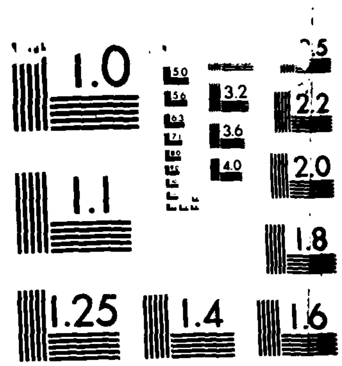
AD-A163 998 AEROBIC CAPACITY AND CORONARY RISK FACTORS IN A MIDDLE-AGED ARMY POPULATION(U) ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MA J F PATTON ET AL 1/1

UNCLASSIFIED JAN 86 USRIEM-M-10/86 F/G 6/14 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
3.2
3.6
4.0

(1)

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER M10/86	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Aerobic Capacity and Coronary Risk Factors in a Middle-Aged Army Population	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John F. Patton, Ph.D., James A. Vogel, Ph.D., COL Julius L. Bedynek, Jr., M.D.,Ph.D., MC, MAJ Donald Alexander, M.D.,MC, MAJ Ronald Albright, M.D.,MC	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Research Institute of Environmental Medicine, Natick, MA 01760	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Same as 9. above	12. REPORT DATE January 1986
	13. NUMBER OF PAGES 19
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aerobic capacity, coronary risk factors, treadmill testing, peak oxygen uptake.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to assess the relationship between coronary risk factors (CRF) and aerobic capacity measured by the direct determination of oxygen uptake during maximal exercise testing. Subjects comprised 295 male Army personnel (40-53 yrs of age) who underwent multiple serial screening procedures to include a medical and physical evaluation, calculation of a Framingham risk factor index (RI) and a graded treadmill exercise test (GXT) with the determination of peak oxygen uptake ($p\dot{V}O_2$). CRF included resting systolic (SBP) and diastolic (DBP) blood pressures, total cholesterol (TC), HDL-C, triglycer-

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) ides (TRIG), fasting blood sugar (FBS), smoking history, resting ECG, and percent body fat (% BF). The mean $\pm$ SD for pVO_2 and % BF was 38.1 $\pm$ 6.2 ml/kg.min and 26.1 $\pm$ 4.7%. An inverse relationship was found between CRF and level of aerobic capacity. SBP, DBP, FBS, and TRIG were significantly lower and HDL-C significantly higher in the most aerobically fit subjects ($pVO_2 > 45.0$ ml/kg·min) compared to those in the least fit group (pVO_2 30 ml/kg·min). Thus, the more fit group had a lower RI(p .01) than the less fit subjects (2.5 $\pm$ 0.2% vs. 4.7 $\pm$ 0.4%). These results, although cross-sectional, imply that a high level of aerobic capacity is associated with lower coronary risk factors.

Aerobic Capacity and Coronary Risk Factors in a Middle-Aged Army Population

by

John F. Patton, Ph.D., James A. Vogel, Ph.D.,

COL Julius L. Bedynek, Jr., M.D., Ph.D., MC,

MAJ Donald Alexander, M.D., MC, MAJ Ronald Albright, M.D., MC

US Army Research Institute of Environmental Medicine, Natick, MA.,

Office of the Surgeon General, Pentagon, Washington, DC.

Dwight D. Eisenhower Army Medical Center, Fort Gordon, GA.

Martin Army Community Hospital, Fort Benning, GA.

Send Correspondence to:

