Rapid Changes in the Prevalence of Obesity and Known Diabetes in an Adult Norwegian Population

The Nord-Trøndelag Health Surveys: 1984–1986 and 1995–1997

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OBJECTIVE — To determine whether changes in mean BMI and the prevalence of obesity in a total adult population during a short (11-year) period were associated with changes in the prevalence of diabetes.

RESEARCH DESIGN AND METHODS — This study involved cross-sectional surveys of all inhabitants aged ≥20 years of the county of Nord-Trøndelag from 1984 to 1986 (n = 85,100) and from 1995 to 1997 (n = 92,434). Attendance rates were 88.1 and 71.3%, respectively, and 90.0% in an additional survey of people aged 13–19 years from 1995 to 1997 (n = 9,593). Main outcome measures were age-specific mean BMI for the diabetic and nondiabetic subgroups and the prevalence of obesity and diabetes. For comparison, mean BMIs from 18 of 19 Norwegian counties for the group aged 40–42 years were examined.

RESULTS — Mean BMI increased from 27.2 to 29.0 kg/m^2 in the diabetic population and from 25.1 to 26.3 kg/m^2 in the nondiabetic population. The BMI distribution curve shifted to the right, but homogeneity was also reduced. A comparison with other Norwegian counties indicated that this increase occurred during the last 6 years between the surveys. The prevalence of obesity (BMI ≥30 kg/m^2) increased from 7.5 to 14% in nondiabetic men and from 13 to 18% in nondiabetic women. The increase was particularly great in men aged <60 years and in women aged <50 years. The overall prevalence of known diabetes increased between the two surveys (from 2.9 to 3.2%) but only in men. The largest increase was observed in the corresponding younger sex and age-groups.

CONCLUSIONS — A substantial increase in mean BMI and the prevalence of obesity occurred in the younger age-groups at the same time as an increase in the prevalence of diabetes. A greater increase in diabetes prevalence in this ethnically stable Western European population may follow if effective primary preventive strategies are not undertaken.

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The prevalence of type 2 diabetes has been increasing in most countries for the last 20–30 years (1,2) and will probably continue to increase in the future (3,4). An increase is predicted in absolute numbers, especially in developing countries and to a lesser extent in Western countries. Studies in populations undergoing rapid changes in lifestyle (e.g., migration) show that changes in lifestyle factors such as diet and physical activity are associated with changes in diabetes prevalence (5–8). A considerable increase in diabetes prevalence has been reported in Norway (9) and in other Nordic countries (10–12).

A change in the risk factors for type 2 diabetes, particularly obesity, has been observed in Western societies (13–18). In a previous Norwegian study, rapid changes in the incidence of diabetes coincided with profound changes in living conditions such as those experienced during World War II (19). The duration of a factor like obesity is also very important (20–23).

We wanted to study whether short-term changes in mean BMI and the prevalence of obesity occurred in an ethnically stable adult Western Caucasian population, to determine whether a particular sex or age-group is at risk, and to see whether coinciding short-term changes in the prevalence of diabetes could be observed.

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Abbreviations: HUNT 1, First Nord-Trøndelag Health Survey; HUNT 2, Second Nord-Trøndelag Health Survey.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

RESEARCH DESIGN AND METHODS

Nord-Trøndelag County

Nord-Trøndelag County is located in the middle of Norway at a latitude of ~65°N. The population is ~127,000 people. The county is fairly representative of Norway as a whole, except that it has no large cities, and the average educational and income levels are somewhat lower than the mean for Norway. Nord-Trøndelag County has a fairly stable population both ethnically and geographically, with only a minor percentage (~3%) of Lapps and people of non-Caucasian origin (24).

First Nord-Trøndelag Health Survey (1984–1986)

An extensive health survey was undertaken, the First Nord-Trøndelag Health Survey (HUNT 1), from 1984 to 1986 of all 85,100 inhabitants aged ≥20 years. The participation rate was 88.1%. The survey focused on hypertension, quality of life, and lung diseases as well as diabetes. The survey methods and participation rates are published elsewhere (9,25,26). The survey registered 2,242 known diabetic patients in this population (a prevalence of 2.9%) (9). The participants were given a self-administered questionnaire along with an invitation to a clinical examination. Diabetic subjects were identified by answering "yes" to the question "Do you have, or have you had any of the following diseases:…diabetes?"

