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CORRELATES OF BODY MASS INDEX IN 1926 DUTCH MEN AND WOMEN

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The relationship between body mass index (BMI) and demographic, socio-economic, and life-style characteristics was investigated among Dutch subjects, who participated in a nation-wide survey about knowledge, attitude and behaviour with respect to cardiovascular risk factors. A random sample of 882 men and 1044 women, aged 18 to 64 yr, was personally interviewed according to a structured questionnaire. BMI was calculated from self-reported height and body weight. To identify correlates of BMI, data were analysed by multiple regression for men and women separately.

Among men a positive association of BMI was found with age, daily amount of tobacco consumption and family history of coronary heart disease (CHD). An inverse relationship was revealed for level of education, unemployment and smoking *per se*. Among women age, being married, widowed or divorced, and sedentary living were positively related to BMI. A negative contribution to BMI was provided by education level, familial social class and duration of leisure time physical activity.

Introduction

Obesity can be seen as an indirect factor in the aetiology of coronary heart disease (CHD), ie, its contribution derives mainly from the relationship with other known coronary risk factors (Pooling project, 1978; Van Itallie, 1979; Noppa, 1980).

Studies on determinants of overweight, like socio-economic and life-style characteristics, have not produced a consistent body of evidence. With respect to demographic factors a rise in obesity with age and a higher prevalence in women compared with men is found generally (McLean Baird *et al.*, 1975; Strata *et al.*, 1977). For family size, birth order and marital status findings are contradictory (Kittel *et al.*, 1978; Ravelli & Belmont, 1979; Noppa & Bengtsson, 1980*a*; Susanne, 1980). Urbanization level is positively related to obesity in men (Kohrs *et al.*, 1979). Among women the highest prevalence of obesity is found in the lower socio-economic categories (Rimm & Rimm, 1974; McLean Baird *et al.*, 1975; Garn *et al.*, 1977; Kohrs *et al.*, 1979; Noppa & Bengtsson, 1980*a*). Also, among men an inverse relation of body mass index (BMI) with occupation level

(Kittel *et al.*, 1978) and household income is observed (Garn *et al.*, 1977; Kohrs *et al.*, 1979), while a positive relation with education exists (Garn *et al.*, 1977; Kohrs *et al.*, 1979; Susanne, 1980).

Life-style patterns have also been topics in research on obesity. Current smokers appear to be leaner than non-smokers in both sexes (Khosla & Lowe, 1972; Noppa & Bengtsson, 1980*a*; Tillotson *et al.*, 1981), and cessation of smoking is often accompanied by weight gain, both in men (Gordon *et al.*, 1975) and women (Blitzer, Rimm & Giefer, 1977; Noppa & Bengtsson, 1980*b*). However, a positive relationship is found between the daily tobacco consumption and the degree of obesity (Hjermann *et al.*, 1976; Blitzer *et al.*, 1977; Noppa & Bengtsson, 1980*b*).

In the Seven Countries Study (Keys *et al.*, 1976) an initial strong negative relationship between physical activity and prevalence of obesity disappears when allowances for differences in social class are made. In other studies obese and non-obese individuals have sometimes different (Dorris & Stunkard, 1957) and sometimes similar (Maxfield & Konishi, 1966; Kittel *et al.*, 1978) levels of activity.

Finally, two reports on energy intake demonstrate an inverse correlation with body fatness (Lincoln, 1972; Keen *et al.*, 1979).

In general, these findings derive from studies in which overweight is related to a relatively small number of variables. These univariate associations, standardized for one or two variables like age and sex, may have been confounded by other determinants of overweight. From a comprehensive survey on cardiovascular risk factors, designed to support and guide public health education in the Netherlands, data on a broad spectrum of potential determinants of overweight were available. The objective of the present report is to bring out the independent contribution to the BMI of several variables, by controlling for interfering effects through multivariate analysis.

Methods

Data on height and body weight were collected in 1978 among the Dutch adult population through a national survey on knowledge, attitude, and behaviour with respect to coronary risk factors.

A multi-stage stratified random sample of 2562 men and women, aged 18 to 64 yr, and representative of the Dutch adult population was drawn in three stages. First, a selection of communities within each province representing urbanization levels; second, a selection of addresses within each community representing the various neighbourhoods; third, a selection of a member of the household, who satisfied the study criteria of being aged between 18 and 64 yr. The response rate was 77 per cent. There were 14 per cent refusals, and 9 per cent could not be reached.

