Associations between health behaviours and health related fitness

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Abstract

Objective—To examine relations between health behaviours and health related fitness.

Methods—Subjects were a convenience sample of 350 healthy adults (172 men, 178 women). Covariance analysis adjusted data for significant influences of age and socioeconomic status. Obesity was assessed by anthropometry and body density. Cardiovascular fitness was assessed and various metabolic measurements were made. Questionnaires on physical activity and health related behaviours were completed.

Results—Cigarette abstinence was associated with a small abdominal circumference (men) and a low trunk/extremity skinfold ratio (women). Obesity indices (body mass index, total skinfolds, percent fat, and abdominal circumference) were negatively associated with perceived fitness. Leisure activity and exercise frequency were also negatively linked to some obesity indices. Blood glucose, cholesterol, HDL-cholesterol, and triglycerides were favourably influenced by perceived activity, exercise frequency, and perceived fitness, but not by exercise intensity. Abstinence from coffee was associated with a low cholesterol/HDL ratio (men only). Principal component, discriminant, and multiple logistic regression analyses showed only weak clustering of habitual physical activity with other positive health behaviours.

Conclusions—Although multiphasic health promotion programmes are economical, favourable interactions between individual programme elements seem likely to be quite limited.

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Key terms: health related fitness; metabolic fitness; obesity; physical activity

Several reports have suggested that there is an association between regular exercise or attained physical fitness and other favourable health behaviours.¹⁻⁶ Such an association could indicate interactions between the various types of health promotion, pointing to the therapeutic value of multifaceted lifestyle programmes rather than simple exercise classes as a means of enhancing individual or community health. Nevertheless, the evidence for a clustering of habitual physical activity with

other positive health behaviours is not particularly strong,^{2,7} and it is difficult to rule out a mutual dependence of exercise and other health behaviours upon extrinsic variables such as the age or socioeconomic status of the subject.⁸⁻¹¹

In this report we therefore consider the extent of associations between health behaviours and indices of health related fitness (obesity, metabolic health, and cardiovascular fitness) in a substantial sample of Québécois adults after covariance adjustment of data for the influences of age and a composite index of socioeconomic status. Principal component analyses examine the clustering of reported health behaviours after such covariance adjustment, and the specific impact of reported leisure activities upon the consumption of alcohol, coffee, tea, and cigarettes is tested by discriminant analysis and multiple logistic regression analysis.

Methods

SUBJECTS AND EXPERIMENTAL PLAN

A convenience sample of clinically healthy but relatively sedentary volunteers (172 men and 178 women) were recruited in accordance with a protocol approved by the Laval University Committee on Human Experimentation. A radio announcement indicated an opportunity to participate in a study that would provide measurements of fitness and body composition, and would explore the relations of these variables to current lifestyle. Respondents came from an area of some 80 km around Quebec City; it is likely that they had an above average interest in health, and application of the Blishen scale showed that their median socioeconomic status was somewhat greater than that of the overall Canadian population.

A preliminary clinical examination excluded those with any chronic disease. Ages ranged from 14 to 68 years [mean(SD) 38.8(15.6) years, men; 39.4(15.0) years, women]. The average height [1.74(0.06) m, men; 1.61(0.06) m, women] corresponded closely with norms for middle aged Canadian adults.⁹ However, the body mass [74.9(11.6) kg, men; 59.7(8.3) kg, women] was a little below these same Canadian norms.¹²

Measurements of obesity included the body mass index, skinfold thicknesses and their ratios, hydrostatic estimates of percentage body fat, and abdominal circumference. Metabolic measures included resting blood glucose, total cholesterol, high density lipoprotein (HDL), cholesterol, and triglycerides.

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Cardiovascular fitness was assessed from resting heart rate, physical working capacity at a heart rate of 150 beats·min⁻¹ (PWC₁₅₀), and systolic and diastolic blood pressures.

Subjects also completed recently validated questionnaires relating to education, occupation, habitual physical activity, and other health behaviours.¹³

MEASURES OF HEALTH RELATED FITNESS

Obesity

The height and body mass were determined by stadiometer and clinical scales, respectively, with the subjects wearing only shorts and a t-shirt.

Skinfolds (biceps, triceps, subscapular, abdominal, suprailiac, and medial calf) were measured on the left side of the body, using Harpenden calipers. Estimates were made of total subcutaneous fat^{14 15} and the ratio of central to peripheral skinfold measurements.¹⁶ Total body fat was determined by underwater weighing,^{17 18} using the mean of six valid measurements.

