted using the Monark 818 Ergomedic bike. The submaximal cycle ergometer test was conducted as follows:

1. The subjects sat on the Monark bike with the BP monitoring equipment attached.
2. The subjects were asked to remain motionless for 5 minutes while resting BP and heart rates were recorded.
3. Seventy percent of the subjects' heart rate reserve (HRR) was then calculated from the resting heart rate and estimated maximal heart rate, using the Karvonen formula.
4. The subject was then required to cycle at 50 rpm while resistance on the Monark bike was increased 1 kp per minute until 70% of the subjects' HRR was reached.
5. When the subjects reached 70% of HRR, the subjects were required to maintain that power setting for six minutes while the BP was recorded each minute.
6. A 2-to-3-minute cooldown was performed at the end of the submaximal test.

The power of F test, based on the pilot study, revealed that a sample size of 15 subjects per group was needed to show a statistically significant F ratio at the 0.05 alpha level. It was decided to increase this sample size to 30 to insure validity in the research study.

Statistical Analysis Procedures

Tables 4 and 5 show the means and standard deviations for BP in each racial group during static (30% MVC) and dynamic(70% HRR) exercise. No other data analysis was conducted on the pilot study data.

Table 4

Pilot Study of BP Responses to Acute Static Exercise at 30 % of MVC (Mean + SD)

Racial group	N	Rest		Exercise	
		BP_{sys}	BP_{dia}	BP_{sys}	BP_{dia}
African Americans	4	115	75	135	102
		8	3	12	19
Asian Americans	4	123	67	139	94
		15	7	22	24
Caucasian	4	116	72	152	110
Americans		12	8	12	12

Table 5

Pilot Study of BP Responses to Acute Dynamic Exercise at 70% of Heart Rate Reserve (Mean + SD)

Racial group	N	Rest		Exercise	
		BP_{sys}	BP_{dia}	BP_{sys}	BP_{dia}
African Americans	4	108	66	159	78
		4	5	15	18
Asian Americans	4	113	66	159	79
		15	10	18	16
Caucasian	4	116	73	166	74
Americans		15	10	20	22

CHAPTER IV

RESULTS

Subject Characteristics

Table 6 shows the means (with standard errors (SE) in parentheses) for each racial and gender group's age, height (HT), weight (WT), percentage of body fat (%BF), maximal voluntary contraction (MVC), and maximal oxygen consumption (VO_{2max}). Two way ANOVAs were conducted on each variable to determine possible differences between the racial and gender groups. Table 7 shows the F ratios and p values from these analyses. A post hoc analysis of significant F values (Table 8) revealed that African Americans (AF) and Caucasian Americans (C) were significantly taller and heavier than Asian Americans (AS). Also, males were taller and heavier than females. The VO_{2max} of the Caucasian American group was significantly greater than that of the African Americans and Asian Americans. Other significant differences were that males had a greater MVC and VO_{2max} than females, while females had a greater percentage of body fat than males. (Note: Appendix E contains raw data for all subjects).

Table 6

Subject Characteristics (Means + SE)

	Racial - Gender Groups					
	African American		Asian American		Caucasian American	
	M	F	M	F	M	F
AGE	21.6	27.7	27.8	27.0	26.4	25.2
(yr)	(0.3)	(1.6)	(1.9)	(1.6)	(1.8)	(1.7)
HT	175	165	169	160	180	162
(cm)	(2.4)	(3.0)	(0.9)	(1.6)	(1.1)	(1.4)
WT	82.5	62.1	69.0	54.7	83.2	60.0
(kg)	(5.1)	(1.9)	(1.9)	(1.4)	(2.2)	(2.7)
%BF	11.0	23.4	15.2	24.8	16.3	22.8
	(1.6)	(1.8)	(1.6)	(0.7)	(1.7)	(1.5)
MVC	431	358	461	321	580	367
(N)	(35)	(31)	(34)	(27)	(45)	(31)
VO_{2max}	2.20	1.43	2.04	1.20	2.79	1.94
($L \cdot min^{-1}$)	(0.13)	(0.09)	(0.11)	(0.07)	(0.13)	(0.11)

Table 7

F ratios and p values from ANOVA on Subject Characteristics

		Race	Gender	Race * Gender
AGE	(p)	0.2359	0.3521	0.0653
	(F)	(1.4)	(0.8)	(2.8)
HT	(p)	0.0018	0.0001	0.0438
	(F)	(6.8)	(60.0)	(3.2)
WT	(p)	0.0004	0.0001	0.2240
	(F)	(8.6)	(65.2)	(1.5)
%BF	(p)	0.0973	0.0001	0.1618
	(F)	(2.4)	(51.5)	(1.8)
MVC	(p)	0.0802	0.0001	0.2120
	(F)	(2.6)	(20.0)	(1.5)
VO_{2max}	(p)	0.0001	0.0001	0.9353
	(F)	(23.3)	(75.5)	(0.07)

Table 8

Significant Differences in Subject Characteristics

	Race	Gender
AGE	ns	ns
HT	AF,C > AS	M > F
WT	AF,C > AS	M > F
%BF	ns	F > M
MVC	ns	M > F
VO_{2max}	C > AF, AS	M > F

Static Exercise

The three racial group's BPs were analyzed for possible differences during rest and static exercise. Table 9 shows the means (with SE in parentheses) for systolic and diastolic BP at rest (SYS_{rst}, DIA_{rst}) and during the third minute of static exercise at 30% of MVC (SYS_{ex}, DIA_{ex}). Figures 1 and 2 graphically display systolic and diastolic BP before and during static exercise for all three racial groups. A repeated measures MANOVA was conducted to determine possible differences in BP responses between racial and gender groups. Table 10 shows the F ratios and p values from the analysis of resting BP obtained immediately prior to static exercise. Table 11 shows the $\underline{F}$ ratios and $\underline{p}$ values for the change in BP from rest to static exercise. A post hoc analysis of significant $\underline{F}$ values (Table 12) revealed that African Americans' and Caucasian Americans' systolic resting BP was significantly greater than that of Asian Americans. Also, males had higher resting systolic BPs than females. Static exercise produced large, significant increases in both systolic and diastolic BP (on average 35 $\pm$ 1.5 and 29 $\pm$ 1.3 mmHg, respectively). However, there were no significant differences between racial or gender groups in this response.

Table 9

Subjects' Blood Pressure (mmHg) during Rest and Static Exercise (Means + SE)

	Racial - Gender Groups					
	African American		Asian American		Caucasian American	
	M	F	M	F	M	F
SYS_{rst}	124	111	114	101	121	111
	(2.7)	(2.7)	(1.1)	(1.5)	(1.9)	(1.9)
DIA_{rst}	74	74	74	70	75	71
	(2.1)	(1.8)	(1.4)	(1.4)	(1.9)	(1.6)
SYS_{ex}	159	147	149	139	162	137
	(3.7)	(2.8)	(4.0)	(2.2)	(5.4)	(3.3)
DIA_{ex}	107	103	102	98	107	99
	(3.5)	(4.4)	(3.8)	(3.7)	(3.3)	(3.8)

