The Tromsø study: physical fitness, self reported physical activity, and their relationship to other coronary risk factors

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Abstract

Study objective—The aim was to investigate the associations between physical fitness, leisure physical activity, and coronary risk factors.

Design—This was a cross sectional study of a random sample of men and women, following a population survey.

Setting—The municipality of Tromsø, Norway in 1986-1987.

Participants—All men born 1925-1966 and all women born 1930-1966 were invited to the survey; 21 826 subjects attended (81% of the eligible population): of these, 297 men and 312 women, randomly selected, attended the present study (attendance rates 94% in men and 89% in women).

Measurements and main results—Fitness was tested by bicycle ergometry. Physical activity was reported on a questionnaire. Multiple regression analysis was performed with fitness and leisure activity as dependent variables, and coronary risk factors as independent variables. Fitness and leisure activity were positively related ($p < 0.05$). Prominent findings for fitness were negative associations with age and smoking ($p < 0.05$), and positive associations with body mass index in both sexes ($p < 0.01$). HDL cholesterol and systolic blood pressure were significant predictors of fitness in men ($p < 0.01$). Smoking emerged as a strong negative predictor for leisure activity in women ($p < 0.01$), and a negative relation between leisure activity and total cholesterol was found in men ($p < 0.01$).

Conclusions—The study indicates that coronary risk factors are more closely linked to physical fitness than to leisure physical activity.

physical activity. The present report aims at studying cross sectionally both the physical performance and the self reported physical activity levels in the same population, their intercorrelations and the associations with other coronary heart disease risk factors.

Methods

In 1986-87, 28 847 subjects were invited to take part in a health survey in the municipality of Tromsø. This included all men born between 1925 and 1966, and all women born between 1930 and 1966. Among the invited subjects, 49 were dead, 1600 had moved, and 583 were temporarily living outside Tromsø during the screening period, giving 26 615 as the eligible population; of these, 21 826 subjects attended the screening (179 without invitation), giving an attendance rate of 81.3% of the eligible population. The screening programme started August 1986 and was finished April 1987. Enclosed with the letter of invitation was a questionnaire covering among others the following aspects: previous cardiovascular disease, physical activity at work and in leisure time, and smoking habits. The participants were asked to fill in the questionnaire at home and return it at the examination. This questionnaire was almost identical to those used in the former studies in Tromsø.^{20 21} The examination comprised checking the questionnaire for inconsistency, measurements of weight, height, and blood pressure, and the collection of venous non-fasting blood samples for measurements of blood lipids.

Total cholesterol and triglycerides were analysed in fresh serum by enzymatic colorimetric methods with commercial kits (CHOD-PAP, Boehringer Mannheim, for cholesterol, and GPO-PAP, Boehringer Mannheim, for triglycerides). High density lipoprotein (HDL) cholesterol was determined after precipitating serum with $MgCl_2$. The laboratory analyses were performed by the Division of Clinical Chemistry, University Hospital of Tromsø.

In the questionnaire, physical activity in leisure time was graded from I to IV according to which of the following categories could best describe the participants' level of physical activity: Grade I: reading, watching television, or activities which do not need physical activity; Grade II: walking, cycling, or some other form of physical activity for at least 4 h per week; Grade III: exercises to keep fit, heavy gardening, etc, for at least 4 h per week; Grade IV: hard training or participation in competitive sports, regularly and several times a week. If leisure activity varied between summer

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The epidemiological evidence linking either objectively measured physical fitness or subjective reports on physical activity to risk of coronary heart disease is abundant but inconclusive.¹⁻¹¹ One unsolved problem concerns to what extent the cardiovascular risk is related to fitness as such or to the accompanying levels of physical activity. Another is whether the physical fitness factor and the level of physical activity act directly or through concomitant variation in other known coronary risk factors.¹²⁻¹⁹ Few epidemiological studies involve simultaneous assessments of objectively measured physical capacity as well as subjective reports on habitual

and winter, the person was asked to state the average.

Physical activity at work was graded from I to IV according to the following categories: I=mostly sedentary work, II=work leading to much walking, III=work leading to much walking and lifting, IV=heavy manual labour. The questions on physical activity in this study have been widely used in different Scandinavian studies, since they were first described in 1968, and they have been extensively validated.²²⁻²⁵

In the analyses, physical activity categories III and IV were merged both in leisure and at work since there were very few subjects in category IV.