Abdominal circumference measurements followed the recommendations of the Airlie Conference of 1988.¹⁴ The subject stood erect, with the abdomen relaxed, the arms at the sides, and the feet together. The observer faced the subject and placed an inelastic tape in a horizontal plane at the narrowest part of the torso. The reading was taken at the end of a normal expiration, taking care that the tape did not compress the skin.

Metabolic fitness

Plasma glucose was determined enzymatically.¹⁹ Cholesterol and triglyceride concentrations in plasma and in lipoprotein fractions were determined by an enzymatic method (RA-1000 analyser, Technicon), using specimens of antecubital venous blood collected after a 12 h overnight fast. Very low density lipoproteins were isolated by ultracentrifugation.²⁰ The HDL fraction was estimated after the low density lipoprotein had been precipitated using heparin and manganese chloride.²¹

Cardiovascular fitness

Measurements were made at 8 am, with the subjects fasting. Two heart rate determinations and two sphygmomanometer readings of blood pressure²² were made in a supine position, after 10 and 12 min of rest respectively. The PWC₁₅₀ per kg of body mass was determined with a Monark ergometer, using a progressive test protocol. Three individually adjusted loadings of 6 min duration were each separated by 1 min recovery intervals for a total exercise time of 18 min.²³

QUESTIONNAIRE DATA

Socioeconomic status

Questionnaires evaluated (1) attained education (results collapsed to three level scale: 1 = secondary school not completed or less, 2 = university not completed, 3 = university qualification); (2) profession (collapsed to three level scale; 1 = office supervisor, salesperson, skilled, semiskilled or unskilled worker,

other; 2 = semiprofessional, technician, owner of small business or manager; 3 = professional, administrator, owner of factory or large company); and (3) total family revenue (average dollar value of \$64 500 per year converted to three level scale). A nine grade socioeconomic status categorisation was derived by adding:

Education (1, 2, or 3) + Occupation (1, 2, or 3) + Family income (1, 2, or 3).

Habitual physical activity

"Demanding" physical activity was evaluated on a three level scale. Workplace walking (sitting, standing, or walking) and lifting or the manipulation of heavy objects ("heavy handling") were each evaluated on a four level scale, ranging from 1 = "rarely/never" to 4 = "all the time".

Perceived leisure activity was compared with age matched peers on a five level scale, ranging from 5 = "much more active" to 1 = "much less active". The typical frequency of participation in physical activity sufficient to provoke sweating and a rapid heart beat ("exercise frequency") and the typical intensity of participation in sport or leisure activity ("exercise intensity") were each rated on a three level scale (1 = "rarely/never" to 3 = "at least three times per week", and 1 = "light" to 3 = "intense", respectively). Perceived fitness relative to age matched peers, and changes in fitness status over the past 10 years were each rated on a five level scale (1 = "very bad" to 5 = "very good" and 1 = "much worsened" to 5 = "much improved", respectively).

Other health behaviours

The consumption of alcohol, coffee, tea, and cigarettes were each assessed on a simple yes = 1/no = 2 scale.¹³

STATISTICAL ANALYSIS

Descriptive statistics [mean(SD), by sex] were calculated for age, socioeconomic status, health related behaviours, and health related fitness. Sex-specific associations between age, socioeconomic status and health behaviours were examined using Spearman rank order correlations, fitted by the method of least squares. Correlations between health behaviours and measurements of health related fitness were tested in similar fashion after covariance adjustment of the latter for the effects of age, socioeconomic status (combined index), and age plus socioeconomic status. Principal component analyses (varimax rotation) examined the clustering of health behaviours after covariance adjustment for age and socioeconomic status. Discriminant analyses tested the associations between the consumption of alcohol, coffee, tea, and cigarettes and selected measures of occupational and leisure activity. A sex-specific generalised squared distance function of the type:

$$D_j^2(X) = (X - \bar{X}_j)' \text{COV}^{-1}(X - \bar{X}_j)$$

was fitted for each type of consumption, using the standard SAS program. The posterior

probability of membership in each category of consumption was calculated as:

$$\Pr(J|X) = \exp[-.5 D_j^2(X)] / \sum_K \exp[-.5 D_K^2(X)],$$

and the error count between predicted and actual consumption was then examined.

Multiple logistic regressions examined the association between each of several indices of habitual physical activity and alcohol, coffee, tea, and cigarette consumption. Odds ratios and χ^2 tests examined the predictive value of individual activity indices, and those showing significant associations with consumptions were included in a multiple logistic regression calculation. Only indices that proved significant in this final calculation were retained.

