Exercise Capacity and Mortality in Black and White Men

Peter Kokkinos, PhD; Jonathan Myers, PhD; John Peter Kokkinos; Andreas Pittaras, MD; Puneet Narayan, MD; Athanasios Manolis, MD; Pamela Karasik, MD; Michael Greenberg, MD; Vasilios Papademetriou, MD; Steven Singh, MD

Background—Exercise capacity is inversely related to mortality risk in healthy individuals and those with cardiovascular diseases. This evidence is based largely on white populations, with little information available for blacks.

Methods and Results—We assessed the association between exercise capacity and mortality in black (n=6749; age, 58±11 years) and white (n=8911; age, 60±11 years) male veterans with and without cardiovascular disease who successfully completed a treadmill exercise test at the Veterans Affairs Medical Centers in Washington, DC, and Palo Alto, Calif. Fitness categories were based on peak metabolic equivalents (METs) achieved. Subjects were followed up for all-cause mortality for 7.5±5.3 years. Among clinical and exercise test variables, exercise capacity was the strongest predictor of risk for mortality. The adjusted risk was reduced by 13% for every 1-MET increase in exercise capacity (hazard ratio, 0.87; 95% confidence interval, 0.86 to 0.88; P<0.001). Compared with those who achieved <5 METs, the mortality risk was ≈50% lower for those with an exercise capacity of 7.1 to 10 METs (hazard ratio, 0.51; 95% confidence interval, 0.47 to 0.56; P<0.001) and 70% lower for those achieving >10 METs (hazard ratio, 0.31; 95% confidence interval, 0.26 to 0.36; P<0.001). The findings were similar for those with and without cardiovascular disease and for both races.

Conclusions—Exercise capacity is a strong predictor of all-cause mortality in blacks and whites. The relationship was inverse and graded, with a similar impact on mortality outcomes for both blacks and whites. (Circulation. 2008;117: 614-622.)

Key Words: African Americans ■ epidemiology ■ exercise tolerance ■ mortality ■ exercise test

Evidence from long-term and widely cited epidemiological studies supports the concept that the fitness status of an individual is inversely and strongly related to cardiovascular and overall mortality in apparently healthy individuals1-9 and in patients with documented cardiovascular disease (CVD).10 This relationship remains robust even after adjustments of potential confounding factors.1–10 In addition, these health benefits are realized at relatively low fitness levels and increase with higher physical activity patterns or fitness status in a dose-response fashion.1,2,6,7,9 However, most of this evidence is based on studies conducted among individuals in the middle and upper socioeconomic strata4–6,9; limited information is available for other populations.10 In particular, information on the association between exercise capacity and mortality for blacks is lacking, and potential racial differences related to this association have not been explored.

Clinical Perspective p 622

It is well documented that the age-adjusted all-cause mortality rates in blacks are as much as 60% higher than those of whites.11,12 This has been attributed in part to the fact that race and income are reported to negatively influence access to medical care.13 The Veterans Health Administration in the US Department of Veterans Affairs Health Care System is unique in that it ensures equal access to care independently of a patient’s financial status.14 Improved access to care and higher-quality health have been demonstrated in the Veterans Affairs Health Care System.14 In addition, the Veterans Affairs electronic healthcare database is uniquely suited to determine mortality and other outcomes accurately and facilitates risk-adjustment models to study outcomes.15 Thus, the system provides a unique opportunity to assess the association between mortality and exercise capacity in blacks and whites while minimizing the influence of disparities in medical care.

In the present study, we assessed the prognostic value of exercise capacity among black and white patients referred for an exercise test for clinical reasons. We addressed the following questions: Is exercise capacity an independent predictor of overall mortality for both black and white men? And are there racial differences in how exercise capacity influences the risk of mortality?
Table 1. Demographic and Clinical Characteristics in Blacks and Whites

