

Cardiorespiratory Fitness as a Feature of Metabolic Syndrome in Older Men and Women

The Dose-Responses to Exercise Training Study (DR's EXTRA)

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OBJECTIVE — We studied the associations of cardiorespiratory fitness with metabolic syndrome in older men and women, because such data are limited in representative population samples.

RESEARCH DESIGN AND METHODS — We studied a population sample of 671 men and 676 women aged 57–79 years at baseline of a randomized controlled intervention study. We assessed maximal oxygen uptake (VO_{2max}) by respiratory gas analysis during a maximal bicycle exercise test.

RESULTS — VO_{2max} had a strong, inverse, and graded association with the risk of having metabolic syndrome as defined by the National Cholesterol Education Program criteria. Men and women in the lowest third of VO_{2max} had 10.2- and 10.8-fold higher risks and those in the middle third had 2.9- and 4.7-fold higher risks ($P < 0.001$ all) of metabolic syndrome than those with the highest VO_{2max} after multivariable adjustments. Factor analysis generated a principal factor that was strongly loaded by the main components of metabolic syndrome and VO_{2max} (-0.68 in men and -0.70 in women).

CONCLUSIONS — Low cardiorespiratory fitness is associated with metabolic syndrome in older men and women. Our findings suggest that low cardiorespiratory fitness could be considered a feature of metabolic syndrome.

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The epidemic of metabolic syndrome is due in part to sedentary lifestyle, poor cardiorespiratory fitness, unhealthy diet, and increased overweight and obesity (1). Metabolic syndrome is associated with an increased risk of type 2 diabetes, cardiovascular disease (CVD), and premature mortality (2,3). Higher levels of physical activity and cardiorespiratory fitness have been associated with a decreased risk of developing metabolic syndrome (4–7) and its consequences of

type 2 diabetes, CVD, and premature mortality (8–11).

Only a few population-based studies have been published on the association of cardiorespiratory fitness with metabolic syndrome (4,5,7,12,13). Most have included only young and middle-aged individuals or men and have used indirect measurements of maximal oxygen uptake (VO_{2max}). We have previously found strong association of a low VO_{2max} with an increased risk of having or developing

metabolic syndrome in middle-aged men (4,12). Based on factor analysis, we have suggested that poor cardiorespiratory fitness could be considered a feature of metabolic syndrome (12).

We assessed the association of directly measured VO_{2max} with metabolic syndrome and impaired glucose metabolism in a large population sample of older men and women. Because metabolic syndrome consists of highly correlated features, factor analysis was used as a complementary statistical approach. The present study extends our knowledge on the association of cardiorespiratory fitness with metabolic syndrome in middle-aged men (12) to older men and women, the fastest growing segment of the population.

RESEARCH DESIGN AND METHODS

We used the baseline data of the Dose-Responses to Exercise Training Study (DR's EXTRA), which is an ongoing 4-year randomized controlled trial on the health effects of regular physical exercise and diet. The subjects were a representative population sample of 1,500 men and 1,500 women aged 55–74 years from the city of Kuopio in Eastern Finland. Of these individuals, 1,479 participated in the baseline examinations in 2005–2006. The exclusion criteria were conditions that inhibit safe engagement in exercise training, malignant diseases, and conditions considered to prevent cooperation. The present study population consisted of 1,347 individuals (671 men and 676 women) aged 57–79 years who had complete data on VO_{2max} , glucose metabolism, and metabolic syndrome and did not have type 1 diabetes. Of these individuals, 564 men and 613 women did not have type 2 diabetes. The study protocol was approved by the ethics committee of the University of Kuopio and Kuopio University Hospital. All participants gave written informed consent.

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Abbreviations: CVD, cardiovascular disease; IGR, impaired glucose regulation.

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Assessment of cardiorespiratory fitness

Cardiorespiratory fitness was assessed during a symptom-limited maximal exercise stress test to exhaustion on an electrically braked cycle ergometer (ergoline, Bitz, Germany). The tests were supervised by physicians according to a standardized test protocol with a warm-up of 3 min at 20 W and a 20-W increase in the workload per minute. Participants were verbally encouraged to maximal exertion. Oxygen consumption was measured directly by the breath-by-breath method using the VMax respiratory gas analyzer (SensorMedics, Yorba Linda, CA). $\dot{V}O_{2\max}$ was defined as the mean of the three highest values of the averaged oxygen consumption measured consecutively over 20-s intervals. A total of 98% of the subjects achieved the respiratory exchange ratio of ≥ 1.1 . Electrocardiography was recorded throughout the exercise test using Cardiosoft software (GE Medical Systems, Freiburg, Germany).

