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Self-Reported Cardiorespiratory Fitness: Prediction and Classification of Risk of Cardiovascular Disease Mortality and Longevity—A Prospective Investigation in the Copenhagen City Heart Study

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Background—The predictive value and improved risk classification of self-reported cardiorespiratory fitness (SRCF), when added to traditional risk factors on cardiovascular disease (CVD) and longevity, are unknown.

Methods and Results—A total of 3843 males and 5093 females from the Copenhagen City Heart Study without CVD in 1991–1994 were analyzed using multivariate Cox hazards regression to assess the predictive value and survival benefit for CVD and all-cause mortality from SRCF. The category-free net reclassification improvement from SRCF was calculated at 15-year follow-up on CVD and all-cause mortality. Overall, 1693 individuals died from CVD. In the fully adjusted Cox model, those reporting the same (hazard ratio [HR], 1.17; 95% confidence interval [CI], 1.04 to 1.32) and lower (HR, 1.91; 95% CI, 1.62 to 2.24) SRCF than peers had an increased risk of CVD mortality, compared with individuals with higher SRCF. Compared with individuals with higher SRCF, those with the same and lower SRCF had 1.8 (95% CI, 1.0 to 2.5) and 5.1 (95% CI, 4.1 to 6.2) years lower life expectancy, respectively. Individuals with lower SRCF had a significantly increased risk of CVD mortality, compared with individuals with higher SRCF, within each strata of leisure time physical activity and self-rated health, and SRCF significantly predicted CVD mortality independently of self-rated health and walking pace. A net reclassification improvement of 30.5% (95% CI, 22.1% to 38.9%) for CVD mortality was found when adding SRCF to traditional risk factors. Comparable findings were found for all-cause mortality.

Conclusions—SRCF has independent predictive value, is related to a considerable survival benefit, and improves risk classification when added to traditional risk factors of CVD and all-cause mortality. SRCF might prove useful in improved risk stratification in primary prevention. (*J Am Heart Assoc.* 2015;4:e001495 doi: 10.1161/JAHA.114.001495)

Key Words: cardiovascular mortality • net reclassification improvement • self-reported fitness

Low cardiorespiratory fitness is a well-documented predictor of cardiovascular disease (CVD) and mortality in the general population independently of classical risk factors, including physical activity, blood pressure (BP), cholesterol, body mass index (BMI), and smoking.^{1–3}

It has been recommended to include test of cardiorespiratory fitness in regular visits of primary care providers to support participation in physical activity and health programs.^{4–6} Despite this recommendation, a cardiorespiratory fitness test is not regularly included in primary care provider visits. This may mainly be owing to the fact that cardiorespiratory fitness usually is estimated from a physical test, requiring equipment, time, instructors, and ability of the person to perform the exercise.

For attending a more convenient and feasible measure of physical fitness, self-reported cardiorespiratory fitness (SRCF) has been recommended and shown to correspond well with physiological tests.^{7,8} However, the potential independent predictive value of SRCF on CVD mortality in larger epidemiological studies has not previously been addressed. Moreover, the impact on survival of high SRCF is not known. Furthermore, it is also unknown whether SRCF improves risk classification for CVD and all-cause mortality when added to traditional risk factors.

Accordingly, we investigated the independent predictive value, survival benefit, and potentially improved risk

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classification on CVD and all-cause mortality from SRCF in the large Danish prospective cardiovascular epidemiological study—the Copenhagen City Heart Study.

Methods

Study Design and Population

The Copenhagen City Heart Study is a prospective population study in which a random sample of the population living in an area of Copenhagen is invited to participate at regular intervals. Details of the enrolment and examinations are described elsewhere.⁹

In 1991–1994, 10 135 participants filled in a self-administered questionnaire and participated in a physical examination, including the same standardized and validated methods as previously described in detail.⁹ Participants with previous myocardial infarction or stroke, either by self-report or ascertained through The Danish National Patient Register from establishment of the register in 1977 until participant study inclusion, were excluded (n=793). Participants without follow-up owing to immigration before the examination (n=2) or missing information on SRCF were also excluded (n=404), leaving 8936 persons eligible for analyses.

