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Socio-demographic variables and 6 year change in body mass index: longitudinal results from the GLOBE study

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Background: Body mass index (BMI) differs by socio-demographic variables, but the origin of these associations remains relatively unknown.
Objective: To investigate the association between socio-demographic variables and the subsequent change in BMI over six years.
Design: A Dutch prospective cohort study (GLOBE) from which data were used from initially 20–49-year-old subjects (males: $n = 362$; females: $n = 405$). BMI was calculated from self-reported body height and weight data obtained in 1991 and 1997. Socio-demographic variables used were sex, age, educational level and the occupational level of the main breadwinner, family income, marital status, religious affiliation and degree of urbanization and measured in 1991.
Results: Cross-sectionally, BMI was higher in males than in females. BMI was positively associated with age and negatively associated with educational level in both sexes, after adjustment for the other socio-demographic variables. A positive association of BMI with family income was found in males and a negative association with occupational level was found in females. During follow-up, BMI increased significantly more in females (from 23.0 (s.d. 3.3) to 24.2 (s.d. 3.8)) than in males (from 24.3 (s.d. 2.9) to 25.1 (s.d. 3.5)). With the exception of a significant lesser increase in BMI in initially 30–39-year-old women compared to initially 40–49-year-old women, no other statistically significant associations were found between socio-demographic variables and the 6-year change in BMI.
Conclusions: Cross-sectional differences in BMI by socio-demographic variables are not due to different 6-year changes in BMI for categories of these variables in adulthood. Cross-sectional differences in BMI by educational level are probably established at the end of adolescence.
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Introduction

Obesity is an important risk factor of coronary heart disease (CHD)[1–3] and type 2 diabetes mellitus.[4–5] In the past decade, increasing prevalence rates of obesity, defined as a body mass index (BMI; kg/m^2) above 30, have been reported.[6,7] In the Netherlands, it is estimated that the prevalence of obesity is 7% and 9% in 20–60-year-old males and females, respectively.[8]

Cross-sectional research shows that BMI differs by socio-demographic variables. A consistent finding in this context is an inverse association of socio-economic status (SES) with BMI, especially in females.[9] However, inconsistent results are found for the association between marital status and BMI, with higher prevalences of obese subjects reported in both married and unmarried subjects.[10–12] In a Dutch study, an association was found between religious affiliation and BMI, with a higher mean BMI in Lutheran males and females compared to non-Lutheran males and females.[13] In this study, the mean BMI of males living in rural areas was higher than in males living in urban areas.

The importance of such information is that it may result in the identification of target populations for primary prevention of obesity. For the development of effective strategies of prevention, additional information is required about how these associations become established, which is currently far from clear.[12,14] Theoretically, BMI could influence socio-demographic variables (a selection mechanism).[15] Furthermore socio-demographic variables could have an influence on the BMI (a causation mechanism) through intermediate factors, such as health related behaviour, psychosocial or material factors. With respect to the development of socio-economic differences, the causation theory is believed to play a more important role compared to the selection theory.[16] Furthermore, selection is not possible once socio-demographic variables are established and do not change over time, as for example with educational

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level in adulthood. With regard to the development of socio demographic differences in BMI however, only few studies have investigated causal[17–20] and selection mechanisms,[15,21] probably because this requires a longitudinal research design.

The Dutch GLOBE study is a prospective cohort study, aimed at explaining socio-economic differences in health in the Netherlands.[22] Within the framework of the study several socio-demographic variables have been measured. In the present study, we hypothesised the causation mechanism in adulthood to be responsible for socio-demographic differences in BMI in that period of life. Therefore, we investigated the association between socio-demographic variables and the subsequent 6-year change in BMI in adulthood.

Material and methods

Population

GLOBE is the Dutch acronym for 'Health and Living Conditions of the Population of Eindhoven and Surroundings'. A detailed description of the purpose and design of the GLOBE study is presented elsewhere.[22] In short, the study aims at making a quantitative contribution to the explanation of socio-economic health differences. A sample of 27,070 non-institutionalised Dutch persons between 15 and 75 years of age, living in or near the city of Eindhoven (in the south of the Netherlands) was asked to fill in a postal questionnaire, including questions about body height and weight, in 1991. The response rate was 70.1% and hence information was available from 18,793 persons.