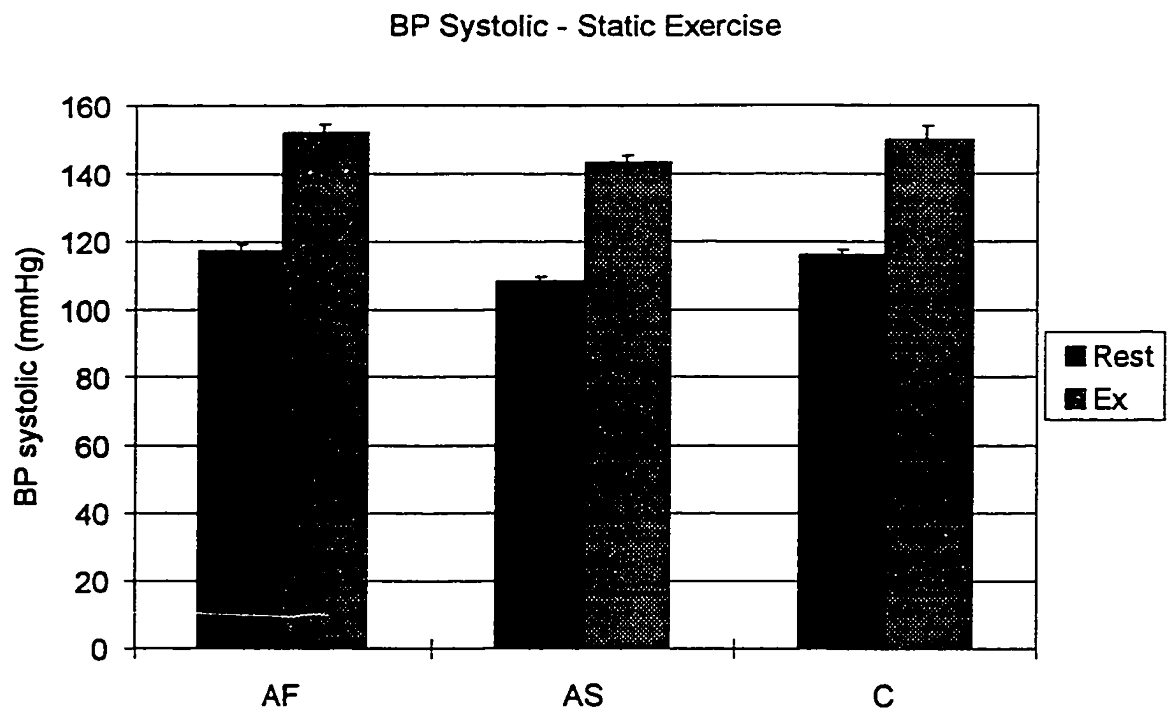

Figure 1.

Systolic BP for all three racial groups prior to and during Static exercise.

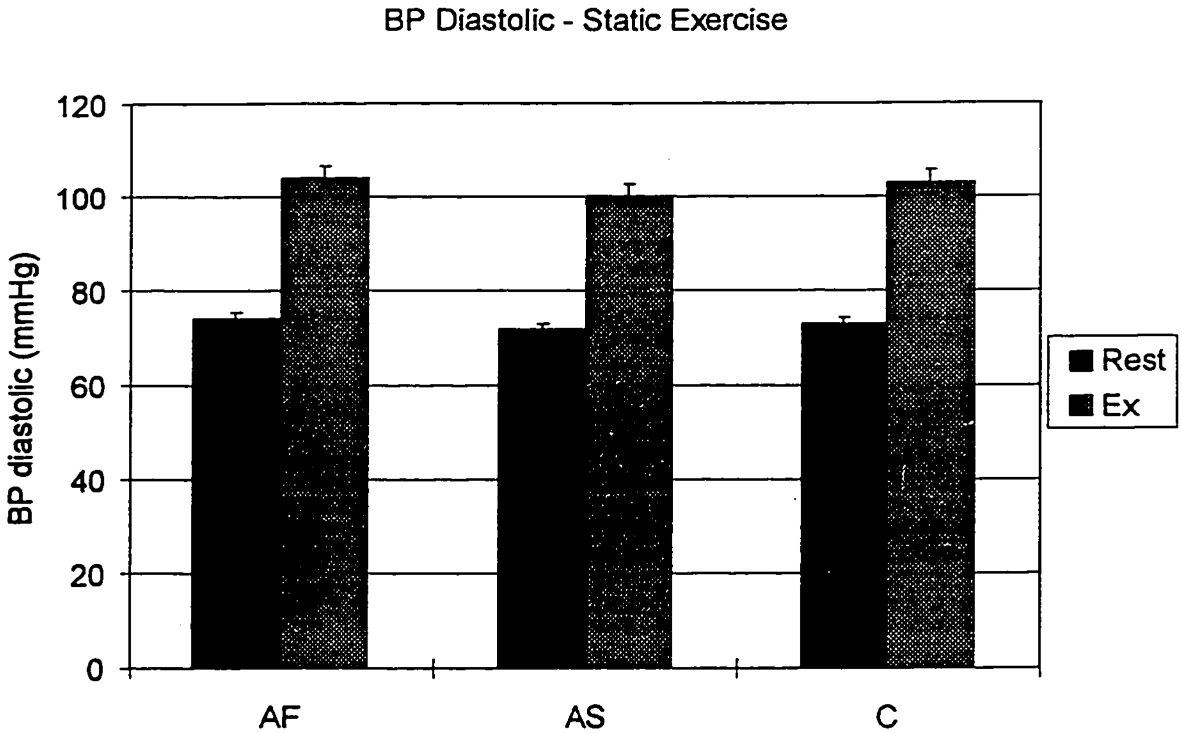

Figure 2.

Diastolic BP for all three racial groups prior to and during Static exercise.

Table 10

F ratios and p values from MANOVA on Subjects' Blood Pressure during Rest (prior to Static Exercise)

		Race	Gender	Race * Gender
SYS_{rst}	(p)	0.0001	0.0001	0.8156
	(F)	(12.23)	(49.49)	(0.20)
DIA_{rst}	(p)	0.6204	0.0764	0.4098
	(F)	(0.48)	(3.22)	(0.90)

Table 11

F ratios and p values from Repeated measures MANOVA on Subjects' Blood Pressure from Rest to Static Exercise (Within Subject Effects)

		Trial	Trial * Race	Trial * Gender
SYS_{rst} - SYS_{ex}	(p)	0.0001	0.9033	0.2449
	(F)	(543.70)	(0.1)	(1.3)
DIA_{rst} - DIA_{ex}	(p)	0.0001	0.6390	0.4020
	(F)	(460.09)	(0.45)	(0.71)

Table 12

Significant Differences in Subjects' Blood Pressure during Rest and Static Exercise

	Race	Gender
SYS_{rst}	AF, C > AS	M > F
DIA_{rst}	ns	ns
$SYS_{rst} - SYS_{ex}$	ns	ns
$DIA_{rst} - DIA_{ex}$	ns	ns

Dynamic Exercise

The three racial group's BPs were analyzed for possible differences during rest and dynamic exercise. Table 13 shows the means (with SE in parentheses) for systolic and diastolic BP at rest and during the sixth minute of dynamic exercise at 70% VO_2 reserve. Figures 3 and 4 graphically display systolic and diastolic BP during rest and dynamic exercise for all three racial groups. A repeated measures MANOVA was conducted to determine possible differences in BP responses between racial and gender groups. Table 14 shows the F ratios and p values from the analysis of resting BPs obtained immediately prior to dynamic exercise. Table 15 shows the *F* ratios and *p* values for the change in BP from rest to dynamic exercise. A post hoc analysis of significant *F* values (Table 16) revealed that African Americans' and Caucasian Americans' systolic resting BP was significantly greater than that of Asian Americans. Additionally, males had significantly higher systolic and diastolic BPs than females at rest. Dynamic exercise produced large, significant increases in systolic BP (51 ± 1.6 mmHg on average) and moderate, yet significant increases in diastolic BP (8 ± 1.0 mmHg on average). However, the only significant differences between groups in this response was that males exhibited a greater increase in systolic BP than did females.