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total (n=15 660)</th>
<th>Blacks (n=6749)</th>
<th>Whites (n=8911)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>59±11</td>
<td>58.0±11</td>
<td>60±11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>28.2±5.2</td>
<td>28.4±5.3</td>
<td>28.2±5.1</td>
<td>0.06</td>
</tr>
<tr>
<td>Resting HR, bpm</td>
<td>73±14</td>
<td>73±14</td>
<td>73±14</td>
<td>0.07</td>
</tr>
<tr>
<td>Resting systolic BP, mm Hg</td>
<td>133±21</td>
<td>134±21</td>
<td>132±20</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Resting diastolic BP, mm Hg</td>
<td>81±12</td>
<td>82±12</td>
<td>80±11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CVD, %</td>
<td>33.6</td>
<td>35.6</td>
<td>32.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Previous MI, %</td>
<td>40.3</td>
<td>37.1</td>
<td>46.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Smoking, %</td>
<td>30.5</td>
<td>32.7</td>
<td>28.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>49.1</td>
<td>54.8</td>
<td>44.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes mellitus, %</td>
<td>17.5</td>
<td>23.6</td>
<td>12.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dyslipidemia, %</td>
<td>12.9</td>
<td>17.6</td>
<td>9.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Obesity (BMI ≥30 kg/m²), %</td>
<td>31.6</td>
<td>32.7</td>
<td>29.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>β-Blocker, %</td>
<td>15.6</td>
<td>11.7</td>
<td>18.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CCB, %</td>
<td>20.8</td>
<td>20.2</td>
<td>21.2</td>
<td>0.103</td>
</tr>
<tr>
<td>ACE-I, %</td>
<td>13.5</td>
<td>14.8</td>
<td>12.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diuretics, %</td>
<td>8.8</td>
<td>14.8</td>
<td>4.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nitrates, %</td>
<td>12.1</td>
<td>7.7</td>
<td>15.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Statins, %</td>
<td>5.1</td>
<td>5.3</td>
<td>5.0</td>
<td>0.323</td>
</tr>
<tr>
<td>Exercise data*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak HR, bpm</td>
<td>139±27</td>
<td>141±26</td>
<td>137±27</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Peak systolic BP, mm Hg</td>
<td>180±31</td>
<td>186±32</td>
<td>176±30</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Peak diastolic BP, mm Hg</td>
<td>87±18</td>
<td>91±16</td>
<td>84±18</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Peak METs</td>
<td>7.3±2.9</td>
<td>6.9±2.4</td>
<td>7.6±3.2</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

MI indicates myocardial infarction; CCB, calcium channel blocker; and ACE-I, angiotensin-converting enzyme inhibitor.

*Adjusted for age and resting systolic and diastolic BPs.

**Methods**

**Study Design and Population**

Between May 1983 and December 30, 2006, a symptom-limited exercise tolerance test was administered to 15 660 male veterans at the Veterans Affairs Medical Center, Washington, DC (n=8982), and the Veterans Affairs Palo Alto (Calif) Health Care System (n=6618) either as a routine evaluation or to evaluate for exercise-induced ischemia. The following patients were excluded from the study: those with a history of an implanted pacemaker, those who developed left bundle-branch block during the test, and those who were unstable or required emergent intervention.16 To avoid an overestimation of the impact of exercise capacity on mortality, individuals with impaired chronotropic response, defined as a ratio of <0.8 between the percent heart rate (HR) reserve to metabolic reserve achieved at peak exercise,17,18 also were excluded from the analysis.

The 15 660 participants included in the study were either black (n=6749) or white (n=8911) men. All subjects gave written consent before the exercise tolerance test. The study was approved by the Internal Review Board at each institution. All demographic, clinical, and medication information was obtained from patients’ computerized medical records just before the exercise tolerance test. Each individual also was asked to verify the computerized information with regard to history of chronic disease, current medications, and cigarette smoking habits. Body weight and height were recorded before the test. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m²). Demographic data are included in Table 1. Individuals with CVD were defined as those with a history of myocardial infarction, angiographically documented coronary artery disease, coronary angioplasty, coronary bypass surgery, chronic heart failure, and/or peripheral vascular disease.

We recorded death dates from the Veterans Affairs Beneficiary Identification and Record Locator System File. This system, used to determine benefits to survivors of veterans, is complete and accurate.16 The Social Security Death Index was used to match all subjects to their record according to Social Security number. Vital status was determined as of June 30, 2007.