All subjects participating in the survey were personally interviewed, according to a structured questionnaire, by a team of 174 professional interviewers. Of the 1973 subjects in the survey, 882 men and 1044 women provided complete information on relevant variables. Beside weight, height, and personal data, information was obtained on smoking and drinking habits, nutrition, sedentary living, leisure time physical activity and on family history of CHD.

Dependent variable
BMI, one of the best estimates for body fatness (Keys *et al.*, 1972), was calculated from stated height and body weight as the ratio of body weight (in kg) and the square of the height (in m).

Independent variables

Age was registered in years; *civil status* as never married, married, and divorced or widowed.

Urbanization level was established on the basis of the population structure and dichotomized: rural communities with an agricultural population of 10 per cent or more, and urban communities with an agricultural population of less than 10 per cent.

Education level was determined by the highest completed school training of the respondent, ie, primary school and low vocational training; secondary school and middle vocational training; university and high vocational training.

Occupation of the respondent ranging from unskilled worker to company director was classified in three categories: high— company directors, self-employed persons like lawyers and physicians, higher white-collar workers; middle— middle and lower white-collar workers; low— blue-collar workers. The respondent's employment status was introduced as a dummy variable: 1 = unemployed, 0 = employed.

Familial social class, based on education and occupation level of the main wage-earner of the household, was classified according to the standards of the Netherlands Central Bureau of Statistics into three groups: upper, middle and lower class.

Family income data were not used to establish socio-economic status, because of the possibility of unreliable responses, and the degree of missing data, ie, 24 per cent did not know or refused to tell their income. This variable was introduced separately in the analysis, with the following categories: less than 1250, 1250-1750, 1750-2250, 2250-2750, 2750-3250, 3250-3750, more than 3750 guilders per month (1000 guilders = US$465 in 1978).

For each of the life-style patterns we constructed a dummy variable indicating the respondent's status with respect to: smoking (1 = current smoker, 0 = nonsmoker), alcohol use (1 = alcohol use, 0 = no alcohol use), and leisure time physical activity (1 = regular exercise, 0 = occasional exercise). In addition the intensity of practising these habits was studied.

Tobacco consumption was included in the analysis as a continuous variable, ie, the average daily consumption of cigarettes, cigars, cigarillos and pipe tobacco, expressed in grams, was summarized.

Alcohol intake was assessed from the reported number of the alcoholic drinks per day. An average consumption of less than one alcoholic drink per day was recorded as none.

Leisure time physical activity was ascertained from the number of minutes per week the subjects engaged in sports, walking or cycling. Sixty minutes per week or less engagement in sports, or its equivalent in walking (90 min/wk or less) or cycling (75 min/wk or less) was awarded one point. More than 60 min weekly engagement in sports or its equivalents in walking or cycling received two points.

These points were summarized into a score.

The variable *sedentary living* was derived from information on the number of hours per day occupied by sedentary activities.

Family history of CHD was determined by the prevalence of CHD in the respondent's immediate family ie, the respondent, his or her parents or children.

Statistics

The independent variables that were considered as potential descriptive correlates of BMI were run in a multiple regression with BMI as dependent variable. For occupation and for each of the life-style patterns, two variables were introduced in the analysis: a dummy variable (D_i) indicating presence or absence, and an interaction term (D_iL_i) indicating the level of occupation or life-style characteristics, if present. In a similar manner we dealt with missing data for family income: here the D_i indicates presence or absence of the information, and if income data were available the interaction term expressed its strength. All other variables (X_i) were entered as simple additive terms. Thus the regression of all independent variables on BMI was explored according to the following model:

$$\text{BMI} = \text{Intercept} + \Sigma(\beta_{X_i} X_i + \beta_{D_i} D_i + \beta_{L_i} D_iL_i).$$

The analysis was performed separately for men and women because of expected differences in relationships.

Significance of the effects is expressed in their *t*-values, calculated as the ratio of the regression coefficient (β_i) and its standard error. An effect was considered statistically significant for values of $t \geqslant 1.96$ ($P \leqslant 0.05$). For trends in opinions related to body build a linear trend analysis was applied (Armitage, 1977).

Results

Frequency distributions of characteristics used in the multiple regression are shown in Table 1. These distributions also provide information on the study population. The mean of BMI in men was 24.1 (range: 15.5-36.7) in women it was 23.5 (range: 15.4-43.3). In this table we observed sex differences for prevalence and level of smoking and alcohol drinking, while regular physical activity, sedentary living and family history of CHD were equally distributed.