Ethical Approval

The Committee of Biomedical Research Ethics for the Capital region in Denmark approved the study (H-KF-01-144/01). All data were deidentified and analyzed anonymously. Participants provided written consent to participate in the study. The ethics committee approved this consent procedure.

Main Variable of Interest

A single question with 3 response categories was applied for measuring SRCF: “How do you rate your cardiorespiratory fitness compared to your peers?” with response categories: “same,” “higher,” or “lower.”

Covariates

Information on smoking habits was categorized as never-smokers, ex-smokers, and current smokers of 1 to 14, and ≥ 15 cigarettes per day. Information on alcohol consumption was self-reported as abstainers, monthly, weekly, or daily consumers. Education was self-reported and categorized into < 8 , 8 to 10, and > 10 years of school. Income was based on self-reported total household income last year in categories low, medium, and high. Diabetes was self-reported or a nonfasting blood glucose ≥ 11.1 . Treatment for hypertension was self-reported and categorized as yes/no. Systolic blood

pressure (SBP) was measured in a sitting position after 5 minutes of rest. BMI was calculated as measured weight (kg) divided by measured height squared (m^2) and categorized for the statistical analyses as underweight (< 18.5), normal weight (18.5 to 24.9), overweight (25.0 to 29.9), and obese (≥ 30). Cholesterol was measured nonfasting in mmol/L and applied as a continuous variable in the statistical analysis. Self-rated health was measured by the question: “How do you rate your health the past year?” with response categories “very good,” “good,” “poor,” and “very poor.” Walking pace was measured by the question: “What is your walking pace?”, with response categories “slow,” “normal,” “fast,” and “very fast.” A single question with 4 answer options was applied for measuring leisure time physical activity: “Which description most precisely covers your pattern of physical activity during leisure time?”¹⁰ with the following response categories:

1. Being almost entirely sedentary (eg, reading, watching television or movies, engaging in light physical activity, such as walking or biking, for less than 2 hours per week). [Score, 1]
2. Engaging in light physical activity for 2 to 4 hours per week. [Score, 2]
3. Engaging in light physical activity for more than 4 hours per week or more-vigorous activity for 2 to 4 hours per week (eg, brisk walking, fast biking, heavy gardening, sports that cause perspiration or exhaustion). [Score, 3]
4. Engaging in highly vigorous physical activity for more than 4 hours per week or regular heavy exercise or competitive sports several times per week. [Score, 4]

Because of very few females and males in the highest category of leisure time physical activity, the variable was categorized into: score 1= “low,” score 2= “moderate,” and score 3 to 4= “high.”

Follow-up

Follow-up was carried out by data linkage to national registers. Deaths were obtained until April 2013 from The Civil Registration System and causes of death from The National Register of Causes of Death until December 2011. CVD death was defined as International Classification of Diseases (ICD)-8 390 to 458 and ICD-10 I00 to I99.

Analyses

The associations between SRCF at baseline in 1991–1994, CVD mortality, and all-cause mortality were studied using Cox proportional hazards regression models. The Cox models were performed with age as underlying time scale and age at baseline as entry time. The analyses were performed with and without stratification on sex. Four Cox models with forced

entry of the following covariates were performed: (a) sex; (b) model a+smoking, BMI, SBP, BP medication, diabetes, cholesterol, education, income, drinking habits, and leisure time physical activity; (c) model b+self-rated health; and (d) model c+walking pace.

For closer investigation of the interplay between SRCF and leisure time physical activity, the same 4 Cox models were applied within each strata of leisure time physical activity. Moreover, adjusted sex-specific Cox proportional hazards regression analyses were performed with a multiplicative interaction term between SRCF, leisure time physical activity, and the outcomes CVD and all-cause mortality, respectively. Similarly, the interaction between SRCF and age was tested for both outcomes. Additionally, Cox models were applied within each strata of self-rated health.

Survival benefits were estimated by integrating the model-adjusted mean survival curves for each of the groups “higher,” “same,” and “lower.” These Makuch-Ghali curves are the average of the survival curves for all individuals in the sample based on the multivariate Cox models.¹¹ The bias-corrected survival benefits and confidence intervals (CIs) were estimated by bootstrap resampling (10 000 samples) by subtracting the bootstrapped biases from the survival benefit estimates of the original sample.