A random sample of these subjects was additionally interviewed at home ($n = 2802$) in the same year and constituted the study population for longitudinal research purposes. A follow-up measurement by postal questionnaire was carried out 6 years later, in 1997. During follow-up, some subjects died or were lost to follow-up (refused to participate, emigrated or other reasons) ($n = 236$). Of the remaining population, 2148 subjects returned their questionnaire (response rate 83.7%). The analyses for the present study were based on subjects aged between 20 and 49 years of age ($n = 1009$). These age criteria were chosen to avoid changes in BMI caused by changes in body height. Subjects with missing information on body height, body weight or any of the included socio-demographic variables were excluded ($n = 191$). Subjects with a serious heart problem (including a myocardial infarction), cancer or diabetes mellitus were excluded from the analyses ($n = 28$). Subjects were further eliminated from the analyses if the difference between their reported body height at baseline and at follow-up was more than 5 cm, in order to restrict the effect of reporting error ($n = 23$). As a consequence, the population under study consisted of 362 males and 405 females. Table 1 presents the percentages of subjects according to four main variables in this study population and in the GLOBE population at the baseline measurement. The table shows that unmarried males and males between 20 and 29 years of age were relatively underrepresented in the current study population compared to the GLOBE population. In general however, it suggests that our restriction criteria and drop out did not influence the composition of the population to a large extent.

Table 1 Percentage of subjects in current study population compared to GLOBE population by socio-demograpic variables and BMI at baseline

	Males		Females	
	*Study population**	*GLOBE population†*	*Study population**	*GLOBE population†*
Age				
20–29	22.7	31.4	27.9	30.6
30–39	32.9	27.3	26.4	25.9
40–49	44.5	41.4	45.7	43.5
Marital status				
married	70.7	58.6	70.9	65.1
unmarried	29.3	40.4	29.1	33.8
missing		0.9		1.1
Education				
1 (low)	5.8	9.3	8.6	9.8
2	30.7	30.9	43.0	44.6
3	27.1	25.5	27.4	26.7
4 (high)	36.5	32.0	21.0	17.0
missing		2.4		2.0
BMI 1991				
≤20	6.6	6.5	16.3	16.1
20–25	56.9	56.3	65.2	59.7
25–30	32.9	31.1	14.1	17.0
>30	3.6	4.3	4.4	5.0
missing		1.9		2.2

*Study population: population used in this study and for which follow-up data were available (males: $n = 362$; females: $n = 405$).
†GLOBE population: all GLOBE participants aged between 20 and 49 years of age (males: $n = 4203$; females: $n = 4283$).

Relative body weight

Open-ended questions in the postal questionnaires in 1991 and 1997 were used to obtain information about body height (in cm) and body weight (in kg). These self-reported body height (in cm) and weight (in kg) data were used to calculate BMI (weight (kg)/height^2(m)). The change in BMI was calculated by subtracting the value obtained in 1991 from the value obtained in 1997.

Socio-demographic variables

Socio-demographic variables, all measured in 1991, included in this study were sex, age, SES, marital status, level of urbanisation and religious affiliation. Age of the respondents was categorised into three 10-year groups (20–29 y; 30–39 y and 40–49 y). SES was measured by three different indicators. First, we used the highest attained educational level, where subjects still attending school were classified according to their current educational level. Four different groups were created (primary school only; lower vocational or lower secondary general education; intermediate vocational or higher secondary general education; higher vocational education or university). Secondly, information was obtained about the occupation of the main breadwinner, which was classified according to the Ericson, Goldthorpe and Portocarero (EGP) Scheme.[23] Five categories were created (higher grade professionals; lower grade professionals or routine non-manual workers; self-employed workers; skilled manual workers; unskilled manual workers). In some cases, it was not possible to categorise subjects in one of these groups, for example because they lived alone and never had a job. These subjects were captured in a sixth category. As a third indicator of SES, information about family income was obtained. In order to give less weight to children compared to adults, we divided the net income of the family (in Dutch currency) by the root of the number of adults plus 0.7 times the number of children in the family.

