Newly Diagnosed Type 2 Diabetics Have The Lowest Body Mass Index Change Among Rural Populations Of Sweden And The United States

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Citation

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Abstract

Objective: To evaluate demographic and cardiovascular risk factors associated with ten-year BMI development in rural populations using observational panel studies.

Methods: 1145 Swedish (547 men, 598 women) and 8122 U.S. (3837 men, 4285 women) adults aged 25-64 yr were recruited. Body mass index (kg/m^2) was obtained in 1989 and 1999. Demographics, smoking status, type 2 diabetes, physical inactivity and use of antihypertensive medications were obtained at each survey.

Results: Both populations had mean increases in BMI over 10 years. Age, baseline BMI, smoking, diabetes, use of antihypertensive medication and physical inactivity were strongly associated with BMI development. Newly diagnosed type 2 diabetics had the lowest mean BMI increases.

Conclusion: BMI development in these rural populations is associated with age and cardiovascular risk factors. Obesity prevention strategies may be most effective in specific high risk subgroups (e.g. newly diagnosed diabetics).

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INTRODUCTION

Obesity is quickly increasing in the U.S. and Sweden.[1, 2] Much remains to be understood about the reasons for the obesity epidemic, although behavioural factors are potentially the most amenable to change. Many studies have shown that the risk associated with increasing obesity occurs along a continuum, and the adverse effects are clearly seen with body mass indices (BMI) above 25 kg/m^2.[3, 4]

Approximately a fourth of Swedish and U.S. populations live in rural areas,[5, 6] and in Northern Sweden this number is even higher.[7] Rural populations are less studied than urban and suburban groups. Understanding what factors are important for obesity development or progression in rural populations is important since these populations differ from those in urban areas.[8]

Using panel data from two populations with both similarities and differences,[9, 10] and data collected during a similar time period, we have a unique opportunity to understand what factors are most influential in BMI development in rural populations.

The primary aim of this paper is to evaluate demographic and established cardiovascular risk factors that are predictive of ten-year BMI development (maintenance or change) in the rural, adult populations of Sweden and the U.S. A secondary aim is to evaluate whether there are differences in predictive risk factors between the two countries.

MATERIAL AND METHODS

The Swedish data are from the WHO Multinational Monitoring of Trends and Determinants in Cardiovascular

Disease (MONICA) in Northern Sweden. The U.S. data are from Health Census '89 and Health Census '99 conducted in Otsego County, New York.

The Northern Sweden MONICA study was approved by the Research Ethics Committee of Umeå University, Umeå, Sweden and computer data handling procedures were approved by the Swedish National Computer Data Inspection Board. Collection of the Health Census '89 and '99 data were approved by the Institutional Review Board of The Mary Imogene Bassett Hospital in Cooperstown, NY and approval for data use for this analysis was granted by the Health Census '99 Data Monitoring Committee.

MONICA was initiated in the early 1980s as repeated, representative, random sample, cross-sectional studies.[11] The cross-sectional surveys were supplemented in Northern Sweden with a panel cohort composed of adults aged 25-64 years seen in 1990 and 1999. Data were collected between January and April. Self-reported information included age, sex, civil status, years of education, daily tobacco use, intake of antihypertensive medications, type 2 diabetes and leisure activity. Height and weight were measured in a standardized fashion.[12] Demographics and cardiovascular risk factors for this population are published elsewhere.[10, 13]

The Health Censuses were conducted on the entire adult (18 years) population of Otsego County between June and December in 1989 and 1999 [14]. Each adult who participated in both surveys and was aged 25-64 years in 1989 was included in this analysis. All data were self-reported. Demographics and cardiovascular risk factor rates for this population are published elsewhere.[15, 16]

A combined dataset was formed and common variable classifications were established.[9] "Country" was used as a factor potentially explaining cultural, environmental or genetic differences. Civil status was categorized as "married" [married or in partnership (Sweden only)] or "unmarried" [never married, divorced, widowed or separated (U.S. only)]. Education was used both as a continuous variable (in models) and categorized into low (Sweden 9 yr, U.S. <12 yr), medium (Sweden 10-13 yr, U.S. 12-15 yr) or high (Sweden 14 yr, U.S. 16 yr) for Tables.[2,9] Use of antihypertensive medication was used as to identify hypertension as this was the only comparable question. Physical activity levels were assessed differently, but responses indicating lack of physical activity were similar; therefore, physical inactivity was used as the cardiovascular risk factor.

