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PAPER

Associations of fitness and fatness with mortality in Russian and American men in the lipids research clinics study

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OBEJECTIVE: To examine the relative size of the effects of fitness and fatness on mortality in Russian men, and to make comparison to US men.
DESIGN: Prospective closed cohort.
SUBJECTS: 1359 Russian men and 1716 US men aged 40–59 y at baseline (1972–1977) who were enrolled in the Lipids Research Clinics Study.
MEASUREMENTS: Fitness was assessed using a treadmill test and fatness was assessed as body mass index (BMI) calculated from measured height and weight. Hazard ratios were calculated using proportional hazard models that included covariates for age, education, smoking, alcohol intake and dietary keys score. All-cause and cardiovascular disease (CVD) mortality were assessed through 1995.
RESULTS: In Russian men, fitness was associated with all-cause and CVD mortality, but fatness was not. For mortality from all causes, compared to the fit-not fat, the adjusted hazard ratios were 0.87 (95% CI: 0.55, 1.37) among the fit-fat, 1.86 (95% CI: 1.31, 2.62) among the unfit-not fat and 1.68 (95% CI: 1.06, 2.68) among the unfit-fat. Among US men, the same hazard ratios were 1.40 (95% CI: 1.07, 1.83), 1.41 (95% CI: 1.12, 1.77) and 1.54 (95% CI: 1.24, 2.06), respectively. There were no statistically significant interactions between fitness and fatness in either group of men for all-cause or CVD mortality.
CONCLUSION: The effects of fitness on mortality may be more robust across populations than are the effects of fatness.
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Introduction

Reports from the Aerobics Center Longitudinal Study have examined the independent and combined effects of fatness and fitness on all-cause and cardiovascular disease (CVD) mortality in men[1–6] and in women.[2,7] These studies examined clients who received medical examinations at the Cooper Institute for Aerobics Research in Dallas, Texas[2] and who were predominantly white, college graduates. The reports from the Aerobics Center Longitudinal Study presented some evidence that fitness was a more potent risk factor for mortality than was fatness. Recently, we reported an analysis of data from a cohort of US women and men drawn from diverse geographic locations examining the inter-related effects of fitness and body mass index (BMI) on all-cause and CVD mortality.[8] We found that both fitness and fatness were associated with mortality from all causes and from CVD and that fit men and women were not protected from increased risk associated with fatness.

Additional studies in other populations are needed. In an effort to broaden the reports on this topic to more diverse groups, we undertook the examination of the fitness and fatness controversy in men living in Russia (previously United Soviet Socialist Republic (USSR)). The current study examines the magnitude of the effects of cardiorespiratory fitness and BMI on mortality from all causes and from CVD

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in Russian men and contrasts those findings with those from US men obtained using the same methodologies and analytic strategies.

Materials and methods

The lipids research clinics (LRC) cohort

The data used in these analyses were collected as part of the Joint US–Russia LRC First Prevalence Studies and the Mortality Follow-up Studies.[9] The US sample was drawn from eight geographically diverse centers in the United States between 1972 and 1976. The Russian sample was drawn from well-defined residential areas of two major cities (Moscow and St Petersburg, previously Leningrad) between 1975 and 1977. In both the US and Russia, a two-stage procedure was used to select participants. A brief initial examination was followed by a more extensive examination. In the Russian sample, the second examination followed the first by 2–6 weeks and in the US sample, the median time between examinations was 96 days. For both cohorts participants in the second examination consisted of a 15% random sample of all visit 1 participants and 100% of those with elevated plasma lipids and those taking lipid-lowering medications. In the US cohort, the response rates for each strata was 85%, and in the Russian cohort, the response rates were 90% for each strata. It was during the second examination that cardiorespiratory fitness measures were obtained, and this examination provided the baseline measures for this study.