A validity study in one municipality examined all 169 diabetic patients and 338 nondiabetic control subjects of the same sex and age. Diabetes status was verified by medical records in 163 of the 169 subjects with self-reported diabetes (96.4%) and in 337 of the 338 subjects without diabetes (99.7%) (27). Subjects attending HUNT 1 also completed another questionnaire that involved details on diabetes treatment and control, blood pressure treatment, lifestyle, and quality of life.

The clinical examination included measurement of height, weight, blood pressure, and resting pulse rate. Height was measured without shoes to the nearest centimeter, and weight was measured to the nearest half-kilogram while wearing light clothing without jackets, shoes, and outdoor garments. BMI was calculated in kilograms per meters squared. Blood pressure was registered as the mean of two recordings measured in the sitting position after a minimum of 5 min rest by applying standard mercury sphygmomanometers. Pulse rate was measured in the radial artery in between the blood pressure recordings.

Second Nord-Trøndelag Health Survey (1995–1997)

A second and more extensive survey, the Second Nord-Trøndelag Health Survey (HUNT 2), that addressed the entire population aged ≥13 years was undertaken from 1995 to 1997. The total eligible population aged ≥20 years was 92,434. The participation rate in adults (71.3%) was lower than in HUNT 1. In addition, subjects aged 13–19 years were examined in schools (attendance rate 90%). HUNT 2 included the same question regarding diabetes as the questionnaire in HUNT 1. Height and weight were measured in the same way as in HUNT 1. Blood pressure was recorded as the mean of the second and third of three recordings by using an automatic oscillometric method (Dinamap 845XT; Criticon, Tampa, FL) (28); pulse rate was measured automatically.

In HUNT 1, no blood samples were drawn from the general population. In HUNT 2, serum samples were analyzed at the Central Laboratory at Innherred Hospital, Levanger, on an Hitachi 911 Autoanalyzer (Hitachi, Mito, Japan) by applying reactants from Boehringer Mannheim (Mannheim, Germany). Blood sampling was done whenever subjects attended (i.e., in the nonfasting or "random" state). Glucose was measured by using an enzymatic hexokinase method, total cholesterol and HDL cholesterol were measured by using an enzymatic colorimetric cholesterolesterase method, and HDL cholesterol was measured after precipitation with phosphortungsten and magnesium ions. Triglycerides were also measured with an enzymatic colorimetric method. The day-to-day coefficients of variation were 1.3–2.0% for glucose, 1.3–1.9% for cholesterol, 2.4% for HDL cholesterol, and 0.7–1.3% for triglycerides. C-peptide and anti-GAD were measured in the fasting state and analyzed at Aker Hospital (Oslo). C-peptide was measured with a radioimmunoassay method (Diagnostic System Laboratories, Webster, TX), anti-GAD was measured via immunoprecipitation by using [^{3}H]leucine translation–labeled GAD65 as an indicator. Reagents were supplied by Novo Nordisk Pharma AS (Bagsvaerd, Denmark).

Age 40 program

To study the development of cardiovascular risk factors, the National Health Screening Service performs repetitive screenings of all inhabitants aged 40–42 years in Norwegian counties. Data were available for 18 of 19 counties for 1974–1998. The background and methods of these surveys are described elsewhere (29,30). Height and weight were measured in the same way as in the HUNT surveys, and the same question concerning diabetes was used. The participation rate varied from 90% in Oppland County in 1976 to 54% in Akershus County in 1996. Nord-Trøndelag took part in the age 40 program in 1989 and 1992 with attendance rates of 80% in 1989 (n = 4,324) and 74% in 1992 (n = 3,977).

Consent

Attendance was completely voluntary. The data were registered by using the National Personal Identification Number for each citizen, but personal identification was removed before data were supplied to the researchers. All surveys were approved by the Norwegian Data Inspectorate and were recommended by the central or regional medical research ethical committees.

Statistical analysis

Data were analyzed by using the SPSS program (SPSS, Chicago). For the prevalence calculations, the total number of people answering the actual question or participating in the measurements was used as denominator. A few answered and returned the questionnaire without participating in the examination; their questionnaire data were included. Sex differences in the prevalence of diabetes were tested with the SPSS by using the χ^2 statistic. A P value <0.05 was considered statistically significant. The program StatMate (GraphPad Software, San Diego, CA) was used to calculate 95% CIs for proportions (by using the binomial distribution) and for mean values.