Other assessments

Blood samples were taken after a 12-h fast. Serum total, LDL, and HDL cholesterol and triglycerides were measured by enzymatic photometric methods. Fasting plasma glucose was measured by the hexokinase method. A 2-h oral glucose tolerance test with a 75-g glucose load was performed after a 12-h fast excluding individuals with diagnosed type 2 diabetes. BMI was calculated from height and weight. Waist circumference was measured mid-distance between the bottom of the rib cage and the top of the iliac crest. Hip circumference was measured at the level of the trochanter major. Blood pressure was recorded in a sitting position after a 5-min rest. Prevalent diseases, use of medications, alcohol consumption, and smoking status were assessed by a questionnaire.

Classification of glucose tolerance

On the basis of the World Health Organization criteria, the subjects were classified as having normal glucose tolerance if the fasting glucose was < 6.1 mmol/l and 2-h glucose was < 7.8 mmol/l, impaired fasting glucose if the fasting glucose was 6.1–6.9 mmol/l and 2-h glucose was < 7.8 mmol/l, impaired glucose tolerance if the fasting glucose was < 7.0 mmol/l and 2-h glucose was 7.8–11.1 mmol/l, and type 2 diabetes if the fasting glucose was ≥ 7.0 mmol/l or 2-h glucose was ≥ 11.1 mmol/l or type 2 diabetes had been diagnosed previously. Impaired glucose regulation

(IGR) was defined as the presence of impaired fasting glucose or impaired glucose tolerance.

Definition of metabolic syndrome

Metabolic syndrome was defined by the National Cholesterol Education Program criteria (14) based on the presence of elevated blood pressure ($\geq 130/85$ mmHg or drug treatment), increased fasting plasma glucose (≥ 6.1 mmol/l), low serum HDL cholesterol (< 1.03 mmol/l in men and < 1.29 mmol/l in women), high serum triglycerides (≥ 1.7 mmol/l), and abdominal obesity (waist circumference > 102 cm in men and > 88 cm in women). The existence of at least three risk factors was defined as metabolic syndrome.

Statistical analyses

$\dot{V}O_{2\max}$ was used as a continuous variable and categorized into thirds separately in men and women. Differences in clinical and biochemical characteristics were analyzed using independent-samples *t* test, Mann-Whitney test, or χ^2 -test as appropriate. The heterogeneity of the means of the components of metabolic syndrome among the thirds of $\dot{V}O_{2\max}$ was tested using analysis of covariance, adjusted for age, smoking, alcohol consumption, and a prevalent CVD. CVD was considered present if the subject reported a history of angina pectoris, myocardial infarction, coronary artery bypass surgery, percutaneous transluminal coronary artery angioplasty, stroke, transient ischemic attack, or peripheral artery disease. The association of $\dot{V}O_{2\max}$ with metabolic syndrome or IGR was studied using logistic regression analysis.

As a complementary approach for assessing the associations of cardiorespiratory fitness with the risk of metabolic syndrome, factor analysis was carried out using core components of or factors related to metabolic syndrome and $\dot{V}O_{2\max}$. Principal component analysis was used for the extraction of the initial factors. Factors with eigenvalues > 1.0 were retained to the analysis. The initial factors were then subjected to promax rotation. For interpretation, we considered variables with an absolute value ≥ 0.40 to be heavily loaded and 0.30–0.39 to be moderately loaded on the factor. All statistical analyses were performed using SPSS for Windows (release 11.5; SPSS, Chicago, IL). $P < 0.05$ was considered significant.