Dr. John F. Patton

US Army Research Institute of

Environmental Medicine

Natick, MA 01760-5007

HUMAN RESEARCH

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

ABSTRACT

The purpose of this study was to assess the relationship between coronary risk factors (CRF) and aerobic capacity measured by the direct determination of oxygen uptake during maximal exercise testing. Subjects comprised 295 male Army personnel (40-53 yrs of age) who underwent multiple serial screening procedures to include a medical and physical evaluation, calculation of a Framingham risk factor index (RI) and a graded treadmill exercise test (GXT) with the determination of peak oxygen uptake ($p\dot{V}O_2$). CRF included resting systolic (SBP) and diastolic (DBP) blood pressures, total cholesterol (TC), HDL-C, triglycerides (TRIG), fasting blood sugar (FBS), smoking history, resting ECG, and percent body fat (% BF). The mean $\pm$ SD for $p\dot{V}O_2$ and % BF was 38.1 $\pm$ 6.2 ml/kg·min and 26.1 $\pm$ 4.7%. An inverse relationship was found between CRF and level of aerobic capacity. SBP, DBP, FBS, and TRIG were significantly lower and HDL-C significantly higher in the most aerobically fit subjects ($p\dot{V}O_2 > 45.0$ ml/kg·min) compared to those in the least fit group ($p\dot{V}O_2 < 30$ ml/kg·min). Thus, the more fit group had a lower RI ($p < .01$) than the less fit subjects (2.5 $\pm$ 0.2% vs. 4.7 $\pm$ 0.4%). These results, although cross-sectional, imply that a high level of aerobic capacity is associated with lower coronary risk factors.

Short Title: Aerobic Capacity and Coronary Risk Factors

Index Terms: Aerobic capacity, coronary risk factors, treadmill testing, peak oxygen uptake.

Introduction

The age-adjusted cardiovascular mortality rate has fallen considerably in the United States over the past 20-30 years. One of the primary reasons for this decline has been the identification and modification of factors which place an individual at an increased risk for the development of coronary heart disease.[1] Such modifications have included dietary changes, cessation of smoking, hypertension control, and increased physical activity. The role of physical activity in the development of premature coronary heart disease and in modifying coronary risk factors has been the subject of considerable research over the past few years.[2-3]

The determination of maximal oxygen uptake provides the most objective index of an individual's physical fitness or aerobic capacity.[4-5] To avoid the disadvantages of directly measuring oxygen uptake (equipment cost, personnel time, etc) attempts have been made to predict this variable; the most widely used method is to estimate it from maximal exercise time.[6] Studies have shown, however, that maximal oxygen uptake can only be grossly estimated from maximal treadmill time using either the Bruce or Balke protocols.[7]

In cross-sectional studies reporting on the relationship between physical fitness and coronary risk factors, treadmill time[8-9] and submaximal heart rate[10] have been used to predict aerobic capacity and to categorize individuals into various cardiorespiratory fitness levels. The present study provides further cross-sectional data on the relationship between aerobic capacity and coronary risk factors where a direct determination of oxygen uptake and, therefore, an objective measure of aerobic capacity was used during maximal treadmill testing.

Methods

Subjects participating in this study were 295 male personnel aged 40 and over (age range 40-53) who were randomly selected from approximately 600 individuals assigned to a US Army post. Subjects volunteered to participate and informed consent was obtained. The sample consisted of 173 enlisted and 122 officer personnel who represented a typical cross-section of job assignments, i.e. medical, administrative, tactical, unit commanders, etc. common to any large Army installation.

The data on all subjects were collected within a three week period. During the first week each subject completed a cardiovascular history and underwent a physical examination. Any of the following conditions found during either the history or the exam resulted in a positive or abnormal rating: angina pectoris or suspicious chest discomfort, dyspnea at rest, syncope, precordial palpitation, prior diagnosis of hypertension or treatment of hypertension, history of myocardial infarction, significant cardiovascular finding (e.g. pathologic murmur or heart sound, cardiomegaly, etc) and any other clinical cardiovascular finding which was significant in the judgment of the examiner.

The following coronary risk factors as identified in the Framingham Heart Study[11] were assessed: age, blood pressure, smoking history, carbohydrate tolerance, resting ECG and total serum cholesterol. These factors were then used to calculate a risk factor index for each subject as described by Kannel et al[12]. A standard 12-lead scalar resting ECG was obtained using disposable skin electrodes. Blood pressure was taken in a quiet place with the subject relaxed and sitting comfortably. Subjects were grouped as smokers ($\geq$ 10 cigarettes/day) or nonsmokers. No attempt was made to record the length of time since the start of smoking or whether nonsmokers had ever smoked. A 10 ml blood sample was taken from the antecubital vein at least 12 hours after the last meal. Total cholesterol (TC) and fasting blood sugar (FBS) as well as triglycerides (TRIG) and HDL-cholesterol (HDL-C) were analyzed by standard automated laboratory procedures.