Subjects were asked for their marital status and classified into two categories (married *vs* unmarried, the latter including single, divorced or widowed subjects). Four different levels of urbanisation were created. Three groups of religious affiliation were created (no religion, Roman Catholic and other). Females were asked whether they had children or not, in order to adjust for the effects of parity on (changes in) BMI. All indicators were obtained from the postal questionnaire, except for the information about family income, which was obtained in the interview.

Statistical analyses

The association between socio-demographic variables (independent variables) and BMI (dependent variable) in 1991 was investigated in multivariate linear regression analysis. Subsequently, such analyses were performed with the 6-year change in BMI as dependent variable. Categorical independent variables were treated as dummy variables. Hence, the regression coefficients show the difference in (the change in) BMI for a specific group as compared to a reference group.

The first socio-demographic variable for which we investigated the association with BMI was sex. There appeared to be significant interaction effects between sex and both occupational level and family income and therefore it was decided to perform sex-specific analyses.

BMI at baseline was not related to the subsequent 6-year change in BMI (correlation coefficients in males: $r = -0.06$, $P = 0.25$, and in females: $r = -0.04$, $P = 0.44$). Hence, adjustment for BMI at baseline yielded essentially similar results as analyses without this adjustment. Therefore, only the latter are presented.

Results

Table 2 presents the means (s.d.) of BMI at baseline (1991) by the socio-demographic variables.

BMI was significantly higher in males than in females ($\beta = 1.34$; 95% CI [0.90; 1.78]) (not tabulated). Table 3 shows the associations between the other socio-demographic variables and BMI in 1991 in males. BMI in the lowest age category was significantly lower compared to BMI in the highest age category. An inverse association between educational level and mean BMI was found, independent of the other socio-demographic variables, except in the group with primary school as highest attained educational level. A positive association was found between family income and BMI.

In females, BMI was significantly lower in the 30–39-year-old age group compared to BMI in the 40–49-year-old age group (Table 4). BMI increased with

Table 2 BMI at baseline by socio-demograpic variables

	Males (n = 362)		*Females (n = 405)*	
	N	*Mean (s.d.)*	*N*	*Mean (s.d.)*
Overall	362	24.3 (2.9)	405	23.0 (3.3)
Age (y)				
20–29	82	22.7 (2.5)	113	22.2 (2.9)
30–39	119	24.5 (3.0)	107	22.7 (3.4)
40–49	161	24.9 (2.6)	185	23.7 (3.4)
Education*				
1 (low)	21	24.8 (2.4)	35	24.7 (3.5)
2	111	25.0 (2.5)	174	23.4 (3.5)
3	98	24.6 (3.3)	111	23.0 (3.3)
4 (high)	132	23.4 (2.6)	85	21.7 (2.4)
Occupation†				
1 (high)	67	24.4 (3.1)	41	22.7 (3.0)
2	153	23.9 (2.9)	189	22.6 (2.9)
3	10	25.8 (3.8)	11	22.4 (1.4)
4	61	24.9 (2.4)	81	23.0 (3.3)
5 (low)	53	24.7 (2.6)	55	25.1 (4.7)
6	18	22.8 (2.6)	28	22.5 (3.0)
Income‡				
1 (low)	90	24.3 (2.7)	101	23.5 (3.8)
2	89	24.2 (2.7)	95	23.6 (3.6)
3	82	24.0 (2.9)	97	22.6 (3.0)
4 (high)	101	24.5 (3.1)	112	22.5 (3.0)
Marital status				
married	256	24.7 (2.8)	287	23.3 (3.4)
unmarried	106	23.3 (2.8)	118	22.3 (3.0)
Urbanisation				
1 (rural)	38	24.6 (2.9)	49	22.7 (3.0)
2	69	24.5 (2.8)	75	22.9 (3.0)
3	50	24.8 (3.1)	58	23.4 (4.0)
4 (urban)	205	24.0 (2.8)	223	23.1 (3.4)
Religion				
no	48	23.7 (2.4)	46	23.2 (4.1)
Roman catholic	260	24.4 (2.9)	320	23.0 (3.2)
else	54	24.0 (3.1)	39	23.2 (3.7)

*1 = primary school; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.
†1 = higher grade professionals; 2 = lower grade professionals or routine non-manual workers; 3 = self-employed workers; 4 = skilled manual workers; 5 = unskilled manual workers; 6 = others.
‡Based on quartiles in Dutch currency, (P25 = 1493.90; P50 = 2050.00; P75 = 2722.35 in males and P25 = 1390.14; P50 = 1838.48; P75 = 2494.70 in females).