RESULTS— Men and women with metabolic syndrome had a lower $\dot{V}O_{2\max}$

and more pronounced features of metabolic syndrome than those without it (Table 1). As a continuous variable, a 1-SD decrease in $\dot{V}O_{2\max}$ in men ($6.3 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) and women ($4.9 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$) was associated with a 3.2-fold (95% CI 2.45–4.10, $P < 0.001$) increase in the risk of having metabolic syndrome in men and a 3.1-fold (2.39–4.00, $P < 0.001$) increase in women, adjusted for age, smoking, alcohol consumption, and CVD. Further adjustment for waist circumference (OR 1.5 [95% CI 1.09–2.03], $P = 0.012$, in men; 1.4 [1.00–1.90], $P = 0.053$, in women) or BMI (1.8 [1.31–2.36], $P < 0.001$, in men; 1.5 [1.12–2.07], $P = 0.008$, in women) weakened the association. Further adjustment for other components of metabolic syndrome had much more modest effects on the associations (ORs 2.4–3.1 in men and 2.7–3.0 in women, data not shown). When $\dot{V}O_{2\max}$ was expressed as liters per minute, a 1-SD decrease in $\dot{V}O_{2\max}$ was associated with a 1.8-fold (1.37–2.31, $P < 0.001$) increase in the risk of having metabolic syndrome in men and a 1.4-fold (1.10–1.87, $P = 0.007$) increase in women, adjusted for age, smoking, alcohol consumption, CVD, and body weight.

In men and women, $\dot{V}O_{2\max}$ was associated with all of the components of metabolic syndrome (Table 2). $\dot{V}O_{2\max}$ had a strong, inverse, and graded association with metabolic syndrome (Table 2). Men in the lowest third of $\dot{V}O_{2\max}$ had a 10.2 times higher and women in the lowest third of $\dot{V}O_{2\max}$ had a 10.8 times higher risk of having metabolic syndrome than those in the highest $\dot{V}O_{2\max}$ after these adjustments (Table 2).

The association between $\dot{V}O_{2\max}$ and the risk of metabolic syndrome seemed to be stronger in men > 70 years of age than in other men. The risk of having metabolic syndrome in men aged < 61 , 61–65, 66–70, and > 70 years increased 3.0 (95% CI 1.81–5.13, $P < 0.001$), 2.6 (1.60–4.08, $P < 0.001$), 3.0 (1.90–4.90, $P < 0.001$), and 6.3 (3.07–13.16, $P < 0.001$)-fold, respectively, with a 1-SD decrease in $\dot{V}O_{2\max}$. In women, age did not materially modify the association (OR 2.4–4.5, $P < 0.001$ for all age groups).

In men and women without diabetes, there was an inverse association between $\dot{V}O_{2\max}$ and the risk of having IGR. A 1-SD decrease in $\dot{V}O_{2\max}$ was associated with a 1.4-fold (95% CI 1.15–1.78, $P = 0.001$) increase in the risk of IGR in men and with a 1.6-fold (1.25–2.08, $P < 0.001$) increase in the risk in women, adjusted

Table 1—Characteristics of men and women according to the presence of the metabolic syndrome