During the next two weeks, all subjects underwent a physician-supervised, multistage, symptom-limited exercise tolerance test using the US Air Force School of Aerospace Medicine (USAFSAM) treadmill protocol.[13] This is a modified Balke procedure where the treadmill is set at a fixed speed of 90 m/min (3.3 mph) at 0% grade. With the speed kept constant, the grade is raised 5% every 3 min without interruption until the subject is unable to continue due to exhaustion or until symptoms occur. The American Heart Association standards[14] were followed during performance of the test. To determine aerobic capacity, oxygen uptake was measured at each level of exercise and the highest value achieved at the time of exhaustion was taken as peak oxygen uptake ($p\dot{V}O_2$). This term is used to distinguish it from maximal oxygen uptake which implies a plateauing in $\dot{V}O_2$ with increased exercise intensity. In agreement with Taylor et al[15], we found that plateauing of $\dot{V}O_2$ seldom occurs with continuous treadmill protocols.

During the third minute at each stage of exercise, expired gas samples were collected through a mouthpiece attached to a Koegel low-resistance breathing valve into Douglas bags. An aliquot of expired air was analyzed for O_2 and CO_2 by means of an Applied Electrochemistry S-3A analyzer and a Beckman LB-2 analyzer, respectively. Expired air volumes were measured with a Collins chain-compensated tissot gasometer. The following parameters were derived from the gas exchange data: minute ventilation ($\dot{V}_E$), oxygen uptake ($\dot{V}O_2$) and the respiratory exchange ratio (RER).

Body weight (kg) and height (cm) were measured and skinfold thickness (mm) determined at the subscapular, triceps, biceps, and suprailiac sites using Harpenden calipers. Age-adjusted regression equations were used to estimate percent body fat.[16]

Of the 295 subjects initially evaluated, 25 had an abnormal graded exercise test while an additional 9 did not achieve a sufficient exercise intensity to elicit a $p\dot{V}O_2$. These individuals, therefore, were not included in the data analysis. Subjects were grouped based on their $p\dot{V}O_2$ into five levels of aerobic capacity: < 30; 30-34, 35-39; 40-44; and $\geq$ 45 ml/kg•min. A one-way analysis of variance (ANOVA) was used to determine significant differences among levels of aerobic capacity and the risk factors. The multicomparison test, Tukey's highly significant difference (HSD), was employed to establish statistical significance of mean differences. The mean square of the ANOVA was corrected for the differences in sample size among levels of $p\dot{V}O_2$ in order to calculate the t-statistic using Tukey's HSD.

Results

The descriptive data for age, anthropometric measures, peak physiological responses to exercise and coronary risk factors are presented in Table 1. The mean $p\dot{V}O_2$ was 38.1 $\pm$ 6.2 ml/kg•min (range 25.3 to 61.1 ml/kg•min).

The prevalence of coronary risk factors is presented in Table 2. The data show 64% of the individuals with body fat contents greater than 25%, 24% had blood pressures greater than 140/90 mmHg, 61.8% had blood cholesterol levels above 200 mg/dl, and 50% of the sample had a positive smoking history.

These data resulted in 18% of the subjects acheiving a Framingham risk factor index equal to or greater than 5%. Abnormal graded exercise tests were found in 8.8% of the sample. These were divided into three categories as follows: $\geq$ 1.0 < 2.0 mm ST segment depression (72%); $\geq$ 2.0 mm ST segment depression (16%); ventricular ectopy (12%).