Table 3 Effects of socio-demographic variables on BMI at baseline in males

	β*	95% CI
Age (y)		
20–29	**−2.05**	**(−2.96; −1.15)**†
30–39	−0.36	(−1.02; 0.30)
40–49	0	
Education†		
1 (low)	1.41	(−0.11; 2.92)
2	**1.55**	**(0.57; 2.52)**
3	**1.33**	**(0.50; 2.16)**
4 (high)	0	
Occupation‡		
1 (high)	0	
2	−0.42	(−1.27; 0.42)
3	0.39	(−1.54; 2.33)
4	0.12	(−1.08; 1.32)
5 (low)	0.02	(−1.26; 1.30)
6	1.42	(−0.43; 3.26)
Income§		
1 (low)	**−1.08**	**(−2.02; −0.13)**
2	**−1.11**	**(−1.97; −0.26)**
3	−0.78	(−1.61; 0.04)
4 (high)	0	
Marital status		
married	0	
unmarried	−0.35	(−1.10; 0.40)
Urbanisation		
1 (rural)	0.13	(−0.85; 1.11)
2	0.19	(−0.58; 0.95)
3	0.51	(−0.37; 1.38)
4 (urban)	0	
Religion‖		
1	−0.17	(−1.06; 0.72)
2	0.23	(−0.88; 1.33)
3	0	

*Adjusted for the other variables.
†1 = primary school; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.
‡1 = higher grade professionals; 2 = lower grade professionals or routine non-manual workers; 3 = self-employed workers; 4 = skilled manual workers; 5 = unskilled manual workers; 6 = others.
§Based on quartiles in Dutch currency (P25 = 1493.90; P50 = 2050.00; P75 = 2722.35).
‖1 = Roman Catholic; 2 = other; 3 = no religion.
**Bold: 95% CI does not include 0.

Table 4 Effects of socio-demographic variables on BMI at baseline in females

	β*	95% CI
Age (y)		
20–29	−0.91	(−1.91; 0.10)
30–39	**−0.92**	**(−1.72; −0.12)****
40–49	0	
Education†		
1 (low)	**2.16**	**(0.73; 3.59)**
2	**1.02**	**(0.08; 1.97)**
3	**1.39**	**(0.45; 2.32)**
4 (high)	0	
Occupation‡		
1 (high)	0	
2	−0.34	(−1.48; 0.80)
3	−1.27	(−3.47; 0.93)
4	−0.53	(−1.86; 0.80)
5 (low)	**1.56**	**(0.11; 3.01)**
6	−0.08	(−1.83; 1.68)
Income§		
1 (low)	0.63	(−0.41; 1.68)
2	0.52	(−0.51; 1.56)
3	0.19	(−0.79; 1.17)
4 (high)	0	
Marital status		
married	0	
unmarried	−0.55	(−1.45; 0.36)
Urbanisation		
1 (rural)	−0.50	(−1.53; 0.53)
2	−0.19	(−1.06; 0.68)
3	−1.60	(−0.96; 0.96)
4 (urban)	0	
Religion‖		
1	−0.48	(−1.51; 0.55)
2	0.14	(−1.27; 1.54)
3	0	

*Adjusted for the other variables and parity (0 = no children; 1 = at least one child).
†1 = primary school; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.
‡1 = higher grade professionals; 2 = lower grade professionals or routine non-manual workers; 3 = self-employed workers; 4 = skilled manual workers; 5 = unskilled manual workers; 6 = others.
§Based on quartiles in Dutch currency (P25 = 1390.14; P50 = 1838.48; P75 = 2494.70).
‖1 = Roman Catholic; 2 = other; 3 = no religion.
**Bold: 95% CI does not include 0.

decreasing educational level. The absolute difference between BMI in the highest and lowest educational group was higher in females than in males. Compared to the reference groups, females in the lowest occupational group had a significantly higher mean BMI.