The predictive power of the Cox models was summarized by Harrell's C-index. The magnitude of improvement in prediction performance should be of main interest, given that testing for improvement is redundant when it has already been established that a variable is a significant risk factor. To

further evaluate the improvement in prediction performance in models with and without SRCF, continuous category-free net reclassification improvement (NRI)¹² was calculated for models including all other traditional risk factors (ie, age, sex, smoking, BMI, SBP, BP medication, diabetes, cholesterol, income, drinking habits, and leisure time physical activity). NRI measures the expanded models' ability to correctly reclassify individuals with and without events during follow-up into higher or lower risk, respectively. To account for censored data, the expected number of events and nonevents were used in the estimation of continuous NRI and calculated by multiplying the total number of individuals by the Kaplan-Meier estimates at end of follow-up.¹³ This method is optimal for calibration of survival models.¹⁴ We estimated the integrated discrimination improvement (IDI),¹⁵ which can be interpreted as the increase in proportion of explained variation by the model including SRCF compared to the model without.¹⁶ Finally, the relative IDI was estimated. Bias-corrected continuous NRI, IDI, relative IDI, and CIs were estimated by bootstrap resampling (10 000 samples) by subtracting the bootstrapped biases from the estimates of the original sample.

The assumption of proportionality in the Cox regression models was tested with the Lin, Wei, and Ying score process test.¹⁷ Misspecification of the functional form of the continuous covariate was tested by plotting it against the cumulative residual and comparing it to random realizations under the model. *P* values below 0.05 were considered statistically significant. Statistical analyses were performed with R

Table 1. Demographic and Lifestyle Factors of 3843 Males and 5093 Females Without a History of Cardiovascular Disorders Stratified by Self-Reported Cardiorespiratory Fitness (1991–1994) in the Copenhagen City Heart Study

	Higher (N=2530)	Same (N=5043)	Lower (N=1363)
Males, % (95% CI)	46.8 (44.9 to 48.8)	41.5 (40.1 to 42.9)	41.5 (38.9 to 44.2)
Age, y—mean (95% CI)	60.0 (59.4 to 60.6)	56.3 (55.9 to 56.7)	55.8 (55.0 to 56.7)
High leisure time physical activity, % (95% CI)	55.2 (53.1 to 57.0)	30.4 (29.0 to 31.6)	14.2 (12.4 to 16.2)
Body mass index ≥ 30 , % (95% CI)	8.9 (7.8 to 10.0)	14.6 (13.5 to 15.5)	22.3 (19.6 to 24.1)
Never-smoker, % (95% CI)	30.5 (28.6 to 32.2)	25.3 (24.1 to 26.5)	19.4 (17.3 to 21.5)
Alcohol, never—% (95% CI)	14.4 (13.1 to 15.9)	17.0 (16.0 to 18.0)	23.7 (21.4 to 26.0)
Systolic blood pressure, mean (95% CI)	139.2 (138.3 to 140.0)	137.7 (137.1 to 138.3)	136.8 (135.6 to 138.0)
Antihypertensive drugs, % (95% CI)	7.7 (6.7 to 8.8)	10.6 (9.7 to 11.4)	12.3 (10.5 to 14.1)
Cholesterol, mmol/L—mean (95% CI)	6.1 (6.1 to 6.2)	6.1 (6.1 to 6.2)	6.1 (6.0 to 6.2)
Diabetes, % (95% CI)	2.6 (2.1 to 3.4)	3.9 (3.4 to 4.5)	5.5 (4.4 to 6.9)
Years in school < 8 , % (95% CI)	29.9 (28.1 to 31.7)	32.8 (31.5 to 34.1)	36.8 (34.1 to 39.3)
Low household income, % (95% CI)	36.1 (33.4 to 37.2)	34.3 (32.2 to 34.9)	45.8 (42.2 to 47.5)
Slow walking pace, % (95% CI)	3.0 (2.4 to 3.8)	6.5 (5.8 to 7.1)	35.3 (32.0 to 37.2)
Outstanding self-rated health, % (95% CI)	17.2 (15.6 to 18.6)	6.6 (5.9 to 7.3)	2.0 (1.3 to 2.9)

P values of differences between the groups of self-reported cardiorespiratory fitness are provided. CI indicates confidence interval.

software (version 3.0.1; R Foundation for Statistical Computing, Vienna, Austria).

