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Cigarette Smoking, Use of Alcohol, and Leisure-Time Physical Activity Among Same-Sexed Adult Male Twins

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INTRODUCTION

Smoking, alcohol use, and physical activity have been much studied as risk factors of disease. Smoking and alcohol have been commonly linked with both total mortality risk and specific causes of death [1, 17, 23, 24]. Physical activity would seem to protect from certain specific diseases, particularly coronary heart disease [16, 20, 26].

These three factors, however, are not independent of each other and the correlation between smoking and alcohol use is well known [11, 27]. The study of interactions among various health risk behavior patterns is therefore necessary. In the formation of health behavior patterns and their manifestation in adult life, familial and possibly genetic factors are of importance. Because these factors are interrelated, the finding of higher concordance rates in twin studies for diseases that are known to be related to smoking, alcohol use, or physical inactivity may be explained by the higher association of the risk factors and not necessarily by a genetic or familial influence on the disease itself.

The purpose of this chapter is to present the relationships of cigarette smoking, alcohol use, and leisure-time physical activity among adult men in a Finnish population study of twins. Combinations of these factors will be considered, and the relationship of the factors to each other in relation to the twin pair situation will also be examined.

MATERIALS AND METHODS

The Finnish Twin Registry consists of those same-sexed twin pairs with both members alive in 1967 and born before 1958. The material was compiled from the Finnish Central Population Register computer files by selecting as twin candidates those pairs of persons with the same date of birth, the same surname of birth and the same community of birth. This procedure yielded also twin candidate pairs

that were singletons matched for these variables. To clarify twinship and zygosity, and to measure baseline characteristics of the material, a questionnaire was mailed in 1975 to all those pairs with both members alive at that date. A response rate of 89% was obtained for the twins, and the nontwins could be distinguished from the material using their responses and further clarification from the local population registries. The final material consisted of 16,269 twin pairs. The compilation process of the registry has been described elsewhere [8]. Univariate and pairwise results for the variables of the questionnaire study have been documented earlier [9, 10, 14].

Twin zygosity was determined by examining the response of both members of the twin pair to questions on similarity of appearance and confusion by strangers during childhood. A set of decision roles was used to classify the twin pairs as monozygotic (MZ), undetermined, or dizygotic (DZ). Some 93% of all respondent pairs could be correctly classified with a very small probability of misclassification (1.7%) as verified by using blood tests [21]. In this study, responses from 1537 MZ and 3507 DZ male pairs aged 18 and over were analyzed (Table 1).

A cigarette smoker was defined as a person who had smoked at least 5–10 packs of cigarettes in his whole life and had smoked daily or nearly daily. Persons not satisfying these criteria were determined to be nonsmokers. Smokers were then classified as current smokers or ex-smokers depending on whether they smoked at present or not. The amount currently or last smoked and the age of starting and stopping smoking were also asked. Because the number of regular cigar- and pipe-smokers was small (2.5% and 4.0% respectively), these variables were not included in the smoking analyses presented in this chapter.

Alcohol use was queried by asking the amount of beer, wine, and spirits consumed on average per week or month as well as the frequency of their use. The average current consumption was transformed to give the amount in grams of alcohol per month. Also it was queried whether alcohol use had been greater previously then at present. Heavy drinking was asked for by whether at least once a month on the same occasion at least five bottles of beer, a bottle of wine, or a half-bottle of spirits was consumed.

Leisure-time physical activity was measured by the individual's subjective opinion of the amount of physical activity currently engaged in, its intensity and duration, and number of years of physical activity engaged in the adult life. The intensity score for physical activity was based on three questions related to sweating and breathlessness and the self-rated intensity of the leisure-time physical activity compared to walking, jogging, or running. For the duration score, the number of minutes on one leisure-time physical activity session and the number of such sessions per week were also asked for. The intensity and duration scores were multiplied together to obtain an activity score.