The Russian sample included 1989 men 40–59 y of age. Therefore, only men in this age range were included here from the US sample ($n=2354$). Unfortunately, fitness tests were done on only a subsample of the Russian women, and therefore, there were inadequate data to examine associations with fitness in Russian women. Results on associations of fitness and fatness with mortality in US women in the LRC study have been published elsewhere.[8,10] To reduce confounding from pre-existing illness[11,12] participants who died in the first year of follow-up, participants who reported a history of coronary heart disease or stroke and participants with a BMI less than 18.5 kg/m^2 were excluded ($n=306$ Russian and 155 American). Since heart rate response to exercise was used as an indicator of fitness, we excluded participants taking medication that may alter heart rate and participants with heart rates outside our quality control limits (resting heart rate less than 40 or greater than 120 bpm or a maximum heart rate greater than 250 bpm). We also excluded participants with a positive graded exercise test indicating possible CVD and participants with contraindications for participating in the exercise test (eg aortic stenosis, congestive heart failure, excessive blood pressure at rest, R-on-T type premature ventricular contractions, ventricular tachycardia, parasystolic focus, atrial flutter, atrial fibrillation, congenital heart disease).[13] If the duration of the graded exercise test was less than 1 min, participants were excluded since a steady state for exercise was not reached. These criteria resulted in the exclusion of an additional 311 Russian men and 201 American men. Overall, 13 Russian men and 14 US men who were missing data on height, weight or covariates used in our analyses were excluded. The final analysis sample included 3075 men: 1359 from Russia and 1716 from the US.

Measurements

The Russian and US cohorts were studied using uniform protocols and procedures for most variables and a single Coordinating Center. Height and weight were measured with the participant wearing light clothing and no shoes. Weight was measured to the nearest 0.1 kg using a balance scale. Height was measured to the nearest 0.5 cm using a headboard and a vertical rule fixed to a wall. Fatness was assessed as BMI and calculated as weight in kilograms divided by height in meters squared. Quintiles of fatness and fitness were formed using the data from the Russian men in order to maximize the statistical power in that group.

Cardiorespiratory fitness, here called 'fitness' for the remainder of this report, was quantified as the duration of the exercise test in minutes. Participants were told to refrain from eating for 2 h prior to testing and most tests were performed in the morning. The test was conducted according to a Bruce protocol, as described in previous publications.[14–16] Seven, 3-min stages were used in which the speed and inclination were increased in a stepwise fashion as follows: Stage 1–1.7 miles per hour (MPH) and 10% inclination; Stage 2–2.5 MPH and 12% inclination; Stage 3–3.4 MPH and 14% inclination; Stage 4–4.2 MPH and 16% inclination; Stage 5–5.0 MPH and 18% inclination; Stage 6–5.5 MPH and 20% inclination; Stage 7–6.0 MPH and 22% inclination.

The electrocardiogram was monitored continuously and blood pressure was measured at the end of each stage. Heart rate was monitored continuously and was also recorded at the end of each stage, or earlier if the participant stopped during a stage. The test was terminated early if the participant was unable to continue because of chest pain, fatigue, dyspnea, or leg pain or because of abnormalities in the electrocardiogram ($\geq$1 mm horizontal ST-segment change, major arrhythmias or conduction defects), a decrease in systolic blood pressure, technical difficulties, or if participants were unwilling to continue. Otherwise, the test was stopped when the participant attained 90% of predicted maximal heart rate (based on age and physical training[15,17]) and either maintained it for 1 min, maintained it to the end of the stage, or exceeded the target heart rate by 8 bpm, whichever occurred first.[15]

Education was categorized as: less than high school graduate, high school graduate or more than high school. Cigarette smoking was categorized as: current >20 cigarettes per day, current $=20$ cigarettes per day, current <20 cigarettes per day, former or never. Participants were questioned on the type and amount of different types of alcoholic beverages consumed in the past 7 days and average grams of ethanol per day was calculated. Dietary intake was assessed with a 24 h recall and Keys score was calculated as described by Anderson *et al.*[18]

Physical activity was assessed with two questions and categorized as: (1) Very active: Individuals reporting strenuous exercise ≥ 3 times per week; (2) Moderately active: Individuals reporting strenuous activity <3 times per week; (3) Inactive: Individuals reporting no strenuous exercise.[19]

Vital status follow-up

Standardized procedures were used to collect mortality follow-up information on the Russian and US cohorts. Deaths were obtained by annual follow-up contacts with the cohort (predominantly by phone) up to the end of 1987. At the end of 1987, vital status was known on 99.4% of the Russian cohort and 99.6% of the US cohort. Subsequent to 1987 annual follow-up contacts were continued for the Russian cohort, but the US cohort was followed by searching the National Death Index (1988–1991) and the Epidemiology Research Index (1992–1995). Cause of death was ascertained by nosologist's codings (International Classification of Deaths) of the death certificates for the entire follow-up in both countries. We used ICD-9 codes 390–459 to identify CVD deaths. For both cohorts, vital status follow-up through 1995 was used here.