Table 13

Subjects' Blood Pressure (mmHg) during Rest and Dynamic Exercise (Means + SE)

	Racial - Gender Groups					
	African American		Asian American		Caucasian American	
	M	F	M	F	M	F
SYS_{rst}	123	109	111	99	118	105
	(2.4)	(2.3)	(1.8)	(2.3)	(2.6)	(2.4)
DIA_{rst}	74	71	69	67	75	67
	(1.7)	(2.2)	(1.2)	(1.7)	(2.1)	(1.9)
SYS_{ex}	183	157	169	141	166	155
	(3.4)	(4.1)	(3.9)	(3.8)	(3.2)	(3.6)
DIA_{ex}	84	81	78	77	77	80
	(3.2)	(3.3)	(1.5)	(2.1)	(2.2)	(2.2)

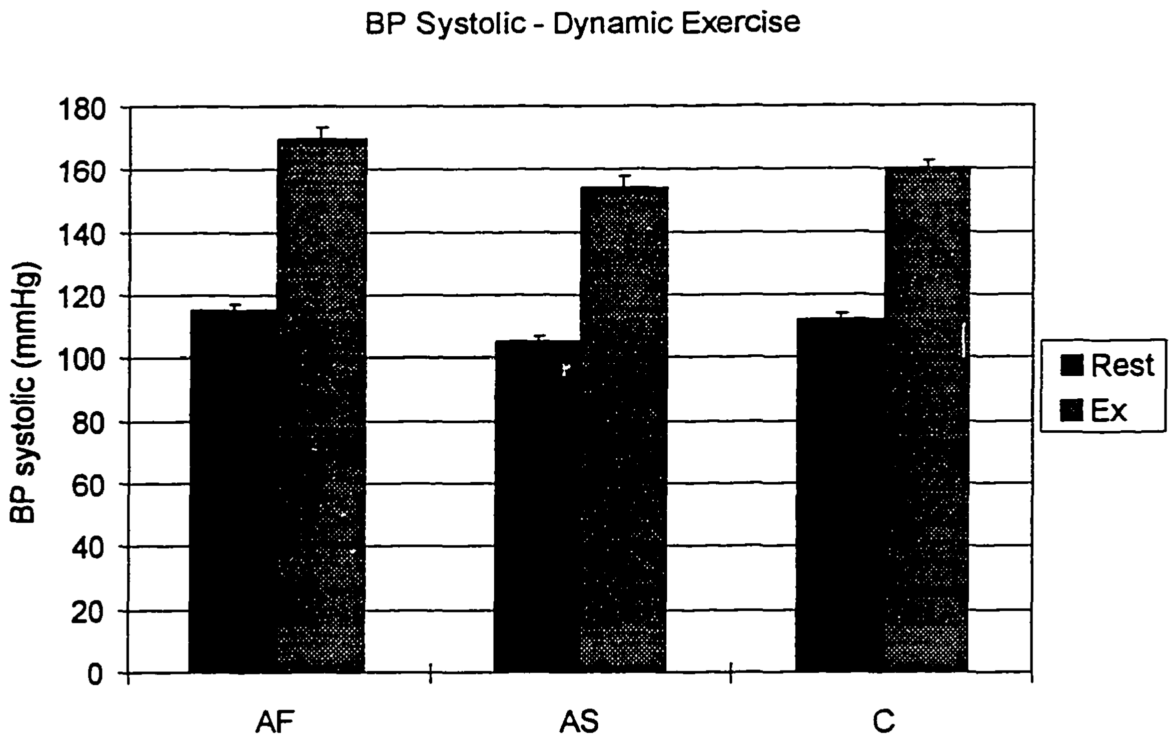

Figure 3.

Systolic BP for all three racial groups prior to and during Dynamic exercise.

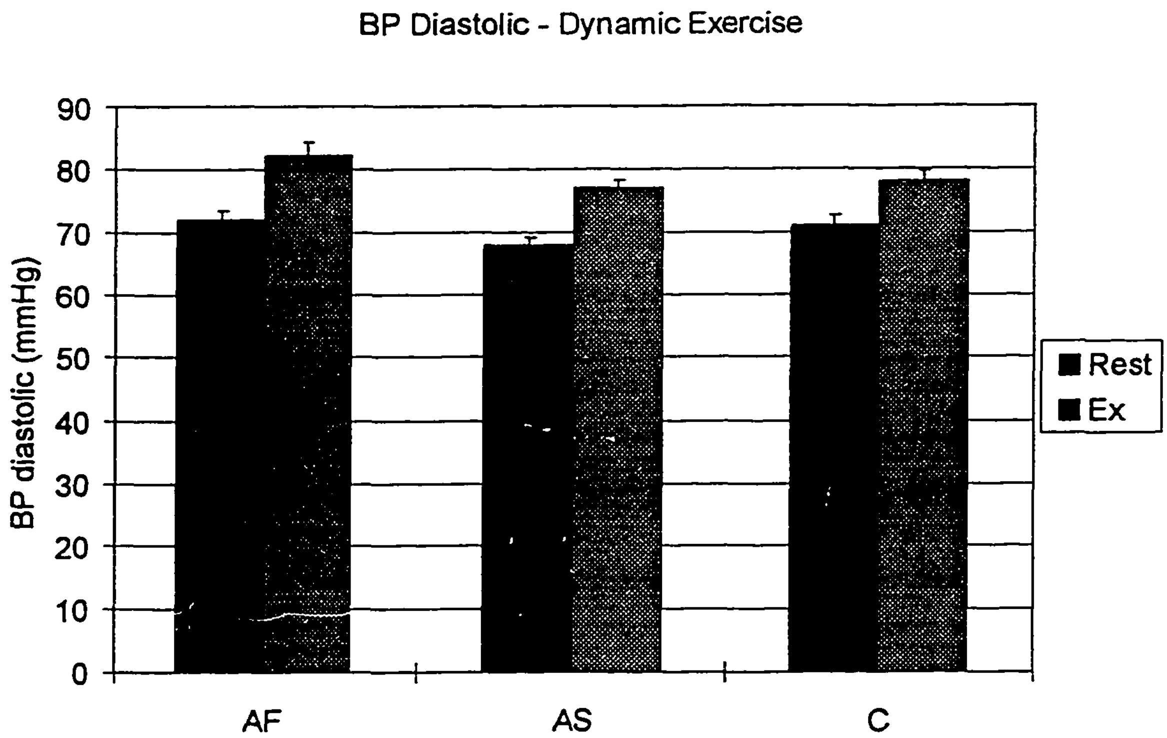

Figure 4.

Diastolic BP for all three racial groups prior to and during Dynamic exercise.