The present study constitutes a random subsample of those attending the screening. Invitation was sent by mail 2-6 weeks after the initial screening to 316 men and 350 women who were randomly selected from the screened population; 297 men and 312 women attended the survey, giving attendance rates of 94% and 89% in men and women, respectively.

Four women and one man were unable to perform the exercise test because of disabilities in the musculoskeletal system. One woman and eight men with previous myocardial infarction were included in the study.

The examinations were performed from October 1986 to June 1987. The examination consisted of a history of previous disease, a 12 lead resting electrocardiogram and an exercise test. Physical working capacity was measured with a graded submaximal or maximal bicycle exercise test with a pedalling frequency of 60/min. The initial work load was set at 25 W, with 25 W increments every minute up to a maximum of 250 W (10 minutes). The tests were interrupted prematurely when symptoms such as angina pectoris, dyspnoea, or exhaustion made this necessary. No complications were noted during the exercise tests. Physical fitness was defined as the maximum work load (watts) performed.

Because of missing data, the number of subjects included in the individual analyses varies.

STATISTICAL ANALYSIS

SAS (Statistical Analysis System)²⁶ was used in the statistical analyses. Two way analysis of covariance were performed to test for linear trend of fitness according to activity at leisure and at work. To determine the age adjusted coronary risk factors, analysis of covariance was used. Age adjusted correlation coefficients were determined for combinations of physical fitness and leisure physical activity with the coronary risk factors. Multiple linear regression analyses were performed to estimate the partial impact of coronary risk factors as independent variables on the dependent variables physical fitness and physical activity at leisure.

Results

SUBJECT CHARACTERISTICS

Fitness and activity levels of the study population are presented in table I. The mean physical fitness in the age group 20-59 years was higher in men (231 W) than in women (161 W) ($p < 0.0001$). In men, fitness generally decreased with age. In women, the trend was not so clear, as there was a tendency for better fitness in the age group 40-49 years than in the younger age group. However, the age trend was significant for each sex separately ($p < 0.0001$).

High and moderate physical activity in leisure time was considerably more common in men (29%) than in women (9%) ($p < 0.001$). For women, there were no significant differences in physical activity in leisure time between the age groups below 50 years. In men, leisure time physical activity in general decreased with age ($p < 0.05$).

At work, women were less physically active than men (18% versus 25%), and the difference between the sexes was significant ($p < 0.01$). Only in men was a significant difference in physical activity at work present between the age groups, the youngest and the oldest being the most active. However, this finding is based upon small numbers in the oldest age group (17 men).

Conventional coronary risk factors as well as their correlations with fitness and leisure activity are shown in table II. The table indicates that a number of significant relations between the fitness level and the risk factors were present. Important observations were the significant associations between fitness level and total cholesterol ($p < 0.05$), triglycerides ($p < 0.05$), heart rate ($p < 0.001$), and smoking ($p < 0.001$) in both sexes. HDL cholesterol and systolic blood pressure (both $p < 0.001$) in men and body mass index in women ($p < 0.01$) were also significantly related to fitness.

Table I Levels of physical fitness and moderate/heavy physical activity in leisure and at work according to age.

Age (years) n	Men				Women			
	n	Fitness (watts) Mean (SD)	Activity		n	Fitness (watts) Mean (SD)	Activity	
			Leisure (%)	Work (%)			Leisure (%)	Work (%)
20-9	41	249.4 (3.9)	41.5	51.2	50	169.0 (41.5)	10.0	26.0
30-9	82	243.3 (16.2)	34.1	25.6	98	164.8 (35.7)	12.2	15.3
40-9	87	238.2 (26.1)	24.1	16.1	95	167.1 (38.6)	8.4	15.8
50-9	66	195.1 (57.6)	21.2	21.2	65	140.4 (35.0)	3.1	16.9
60-1	17	182.4 (53.6)	5.9	35.3				
20-59	276	231.1 (38.7)	29.0	25.4	308	161.0 (38.8)	8.8	17.5
20-61	293	228.2 (41.2)	27.6	25.9				

Table II Age adjusted means of coronary risk factors and their correlation with physical fitness and physical activity in leisure.