**Exercise Assessments**

The exercise capacity for the individuals at the Veterans Affairs Medical Center (Washington, DC) was assessed by the standard Bruce protocol. For the individuals assessed at the Veterans Affairs Palo Alto Health Care System, an individualized ramp protocol was used as described elsewhere.20 Peak exercise time was recorded in minutes. Peak workload was estimated as metabolic equivalents (METs). One MET is defined as the energy expended at rest, which is equivalent to an oxygen consumption of 3.5 mL/kg body weight per minute.21 Exercise capacity (in METs) was estimated on the basis of exercise time via a commonly used equation for the Bruce protocol22 and based on American College of Sports Medicine equations for the ramp protocol.21 Subjects were encouraged to exercise until volitional fatigue in the absence of symptoms or other indicators of ischemia.16 The use of handrails during the exercise test was discouraged. Age-predicted peak exercise HR was determined with standardized methods.21 Medications were not changed or stopped before testing.

Supine resting HR and blood pressure (BP) were assessed after 5 minutes of rest. Exercise BP was recorded at 2 minutes of each exercise stage, at peak exercise, and during recovery. Indirect arm-cuff sphygmomanometry was used for all BP assessments. ST-segment depression was measured visually. ST depression ≥1.0 mm that was horizontal or downsloping was considered suggestive of ischemia.
**Determination of Fitness Categories**

Four fitness categories were established on the basis of the MET level achieved. For practical reasons, the MET cutoffs used to define the fitness categories were based on the approximate MET level for each stage of the Bruce protocol. Subjects who achieved <5 METs made up the low fitness category (Low-Fit; n=3170); those who achieved 5 to 7 METs were in the moderate fitness category (Moderate-Fit; n=5153); those who achieved 7.1 to 10 METs made up the high fitness category (High-Fit; n=5075); and those who achieved >10 METs made up the highest fit category (Very-High-Fit; n=2261).

**Statistical Analysis**

Continuous variables are presented as mean±SD; categorical variables are expressed as absolute and relative frequencies (percent). Associations between categorical variables were tested with Pearson’s χ² test. One-way ANOVA was applied to determine age and BMI differences between the 2 races and among fitness categories. Post hoc procedures also were used to discern differences between fitness categories. The Bonferroni rule to correct for the inflation in the type I error was applied with multiple comparisons. Equality of variances between treatment groups was tested by the Levene’s test. ANCOVA was used to assess whether exercise variables were associated with race.

The relative risk for mortality was calculated for each fitness category. We considered individuals with an exercise capacity of <5 METs as Low-Fit; these subjects made up the reference group. Survival analysis was performed with the use of Kaplan-Meier curves, and Cox proportional-hazard models were used to determine the variables that were independently and significantly associated with mortality. The analyses were adjusted for age in years, BMI, cardiovascular medications (aspirin, angiotensin-converting enzyme inhibitors and diuretics), smoking, and diabetes. Whites had a higher prevalence of a previous myocardial infarction and were more likely to be treated with β-blockers, calcium channel blockers, and statins.

**Results**

The mean±SD follow-up period was 7.5±5.3 years (range, 0.08 to 22.92 years). A total of 3912 deaths occurred, with an average annual mortality of 3.3%. Approximately 80% of subjects achieved a peak HR that was at least 85% of the age-predicted value. Approximately 35% of those who did not achieve this level were receiving β-blockers.

Comparisons between fitness categories revealed that age was significantly lower (P<0.001) for the more fit versus the less fit categories (51±11, 56±10; 62±10, and 66±10 years, respectively). Similar findings were observed for both races. BMI was lower (P<0.001) in the 2 highest fitness categories compared with the Moderate-Fit and Low-Fit categories (28.2±5.7 versus 28.7±5.5, 28.3±4.7, and 27±4 kg/m², respectively). Thus, age and BMI were used as covariates when assessing differences in resting and exercise HR, BP, and MET levels among the fitness categories.

**Table 2. Hazard Ratios for Mortality According to Exercise Capacity**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (n=15,660)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.82</td>
<td>0.81–0.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.87</td>
<td>0.86–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, CV medications†</td>
<td>0.87</td>
<td>0.86–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, CV medications, and CVD‡</td>
<td>0.87</td>
<td>0.86–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blacks (n=6749)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.79</td>
<td>0.78–0.81</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.85</td>
<td>0.83–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, CV medications†</td>
<td>0.85</td>
<td>0.83–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, CV medications, and CVD‡</td>
<td>0.86</td>
<td>0.83–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Whites (n=8911)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.83</td>
<td>0.82–0.84</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.87</td>
<td>0.86–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, CV medications†</td>
<td>0.88</td>
<td>0.86–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors§, CV medications†, and CVD‡</td>
<td>0.88</td>
<td>0.86–0.89</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Cardiovascular (CV) risk factors include hypertension, diabetes mellitus, dyslipidemia, and smoking.
†CV medications include β-blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors, and diuretics.
‡CVD includes cardiac surgery for coronary artery disease, percutaneous transluminal coronary angioplasty, myocardial infarction, stroke, heart failure, and peripheral vascular disease.