Table 14

F ratios and p values from MANOVA on Subjects' Blood Pressure during Rest (prior to Dynamic Exercise)

		Race	Gender	Race * Gender
SYS_{rst}	(p)	0.0004	0.0001	0.7741
	(F)	(8.67)	(42.74)	(0.26)
DIA_{rst}	(p)	0.1276	0.0109	0.3882
	(F)	(2.11)	(6.78)	(0.96)

Table 15

F ratios and p values from Repeated measures MANOVA on Subjects' Blood Pressure from Rest to Dynamic Exercise (Within Subject Effects)

		Trial	Trial * Race	Trial * Gender
SYS_{rst} - SYS_{ex}	(p)	0.0001	0.3324	0.0029
	(F)	(1105.61)	(1.12)	(9.41)
DIA_{rst} - DIA_{ex}	(p)	0.0001	0.5630	0.1376
	(F)	(71.92)	(0.58	(2.25)

Table 16

Significant Differences in Subjects' Blood Pressure during Rest and Dynamic Exercise

	Race	Gender
SYS_{rst}	AF, C > AS	M > F
DIA_{rst}	ns	M > F
$SYS_{rst} - SYS_{ex}$	ns	M > F
$DIA_{rst} - DIA_{ex}$	ns	ns

CHAPTER V

DISCUSSION

This chapter will discuss the findings of the research study as it relates to the hypotheses. Furthermore, the subjects' BP responses to acute static or dynamic exercise will be compared to past literature. And finally, suggestions for future research in acute BP responses in different racial groups will be discussed.

Subject Characteristics

Hypothesis 1.

There will be no significant difference between groups in age, height, weight, percent of body fat, VO_{2max}, or MVC in the static knee extension.

The data did support this hypothesis regarding age, percent of body fat, and MVC in static knee extension. However, there were differences between the races in height, weight, and VO_{2max}.

Specifically, African Americans and Caucasian Americans were significantly heavier and taller than their Asian American counterparts. Furthermore, the VO_{2max} of the Caucasian American group was significantly greater than that of the African Americans and Asian Americans.

Metheny (1939) and Ama et al. (1986) have documented that there is no significant difference between the African American and Caucasian American racial groups in overall height. However, Jones (1941) points out that there is a significant difference in height and weight between African Americans, Asian Americans and Caucasian Americans, with the Asian American group being the smaller in both height and weight. Thus, the findings of the current research are consistent with the past literature.

In regards to VO_{2max}, Wyndham et al. (1963) found no statistical difference in VO_{2max} between African Americans and Caucasian Americans. Conversely, Davies et al. (1972) and Davies et al. (1973) found that Africans have a lower VO_{2max} than their European counterparts. The findings of this research study are in concert with Davies' studies.

When subjects volunteered for the study, all subjects met the same inclusionary criteria, therefore, subjects were expected to be similar in subject characteristics. The ANOVA revealed that some significant differences did exist between the three racial groups, although, these differences are consistent with previous literature. More strict inclusionary criteria could have been utilized, but the external validity of the study would have been compromised due to generalizability of the study to subjects outside of such strict inclusionary criteria.

Hypothesis 2.

There will be no significant difference between groups in resting BP_{sys} or BP_{dia}.

The data did support this hypothesis regarding diastolic BP, but not systolic BP. The study revealed that prior to static and dynamic exercise, African Americans' and Caucasian Americans' systolic resting BP was significantly greater than that of Asian Americans.

An analysis of covariance (ANCOVA) was used to investigate if the independent variable weight contributed to this phenomenon. After accounting for the variable of weight, the ANCOVA revealed no significant differences between the racial groups in resting systolic BP prior to static exercise, while the differences observed prior to dynamic exercise were reduced, although not eliminated. Taken together, the study suggests that the differences in resting BP between the racial groups were primarily weight related. Differences in resting BP were also found between the genders, and those were entirely eliminated by covarying with weight. Previous research (Kotchen et al., 1974) has also found a positive correlation between weight and resting BP.

Static Exercise

Hypothesis 3.

African Americans will have significantly greater increases in BP_{sys} during static exercise than will Caucasian Americans or Asian Americans.

The data did not support this hypothesis. Though static exercise produced large, significant increases in systolic BP, there were no significant differences between racial groups in this response.

Hypothesis 4.

African Americans will have significantly greater increases in BP_{dia} during static exercise than will Caucasian Americans or Asian Americans.

The data did not support this hypothesis. Though static exercise produced large, significant increases in diastolic BP, there were no significant differences between racial groups in this response.

The findings of hypotheses 3 and 4 are important because African Americans are known to have a higher incidence of hypertension than Caucasian Americans and Asian Americans. It was postulated that a greater BP response during static exercise would be seen among the African Americans as an indication of a greater risk of developing future hypertension. However, this was not the case.

The pressure responses to static exercise observed among subjects in this study were consistent with previous studies on BP responses during static exercise. Static exercise increases both systolic and diastolic BP, and such pressure responses are generally related to the amount of muscle mass contracting, and the intensity (% MVC) of the contraction. In this study, isometric knee extension of one leg at 30% MVC increased BP_{sys} and BP_{dia} by 35 and 29 mmHg, respectively, to average values of 149 mmHg systolic and 103 mmHg diastolic.

Lind and McNicol (1967) found that the BP response during handgrip exercise increased as the force of static contraction increased from 20% to 30%, and then to 50% of MVC. Mitchell et al. (1980) used a constant percent of MVC (40%), and found that the BP response was greater as larger muscle groups were used (from a static contraction by two fingers to a handgrip, and to a single knee extension). In that study, BP increased from a resting value of 134 mmHg systolic and 83 mmHg diastolic to 204 mmHg systolic and 138 mmHg diastolic with knee extension. This is a greater increase than seen in the current study using 30% of MVC during knee extension. Bezucha et al. (1982) used exactly the same protocol for static exercise as in the current study, i.e. 3 minutes of single knee extension at 30% of MVC. They found that BP increased from a resting value of 136 mmHg systolic and 73 mmHg diastolic to 163 mmHg systolic and 101 mmHg diastolic. These increases of 27 mmHg systolic and 28 mmHg diastolic are very similar to those obtained in the current study (35 and 29 mmHg, respectively).

Dynamic Exercise

Hypothesis 5.

African Americans will have significantly greater increases in BP_{sys} during dynamic exercise than will Caucasian Americans or Asian Americans.

The data did not support this hypothesis. Though dynamic exercise produced large significant increases in systolic BP, there were no significant differences between racial groups in this response.

Hypothesis 6.

African Americans will have significantly greater increases in BP_{dia} during dynamic exercise than will Caucasian Americans or Asian Americans.

The data did not support this hypothesis. Again, dynamic exercise produced significant (although modest in magnitude) increases in diastolic BP, however, there were no significant differences between racial groups.

As with hypotheses 3 and 4, the findings of hypotheses 5 and 6 indicate that African Americans, as a group, are not more prone to exaggerated BP responses during exercise than are other racial groups.

The pressure responses to dynamic exercise observed among subjects in this study were consistent with previous studies on BP responses during dynamic exercise. Dynamic exercise significantly increases BP_{sys} while having only a modest effect on BP_{dia}. The BP_{sys} response is generally related to the relative amount of work (% of maximal aerobic capacity) exerted by the individual. In this study, cycling at 70% VO_2 reserve increased BP_{sys} and BP_{dia} by 51 and 8 mmHg, respectively, to average values of 162 mmHg and 80 mmHg.