RESULTS

Background variables

At HUNT 2, the mean age of the participants was significantly higher for the nondiabetic population but significantly lower for known diabetic patients (Table 1). We found a considerable increase in mean BMI in both the diabetic and the nondiabetic populations. The proportion of daily smokers increased between the two surveys for both diabetic and nondiabetic women but was reduced for nondiabetic men. Despite a lower mean age for diabetic patients at HUNT 2, the proportion who reported ever using antihypertensive medication increased much more in the diabetic population than in the nondiabetic population.

Compared with nondiabetic people, diabetic patients had a higher waist-to-hip ratio and higher total cholesterol, lower HDL cholesterol, and higher triglyceride levels. Mean serum glucose was significantly higher in male versus female diabetic patients. At HUNT 2, diabetic patients more often reported leisure-time physical inactivity (36.8%) than their nondiabetic counterparts (26.7%) (less than 1 h of such activity per week) (data not shown in Table 1). This inactivity was not merely a result of age because it was the case for almost all age-groups. Diabetic patients, however, reported having slightly more often physically strenuous work than nondiabetic subjects (46.2 vs. 43.7%). Pulse rate in nondiabetic participants was significantly lower at HUNT 2 than at HUNT 1.

Table 1—*Age, BMI, and other background variables for the diabetic and nondiabetic subjects in the participating population in Nord-Trøndelag from 1984 to 1986 (HUNT 1) and from 1995 to 1997 (HUNT 2) by sex*

	Men		Women	
Variable	1984–1986	1995–1997	1984–1986	1995–1997
*n**				
Diabetic	986	985	1,256	1,117
Nondiabetic	36,688	29,602	37,955	33,849
Age (years)				
Diabetic	66.6 (65.7–67.5)	65.1 (64.1–66.0)	70.4 (69.7–71.1)	69.2 (68.3–70.0)
Nondiabetic	48.3 (48.2–48.5)	49.6 (49.4–49.8)	49.4 (49.2–49.6)	50.1 (49.9–50.3)
BMI (kg/m^2)				
Diabetic	26.2 (26.0–26.5)	28.0 (27.7–28.3)	27.9 (27.6–28.2)	29.9 (29.6–30.3)
Nondiabetic	25.2 (25.2–25.2)	26.4 (26.4–26.5)	25.0 (24.9–25.0)	26.2 (26.1–26.2)
BMI ≥30.0 (%)				
Diabetic	15.1 (12.8–17.6)	28.0 (25.1–31.0)	33.2 (30.4–36.1)	45.9 (42.7–49.1)
Nondiabetic	7.5 (7.2–7.8)	14.0 (13.6–14.4)	13.0 (12.7–13.3)	17.8 (17.5–18.2)
Waist-to-hip ratio				
Diabetic	—	0.94 (0.93–0.94)	—	0.85 (0.85–0.85)
Nondiabetic	—	0.90 (0.90–0.90)	—	0.80 (0.80–0.80)
Daily smokers (%)				
Diabetic	25.2 (22.1–28.5)	27.4 (24.2–30.7)	11.2 (9.3–13.4)	17.7 (15.0–20.6)
Nondiabetic	36.3 (35.7–37.0)	31.8 (31.3–32.4)	31.0 (30.4–31.6)	34.5 (33.9–35.1)
Ever used hypertensive medication (%)				
Diabetic	28.5 (25.6–31.4)	38.1 (35.0–41.3)	49.0 (46.2–51.9)	51.6 (48.6–54.7)
Nondiabetic	9.4 (9.1–9.7)	11.7 (11.3–12.0)	14.6 (14.3–15.0)	13.7 (13.3–14.1)
Systolic blood pressure (mmHg)				
Diabetic	152.1 (150.5–153.8)	150.5 (149.1–152.0)	161.7 (160.0–163.3)	157.0 (155.4–158.5)
Nondiabetic	139.6 (139.4–139.8)	139.5 (139.2–139.8)	136.4 (136.1–136.6)	135.1 (134.8–135.3)
Diastolic blood pressure (mmHg)				
Diabetic	88.2 (87.5–89.1)	84.5 (83.7–85.4)	88.3 (87.5–89.0)	84.1 (83.3–85.0)
Nondiabetic	86.0 (85.9–86.1)	81.7 (81.5–81.8)	83.1 (83.0–83.2)	78.4 (78.3–78.5)
Pulse rate (beats/min)				
Diabetic	75.3 (74.4–76.2)	73.8 (72.9–74.7)	76.8 (76.0–77.6)	77.6 (76.8–78.5)
Nondiabetic	73.5 (73.3–73.6)	70.9 (70.8–71.1)	76.2 (76.1–76.4)	75.0 (74.9–75.2)
Glucose (mmol/l)				
Diabetic	—	10.0 (9.7–10.3)	—	9.3 (9.0–9.6)
Nondiabetic	—	5.4 (5.4–5.4)	—	5.3 (5.3–5.3)
Cholesterol (mmol/l)				
Diabetic	—	5.85 (5.77–5.93)	—	6.42 (6.34–6.50)
Nondiabetic	—	5.82 (5.80–5.83)	—	5.95 (5.94–5.96)
HDL cholesterol (mmol/l)				
Diabetic	—	1.16 (1.13–1.18)	—	1.32 (1.30–1.35)
Nondiabetic	—	1.24 (1.24–1.24)	—	1.50 (1.50–1.50)
Triglycerides (mmol/l)				
Diabetic	—	2.40 (2.30–2.51)	—	2.39 (2.30–2.49)
Nondiabetic	—	1.96 (1.95–1.97)	—	1.55 (1.54–1.57)