Results

SOCIOECONOMIC DESCRIPTORS

The sample was of above average socioeconomic status for Quebec, comprising 85 professionals (56 M, 29 F), 64 semi-professionals (36 M, 28 F), and 201 non-professionals (80 M, 121 F). The majority of the men (165/172) and women (165/178) had completed both secondary school and junior college, and many (76/172 men, 67/178 women) had also completed some university education. The men reported a family revenue of \$63.3(24.0) K, and the women an average of \$65.6(24.5) K.

Spearman correlations tested the associations of age, education, occupation, and family revenue with health behaviours (table 1). In the men, aging was associated with an increased likelihood of regular coffee and tea drinking, decreased physical activity at work, and a decreased intensity of physically active leisure. In the women, coffee and tea drinking showed parallel trends, but cigarette and alcohol consumption were less likely in older subjects. The three socioeconomic indicators of table 1 were combined to yield a single index of SES (table 2). Data for the men showed that a high socioeconomic index was associated with a reduced likelihood of smoking and of physical activity at work, and a greater frequency and intensity of leisure activity. Moreover, these findings were changed little when the data were covaried to allow for the effects of age as well as socioeconomic status (table 2). The women showed a positive association of the socioeconomic index with exercise frequency and

intensity, and a greater likelihood of alcohol consumption in women of high socioeconomic status. However, in the women, none of these associations remained statistically significant after covariance adjustment for the effects of age.

HEALTH BEHAVIOURS

Social habits and addictions

Alcohol consumption was reported by 86.5% of the men and 86.4% of the women. Coffee was consumed regularly by 69.6% of men and 74.8% of women, but tea was a less popular beverage (41.3% of men, 42.9% of women). The percentage of smokers was substantially less than in the general population of Quebec (15.6% of men, 18.4% of women), suggesting the recruitment of a health conscious sample.

Patterns of habitual activity

Relatively few subjects had a physically demanding job. The handling of heavy objects for a half or more of the day was reported by 36/172 men, and 19/178 women. Walking "most or all of the time" was noted by 39/172 men and 52/178 women.

Not all subjects were participating in demanding physical activity. However, 33/97 men and 24/102 women claimed to engage in such activity at least three times per week. The current rating of fitness was good or very good in 105/172 men, and 101/178 women; 60/162 men and 43/175 women rated their involvement in sport or leisure activity as intense.

HEALTH RELATED FITNESS

Obesity

The body mass index (BMI) averaged 24.9(3.7) kg/m² in the men and 23.0(3.4) kg/m² in the women. The hydrostatic estimate of body fat was 21.1(8.0)% in the men and 29.9(9.1)% in the women. The sum of the six skinfold readings was 103.8(43.0) mm in the men and 145.8(53.0) mm in the women. The ratio of trunk to peripheral skinfolds showed the anticipated gender difference, averaging 1.76(0.49) in the men and 0.93(0.27) in the women. Respective values for abdominal circumferences were 0.90(0.11) and 0.84(0.11) m.

Association between these variables and health behaviours (after adjustment for the effects of age, socioeconomic status, and age plus socioeconomic status) is summarised in

Table 1 Spearman correlation matrices showing association between age, various indices of socioeconomic status and health behaviours (172 men 178 women)

Variable	Age		Education		Occupation		Family revenue	
	M	F	M	F	M	F	M	F
Alcohol	NS	0.19	NS	-0.29	NS	NS	-0.19	-0.23
Coffee	-0.48	-0.40	NS	NS	NS	NS	NS	NS
Tea	-0.50	-0.28	NS	NS	NS	NS	NS	NS
Cigarettes	NS	0.15	0.20	NS	0.22	NS	NS	-0.16
Demanding exercise	NS	NS	NS	0.33	NS	NS	NS	NS
Walking at work	-0.15	0.21	NS	-0.25	-0.18	NS	NS	-0.16
Heavy handling	-0.22	NS	-0.19	NS	-0.24	NS	-0.16	NS
Perceived activity	NS	NS	NS	NS	NS	NS	NS	NS
Exercise frequency	NS	-0.28	NS	0.30	NS	NS	NS	NS
Perceived fitness	NS	0.27	NS	NS	NS	NS	NS	NS
Exercise intensity	-0.33	-0.17	NS	0.22	NS	NS	NS	NS

High scores indicate avoidance of alcohol, coffee, tea, and smoking, high fitness or physical activity, extended education, high status occupation, and high family income. All correlation coefficients must attain values of 0.15, 0.19, and 0.25 or greater to reach respective probability levels of $P < 0.05$, 0.01, and 0.001. Given multiple comparisons, values of $r < 0.25$ should be regarded as trends only.