To make the U.S. self-reported weight and height data comparable to the objectively measured Swedish data, they were adjusted for self-report bias [16]. Adjustments were made by multiplying the self-reported BMI with a factor ranging from 1.029 to 1.068 that was specific to sex and BMI category (<18.5, 18.5-24.9, 25-29.9, 30) as previously validated in the same U.S. population (Jenkins PJ unpublished data).

BMI was used as a validated index of relative obesity.[17] BMI was categorized as normal 18-24.9, overweight 25-29.9, or obese ?30.[18] Since a BMI of <18 could represent malnutrition, these individuals (0.5% and <0.5% in both countries during 1989 and 1999, respectively) were excluded from the analyses.

Demographics and cardiovascular risk factors were compared between countries using ^{2} or independent t-tests as appropriate. Analysis of covariance was used to evaluate ten-year BMI change for each demographic (age, civil status, education) and risk factor (smoking, use of antihypertensive medication, diabetes, physical inactivity). Men and women were evaluated separately with age and baseline BMI included as continuous covariates in each model, and the effect of country was assessed. Those factors significantly related to ten-year BMI change at the univariate level were then combined into a single model that included both 2-way and 3-way interaction terms. Interaction terms that were not significant were removed to gain error degrees of freedom in the model.

RESULTS

Participation rates for the Swedish surveys were 80%.[19] Response rates for Census surveys were 86% (1989) and 79% (1999).[14] Demographics and prevalences of assessed cardiovascular risk factors are shown in Table I. Mean BMI was higher in the U.S. during both surveys.

Figure 1

Table 1: Demographic Characteristics and Cardiovascular Risk Factor Prevalence of the Northern Sweden and U.S. Study Populations by Country and Sex.

	Men	Women	Men	Women	Men	Women
	547	598	3837	4285	<0.001	<0.001
²)						
89	25.8 ± 3.2	24.8 ± 4.13	27.5 ± 4.17	26.3 ± 5.51	<0.001	<0.001
99	26.9 ± 3.4	26.4 ± 4.57	28.9 ± 4.82	28.9 ± 6.17	<0.001	<0.001
p						
nean ± SD)	45.8 ± 11.0	45.3 ± 11.1	44.0 ± 10.5	44.2 ± 10.7	<0.001	<0.17
age group:						
-34 yr	20%	21%	24%	24%	<0.001	0.003
-44 yr	26%	26%	31%	31%		
-54 yr	29%	27%	25%	24%		
-64 yr	26%	27%	20%	22%		
1989 (%)	84.2	82.4	84.0	83.2	0.89	0.65
years (mean ± SD)	10 ± 3	11 ± 3	13 ± 3	14 ± 4	<0.001	<0.001
oker						
89	20%	23%	28%	25%	<0.001	0.25
99	14%	18%	21%	19%	<0.001	0.65
etes						
89	1.5%	1.7%	2.4%	3.0%	0.17	0.62
99	4.0%	3.4%	7.3%	6.3%	0.005	0.004
ypertensive medication						
89	6%	10%	9%	9%	0.04	0.57
99	14%	17%	20%	19%	<0.001	0.23
activity						
89	17%	18%	40%	49%	<0.001	<0.001
99	20%	20%	40%	36%	<0.001	<0.001

There was no significant difference in type 2 diabetes prevalence between countries in 1989, but by 1999 the prevalence was higher in the U.S. Those developing diabetes were significantly more likely to have a lower BMI change ($p < 0.001$). Ten-year incidence of diabetes was 2.5/100 in Sweden and 4.9/100 in the U.S.