Data are means (95% CIs) or % (95% CIs). **n* varies somewhat depending on the actual participation in the different tests/questionnaires.

BMI and obesity

Mean BMI increased considerably between the two surveys for both men and women (Table 1). The overall mean increased from 27.2 to 29.0 kg/m^2 in diabetic patients and from 25.1 to 26.3 kg/m^2 in nondiabetic subjects. The percentage of participants classified as obese (BMI ≥30.0) increased in both sexes and in all age-groups except in men ≥90 years (Table 2). The largest increase was seen, however, in men aged <60 years and in women aged <50 years. After adjusting for mean height for each sex and age-group, the largest increase in mean weight from HUNT 1 was in the group aged 20–29 years (4.2 kg in men and 5.7 kg in women). Mean weight increased >3 kg in all groups aged <90 years for men and in all groups aged <50 years for women, which confers a total mean weight increase of 4.0 kg for men and 3.3 kg for women.

The distribution curve for BMI shifted to the right between the two surveys for both men and women (Fig. 1). The distribution curve for women was broader (and thus the cumulative curve less steep) than for men at both surveys.

Table 2—*Changes in the prevalence of known diabetes and of obesity in the nondiabetic population aged ≥20 years in Nord-Trøndelag from 1984 to 1986 (HUNT 1) and from 1995 to 1997 (HUNT 2) by sex and 10-year age-groups*

