Trends in Obesity and its Distribution: Data from the Northern Sweden MONICA Survey, 1986–2004

Mikael Lilja,[*] Mats Eliasson,†‡ Birgitta Stegmayr,† Tommy Olsson,† Stefan Söderberg†

[*]The Research and Development Unit, Jämtland County Council, Östersund, Sweden; †Department of Public Health and Clinical Medicine, Faculty of Medicine, Umeå University, Umeå, Sweden; ‡Department of Medicine, Sunderby Hospital, Luleå, Sweden.

Running title: Trends in obesity in northern Sweden

Word count: 3339

Correspondence: Mikael Lilja, Odensala Hälsocentral, Klöverv.2, SE-831 62 Östersund, Sweden.

E-mail: mikael.lilja@jll.se

Phone: +4663142214, fax: +4663142221

Abstract

Objective: Obesity, especially abdominal, is a risk factor for many diseases. This study explored trends in the prevalence of general and abdominal obesity, 1986–2004, in northern Sweden.

Research Methods and Procedures: Cross–sectional population surveys were performed in 1986, 1990, 1994, 1999, and 2004; 250 men and 250 women aged 25–34, 35–44, 45–54, and 55–64 years (from 1994, also 65–74 years) were randomly selected; the overall participation rate was 77%. Anthropometric data were used.

Results: Weight and BMI increased in all men, most significantly in men aged 25–64 years ($p < 0.0005$). Weight increased in women aged 25–64 years ($p < 0.005$) and BMI in women aged 25–44 years ($p < 0.005$). Prevalence of obesity (BMI ≥ 30) increased significantly in men aged 25–44 and 55–74 years ($p < 0.005$; for men 65–74 years old, $p < 0.05$) and in women aged 25–44 years ($p < 0.005$). Waist circumference decreased significantly between 1986 and 1990 in all women ($p < 0.005$) and in men aged 55–64 years ($p < 0.05$). After 1990 waist circumference increased, most markedly so in women; by 2004 circumference measurements for women, and for men aged 55–64 years, were equal to those of 1986, while for men aged 25–54 years they were higher. Prevalence of abdominal obesity has increased since 1990, most markedly so in women aged 45–64 years ($p < 0.0005$).

Discussion: The rapid increase in both general and central obesity raises concern for the future; increasing abdominal obesity in women is particularly alarming.

Key words: abdominal adiposity, trends, waist circumference

Introduction

The global obesity epidemic and its influence on morbidity and mortality have been described with reference to many populations around the world (1,2). According to the WHO project Multinational Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA), conducted in 26 countries on four continents for 10 years starting in the mid 1980s, obesity prevalence differed greatly between countries. MONICA centres in Sweden (northern Sweden and Gothenburg) and Denmark (Glostrup) reported lower body mass index (BMI) levels than did other centres in Europe, the USA, and Australia. The increases over time in BMI and the proportions of obese and overweight people in Sweden, especially in Gothenburg, and in Denmark were among the lower ones (3). In particular, centrally located, abdominal adiposity has been linked to increased risk of cardiovascular disease (CVD)(4–6) and type 2 diabetes mellitus (T2DM) (7,8). It is thus notable that few studies have focused on changes in waist circumference over time, using repeated and standardized anthropometric measurements in a population. Most published studies have not used long-term consecutive surveys with objective measurements and, unlike the Northern Sweden MONICA study, are often based on self-reported data.

We earlier reported increasing BMI between 1986 and 1999 (9). Notably, this weight gain was associated with increased peripheral rather than abdominal obesity, and may relate to lower intake of saturated fat, less smoking, and higher intake of low-glycemic-index carbohydrates (10). The preponderance of a more peripheral fat distribution might explain why diabetes prevalence did not increase between 1986 and 1999, despite increasing BMI (11). This study expands on our earlier work, by reporting secular trends of obesity and its distribution from 1986 to 2004.

Research Methods and Procedures

Subjects

The WHO MONICA Project was initiated in the late 1970s to follow time trends in cardiovascular morbidity and mortality and in their risk factors (12). Two Swedish sites were identified, the Gothenburg and Northern Sweden MONICA centres. In the Northern Sweden Centre, the first survey was performed in 1986 and has since been repeated using identical methodology in 1990, 1994, 1999, and 2004. For each survey, 250 men and 250 women from each age group (i.e., 25–34, 35–44, 45–54, and 55–64 years old) were selected; starting in 1994, the 65–74 age group was included. The surveys took place in Sweden's two northernmost counties, Norrbotten and Västerbotten.