Statistical analysis

Mortality rates were calculated averaging across lipid strata using the inverse of the sampling probability as the weight. Associations between BMI and fitness and mortality were examined using stratified Cox proportional hazards models, with the sampling strata (hyperlipidemics and normolipidemics) as the stratifying variable. These analytic techniques permit inferences to be made to the samples screened at visit 1. The Statistical Analysis System[20] was used to conduct analyses.

Results

The mean BMI and fitness measures were similar in Russian and American men. Among Russian men, 36% were normal weight (BMI 18.5–24.9 kg/m^2), 51% were overweight (BMI 25.0–29.9 kg/m^2) and 13% were obese (BMI $\geq 30\,kg/m^2$). Among US men, 31% were normal weight, 54% were overweight and 15% were obese. The mean (s.d.) time on the treadmill was 9.8 (1.9) min over all Russian men and 9.4 (2.2) min in US men. Metabolic equivalent (MET) values were extrapolated from published exercise intensities,[13,21] and yielded corresponding values of 11.1 METS (stage 4) for Russian men and 10.6 METS (stage 4) for US men. These values represent the capacity required to walk on the treadmill at the corresponding speed and grade. Most participants stopped the exercise test beyond 90% of predicted maximal heart rate. In Russian men, the median was 96.9% (interquartile range 93.0–99.6%) and 97.7% in US men (interquartile range 94.3–100%).

Fitness tended to decline as BMI increased, however, the unadjusted correlation between BMI and fitness was not very high: $r=-0.12$ in Russian men, -0.10 in US men. Among Russian men, 9% who were obese were in the most-fit quintile, while 19% were in the least-fit quintile. Among normal weight Russian men, 42% were in the most-fit quintile, while 34% were in the least fit. For US men, 10% who were obese were in the most-fit quintile, while 20% were in the least-fit quintile. Among normal weight US men, 35% were in the most-fit quintile, while 28% were in the least fit. As shown in Table 1, Russian and US men in the 5th quintile of BMI tended to have lower scores on the graded exercise test compared to men with lower BMI values, and men in the first quintile of fitness tended to be heavier than more fit men.

Overall, dietary Keys scores were similar in the two groups of men (US: 58.5 and Russian: 58.6), while alcohol consumption was higher in US than in Russian men (15.1 and 13.5 g, respectively). The percentage of men in 5th quintile of BMI that had less than a high school education was larger in Russian men (34%) than in American men (18%). Similarly, the proportion of men in the first quintile of fitness who had less than a high school education was also higher among the Russian men (39%) than the American men (11%). Overall, smoking was more prevalent among Russian men (56%) than in US men (35%). The percentage of never smokers was higher in the 5th quintile of BMI than in the other quintiles, and higher in fitness quintiles 2–5 than in the least-fit quintile. Overall, 68% of Russian men and 66% of US men were in the lowest physical activity category.

Confounding by pre-existing illness was tested by examining coefficients for BMI and fitness after excluding participants who died in the first year *vs* the first 4 y of follow-up.[12] The hazard ratios were very similar in both sets of analyses and varied by less than 1%. Therefore, deaths in years 2–4 of follow-up were not excluded.

We examined possible confounding of BMI by cigarette smoking by examining the BMI–mortality association within smokers and nonsmokers in the Russian and US men separately. We used the full covariate adjusted model, and included indicators for former *vs* never smoking in the analyses of nonsmokers and indicators of smoking dose (<20, $=20$, >20 cigarettes per day) in the analyses of the smokers. In analyses that examined BMI in quintiles, there was no evidence that the hazard ratio associated with the lowest quintile of BMI (18.6–22.8 kg/m^2), compared to the second quintile (22.9–24.8 kg/m^2), was elevated in smokers compared to nonsmokers, and there was no evidence of an accentuated J- or U-shape in the smokers compared to the nonsmokers. There was also no indication that the association of elevated BMI with all-cause or CVD mortality was systematically attenuated in smokers compared to nonsmokers in the highest *vs* the lowest quintiles of BMI analysis. In addition, two-way interactions of smoking