Results

During a median follow-up of 17.9 years (interquartile range [IQR], 7.7; lower quartile, 11.2; upper quartile, 18.9) for CVD mortality and 19.1 years (IQR, 8.9; lower quartile, 11.2; upper quartile, 20.1) for all-cause mortality, 1693 (males, 794) died from CVD and 4014 (males, 1836) from all causes.

Table 1 shows demographic, lifestyle, and clinical factors according to level of SRCF among 3843 males and 5093 females without a history of cardiovascular disorders in 1991–1994 in the Copenhagen City Heart Study. Persons with higher SRCF were more often male and were older. For several factors, they had a more beneficial CVD risk profile: They were less frequently overweight, more were never-smokers, fewer had diabetes or were in antihypertensive treatment and drank less alcohol, were more physically active during leisure time, had higher walking pace, and a better self-reported health. Conversely, BP was higher in this group, although this may be related to the higher age, and there was no difference in cholesterol levels.

Figure illustrates the risk estimates and corresponding forest plots for CVD and all-cause mortality from SRCF among males and females in 4 Cox regression models with progres-

sive adjustment for potential confounders. With adjustment for age, sex, smoking, BMI, SBP, BP medication, diabetes, cholesterol, education, income, drinking habits, and leisure time physical activity, an increased risk for CVD mortality was found among those with the same (HR, 1.17; 95% CI, 1.04 to 1.32) and lower (HR, 1.91; 95% CI: 1.62 to 2.24) SRCF, compared with those with higher SRCF. Similar, but weaker, associations between SRCF and CVD mortality were found with additional adjustment for self-rated health and walking pace.

Regarding all-cause mortality, similar results were found, with increased risk (HR, 1.21; 95% CI, 1.12 to 1.30) and 1.72 (95% CI, 1.54 to 1.91) for same or lower, compared with higher SRCF, respectively. The corresponding estimated impact on life expectancy was 5.1 (95% CI, 4.1 to 6.2) years for those with higher SRCF, compared with those with lower SRCF. In the last model, additionally adjusted for self-rated health and walking pace, the gap in estimated life expectancy was reduced to 2.5 (95% CI, 1.3 to 3.7) years. A sensitivity analysis of excluding subjects with events within the first 2 years yielded similar results for both CVD and all-cause mortality (data not shown).

Table 2 presents the risk estimates for CVD and all-cause mortality from SRCF stratified on sex. Generally, similar risk estimates for CVD and all-cause mortality from SRCF were found for both sexes, with some higher numerical estimates for males. No statistical interaction between sex and SRCF