Bezucha et al. (1982) had subjects perform 3 minute bouts of cycling exercise at increasing intensities. In that study, BP increased from 136 mmHg systolic and 73 mmHg diastolic at rest to 164 mmHg systolic and 76 mmHg diastolic at 38% of VO_{2max}, to 182 mmHg systolic and 80 mmHg diastolic at 58% VO_{2max}, and then to 194 mmHg systolic and 84 mmHg diastolic at 82% of VO_{2max}. The current study expressed intensity in %VO_2 reserve units. At the same numerical values, a given %VO_2 reserve is a slightly greater intensity than a workload expressed in %VO_{2max} units. Thus, the 70% VO_2 reserve used in the current study represents a relative workload that falls between the 58% and 82% of VO_{2max} in the Bezucha study. At those intensities, systolic BP increased by 46 to 58 mmHg, and diastolic BP increased by 7 to 11 mmHg. These increases are very similar to those obtained in the current study (51 and 8 mmHg, respectively).

Implications and Limitations of the Study's Findings

When African Americans exercise (static or dynamic) the mean BP (systolic or diastolic) responses to exercise were similar in relation to the other racial groups in this study, and consistent with previous literature (studying primarily Caucasian Americans). It was believed that African Americans would have significantly greater increases in BP response during static and dynamic exercise.

Such exaggerated BP responses have been correlated to later hypertension. Wilson and Meyer (1981) had 2,746 normotensive subjects perform a maximal treadmill test. They had defined an exaggerated response as achieving exercise BPs of at least 225 mmHg systolic and 90 mmHg diastolic. A total of 12.4% of the subjects exhibited such a response, and they developed a 2.3 times greater incidence of future hypertension than the remaining subjects. Davidoff et al. (1982) had 721 normotensive subjects perform cycling exercise at 70% of estimated maximal heart rate. Exaggerated BP response was defined as a systolic BP greater than 200 mmHg, or any increase in diastolic pressure. These criteria were met by 8.7% and 13.3% of the subjects, respectively, who had relative risks of developing future hypertension of 2.1 and 1.3, respectively. Jackson et al. (1983) had 114 normotensive subjects perform treadmill or cycling exercise at 90% of estimated maximal heart rate. Exaggerated BP response was defined as greater than 230 mmHg systolic and 110 mmHg diastolic, which was attained by 20.2% of the subjects. These subjects had a 3.4 relative risk of developing future hypertension. Chaney and Eyman (1988) evaluated the BP response to static as well as dynamic exercise in relation to future hypertension. However, rather than defining an exaggerated response and then determining relative risk, they simply reported the initial responses of those who later did or did not become hypertensive. One minute of maximal handgrip produced BPs of 180 mmHg systolic and 120 mmHg diastolic in the 16 subjects who later became hypertensive, and BPs of 160 mmHg systolic and 105 mmHg in 84 subjects who did not. Maximal treadmill exercise produced BPs of 190 mmHg systolic and 100 mmHg diastolic and 170 mmHg systolic and 90 mmHg diastolic, respectively, in the two groups.

From the three relative risk studies (Wilson and Meyer, 1981, Davidoff et al., 1982, and Jackson et al., 1983) it is seen that approximately 9-20% of subjects have an exaggerated BP response to dynamic exercise, depending on the intensity of the exercise and the definition of exaggerated response. The intensity in the current study, of 70% of VO_2 reserve, would fall between that of the Davidoff and Jackson studies. Using a definition of exceeding a systolic BP of 200 mmHg or diastolic BP of 100 mmHg, 10% of the African Americans (2 males and 1 female) in the current study exhibited an exaggerated BP response, while no members of the other racial groups did. This provides some support for the theory that exercise testing may help in evaluating the increased risk for hypertension in the African American population. However, the sample size in the current study is much too small to draw any conclusions regarding individual differences. The principal finding of this study is that, as a *group*, African Americans did not exhibit greater BP responses to exercise than did Caucasian Americans or Asian Americans.

Although the study had enough subjects to ascertain statistically significant group differences, had they existed, the study's subject size would have to be increased in order to increase the generalizability. Secondly, the subjects in the study were asked to decide their racial group based upon the racial identity of their grandparents. The racial identity of the subjects' grandparents was based upon the subjective judgement of the subjects. It was understood that the intermixing of major racial groups had occurred. Within the Asian American group, Filipinos constituted 12 of the 15 males and 9 of the 15 females. Thus, the Asian American group was heavily represented by a subgroup with significant Caucasian (Spanish) admixture. It must be emphasized that the three racial groups in this study are not genetically distinct, but represent social and biocultural differentiation. Reed (1968), Nei and Roychoudhury (1974), and Bouchard (1988) point out that the majority of genetic variations are shared by all races. Additionally, the results can be generalized to subjects from an urban environment.

Suggested Directions for Future Research

There are many important issues in BP response in different racial groups resulting from this study. One logical extension of this study would be to analyze the effects of environmental factors on the different racial groups (i.e. socio-economic-status of individual, educational background of parents and subjects). Another extension of the study would be to analyze the acute BP response in individuals who are normotensive, but are at risk of developing hypertension based on obesity, physical inactivity, age, and family history, such as having parents who are hypertensive. Since it is recognized that racial groups are extremely intermixed, further investigation into the effects of dynamic or static exercise could focus on specific subgroups. This is one of the first studies to evaluate BP responses to exercise among Asian Americans, and additional research with that group is needed. Since all the subjects were between the ages of 18 to 40, future research could examine older subjects due to the fact that as individuals get older, their BPs generally increase (Horan and Lenfant, 1990).

Finally, longitudinal studies of BP responses to exercise and the incidence of future hypertension are warranted. While no differences were seen in group responses, more African Americans in the current study exhibited individually exaggerated BP responses to dynamic exercise than did members of the other racial groups. A large number (several hundred) of subjects from each racial group could be tested for their BP response to cycling at 70% of heart rate reserve, and followed for 5 to 10 years to determine their respective incidence of hypertension.

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Appendix A

Exercise Test Screening Questionnaire

Name__________________ Sex______ Date_____

I. **Symptoms of Heart Disease**

1. Have you ever had a heart attack or stroke, or been told by a physician that you have heart problems or pulmonary disease?

2. Has a physician ever said you have a heart murmur?

3. Do you ever have pain or discomfort in your chest or surrounding areas?

4. Do you ever have heart palpitations, or an unusual period of rapid heart rates?

5. Do you ever have experience pain in your legs?

6. Do your ankles ever become swollen?

7. Do you ever feel faint or dizzy?

8. Do you ever feel unusually fatigued or find it difficult to breathe with usual activities?

9. Do you find it difficult to breathe when you are lying down or sleeping?

II. **Risk Factors for Heart Disease**

1. Do you have high blood pressure (greater than or equal to 140/90 mmHg) or take blood pressure medication?

2. Do you have a high cholesterol level?

a. total cholesterol greater than 200

b. HDL less than 35

c. "negative risk factor" HDL greater than 60

3. Do you currently smoke?

4. Have any of your parents, brothers, or sisters had a heart attack or sudden death prior to the age of 55 (male relatives) or 65 (female relatives).

5. Do you have diabetes (Type I or Type II)? If so, how old were you when it was first diagnosed?

6. How old are you?

a. males greater than 45

b. females greater than 55

7. Do you have a physically active job or do you regularly participate in exercise or physically active recreation?

III. **Other Problems**

1. Do you have any bone or joint problems such as arthritis or a past injury that might get worse with exercise?

2. Do you have a cold or flu, or any other infections?

3. Do you have any other problems that might make it difficult for you to do strenuous exercise?

Appendix B

Blood Pressure Study Participant Racial Background Questionnaire

Name___________________ Sex ______ Date______

Race ______

_____ African American

- ______ West or Central African
- ______ East African (Ethiopian, Kenyan)
- ______ Other, please specify ___________

_____ Asian American

- ______ Chinese
- ______ Filipino
- ______ Japanese
- ______ Korean
- ______ Southeast Asian (Vietnamese, Laotian, etc.)
- ______ Other, please specify ___________

____ Caucasian American

______ Arabic

______ European descent

______ Other, please specify ___________

Were all four of your natural grandparents from the same racial group (African American, Asian American, or Caucasian American)?