**Demographic and Clinical Characteristics**

Participant characteristics and exercise data for the entire cohort and for each race are presented in Table 1. Blacks were younger than whites (58±11 versus 60±11 years; P<0.001) and had higher resting systolic and diastolic BPs. They also were more likely to smoke; to be obese; and to have CVD, hypertension, diabetes, and dyslipidemia. Accordingly, they were more likely to be treated with angiotensin-converting enzyme inhibitors and diuretics.

Whites had a higher prevalence of a previous myocardial infarction and were more likely to be treated with β-blockers and nitrates. After adjustment for age and resting BP, the peak exercise systolic and diastolic BPs and HR were significantly higher in blacks compared with whites, whereas peak MET level was higher in whites.

**Racial Differences in Mortality**

After adjustments for racial differences in age, resting BP, smoking habits, myocardial infarction, cardiovascular risk factors, and cardiac medications (Table 2), mortality was 11% higher in blacks than in whites (hazard ratio, 1.11; 95% confidence interval [CI], 1.01 to 1.18; P=0.001). Blacks who
died were significantly older (63±10 versus 56±11 years; \( P<0.001 \)) and had higher resting HRs (74±14 versus 72±14 bpm) and systolic BPs (139±22 versus 132±20 mm Hg; \( P<0.001 \)) compared with those alive. They also had lower BMI (27.1±5.4 versus 28.8±5 kg/m\(^2\); \( P<0.001 \)), peak exercise HR (130±25 versus 145±25 bpm; \( P<0.001 \)), peak systolic BP (180±34 versus 188±31 mm Hg; \( P<0.001 \)), and MET level achieved (5.6±1.9 versus 7.2±2.4; \( P<0.001 \)); were more likely to smoke; and had a higher prevalence of diabetes, CVD, and previous myocardial infarction.

Similarly, whites who died were older (65±10 versus 58±11 years; \( P<0.001 \)) and had a higher resting HR (75±14 versus 73±14 bpm; \( P<0.001 \)) and systolic BP (134±23 versus 131±20 mm Hg; \( P<0.001 \)) than those alive. In addition, they had significantly lower BMI (27.0±4.8 versus 28.5±5.1 kg/m\(^2\); \( P<0.001 \)), peak exercise HR (127±27 versus 140±25 bpm; \( P<0.001 \)), peak systolic BP (170±32 versus 178±30 mm Hg; \( P<0.001 \)), and MET level achieved (6.1±2.7 versus 8.0±3.1; \( P<0.001 \)) and were more likely to have hypertension and CVD and less likely to have dyslipidemia.

**Predictors of All-Cause Mortality for the Entire Cohort**

Hazard ratios for exercise capacity for the entire cohort and for each race are presented in Table 2. Exercise capacity was the strongest predictor of mortality (hazard ratio, 0.87) (ROC area, 0.71; \( P<0.001 \)), followed by age (hazard ratio, 1.04; 95% CI, 1.03 to 1.04; \( P<0.001 \)) (ROC area, 0.67; \( P<0.001 \)), cardiovascular risk factors (hazard ratio, 1.16; 95% CI, 1.08 to 1.24; \( P<0.001 \)) (ROC area, 0.50; \( P<0.001 \)), and BMI (hazard ratio, 0.96; 95% CI, 0.96 to 0.97; \( P<0.001 \)) (ROC area, 0.41; \( P<0.001 \)).

Cox proportional-hazards analysis revealed a 13% reduction in mortality risk for every 1-MET increase in exercise capacity (hazard ratio, 0.87). The findings were similar (\( P=0.60 \)) when individuals receiving β-blockers (n=2448) were excluded from the analysis (hazard ratio, 0.87; 95% CI, 0.86 to 0.88; \( P<0.001 \)) or were analyzed separately (hazard ratio, 0.87; 95% CI, 0.84 to 0.90; \( P<0.001 \)).