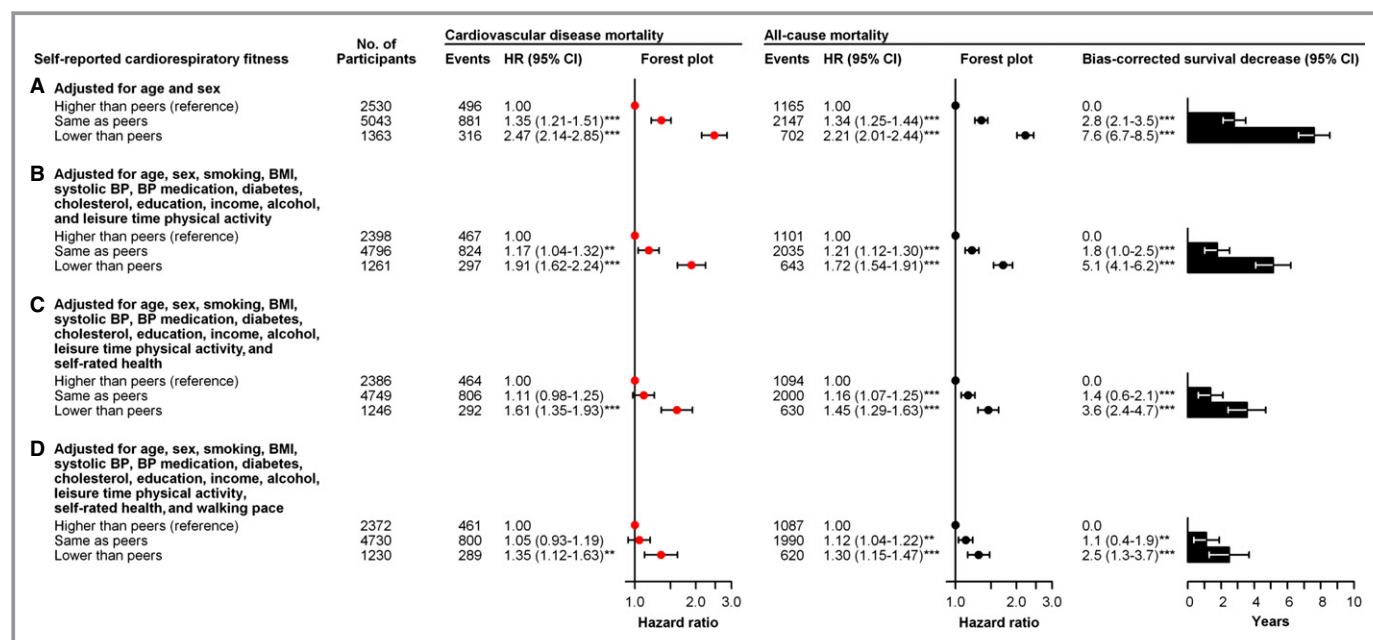


Figure. Self-reported cardiorespiratory fitness (Cox regression HRs with 95% CIs) from 1991 to 1994 as predictor of cardiovascular disease mortality and all-cause mortality with median follow-up of 17.9 years among males and females without a history of cardiovascular disorders in the Copenhagen City Heart Study (n=8936). Survival benefits were calculated by integrating the Cox regression model-adjusted mean survival Makuch-Ghali curves for each of the groups “higher than peers,” “same as peers,” and “lower than peers” self-reported cardiorespiratory fitness. * $P<0.05$; ** $P<0.01$; *** $P<0.001$. BMI indicates body mass index; BP, blood pressure; CI, confidence interval; HR, hazard ratio.

Table 2. Self-Reported Cardiorespiratory Fitness (Cox Proportional Hazards Regression) From 1991 to 1994 as Predictor for Cardiovascular Disease Mortality and All-Cause Mortality With Median Follow-up of 17.9 Years Among 3843 Males and 5093 Females Without a History of Cardiovascular Disorders in the Copenhagen City Heart Study

	No. of Participants	No. of Events	Hazard Ratio (95% CI) [†]	Hazard Ratio (95% CI) [‡]	Hazard Ratio (95% CI) [§]
Cardiovascular disease mortality					
Females					
Higher self-reported fitness	1345	260	1 (reference)	1 (reference)	1 (reference)
Same self-reported fitness	2951	458	1.27 (1.09 to 1.49)**	1.11 (0.94 to 1.31)	0.97 (0.82 to 1.15)
Lower self-reported fitness	797	181	2.21 (1.83 to 2.68)***	1.79 (1.45 to 2.22)***	1.30 (1.01 to 1.67)*
Males					
Higher self-reported fitness	1185	236	1 (reference)	1 (reference)	1 (reference)
Same self-reported fitness	2092	423	1.44 (1.23 to 1.69)***	1.25 (1.05 to 1.48)*	1.15 (0.96 to 1.38)
Lower self-reported fitness	566	135	2.80 (2.25 to 3.47)***	2.08 (1.64 to 2.65)***	1.45 (1.09 to 1.92)**
All-cause mortality					
Females					
Higher self-reported fitness	1345	629	1 (reference)	1 (reference)	1 (reference)
Same self-reported fitness	2951	1147	1.26 (1.14 to 1.39)***	1.15 (1.04 to 1.28)**	1.07 (0.96 to 1.20)
Lower self-reported fitness	797	402	1.97 (1.74 to 2.24)***	1.60 (1.38 to 1.84)***	1.22 (1.03 to 1.45)*
Males					
Higher self-reported fitness	1185	536	1 (reference)	1 (reference)	1 (reference)
Same self-reported fitness	2092	1000	1.43 (1.29 to 1.59)***	1.27 (1.13 to 1.42)***	1.19 (1.05 to 1.34)**
Lower self-reported fitness	566	300	2.54 (2.20 to 2.94)***	1.89 (1.61 to 2.22)***	1.42 (1.18 to 1.71)***