Table 2 Spearman coefficients of correlation between health behaviours and new indicator of socioeconomic status without (SES) and with (AS) covariance adjustment for age of subject (172 men, 178 women). For note on scoring and statistical significance, see table 1

Variable	Men		Women	
	SES	AS	SES	AS
Alcohol	NS	NS	-0.19	NS
Coffee	NS	NS	NS	NS
Tea	NS	NS	NS	NS
Cigarettes	0.27	0.24	NS	NS
Demanding exercise	NS	NS	NS	NS
Walking at work	-0.19	NS	NS	NS
Heavy handling	-0.29	-0.24	NS	NS
Perceived activity	NS	NS	NS	NS
Exercise frequency	0.25	0.27	0.22	NS
Perceived fitness	NS	NS	NS	NS
Exercise intensity	0.19	0.26	NS	NS

tables 3 and 4. Avoidance of coffee and tea consumption was apparently negatively associated with various indices of obesity in both men and women, but this effect was no longer statistically significant after allowing for the effects of age and socioeconomic status. Abstinence from cigarettes was associated with a lesser abdominal circumference in men, and a lesser trunk/extremity skinfold ratio in women. Walking at work was associated with a lower body mass index and abdominal circumference in women only. In men, heavy handling was positively associated with the trunk/extremity skinfold ratio. Perceived physical activity was associated with lower skinfold totals in both men and women, and the frequency of exercise was also associated negatively with the abdominal circumference (in men only). Finally, perceived fitness showed relatively strong negative associations with obesity in both sexes.

Metabolic fitness

Resting blood glucose levels were normal [5.00(0.96) mM, men; 4.83(2.30) mM, women]. Total cholesterol [5.01(0.96) mM, men; 5.18(1.07) mM, women] and HDL cholesterol [1.15(0.28) mM, men; 1.43(0.33), women] were higher (or lower, HDL cholesterol) than desirable, but were very typical of adult Canadians. Triglyceride readings [1.46(0.76) mM in the men, 1.30(0.64) in the women] were also unremarkable.

Associations between health behaviours and these indices of metabolic health are summarised in tables 5 and 6. Avoidance of coffee and tea consumption tended to be negatively associated with serum cholesterol and triglyceride concentrations, but (with the exception of cholesterol/HDL cholesterol in the men) such associations were no longer statistically significant after covariance adjustment for the effects of age and socioeconomic status. Perceived leisure activity had a negative association with blood glucose and cholesterol/HDL cholesterol ratio in men only. Exercise frequency was negatively associated with blood glucose in men, and was positively associated with HDL cholesterol in women. Perceived fitness also had a positive association with HDL cholesterol and a negative association with triglyceride concentrations in men, but not in women.

Cardiovascular fitness

The resting heart rate was relatively slow [58.0(9.6) beats·min⁻¹, men; 62.7(7.6) beats·min⁻¹, women] but the PWC₁₅₀ was unremarkable [126(43) W, 1.82(0.52) W·kg⁻¹, men; 74(23) W, 1.27(0.42) W·kg⁻¹, women].

Table 3 Spearman coefficients of partial correlation between health behaviours and measures of obesity in men (n = 172), calculated after adjustment of obesity measures for effects of age (A), socioeconomic status (SES), and age plus SES (AS). For note on units and statistical significance, see table 1

Variable	BMI			% Fat			Sum of skinfolds			Trunk/extr ratio			Abd circ		
	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS
Alcohol	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Coffee	NS	-0.26	NS	NS	-0.30	NS	NS	-0.26	NS	NS	-0.27	NS	NS	-0.34	NS
Tea	NS	-0.18	NS	NS	-0.22	NS	NS	-0.21	NS	NS	-0.20	NS	NS	-0.24	NS
Cigarettes	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Walking at work	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Heavy handling	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.21	NS	0.19	NS	NS	NS
Perceived activity	NS	NS	NS	NS	NS	NS	NS	NS	-0.20	NS	NS	NS	NS	NS	NS
Exercise frequency	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.20	-0.20	-0.20
Perceived fitness	-0.16	NS	-0.26	-0.23	NS	-0.31	-0.24	-0.21	-0.31	NS	NS	NS	-0.21	NS	-0.32
Exercise intensity	NS	NS	NS	NS	-0.25	NS	NS	NS	NS	NS	-0.18	NS	NS	-0.19	NS

BMI, body mass index; extr, extremity; Abd circ, abdominal circumference.