The data comparing anthropometric, physiological, and risk factor variables among the five ranges in $p\dot{V}O_2$ are shown in Tables 3 and 4. Significant differences in respect to only the highest $p\dot{V}O_2$ range (> 45 ml/kg•min) are indicated in both tables. There were no differences in age across the $p\dot{V}O_2$ levels (Table 3). Body weight and % body fat were inversely related to the level of aerobic capacity. No differences were found in peak HR or peak RER among groups suggesting that subjects in each of the $p\dot{V}O_2$ ranges achieved similar levels of exertion during the exercise test. A significant positive relationship was found between $p\dot{V}_E$ and $p\dot{V}O_2$ range; 104 1/min in the lowest $p\dot{V}O_2$ group compared to 140 1/min in the highest $p\dot{V}O_2$ group. Treadmill time was also significantly greater with each higher level of $p\dot{V}O_2$.

In Table 4 a direct inverse relationship was seen among levels of aerobic capacity and each of the CRF. However, the relationship did not reach levels of significance for all factors. Over 70% of the subjects in the lower $p\dot{V}O_2$ groups had a positive smoking history whereas only 20-30% of those in the higher aerobic ranges were smokers ($p<.01$). Total blood cholesterol was 17 mg/dl higher in the lowest $p\dot{V}O_2$ group compared to the highest (220 vs 203 mg/dl) but this difference was not statistically significant. HDL-C levels were 10mg % lower in individuals with a $p\dot{V}O_2$ less than 35 ml/kg•min compared to those with a value greater than 45ml/kg•min ($p<.05$). These data resulted in a TC/HDL-C ratio of 6.1 for the lowest $p\dot{V}O_2$ group compared to a ratio of 4.6 for the highest $p\dot{V}O_2$ group (P <.05). Plasma triglyceride levels also showed progressively lower mean values with higher levels of aerobic capacity but did not reach levels of significance. Both systolic and diastolic blood pressures were approximately 10 mmHg higher in the < 30 ml/kg·min group compared to the > 45 ml/kg·min group and showed a progressive lowering across groups. Fasting blood sugar was significantly higher (p<.05) in the lowest $p\dot{V}O_2$ group compared to the highest. The risk factor index was nearly 50% higher (p<.01) in the lowest aerobically fit group (4.7%) compared to the highest fit group (2.5%) and showed a progressive lowering across all groups.

Intergroup comparisons showed no significant differences between the two highest $p\dot{V}O_2$ groups for any of the variables except treadmill time (p <.05, Table 3). Further analyses demonstrated significant differences in $p\dot{V}_E$ between the 40-44 ml/kg·min group and each of the lowest two $p\dot{V}O_2$ groups. Significant differences were found in treadmill time for all comparisons except that between the least two aerobically fit groups. Body weight and percent body fat of the lowest $p\dot{V}O_2$ range were significantly higher (p <.01) than values found for either the 35-39 or 40-44 ml/kg·min groups.

Fasting blood sugar values (Table 4) were found to be significantly higher in the least aerobically fit groups compared to the $p\dot{V}O_2$ ranges of 35-39 (p <.05) and 40-44 (p<.01) ml/kg·min. The risk factor index was significantly greater in the <30 ml/kg·min group than in the 40-44 ml/kg·min group (p <.05). A significantly greater percentage of smokers occurred in the two lowest $p\dot{V}O_2$ ranges when compared to either the 35-39 or 40-44 ml/kg·min groups. In addition, these latter two groups also differed significantly (p <.05) in percent smokers.

Discussion

The principal finding of this study was the significant inverse relationship seen among levels of aerobic fitness and many of the factors related to the development of CAD in an asymptomatic, middle-aged population. While these results confirm the findings of earlier cross-sectional studies,[8-10] they differ in one important respect: the direct measurement of oxygen uptake during maximal exercise was used to objectively determine aerobic capacity rather than indirect estimates such as treadmill time or submaximal heart rate.