BMI indicates body mass index; CI, confidence interval.

[†]Control made for age and sex.

[‡]Control made for age, sex, smoking, BMI, systolic blood pressure, blood pressure medication, diabetes, cholesterol, education, income, drinking habits, and leisure time physical activity.

[§]Control made for age, sex, smoking, BMI, systolic blood pressure, blood pressure medication, diabetes, cholesterol, education, income, drinking habits, leisure time physical activity, self-rated health, and walking pace.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

was found for CVD ($P=0.50$) and all-cause mortality ($P=0.08$) when adjusting for traditional risk factors (ie, age, smoking, BMI, SBP, BP medication, diabetes, cholesterol, education, income, drinking habits, and leisure time physical activity). No statistical interaction between age and SRCF was found for CVD ($P=0.74$) and all-cause mortality ($P=0.62$).

When stratified on leisure time physical activity, similar associations between SRCF and CVD mortality were found. For CVD mortality, individuals with lower SRCF had an increased risk both among those with low (HR, 2.24; 95% CI, 1.44 to 3.48), moderate (HR, 1.65; 95% CI, 1.33 to 2.05), and high leisure time physical activity (HR, 2.06; 95% CI, 1.42 to 3.00), compared with those with higher SRCF. For all-cause mortality, individuals with lower SRCF had an increased risk both among those with low (HR, 1.84; 95% CI, 1.37 to 2.48), moderate (HR, 1.58; 95% CI, 1.36 to 1.82), and high leisure time physical activity (HR, 1.83; 95% CI, 1.44 to 2.33), compared with those with higher SRCF. There was no significant interaction between leisure time physical activity and SRCF neither for CVD ($P=0.47$) or all-cause mortality ($P=0.32$).

With adjustment for age, sex, smoking, BMI, SBP, BP medication, diabetes, cholesterol, education, income, drinking habits, and leisure time physical activity, those with lower SRCF had an increased risk for CVD mortality, compared with those with higher SRCF among those with outstanding (HR, 2.00; 95% CI, 0.46 to 8.71), good (HR, 1.83; 95% CI, 1.38 to 2.43), poor (HR, 1.42; 95% CI, 1.07 to 1.90), and very poor self-rated health (HR, 1.51; 95% CI, 0.45 to 5.13).

Table 3 shows that adding SRCF to the traditional risk factors (ie, age, sex, smoking, BMI, SBP, BP medication, diabetes, cholesterol, education, income, drinking habits, and leisure time physical activity) improved discrimination, indicated by the increase in the bias-corrected C-index of 0.0024 (95% CI, 0.0021 to 0.0028) for CVD mortality and 0.0018 (95% CI, 0.0015 to 0.0020) for all-cause mortality. The addition of SRCF to the traditional risk factors showed a bias-corrected continuous NRI of 30.5% (95% CI, 22.1% to 38.9%) for CVD mortality and 25.4% (95% CI, 18.3% to 32.4%) for all-cause mortality, respectively. Moreover, the bias-corrected IDI and bias-corrected relative IDI was 0.009 (95% CI, 0.006 to

Table 3. Continuous Net Reclassification Improvement (NRI) From Self-Reported Cardiorespiratory Fitness at 15-Year Follow-up on Cardiovascular Disease Mortality and All-Cause Mortality Without a History of Cardiovascular Disorders in 1991–1994 in the Copenhagen City Heart Study (n=8936)