Table 1 Description of analysis sample by quintiles of BMI and fitness from the Lipids Research Clinics Prevalence Study

	Russian men (n = 1359)				*United States men (n = 1716)*			
	Mean ± s.d. or percentage				*Mean ± s.d. or percentage*			
	BMI quintiles 1–4	*BMI 5th quintile*	*Fitness 1st quintile*	*Fitness quintiles 2–5*	*BMI quintiles 1–4*	*BMI 5th quintile*	*Fitness 1st quintile*	*Fitness quintiles 2–5*
Age (y)	48.5 ± 5.1	49.0 ± 5.2	50.1 ± 5.4	48.2 ± 5.0	48.4 ± 6.3	48.0 ± 6.2	50.0 ± 6.4	47.5 ± 6.0
BMI (kg/m^2)	24.9 ± 2.3	30.6 ± 1.8	26.8 ± 3.7	26.1 ± 3.1	25.3 ± 2.0	31.2 ± 2.6	27.4 ± 3.8	26.6 ± 3.2
Graded Exercise Test (min)	9.9 ± 1.9	9.3 ± 1.8	7.2 ± 1.3	10.5 ± 1.3	9.5 ± 2.2	9.2 ± 2.1	7.1 ± 1.4	10.6 ± 1.4
Alcohol (g/day)	13.3 ± 21.1	14.0 ± 20.5	13.1 ± 22.1	13.6 ± 20.6	15.0 ± 19.8	15.4 ± 22.1	17.4 ± 23.0	14.0 ± 19.0
Smoking (cigarettes/day)	11.1 ± 11.0	7.5 ± 10.4	11.3 ± 11.3	9.9 ± 10.8	9.7 ± 15.6	9.0 ± 17.1	10.6 ± 16.6	9.0 ± 15.7
Keys Score	58.4 ± 16.0	58.5 ± 16.4	58.6 ± 15.5	58.4 ± 16.3	51.3 ± 15.2	53.6 ± 15.9	51.8 ± 16.3	52.0 ± 15.0
Education (%)								
Less than high school	34	34	39	33	12	18	11	15
High school	26	25	23	26	34	36	32	35
Greater than high school	40	41	39	41	54	48	56	50
Smoking (%)								
Never smoked	20	22	16	21	26	29	23	28
Quit smoking	21	34	24	24	38	40	39	38
Current smoker								
Less than 20/day	22	22	21	22	8	8	8	8
20/day	23	13	23	20	10	7	10	9
Greater than 20/day	14	10	16	12	19	16	21	17
Physical activity (%)								
Very active	31	25	21	32	27	26	17	32
Moderate active	2	1	2	2	7	7	5	7
Not active	67	73	77	66	66	67	79	61

with either BMI quintiles or with fitness quintiles were not significant.

Overall, the age-adjusted rates for mortality from both all causes and CVD mortality were higher in the Russian men (13.5 and 6.5 per 100 000 person-years) than in the US men (9.8 and 3.8 per 100 000 person-years). The number of deaths and the age-adjusted death rates for each quintile of BMI and fitness are shown in Table 2. In Russian men, the highest all-cause mortality rate was seen in the lowest quintile of BMI and the rate tended to decline as BMI increased. This differed from what was seen in US men in whom the highest all-cause death rate was in the quintile with the highest BMI. For CVD mortality there was no pattern among Russian men, but in US men the death rate tended to increase with increasing BMI quintiles. For fitness, the age-adjusted death rate was consistently highest in the least-fit quintile for both all-cause and CVD mortality for both Russian and the US men.

Table 3 shows associations between BMI and all-cause and CVD mortality, with and without adjustment for fitness (in the continuous form). The hazard ratios showed no statistically significant differences among the BMI quintiles in either Russian or American men. The highest BMI quintile tended to be associated with the highest relative risk in all comparisons in the US men. For fitness, the hazard ratio was elevated for the least-fit quintile compared to the most-fit quintile, although the *P*-value for this difference was not less than 0.05 for CVD mortality in the US men. The addition of BMI to the models examining fitness, and the addition of fitness to the models examining BMI changed the hazard ratios only slightly.