The measurement of oxygen uptake during maximal exercise is considered the best index of aerobic capacity.[5] Because of the technical difficulties, most laboratories do not directly determine this variable during graded exercise testing. The most common method for estimating oxygen uptake has been to use linear regression equations relating treadmill performance to oxygen uptake.[6,7] These predictive equations, however, tend to be population specific and valid only through a limited range. Furthermore, oxygen uptake can vary widely among individuals for any given treadmill time in either the Bruce or Balke protocols.[7]

The aerobic capacity reported herein agrees favorably with values from civilian studies on the age 40 and over individual.[17-20] While valid comparisons are difficult due to differences in testing methods and in the physical activity history of the subjects, these studies have generally found the maximal oxygen uptake to range between 30 and 40 ml/kg•min. Only a few studies on military populations are available for comparison. Froelicher et al[21] found an average maximal oxygen uptake of 34.0 ml/kg•min for USAF aircrewmen of comparable age. In a large survey of Canadian Forces personnel between the ages of 40-55 years, Myles and Allen[22] reported a predicted maximal value of 32.4 ml/kg·min which, when corrected upwards by 15% to account for differences between the cycle ergometer and treadmill,[23] is similar to that reported herein.

The mean values for the various CRF also fell within the range of values reported for other comparably aged, asymptomatic male subjects.[3,8,24] The most prevalent risk factors found in this study were obesity, elevated blood cholesterol, hypertension and positive smoking history. Obesity has been identified as one of the most prevalent health problems at all ages in the United States and has recently been shown to be an independent risk factor for CAD.[25] The 63.8% prevalence of body fat content in excess of 25% (17.4% in excess of 30%) found in this group would appear to be rather high. However, similarly high levels of body fat have been reported for other 40 and over age groups.[8,10]

The high incidence of smokers (50%) is similar to that reported for other military populations,[10,26,27] and represents the most predominant risk factor in this group. The demonstrated inverse relationship between aerobic fitness and percent smokers is also in agreement with previous cross-sectional reports[3,10] and with studies on the effects of smoking on maximal oxygen uptake.[28,29] Cigarette smoking is known to interfere at a number of points in the O_2 delivery system, most notably by increasing the levels of carboxyhemoglobin[30] and through a negative effect on pulmonary function.[31] Indeed, the significantly lower maximal ventilation in the less aerobically fit groups suggests an effect of smoking on airway conductance.

While the relationship between total cholesterol levels and aerobic fitness did not reach statistical significance, the magnitude of the differences between the least and most aerobically fit groups was similar to that reported in other cross-sectional studies.[8,10] Furthermore, the differences in HDL-C values among groups were also in agreement with other cross-sectional data relating higher levels of HDL-C to higher levels of physical activity in men.[32,33] Such findings resulted in higher TC/HDL-C ratios in the lowest $p\dot{V}O_2$ groups compared to the highest. Gibbons et al[9] found this ratio to have the strongest association with fitness as measured by treadmill time among all the risk factors studied in a large sample of women. Furthermore, Wilson et al[34] believe this ratio to be the best predictor of CAD risk among all of the blood lipid indexes while Uhl et al [35] have suggested that a TC/HDL-C ratio ≥ 6 is a significant additional risk factor.

The effects of exercise on blood pressure are dependent upon many interrelated factors such as the dietary habits and body composition of the subjects under investigation. Furthermore, showing a significant relationship between blood pressure and aerobic fitness has been more difficult in normotensive then hypertensive subjects. Thus changes in blood pressure which have been documented due to exercise have been modest in most studies.[36-38] In the present study small differences were seen across fitness groups for both systolic and diastolic blood pressures but levels of significance were reached only when the two extreme $p\dot{V}O_2$ groups were compared. Similar results have also been reported in other cross-sectional studies with the magnitude of changes (10 and 9 mm Hg for systolic and diastolic pressures, respectively) being nearly identical to those reported by Cooper at al[8] and Brown et al[10] for comparably aged subjects.

In conclusion, the data from this study show that a significant inverse relationship exists among levels of aerobic capacity as measured by the direct determination of oxygen uptake and many of the factors purported to place an individual at increased risk for the development of CAD. Since, the data are cross-sectional in nature, a cause and effect relationship can not be established. However, the findings support the implied risk factor improvement suggested by other cross-sectional studies [8-10] and a recent longitudinal study [3] all of which utilized indirect measures to assess aerobic fitness.

ACKNOWLEDGEMENTS

The authors wish to express their sincere appreciation to Mrs. Emily Hamilton and Mrs. Dora Ward for the excellent preparation of the manuscript.

