The importance of physical fitness versus physical activity for coronary artery disease risk factors: a cross-sectional analysis.

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A study has examined the relationship between physical exercise and physical fitness in reducing risk of coronary artery disease (CAD). Male police officers from Austin, Texas participated in the study. Health assessment considered cardiovascular fitness, blood pressure, cholesterol, smoking habits and percent body fat. A questionnaire determined levels of physical activity over the previous year. Results confirmed that low physical fitness and low activity levels contributed to greater risk of CAD. However, physical exercise was inadequate for reducing risk unless associated with increased fitness.

Numerous epidemiological investigations have shown that low physical fitness and low physical activity are related to the incidence of coronary artery disease (CAD). Most studies, however, have not examined both variables concurrently to determine which has the strongest association with CAD risk. The purpose of this investigation was to cross-sectionally examine the relationships among physical fitness, physical activity, and risk factors for CAD. Male law enforcement officers (N = 412) from the City of Austin, Texas, were subjects for this study. Physical fitness, physical activity, and risk factors for CAD were assessed through health screenings and from data collected as part of an annual physical fitness assessment. Multivariate analysis of covariance revealed that physical fitness, but not physical activity, was related to several single CAD risk factors. Percent body fat, smoking habits, and Type A behavior score were negatively related to physical fitness level, and high density lipoprotein (HDL) cholesterol was positively related to physical fitness level. Univariate analysis of variance found both physical fitness and physical activity to be significantly related to a composite CAD risk score. Low physical fitness and low physical activity were associated with a high CAD risk score. These data suggest that physical activity must be sufficient to influence physical fitness before statistically significant risk-reducing benefits on single CAD risk factors are obtained, although minimal engagement in weekly vigorous activity provides a significant benefit for the composite CAD risk score. It is plausible, however, that physical fitness is a stronger measure than physical activity and optimally characterizes the relationship among physical activity and CAD risk factors.

Key words: physical fitness, physical activity, cardiovascular disease

It is well accepted that habitual physical activity is related to reduced incidence of coronary artery disease (CAD). Numerous epidemiological studies have documented this association (Leon, Connett, Jacobs, & Rauramaa, 1987; Morris, Everitt, Pollard, Chase, & Semmence, 1980; Morris, Heady, Raffle, Roberts, & Parks, 1953; Paffenbarger & Hale, 1975; Paffenbarger, Hyde, Wing, & Hsieh, 1986; Paffenbarger et al., 1993). Based on these and other investigations, physical inactivity is thought to be an independent predictor of a magnitude similar to the more "traditional" risk factors such as hypertension, hypercholesterolemia, and smoking history (Powell, Thompson, Caspersen, & Kendrick, 1987).

Epidemiological investigations also have documented a relationship between physical fitness and CAD. Low physical work capacity was related to CAD incidence in a large, predominantly white, upper middle-class population (Blair, Kohl, et al., 1989); a sample of Los Angeles County fire and law enforcement employees (Peters, Cady, Bischoff, Bernstein, & Pike, 1983); a population of men with high serum cholesterol levels (Ekelund et al., 1988); and Belgian male factory workers (Sobolski et al., 1987).

Although physical fitness and physical activity are related (e.g., activity at a level that meets specified requirements for intensity, duration, and frequency will result in improved physical fitness; American College of Sports Medicine, 1990), many epidemiological investigations have examined only one of these variables, most commonly physical activity. This is presumably due to the time and expense required to test large populations for fitness and the relative ease in assessment of physical activity. To our knowledge, only one study has looked simultaneously at both variables. Lochen and Rasmussen (1992) found a stronger relationship between physical fitness and coronary risk factors than between leisure-time physical activity and coronary risk factors.