Figure 1 shows the hazard ratios for participants categorized as fit-not fat (the reference), fit-fat, unfit-fat, and unfit-not fat. For this analysis, both fitness and fatness were categorized using the highest risk quintile (Quintile 5 for BMI, Quintile 1 for fitness) *vs* all other quintiles combined. In Russian men, the hazard ratios for mortality from all causes (0.87, 95% CI: 0.55, 1.37) and from CVD (0.94, 95% CI: 0.49, 1.81) were not elevated in the fit-fat group, and in fact the point estimates were less than one. The hazard ratios were increased for both outcomes in both the unfit-not fat group and the unfit-fat group. Although the hazard ratio for CVD mortality appeared greater in the unfit-fat men (3.05, 95% CI: 1.74, 5.34) than in the unfit-not fat men (1.85, 95% CI: 1.09, 3.15) the confidence intervals overlapped. In US men, for all-cause mortality, the hazard ratio was increased above the reference for all the groups. For CVD mortality, the hazard ratios were also increased, but the difference was not statistically significant in the fit-fat group (1.32, 95% CI: 0.85, 2.06). Two-way interactions between fitness and fatness were tested for all-cause and CVD mortality in the Russian and the US men and none were statistically significant.

Discussion

In the LRC cohort, fitness was associated with all-cause and CVD mortality in both the US and Russian men. BMI was not

Table 2 All-cause and CVD death rates by quintiles of BMI and fitness for LRC Russian and US men[a]

	BMI[b]		Fitness[c]	
	Number of deaths	Age-adjusted death rate (per 100 000 person-years)	Number of deaths	Age-adjusted death rate (per 100 000 person-years)
Russian men				
All-cause mortality				
Quintile 1	38	18.2	77	19.9
Quintile 2	41	13.2	36	9.2
Quintile 3	45	13.7	32	9.8
Quintile 4	36	9.7	39	13.3
Quintile 5	51	11.9	27	8.8
CVD mortality				
Quintile 1	10	5.0	40	9.8
Quintile 2	15	4.6	18	4.7
Quintile 3	22	7.0	10	2.8
Quintile 4	19	5.1	18	6.2
Quintile 5	32	7.3	12	3.8
US men				
All-cause mortality				
Quintile 1	41	12.0	193	14.0
Quintile 2	79	10.7	80	11.5
Quintile 3	100	10.9	70	12.9
Quintile 4	97	11.1	72	9.0
Quintile 5	143	14.4	45	10.0
CVD mortality				
Quintile 1	16	4.9	80	5.9
Quintile 2	26	3.4	29	4.2
Quintile 3	39	4.3	27	5.1
Quintile 4	43	4.9	23	3.0
Quintile 5	54	5.6	19	4.4

[a]Adjusted for lipid strata and age adjusted using 5-y age strata and the distribution of age in visit 1. [b]Q1: 18.6–22.8, Q2: 22.9–24.8, Q3: 24.9–26.5, Q4: 26.6–28.5, Q5: 28.6–37.4. [c]Q1: 1.5–8.8, Q2: 8.9–9.5, Q3: 9.6–10.2, Q4: 10.3–11.6, Q5: 11.7–18.0.

associated with either outcome in the Russian men. In US men, BMI tended to be a significant predictor of both outcomes but was statistically significant only for all-cause mortality in the final models shown in Figure 1. We have previously reported the association between BMI and CVD and all-cause mortality in 30–74 y-old US men in this cohort.[8] In the current study, the age range of the men included in the study sample was restricted to 40–59 y and the mortality follow-up was truncated by 3 y to match the data available in the Russian men. In addition, the quintiles were formed using the distributions of BMI and fitness in the Russian cohort, and so cut points varied slightly between the studies. All these changes reduced the statistical power available in the US men in the current study compared to the previous study. In both analyses of US men, there were no statistically significant differences in all-cause mortality in BMI quintiles 1–4 (separately) compared to the first BMI quintile, however, in the earlier analysis there was a statistically significant increase in CVD mortality observed, even after controlling for fitness level (hazard ratio for fifth compared to first BMI quintile was 1.56, 95% CI: 1.01, 2.41). In the models that compared the 5th quintile of BMI to quintiles 1–4 (combined), findings were very similar between the two studies and the largest discrepancy noted between the hazard ratios in the two studies was 0.15.