Mean BMI increased from 24.3 (s.d. 2.9) in 1991 to 25.1 (s.d. 3.2) in 1997 in males. Over the same period of time, BMI increased from 23.0 (3.3) to 24.2 (3.8) in females. Sex was significantly associated with the change in BMI, with a larger increase in females ($\beta = -0.29$; 95% CI [-0.55; -0.04]). This association became slightly weaker after adjustment for BMI at baseline ($\beta = -0.26$; 95% CI [-0.52; 0.00]) (results not tabulated). For the other socio-demographic variables, their relation with the 6-year change in BMI was investigated sex-specifically. Despite the cross-sectional differences in BMI by age and educational level, no statistically significant associations were found between both variables and the 6-year change in BMI in males (Table 5). In females, the increase in BMI in 30–39-year-old subjects was significantly lower compared to the change in 40–49-year-old women (Table 6). As in males, no association was found between SES and the change in BMI in females.

Discussion

In the present study, we investigated whether the causal mechanism was responsible for associations between socio-demographic variables and BMI in adulthood. The inverse association with educational level is often described. Probably the most important finding of the present study therefore is that the inverse association between educational level and BMI, as found in cross-sectional analyses, does not

Table 5 Effects of socio-demographic variables on the 6-year change in BMI in males

	β*	95% CI
Age (y)		
20–29	0.19	(−0.35; 0.72)
30–39	0.19	(−0.20; 0.58)
40–49	0	
Education†		
1 (low)	−0.25	(−1.14; 0.65)
2	0.02	(−0.56; 0.60)
3	0.02	(−0.47; 0.51)
4 (high)	0	
Occupation‡		
1 (high)	0	
2	0.18	(−0.33; 0.68)
3	−0.09	(−1.24; 1.05)
4	0.11	(−0.60; 0.82)
5 (low)	0.34	(−0.42; 1.09)
6	−0.21	(−1.30; 0.88)
Income§		
1 (low)	−0.24	(−0.80; 0.32)
2	−0.37	(−0.88; 1.14)
3	−0.12	(−0.61; 0.36)
4 (high)	0	
Marital status		
married	0	
unmarried	0.42	(−0.03; 0.86)
Urbanisation		
1 (rural)	0.15	(−0.43; 0.73)
2	−0.05	(−0.51; 0.40)
3	−0.10	(−0.62; 0.42)
4 (urban)	0	
Religion‖		
1	0.02	(−0.51; 0.55)
2	−0.34	(−1.00; 0.31)
3	0	

*Adjusted for the other variables.
†1 = primary school; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.
‡1 = higher grade professionals; 2 = lower grade professionals or routine non-manual workers; 3 = self-employed workers; 4 = skilled manual workers; 5 = unskilled manual workers; 6 = others.
§Based on quartiles in Dutch currency (P25 = 1493.90; P50 = 2050.00; P75 = 2722.35).
‖1 = Roman Catholic; 2 = else; 3 = no religion.

Table 6 Effects of socio-demographic variables on the 6-year change in BMI in females

	β*	95% CI
Age (y)		
20–29	−0.47	(−1.06; 0.12)
30–39	−0.61	(−1.08; −0.14)**
40–49	0	
Education†		
1 (low)	−0.68	(−1.52; 0.17)
2	0.12	(−0.44; 0.68)
3	−0.15	(−0.70; 0.40)
4 (high)	0	
Occupation‡		
1 (high)	0	
2	0.50	(−0.17; 1.17)
3	0.48	(−0.81; 1.77)
4	0.61	(−0.17; 1.39)
5 (low)	0.61	(−0.19; 1.51)
6	0.19	(−0.91; 1.16)
Income§		
1 (low)	−0.14	(−0.76; 0.47)
2	−0.29	(−0.90; 0.32)
3	0.03	(−0.55; 0.61)
4 (high)	0	
Marital status		
Married	0	
Unmarried	0.25	(−0.29; 0.78)
Urbanisation		
1 (rural)	−0.05	(−0.65; 0.56)
2	0.23	(−0.28; 0.74)
3	−0.36	(−0.92; 0.20)
4 (urban)		
Religion‖		
1	0.09	(−0.51; 0.70)
2	0.33	(−0.50; 1.16)
3	0	