	Men			Women		
	No metabolic syndrome	Metabolic syndrome	P for difference	No metabolic syndrome	Metabolic syndrome	P for difference
n	487	184		507	169	
Age (years)	66.4 ± 5.4	65.9 ± 5.6	0.272	66.6 ± 5.3	66.4 ± 5.3	0.607
Height (cm)	173.5 ± 6.0	173.8 ± 6.2	0.582	160.0 ± 6.0	160.0 ± 5.4	0.985
Weight (kg)	79.7 ± 10.9	93.8 ± 14.7	<0.001	66.6 ± 10.0	82.2 ± 13.6	<0.001
BMI	26.4 ± 3.0	31.0 ± 4.3	<0.001	26.0 ± 3.8	32.1 ± 4.9	<0.001
Waist circumference (cm)	95.3 ± 8.9	108.6 ± 10.7	<0.001	84.3 ± 10.4	101.6 ± 11.1	<0.001
Hip circumference (cm)	97.7 ± 6.5	105.4 ± 8.8	<0.001	99.0 ± 7.9	110.2 ± 10.0	<0.001
VO _{2max} (ml · kg ⁻¹ · min ⁻¹)	27.8 ± 6.1	22.7 ± 5.4	<0.001	21.8 ± 4.9	18.1 ± 3.6	<0.001
Alcohol consumption (doses/week)	6.3 ± 7.9	6.5 ± 8.4	0.510	2.4 ± 4.7	1.8 ± 2.9	0.398
Smoking (never/past/current)	39/49/12	23/56/21	<0.001	74/19/7	73/19/8	0.778
Fasting plasma glucose (mmol/l)	5.7 ± 0.6	6.7 ± 1.3	<0.001	5.4 ± 0.5	6.3 ± 1.2	<0.001
Serum total cholesterol (mmol/l)	4.9 ± 0.9	4.8 ± 1.0	0.332	5.3 ± 0.9	5.1 ± 1.0	0.037
Serum LDL cholesterol (mmol/l)	3.2 ± 0.8	3.2 ± 0.9	0.991	3.2 ± 0.8	3.3 ± 0.9	0.664
Serum HDL cholesterol (mmol/l)	1.6 ± 0.4	1.2 ± 0.3	<0.001	2.0 ± 0.5	1.5 ± 0.4	<0.001
Serum triglycerides (mmol/l)	1.2 ± 0.5	2.0 ± 1.0	<0.001	1.1 ± 0.4	1.9 ± 0.8	<0.001
Systolic blood pressure (mmHg)	144.7 ± 19.2	147.5 ± 18.0	0.090	148.9 ± 21.0	153.9 ± 20.9	0.007
Diastolic blood pressure (mmHg)	83.9 ± 9.2	85.1 ± 9.8	0.166	81.6 ± 8.7	84.6 ± 9.8	<0.001
IFG/IGT/diabetes	12/9/8	20/16/38	<0.001	4/9/3	15/17/28	<0.001
Cardiovascular disease	25	32	0.052	17	21	0.328
Lipid-lowering medication	33	41	0.046	31	44	0.003
Antihypertensive medication	35	57	<0.001	33	69	<0.001
No. metabolic risk factors	1.3 ± 0.6	3.5 ± 0.7	<0.001	1.3 ± 0.7	3.5 ± 0.7	<0.001

Data are presented as means ± SD or percentages (%). P values are from independent-samples t test, Mann-Whitney test, or χ^2 test as appropriate. For glucose and triglycerides, P values were derived from log-transformed values. BMI was calculated as weight in kilograms divided by the square of height in meters. IFG, impaired fasting glucose; IGT, impaired glucose tolerance.

for age, smoking, alcohol consumption, and CVD. Men and women in the lowest third of VO_{2max} had a 2.4 times higher risk of IGR than those in the highest third of VO_{2max} (Table 2).

In the factor analysis containing core components of metabolic syndrome, cardiorespiratory fitness, smoking, and alcohol consumption, four first-degree factors with eigenvalues >1 were extracted and rotated using the promax method. These factors explained 62% of the total variance. The factor explaining the greatest proportion of the total variance (29% in

men and 30% in women) had heavy loadings by the core components of metabolic syndrome and VO_{2max} (Table 3). The second strongest factor had heavy loadings by measures of dyslipidemia in both men and women.

CONCLUSIONS— We found that cardiorespiratory fitness had a strong, inverse, graded, and independent association with the risk of metabolic syndrome in a population-based sample of older men and women. Men and women who were in the lowest sex-specific third of

VO_{2max} had a 10 times higher risk of metabolic syndrome than those who were in the highest third. Low cardiorespiratory fitness was also associated with IGR in men and women without diabetes, but the relationship was weaker than that for metabolic syndrome.

The present results support the findings of cross-sectional (12,15,16) and prospective (4–7) studies concerning the association of cardiorespiratory fitness with metabolic syndrome. In a cross-sectional population-based study, middle-aged men who were in the lowest

Table 2—Components of metabolic syndrome and ORs for metabolic syndrome and IGR according to sex-specific thirds of maximal oxygen uptake

	Thirds in men			P
	<23.3 ml · kg ⁻¹ · min ⁻¹	23.3–29.1 ml · kg ⁻¹ · min ⁻¹	>29.1 ml · kg ⁻¹ · min ⁻¹	
Waist circumference (cm)	107.2	98.7	90.9	<0.001
BMI (kg/m ²)	30.5	27.4	25.2	<0.001
Plasma glucose (mmol/l)	6.3	5.9	5.8	<0.001
Serum triglycerides (mmol/l)	1.7	1.4	1.2	<0.001
Serum HDL cholesterol (mmol/l)	1.4	1.5	1.7	<0.001
Systolic blood pressure (mmHg)	148.0	145.8	142.7	0.027
Diastolic blood pressure (mmHg)	85.6	84.3	82.8	0.015
OR (95% CI) for metabolic syndrome	10.2 (5.79–17.96)	2.9 (1.68–4.96)	1	<0.001
OR (95% CI) for IGR	2.4 (1.45–4.03)	1.3 (0.85–2.14)	1	0.001