REFERENCES

1. Levy RI: Causes of the decrease in cardiovascular mortality: Am. J. Cardiol. 1984; 54:7C-13C.

2. Kannel WB, Wilson P, Blair SN: Epidemiological assessment of the role of physical activity and fitness in development of cardiovascular disease. Am. Heart J. 1985; 109:867-885.

3. Blair SN, Cooper KH, Gibbons LW, Gettman LR, Lewis S, Goodyear N: Changes in coronary heart disease risk factors associated with increased treadmill time in 753 men. Am. J. Epidemiology 1983; 118:352-359.

4. Mitchell JH, Sproule BJ, Chapman CB: The physiological meaning of the maximal oxygen intake test. J. Clin. Invest 1958; 37:538-547.

5. Astrand PO, Rodahl K: Textbook of Work Physiology. New York, 1977, McGraw-Hill p.331.

6. Bruce RA, Kusumi F, Hosmer D: Maximal oxygen uptake and nomographic assessment of functional aerobic impairment in cardiovascular disease. Am Heart J. 1973; 85:546-551.

7. Froelicher VF, Thompson AJ, Noguera I, Davis G, Stewart A, Triebwasser JH: Prediction of maximal oxygen consumption: Comparison of the Bruce and Balke treadmill protocols. Chest 1975; 68:331-336.

8. Cooper KH, Pollock ML, Martin RP, White SR, Linnerud AC, Jackson A: Physical fitness levels vs selected coronary risk factors. A cross-sectional study. J. Am Med Assoc 1976; 236:166-169.

9. Gibbons LW, Blair SN, Cooper KH, Smith M: Association between coronary heart disease risk factors and physical fitness in healthy adult women. Circulation 1983; 67:977-983.

10. Brown TE, Myles WS, Allen CL: The relationship between aerobic fitness and certain cardiovascular risk factors. Aviat. Space Environ Med 1983; 54:543-547.

11. Kannel WB, Dawber TR, Kagan A, Revotskie N, Stokes J: Factors of risk in development of coronary heart disease - six year followup experience. The Framingham Study. Ann Intern Med 1961; 55:33-50.

12. Kannel WB, McGee D, Gordon T: A general cardiovascular risk profile: The Framingham Study. Am J. Cardiol 1976; 38:46-51.

13. Wolthius RA, Froelicher VF, Rischer J, Noguera I, Davis G, Stewart AJ, Triebwasser JH: New practical treadmill protocols for clinical use. Am J Cardiol 1977; 39: 697-700.

14. Exercise Testing and Training of Apparently Healthy Individuals: A Handbook for Physicians. American Heart Association, 1972.

15. Taylor HL, Wang Y, Rowell L, Blomquist G: The standardization and interpretation of submaximal and maximal tests of working capacity. Pediatrics (Suppl) 1963; 32:703.

16. Durnin, JVGA, Womersley JW: Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72. Brit. J. Nutr. 1974; 32:77-92.

17. Cumming GR, Borysyk LM: Criteria for maximum oxygen uptake in men over 40 in a population survey. Med Sci Sports 1972; 4:18-22.

18. Wilmore J, Royce J, Girandola R, Katch F, Katch V: Physiological alterations resulting from a 10 week program of jogging. Med Sci Sports 1970; 2:7-14.

19. Saltin B, Hartley L, Kilbom A, Astrand A: Physical training in sedentary middle-aged and older men. II. Scand J. Clin Lab Invest 1969; 24:323-324.

20. Hanson J, Tabakian B, Levy A, Nedde W: Long-term physical training and cardiovascular dynamics in middle-aged men. Circulation 1968; 38:783-799.

21. Froelicher VF, Allen M, Lancaster MC: Maximal treadmill testing of normal USAF aircrewman. Aerospace Med 1974; 45:310-313.

22. Myles WS and Allen CL: A survey of aerobic fitness levels in a Canadian military population. Aviat. Space Environ Med 1979; 50:813-815.