Mean ten-year change in BMI for each demographic and risk factor category is shown in Table II. In both surveys, the Swedish population had higher prevalences of normal BMI compared to the U.S. (50.8% vs. 40.2% in 1989; 37.2% vs. 28.3% in 1999). A greater proportion of the U.S. population was obese at both surveys compared to the Swedish population (21.4% vs. 9.6% in 1989; 32.2% vs. 18.3% in 1999). Women were more likely than men to have a normal BMI at either survey. Mean BMI increased in all subgroups except Swedish adults diagnosed with diabetes during the ten-year interval and Swedish women with diabetes at baseline (Figure). Those who required initiation of antihypertensive medication between surveys had the greatest mean BMI increases.

Figure 2

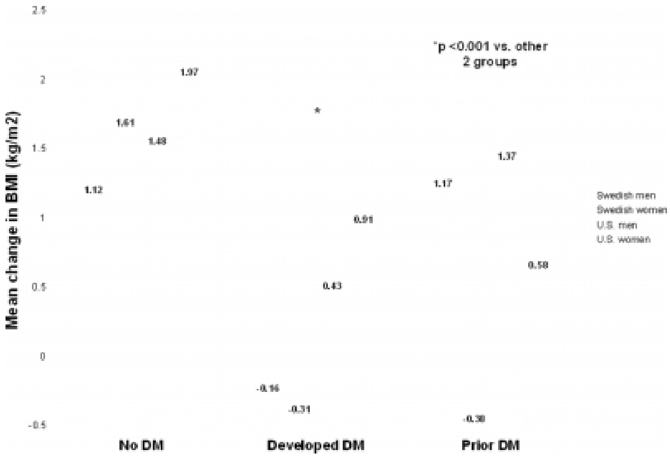
Table 2: Mean (± SD) Ten-year Change in Body Mass Index for Each Demographic and Cardiovascular Risk Factor Category by Country and Sex.

	Sweden				U.S.			
	Men		Women		Men		Women	
Demographic factors	BMI Change n = 547	Percent	BMI Change n = 598	Percent	BMI Change n = 3837	Percent	BMI Change n = 4285	Percent
Age group in 1989								
25-34	1.72 ± 1.72	20	1.80 ± 2.44	21	1.91 ± 3.13	24	2.42 ± 3.63	24
35-44	1.30 ± 1.83	26	2.22 ± 2.01	26	1.62 ± 2.80	31	2.22 ± 3.55	31
45-54	0.96 ± 1.71	29	1.41 ± 2.65	27	1.20 ± 3.02	25	1.77 ± 3.07	24
55-64	0.52 ± 1.78	26	0.80 ± 2.04	27	0.72 ± 2.70	20	0.95 ± 3.15	22
Civil status[1]								
Married 1989 and 1999	1.05 ± 1.75	76	1.53 ± 2.27	72	1.36 ± 2.81	78	1.88 ± 3.23	72
Unmarried in 1989, married in 1999	1.39 ± 1.64	4	2.78 ± 2.04	6	1.97 ± 2.91	6	2.14 ± 3.62	2
Married in 1989, unmarried in 1999	0.89 ± 1.68	9	1.19 ± 2.87	11	1.43 ± 3.01	6	1.56 ± 3.95	11
Unmarried in 1989 and 1999	1.33 ± 2.29	11	1.36 ± 2.26	12	1.39 ± 3.82	10	2.14 ± 3.84	15
Education								
Low	0.71 ± 1.70	42	1.26 ± 2.30	39	1.40 ± 3.20	53	1.75 ± 3.68	48
Medium	1.41 ± 1.94	44	1.72 ± 2.48	41	1.57 ± 2.85	23	2.08 ± 3.42	26
High	1.18 ± 1.46	14	1.71 ± 2.11	20	1.28 ± 2.95	24	1.93 ± 2.85	26
Cardiovascular Risk factors								
Smoking status								
Nonsmoker	1.06 ± 1.63	69	1.56 ± 2.29	68	1.39 ± 2.86	67	1.92 ± 3.24	72
Ex-smoker (quit)	1.25 ± 2.16	17	2.20 ± 2.58	14	1.97 ± 3.19	13	2.59 ± 4.29	10
New smoker (started)	1.16 ± 1.37	2	0.56 ± 2.23	2	0.94 ± 3.30	3	1.33 ± 3.58	2
Chronic smoker (both time points)	1.00 ± 2.30	12	0.98 ± 2.26	16	1.09 ± 2.92	18	1.37 ± 3.52	16
Type 2 diabetes								
No	1.12 ± 1.78	96	1.61 ± 2.27	97	1.48 ± 2.78	93	1.97 ± 3.22	94
No at baseline, became diabetic	-0.16 ± 2.49	3	-0.31 ± 3.86	2	0.43 ± 3.83	5	0.91 ± 6.30	4
Yes, throughout 10 yr interval	1.17 ± 2.72	1	-0.38 ± 3.6	2	1.37 ± 4.62	2	0.58 ± 3.80	2
Use of antihypertensive medication								
No	1.34 ± 2.19	40	1.03 ± 2.20	40	1.38 ± 2.83	78	1.93 ± 3.31	79
Yes at baseline, no by 1999	-1.46	<1	1.93 ± 2.44	2	1.05 ± 2.84	2	0.25 ± 3.75	2
No at baseline, yes by 1999	1.14 ± 1.52	36	2.22 ± 2.11	29	1.51 ± 3.33	13	2.08 ± 3.86	12
Yes, throughout 10 yr interval	0.52 ± 1.85	23	1.26 ± 3.06	29	1.55 ± 3.47	7	1.46 ± 3.64	7
Physical inactivity								
No	1.08 ± 2.42	10 (48)	1.70 ± 2.05	8	1.28 ± 2.90	14	2.39 ± 3.75	17
Yes at baseline, no by 1999	1.33 ± 1.87	11 (55)	2.10 ± 2.54	12	1.45 ± 3.15	26	1.86 ± 3.86	19
No at baseline, yes by 1999	1.32 ± 1.80	8 (39)	1.96 ± 2.00	9	1.41 ± 2.57	25	1.77 ± 2.90	32
Yes, throughout 10 yr interval	1.02 ± 1.71	72 (353)	1.41 ± 2.39	70	1.61 ± 3.28	35	1.89 ± 3.42	32