Survey procedures have been reported earlier (13). In short, in each survey, blood samples were taken and blood pressure and anthropometric measurements made, and questionnaires covering medical and social history, life style, psychosocial situation, and food consumption frequency were administered. Samples were independently chosen for each survey, i.e., participants for the second and following surveys were selected irrespective of whether or not they had been selected to participate in previous surveys.

The rate of participation in the different surveys ranged between 59 and 90% in the various age and gender groups (Table 1), the lowest participation rate being that of younger men in the most recent surveys. The population studied was predominantly European, with only 2% born outside Sweden or Finland. The Northern Sweden MONICA surveys were approved by the Ethics Committee at Umeå University, and informed consent was obtained from all participants.

Anthropometry

Study subjects were invited to the nearest healthcare centre, where specially trained teams conducted the examinations to ensure correctness, uniformity, and comparability of results. The subjects wore light clothes and no shoes, and weight was measured to the nearest 0.2 kg and height to the nearest centimetre. The waist and hip circumferences were measured in standing position with the feet fairly close together (12–15 cm). Tight undergarments were released or taken off before measuring the waist circumference, which was measured midway between the lower rib margin and the iliac crest. The measuring tape was placed over the belly button on most occasions. At time of measuring, the subject was asked to exhale gently. The hip circumference was measured at the maximum circumference over the buttocks to the nearest 0.5 cm. Waist hip ratio (WHR) and BMI were calculated as waist circumference divided by hip circumference and as weight (kg) divided by height (m) squared, respectively.

The two most widely used definitions of metabolic syndrome are the WHO definition from 1999 (14) and the National Cholesterol Education Program's Adult Treatment Panel III definition (NCEP) from 2001 (15). According to the WHO, a WHR >0.90 in men or >0.85 in women and/or a BMI ≥30 defines a disadvantageous amount of fat. According to the NCEP definition, the cut-offs for waist circumference are >102 cm in men and >88 cm in women, but >94 cm can be used in genetically predisposed men; however, the present data do not let us identify such individuals. In 2005, the International Diabetes Federation (IDF) suggested a new definition of metabolic syndrome, using anthropometric measures of waist circumference ≥94 cm for men and ≥80 cm for women of European origin (16). The present study uses BMI cut-offs according to the WHO, and waist circumference cut-offs according to the NCEP and IDF definitions to identify disadvantageous levels of obesity. Overweight was defined as BMI 25–29.9, and obesity as BMI ≥30 kg/m^2

Statistical analysis

Anthropometric measurements are presented as means with SDs and as proportions of overweight and obese subjects. Differences between the results of all surveys were explored using univariate analysis of variance (ANOVA) with post hoc Bonferroni analysis. To adjust for potential skewness in age distribution in each age group on the different survey occasions, a second analysis was performed, introducing actual age at time of survey as a covariate (ANCOVA). As the differences between these two analyses were minimal, only unadjusted data are presented. Time trends were explored using ANOVA analysis with the time squared if curvilinear changes over time. The difference between participants and non-participants was explored using ANCOVA analysis with sex, survey year, and age group as covariates. Prevalence estimates were standardized using the direct method against the population distribution of the two surveyed counties in 2004. Pregnant women were excluded, and their numbers ranged from zero in 1990 to 17 in the following three surveys. Pregnancies were not registered in 1986, but weight, waist, and hip circumference were not measured on that occasion if the subjects were pregnant. All calculations were made using the SPSS version 11.0.4 statistical programme.

Results

Data regarding weight, BMI, WHR, and waist and hip circumference from all surveys, stratified by age class, together with the absolute and relative changes over the 1986–2004 and 1990–2004 periods (1994–2004 for the oldest age group) are presented in Table 2. From 1986 and onwards, increasing weight was observed in all investigated groups. For men of all ages and women 25–44 years old, BMI increased significantly. The increase in weight and BMI was more pronounced in younger age groups.