	Thirds in women			P
	<18.4 ml · kg ⁻¹ · min ⁻¹	18.4–22.8 ml · kg ⁻¹ · min ⁻¹	>22.8 ml · kg ⁻¹ · min ⁻¹	
Waist circumference (cm)	96.9	89.1	79.8	<0.001
BMI (kg/m ²)	30.7	27.6	24.3	<0.001
Plasma glucose (mmol/l)	5.9	5.6	5.4	<0.001
Serum triglycerides (mmol/l)	1.5	1.4	1.1	<0.001
Serum HDL cholesterol (mmol/l)	1.7	1.8	2.0	<0.001
Systolic blood pressure (mmHg)	153.0	151.0	146.4	0.005
Diastolic blood pressure (mmHg)	83.6	83.2	80.3	<0.001
OR (95% CI) for metabolic syndrome	10.8 (5.98–19.34)	4.7 (2.64–8.45)	1	<0.001
OR (95% CI) for IGR	2.4 (1.38–4.23)	1.6 (0.93–2.85)	1	0.002

Values are means and *P* values for differences among thirds from ANCOVA or ORs (95% CI) and *P* values for trends across thirds from logistic regression analysis. Data are adjusted for age, smoking, alcohol consumption, and CVD. For glucose and triglycerides, *P* values were derived from log-transformed values. BMI was calculated as weight in kilograms divided by the square of height in meters.

third of directly measured $\text{VO}_{2\text{max}}$ were almost 7 times more likely to have metabolic syndrome than those in the highest third (12). In a 4-year follow-up of these men, those who were in the upper third of directly measured $\text{VO}_{2\text{max}}$ were 75% less likely to develop metabolic syndrome than those in the lower third (4). In a 15-year population study, young adults with

poor fitness were 3–6 times more likely to develop diabetes, hypertension, and metabolic syndrome than those with high fitness (7). In two studies, cardiorespiratory fitness was only weakly associated with metabolic syndrome or its development (5,13).

Both low cardiorespiratory fitness and metabolic syndrome are important

and independent risk factors for type 2 diabetes (3,10), progression of carotid atherosclerosis (17,18), CVD, and all-cause mortality (2,8,9). Metabolic syndrome and type 2 diabetes may be a stronger predictor for future risk of CVD in women than in men (19). A sedentary lifestyle lowers cardiorespiratory fitness, impairs glucose homeostasis, and in-

Table 3—Loadings of 12 variables related to metabolic syndrome on the four factors extracted and rotated (promax) with factor analysis and the variance explained by each factor

Factor	Men				Women			
	1	2	3	4	1	2	3	4
Proportion of variance (%)	29	12	11	10	30	12	10	10
Waist girth	0.79	0.19	0.19	0.003	0.93	-0.07	-0.10	0.11
BMI	0.78	0.20	0.14	0.04	0.93	-0.12	-0.04	0.10
Plasma glucose	0.75	-0.17	0.03	0.23	0.64	0.01	0.18	0.05
2-h glucose load	0.68	-0.09	-0.09	0.40	0.57	0.07	0.38	-0.03
Serum triglycerides	0.25	0.67	-0.02	-0.04	0.28	0.58	-0.08	-0.19
Serum HDL cholesterol	-0.28	-0.50	0.39	0.23	-0.30	-0.39	0.22	0.33
Serum LDL cholesterol	-0.40	0.79	0.18	0.28	-0.31	0.91	0.15	0.21
Systolic blood pressure	0.28	0.07	-0.05	0.84	0.26	0.15	0.65	0.21
Maximal oxygen uptake	-0.68	0.05	0.05	0.07	-0.70	0.03	-0.11	0.02
Alcohol consumption	0.09	0.04	0.85	0.03	0.14	0.06	-0.10	0.88
Smoking	0.17	-0.05	0.59	-0.44	0.04	0.09	-0.71	0.41

creases the risk of type 2 diabetes (10,11), CVD, and premature mortality (8,9).