Table 4 Spearman coefficients of partial correlation between health behaviours and measures of obesity in women (n = 178), calculated after allowance for effects of age (A), socioeconomic status (SES) and age plus socioeconomic status (AS). For note on units and statistical significance, see table 1

Variable	BMI			% Fat			Sum of skinfolds			Trunk/extr ratio			Abd circ		
	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS
Alcohol	NS	NS	NS	NS	NS	NS	NS	NS	-0.17	NS	NS	NS	NS	NS	NS
Coffee	NS	-0.19	NS	NS	-0.21	NS	NS	NS	NS	NS	NS	NS	NS	-0.22	NS
Tea	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cigarettes	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.16	-0.22	-0.26	NS	NS	NS
Walking at work	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.16	NS	NS	-0.16	NS	-0.22
Heavy handling	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Perceived activity	NS	NS	NS	NS	NS	NS	-0.16	NS	-0.20	NS	NS	NS	NS	NS	NS
Exercise frequency	NS	NS	NS	NS	NS	NS	NS	-0.19	NS	NS	NS	NS	NS	NS	NS
Perceived fitness	NS	NS	-0.18	-0.25	NS	-0.25	-0.25	-0.19	-0.31	NS	NS	NS	NS	NS	-0.17
Exercise intensity	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

BMI, body mass index; extr, extremity; Abd circ, abdominal circumference.

Table 5 Spearman coefficients of partial correlation between health behaviours and biochemical workers of metabolic health in men ($n = 172$), calculated after allowance for effects of age (A), socioeconomic status (SES), and age plus socioeconomic status (AS). For note on units and statistical significance, see table 1

Variable	Glucose			Cholesterol			HDL-C			Cholesterol/HDL-C			Triglyceride		
	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS
Alcohol	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Coffee	NS	-0.21	NS	NS	-0.34	NS	NS	NS	NS	NS	-0.34	NS	NS	-0.29	NS
Tea	0.18	NS	NS	NS	-0.34	NS	NS	NS	NS	NS	-0.21	NS	NS	-0.16	0.16
Cigarettes	NS	NS	NS	NS	NS	NS	0.18	NS	NS	-0.25	NS	-0.19	-0.22	NS	NS
Walking at work	NS	-0.20	NS	NS	NS	NS	NS	0.17	0.16	NS	-0.19	NS	-0.18	NS	NS
Heavy handling	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.16	NS	NS	NS	NS	NS
Perceived activity	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.16	NS	-0.17	NS	NS
Exercise frequency	NS	-0.20	-0.19	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Perceived fitness	NS	NS	NS	NS	NS	NS	0.26	0.25	0.28	NS	NS	-0.28	NS	NS	-0.22
Exercise intensity	NS	-0.23	NS	NS	-0.19	NS	NS	NS	NS	NS	-0.16	NS	NS	-0.19	NS

HDL-C, high density lipoprotein cholesterol.

Table 6 Spearman coefficients of partial correlation between health behaviours and biochemical markers of metabolic health in women ($n = 178$), calculated after allowance for effects of age (A), socioeconomic status (SES), and age plus socioeconomic status (AS). For note on units and statistical significance, see table 1

Variable	Glucose			Cholesterol			HDL-C			Cholesterol/HDL-C			Triglyceride		
	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS
Alcohol	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.17	NS	NS	NS
Coffee	0.24	NS	0.17	NS	-0.23	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tea	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cigarettes	NS	NS	NS	NS	NS	NS	NS	0.17	0.16	NS	NS	-0.17	NS	NS	NS
Walking at work	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.17	NS	NS	NS
Heavy handling	NS	NS	NS	0.17	NS	0.18	NS	NS	NS	NS	NS	0.17	NS	NS	NS
Perceived activity	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Exercise frequency	NS	NS	NS	NS	-0.17	NS	0.28	0.19	0.24	-0.29	-0.34	-0.24	-0.16	-0.21	NS
Perceived fitness	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Exercise intensity	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

HDL-C, high density lipoprotein cholesterol.

Likewise, systolic and diastolic blood pressures [120(14)/74(10) mm Hg, men; 115(15)/71(10) mm Hg, women] were in the normal range.

Associations between indicators of cardiovascular fitness and health behaviours are summarised in tables 7 and 8. Resting heart rate had strong negative associations with the various markers of habitual activity in both men and women, and these associations persisted after covariance adjustment of data for both age and socioeconomic status. In men, the PWC_{150} was positively associated with heavy handling at work, perceived activity, fitness, and exercise intensity, but was negatively associated with abstinence from cigarettes. In women, frequency of exercise had a positive association with PWC_{150} . There were few associations between blood pressures and health behaviours. However, in women, abstinence from tea drinking was associated with lower systolic pressures, and abstinence from cigarettes with higher diastolic pressures.