Scientific evidence regarding these relationships is sparse; less-than-optimal information is available to public health professionals on the potential health benefits of physical activity and/or physical fitness. Additional studies are needed in a
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variety of population samples to determine if the relationship endures under alternative scientific methodology. If physical fitness is confirmed in subsequent studies to have a stronger relationship with CAD risk factors than physical activity, the public health benefits of vigorous physical activity that can impact physical fitness should continue to be emphasized. Alternatively, if physical activity is found to have a stronger relationship, then it may not be necessary to promote physical activity levels necessary to induce substantial physical fitness improvements. It would be sufficient to promote engagement in minimal physical activity that may or may not impact physical fitness, depending on an individual’s initial fitness status. It is essential to continue to examine the physical activity process itself as well as its contribution to appreciable physical fitness improvements to determine how both physical activity and physical fitness are associated with CAD risk factors.

This investigation is a cross-sectional approach to this issue. Physical fitness and physical activity levels were independently compared to risk factors for CAD in a sample of male law enforcement officers. Additionally, this investigation evaluated a composite CAD risk score that provided information on the cumulative effect of the risk factors.

Method

Subjects

Male law enforcement officers from the City of Austin, Texas, served as subjects in this investigation. All officers are required to report to the City of Austin Police Department Wellness Office during their birth month for an annual physical fitness assessment. Data for this investigation were gathered from existing data files based on the subjects’ most recent physical fitness assessment (August 1990 through July 1991) and through health screenings. To preserve subject confidentiality, each subject was given an identification number and all data were collected using this unique number. The average age of the sample of officers used in the study (N = 412) was 35.9 years (SD = 6.7) with an ethnic breakdown of 71% Caucasian, 10% African-American, 18% Hispanic, and 1% other. These demographics are similar to those of the City of Austin law enforcement officer population (approximately 780, including female officers). Approval from The University of Texas Institutional Review Board was given prior to data collection. Informed consent was obtained prior to participation in health screenings.

Measures

Physical fitness. Cardiovascular fitness was assessed by maximal treadmill exercise testing using the Bruce protocol (Bruce, Kusumi, & Hosmer, 1973). All testing was performed by the staff physician at the Wellness Office of the City of Austin. Because maximal heart rate data were available for most subjects, maximal effort was based on the subjects’ unwillingness or inability to continue the protocol. Maximal time on the treadmill was converted to estimated maximal oxygen uptake and used to place subjects into percentiles derived from age-based physical fitness norms (Pollock & Wilmore, 1990).

Because low physical fitness is related to all-cause and cardiovascular mortality (Blair, Kohl, et al., 1989), data were grouped by normative standards (Pollock & Wilmore, 1990) rather than by cutpoints determined from the physical fitness distribution for the sample. This procedure also provides for a potentially more precise description of physical fitness in this sample because comparisons can be made against norms rather than artificial, sample-derived cutpoints. Physical fitness level was then determined by grouping these norms into quintiles.

Although this resulted in small sample sizes in the two lowest fitness groups (ns = 9 to 17), it was thought these groups would provide critical information on risk factor status in the low fit as well as contribute to the study’s generalizability to the City of Austin law enforcement population and other samples. Minimal loss of validity for the fitness measure should be expected from categorization of maximal time on the treadmill into age-based fitness norms.

Physical activity. Self-reported recall was used to determine physical activity level for the previous year. Because many of the subjects worked a monthly rotating shift schedule that can acutely affect regular daily routines, subjects were asked about their activity patterns over an extended period of time (year) rather than a more recent time frame. Pilot data indicated that physical activity for the previous year and the previous month were highly correlated, r (410) = .73, p < .001.
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Subjects were asked to report their overall physical activity, with a range, from 0 (avoid walking or exertion) to 10 (run over 25 miles per week or spend over 8 hours per week in comparable physical activity) (see Table 1 for the complete scale). The scale was modified from the original (Weir, Jackson, & Pinkerton, 1989) to include walking for exercise as a description of moderate activities. Because the scale measured overall activity instead of only leisure-time activity, officers who participated in the study and were assigned to walking, cycling, or equestrian beats (n < 20) could include these routine activities in their self-report. This instrument significantly correlated with maximal treadmill time, r (407) = .59, p < .001, in this study’s sample. Test-retest reliability determined on a random subsample of 47 subjects yielded an interclass correlation of r = .89.