Age-group (years)	Known diabetes 1984–1986 *n*	Known diabetes 1984–1986 %	Known diabetes 1995–1997 *n*	Known diabetes 1995–1997 %	Known diabetes Change (%)	Obesity (BMI ≥30.0) 1984–1986 (%)	Obesity (BMI ≥30.0) 1995–1997 (%)	Obesity (BMI ≥30.0) Change (%)
Men								
20–29	5,957	0.50 (0.34–0.72)	3,919	0.69 (0.45–1.00)	+38.0	3.54 (3.07–4.05)	8.44 (7.59–9.33)	+138.4
30–39	8,109	0.49 (0.35–0.67)	5,399	0.65 (0.45–0.90)	+32.7	5.23 (4.75–5.72)	12.74 (11.88–13.66)	+143.6
40–49	6,176	0.97 (0.74–1.25)	6,489	1.28 (1.02–1.59)	+32.0	7.71 (7.07–8.41)	14.02 (13.18–14.92)	+81.8
50–59	5,620	1.99 (1.65–2.39)	5,386	3.14 (2.68–3.64)	+57.8	9.44 (8.68–10.22)	17.12 (16.12–18.18)	+81.4
60–69	6,224	4.31 (3.81–4.85)	4,338	5.03 (4.39–5.73)	+16.5	10.52 (9.73–11.30)	16.41 (15.26–17.55)	+56.0
70–79	4,078	7.36 (6.57–8.20)	3,744	8.39 (7.50–9.33)	+14.0	10.48 (9.51–11.48)	15.53 (14.35–16.82)	+48.2
80–89	1,364	11.14 (9.52–12.92)	1,221	11.30 (9.60–13.19)	+1.4	7.64 (6.14–9.39)	11.41 (9.46–13.64)	+49.3
90+	146	16.44 (10.84–23.46)	125	9.60 (5.07–16.16)	−41.6	5.33 (1.47–13.08)	3.70 (0.45–12.76)	÷30.6
Total	37,674	2.62 (2.46–2.79)	30,621	3.25 (2.95–3.33)	+24.0	7.52 (7.23–7.82)	14.0 (13.59–14.42)	+86.2
Women								
20–29	5,862	0.22 (0.12–0.38)	4,712	0.34 (0.19–0.55)	+54.5	3.83 (3.34–4.37)	10.50 (9.65–11.43)	+174.2
30–39	8,085	0.40 (0.27–0.56)	6,114	0.65 (0.47–0.89)	+72.5	5.87 (5.38–6.42)	11.76 (10.97–12.62)	+100.3
40–49	6,204	0.64 (0.46–0.88)	7,039	0.99 (0.78–1.25)	+54.7	9.41 (8.70–10.19)	14.25 (13.39–15.07)	+51.4
50–59	5,649	2.04 (1.68–2.44)	5,771	2.10 (1.74–2.51)	+2.9	15.67 (14.74–16.66)	19.83 (18.82–20.89)	+26.5
60–69	6,370	4.55 (4.05–5.09)	4,698	4.17 (3.62–4.77)	−8.4	22.20 (21.10–23.21)	25.77 (24.56–27.04)	+16.1
70–79	4,868	9.90 (9.10–10.78)	4,501	9.11 (8.31–10.00)	−7.4	25.02 (22.67–27.42)	28.04 (26.61–29.53)	+11.3
80–89	1,933	12.62 (11.20–14.15)	1,906	12.43 (10.97–14.03)	−1.5	17.61 (15.63–19.71)	25.02 (22.67–27.42)	+42.1
90+	240	16.67 (12.19–22.04)	237	12.24 (8.37–17.13)	−26.6	4.04 (1.11–10.01)	14.67 (7.54–24.75)	+263.1
Total	39,211	3.20 (3.03–3.39)	34,978	3.20 (3.03–3.38)	0	12.95 (12.65–13.26)	17.84 (17.45–18.24)	+37.8

Data in parentheses are 95% CIs.

Mean weight and the prevalence of obesity also increased in the known diabetic patients. This increase was most prominent in the youngest age-groups. According to European recommendations (31,32), 50% of the diabetic patients were in the "poor" group (BMI >27 and >26 kg/m², men and women, respectively), and 30% were in the "good" BMI category (<25 and <24 kg/m², men and women, respectively) at HUNT 1 compared with 65 and 18%, respectively, at HUNT 2.

Prevalence of known diabetes

The total prevalence of known diabetes increased between the surveys but only in men (Table 2). For both sexes combined, the total prevalence was 2.92% at HUNT 1 and 3.22% at HUNT 2, a relative increase of 10%. In the group aged 13–19 years (data not shown in Table 2), the diabetes prevalence at HUNT 2 was 0.58% for male subjects and 0.44% for female subjects. The sex difference ≥20 years observed at HUNT 1 (2.62 vs. 3.20%) ($P < 0.001$) (9) had disappeared at HUNT 2 (3.20% in both sexes). The changes in prevalence differed considerably, however, between age-groups. An increase in diabetes prevalence was observed for men in all groups aged <70 years and for women in all age-groups aged <50 years, which corresponds to the age-groups with the greatest increase in the prevalence of obesity. The increase in diabetes prevalence in younger women was compensated for, however, by a decline in the groups aged >60 years.

At HUNT 1, no clear distinction could be made between type 1 and type 2 diabetes. At HUNT 2, C-peptide and anti-GAD were analyzed in more than 1,400 diabetic patients. Of the subjects, ~80% were classified with type 2 diabetes, whereas 17.5% were classified with type 1 diabetes (including latent autoimmune diabetes in adults [LADA]). Of subjects at HUNT 2 who had contracted diabetes since HUNT 1, 88% had type 2 diabetes. Although the prevalence of type 1 diabetes is increasing in Norway (33), the largest increase involved type 2 diabetes.

Age 40 program surveys

For subjects aged 40–42 years, the mean BMI and the prevalence of known diabetes were also established in 1989 and 1992. The largest increase both in the prevalence of diabetes and in mean BMI was seen from 1992 to 1995–1997. Similar results concerning BMI are demonstrated in the other counties screened by the National Health Screening Service (Fig. 2). A considerable increase in mean BMI was likewise observed in the other counties, especially since 1992. The data for women had a U-shaped curve with a plateau during the 1980s (Fig. 2*A*). In men, a continuous increase was registered but with a similar plateau in the 1980s (Fig. 2*B*). No clear regional differences were observed after classifying the counties according to location in the north, middle, southwest, or southeast regions of the country. The increase since 1992 was evident in all regions.