For these variables on alcohol, smoking, and physical activity, questionnaire results from the twins considered as individuals (with one member of each pair being included) were used. Three factor analyses were carried out (one on each variable group) to yield a condensed score for each variable group. The factor loadings in the principal components model of the raw variables, their communality

TABLE 1. Age Distribution of Study Series

Age group (years)	No. of pairs by zygosity	
	MZ	DZ
18–29	731	1,628
30–39	351	812
40–49	191	563
50–59	137	300
60+	127	204
Total	1,537	3,507

TABLE 2. Factor Analysis of Individual Risk Variables; Cigarette Smoking, Use of Alcohol, and Physical Activity

Factor analysis for	Factor loading	Communality estimate
alcohol use variables		
Beer drinking frequency	0.658	0.527
Wine drinking frequency	0.539	0.481
Spirit drinking frequency	0.705	0.560
Heavy drinking once/month	0.600	0.486
Earlier drunk more	0.074	0.091
Current grams/month	0.787	0.560
Eigenvalue for factor = 2.21		
Factor analysis for cigarette smoking variables		
Years smoked	0.793	0.688
Cigarettes smoked per day	0.847	0.776
Current smoker	0.756	0.647
Ever smoker	0.881	0.776
Eigenvalue for factor = 2.70		
Factor analysis for leisure-time physical activity variables		
Physical activity on work journey	0.089	0.152
Subjective opinion of own physical activity	0.768	0.632
Intensity score for physical activity	0.649	0.601
Duration score for physical activity	0.824	0.813
Activity score for physical activity	0.897	0.813
Years of physical training in adulthood	0.468	0.404
Eigenvalue for factor = 2.72		

estimates, and the eigenvalues of the factors are shown in Table 2. These factor scores were used as the basis for the univariate analyses in individuals and pairs.

To examine whether the study material could be differentiated into various constellations according to the study variables, a cluster analysis was carried out. The cluster analysis was carried out using as variables three factors obtained by factor analysis of all study variables in the same analysis. This was done to obtain uncorrelated variables for the cluster analysis, as this procedure yields more stable results than when correlated variables are used. The cluster analyses were repeated

with different numbers of clusters set and different random starts until a stable pattern was obtained. Eight clusters were found to be stable in group–regroup situations with over 90% of members remaining in the same cluster from one analysis to another. Because the cluster analysis was performed on a random sample, 799 members (all from different pairs) of the whole series, the classification of the study series into the obtained clusters was done using a multiple discriminant analysis where the analysis model was constructed using the three factors and their grouping result.

The effect of intrapair contact on response pattern of individuals to the mailed questionnaire was studied by examining the relationship of variables measuring contact frequency between the twins to the use of alcohol, smoking habits, and leisure-time physical activity (Table 3). Fairly weak correlations were found, indicating that the level of risk factors was only slightly dependent on the amount of intrapair contact. The highest correlation was 0.15 for cigarette smoking and cohabitation status, ie. twins living apart smoked more than twins living together.

RESULTS

The age-specific mean standardized scores for the cigarette smoking, alcohol, and leisure-time physical activity factor are shown in Figure 1. The physical activity factor means were almost constant over age, but there was a decrease with age in the alcohol consumption factor score after an initial rise. For the smoking factor, there was a steady increase with age until 50–54 years, after which a slight decrease occurred. All variations are at most half a standard deviation from the mean. Because of the observed age trends, the results of all further analyses were age-adjusted.

The correlation coefficients between the factors in the whole series are shown in Table 4. A high correlation ($r = 0.32$) was found between the cigarette smoking and use of alcohol factors. Small negative correlations existed for the physical activity and cigarette smoking factors and, on the other hand, for physical activity and use of alcohol factors.

The intraclass correlations for the factor scores were computed by age and zygosity (Table 5). It can be seen that, for nearly all age groups, the differences of MZ and DZ correlations are statistically significant, as are also the differences of total intraclass correlations of all three factors. For physical activity, there is a decrease in intraclass correlations with age for both MZ and DZ pairs, but the heritability estimates remain fairly stable over age, whereas for cigarette smoking and alcohol use, heritability estimates are low in those older than 60.