Table 1. Physical Activity Questionnaire

Please check ONE category below (0-10) that best describes your overall physical activity for the previous year:

- 0 = avoid walking or exertion; e.g., always use elevator, drive when possible instead of walking
- 1 = walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration
- 2 = moderate activity; 10 to 60 minutes per week of moderate activity, such as golf, horseback riding, calisthenics, table tennis, bowling, weightlifting, yard work, walking for exercise
- 3 = moderate activity; over 1 hour per week of moderate activity as described above
- 4 = vigorous activity; run less than 1 mile per week or spend less than 30 minutes per week in comparable physical activity such as indoor biking, swimming, cycling, rowing, skipping rope, running in place, or engaging in vigorous aerobic type exercise such as tennis, basketball, or handball
- 5 = vigorous activity; run 1-5 miles per week or spend 30-60 minutes per week in comparable physical activity as described above
- 6 = vigorous activity; run 6-10 miles per week or spend 1-3 hours per week in comparable physical activity as described above
- 7 = vigorous activity; run 11-15 miles per week or spend 4-6 hours per week in comparable physical activity as described above
- 8 = vigorous activity; run 16-20 miles per week or spend over 6-7 hours per week in comparable physical activity as described above
- 9 = vigorous activity; run 21-25 miles per week or spend over 7-8 hours per week in comparable physical activity as described above
- 10 = vigorous activity; run over 25 miles per week or spend over 8 hours per week in comparable physical activity as described above

Categories for the instrument were collapsed into quintiles for statistical analyses based on natural breakpoints in the scale and relabeled as follows: Categories 0, 1 = 1, or low activity; Categories 2, 3 = 2, or moderate activity; Categories 4, 5 = 3, or less than 60 min per week of vigorous activity; Categories 6, 7 = 4, or 1 to 6 hours per week of vigorous activity; and Categories 8, 9, 10 = 5, or more than 6 hours per week of vigorous activity. The categorized scale significantly correlated with the original scale, Pearson r (410) = .97, p < .001, and had a similar correlation to maximal treadmill time, r (407) = .57, p < .001, as the original scale. Based on these findings, the categorized scale did not substantially reduce the information available from the full 0-10 scale.

CAD risk factors. Systolic and diastolic blood pressure, total cholesterol, high density lipoprotein (HDL) cholesterol,
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smoking habits, percent body fat, and Type A behavior score were assessed on the subjects. Blood pressure was measured with a mercury sphygmomanometer after subjects had been sitting quietly for at least 5 min. Three blood pressure measurements were made following American Heart Association guidelines (Frolich et al., 1988); the last two measurements were averaged and used for analysis. Cholesterol concentrations were determined from blood obtained after at least an 8-hour fast. Blood samples were analyzed by a local commercial Center for Disease Control-certified laboratory for lipid determination. Blind duplicate samples were obtained during the same blood draw on limited subjects (n = 25) throughout the study and sent to the laboratory for lipid analysis. Intraclass coefficients, derived from one-way repeated measures analysis of variance source tables, were R = .97 for total cholesterol and R = .99 for HDL cholesterol, indicating good internal laboratory consistency.

The sum of three skinfold measures were used to estimate percent body fat. Chest, abdomen, and thigh sites were measured by staff of the City of Austin Wellness Office. These measurements were converted to percent body fat using the equation developed by Jackson and Pollock (1978).