When predictors of mortality for each race were explored, each 1-MET increase in exercise capacity conferred a 14% lower risk for mortality among blacks (hazard ratio, 0.86) and a 12% lower risk for whites (hazard ratio, 0.88). The mortality risk reduction for each 1-MET increase in exercise capacity was similar (\( P=0.49 \)) for both blacks and whites.

A MET level of 7.0 was the optimal threshold for increased risk in mortality (sensitivity, 75%; specificity, 55%). Those below this threshold had a 2.6-fold increase in risk for mortality (95% CI, 2.4 to 2.8; \( P<0.001 \)) compared with those above it. The findings were similar for blacks and whites.

**Table 3. Risk of Death for the CVD Cohort According to Clinical and Exercise Variables**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (n=5210)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.82</td>
<td>0.80–0.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.87</td>
<td>0.85–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, and CV medications</td>
<td>0.87</td>
<td>0.85–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blacks (n=2173)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.78</td>
<td>0.75–0.81</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.85</td>
<td>0.81–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, and CV medications</td>
<td>0.85</td>
<td>0.81–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Whites (n=1518)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.84</td>
<td>0.81–0.86</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.88</td>
<td>0.86–0.91</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, and CV medications</td>
<td>0.88</td>
<td>0.86–0.91</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Data from Cox proportional-hazards models adjusted for age, cardiovascular (CV) risk factors, and cardiac medications.

Risk of Mortality Across Fitness Categories: Entire Cohort

Survival curves across fitness categories and relative risks for the entire cohort and for each race are presented in Figures 1 through 4. Relative risks across fitness categories for the
CVD and no CVD cohorts and for each race are presented in Figures 5 and 6. For the entire cohort, the adjusted relative risks for those who achieved peak exercise capacity levels of 5 to 7, 7.1 to 10, and >10 METs compared with those in the Low-Fit category (<5 METs) are shown in Figure 4. The relative risk of mortality was progressively lower as exercise capacity increased to 5 to 7 METs (hazard ratio, 0.81; 95% CI, 0.73 to 0.90; P<0.001), 7.1 to 10 METs (hazard ratio, 0.50; 95% CI, 0.43 to 0.58; P<0.001), and >10 METs (hazard ratio, 0.31; 95% CI, 0.26 to 0.37; P<0.001). Among whites, the corresponding relative risks were 0.79 (95% CI, 0.71 to 0.87; P<0.001), 0.52 (95% CI, 0.46 to 0.58; P<0.001), and 0.34 (95% CI, 0.28 to 0.41; P<0.001).

### Risk of Mortality Across Fitness Categories for Subjects With and Without CVD

For individuals with CVD, the adjusted relative risks for those in each fitness category are shown in Figure 5. For the entire CVD cohort, the relative risk of mortality was progressively lower for those achieving 5 to 7 METs (hazard ratio, 0.81; 95% CI, 0.73 to 0.90; P<0.001), 7.1 to 10 METs (hazard ratio, 0.50; 95% CI, 0.43 to 0.58; P<0.001), and >10 METs (hazard ratio, 0.42; 95% CI, 0.31 to 0.56; P<0.001). In blacks, the relative risk was similar for individuals who achieved <5 and 5 to 7 METs (hazard ratio, 0.86; 95% CI, 0.73 to 1.0; P=0.07). Significantly higher risk was noted only for individuals achieving 7.1 to 10 METs (hazard ratio, 0.46; 95% CI, 0.36 to 0.59; P<0.001) and >10 METs (hazard ratio, 0.34; 95% CI, 0.18 to 0.63; P<0.001). For whites, the relative risk was progressively lower for those achieving 5 to 7 METs (hazard ratio, 0.78; 95% CI, 0.67 to 0.91; P=0.002), 7.1 to 10 METs (hazard ratio, 0.53; 95% CI, 0.44 to 0.65; P<0.001), and >10 METs (hazard ratio, 0.46; 95% CI, 0.33 to 0.64; P<0.001). For those with no CVD (Figure 6), the findings were similar to those of the entire cohort.