CONCLUSIONS

Obesity and overweight

We observed a substantial increase in both mean BMI and the prevalence of obesity between the two surveys in Nord-Trøndelag. The prevalence of overweight and obesity has been increasing in most industrialized countries and is rapidly increasing in many developing countries (34). The prevalence of obesity in adults is 10–25% in most Western European countries and 20–25% in some countries in the Americas. In women, prevalence rates as high as 40% have been documented in Eastern Europe and some Mediterranean countries, and on the Micronesian island of Nauru, 70% of adult women and 65% of adult men are obese (BMI ≥30 kg/m^2).

During the 11 years between the two surveys in Nord-Trøndelag, the prevalence of obesity in men almost doubled in both the diabetic and nondiabetic populations. The increase in the prevalence of obesity is almost parallel with the development of obesity in the U.K. in the same period (35). The prevalence figures from HUNT 2 fit reasonably well with findings in other Scandinavian and Western European countries but are lower than in many countries in Eastern Europe (17,35). The increase in mean BMI in Nord-Trøndelag (from 25.1 to 26.4 kg/m^2) was much greater than that observed in the neighboring country of Sweden in the 1980s (13). In Americans aged 20–74 years, mean BMI increased from 24.8 during 1960–1962 to 25.3 during 1976–1980 to 26.3 kg/m^2 during 1988–1991 (14,36). For corresponding age-groups, the increase in Nord-Trøndelag between HUNT 1 and HUNT 2 was from 25.0 to 26.3 kg/m^2, which is almost the same as in the U.S., but this increase occurred during a much shorter period in Norway.

Changes in overweight in the population are often expressed by mean BMI. BMI as a risk factor for disease may increase, however, even if mean BMI remains unchanged, because of decreased homogeneity (37). In Nord-Trøndelag, both mean BMI and the prevalence of obesity increased, and we observed a corresponding shift of the distribution curve to the right (Fig. 1). We also observed a decreased homogeneity because the curve is broader, which indicates that, as a risk factor, obesity increased more than the mean BMI predicted.

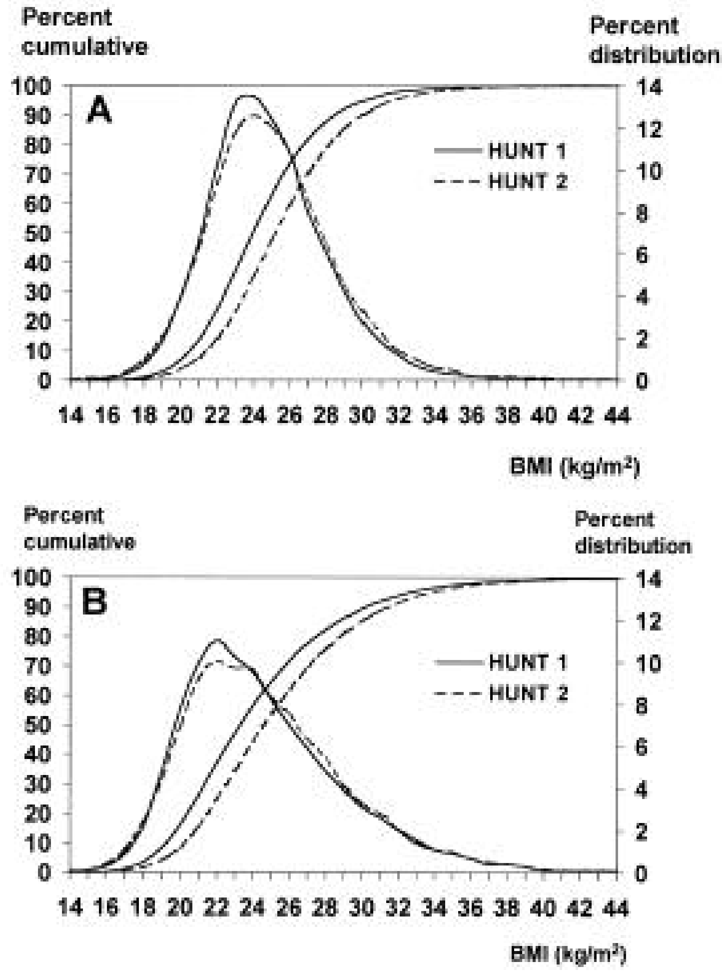

Figure 1—A*: Distribution of BMI in men at HUNT 1* (n *= 36,536) and HUNT 2* (n *= 30,229) expressed as a percentage distribution and cumulatively.* B*: Distribution of BMI in women at HUNT 1* (n *= 37,858) and HUNT 2* (n *= 34,170) expressed as a percentage distribution and cumulatively*.