Results of multivariate analysis are presented in Table 2. Beside a difference between the sexes in significance of correlations, the direction of the association differs for some variables. Among men BMI is positively correlated with age, daily amount of tobacco consumption among those who smoke and family history of CHD. Among women a positive independent relationship with BMI is found for age, being married, widowed or divorced, and sedentary living. Inverse associations for men are found for education level, unemployment, smoking *per se* and among women for education level, familial social class, and duration of leisure time physical activity.

As regards topics related to body build, in both sexes body image and attempts to reach normal weight show a trend over the quintiles of BMI, though sex differences in the overall frequencies can be observed (Table 3). Further, with increasing BMI, the percentage of women who consider their degree of physical activity sufficient declines, and the fraction of men who think their dietary habits are unhealthy rises.

Table 1. *Distribution in the study population of characteristics used for the multiple regression*

Characteristic		*Distribution* Men (n = 882)	Women (n = 1044)
Dependent variable:			
Body mass index*	range	15.5-36.7	15.4-43.3
(kg/m^2)	mean	24.1	23.5
	se	0.11	0.11
Independent variables:			
Age*	range	18-64	18-64
(yr)	median	38	41
Civil status**	unmarried	17	12
(%)	married	79	76
	divorced/widowed	4	12
Urbanization**	rural	45	40
(%)	urban	55	60
Education**	primary school and low vocational training	49	61
(%)	secondary school and middle vocational training	33	31
	university and high vocational training	18	8
Occupation**	unemployment	19	74
(%)	low occupation	17	3
	middle occupation	43	19
	high occupation	21	4
Familial social class**	lower class	55	59
(%)	middle class	23	21
	upper class	22	20
Family income**	unknown	19	27
(%)	< 1250 (guilders/month)	4	8
	1250-1750	12	12
	1750-2250	19	16
	2250-2750	18	14
	2750-3250	10	7
	3250-3750	6	5
	> 3750	12	11
Smoking**	never smokers	20	45
(%)	ex-smokers	22	19
	current smokers	58	36
Tobacco consumption*	range	1-87	1-50
(g/d)	median	19	12
Alcohol**	non-drinkers	16	8
(%)	drinkers	84	92
Alcohol consumption*	range	1-13	1-12
(glasses/d)	median	2	1
Sedentary living*	range	1.5-16	1.5-16
(h/d)	median	9.5	9.5
Physical activity in leisure time** (%)	occasional	22	19
	regular	78	81
Duration of activity*	scoring range	1-6	1-6
	mode	2	2
Family history of CHD** (%)	no	74	73
	yes	26	27

* Included in the regression as continuous variable ** Included in the regression in categories.

Discussion

By multiple regression we studied the relationship of BMI with demographic, social and life-style characteristics in a random sample of the Dutch adult population. This paper adds to the accumulated cross-cultural literature on social and life-style variables in relation to obesity. The cross-sectional nature of the data, however, makes interpretation of the findings difficult. The specific strength of this study lies in the fact that several determinants of obesity have been considered simultaneously in a multivariate analysis. This way the independent contribution of a determinant can be estimated, since the influence of interrelations between determinants, which cannot be detected in 2 x 2 contingency tables, will be eliminated; thus confounding is minimized, at least for the introduced variables.

Table 2. *Relationship of demographic, socioeconomic, and life-style characteristics with BMI; t-values and regression coefficients (β) obtained by multiple regression analysis.*

*Determinant**	*Men* (*n* = 882)		*Women* (*n* = 1044)	
	β	*t*	*β*	*t*
Demographic:				
Age (yr)	0.060	6.98**	0.061	7.01**
Married	0.376	1.29	1.141	3.27**
Widowed/divorced	0.382	0.71	0.991	2.18**
Urbanization	–0.173	–0.92	–0.243	–1.17
Socioeconomic:				
Education level	–0.676	–3.73**	–0.780	–3.92**
Occupation				
Unemployment	–1.130	–2.58**	0.191	0.24
Level of employment	–0.344	–1.84	0.076	0.21
Familial social class	0.161	0.88	–0.326	–1.99**
Family income	0.076	1.05	0.098	0.32
Life-style:				
Smoking				
Current smoking	–0.839	–3.15**	–0.460	–1.36
Tobacco consumption (g/d)	0.021	2.24**	0.016	0.79
Alcohol				
Alcohol use	–0.426	–1.67	0.182	0.48
Alcohol consumption (glasses/d)	0.034	0.60	0.143	1.15
Sedentary living (h/d)	–0.018	–1.10	0.041	2.01**
Leisure time physical activity				
Regular exercise	0.173	0.68	–0.269	–0.92
Duration of activities	–0.054	–0.61	–0.206	–2.09**
Family history of CHD	0.574	2.79**	–0.163	–0.70
(Intercept)	22.340		20.329	
	r square: 0.16 *F*-value = 8.82 (df = 18, 863)		*r* square: 0.17 *F*-value = 11.67 (df = 18, 1025)	