CLUSTERING OF HEALTH BEHAVIOURS

After covarying data for age and socioeconomic status, principal component analysis identified four statistically significant factors (table 9). These factors accounted for similar proportions of the total variance in both men and women. Factor 1 was heavily loaded by the assessments of habitual activity, and was negatively correlated with the hydrostatic estimate of body fat. Factor 2 was associated with abstinence from alcohol, coffee, tea, and cigarettes, with low perceptions of fitness, and with an accumulation of body fat. Body fat loaded most strongly on factor 3. Factor 4 was associated with cigarette addiction in the men, and with the consumption of tea in the women.

DISCRIMINANT ANALYSES

High misclassification rates show that none of the discriminant analyses gave a very precise indication of subjects who were likely to

Table 7 Spearman coefficients of partial correlation between health behaviours and cardiovascular health in men ($n = 172$), calculated after adjustment for effects of age (A), socioeconomic status (SES), and age plus socioeconomic status (AS). For note on units and statistical significance, see table 1

Variable	Resting heart rate			PWC_{150}			Systolic BP			Diastolic BP		
	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS
Alcohol	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Coffee	NS	NS	NS	NS	NS	NS	NS	-0.18	NS	NS	-0.20	NS
Tea	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.20	NS
Cigarettes	NS	NS	NS	-0.17	-0.22	-0.21	NS	NS	NS	NS	NS	NS
Walking at work	NS	NS	NS	NS	0.17	NS	NS	NS	NS	NS	NS	NS
Heavy handling	NS	NS	NS	NS	0.16	0.16	NS	NS	NS	NS	NS	NS
Perceived activity	-0.32	-0.27	-0.27	0.28	0.22	0.23	NS	NS	NS	NS	0.16	NS
Exercise frequency	-0.26	-0.27	-0.27	NS	NS	NS	NS	NS	NS	NS	NS	NS
Perceived fitness	-0.26	-0.24	-0.24	0.20	0.17	0.18	NS	NS	NS	NS	NS	NS
Exercise intensity	NS	-0.19	-0.18	0.20	0.21	0.20	NS	NS	NS	NS	0.17	NS

PWC_{150} , physical work capacity at a heart rate of 150 beats·min⁻¹; BP, blood pressure.

Table 8 Spearman coefficients of partial correlation between health behaviours and cardiovascular health in women ($n = 178$), calculated after adjustment for effects of age (A), socioeconomic status (SES), and age plus socioeconomic status (AS). For note on units and statistical significance, see table 1

Variable	Resting heart rate			PWC ₁₅₀			Systolic BP			Diastolic BP		
	A	SES	AS	A	SES	AS	A	SES	AS	A	SES	AS
Alcohol	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Coffee	NS	NS	NS	NS	NS	NS	NS	-0.18	NS	NS	NS	NS
Tea	NS	NS	NS	NS	NS	NS	NS	-0.29	NS	NS	-0.25	NS
Cigarettes	NS	NS	NS	-0.21	-0.24	-0.22	NS	0.19	NS	0.27	0.29	NS
Walking at work	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Heavy handling	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Perceived activity	-0.29	-0.26	-0.26	0.21	0.20	0.22	NS	NS	NS	NS	NS	NS
Exercise frequency	-0.25	-0.25	-0.26	0.23	0.26	0.26	NS	NS	NS	NS	-0.20	NS
Perceived fitness	-0.17	-0.18	-0.17	0.22	0.26	0.29	NS	NS	NS	NS	NS	NS
Exercise intensity	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

PWC₁₅₀, physical work capacity at a heart rate of 150 beats·min⁻¹; BP, blood pressure.

Table 9 Principal component analysis of health behaviours and risk factors. All variables adjusted for covariance of age and socioeconomic status

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Men				
Cumulative variance	24.9%	40.3%	54.0%	65.3%
Alcohol	0.30	0.29	0.44	0.35
Coffee	0.24	0.59	-0.49	0.17
Tea	0.10	0.59	-0.46	0.26
Cigarettes	0.34	0.44	0.13	-0.71
Perceived activity	0.61	0.06	0.03	-0.40
Exercise frequency	0.76	-0.11	0.22	0.23
Perceived fitness	0.59	-0.50	-0.36	0.14
Exercise intensity	0.72	0.06	0.32	0.17
Body fat %	-0.40	0.36	0.55	0.18
Women				
Cumulative variance	25.6%	41.3%	53.9%	64.8%
Alcohol	0.14	0.37	-0.40	-0.04
Coffee	0.19	0.76	-0.19	-0.08
Tea	0.09	0.51	0.41	-0.67
Cigarettes	0.45	0.25	-0.16	0.43
Perceived activity	0.79	-0.18	0.38	-0.00
Exercise frequency	0.69	0.03	0.41	0.23
Perceived fitness	0.72	-0.28	-0.10	-0.28
Exercise intensity	0.57	0.21	-0.40	0.11
Body fat %	-0.31	0.46	0.51	0.45

consume alcohol, coffee, tea, and cigarettes (table 10). Similar conclusions of limited success in classification were drawn from the multiple logistic regressions (not shown).