	Bias-Corrected C-Index, <i>P</i> Value (Test for Difference)		Bias-Corrected NRI (95% CI), <i>P</i> Value	Bias-Corrected IDI (95% CI), <i>P</i> Value	Bias-Corrected Relative IDI (95% CI), <i>P</i> Value
Cardiovascular disease mortality					
Model (a) <i>without</i> self-reported cardiorespiratory fitness	0.845	<i>P</i> <0.001	Nonevents: 49.5% (22.5% to 76.4%), <i>P</i> <0.001 Events: 22.0% (–18.8% to 62.8%), <i>P</i> =0.29 Overall: 71.5% (52.8% to 90.1%), <i>P</i> <0.001	0.015 (0.011 to 0.018), <i>P</i> <0.001	5.9% (4.4% to 7.4%), <i>P</i> <0.001
Model (a) <i>including</i> self-reported cardiorespiratory fitness	0.854				
Model (b) <i>without</i> self-reported cardiorespiratory fitness	0.870	<i>P</i> <0.001	Non-events: 55.8% (34.5% to 77.1%), <i>P</i> <0.001 Events: –25.3% (–50.4% to –0.2%), <i>P</i> =0.05 Overall: 30.5% (22.1% to 38.9%), <i>P</i> <0.001	0.009 (0.006 to 0.011), <i>P</i> <0.001	3.0% (2.0% to 4.0%), <i>P</i> <0.001
Model (b) <i>including</i> self-reported cardiorespiratory fitness	0.873				
All-cause mortality					
Model (a) <i>without</i> self-reported cardiorespiratory fitness	0.790	<i>P</i> <0.001	Nonevents: 53.6% (31.3% to 75.9%), <i>P</i> <0.001 Events: 14.6% (–17.6% to 46.8%), <i>P</i> =0.37 Overall: 68.2% (54.2% to 82.3%), <i>P</i> <0.001	0.017 (0.014 to 0.019), <i>P</i> <0.001	5.0% (4.1% to 5.9%), <i>P</i> <0.001
Model (a) <i>including</i> self-reported cardiorespiratory fitness	0.798				
Model (b) <i>without</i> self-reported cardiorespiratory fitness	0.816	<i>P</i> <0.001	Non-events: 46.0% (22.1% to 69.9%), <i>P</i> <0.001 Events: –20.6% (–46.1% to 4.9%), <i>P</i> =0.11 Overall: 25.4% (18.3% to 32.4%), <i>P</i> <0.001	0.006 (0.004 to 0.008), <i>P</i> <0.001	1.5% (1.0% to 2.0%), <i>P</i> <0.001
Model (b) <i>including</i> self-reported cardiorespiratory fitness	0.817				

Continuous NRI is a measure for evaluating the improvement in prediction performance in models with and without self-reported cardiorespiratory fitness. The integrated discrimination improvement (IDI) is the increase in proportion of explained variation by the model, including self-reported cardiorespiratory fitness, compared to the model without. Model (a) is adjusted for age and sex. Model (b) is adjusted for age, sex, smoking, BMI, systolic blood pressure, blood pressure medication, diabetes, cholesterol, education, income, alcohol, and leisure time physical activity. BMI indicates body mass index; CI, confidence interval.

0.011) and 3.0% (95% CI, 2.0% to 4.0%) for CVD mortality and 0.006 (95% CI, 0.004 to 0.008) and 1.5% (95% CI, 1.0% to 2.0%) for all-cause mortality when adjusted for the traditional risk factors.

When estimating the continuous NRI without SRCF, but with and without leisure time physical activity (in model (b)), the continuous NRI was very small: 0.8% (95% CI, –11.5% to 16.8%) for CVD mortality and 2.7% (95% CI, –21.5% to 23.1%) for all-cause mortality.

Discussion

The main findings of this study were the strong independent predicting value, a considerable influence on survival benefit, and substantial net reclassification of CVD and all-cause mortality from a single question about SRCF, compared to peers in the general population free from CVD at baseline participating in the Copenhagen City Heart Study.

In this study on a general population free of CVD at baseline, the single question about SRCF, compared to peers, had a relatively strong predictive value on both CVD and all-cause mortality. For CVD mortality, those reporting same

SRCF as peers had a 17% increased risk and those reporting lower than peers had a 91% increased risk, compared with those reporting higher SRCF than peers.