β = regression coefficient.
t = β divided by its standard error; a (—) sign indicates a negative relationship.
* For categories of the discontinuous variables see Table 1.
** Significant at 0.05 level.

Table 3. *Trends in opinions related to body build over quintiles of BMI by sex*

Respondent . . .		Overall %	I %	II %	III %	IV %	V %	Chi² for linear trend (df=1)
			Quintiles of BMI					
considers him/herself overweight	men	32	3	10	22	55	72	*
	women	39	7	19	32	58	82	*
made one or more attempts in the past to reach normal weight	men	38	23	31	33	55	50	*
	women	50	34	40	51	61	66	*
considers his/her degree of physical activity sufficient	men	70	66	73	76	67	67	
	women	72	77	78	74	71	65	*
thinks his/her dietary habits are unhealthy	men	13	8	11	13	13	20	*
	women	11	12	10	9	11	14	
believes that modification of dietary habits is difficult	men	29	26	23	30	25	43	*
	women	30	28	25	31	30	34	
Range of BMI (kg/m^2)	men	16-37	16-	22-	23-	25-	27-37	
	women	15-43	15-	21-	22-	24-	26-43	
No. of subjects	men n = 882							
	women n = 1044							

*Significant at 0.05 level (one-tail)

The results, representative for the Netherlands, are in partial agreement with studies from other countries in which usually univariate associations, sometimes stratified for one or two variables, were explored. Consistent with a recent study in Belgium (Kittel *et al.,* 1978), marital status shows no relationship with BMI in men. Married, divorced or widowed women, however, seem to be heavier in our sample, while Noppa & Bengtsson (1980*a*) reported the opposite in a population study of Swedish women. A possible explanation could be that they included a number of children in their analysis, which we did not. It is a common experience for women to become heavier with each pregnancy, because the weight gained is often not entirely lost afterwards. Thus, the positive effect of obesity found for marital status might disappear with control for number of children. Psychosocial factors may provoke the development of obesity in divorced and widowed women. However, in the domain of life event research we did not find studies that enlighten this hypothesis.

Review of the literature on socio-economic factors and obesity shows that the definition of socio-economic status (SES) differs from study to study. In our investigation we separated the effect of the respondent's own educational and occupational attainment from that of familial social factors. For the students (3 per cent) in our sample, who had not yet finished their training, this may have resulted in some distortion. Despite the variation in definition of SES, our findings on components of SES are in remarkable agreement with previous other reports (Rimm & Rimm, 1974; Garn *et al.,* 1977; Kittel *et al.,* 1978; Kohrs *et* *al.*, 1979; Noppa & Bengtsson, 1980*a*; Susanne, 1980), with the exception of educational level in men for which we found a negative association with BMI (Garn *et al.*, 1977; Kohrs *et al.*, 1979; Susanne, 1980). For one publication (Garn *et al.*, 1977) the time lag of nearly twenty years between their data collection and ours offers a possible explanation, ie, in the early sixties affluent people were heavier. Still, it seems that in the Netherlands, men in higher education strata are now more conscious of their stature, as compared with men in other countries, like Belgium, Germany and the USA (Kohrs *et al.*, 1979; Susanne, 1980). Finally, the negative association of unemployment with BMI in males is important: because of the negative effects of thinness on health. This category consists also of persons on sick leave or disability pension or early retirement, who are potentially more at risk.