*Adjusted for the other variables and parity (0 = no children; 1 = at least one child).
†1 = primary school; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.
‡1 = higher grade professionals; 2 = lower grade professionals or routine non-manual workers; 3 = self-employed workers; 4 = skilled manual workers; 5 = unskilled manual workers.
§Based on quartiles in Dutch currency (P25 = 1390.14; P50 = 1838.48; P75 = 2494.70).
‖1 = Roman Catholic; 2 = else; 3 = no religion.
**Bold: 95% CI does not include 0.

seem to be the result of a larger increase in BMI in subjects with a lower educational level in adulthood compared to the change in BMI in subjects with a higher educational level. Theoretically, it can either mean that we were not able to detect such differences, or that they are really absent, in which case our hypothesis needs to be rejected.

A methodological drawback of the study is the use of self-reported data on body height and weight. In general, correlation coefficients between self-reported and actually measured height and weight data are very high, often around 0.95.[24] Because this could be the result of a consistent under- or overestimation, self-reported data are of limited use if absolute values are needed. If subjects consistently under- or overestimate their body weight or body height, changes are still accurately determined. In our hypothesised causal mechanism however, it is expected that subjects with a low educational level (and often a high BMI) experience a larger increase of BMI compared to subjects with a higher educational level. Overweight subjects tend to underestimate their weight more compared to normal weight subjects.[25] Hence, changes in BMI in the lower educational groups could be underestimated to a larger extent than changes in BMI in the higher educational groups, making it more difficult to detect significant differences in the changes in BMI between the groups.

Another reason for the absence of a significant association between SES and the change in BMI could be that the follow-up period of 6 years is too short to detect a significant difference. The changes in BMI over 6 years for all educational groups are rather small compared to the changes in the reference group. Extrapolating these differences over a longer period of follow-up, for example 10 years, would still result in much smaller differences in BMI by SES than found in the cross-sectional analyses. This seems to be in agreement with results in the Whitehall II study, where the change in BMI was only 0.37 and 1.19

units more in grade III compared to grade I over 25 years of follow-up in adult males and females, respectively.[20] The duration of follow-up is unlikely to be the major explanation for the absence of significant associations between SES and the change in BMI.

In general, BMI of smokers is lower compared to that of non-smokers.[26] The percentage of smokers and the number of cigarettes smoked are generally higher in lower SES groups.[27] Longitudinal studies have further shown that those who quit smoking are at increased risk of a weight gain. Using follow-up information collected in 1997, analyses in the present study population showed a larger increase in BMI in those who quitted smoking during follow-up in males ($\beta = 0.64$, 95% CI [-0.56; 1.33]) and females ($\beta = 0.81$, 95% CI [0.16; 1.46]) compared to never smokers. In females, those who smoked at baseline and during follow-up showed a decrease in BMI ($\beta = -0.45$; 95% CI [-0.88; -0.02]). However, adding the change in smoking behaviour to the models presented (Tables 5 and 6), socio-economic differences in the change in BMI remained essentially similar. For educational level, for example, the regression coefficients for the lowest educational group changed to $\beta = 0.06$ (95% CI [-0.43; 0.56]) and $\beta = -0.11$ (95% CI [-0.68; 0.45]) in males and females, respectively.

The available comparable studies produced inconsistent results. In a study using actually measured body height and weight an excess increase of 0.3 (in females) and 0.6 units (in males) in BMI was found in the lowest (less than the 12th grade) compared to the highest educational group (more than the 12th grade) during 10 years of follow-up.[23] Sundquist *et al*,[18] recently reported no effect of educational level on the 8-year change in BMI in females, using self-reported body height and weight data. Males in the lowest educational group increased their BMI over this period even significantly less compared to subjects in the highest educational group.

Our results suggest that other mechanisms are responsible for the cross-sectional differences in BMI by educational level in adulthood than the hypothesised causal mechanisms. As mentioned earlier, the highest educational level is generally reached at the end of adolescence or in early adulthood. Therefore it is hardly possible that a change in BMI in adulthood subsequently affects the educational level. Hence, it seems impossible that a selection mechanism, occurring in adulthood, is responsible for the inverse association between educational level and BMI.