This strong predictive value of SRCF is in accord with the previously well-documented increased risk for CVD and all-cause mortality from measured cardiorespiratory fitness during exercise testing when adjusting for traditional risk factors, including physical activity, BP, cholesterol, BMI, and smoking.^{1–3}

To our knowledge, this is the first study documenting a strong predictive value of SRCF for CVD and all-cause mortality in a larger general study population free from CVD at baseline when adjusting for traditional risk factors for CVD. Of note, although SRCF was strongly associated with self-reported physical activity, including walking speed, SRCF showed a strong predictive value for CVD and all-cause mortality both after adjustment and stratification for leisure time physical activity. Specifically, the increased risk for CVD mortality from having lower SRCF was 124% among those with low leisure time physical activity, 65% among those with moderate leisure time physical activity, and 106% among those with high leisure time physical activity, when compared to those with higher SRCF, respectively.

Generally similar risk estimates were found for females and males, with some higher numerical estimates for CVD and all-cause mortality from SRCF for males. This indicates that SRCF predicts CVD and all-cause mortality equally well among sex. The association between SRCF and outcomes was independent of age. Those reporting higher SRCF than peers were observed to be older than participants reporting same or lower SRCF than peers. This may be explained by high fitness being important for participation in the survey among old persons. However, this observation is not likely to introduce a bias in our study after adjustment for age, classical risk factors for CVD, as well as self-rated health.

The predictive role of SRCF may be explained by underlying health issues not being sufficiently adjusted for (ie, reverse causation). Therefore, we also investigated the association between SRCF and CVD and all-cause mortality with additional adjustment for self-rated health and walking pace and by excluding the first few years of follow-up. Additional adjustments for self-rated health and walking pace attenuated the associations, but SRCF remained a significant risk factor for both outcomes. Thus, some of the information held in SRCF overlaps with that of self-rated health, which has previously been shown to be a strong predictor of prognosis in several studies,¹⁸ but SRCF was observed to be positively associated with CVD mortality within each strata of self-rated health, and showing that SRCF contains predictive information independent of self-rated health.

When adding SRCF to traditional risk factors, an improved reclassification was found for both CVD and all-cause mortality. Measured cardiorespiratory fitness by physical exercise test has previously been shown to improve classification of CVD mortality.⁴ However, this is the first study documenting the improved net reclassification improvement for CVD and all-cause mortality from SRCF. Actually, with respect to this measure, adding SRCF to traditional risk factors improved net reclassification improvement for CVD mortality with as much as 30% and all-cause mortality with 25%. In comparison, adding self-reported leisure time physical activity to traditional risk factors only provided a very small improved net reclassification improvement for CVD mortality (0.8%) and all-cause mortality (2.7%). This finding indicates that SRCF can be at least as useful as more-classical risk factors, such as biomarkers for identifying risk for CVD mortality. Thus, SRCF, a very simple, easily obtained measure, may provide valuable information to practicing clinicians and, if confirmed, could prove useful in primary prevention assessment.

Study Strengths and Limitations

The main strengths of the present study are the relatively long follow-up time, inclusion of both males and females in a general population, several objective measures of risk factors

for CVD, and adjustment for traditional risk factors for CVD, as well as factors such as household income, self-rated health, and walking pace.

Limitations of the study are lacking information about cardiorespiratory fitness measured by exercise testing for validation of the question used and comparison, as well as lacking information about changes in SRCF or potential confounders throughout the follow-up period. Moreover, despite of extensive adjustments for classical risk factors for CVD mortality, the observation that those with high SRCF are generally healthier than the other fitness groups at baseline, this may have attributed to the low risk for CVD mortality among those with high SRCF.

Conclusion

The strong independent predicting value, noticeable relation to life expectancy, and substantial risk reclassification improvement of SRCF, when added to traditional risk factors of CVD and all-cause mortality, indicates that SRCF can provide valuable information to practicing clinicians and ought to be considered to be included in primary care visits of the general population.

Disclosures

None.

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