In women, waist circumference and WHR decreased highly significantly between 1986 and 1990, waist circumference decreasing by approximately 6 cm in the 35–54 year age

group. In men, waist circumference decreased over the same period only in subjects aged 55–64 years, and WHR decreased only in the 35–44 and 55–64 year age groups. After 1990, waist circumference increased in all age groups, more markedly so in women than in men; among men, the 2004 circumference exceeds the 1986 circumference in the 25–54 year age group, but remains unchanged in the other age groups.

Between 1986 and 1999, hip circumference increased more rapidly than waist circumference did, leading to decreasing WHR in all groups. The tendency towards more peripherally located adiposity seen in the first surveys was no longer evident in 2004. Between 1999 and 2004, adiposity became more centrally located, as indicated by a significant increase in WHR in all age groups in both men and women. This was accentuated by a simultaneous reduction in hip circumference, which was significant in men in all age groups (except the 35–44 year group) and in women aged 35–44 years.

The prevalence of overweight and obesity together with the absolute and relative changes in their prevalence from the two first surveys up to 2004 are presented in Table 3. A significant increase in obesity with time was seen in women aged 25–44 years and in men aged 25–44 and 55–74 years. The prevalence of obesity in 1986 and 2004, standardized to the population of 2004 in the two survey counties, increased in men aged 25–64 years from 10.4% to 19.1% and in women from 12.9% to 17.9%.

The proportions of men with waist circumference ≥94 cm and >102 cm and of women with waist circumference ≥80 cm and >88 cm and their absolute and relative changes over time are presented in Table 4. In men, the most rapid and prominent increase of waist circumference >102 cm was seen in the youngest age group investigated, with almost a fourfold increase in prevalence between 1986 and 2004. In women, the proportions with waist circumference ≥80 and >88 cm decreased between 1986 and 1990; thereafter, these proportions increased again, and by 2004 had reached the same levels as in 1986. Between

1990 and 2004 the most pronounced increase in the prevalence of abdominal obesity, according to both NCEP and IDF criteria, was seen in women; for example, abdominal obesity prevalence in women 45–64 years old increased 24.6% units (NCEP criteria). The age-standardized prevalence of disadvantageous BMI and waist circumference for the period studied are presented in Figures 1 and 2.

Attempts were made to contact all non-participants by means of telephone interviews, achieving an overall response rate of 58%. As a group, non-participants were younger and mostly male. Table 5 presents interview responses from non-participants together with responses and BMI results for participants in five surveys. It was found that non-participants, compared to participants, were less likely to be married/cohabiting, reported a lower BMI, and were more likely to be cigarette or *snus* (a form of moist snuff) users; however, educational level and other parameters in the table did not differ between non-participants and participants, taking the results of each survey separately (data not shown).

Discussion

This study describes anthropometric changes over the 1986–2004 period in five population-based samples of subjects aged 25–64 years (from 1994 25-74 years) living in the two northernmost counties in Sweden, and strongly confirms that the obesity epidemic is also occurring in this area. In subjects aged 25–64 years, the prevalence of obesity rose from 11.5% in 1986 to 18% in 2004, with an annual average BMI increase of 0.1 kg/m^2. Like the weight gain, the BMI increase was greatest in the younger age groups, raising concern as to its impact on the future health status of the population. For example, men aged 25–34 years in 2004 had approximately the same percentage of overweight and obesity as men 20 years older had in 1986.

Most prevalence data regarding obesity are based on self-reported measurements. Recent European data from 1997–2000 (17) indicate a range of age-adjusted prevalence of obesity in subjects aged 15 years and older, from 6–7% in Norway and Switzerland to approximately 20% in Great Britain and Germany, with Sweden at an intermediate level of 10%. In 1999–2002, the overall self-reported prevalence of obesity in the US population ≥20 years old was 30.4% (29.4% in non-Hispanic white) (18); in contrast, the prevalence was 11% in men and 16% in women in 1960–1961 and 21% in men and 26% in women, measured between 1988 and 1994 (19).

According to recent *self-reported* data pertaining to the Swedish population 16–84 years old, the prevalence of obesity in 2000–2001 was 9.5% and 11% in men and women, respectively, in Northern Sweden (20). However, our *objectively* obtained data representing almost half the population of northern Sweden indicate a notably higher obesity prevalence at the approximately the same time (1999). Adjusted according to the population in the survey counties in 1999, the obesity prevalence in the group 25–74 years old was 14.7% in men and 17.8% in women. Local differences within the defined survey area can exist, but self-reports most likely underestimate true weight and/or overestimate height (9,13).