______ Yes ______No

Appendix C

INFORMED CONSENT DOCUMENT

Old Dominion University

Darden College of Education

Wellness Institute and Research Center

Department of Exercise Science, Physical Education and Recreation

TITLE OF RESEARCH: ACUTE BLOOD PRESSURE RESPONSES TO STATIC AND DYNAMIC EXERCISE: RACIAL DIFFERENCES

INVESTIGATORS: Reuben L. Wright, MS, MMAS

David P. Swain, PhD

DESCRIPTION OF RESEARCH:

The purpose of this investigation is to examine the differences in acute blood pressure (BP) responses in different racial groups during static and dynamic exercise. I,__________________, have agreed to participate as a subject in this study. I understand that I will be participating in a study involving strenuous exercise in a laboratory while measures of my heart rate, BP and oxygen consumption are made using non-invasive procedures.

EXCLUSIONARY CRITERIA:

I have completed a screening questionnaire. To the best of my knowledge, I do not have heart disease, pulmonary disease, or diabetes, and I am not aware of any signs or symptoms of heart or pulmonary disease that would prohibit my participation in this study. Nor do I have more than one risk factor for coronary heart disease as defined by the American College of Sports Medicine (see questionnaire).

RISK AND BENEFITS:

The testing procedures that I will undergo may result in inappropriate response in my heart rate, heart rhythm or BP, or even a heart attack or stroke. There also exists the possibility that I may be subject to risks that have not yet been defined. I also understand, however, that these risks are acceptable under American College of Sports Medicine guidelines and that reasonable precautions will be taken to ensure my safety. I understand that the main benefit to accrue from this study is the attainment of information relative to my aerobic capacity. I also understand that pertinent information relative to my responses to this study will be discussed with me by the investigator of this study.

COST AND PAYMENT:

I understand that my efforts in this study are voluntary, and I will not receive remuneration to help defray incidental expenses associated with my participation.

NEW INFORMATION:

I understand that any new information obtained during the course of this research that is directly related to my willingness to continue to participate in this study will be provided to me.

CONFIDENTIALITY:

I understand that any information obtained about me from this research, including questionnaires and laboratory findings will be kept strictly confidential. I also understand that the data derived from this study could be used in reports, presentations, and publications, but that I will not be individually identified unless my consent is granted. I do understand, however, that my records may be subpoenaed by court order or may be inspected by federal regulatory authorities.

WITHDRAWAL PRIVILEGE:

I understand that I am free to refuse to participate in this study or withdraw at any time and that my decision to withdraw will not adversely affect my care at this institution or cause a loss of benefit to which I might otherwise be entitled. If I do decide to withdraw, I agree to undergo all trial evaluations necessary for my safety and well-being as determined by the investigator. I also realize that the investigator reserves the right to withdraw my participation if he observes any contraindication to my continued participation.

COMPENSATION FOR ILLNESS AND INJURY:

I understand that in the unlikely event of injury or illness resulting from the research protocol, no monetary compensation will be made, but first aid will be available to me from the investigator. I am advised that if any injury should result from my participation in this research project, Old Dominion University (ODU) does not provide insurance coverage, free medical care or any other compensation for such injury. In the event that I have suffered injury as a result of my participation in this research project, I may contact Reuben L. Wright at (757) 683-3454 or Dr. David Swain (683-6028) at ODU, who will be glad to review the matter with me, and Dr V. J. Derlega, Chairman of the Institutional Review Board, Old Dominion University, at 683-3118.

VOLUNTARY CONSENT:

I certify that I have read the preceding sections of this document, or it has been read to me; that I understand its contents; and that any questions I have pertaining to the research have been answered. If I have any concerns, I can express them to the Darden College of Education Faculty Governance Research Scholarship Committee (Dr. Robert Case, 683-4754, HPE BLDG, room 133). A copy of this informed consent has been given to me.

My signature below indicates that I have freely agreed to participate in this investigation.

____________________ ____________________

Subject's Signature Date

____________________ ____________________

Witness Signature Date

INVESTIGATOR'S STATEMENT:

I certify that I have explained to the subject, whose signature appears above, the nature and purpose of, and the potential benefits and possible risks associated with participation in this study. I have answered any questions that have been raised by the subject and have encouraged him/her to ask additional questions at any time which arise during the course of this study.

________________________ ________________

Investigator's Signature Date

Appendix D

DATA SHEET

ACUTE BP RESPONSES TO STATIC AND DYNAMIC EXERCISE:

RACIAL DIFFERENCES

Name__________________ Sex_______ Date_______

Age_______ ID#_______ Race_______

Anthropometric:

HT_______cm WT_______kg SKFD: C/T _______ _______ _______

A/SI _______ _______ _______

TH _______ _______ _______

Total _______ %FAT _______

Static Exercise - MVC

Resting BP_______ MVC_______ 30% MVC_______

		BP	HR
Min	1	_______	_______
	2	_______	_______
	3	_______	_______

Name__________________ Sex_______ Date______

Age_______ ID#_______ Race_______

Dynamic Exercise - Max Test

Resting BP_______ HR _______ At Max Time on 2900_______

Max BP_______ HR_______

Stage	Time(min)	BP	HR	Stage	Time(min)	BP	HR
15	1	___	___	285	19	___	___
30	2	___	___	300	20	___	___
45	3	___	___	315	21	___	___
60	4	___	___	330	22	___	___
75	5	___	___	345	23	___	___
90	6	___	___	360	24	___	___
105	7	___	___	375	25	___	___
120	8	___	___	390	26	___	___
135	9	___	___	405	27	___	___
150	10	___	___	420	28	___	___
165	11	___	___	435	29	___	___
180	12	___	___	450	30	___	___
195	13	___	___	465	31	___	___
240	16	___	___				
255	17	___	___				
270	18	___	___				

Name____________________ Sex______ Date______

Age______ ID#______ Race_______

Dynamic Exercise - Submax Test

Resting BP______ HR______

70% VO_2 Reserve_____ Power______

Stage	Time (min)	BP	HR
	1 (warm up)	_____	_____
	2	_____	_____
	3	_____	_____
	4	_____	_____
	5	_____	_____
	6	_____	_____