**Discussion**

In the present study, we assessed the association between exercise capacity and all-cause mortality in black and white male veterans. Our findings support a strong inverse and graded reduction in mortality risk with increased exercise capacity. In accordance with recent reports,10,24–26 we found

---

**Table 4. Risk of Death for Those With No CVD According to Clinical and Exercise Variables***

<table>
<thead>
<tr>
<th>Variables</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (n=10 450)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.82</td>
<td>0.81–0.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.87</td>
<td>0.85–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, and CV medications</td>
<td>0.87</td>
<td>0.85–0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blacks (n=4217)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.80</td>
<td>0.78–0.83</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.86</td>
<td>0.83–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, and CV medications</td>
<td>0.86</td>
<td>0.83–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Whites (n=5987)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak exercise capacity (for each 1-MET increment)</td>
<td>0.83</td>
<td>0.83–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age and BMI</td>
<td>0.87</td>
<td>0.85–0.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adjusted for age, BMI, CV risk factors, and CV medications</td>
<td>0.88</td>
<td>0.86–0.89</td>
<td>0.007</td>
</tr>
</tbody>
</table>

*Data from Cox proportional-hazards models adjusted for age, cardiovascular (CV) risk factors, and cardiac medications.
that exercise capacity was a more powerful predictor of risk for all-cause mortality than established risk factors among both blacks and whites after adjustment for cardiac medications and traditional CVD risk factors.

The risk for mortality was 13% lower for every 1-MET increase in exercise capacity for the entire cohort, with similar reductions observed for those with and without CVD. The findings did not change significantly when individuals treated with β-blockers were included or excluded in the analysis. When fitness tertiles were considered, the relative risk for all-cause mortality for the entire cohort was ≈20% lower in those with an exercise capacity of 5 to 7 METs (Moderate-Fit category) compared with those achieving <5 METs. For those with an exercise capacity >7 METs, the mortality risk was ≈50% to 70% lower compared with those achieving <5 METs (Figure 4). This gradient for a reduction in mortality with increasing fitness was similar in blacks and whites in the entire cohort (Figure 4) and in individuals with and without CVD (Figures 5 and 6).

Low levels of physical activity, as determined by self-reported activity questionnaires, have been associated with an increased risk of mortality.3–6,9 These observations have been supported by studies using exercise capacity, a more objective assessment of fitness, to classify the physical status of apparently healthy men1,2,8,10,27 and women.1,2,8–10,27 Our findings support these previous reports.1–10,27 In particular, the 13% reduction in mortality risk for every 1-MET increase in exercise capacity we observed is similar to the 12% reduction reported previously in a veteran cohort10 but somewhat lower than the 17% to 20% reduction reported in women.25,27

Several aspects about the present study are unique. First, the 15 660 subjects make it the largest to assess the association between fitness and mortality in a clinically referred population. Second, the sample included individuals with and without CVD. Finally, the study used a objective and reproducible measure of fitness, exercise capacity, to classify physical status.
Second, our findings make a unique contribution to existing knowledge by providing needed information on the association between exercise capacity and mortality in a relatively large cohort of blacks and compare them with whites. Moreover, we had the opportunity to examine the association between exercise capacity and mortality in blacks and whites with CVD. In this regard, subtle differences were observed among those with CVD and those without CVD. For example, for every 1-MET increase in exercise capacity, the risk for all-cause mortality was 15% lower in blacks compared with 12% in whites. Another finding with potentially important clinical implications was the mortality risk differences between tertiles in the CVD cohort. Specifically, the relative risk among individuals with CVD and an exercise capacity between 5 and 7 METs was significantly lower only in whites, whereas among blacks, significant reductions were realized only when exercise capacity exceeded 7 METs (Figure 6). This suggests that blacks with CVD may require a higher fitness level for the same cardiovascular protection.

Third, most information on the association between physical activity, exercise capacity, and health is derived from populations of middle to upper socioeconomic strata. Such individuals are likely to have greater access to health-related information and may be in a better position to participate in and maintain a healthy lifestyle. Thus, the association between fitness and mortality may be accentuated in such individuals. In contrast, most of the individuals in the present study were of relatively low socioeconomic strata. The 50% lower mortality risk for those with an exercise capacity >7 METs versus <5 METs is similar to that reported by Blair and coworkers in middle to upper socioeconomic strata populations. Thus, our findings and those reported earlier in a similar population (patients from 2 Veterans Affairs Medical Centers) strengthen the evidence that higher exercise capacity is associated with lower all-cause mortality regardless of factors related to socioeconomic strata.