Prevalence of diabetes

The prevalence of known diabetes in Norway increased three- to fourfold from 1956 to 1984 (8,38). The 1956 survey took place in another part of the country but applied the same definition of known diabetes; however, the diagnostic criteria were different in 1956. In this comparison, only subjects with a known diagnosis are included. Most diabetic patients seek medical advice because of symptoms and have values far above diagnostic limits. Changes in the diagnostic criteria thus probably account for only a small fraction of the increase observed. A corresponding increase has been documented in other Scandinavian countries (10,11).

The considerable sex difference in the prevalence of diabetes observed at HUNT 1 disappeared at HUNT 2. This coincided with a reduction in the sex difference in the prevalence of obesity. Previous overviews have documented a different sex ratio in different countries (39,40). In Western Europe, the prevalence of obesity has traditionally been greatest in women (40). Changes in sex ratio over time have also been described in previous Scandinavian surveys (41). Sex differences in the prevalence of diabetes have been attributed to sex differences in body weight (39).

Selection bias

The strength of this study is that it addresses a total, unselected adult population in a fairly representative county in Norway (9,24). HUNT 1 had a very high participation rate. At HUNT 2, the participation rate was considerably lower, which probably illustrates a time trend to be less concerned with health matters. The same trend was evident in the age 40 program. Could the increase in the prevalence of diabetes and obesity be due to the reduction in participation rate? Awareness about the consequences of an unhealthy lifestyle is probably greater now than in the 1980s. The slim body type that is idealized by society may dissuade overweight people from participating. At HUNT 1, reasons for nonattendance were collected from about one-third of the nonattendants. In addition, a random 10% sample of nonattendants was interviewed after the screening. The main reasons for not attending were of a practical nature (not present because of school or work) for young people and poor health (for elderly people) (25). At HUNT 2, a smaller sample of nonattendants to HUNT 2 was inter-