Appendix E

Raw Data

African American Males

Subj	Age (yr)	Ht (cm)	Wt (kg)	% Fat	MVC (N)	VO_{2max} (L/min)
1	21	183	89	8	390	1.8
2	20	175	69	4	636	2.91
3	21	175	74	7	264	1.8
4	22	188	86	11	282	1.8
5	20	160	70	15	363	1.3
6	21	196	139	24	636	2.6
7	23	173	115	24	717	2.9
8	23	180	82	3	322	3.04
9	23	173	78	14.5	345	2.03
10	22	180	68	7	376	2.2
11	22	168	73	10.5	457	2.28
12	21	175	79	8.5	520	2.7
13	21	173	64	7.5	444	1.65
14	22	173	70	7.5	336	2.06
15	23	160	82	14	426	2.05

cont'd

African American Male cont'd

	Static Exercise					Dynamic Exercise					
	SYS_{rst}	DIA_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}	SYS_{rst}	DIA_{rst}	HR_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}
1	94	68	139	94	90	118	73	75	172	83	118
2	128	74	168	102	106	117	74	60	203	105	176
3	128	78	147	98	129	123	68	67	198	84	140
4	129	77	167	99	82	128	78	64	158	83	120
5	124	80	157	97	97	125	76	76	185	74	133
6	138	73	117	121	120	138	78	85	178	79	149
7	131	66	185	112	100	137	75	70	185	75	142
8	125	82	156	105	95	127	83	65	196	89	133
9	126	88	157	132	100	125	88	67	187	110	124
10	122	77	153	106	91	122	69	68	186	63	139
11	127	80	175	130	102	120	80	80	187	93	153
12	121	70	172	122	95	116	61	58	195	89	152
13	111	56	135	96	97	113	67	84	161	68	145
14	116	61	143	89	75	100	70	80	180	82	146
15	136	79	157	96	105	130	69	75	173	80	140

cont'd

Raw Data

African American Females

Subj	Age (yr)	Ht (cm)	Wt (kg)	% Fat	MVC (N)	VO_{2max} (L/min)
1	21	168	67	16	381	1.9
2	21	160	57	12	340	1.62
3	21	180	75	23.5	488	1.8
4	34	175	69	23	291	1.1
5	23	165	48	15	300	1.34
6	33	163	61	14	578	2.08
7	22	175	57	21	242	1.0
8	21	163	68	35	296	1.48
9	26	175	57	28	372	1.0
10	33	160	70	36	291	1.44
11	31	155	61	23	372	1.73
12	19	160	58	23	412	1.19
13	34	132	57	27	372	0.97
14	36	173	73	21	573	1.98
15	34	168	59	27	134	1.33

cont'd

African American Females cont'd

	Static Exercise					Dynamic Exercise					
	SYS_{rst}	DIA_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}	SYS_{rst}	DIA_{rst}	HR_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}
1	109	69	132	86	93	100	65	82	152	63	160
2	128	86	150	119	113	127	84	83	178	107	179
3	114	80	152	116	119	101	68	78	153	86	159
4	124	63	140	80	86	113	69	70	168	75	156
5	112	80	139	96	113	109	71	80	169	89	185
6	116	76	167	135	167	109	78	76	164	68	149
7	112	72	132	91	110	119	79	86	139	68	118
8	94	69	140	85	129	103	60	86	144	61	165
9	115	78	147	103	122	99	60	74	141	69	137
10	116	75	137	92	89	110	74	74	146	82	134
11	94	72	148	99	132	95	58	86	169	97	187
12	97	65	146	99	117	102	72	74	158	84	172
13	108	72	159	99	139	112	74	74	136	76	130
14	122	86	165	135	89	121	86	57	186	94	136
15	105	68	132	93	94	102	62	66	142	78	157

Raw Data

Asian American Males

Subj	Age (yr)	Ht (cm)	Wt (kg)	% Fat	MVC (N)	VO_{2max} (L/min)
1	23	163	62	16	305	1.67
2	21	165	68	18	237	1.88
3	24	170	75	6	627	2.06
4	29	170	74	24	354	2.56
5	35	165	77	23	627	2.0
6	19	165	55	3	470	2.43
7	23	170	67	16	390	1.68
8	31	165	64	14	497	2.31
9	21	173	73	14	641	2.5
10	18	168	68	12.5	632	2.43
11	30	170	79	20.5	403	1.31
12	39	170	75	23	488	1.36
13	40	163	73	16.5	488	2.21
14	23	175	63	8	349	2.36
15	37	170	55	14.5	314	1.5

cont'd

Asian American Males cont'd

	Static Exercise					Dynamic Exercise					
	SYS_{rst}	DIA_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}	SYS_{rst}	DIA_{rst}	HR_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}
1	124	82	142	89	89	120	72	84	195	85	140
2	110	77	140	89	72	116	68	70	178	80	156
3	117	70	173	90	96	116	68	69	170	77	130
4	120	76	143	90	95	113	71	71	186	74	156
5	122	72	177	138	114	117	75	66	164	70	128
6	114	72	160	121	96	113	70	78	179	79	172
7	106	63	131	82	101	102	64	70	159	71	156
8	117	76	136	95	89	103	71	65	182	83	127
9	112	76	173	108	138	118	64	79	183	77	166
10	112	62	144	102	111	118	62	66	144	76	112
11	110	75	136	104	94	106	70	72	157	84	126
12	118	84	146	110	118	116	80	84	146	86	138
13	110	74	150	110	120	103	67	73	156	84	165
14	110	78	138	95	96	115	74	64	192	79	140
15	115	75	133	91	81	97	65	70	164	66	131

cont'd

Raw Data

Asian American Females

Subj	Age (yr)	Ht (cm)	Wt (kg)	% Fat	MVC (N)	VO_{2max} (L/min)
1	24	165	64	22.5	444	1.3
2	23	150	57	23.5	273	1.5
3	23	150	47	21	175	0.87
4	18	155	57	26	470	1.95
5	27	155	52	25	372	1.43
6	20	157	50	24	273	1.19
7	22	165	57	21.5	296	1.02
8	33	163	70	31	282	1.23
9	38	163	55	27.5	327	1.11
10	23	165	50	24.5	340	1.0
11	30	173	59	24.5	367	1.18
12	22	160	50	22	224	1.2
13	35	157	50	25	206	0.84
14	37	160	56	25	327	1.11
15	27	160	56	27	587	1.21

cont'd

Asian American Females cont'd

	Static Exercise					Dynamic Exercise					
	SYS_{rst}	DIA_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}	SYS_{rst}	DIA_{rst}	HR_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}
1	106	71	131	100	97	105	75	64	140	72	132
2	103	71	136	110	91	108	66	67	142	85	157
3	102	62	126	70	76	100	64	60	136	70	124
4	102	69	143	118	116	97	65	72	137	89	180
5	106	72	136	96	107	109	72	76	158	78	155
6	92	70	136	94	99	99	62	72	136	71	160
7	110	75	154	118	92	110	72	70	152	80	135
8	107	67	129	89	89	98	78	80	139	70	134
9	96	70	139	99	103	92	65	78	174	87	168
10	98	65	132	98	106	90	67	84	137	70	144
11	102	82	150	117	95	106	72	80	146	86	165
12	112	77	130	87	90	108	78	74	144	82	134
13	96	62	133	80	119	76	52	80	107	61	149
14	95	72	145	96	105	99	63	78	128	71	134
15	99	72	151	103	109	100	62	72	137	75	175

cont'd

Raw Data

Caucasian American Males

Subj	Age (yr)	Ht (cm)	Wt (kg)	%Fat	MVC (N)	VO_{2max} (L/min)
1	20	170	81	24.5	255	2.41
2	21	173	80	11	520	2.42
3	19	185	105	27	726	3.00
4	21	180	79	11	430	2.84
5	19	173	86	23.5	448	2.13
6	18	183	90	29.5	412	2.83
7	32	173	67	8.5	582	3.00
8	34	183	85	15.5	869	3.6
9	28	180	81	18	694	1.93
10	26	180	80	9	314	3.2
11	40	175	80	18	775	2.73
12	30	180	77	18	394	2.02
13	20	185	78	7	842	2.8
14	35	183	88	13.5	578	3.12
15	27	183	89	20	605	3.45