Our finding of a slightly higher overall mortality in blacks compared with whites is in contrast to a recent report demonstrating higher mortality rates in white veterans compared with blacks and Hispanics. The different findings in the 2 studies may be explained by differences in age and baseline comorbidities between the races. In the earlier study, whites were 6.4 years older than blacks, whereas in the present study, the difference in age was only 2 years. With regard to baseline comorbidities, the prevalence of CVD in the present study was significantly higher in blacks than in whites, whereas the prevalence of all other comorbidities was similar.
Our study has several limitations. The inverse relationship between fitness and mortality does not demonstrate cause. Although similar relationships have been demonstrated for CVD mortality, we had information only on all-cause mortality, not cardiovascular interventions. In addition, we did not have information on the physical activity level of the individuals in our study; the extent to which exercise capacity reflects the physical activity pattern in our sample is unknown. The onset of chronic diseases, their severity, and duration of therapy were not evaluated in our study because of incomplete records. In addition, it is likely that direct measurements of oxygen uptake would yield more precise findings. The use of 2 different exercise protocols to assess fitness also is a potential limitation. Our previous work suggests that the ramp protocol is somewhat more accurate in predicting measured METs. We analyzed the data separately from both locations and found that for every 1-MET increment, the Bruce protocol yielded an \( \approx \)14% reduction in risk and the ramp protocol yielded a 13% reduction in mortality. Thus, the differences in protocols did not have a substantial impact on results. Finally, our findings are based on men only and cannot be extrapolated to women.

Our findings have a number of clinical applications. These results extend the public health message about the health benefits of fitness and physical activity. Because higher exercise capacity is associated with a lower risk of mortality, physicians and other healthcare professionals should encourage individuals to initiate and maintain a physically active lifestyle consisting of moderate-intensity activities (brisk walking or similar activities). Such programs are likely to improve exercise capacity and lower the risk of mortality. Exercise capacity as assessed by an exercise test is a standardized procedure used throughout the world. Thus, inferences can be made for the many patients undergoing this procedure, and the prognostic power of exercise capacity applies equally to blacks and whites. In fact, a salient finding is that mortality risk was 50% lower for both blacks and whites who achieved an exercise capacity of 5 to 7, 7.1 to 10, or \( > 10 \) METs compared with those who achieved \( < 5 \) METs regardless of CVD status (Figures 4 through 6). These findings also expand the clinical applications of the relationship between fitness and mortality to patients treated with \( \beta \)-blockers. Collectively, these results support the concept that exercise capacity should be given as much attention by clinicians as other major risk factors.

Disclosures

None.

References

The findings of the present study reinforce the concept that the fitness status of an individual is inversely and strongly related to mortality in individuals with and without cardiovascular disease, regardless of factors related to socioeconomic strata. The gradient for a reduction in mortality with increasing fitness was similar in blacks and whites. Specifically, mortality was 13% lower for every 1-MET increase in exercise capacity and 50% lower for both blacks and whites who achieved a moderate exercise capacity (7 to 10 metabolic equivalents [METs]) compared with those who achieved a poor exercise capacity (<5 METs) regardless of cardiovascular disease status. Because exercise capacity as assessed by an exercise test is a standardized procedure used throughout the world, inferences can be made for the many patients undergoing this procedure. The prognostic power of exercise capacity applies equally to blacks and whites and to those with and without cardiovascular disease. It also expands the clinical applications of the relationship between fitness and mortality to patients treated with β-blockers. Collectively, the results of the present and other recent studies support the concept that exercise capacity should be given as much attention by clinicians as other major risk factors.
Exercise Capacity and Mortality in Black and White Men
Peter Kokkinos, Jonathan Myers, John Peter Kokkinos, Andreas Pittaras, Puneet Narayan, Athanasios Manolis, Pamela Karasik, Michael Greenberg, Vasilios Papademetriou and Steven Singh

Circulation. 2008;117:614-622; originally published online January 22, 2008;
doi: 10.1161/CIRCULATIONAHA.107.734764
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2008 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://circ.ahajournals.org/content/117/5/614

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org/subscriptions/