For the cluster analysis, Table 6 shows the mean standard scores with respect to deviations about the total mean of each factor. For the cigarette and alcohol factors there were four clusters both above and below the mean, whereas in the physical activity factor there are five clusters below the mean and only three above. There were three large clusters, four clusters of intermediate size, and one small cluster. Table 7 shows the characteristics of each cluster in relation to original variables and the mean ages of the members of the cluster. Analysis of variance indicated that the mean ages of the clusters differed significantly from each other ($P < 0.001$).

TABLE 3. Correlations Between Risk Factor Scores and Measures of Intrapair Contact (All Men Aged 18+)

	Living apart	Age at separation	Infrequency of contact
Alcohol use	0.073	−0.048	0.029
Cigarette smoking	0.150	0.017	0.140
Physical activity	−0.045	0.033	−0.034

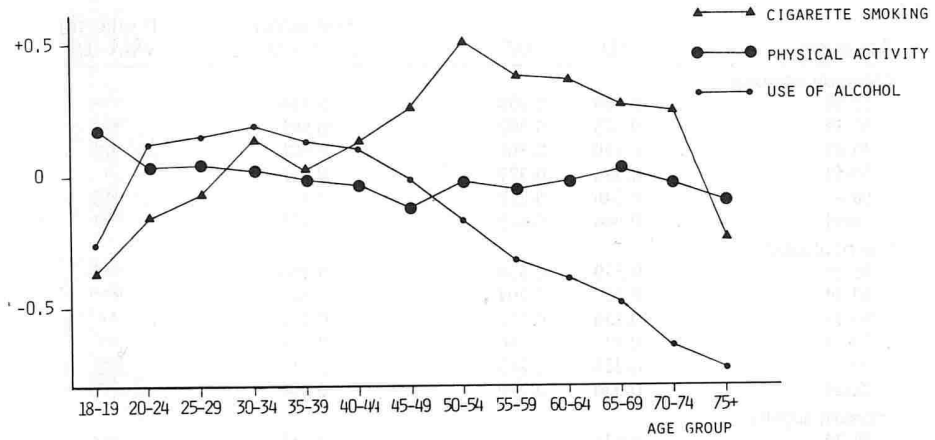

Fig. 1. Mean standardized factor scores for cigarette smoking, physical activity and use of alcohol in men aged 18+ by age group (Mean = 0, SD = 1).

TABLE 4: Intercorrelations of Factor Scores in Men Aged 18+

	Physical activity	Alcohol use
Alcohol use	−0.020	
Cigarette smoking	−0.138	0.322

The largest cluster, with 25.9% of the total sample, contained no current smokers and had below average leisure-time physical activity, and with an alcohol consumption of slightly over 80 grams per month. The subjects of the second cluster, 21.7% of the sample, were nearly 8 years older than the overall mean and smoked more than average, with almost 65% current smokers, smoking an average of 15.5 cigarettes a day. The physical activity was below mean and so was alcohol consumption at 121 grams a month. The third large cluster, containing 19.1% of the sample, was only slightly below mean age and was in smoking characteristics fairly similar to the previous cluster. This cluster had the least physical activity (0.4 hours per week) and above average alcohol consumption, with 72% replying that heavy drinking occurred at least once a month.

The largest medium-size cluster, with 9.7% of the sample, was slightly below the mean age, with nearly 80% current smokers, the physical activity below mean, but greatly increased alcohol consumption with almost 1,200 grams of alcohol per month. The second medium-size cluster (8.9% in size) was of average age, containing 55% current smokers, with a slightly below average alcohol con-

TABLE 5. Intraclass Correlations for Risk Factor Scores of Alcohol Use, Physical Activity, and Cigarette Smoking (Men Aged 18 and Over)

	Intraclass correlation			
Age group	r MZ	r DZ	Heritability 2 (rMZ-rDZ)	P value for rMA-rDZ
Cigarette smoking				
18-29	0.709	0.434	0.550	***
30-39	0.673	0.382	0.582	***
40-49	0.539	0.388	0.302	NS
50-59	0.583	0.377	0.412	*
60+	0.346	0.288	0.116	NS
Total	0.644	0.418	0.452	***
Use of alcohol				
18-29	0.579	0.339	0.480	***
30-39	0.527	0.204	0.646	***
40-49	0.356	0.170	0.372	**
50-59	0.437	0.140	0.594	**
60+	0.225	0.213	0.024	NS
Total	0.536	0.279	0.514	***
Physical activity				
18-29	0.638	0.319	0.638	***
30-39	0.477	0.218	0.518	***
40-49	0.323	0.108	0.430	**
50-59	0.300	0.139	0.322	NS
60+	0.332	0.012	0.620	**
Total	0.569	0.257	0.624	***