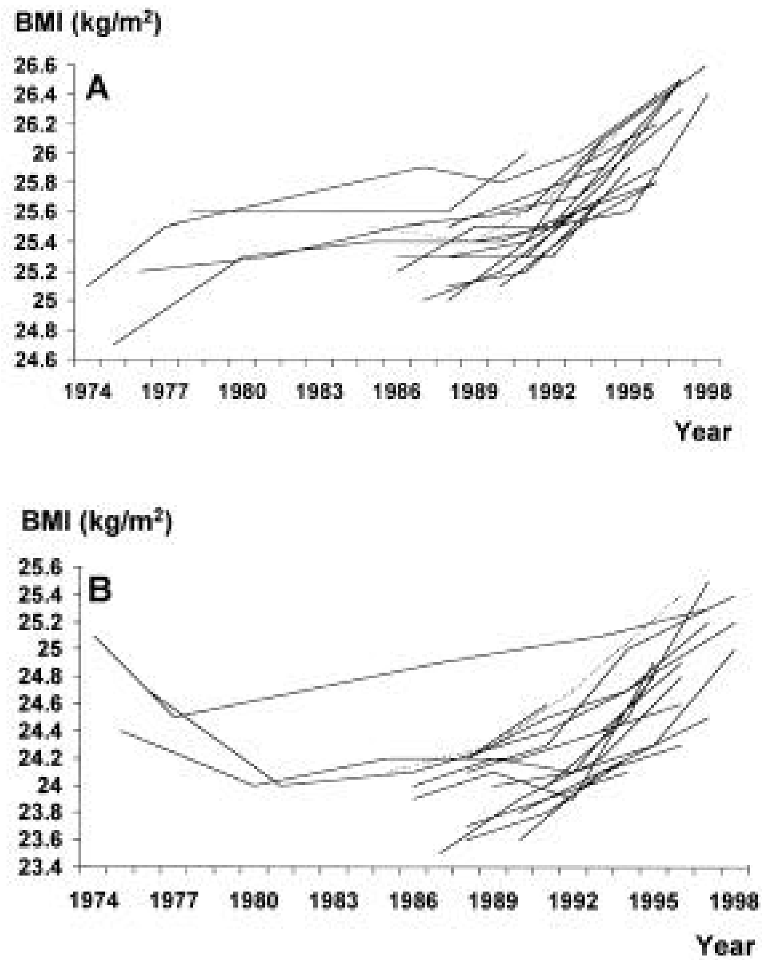

Figure 2—A*: Changes in mean BMI in men aged 40–42 years in Norwegian counties, 1974–1998.* **- - -**, *Nord-Trøndelag.* B*: Changes in mean BMI in women aged 40–42 years in Norwegian counties, 1974–1998.* **- - -**, *Nord-Trøndelag.*

viewed by telephone with similar results. At both HUNT 1 and HUNT 2, nursing homes were visited to allow subjects to participate who were not able to meet at the screening site. In nursing homes, only diabetes status was registered and not BMI. Differences in BMI in institutionalized people versus elderly people living at home may thus affect the comparison between BMI and diabetes prevalence for the oldest age-groups.

Diabetic patients may have been willing to participate because they wanted to have their diabetes status evaluated. On the other hand, most diabetic patients already undergo regular checkups and may believe that an additional survey was less relevant to them than nondiabetic people. In the age 40 program, nonresponders were contacted in 1989 and 1991 (30). They did not attend mainly because of practical reasons, and they had the same risk factor pattern (concerning lipids, systolic blood pressure, and BMI) as attendants. The exception was that nonsmokers and married people had somewhat higher attendance rates than single people and smokers. The decline in attendance rate did not likely cause the observed changes in the prevalence of adiposity and diabetes in this study.

Risk factors and prevention

A strong association between body weight (or lifestyle in general), living conditions, and the risk of type 2 diabetes is well documented in the U.S. (1) and in other countries. Such an association is found also in Norway (19,42). The prevalence and incidence of type 2 diabetes varies considerably between ethnic groups (43,44). Other studies have examined the predicted increase in diabetes prevalence in Western societies with a focus on immigrants from the developing world (4). In Nord-Trøndelag, the immigration rate was still so low that it could not contribute significantly to the increase in the prevalence of obesity or the prevalence and incidence of diabetes in the society. Immigrants from the third world also tended not to attend the survey.

A relationship between physical inactivity and overweight is well established (15,35). Several studies have indicated that a reduction in physical activity and a change in the types of energy intake (perhaps more than changes in total caloric intake) may explain the increase in body weight (5,15, 35). Primary prevention strategies have often focused on personal lifestyle changes (45). Norway has a tradition of a healthy lifestyle with a great deal of leisure-time physical activity. Rapidly increasing automatization and application of computer technology have been evident during the last several years and have eliminated much of the "natural" physical workload. In the two Nord-Trøndelag surveys, different questions were asked to measure physical activity. The questions are not easily comparable, but no great decline was evident in reported leisure-time physical activity. Pulse rate may be applied as a proxy to physical fitness (46). In Nord-Trøndelag, the change in pulse rate may support the fact that no reduction was evident in mean physical activity between the two surveys in Nord-Trøndelag. On the other hand, we noted that the people who are the most overweight reported the least leisure-time physical activity. This may mean that the differences are such that one group increases in overweight and is less active, and one group of people who are lean and active may have improved their lifestyle even more.

Since HUNT 1, more emphasis has been placed on better treatment of diabetic patients in Norway; this involves weight reduction, smoking cessation, physical activity, blood pressure control, and control of serum lipids (47). Our study indicates that more such measures are necessary.

Future perspectives

Our data show a relatively moderate increase in the prevalence of diabetes in adults. It is worrisome that this increase was observed primarily in the younger age-groups, both in men and in women. According to the results from the age 40 program, this increase seemed to occur especially during the last 6–7 years of the period between the two surveys, and the increase was evident throughout Norway. If this rapid increase continues, and young obese people carry their overweight into the age-groups in which the incidence of type 2 diabetes is much higher, this may seriously worsen the predicted increase in diabetes prevalence because of the predicted considerable increase in people aged >80 years during the next 30 years. This increase may also threaten the present favorable decline in the prevalence of coronary disease (48) if we do not upgrade our efforts in primary prevention of diabetes (and cardiovascular disease). Presenting these concerns about the long-term consequences of rapidly changing lifestyles to politicians and to authorities engaged in social planning is a great challenge for epidemiologists and health care professionals.

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