cont'd

Caucasian American Males cont'd

	Static Exercise					Dynamic Exercise					
	SYS_{rst}	DIA_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}	SYS_{rst}	DIA_{rst}	HR_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}
1	128	78	158	97	98	112	64	70	164	75	133
2	126	89	146	115	107	100	68	78	149	71	129
3	126	69	171	107	99	113	73	69	176	79	150
4	126	65	149	92	105	128	81	75	152	87	153
5	118	77	177	100	95	116	65	73	170	78	133
6	123	76	149	91	95	121	75	80	161	77	177
7	121	72	137	103	93	119	84	60	185	77	156
8	115	74	161	123	108	116	73	64	160	69	140
9	124	80	195	131	108	126	76	78	160	84	140
10	113	59	135	96	84	101	61	54	154	67	128
11	119	75	186	123	106	117	76	64	174	61	140
12	116	72	143	96	72	107	65	56	191	82	139
13	139	85	196	120	129	136	86	65	168	84	133
14	124	73	147	96	89	128	87	53	155	91	130
15	108	81	173	106	103	119	82	56	163	68	137

cont'd

Raw Data

Caucasian American Females

Subj	Age (yr)	Ht (cm)	Wt	% Fat (kg)	MVC (N)	VO_{2max} (L/min)
1	19	152	63	23	314	1.9
2	24	165	58	16.5	246	2.13
3	20	160	51	11	390	1.7
4	20	160	56	21	569	2.4
5	19	165	74	28.5	385	2.89
6	23	165	55	19.5	237	1.61
7	40	155	47	18	390	1.22
8	23	165	70	23	439	2.4
9	22	157	85	36	345	1.54
10	40	152	55	26	381	1.51
11	24	165	64	27	421	2.18
12	24	155	50	24	264	1.82
13	22	163	52	23	255	1.59
14	29	168	56	26	246	1.88
15	23	173	68	21	623	2.4

cont'd

Caucasian American Females cont'd

	Static Exercise					Dynamic Exercise					
	SYS_{rst}	DIA_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}	SYS_{rst}	DIA_{rst}	HR_{rst}	SYS_{ex}	DIA_{ex}	HR_{ex}
1	114	68	159	107	104	115	70	70	163	71	163
2	123	69	140	85	92	118	70	70	186	81	168
3	114	83	165	129	124	93	63	63	147	90	171
4	110	74	143	103	99	115	64	48	148	84	149
5	113	72	122	89	102	109	64	80	157	79	171
6	115	68	126	79	80	115	65	67	163	83	160
7	116	70	142	113	123	117	86	67	168	96	159
8	114	76	140	98	95	101	65	75	167	76	168
9	104	63	137	116	139	105	65	80	148	78	165
10	102	64	137	99	96	89	60	60	149	69	164
11	122	84	151	106	110	110	82	65	136	84	88
12	97	64	125	80	117	100	67	78	146	71	160
13	108	68	115	84	107	97	65	86	141	79	148
14	115	71	131	92	84	109	67	58	172	84	166
15	103	68	147	107	99	95	59	54	144	62	157

VITA

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EDUCATION:

Old Dominion University, Norfolk VA
Urban Services - Urban Education Ph.D. Candidate
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Command and General Staff College, Fort Leavenworth, KS
Masters of Military Arts and Science (American History)
(MMAS) - 1992

Prairie View A & M University, Prairie View, TX
Physical Education (Exercise Science) M.S. - 1985

University of Houston, Houston TX
Physical/Health Education B.S. - 1977

PROFESSIONAL CERTIFICATIONS:

1977 - Pres Teaching Certificate (TX)
1993 - Pres Licensed FAA Pilot (Private Single Engine)
1997 - Pres CPR Instructor Certified

EDUCATIONAL EXPERIENCE:

8/94 - 9/96 Graduate Assistant, Student Health Services, Health Education, Old Dominion University.

8/94 - Pres Graduate Assistant, Wellness Institute and Research Center, Old Dominion University.

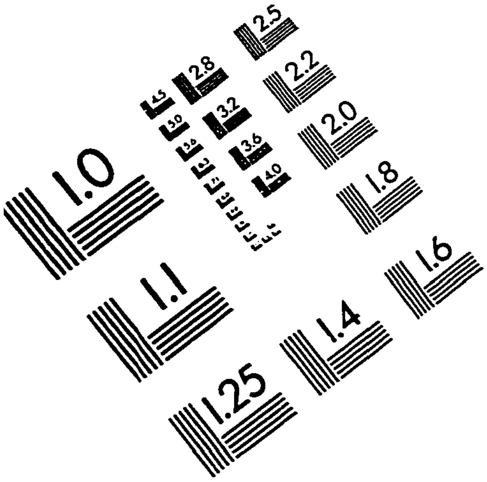
1/96 - Pres Adjunct Assistant Professor, Old Dominion University.

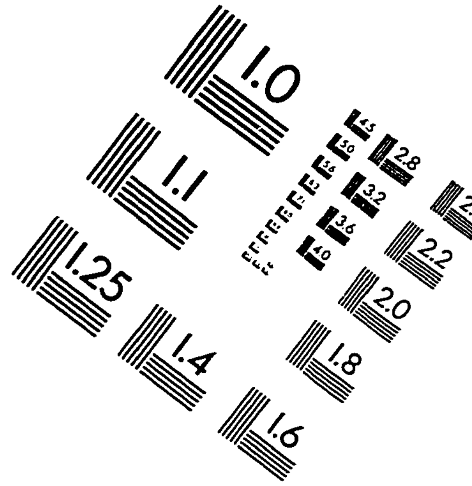
9/96 - 6/97 Administrative Assistant to the Office of the President, Old Dominion University.

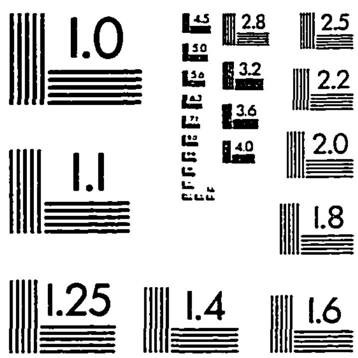
MILITARY EXPERIENCE:

Retired Lieutenant Commander, U.S. Navy, August, 1994.

IMAGE EVALUATION
TEST TARGET (QA-3)







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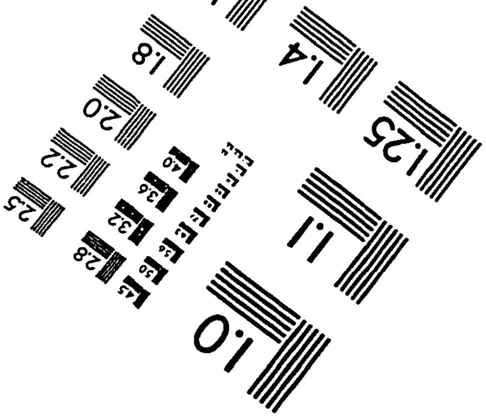

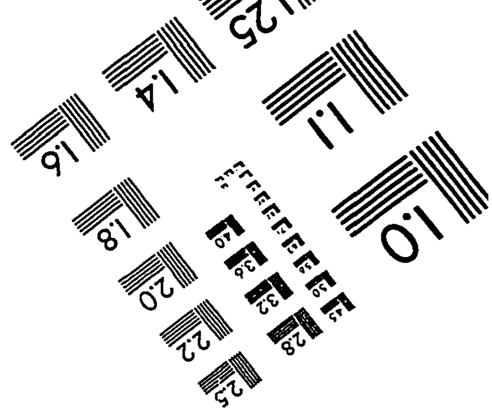

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