A remaining possibility is that this association is established earlier in life (either through causation, selection or a 'third' variable influencing both variables). It could exist already in early adulthood and, to a large extent, remain constant in the next decades. Studies of SES and (over)weight in children and adolescents have shown positive, negative and no associations.[9] It has been suggested that part of these inconsistencies could be due to different ages of the populations under study, with SES differences becoming more pronounced at the end of adolescence. Power *et al*[28] found SES differences (based on occupational level of the father) in BMI of subjects at the age of 23 years, while these differences were almost absent at the age of 7 years. In the Dutch Monitoring Risk Factor Project, an inverse association between SES and the prevalence of obesity was already apparent in 20–29-year-old subjects.[29] Indirect evidence

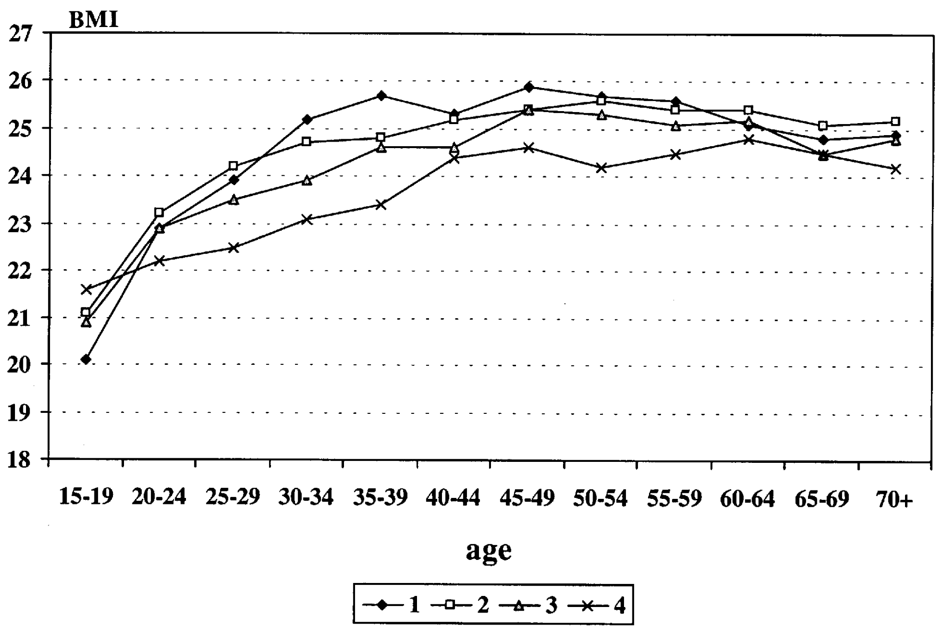

Figure 1 BMI by age and educational level* in males in the GLOBE study in 1991 ($n = 7784$). (*1 = primary school only; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.)

for this hypothesis comes from cross-sectional findings of our study, in which we investigated the association between age, educational level and BMI. Figures 1 and 2 present the findings for the total study population, including 15–19-year-old subjects, participating in the postal questionnaire.

In males, differences in BMI seem to develop in early adulthood, approximately between 15 and 30 years of age. In females, differences in BMI seem to develop even earlier in life (between 15 and 25 years of age) and seem to remain relatively constant in adulthood. Although there might be an influence of cohort effects in these cross-sectional data, the figures seem to confirm the finding of a cross-sectional gradient in BMI by SES throughout adulthood, in the absence of an association between the SES and the change in BMI. Unfortunately, the numbers of subjects in the youngest age categories in our longitudinal population were insufficient to further test this hypothesis. Prospective research seems to be justified in youth and young adulthood, to shed light on the possible development of BMI differences by educational level in this period of life. This should not only address the question if differences in BMI by educational level develop in this period of life, but also how they develop.

With regard to family income, we found no association between family income and BMI in females. In males however, subjects in the lower two quartiles showed a significantly lower BMI. Further, a positive association was found between occupational level and SES in females, but not in males. One explanation for these findings is a relatively high mean BMI in the higher compared to the lower socio-economic groups (based on occupational level and family income) in males. In the present study population, men were probably more often the main breadwinner. Perhaps a (work-related) lifestyle related to a high profession (and/or income) results in a relatively high BMI in males and contributes to the gender differences in the socio-economic gradient in BMI.