[1] Married defined as married or in partnership, unmarried defined as never married, divorced or widowed.

Figure 3

Figure 1: Mean Change in Body Mass Index for Swedish and U.S. Men and Women by Type 2 Diabetes Status between 1989 and 1999.



[1]Significant difference between groups by analysis of covariance, adjusting for sex, age and baseline body mass index.

Levels of significance for single demographic and cardiovascular risk factors for BMI development by sex are shown in Table III. Country had no effect on ten-year BMI change in any subgroup. A country-by-education interaction was not included in the final model because the main effect of education was not significant.

Figure 4

Table 3: Levels of Significance of Individual Demographic and Cardiovascular Risk Factors Evaluated for Association with Ten-year Body Mass Index Development in Adults in Northern Sweden and the U.S., Adjusted for Age and Body Mass Index at Baseline.

	Men		Women	
RiskFactor	P value for RiskFactor	P value for RiskFactor by Country Interaction	P value for RiskFactor	P value for RiskFactor by Country Interaction
Smoking	0.010	0.206	0.000	0.062
Type 2 diabetes	0.101	0.224	0.026	0.097
Antihypertensive medication	0.383	0.171	0.003	0.970
Physical inactivity	0.636	0.067	0.016	0.367
Married[2]	0.684	0.057	0.313	0.379
Low education	0.646	0.011	0.568	0.012

[1]Statistical testing by analysis of covariance.
[2]Married defined as married or in partnership, unmarried defined as never married, divorced or widowed.

A final model combined all subjects and controlled for sex, age and BMI at baseline (Table IV). Education and civil status were not significant. There were no significant two-way or three-way interactions for the main effects.

Figure 5

Table 4: Final Analysis of Covariance Model of Demographic and Cardiovascular Risk Factors Associated with 10-Year Body Mass Index Development in Adults of Northern Sweden and the U.S.

Dependent variable: 10-year BMI development

Adjusted R^2 for model = 0.260

Independent variables:	Significance
Type 2 diabetes	<0.001
Physical inactivity	<0.001
Use of antihypertensive medication	<0.001
Smoking status	<0.001

The model was adjusted for sex, age and BMI in 1989 (baseline). Country was not included in the model because there were no country-by-risk factor interactions identified with univariate analyses. There were no significant two-way or three-way interaction terms.