	Men (n=292)			Women (n=308)		
	Mean	(SD)	Correlation with	Mean	(SD)	Correlation with
			Fitness r			Fitness r
Cholesterol (mmol/litre)	5.90	(1.24)	-0.142*	5.82	(1.32)	-0.143*
HDL cholesterol (mmol/litre)	1.40	(0.36)	0.205‡	1.68	(0.38)	0.065
Triglycerides (mmol/litre)	1.57	(0.95)	-0.206‡	1.10	(0.56)	-0.146*
Body mass index (kg/m ²)	2.47	(0.29)	0.050	2.32	(0.30)	0.158†
Systolic blood pressure (mm Hg)	130.9	(15.6)	-0.213‡	120.2	(16.5)	-0.104
Heart rate (beats/min)	71.8	(12.0)	-0.203‡	76.3	(12.5)	-0.185‡
Daily smoking (%)	44.2		-0.296‡	43.8		-0.210‡

* $p < 0.05$; † $p < 0.01$; ‡ $p < 0.001$

Only a small number of risk factors were significantly associated with activity score. Smoking habits showed a significant relation to activity in both sexes ($p < 0.05$), in addition to total cholesterol in men and heart rate in women (both $p < 0.01$).

RELATIONSHIPS BETWEEN FITNESS AND ACTIVITY

The age adjusted physical fitness by level of physical activity in leisure time and at work is shown in the figure. For both sexes, fitness increased with activity in leisure time ($p < 0.001$), while it decreased with activity at work ($p < 0.05$).

MULTIPLE REGRESSION ANALYSIS

Tables III and IV give the results of the multiple linear regression analyses with physical fitness and leisure activity, respectively, as the dependent variables. In general, the impression from the univariate analyses was confirmed. For fitness, prominent findings were negative associations with smoking and age and positive associations with physical activity in leisure and at work and body mass index in both sexes. Previous myocardial infarction, HDL cholesterol, and systolic blood pressure were significant predictors of fitness in men. The explained variance varied between 46 and 26% in men and women respectively. Thus a substantial part of the variation in fitness was explained by the other coronary heart disease factors.

For leisure physical activity, smoking and heart rate emerged as having firm negative associations with activity in women. A negative association between physical activity and total cholesterol was observed in men. The explained variance was 12% in men and 16% in women, ie much lower than for fitness.

Discussion

FITNESS-ACTIVITY RELATIONSHIPS

The assessment both of activity and fitness levels has inherent methodological problems. Activity grading is simple to perform in an epidemiological study, but the grading is crude and both over- and underestimation of activity level must occur. The awareness in the population of the importance of activity may lead to biased reporting.

Testing of fitness is more cumbersome, even in the shortened version used in this study. We used 250 W as the maximum load, which was found to be too low in many men. The fitness factor might have turned out to be more important if a true maximum exercise test had been performed in all subjects. However, about 95% of the men exercised to a heart rate exceeding 130 beats/min. Another crucial methodological factor was the choice of bicycle ergometry which measures external work only and gives an advantage to heavy and large subjects.

As expected, highly significant positive correlations were found between fitness and leisure activity (figure). Still, the correlations were rather poor, with age adjusted correlation coefficients of 0.18 in men and 0.39 in women (data not shown). This may indicate that the fitness factor and the activity factor may be regarded as two different dimensions that carry largely independent information, and cannot

Age adjusted physical fitness (watts) according to physical activity in leisure time and at work. $p < 0.001$ for linear trend of fitness by leisure activity in both groups; $p < 0.05$ for linear trend of fitness by work activity in both groups.

Table III Multiple regression analysis of physical fitness with several risk factors as independent variables.

	Men (n = 292)		Women (n = 308)	
Fitness mean	228.17		161.04	
R ²	46.2%		25.9%	
Variables	B	p	B	p
Infarction	-44.509	0.0001	-10.135	0.7703
Cholesterol	-1.051	0.5555	-3.462	0.0974
HDL cholesterol	15.344	0.0062	4.175	0.4795
Triglycerides	-3.116	0.1583	-7.904	0.0714
Body mass index	18.973	0.0078	24.268	0.0009
Systolic BP	-0.414	0.0011	-0.193	0.1694
Smoking	-11.909	0.0021	-8.683	0.0384
Heart rate	-0.197	0.2263	-0.242	0.1448
Physical activity				
in leisure	5.336	0.0396	19.428	0.0001
at work	-4.929	0.0104	-5.833	0.0341
Age	-1.916	0.0001	-0.644	0.0157

BP = blood pressure

Table IV Multiple regression analysis of physical activity at leisure with several risk factors as independent variables.