The Northern Sweden MONICA is unique, in that it captures time trends in obesity from uniformly performed population surveys with five cross-sectional samples over an 18-year period. The findings of increased weight, BMI, and obesity are similar to those from other centres, but the marked decrease in central obesity between 1986 and 1990 is of special interest, as increased waist circumference has been linked to increased risk of CVD (4–6) and T2DM (7,8). The correctness of this observation, applying especially to women, is supported by the uniformity of the survey procedures, and by the fact that leptin levels were also found to decrease, although insignificantly, over the same period (data not shown). Two studies

from the USA covering the 1960–2004 period (21,22) and one from Finland covering the 1992–2002 period (23) describe, in contrast, a continuous increase in waist circumference.

However, waist circumference increased after 1990, and by 2004, levels were the same as (in women) or higher (in men) than in 1986. In 2004, abdominal obesity as defined by NCEP was present in 24% of men and in 36% of women aged 25–64 years, and 54% of men and 61% of women met the IDF criteria for abdominal obesity. This could be compared to the US adult population (≥20 years old) in 2003–2004, a majority of whom fulfilled the NCEP criteria (22). For men, the absolute increase in waist circumference between 1990 and 2004 was of the same magnitude in northern Sweden as in the USA. Notably, women aged 35 to 64 years present a substantially higher increase in waist circumference in northern Sweden than in the USA (6.4 cm compared to 2.5–5.8 cm in corresponding age groups). The prevalence of abdominal obesity according to NCEP displays a similar pattern for the same period. In women 45–64 years old, the prevalence increased 24.6% units in northern Sweden compared to 7.6–16.1% units in corresponding age groups in the USA. For men 55–64 years old, the increase was 18.6% units compared to 6.1–12.9% units. In younger age groups, the prevalence of abdominal obesity increased more in the USA. Between the two most recent surveys, in 1999 and 2004, women aged 45–64 years in our study area continued to have a more rapid increase of abdominal obesity (NCEP) than in the USA, 10% units versus 2.7–8% units for corresponding age groups (22).

Rural areas tend to have a higher prevalence of obesity than do urban areas in the same country, as has been demonstrated in the cases of northern Sweden and rural New York (24). A comparison of these two sparsely populated areas indicated a higher prevalence of obesity in rural New York. The BMI distribution in northern Sweden in 1999 was very similar to the corresponding distribution in rural New York in 1989, suggesting that the obesity epidemic in northern Sweden will continue to increase. Our finding of rapidly increasing abdominal

obesity supports this assumption. In the USA in the 1988–2004 period (22), the prevalence of abdominal obesity was higher than in northern Sweden in 2004 when using the NCEP definition; when using the IDF definition, however, the numbers were comparable for men aged 25–55 years and women aged 55–74 years.

The reported changes in waist circumference may relate to altered eating habits. As demonstrated elsewhere, the intake of saturated fat decreased and of low-glycemic-index carbohydrates increased in the Northern Sweden MONICA population between 1986 and 1999 (10). The greatest change took place between 1986 and 1990, and related in particular to the consumption of dairy products. The intake of milk containing 3% fat fell to a third of its previous level, mostly replaced with medium-fat (1.5%) milk (introduced in 1986), while butter intake was halved and the use of margarine spread containing 40% fat concomitantly increased. Recent changes in milk intake, together with increased intakes of vegetable oil and pasta, have been linked to decreased waist circumference, whilst increased abdominal obesity has been linked to the increased intake of beer by men and of hamburgers, French fries, and soft drinks by women (25).

Smoking habits, reported as daily smoking, did not change between 1986 and 1990, but decreased thereafter in men and after 1994 in women. However, the total proportion of tobacco users remained stable over the 1986–2004 period, as an increasing proportion of males, mostly former smokers, started to use *snus* (26). Whether these changes in tobacco use could influence fat distribution is unclear, but male *snus* users have a higher than expected prevalence of overweight and smokers who quit tobacco gain more weight than do those who change to *snus* (27).