DISCUSSION

Our data are unique in being panel data. This allows us to evaluate the individual at the time of each survey and try to identify factors that impact the individual. In these rural populations, mean BMI increased over the evaluated ten-year interval for all age groups, regardless of sex, civil status or educational achievement. In addition, all four cardiovascular risk factors were significantly associated with BMI change. The relationship of younger age to greater increase in BMI has been previously reported.[20, 21] While one could argue the need for targeting young and early middle-aged adults for obesity prevention and/or weight maintenance strategies, the entire population increased in BMI during the observation period. By controlling for age in the regression models, we attempted to evaluate whether there are other specific factors that could guide the focus of intervention strategies.

Women were more frequently at a normal BMI and more likely than men to retain that classification. This protective effect against weight gain among women may be explained by societal norms and pressures on women to be slim.[22]

Cigarette smoking was associated with smaller increases in BMI. This was not surprising since smoking can alter basal metabolic rate, increase caloric expenditure, and thereby contribute to lower body weight.[23] There is evidence that most individuals who quit smoking have a transient weight increase that returns to "pre-smoking cessation" weight within a year of quitting. As we only had two time points, we could not determine the time between quitting and the second survey and therefore cannot comment further on any effect of smoking cessation and weight gain in our populations.

Development of diabetes during the ten-year interval was protective against weight gain for men and women, but was the most profound in Sweden—although our numbers are small. This may reflect greater attention to weight maintenance and weight loss among newly diagnosed diabetics. Other possible explanations include greater awareness of the role of weight in control of hyperglycaemia, and greater attention to patient education for weight control in diabetics. While firm conclusions should be avoided because of the small numbers, these data support the importance and potential impact of targeted health education. Secondary prevention of weight gain may be most effective at the time of diagnosis. Specifically targeting weight control interventions to newly diagnosed diabetics would reach a high risk group and might allow primary care physicians to channel illness behaviours in a positive way. Diabetics could achieve significant benefit from such efforts and should have enhanced motivation to do so. In addition, evaluation of the primary care provided to diabetics in Sweden may provide insight into techniques that could be successfully applied in other chronic disease states (e.g. hypertension).

Although self-reported diabetics appear successfully control weight control to non-diabetics, the known association of diabetes with weight gain is anticipated to continue to translate into new cases of diabetes over time among the >90% of the population without diabetes. Enhanced educational efforts (through both public health and primary health care efforts) in this area might have a significant impact on future morbidity and mortality.

Individuals with hypertension might be expected to maintain or lower body weight as part of their treatment. Only 2% of our populations reported taking antihypertensive medications in 1989 but were no longer doing so in 1999, and the highest mean BMI increases occurred in women who began taking antihypertensive medications. This may reflect both the association of weight gain with development of hypertension and the need to focus on weight maintenance/loss for primary and secondary prevention of hypertension.

Weight loss should be recommended as an initial step in blood pressure control.[24, 25] Our data do not allow us to determine whether the individuals with hypertension were counselled about weight as part of their health care, or if they were aware of the importance of weight reduction. Targeting education on the relationship of weight and hypertension by public health strategies and individual counselling may be beneficial. While we cannot determine whether individuals knew the importance of weight control, this area should be addressed since 29% of American[26] and 36% of Swedish adults[27] are hypertensive by measured blood pressures in population surveys.

Although the Swedish and U.S. surveys were designed and conducted independently, the questionnaires used provided comparable information on demographics and risk factors. The data collection periods for the two populations differed by up to 6 months (?5%) and all of the U.S. data were self-reported. We think the surveys are comparable in spite of the differences in methodology. The evaluated variables (including BMI) are unlikely to have changed suddenly in a given individual. Because these are panel cohorts, rather than cross-sectional samples, unique information that is not readily available from other sources is provided.

While BMI is increasing in rural Sweden and the U.S., country of residence did not predict BMI change. The explanation might be that rapid weight gain is occurring in both countries. However, there are subgroups who show desirable weight change is possible. Further study of newly diagnosed diabetics may provide insight into successful tactics for use in other chronic diseases. Lack of association of BMI development with demographic factors suggests that general public health programs could be developed in addition to focusing on high-risk subgroups.

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