Cross-sectionally, we did not find a significant association between marital status and BMI. Unmarried males showed a borderline significantly larger subsequent increase in BMI over 6 years compared to married subjects during follow-up, which appeared to be independent of age, BMI at baseline and the other socio-demographic variables. Presumably, these seemingly different cross-sectional and longitudinal findings could be explained by changes in marital status. Gerace *et al*[19] found a larger increase of BMI in unmarried males compared to married males after 7 years of follow-up. Kahn *et al*[17] found no effect of marital status on the mean 10-year change in BMI in males, after adjustment for age and several socio-demographic variables, but reported an increased risk of a major weight gain (≥ 4 BMI units) in men who got married during follow-up. Sundquist *et al*[18] also found a larger increase in men who got married compared to consistently married males, but not in consistently single men compared to consistently married males. Future analyses, based on a larger part of our study population, could further elucidate the effects of changes in marital status on changes in BMI.

Our findings justify intervention strategies against obesity specifically targeted to subjects with a low educational level in adulthood. More importantly however, they also suggest that such differences develop earlier in life. For effective prevention of

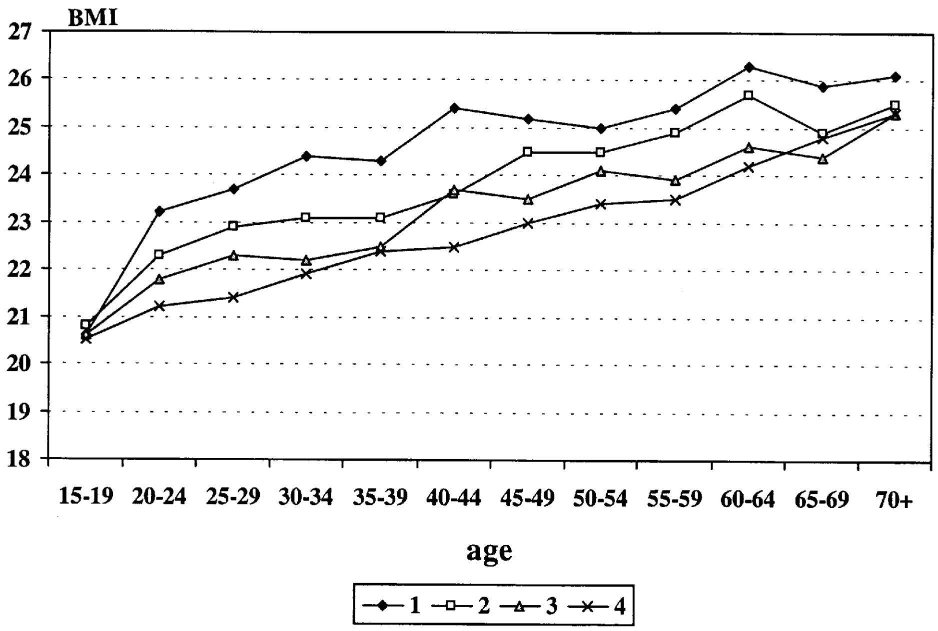

Figure 2 BMI by age and educational level* in females in the GLOBE study in 1991 ($n = 8494$). (*1 = primary school only; 2 = lower vocational or lower secondary general education; 3 = intermediate vocational or higher secondary general education; 4 = higher vocational education or university.)

obesity, the period of early adulthood is rather important. In this period of life, BMI increases rapidly and elevated levels of BMI in adolescence remain relatively high in adulthood. Hence, adolescents, and in particular those with a low educational level, seem to be an important target population in the primary prevention of obesity. With regard to marital status, mainly males could potentially benefit from an intervention aimed at reducing BMI. Such an intervention could further benefit from additional knowledge of the effects of changes in marital status on changes in BMI. Moreover, the present study shows the need for longitudinal studies on the association between socio-demographic variables and obesity, covering a large age range, and preferably including adolescence and early adulthood.

In conclusion, we found cross-sectional differences in BMI by age and educational level. Between 20 and 49 years of age, however, SES was not associated with the 6-year change in BMI. Cross-sectional differences in BMI by educational level in adulthood do not develop through a causal mechanism in this period of life.

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