The prevalence of metabolic syndrome was 27% in men and 25% in women. These rates are comparable to those reported previously (1). Aging per se is associated with an increase and redistribution of body fat, a decrease in skeletal muscle mass, worsening of insulin resistance, and hormonal alterations (20), all of which are important in the development of metabolic syndrome (1). The association of cardiorespiratory fitness with metabolic syndrome seemed to be stronger in men aged >70 years, but otherwise age did not seem to influence the magnitude of the relationship.

The overall findings of the present study hold in men and women after adjustment for several important confounders. Of the individual components of metabolic syndrome, waist circumference markedly weakened the association between cardiorespiratory fitness and metabolic syndrome. Abdominal obesity is closely inversely related to cardiorespiratory fitness and is a core component of metabolic syndrome (1). This is probably in part because a sedentary lifestyle predisposes to weight gain and increased central fat accumulation (7). Moreover, a sedentary lifestyle may reduce cardiorespiratory fitness. BMI attenuated the association of VO_{2max} with metabolic syndrome less than waist circumference, which further suggests that waist circumference is a more useful measure of fat accumulation in the assessment of metabolic syndrome. Other components of metabolic syndrome explained only a small part of the association between cardiorespiratory fitness and metabolic syndrome. Cardiorespiratory fitness was associated with metabolic syndrome also when expressed as absolute values in liters per minute, controlled by body weight.

Factor analysis reduces a large number of correlated variables to fewer factors that can be used to explain and reflect complex underlying phenomena (21), such as those in metabolic syndrome (12,22,23). However, only a few studies have included cardiorespiratory fitness in factor analyses (12). We found a principal factor that had heavy loadings by the main components of metabolic syndrome and cardiorespiratory fitness in men and women aged 57–79 years. Taken together with our previous study among men aged 42–60 years from the same region in Eastern Finland (12), poor cardiorespiratory

fitness could be considered a component of metabolic syndrome.

Others have observed various separate factors with loadings by measures of obesity, dyslipidemia, glucose intolerance, and blood pressure (22,23). These studies have used the varimax rotation, which generates uncorrelated factors that may not reflect the pathophysiological process underlying metabolic syndrome (24). The promax rotation in the present study produced metabolic syndrome factors that correlated strongly with VO_{2max} and the main components of metabolic syndrome. The higher loadings of waist circumference compared with plasma glucose in the principal factor support evidence that central fat accumulation is a strong component of metabolic syndrome and common to each of the other components of the syndrome. Lipids were included in more than one factor. LDL cholesterol is not considered a component of metabolic syndrome (14), which may explain the small and negative loading in the principal factor and high positive loading on the second factor, which could be termed the lipid factor. The small negative loading of LDL cholesterol may also occur in part because in the metabolic syndrome, LDL cholesterol particle size is small (14). If the decrease in LDL particle size is greater than the increase in particle number, this could be reflected in slightly lower LDL cholesterol concentrations, even though LDL concentrations have not been consistently associated with metabolic syndrome. These findings suggest that although metabolic syndrome may differ in its manifestations, there is still a common underlying pathophysiological process that explains the syndrome in most individuals. Abdominal obesity and poor cardiorespiratory fitness seem to be closely related to the underlying metabolic process.

The large representative population sample of older men and women is a strength of the present study. Few such data are available, particularly in women. VO_{2max} was assessed directly using a respiratory gas exchange analysis during a maximal cycle ergometer test, which is an accurate and highly reproducible measure of cardiorespiratory fitness (25). Factor analysis was used as a complementary measure to assess the relationship of cardiorespiratory fitness with metabolic syndrome. Metabolic syndrome was defined by widely used international criteria (14). We did not have a measure of insulin resistance, but detailed assessments of other

features of metabolic syndrome and glucose tolerance partly offset this limitation. We observed a dose-response relationship across the thirds of VO_{2max} for the prevalence of metabolic syndrome and IGR, but determinations of causality cannot be made because of the cross-sectional study design.

Low cardiorespiratory fitness is closely associated with the risk of metabolic syndrome and IGR in older men and women and can be considered a feature of metabolic syndrome. The measurement of VO_{2max} even in individuals with relatively few metabolic risk factors may enable targeting of interventions to decrease the future risk of metabolic disturbances that eventually culminate in chronic and progressive diseases such as type 2 diabetes and CVD. On the basis of the present study, maintenance of good cardiorespiratory fitness by regular physical activity is likely to be important in the prevention of metabolic syndrome.

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