Unfortunately, levels of physical activity 1986 were not coded the same way as in following surveys so comparisons are problematic. Between 1990 and 1999 there was a trend towards more sedentary working conditions for men, especially those highly educated. The

proportion of men engaging in at least two hours of light leisure-time physical activity per week remained fairly stable, though it decreased in men 45–54 years old. Total physical inactivity was reported by 2% of women and 4% of men; this proportion remained stable over the period, though with a tendency towards an increase in men aged 25–34 years (28).

The educational level of the population, as presented elsewhere (10,29), increased between 1986 and 2004. In 1986, more than half the population aged 25–64 years reported primary school as the highest educational level, this being similar for men and women. Between 1986 and 1990 the number of respondents reporting previous university studies increased markedly from 12% to 21% among women, but only from 10% to 13% among men. In 1999, 29% of women and 19% of men reported university studies, 18% of women and 22% of men primary school, and the majority secondary school as the highest educational level. The increase in educational level over time, more pronounced in women, could have influenced the observed changes in food habits and life style.

The Northern Sweden MONICA study has maintained high participation in all its constituent surveys, with an overall participation rate of 77%. The lower participation in younger age groups in recent surveys, especially among men, could influence the results, but our findings indicate no change in the response pattern of self-reports from non-participants over time.

In the mid and late 1980s, community-level health-promotion campaigns concerning cardiovascular risk factors were launched in northern Sweden. Most importantly, the Västerbotten Intervention Program (VIP) started in Norsjö, Västerbotten County, which combined intensive community intervention with an individual approach (30). The labelling of low-fat and high-dietary-fibre food with a “keyhole” symbol was introduced in some grocery stores in the mid 1980s and was nationally adopted in 1989. These measures presumably had important effects, both directly and through the media, in terms of improving

food consumption habits and promoting healthier lifestyles, which might have affected trends in obesity distribution. If true, this is an important and positive message, as it indicates that society can markedly influence lifestyle behaviour and metabolic risk factors. After 1990, though, the prevalence of abdominal obesity has increased more rapidly in women, which might indicate the difficulty of maintaining lifestyle changes.

We have earlier reported that the prevalence of diabetes did not increase between 1986 and 1999 according to the Northern Sweden MONICA surveys (11), and we assumed that this was linked to factors such as reduced central obesity. The shift reported here, towards the more central distribution of adipose tissue and a rapid increase in abdominal obesity, indicates that we may anticipate an increase in diabetes incidence, and hence in its cardiovascular and other complications.

Acknowledgements

We are indebted to the Northern Swedish MONICA Project and to the grants supporting it. This study was also supported by grants from the Swedish National Institute of Public Health, the Swedish Heart and Lung Foundation, the county councils of Northern Sweden (Visare Norr), and the Faculty of Medicine, Umeå University. Dr. Lilja is supported by the Research and Development Unit of Jämtland County Council, Östersund, Sweden and Dr. Stegmayr by grants from the Swedish Medical Research Council.

References

1. **World Health Organization**. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser. 2000; 894:i–xii, 1–253.

2. **Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW Jr.** Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med.* 1999; 341:1097–105.
3. **Silventoinen K, Sans S, Tolonen H, et al.** Trends in obesity and energy supply in the WHO MONICA Project. *Int J Obes Relat Metab Disord.* 2004;28:710–18.
4. **Lapidus L, Bengtsson C, Larsson B, Rybo E, Sjöström L.** Distribution of adipose tissue and risk of cardiovascular disease and death: a 12 year follow up of participants in the population study of women in Gothenburg, Sweden. *BMJ (Clin Res Ed).* 1984;289:1257–61.
5. **Larsson B, Svärdsudd K, Welin L, Willhelmsen L, Björntorp P, Tibblin G.** Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. *BMJ (Clin Res Ed).* 1984;288:1401–04.
6. **Yusuf S, Hawken S, Ounpuu S, et al.** Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case control study. *Lancet.* 2004;364:937–52.
7. **Hartz AJ, Rupley DC Jr, Kalkhoff RD, Rimm AA.** Relationship of obesity to diabetes: influence of obesity level and body fat distribution. *Prev Med.* 1983;12:351–57.
8. **Wei M, Gaskill SP, Haffner SM, Stern MP.** Waist circumference as the best predictor of noninsulin dependent diabetes mellitus (NIDDM) compared to body mass index, waist/hip ratio and other anthropometric measurements in Mexican Americans – a 7-year prospective study. *Obes Res.* 1997;5:16–23.
9. **Eliasson M, Lindahl B, Lundberg V, Stegmayr B.** Diabetes and obesity in Northern Sweden: occurrence and risk factors for stroke and myocardial infarction. *Scand J Public Health Suppl.* 2003;61:71–7.