As to life-style characteristics the effect of smoking on BMI follows the U-shaped pattern reported earlier by others (Khosla & Lowe, 1972; Hjermann *et al.*, 1976; Blitzer *et al.*, 1977; Noppa & Bengtsson, 1980*b*; Tillotson, Gordon & Kassim, 1981), even after controlling for numerous variables. This finding underlines the usefulness of an interaction term (see Methods) in evaluating the different effects on BMI of smoking *per se* and the amount smoked daily. Smokers are leaner than non-smokers and heavy smokers have a higher BMI than light smokers. A higher metabolic rate or a suppressed appetite among smokers could be explanatory for the left part of the curve. Another possibility is that ex-smokers substituted eating for smoking (Noppa & Bengtsson, 1980*b*; Jacobs & Gottenborg, 1981). The right part, however, is not consistent with these hypotheses. Hjermann *et al.* (1976) suggested that 'those who are constitutionally determined to start smoking, are also determined to have higher body weight'. Such a biological trend may also apply to our findings. It has been stated that obese persons have a lower energy intake than their leaner counterparts (Lincoln, 1972; Keen *et al.*, 1979). This information was not available in our study, but the results on alcohol consumption, though not significant, pointed in the opposite direction.

In men no significant correlation with items on physical activity could be revealed. This finding can be genuine (Kittel *et al.*, 1978), but may also have a methodological origin. The signs of the regression coefficients for male subjects, with the exception of duration of activity, are in accordance with the findings of Keys & Brozek (1957): sedentary men are both lighter and fatter while active men are often heavier but leaner. Their conclusion that the effects of physical activity appear chiefly in the adipose tissue reinforces the doubts of the efficacy of BMI to study the effect of physical activity on obesity, because BMI does not discriminate between lean and fat body mass. In women the results paralleled intuitive expectations. The exertion level in active women is generally regarded as too low to induce these physiological effects.

Although equal proportions of men and women reported CHD in the immediate family (Table 1), the association with BMI seemed to exist only for men.

It is apparent from the results of the regression analysis (Table 2) that the enrolled variables are not decisive in determining adult obesity: a condition in which both genetic and environmental factors are important. Only 16 per cent (males) and 17 per cent (females) of the variation in the BMI in our sample can be attributed to all the included variables. On other sources of variation in obesity, like heredity and energy intake, we had no information. An alternative explanation can be observation bias and thus spurious effects of the known variables. For obtaining information on behavioural variables a recall of daily activities seems to be the only known practical method on a population basis. The possibility exists that individuals report more socially desirable behaviours ie, lower tobacco and alcohol consumption and more intensive physical activity. Though not ideal, we assumed measurement on an ordinal scale of these variables to be sufficient to establish an effect on BMI. Observation bias would only affect the strength of the associations. In addition, inferences from the results of our study have to be made with care, because of the possibility of confounding by variables not included in the analysis.

Another methodological question is whether self-reported weight and height can yield valid data on overweight compared to anthropometric measurements. As reported in the literature (Damon, 1965; Biro, 1980), when both self-reported and measured height and weight are recorded in one population, men in the lower part of the distribution of body weight seem to over-estimate their own body weight; in the upper part of the distribution under-estimation occurs. The pattern is different for women; even the lightest women under-report, rather than over-report their weight. Supposing this phenomenon occurred in our study, the consequence would be that, had anthropometric data been available, the regression coefficients would have been more pronounced. Support for the validity of self-reporting can be found in the similarity of the BMI distributions by age and sex of our data with anthropometric data on prevalence of obesity in the Netherlands (Valkenburg *et al.*, 1980). Since our interest was primarily in the existence of associations and not the strength, and in consideration of a possible inaccuracy of stated height and body weight, the inferences are based on *t*-values and not on the regression coefficients (Table 2).

In the multivariate analysis BMI was not categorized, which had the advantage of getting around the problem of choosing cut-off points; the cut-off points above which overweight is associated with increased overall mortality are now being questioned (Sorlie, Gordon & Kannel, 1980; Keys, 1980; Andres, 1980). Keys concluded that risk of dying prematurely or having a heart attack rises substantially only at the extremes of under- and overweight. However, assuming that weight reduction for the highest quintile of BMI (in our data 27 or more for men and 26 or more for women) may have health benefits (Ashley & Kannel, 1974; Van Itallie, 1979; Noppa, 1980), an inventory of opinions relating to body build and prevailing in overweight subjects may be useful for therapy. As Table 3 shows, the majority of individuals in the fifth quintile of BMI were aware of their overweight and half or more of this category had already made one or more attempts to reach normal weight. This has also been observed by others (Ashwell & Etchell, 1974). As to physical exercise, in both sexes two out of three subjects were of the opinion that their customary activity was sufficient. More men than women believed that their dietary habits were unhealthy and that modification would be difficult.

In weight control programmes, in which dietary modification, increase of physical activity, and medications either alone or in combination are the basic methods, these beliefs related to body build should be kept in mind.

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