In an earlier report on the Russian men from the LRC study Shestov *et al*[22] found a significant quadratic association between Quetelet Index ($kg/cm^2 \times 1000$) and all-cause and CVD mortality. Their analyses of crude mortality rates showed a sharp elevation in all-cause mortality for men in the lowest quintile of Quetelet Index (23 deaths per 1000 person-years). The lowest mortality rate was observed in the 3rd quintile of Quetelet index (9 deaths per 1000 person-years), and the death rate was somewhat higher in the 5th quintile (10.5 deaths per 1000 person-years). Differences between quintiles of Quetelet Index were smaller for CVD mortality, but followed the same general pattern. This study by Shestov *et al* had only 7 y of follow-up, whereas the follow-up in the current study was as long as 23 y with a mean of 17.6 y. In our analyses an elevated death rate was not observed in the lowest quintile of BMI, and this difference from the previous work may have been due to the exclusions and covariate adjustments used to avoid sources of confounding and/or to the longer follow-up period.

We know of no other studies that have examined associations between fitness and mortality in Russian men, however, two previous papers have examined data obtained during the treadmill test from the Russian men in the LRC study. The first examined blood pressure and heart rate response during the exercise test.[23] The investigators found that Russian men had higher resting systolic blood pressure than US men, but lower blood pressure during exercise. Russian men had significantly lower heart rate at rest and during exercise compared to US men. In the second report,[24] resting heart rate was examined as a predictor of cardiovascular and total mortality. Age- and clinic-adjusted hazard ratios examining a resting heart rate increment of 10 bpm were similar among the Russian and US men for both mortality from all causes (Russian hazard ratio = 1.35, 95% CI: 1.22, 1.55; US hazard ratio = 1.40, 95% CI: 1.23, 1.60). and CVD mortality (Russian hazard ratio = 1.32, 95% CI: 1.13, 1.53; US hazard ratio = 1.42, 95% CI: 1.18, 1.70).

We found that the time on the treadmill was a significant predictor of all-cause and CVD mortality. The results were similar among the Russian and US men, although the hazard ratios comparing the first to the 5th (reference) quintile tended to be larger in the Russian men (over 2 for all-cause and CVD mortality) than in the US men (approximately 1.4–1.5 for the same estimates). Our previous study of US men in a broader range of ages[8] gave similar results with hazard ratios for the first *vs* the 5th quintile of fitness in the range of approximately 1.5–1.6.

In the LRC cohort, the age-adjusted death rate from all causes was 37% higher in Russian men than in US men,

Table 3 Adjusted hazard ratios[a] (95% confidence intervals—CI) by quintiles of BMI and fitness for LRC Russian and US men

	BMI[b]				*Fitness*[c]			
	Hazard ratio	*95% CI*	*Hazard ratio adjusted for fitness*	*95% CI*	*Hazard ratio*	*95% CI*	*Hazard ratio adjusted for BMI*	*95% CI*
Russian men								
All-cause mortality								
Quintile 1	1.00		1.00		2.10	1.32–3.33	2.13	1.34–3.38
Quintile 2	0.87	0.55–1.39	0.90	0.56–1.44	1.05	0.62–1.77	1.07	0.63–1.81
Quintile 3	1.16	0.72–1.86	1.19	0.74–1.92	1.11	0.65–1.88	1.10	0.65–1.87
Quintile 4	0.84	0.51–1.38	0.88	0.53–1.44	1.42	0.84–2.38	1.41	0.84–2.38
Quintile 5	0.92	0.57–1.47	0.88	0.55–1.41	1.00		1.00	
CVD mortality								
Quintile 1	1.00		1.00		2.23	1.16–4.29	2.17	1.12–4.18
Quintile 2	1.04	0.45–2.43	1.07	0.46–2.50	1.01	0.48–2.14	0.98	0.46–2.07
Quintile 3	1.83	0.82–4.08	1.88	0.84–4.22	0.65	0.27–1.54	0.65	0.27–1.54
Quintile 4	1.33	0.58–3.03	1.40	0.61–3.21	1.25	0.58–2.68	1.25	0.58–2.68
Quintile 5	1.82	0.84–3.95	1.74	0.80–3.79	1.00		1.00	
US men								
All-cause mortality								
Quintile 1	1.00		1.00		1.54	1.10–2.14	1.51	1.08–2.11
Quintile 2	0.87	0.60–1.28	0.86	0.59–1.25	1.28	0.88–1.84	1.27	0.88–1.83
Quintile 3	0.88	0.61–1.27	0.90	0.62–1.30	1.33	0.91–1.95	1.34	0.92–1.95
Quintile 4	0.90	0.62–1.31	0.88	0.61–1.28	1	0.69–1.46	1	0.69–1.45
Quintile 5	1.15	0.80–1.65	1.11	0.77–1.59	1.00		1.00	
CVD mortality								
Quintile 1	1.00		1.00		1.45	0.86–2.43	1.43	0.85–2.40
Quintile 2	0.72	0.38–1.34	0.71	0.38–1.32	1.07	0.60–1.92	1.06	0.59–1.91
Quintile 3	0.87	0.48–1.56	0.90	0.50–1.63	1.20	0.66–2.18	1.20	0.66–2.19
Quintile 4	0.98	0.55–1.76	0.96	0.53–1.72	0.74	0.40–1.36	0.74	0.40–1.35
Quintile 5	1.07	0.60-1.91	1.02	0.57–1.82	1.00		1.00	