* $P<0.05$
** $P<0.01$
*** $P<0.001$

TABLE 6. Distribution of Factor Risk Scores by Risk Cluster

	Mean risk scores (in SD)			
Cluster	Cigarette smoking	Physical activity	Alcohol use	Size (% of total)
1	−1.02	−0.24	−0.56	25.89
2	0.81	−0.37	−0.69	21.69
3	0.62	−0.40	0.36	19.10
4	0.63	−0.13	1.79	9.74
5	0.69	1.03	−0.06	8.91
6	−1.17	−0.13	0.99	8.27
7	−0.39	2.64	−0.26	6.07
8	−0.41	0.43	5.47	0.44
Total	0.03	0.01	0.03	100.00

TABLE 7. Relationship of Cluster Analysis Results to Original Variables

Variable	Cluster							
	1	2	3	4	5	6	7	8
Beer drinking days	1.20	1.80	5.33	10.90	4.35	7.51	4.43	18.10
Wine drinking days	0.64	0.66	1.66	3.31	2.03	2.84	1.43	11.30
Spirits drinking days	0.84	1.00	3.55	6.77	2.90	4.86	2.13	14.40
% with heavy drinking	6.00	8.40	71.70	96.60	46.60	54.60	36.10	100.00
% with previous more	7.50	35.30	17.40	25.00	36.00	18.20	16.40	50.00
Mean monthly consumption	82.40	121.00	452.00	1,166.00	312.00	542.00	255.00	4,782.00
Ever smokers: years smoked	2.00	19.80	11.90	13.70	14.30	1.00	6.00	9.00
Ever smokers: amount daily smoking	2.50	15.50	15.60	18.90	16.20	2.50	13.20	17.30
% current smoker	0.00	64.70	63.80	79.60	54.70	0.00	13.10	50.00
% ever smoker	0.50	100.00	100.00	100.00	100.00	1.30	36.10	50.00
Own physical activity	2.39	2.08	2.07	2.32	3.48	2.54	4.21	2.10
Physical activity intensity	3.34	2.59	2.76	3.52	5.42	4.10	7.16	3.51
Physical activity duration	1.11	0.77	0.44	0.92	3.11	0.80	5.65	5.71
Physical activity intensity • duration	3.48	1.44	1.48	4.00	12.54	3.83	42.80	27.81
Physical activity as adult	1.70	1.40	1.53	1.94	2.75	1.94	3.39	1.42
Age	33.40	41.80	32.20	31.70	35.80	32.30	27.90	31.50

sumption and greatly increased physical activity (three hours per week). The subjects of the third medium-size cluster were nonsmokers, but alcohol consumption was clearly above average, and the physical activity only slightly below average. The last medium-size cluster, with 6.1% of respondents, was physically very active (5.7 hours per week) with only 15.1% current smokers and alcohol consumption below average. The smallest cluster comprised only 0.4% of the study series and differed markedly from the other clusters. It consisted of 56 men, half of whom were current smokers, and below mean age. Their physical activity was above average, but their most distinguishing feature was an extremely high alcohol consumption. Each member of this cluster reported that an episode of heavy drinking occurred at least once a month. Spirits were consumed on 14 days per month on average and mean alcohol monthly consumption was 4,800 grams.