The two remaining risk factors, smoking habits and Type A behavior score, were determined through questionnaire responses. Smoking habits were determined by self-report through questionnaire data gathered at the screening site. Subjects were asked if they currently smoked cigarettes and, if so, how many they smoked each day. Type A behavior score had been assessed the prior year using the Jenkins Activity Survey (JAS; Jenkins, Zyzanski, & Rosenman, 1979) as part of a previous investigation. Type A behavior score had a possible range from -20.0 to +18.0, in which a positive score was considered an indication of Type A behavior tendencies and a negative score indicated a Type B behavior disposition. The more extreme the score, the stronger the display of a particular tendency. Since the JAS has been shown to be consistent over a 4-year time period (Jenkins et al., 1979), Type A behavior score was not assessed again on those subjects who had previously completed this survey. For the subjects who had not yet completed the survey, it was sent through interoffice mail for completion.

CAD risk score. CAD risk was assessed using the multiple logistic equation developed from the Pooling project data (Pooling Project Research Group [PPRG], 1978). This equation incorporates the variables age, diastolic blood pressure, total cholesterol, and smoking habits. It was developed from CAD incidence data and is predictive of CAD risk. For 2,422 men, the equation predicted 133 cardiovascular events, for which there were 112 observed events (PPRG, 1978).

Design and Analysis

Subjects currently on antihypertensive medication (n = 23) were removed from all analyses. Seventy-nine subjects declined participation in the JAS. Moreover, HDL cholesterol, percent body fat, and maximal time on the treadmill were not available for several subjects. To maximize the findings, data analyses were performed with as many subjects who had complete data necessary for a given analysis. Sample sizes, depending on the analysis, ranged from 302 to 389.

Hypothesis testing. Multivariate and univariate analyses of covariance (MANCOVA and ANCOVA), with age as the covariate, were employed to test this investigation’s hypotheses. To determine statistically significant associations of the independent variables (i.e., physical fitness level and physical activity level) to the dependent variables (systolic blood pressure, diastolic blood pressure, total cholesterol, HDL cholesterol, percent body fat, number of cigarettes smoked per day, and Type A behavior score), MANCOVA was utilized, employing a 5 x 5 design. Significant MANCOVA effects were further analyzed with stepwise discriminant analysis and ANCOVA (Bray & Maxwell, 1982). All significant follow-up findings were further examined using Newman-Keuls’ post hoc tests. Univariate analysis of variance was used to examine the relationship among the independent variables (physical fitness and physical activity) and the CAD risk score, again using a 5 x 5 design.

Results

Results from the physical activity questionnaire are shown in Table 2. Table 3 summarizes demographic information and CAD risk factors for the total sample (n = 389) and the sample with complete data (n = 302). Higher levels of physical activity were associated with higher maximal time on the treadmill exercise test, F (4, 381) = 45.13, p < .001, as indicated in Table 4. These results are confirmed by lower resting pulse found across physical activity levels, F (4, 382) = 7.33, p < .001. These findings verify the strength of the physical activity measure chosen for this investigation.
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Table 2. Physical activity patterns for sample of City of Austin law enforcement officers (n = 389)

<table>
<thead>
<tr>
<th>Physical activity level</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-low</td>
<td>12</td>
</tr>
<tr>
<td>2-moderate</td>
<td>34</td>
</tr>
<tr>
<td>3-vigorous, &lt; 1 hour/week</td>
<td>24</td>
</tr>
<tr>
<td>4-vigorous, 1-6 hours/week</td>
<td>21</td>
</tr>
<tr>
<td>5-vigorous, &gt; 6 hours/week</td>
<td>9</td>
</tr>
</tbody>
</table>

Multivariate Analyses

Significant main effects for either physical fitness or physical activity for the CAD risk factors, as well as a potential interaction effect between the independent variables for the dependent variables, were determined from MANCOVA analysis. Using Wilks’s criterion for determination of significance, a significant main effect was found across physical fitness levels for the dependent variables (all CAD risk factors), F (28, 989.34) = 2.74, p < .001. There were no significant differences across physical activity levels for the CAD risk factors, F (28, 989.34) = 0.89, p > .62. Finally, no significant interaction was noted between the independent variables, physical fitness and physical activity, for the CAD risk factors, F (77, 1649.37) = 0.95, p > .60.