23. Shepard RJ: World standards of cardiorespiratory performances. Arch. Environ. Health 1966; 13:664-67224

24. Zoltick JM, McAllister HA, Bedynek JL: The United States Army cardiovascular screening program. J. Cardiac Rehabit 1984; 4:530-535

25. Hubert HB,Feinleib M, McNamara PM,Castelli, WP: Obesity as an independent risk factor for cardiovascular disease: A 26-year follow-up of participants in the Framingham Heart Study. Circulation 1983; 67: 968-977.

26. Denniston JC, Jackson RE, Morgan WP, Ramos MU, Szurek JL, Vogel JA: A survey of cardiopulmonary health and coronary risk factors in a select military population. Milit. Med 1977; 141: 440-444.

27. Patton JF, Vogel JA: Prevalence of coronary heart disease risk factors in a young military population. Aviat. Space Environ. Med 1980; 51: 510-514.

28. Ingermann-Hansen T, Halkjaer-Kristensen J: Cigarette smoking and maximal oxygen consumption rate in humans. Scand. J. Clin. Lab. Invest. 1977; 37: 143-148

29. Hirsch GL, Sue DY, Wasserman K, Robinson TE, Hansen JE: Immediate effects of cigarette smoking on cardiorespiratory responses to exercise. J. Appl. Physiol. 1985; 58: 1975-1981.

30. Seppanen A: Physical work capacity in relation to carbon monixide inhalation and tobacco smoking. Ann Clin Res 1977; 9: 269-274.

31. Marten AR, Holmik EV: The effects of cigarett smoking on maximal oxygen consumption and selected Physiological responses of elite team sportsmen. Eur. J. Appl. Physiol. 1985; 53: 348-352.

32. Rotkis TC, Cote R, Coyle E, Wilmore JH: Relationship between high density lipoprotein cholesterol and weekly running mileage. J. Cardiac Rehab. 1982; 2: 109-112.

33. Hartung GH, Foreyt JP, Mitchell RE, Vlaser I, Gotto AM: Relation of diet to high-density-lipoprotein cholesterol in middleaged marathon runners, joggers and inactive men. New Eng. J. Med. 1980; 302: 357-361.

34. Wilson PW, Garrison RJ, Castelli WP, Manning F, McNamara PM, Kannel WP: Prevalence of coronary heart disease in the Framingham offspring study:role of lipoprotein cholesterol. Am. J. Cardial 1980; 46: 649-655.

35. Uhl GS, Troxler RG, Hickman JR, Clark D: Angiographic correlation of coronary artery disease with high density lipoprotein cholesterol in asymptomatic men. Am. J. Cardial 1981; 48: 903-911.

36. Montoye HJ, Metzner HL, Heller JB, Johnson BC, Epstein FH: Habitual physical activity and blood pressure. Med. Sci. Sports 1972: 4: 175-181.

37. Choquette G, Ferguson RJ: Blood pressure reduction in borderline hypertensives following physical training. Canad. Med. Assn. J. 1973: 108: 699-703.

38. Boyer JL, Kasch FW: Exercise therapy in hypertensive men. JAMA 1970; 211: 1668-1674.

Table 1. Descriptive characteristics of subjects

	Mean ± SD	Range
Physical Characteristics (n = 295)		
Age, yrs	43.8 ± 3.0	40 - 53
Height, cm	178.8 ± 6.7	155 - 196
Weight, kg	83.5 ± 11.4	[illegible].6 - 115.7
%Body Fat	26.0 ± 4.6	[illegible].6 - 36.5
Exercise Capacity (n = 261)		
Peak HR, BPM	182 ± 9	157 - 203
Peak $\dot{V}_E$, ℓ/min	123.1 ± 23.8	60.8 - 189.5
Peak $\dot{V}O_2$, ℓ/min	3.16 ± 0.5	1.71 - 4.58
Peak $\dot{V}O_2$, ml/kg·min	38.1 ± 6.2	25.3 - 61.1
TM time, min	15.3 ± 2.9	6 - 24
Blood Pressure (n = 295)		
Systolic, mmHg	124 ± 14	100 - 194
Diastolic, mmHg	81 ± 9	55 - 120
Blood Constituents (n = 295)		
Cholesterol, mg/dl	215 ± 38	95 - 354
HDL-C,mg/dl	41.2 ± 11.5	14 - 99
Cholesterol/HDL-C	5.5 ± 1.7	1.0 - 9.9
Triglycerides, mg/dl	159 ±112	35 - 399
Fasting Blood Sugar, mg/dl	98 ± 20	30 - 158
Risk Factor Index, %	3.4 ± 2.2	0.7 - 16.9