Discussion

AGE AND HEALTH BEHAVIOURS

In keeping with earlier research,^{8-12 24} habitual physical activity was negatively associated with age. In keeping with the recruitment of a health conscious sample, the proportion of smokers

(20% of both men and women) was lower than in most surveys of Quebec; however, as in other Canadian surveys, older women were less likely to report alcohol and cigarette consumption than their younger peers. In both sexes, aging was associated with an increased likelihood of the regular consumption of tea and coffee. Physical activity at work was less common in the older men, possibly because of promotion to managerial positions. Women also reported less heavy handling, but perceived more walking. Leisure activity showed the expected negative association with age, but perhaps because of selective recruitment, the older women perceived themselves as of above average fitness.

SOCIOECONOMIC STATUS AND HEALTH BEHAVIOURS

As in larger surveys,^{12 24} associations of health behaviour with education, occupational status, and family revenue tended to move in parallel (table 1). Looking at the combined index of socioeconomic status (table 2), the data show the expected negative associations with cigarette consumption and occupational activity (men only), and the expected positive associations with various measures of habitual leisure activity.

In men, the associations were fairly robust, and were not reduced by allowance for age (table 2), but in women most associations were

Table 10 Coefficients predicting presence or absence of given health behaviour (see Methods)

Coefficient	Alcohol		Coffee		Tea		Cigarettes	
	No	Yes	No	Yes	No	Yes	No	Yes
Men								
Constant	-34.84	-33.97	-34.42	-33.84	-33.78	-35.46	-34.27	-33.32
Demanding exercise	-0.67	-0.82	-0.81	-0.80	-0.80	-0.80	-0.85	-0.68
Walking at work	5.63	6.05	6.08	5.98	6.03	6.46	5.97	6.12
Heavy handling	4.83	5.97	5.95	5.81	5.84	5.72	5.64	6.46
Perceived activity	1.26	0.27	-0.06	0.57	0.38	0.53	0.51	-0.02
Exercise frequency	6.32	6.16	5.93	6.29	6.18	6.34	6.48	5.33
Perceived fitness	3.81	4.83	4.77	4.70	4.73	4.94	4.62	5.02
Fitness gains	-2.76	-2.58	-2.27	-2.75	-2.62	-2.96	-2.69	-2.35
Exercise intensity	12.18	11.46	11.97	11.32	11.53	11.62	11.60	11.32
Misclassification	16.7%	21.4%	38.1%	40.7%	51.5%	46.7%	28.6%	33.3%
Women								
Constant	-25.54	-25.44	-25.40	-25.59	-25.18	-27.39	-26.09	-22.14
Demanding exercise	0.16	0.11	0.14	0.09	0.12	0.26	0.15	-0.06
Walking at work	2.85	2.57	2.43	2.85	2.60	1.61	2.51	3.11
Heavy handling	6.95	8.26	8.29	7.75	8.07	9.18	6.99	5.01
Perceived activity	-1.34	-1.69	-1.72	-1.52	-1.64	-1.98	-1.95	-0.19
Exercise frequency	3.85	4.44	3.88	4.94	4.34	3.70	4.13	5.33
Perceived fitness	5.07	4.59	4.47	4.93	4.67	4.70	5.05	2.96
Fitness gains	1.45	0.83	0.98	0.87	0.95	2.07	1.19	-0.24
Exercise intensity	6.11	6.75	7.36	5.73	6.66	7.55	6.99	5.01
Misclassification	20.0%	30.3%	40.0%	33.3%	23.1%	25.0%	10.8%	0.0%

weakened to the point of becoming statistically insignificant.

The implication of these preliminary analyses is that it is important to make due allowance for both age and socioeconomic status before testing associations between health behaviours and various measures of health related fitness.

HEALTH BEHAVIOURS AND HEALTH RELATED FITNESS

Obesity

Both caffeinated beverages and cigarette smoking have sometimes been used as methods of mobilising body fat and thus of controlling obesity.^{25, 26} However, our dataset offers no support for this practice. Indeed, avoidance of coffee and tea consumption was apparently associated with a lesser prevalence of obesity, although this effect disappeared when the data were adjusted for age or age plus socioeconomic status. The association thus seemed to indicate no more than a common influence of age upon both obesity and beverage choice. Likewise, in contrast with the thrust of much cigarette advertising, smoking was associated with a greater abdominal circumference in men, and with a "masculine" distribution of body fat in women. Seidell²⁷ has also commented that smoking is associated with an adverse distribution of body fat, possibly because of hormonal disturbances induced by smoking.