Follow-up stepwise discriminant analysis indicated that percent body fat, number of cigarettes smoked per day, Type A behavior score, and HDL cholesterol were the dependent variables responsible for the significant main effect of physical fitness level for the CAD risk factors. Further follow-up using ANCOVA, with age and the previous variables (determined from stepwise discriminant analysis) as covariates, were employed to determine significant differences for the dependent variables across physical fitness levels (see Table 5). Percent body fat and number of cigarettes smoked per day were lower at higher physical fitness levels. Type A behavior score was significantly lower for the two lowest fitness groups compared to the higher fit groups. HDL cholesterol was significantly greater for the high fit group compared to the lowest fit group. No significant differences were noted across fitness levels for the risk factors of total cholesterol, systolic blood pressure, or diastolic blood pressure.

Because there was a significant correlation between the physical fitness and physical activity measure, r (407) = .59, p < .001, collinearity between the two variables may have been responsible for the significant finding for physical fitness, but not physical activity level, for the CAD risk factors. To test the relationships between either physical fitness or physical activity for the CAD risk factors independently, new fitness/activity variables were created. Z scores were created for both physical fitness and physical activity. Two new scores were subsequently calculated: The first was the sum of the z scores and represented the collinear portions of physical fitness and physical activity, and the second score was the difference between the z scores, representing the noncollinear portion of physical fitness. These derived scores were uncorrelated, r (385) = .00, p [is greater than] .60. When MANCOVA was performed for the newly created independent variables (after categorization into quintiles) and the dependent variables (CAD risk factors), the first score was significant and findings were similar to that previously presented. However, the second variable, which evaluated the noncollinear portion of physical fitness, also was statistically significant. Percent body fat and HDL cholesterol were both significant dependent variables, indicating that physical fitness, irrespective of physical activity levels, was associated with significant CAD risk factor differences.

Univariate Analysis

Physical fitness levels were significantly different for the multiple logistic CAD risk score, F (4, 366) = 3.69, p < .01. There also were significant differences among physical activity level for the CAD risk score, F (4, 366) = 2.74, p [is less than] .05. Table 6 indicates that lower physical fitness levels and physical activity levels were associated with a higher CAD risk score.
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Discussion

This investigation examined the cross-sectional relationships among physical fitness, physical activity, and CAD risk factors in male law enforcement officers. As in other investigations (Adner & Castelli, 1980; Cooper et al., 1976; Ekelund et al., 1988; Thompson et al., 1983), significant differences were found for physical fitness level and the CAD risk factors of percent body fat and HDL cholesterol. Additionally, a significant relationship was found between physical fitness level and Type A behavior score, a finding also observed by others (Ekelund et al., 1988; Kittel et al., 1983). However, no significant main effects were found for physical activity level for the CAD risk factors in this sample. Although several studies have examined both physical fitness and physical activity for CAD risk (Gordon et al., 1987; Leon et al., 1987; Sobolski et al., 1987), only one prior to the present study has looked at the independent contribution of each variable. Lochen and Rasmussen (1992) also found a stronger cross-sectional association among physical fitness and risk factors than with physical activity. The present study uniquely found that both low physical fitness and physical activity levels were associated with a higher composite CAD risk score.

Because significant relationships among physical activity and CAD risk factors, as well as physical fitness and CAD risk factors, are often cited, it was expected similar associations would be observed for both physical activity and physical fitness. Although recent work has shown physiological benefits after an acute bout of exercise with respect to improved glucose tolerance (Bjorntorp et al., 1972; Heath et al., 1983; Holloszy, Schultz, Kusnierkiewicz, Hagberg, & Ehsani, 1986) and reduced platelet aggregation (Sinzinger & Fitscha, 1986), chronic physical activity has primarily been thought to be responsible for most of the CAD risk-reducing benefits. This investigation found, surprisingly, no statistically significant associations for physical activity with respect to the CAD risk factors when fitness was held constant by the statistical analysis examining the main effects of physical activity. These findings support continued public health emphasis on physical activity sufficient to improve physical fitness to obtain single CAD risk factor benefits.