Table 2. Prevalence of coronary risk factors

Risk Factor	Prevalence (percent)
Percent Body Fat $>25 \leq 30$	46.4
>30	17.4
Peak $\dot{V}O_2 \geq 30 < 35$ ml/kg·min	23.5
< 30 ml/kg·min	8.5
Blood Pressure $\geq 140/90 \leq 160/95$	17.8
$> 160/95$	6.1
Cholesterol $\geq 200 \leq 250$ mg/dl	44.0
> 250 mg/dl	17.8
Cholesterol/HDL-C ≥ 6.0	33.1
Fasting Blood Sugar ≥ 115 mg/dl	6.5
Triglycerides ≥ 150 mg/dl	41.3
ECG Abnormalities, at rest	16.7
at exercise	8.8
Cigarette Smoking	50.3
Positive Cardiovascular History	5.0
Positive Cardiovascular Physical	11.0
Risk Factor Index $\geq 5\%$	18.0

Table 3. Levels of aerobic capacity and selected anthropometric and physiologic variables (mean ± SD).

	Aerobic Capacity, ml/kg·min				
	<30	30-34	35-39	40-44	>45
n	23	61	86	59	32
Age, yrs	44.5 3.6	43.9 2.7	44.1 2.9	43.8 3.4	42.8 2.1
Height, cm	180.6 5.8	179.5 6.3	178.0 6.3	179.2 7.5	178.4 7.4
Weight, kg	92.5** 13.7	85.6* 11.3	83.4 10.5	82.0 9.2	76.0 8.2
% Body Fat	31.0** 4.4	26.8* 4.2	26.1* 4.2	24.8 4.4	22.9 3.9
Peak HR,BPM	179 11	181 10	182 9	183 10	181 7
Peak $\dot{V}_E$,ℓ/min	103.7** 14.1	112.8** 19.1	122.3* 21.7	133.0 21.7	139.8 27.5
Peak RER	1.18 0.12	1.18 0.08	1.17 0.08	1.16 0.08	1.15 0.08
TM time, min	12.5** 2.1	13.4** 1.6	15.6** 1.8	17.0* 2.3	18.9 1.9

* $p<.05$; ** $p<.01$. HR = heart rate; $\dot{V}_E$ = minute ventilation; RER = respiratory exchange ratio; TM = treadmill time.

Table 4. Levels of aerobic capacity and coronary risk factors (mean ± SD)

	Aerobic Capacity, ml/kg·min				
	<u><</u>30	30-34	35-39	40-44	<u>></u>45
n	23	61	86	59	32
Smokers, %	77**	72**	48*	29	22
SBP, mmHg	129*	124	125	122	119
	21	15	13	12	11
DBP, mmHg	86*	82	81	80	77
	12	8	8	9	7
TC, mg/dl	222	224	217	205	203
	41	39	35	38	37
HDL-C,mg/dl	38.1*	37.7*	41.8	42.6	48.1
	10.9	7.6	10.4	13.4	14.3
TC/HDL-C	6.1*	6.1*	5.4	5.1	4.6
	1.8	1.5	1.5	1.6	1.6
Trig, ml/dl	189	172	171	137	122
	109	115	138	76	66
FBS, mg/dl	110*	98	96	94	93
	34	10	11	10	8
RF Index, %	4.7**	4.0	3.4	2.6	2.5
	3.5	2.5	2.1	1.8	1.6

* p<.05; ** p<.01; SBP = Systolic blood pressure; DBP = diastolic blood pressure; TC = total cholesterol; Trig = triglycerides; FBS = Fasting blood sugar; RF = risk factor

END

FILMED

3-86

DTIC