	Men (n = 292)		Women (n = 308)	
R ²	12.1%		16.1%	
Variables	B	P	B	P
Infarction	0.463	0.0855	0.268	0.6211
Cholesterol	-0.109	0.0077	0.011	0.7255
HDL cholesterol	-0.058	0.6531	0.003	0.9773
Triglycerides	0.040	0.4264	0.072	0.2976
Body mass index	-0.241	0.1431	-0.081	0.4835
Systolic BP	0.002	0.3994	0.001	0.5678
Smoking	-0.170	0.0574	-0.170	0.0093
Heart rate	-0.004	0.3123	-0.005	0.0367
Physical fitness	0.003	0.0396	0.005	0.0001
Physical activity				
at work	0.071	0.1109	0.014	0.7483
Age	-0.002	0.7096	0.005	0.2435

BP = blood pressure

readily be substituted for each other. This also raises the question regarding which of these factors is most important as a predictor of disease.

The fitness-activity relation was stronger in females than in men, which may partly be explained by the test being truly maximal in most females.

Our results confirm previous studies indicating that leisure time activity is the important physical activity factor in a modern, affluent society.^{2 27}

The negative association between activity at work and fitness may partly be explained by the nature of activity at work, which mostly consists of short bursts of activity which does not give rise to sustained heart rate increase or improve aerobic exercise capacity. In addition, physical activity at work may be regarded as a measure of social class rather than as an indication of activity and fitness level.

RISK FACTORS, ACTIVITY AND FITNESS

Most of the individual risk factors were more closely associated with fitness than with activity. When all risk factors were included in the multivariate analysis, they accounted for 26–46% of the variance in objectively measured fitness, while only 12–16% of the variance in self reported activity was explained. This further supports the argument given above that fitness should be regarded as an independent factor which cannot entirely be explained from the reported activity.

The difference between fitness and activity was particularly noteworthy with regard to blood pressure. While no association between blood pressure and activity was observed, blood pressure and fitness were firmly negatively associated in men. Increased exercise capacity may partially be caused by a lower blood pressure. Both in acute experiments²⁸ and in heart failure²⁹ it is well established that the impedance to left ventricular ejection is one of the major determinants of stroke volume, and thus physical fitness. It has previously been thought that in the normal individual compensatory factors such as cardiac hypertrophy maintain a constant exercise capacity at high pressure levels. Our present findings may indicate that these compensatory factors are incomplete and that exercise capacity therefore decreases with increasing pressure in normal subjects as well. This result should, however, be interpreted with care, as the relation between fitness and systolic blood pressure was significant in men only, even though women showed the same tendency.

As expected, smoking was negatively related both to fitness and activity. The cause may be twofold; on the one hand smoking may decrease exercise performance; on the other, active persons may be more health conscious and thus less likely to smoke.

FITNESS OR ACTIVITY, STRENGTH OR TRAINING?

Activity and fitness are commonly regarded as more or less interchangeable: active people get fit. In this study we found the association to be comparatively weak. It would therefore seem fruitful to recall how activity and fitness are related and how they are not.

One difference between the two is with regard to causative factors. While the activity level is influenced by a host of psychological, social, and environmental factors, fitness may primarily be influenced by constitutional, ie, mostly genetic, factors.¹⁷ Genes linked to fitness may of course also be linked to genes associated with lipids and blood pressure.

In addition to the fact that activity leads to fitness, the opposite may also occur. If you are born with a high physical capacity, you may tend to be more active. The influence on conventional

risk factors like lipids, smoking, blood pressure, and obesity is usually thought to take place through the activity factor. Our observation that fitness generally was much more closely linked to the risk factors is therefore remarkable. One explanation may be that fitness was more precisely measured than activity in this study, as discussed above. A more elaborate questionnaire or interview on leisure time physical activity might have given a better estimation and a stronger relation to coronary risk factors than observed. We believe that this is only part of the explanation, and that fitness actually is more closely linked to risk factors. This may be caused by a salutary effect of fitness on risk factors which is not expressed through the activity level. Even more probable is the hypothesis outlined above, that risk factors, in particular smoking and blood pressure, have retroactive effects on fitness, in contrast to activity. Thus fitness may have a bidirectional "benign circle" interrelationship with the risk factors, while the activity effect may be unidirectional.

Conclusion

From this cross sectional study no conclusions can be drawn with regard to the long term effects of activity and fitness on risk of disease or with regard to effect of changes in lifestyle. That must be left to longitudinal studies. Our study confirms the association between fitness and activity, although the strength of the association was weaker than presumed. It also indicates that coronary risk factors are more closely linked to fitness than to activity. The results indicate that fitness should be added as an important variable in addition to activity in future studies on the relationship between exercise habits and disease.

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