The distribution of pairs by zygosity in the various factor clusters described previously is shown in Table 8. The observed proportions of twins in the same cluster for MZ and DZ pairs are compared to the expected proportion calculated as the square of the proportional size of the cluster as individuals. Overall, 17.9% of pairs would have both members in the same cluster if the twins in a pair were found at random in the clusters. For MZ pairs the proportion observed was 54.7% and for DZ pairs 44.5%. The ratios of observed-to-expected proportions were 3.1 for MZ pairs and 2.5 for DZ pairs. If the small cluster no. 8 (0.4% of the study series) is excluded, the clusters with observed-to-expected ratios most different from the mean were clusters 6 and 7, which comprised 8.3% and 6.1% of the study series, respectively. Both consist of mainly nonsmokers, but cluster 6 has the second highest mean alcohol use, whereas cluster 7 has the highest physical activity factor score mean. For all clusters, the MZ observed-to-expected ratio is greater than the corresponding DZ ratio, although the ratio difference is overall quite small.

DISCUSSION

Twin studies of cigarette smoking, use of alcohol, and physical activity have been carried out to obtain estimates of the relative roles of environmental and genetic factors in the variation of the traits. Some studies have attempted to explain the relationship of these factors to disease in twin pairs.

Twin studies on alcohol use and components of alcohol abuse have been conducted principally in Scandinavia and the United States. Kaij [7] studied twin pairs with alcohol abuse in Sweden. Jonsson and Nilsson [6] studied alcohol consumption in twin pairs in Sweden. In a study of male twins born in 1920–1929 in Finland and their brothers [18], aspects of alcohol control and use with respect to various psychosocial factors were studied. In studies of alcohol metabolism, the dehydrogenation of alcohol has been found to be under genetic control [25]. In the United States, Loehlin [15] found a heritable component to alcohol use in young adult twins.

The study of heritable components of smoking behavior is complex, and has been attempted in twin [3, 5] and family studies [19]. Earlier studies have indicated a higher concordance for MZ than DZ twins with respect to smoking status and amount smoked [2, 4, 22].

TABLE 8. Distribution of Expected and Observed Concordance Proportion by Cluster

	Observed MZ	Observed DZ	Expected	Observed/Expected	
Cluster	%	%	%	MZ	DZ
1	20.95	18.08	6.70	3.13	2.70
2	12.17	10.18	4.70	2.59	2.17
3	7.87	7.27	3.65	2.16	1.99
4	3.19	2.91	0.95	3.36	3.06
5	2.73	1.51	0.79	3.46	1.91
6	3.77	3.31	0.68	5.54	4.89
7	3.84	1.28	0.37	10.38	3.46
8	0.13	0.00	0.002	65.00	0.00
Total	54.65	44.54	17.85	3.06	2.50

Physical activity as a risk factor for disease has not been much analyzed for its heritable components using twin methods, but physical performance and aspects of muscle metabolism have been studied in relatively small samples of healthy twin pairs [12, 13].

Because the three traits under analysis all presented significant heritable factors ($h^2 = 0.45$–0.62) in univariate analysis, it was important to analyze whether this is due primarily to the intracorrelations between traits and the high heritability of only some components or due to independent heritable factors in all three traits. Both MZ and DZ twin pair members were in the same cluster much more often than expected, but the MZ-DZ overall difference was relatively small, indicating that genetic effects on the levels of the variables in the population are probably relatively small. The highest MZ/DZ ratios of observed to expected clustering rates were in two clusters: A) cluster no. 7, which had persons with a high mean degree of leisure-time physical activity; and B) the very small cluster no. 8, which had a very high mean alcohol use.

It may be indicative that these extremes of behavior are then more likely to be genetically determined, although it must be remembered that the analyses in these clusters are based on relatively small sample sizes compared to the whole study series.

When considering the implications of these results with respect to studies of risk factors of disease, it is probable that some of the increased concordance for disease observed among twin pairs is due to the increased similarity with respect to risk-factor behavior patterns. Similarly, familial aggregation of disease is probably in part due to familial aggregation of smoking, alcohol use, and physical inactivity.

Also, the correlations between risk factors should be considered when analyzing twin data on risk factors for disease. Besides the observed dependencies of smoking, alcohol use, and leisure-time physical activity, other factors such as hypertension, hyperlipemias, and nutritional factors may be correlated to the measured risk factors. Likewise, a multivariate analysis of pairwise risk factors of disease should take into account gene–environment interactions of the risk factors.

The study series is being followed up for morbidity and mortality data and will in future permit analysis of the risk factor data in relation to disease experience.

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