[a]Adjusted for age, smoking, education, alcohol, and Keys score. [b]Q1: 18.6–22.8, Q2: 22.9–24.8, Q3: 24.9–26.5, Q4: 26.6–28.5, Q5: 28.6–37.4. [c]Q1: 1.5–8.8, Q2: 8.9–9.5, Q3: 9.6–10.2, Q4: 10.3–11.6, Q5: 11.7–18.0.

whereas the CVD death rate was 70% higher. During the years of this study of Russian men (1975–1995) there were important social, political and economic changes in Russia that dramatically impacted the death rate. After World War II life expectancy in Russia rose rapidly, and for the first time in recorded history became similar to that of Western countries. In 1965, male life expectancy was 64.3 y in Russia compared to 67.5 in France and 66.8 in the United States.[25] As summarized by Notzon *et al*,[26] after that time life expectancy went through two decades of decline in Russia, while it increased steadily in the United States. Between 1985 and 1987 life expectancy abruptly increased in Russia. This increase has been attributed to the sudden drop in per capita alcohol consumption brought about by Gorbachev's anti-alcohol campaign, and may also have been stimulated by the period of 'perestroika' that introduced the notion of social democratization. However, between 1990 and 1994 life expectancy in Russia again dropped and the age-adjusted mortality rates rose by approximately 33%. In 1994, life expectancy for Russian men was 57.7 y compared to 72.4 y in US men. The most important contributors to this decline in life expectancy were cardiovascular diseases (36%) and injuries (29%).[26]

Given the differences in the patterns of mortality in the two nations over the study period it is remarkable that the associations with fitness were so similar between the two groups of men, while the associations with BMI were different. One possible explanation for this difference is that the association between BMI and mortality was attenuated by confounding, while the association between fitness and mortality was not. We can only speculate on this point.

One potential confounding factor is alcohol intake. Self-report of alcohol intake is known to be susceptible to subject response bias related to social desirability. The Russian data reported here were collected between 1975 and 1977, which was 5–10 y before aggressive public health measures to limit alcohol intake were instituted. Therefore, it does not seem very likely that this group of Russian men would be strongly motivated to under-report alcohol consumption. Further, it seems unlikely that reported alcohol consumption would be differentially biased by weight status, but not by fitness status. Nevertheless, it is troublesome that reported alcohol intake was slightly lower in the Russian men than in the US men in this study, as other studies indicate the opposite.[27]

Of course, many factors other than alcohol differed between the Russian and the US men in this study and