The objective measures of obesity showed some associations with perceptions of habitual physical activity, but the strongest associations were with perceptions of fitness. This suggests that in both sexes, a slim figure still has a major influence upon current perceptions of personal fitness.

Metabolic health

Our data show associations between various indices of leisure activity and a favourable lipid profile. In the men, there was also a weak association between abstinence from coffee and a favourable cholesterol/HDL cholesterol ratio, probably due to a clustering of interests in a healthy lifestyle.⁷

Previous investigators^{28, 29} emphasised that optimisation of the blood lipid profile depended upon developing a critical energy expenditure each week (equivalent to the walking of at least 18–20 km). However, benefit was much less dependent on the intensity of exercise. Our cross sectional data support this inference.

Cardiovascular health

The substantial associations between the various indices of habitual activity and resting heart rate support the view^{6, 7} that resting heart rate is a simple and useful indicator of cardiovascular health. However, somewhat in contrast to expectation, our data suggested a closer association with the frequency of exercise than with its intensity, after control for the effects of age and socioeconomic status. Correlations with PWC_{150} are of approximately the same order as those for resting heart rate, despite the greater complexity of the test. The one

exception to this generalisation is the association with exercise intensity, which in women is seen for PWC_{150} but not for the heart rate data.

The weak negative association between abstinence from cigarettes and aerobic fitness has been noted in some earlier studies.^{28, 30} The units of measurement adopted in our study (W/kg) favour light individuals, and smoking may thus augment PWC_{150} by reducing body mass.

The positive association between heavy work and aerobic performance was not observed in some previous studies.^{28, 31} Earlier data tended to be confounded by the conflicting influences of higher socioeconomic status (a reduction of occupational activity, but an increase of leisure activity). However, the present data suggest that if appropriate control is made for socioeconomic status and thus differences in leisure activity, there is an association between type of employment and PWC_{150} .

CLUSTERING OF HEALTH BEHAVIOURS

The principal component analyses support the view^{2, 7} that any clustering of positive health habits is quite weak. Leisure activity tends to emerge as an independent first factor. Health behaviours load only slightly upon this factor, although there are weak negative associations with cigarette consumption and the percentage of body fat. Likewise, abstinence from alcohol, coffee, tea, and cigarettes emerges as a second, orthogonal factor.

Interestingly, this factor is associated with a low perception of fitness, but it is relatively independent of the other measures of physical activity. The negative association with perceived fitness may reflect the fact that health conscious individuals tend to underestimate their fitness, whereas those who are sedentary tend to overestimate it.³²

DISCRIMINANT AND LOGISTIC ANALYSES

If leisure activity had a major association with other health behaviours, this should emerge through the successful prediction of such behaviours by means of discriminant or logistic functions, or both. Leisure activity makes statistically significant contributions to the prediction of alcohol, coffee, tea, and cigarette consumption, but with the exception of cigarette smoking in women, the association between consumptions and habitual physical activity is sufficiently weak as to cause a high incidence of misclassifications.

POLICY IMPLICATIONS

Some of the apparent associations between physical activity and health related fitness reported by earlier investigators reflect failure to allow for covariation with age and socioeconomic status. Nevertheless, after allowing for these factors, heavy worksite activity is positively associated with PWC_{150} in men, and in both sexes habitual leisure activity has favourable associations with various indices of obesity, metabolic health, and cardiovascular fitness. Habitual physical activity shows only limited clustering with other health behaviours

such as abstinence from alcohol, coffee, tea, and cigarettes. Economic arguments may favour the adoption of multiphasic health promotional programmes, but any positive interactions between individual program elements^{33 34} seem likely to be quite limited.

CONCLUSIONS

Health behaviours are significantly associated with age and socioeconomic status, so that covariance adjustment for both of these factors is needed when examining the association of such behaviours with markers of obesity, metabolic health, and cardiovascular fitness. In men, occupational activity has a positive association with all three domains of health related fitness if data have been adjusted for the effects of age and socioeconomic status. Leisure activity shows only a limited clustering with other health behaviours, although various indices of leisure activity show positive associations in all three domains of fitness in both men and women. The relative strength of correlations further suggests that measurements of resting heart rate can be as effective as PWC_{150} determination when seeking a simple estimate of cardiovascular fitness.

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