The relationship between physical fitness and physical activity level and the CAD risk score was noteworthy. Higher levels of both physical fitness and physical activity were associated with a lower CAD risk score. The physical fitness association with the risk score concur with Blair, Kohl, Gordon, and Paffenbarger’s (1992) recommendation of directing public health efforts toward moving individuals out of the lowest fitness category to achieve the greatest overall health benefits. Remarkably, although physical activity level did not significantly impact the risk factors individually, there were effects that translated into an overall lower composite CAD risk score. This suggests that a cumulative CAD risk-reducing benefit may be achieved by engaging in less than 1 hour per week of vigorous physical activity. Because the risk score provides an overall picture of CAD risk, the benefits observed in this study with respect to this level of physical activity are noteworthy. Furthermore, although not statistically significant, favorable risk factors were observed in individuals active at higher levels, findings that support continued public health promotion of all levels of physical activity.

The relative weakness of physical activity assessments and the objectivity of physical fitness may have been responsible for this study’s findings with respect to the single CAD risk factors. Although physical fitness is significantly related to physical activity level, it also has a genetic component that can account for as much as 40% of the variability in fitness measures (Bouchard, 1990). The physical activity measure used in this investigation correlated relatively well with physical fitness; however, many epidemiological physical activity assessment tools do not have a strong association with physical fitness (Blair, Kannel, Kohl, Goodyear, & Wilson, 1989).

Physical activity measures are diverse in their assessment; some evaluate total activity, whereas others examine specific activities that are deemed to be vigorous in nature (Washburn & Montoye, 1986). Not surprisingly, the measures yield differential correlations with physical fitness (.01 [is less than or equal to] r [.is less than or equal to] .51; Kohl, Blair, Paffenbarger, Macera, & Kronenfeld, 1988; Taylor et al., 1978). Low correlations likely result from imprecise estimates of physical activity (Paffenbarger, Blair, Lee, & Hyde, 1993). This can weaken any observed relationship between physical activity and CAD risk factors and outcomes. Perhaps misclassification of physical activity in the present investigation was partially responsible for the nonsignificant findings of physical activity level for the CAD risk factors.

Some investigators have focused on the relationship between physical fitness and CAD outcomes rather than physical activity and CAD outcomes, for physical fitness can be objectively measured and regular physical activity is necessary to improve fitness (Blair, Kohl, et al., 1989). Because both this investigation and that of Lochen and Rasmussen (1992) found a stronger cross-sectional relationship between physical fitness and selected CAD risk factors compared to physical activity.
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activity and selected risk factors, physical fitness measures may be preferable to physical activity measures in determining disease-related associations. Blair, Kannel, et al. (1989) and Jackson et al. (1990) have developed regression equations using variables that can be easily collected in large-scale investigations that predict maximal treadmill time (Blair, Kannel, et al., 1989) and maximal oxygen consumption (Jackson et al., 1990). Perhaps a similar tool that estimates cardiovascular fitness could be more effective in population studies for predicting CAD outcomes than the physical activity measures currently in use.

In summary, these findings suggest two alternative conclusions. First, they suggest that physical activity must be sufficient to impact physical fitness before individual CAD-risk factor-reducing benefits can be obtained, although benefits do occur for a composite CAD risk score. The composite CAD risk score is likely to provide a truer representation of overall CAD risk, thereby verifying the importance of engagement in some vigorous activity on a weekly basis. Second, because physical fitness can be measured more objectively than physical activity assessment and has less potential for misclassification, perhaps CAD risk factor differences are better detected using physical fitness rather than physical activity measurements, even when a relatively strong physical activity measure is used. Researchers should continue to study optimal methods of physical activity assessment to better discern the differential associations physical activity and physical fitness may have on CAD risk. Finally, because this investigation only examined the associations cross-sectionally, future research should be performed both in this sample and in more representative study populations to determine if these relationships hold up under longitudinal analyses.

References


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