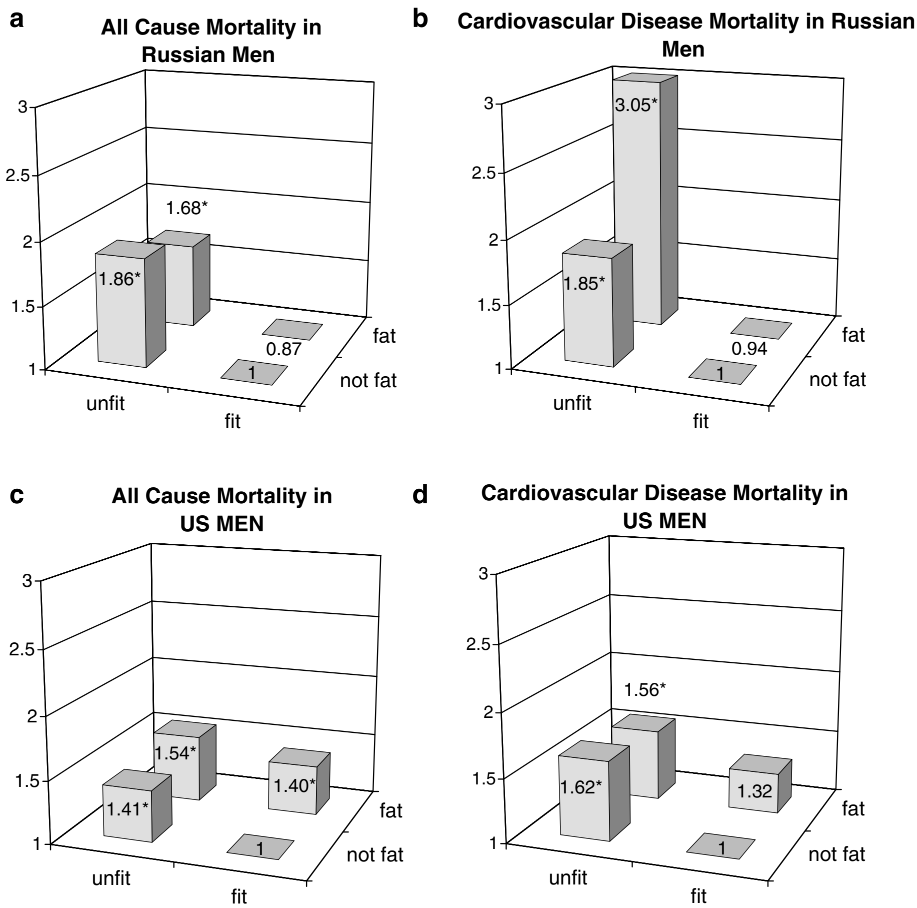

Figure 1 Relative hazard in LRC participants categorized by fitness level (quintile 1 *vs* 2–5) and BMI (quintiles 1–4 *vs* 5) adjusted for age, education, smoking, alcohol, and Keys score. $* = P < 0.05$. Hazard ratios were calculated using the fit-not fat group as the reference. Estimates and 95% confidence intervals (CI) for the fit-fat, the unfit-not fat and the unfit-fat were: all-cause mortality in Russian men, 0.87 (0.55, 1.37), 1.86 (1.31, 2.62), 1.68 (1.06, 2.68); CVD mortality in Russian men, 0.94 (0.49, 1.81), 1.85 (1.09, 3.15), 3.05 (1.74, 5.34); all-cause mortality in US men, 1.40 (1.07, 1.83), 1.41 (1.12, 1.77), 1.54 (1.24, 2.06); CVD mortality in US men, 1.32 (0.85, 2.06), 1.62 (1.01, 2.58), 1.56 (1.08, 2.24).

could have influenced the measured effect of BMI on mortality. Some other potential factors are tobacco use, diet, stress and depression, health care availability and pollution. Although we attempted to control for the effects of tobacco use and diet in our analysis, residual confounding could still remain for these factors. We were unable to control for the other factors.

This study has several strengths and limitations. As in our previous study[8] we chose to form joint categories of fitness and fatness drawing the cut point at the boundary of the highest risk quintile for both BMI and fitness. This method of categorization is arbitrary, but it has the advantage of providing a cut point for the two different measures that is equivalent in at least one aspect, that is, as marker of the 20% at highest risk among the population studied. Other methods of defining these groups could have been used. It should also be noted that BMI is an imperfect measure of adiposity and a more precise measure of body composition could have given different results.

The cohorts studied were not nationally representative samples of either US men or Russian men, but they were drawn from well-defined groups. It is a weakness that the comparability of the nosologists' diagnoses of primary cause of death in the US *vs* in Russia is not known. Because of this, comparisons of cause-specific deaths must be made with caution. It is a strength of the study that the cohorts drawn from such different locations were studied using the same procedures and a single coordinating center.

This study of two populations of men living in very different environments was able to compare the effects of fitness and fatness on mortality. As has been shown before, both fitness and fatness were associated with all-cause and CVD mortality in American men. However in the Russian men, fitness but not fatness, was associated with both types of mortality. This study gives some indication that the effects of fitness on mortality may be more robust across populations than are the effects of fatness.

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