10. **Krachler B, Eliasson M, Johansson I, Hallmans G, Lindahl B.** Trends in food intake in Swedish adults 1986–1999: findings from the Northern Sweden MONICA (Monitoring of Trends and Determinants in Cardiovascular Disease) Study. *Public Health Nutr.* 2005;8:628–35.
11. **Eliasson M, Lindahl B, Lundberg V, Stegmayr B.** No increase in the prevalence of known diabetes between 1986 and 1999 in subjects 25–64 years of age in northern Sweden. *Diabet Med.* 2002;19:874–80.
12. **WHO MONICA Project Principal Investigators.** The World Health Organization MONICA Project (monitoring trends and determinants in cardiovascular disease): a major international collaboration. *J Clin Epidemiol.* 1988;41:105–14.
13. **Stegmayr B, Lundberg V, Asplund K.** The events registration and survey procedures in the Northern Sweden MONICA Project. *Scand J Public Health. Suppl.* 2003;61:9–17.
14. **Alberti KG, Zimmet PZ.** Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus – provisional report of a WHO consultation. *Diabet Med.* 1998;15:539–53.
15. **Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults.** Executive summary of The Third Report of The National Cholesterol Education Program (NCEP) (Adult Treatment Panel III). *JAMA.* 2001;285:2486–97.
16. **Alberti KG, Zimmet P, Shaw J.** Metabolic syndrome – a new world-wide definition: a consensus statement from the International Diabetes Federation. *Diabet Med.* 2006;23:469–80.
17. **Eurostat.** *Health in Europe. Results from 1997–2000 surveys.* Luxembourg: Office for Official Publications of the European Communities; 2003.

18. **Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM.** Prevalence of overweight and obesity among US children, adolescents and adults, 1997–2002. *JAMA*. 2004;291:2847–50.

19. **Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL.** Overweight and obesity in the United States: prevalence and trends, 1960–1994. *Int J Obes Relat Metab Disord.* 1998;22:39–47.

20. **Sundquist K, Qvist J, Johansson SE, Sundquist J.** Increasing trends of obesity in Sweden between 1996/97 and 2000/01. *Int J Obes Relat Metab Disord.* 2004;28:254–61.

21. **Okosun IS, Chandra KM, Boev A, et al.** Abdominal adiposity in US adults: prevalence and trends, 1960–2000. *Prev Med*. 2004;39:197–206.

22. **Li C, Ford ES, McGuire LC, Mokdad AH.** Increasing trends in waist circumference and abdominal obesity among US adults. *Obes Res.* 2007;15:216–24.

23. **Sarlio-Lahteenkorva S, Silventoinen K, Lahti-Koski M, Laatikainen T, Jousilahti P.** Socio–economic status and abdominal obesity among Finnish adults from 1992 to 2002. *Int J Obes.* 2006;30:1653–60.

24. **Nafziger AN, Stenlund H, Wall S, et al.** High obesity incidence in northern Sweden: how will Sweden look by 2009? *Eur J Epidemiol.* 2006;21:377–82.

25. **Krachler B, Eliasson M, Stenlund H, Johansson I, Hallmans G, Lindahl B.** Reported food intake and distribution of body fat: a repeated cross-sectional study. *Nut J.* 2006;5:34.

26. **Stegmayr B, Eliasson M, Rodu B.** The decline of smoking in Northern Sweden. *Scand J Public Health.* 2005;33:321–4.

27. **Rodu B, Stegmayr B, Nasic S, Cole P, Asplund K.** The influence of smoking and smokeless tobacco on weight amongst men. *J Intern Med.* 2004;255:102–7.

28. **Lindahl B, Stegmayr B, Johansson I, Weinehall L, Hallmans G**. Trends in lifestyle 1986–99 in a 25- to 64-year-old population of the Northern Sweden MONICA project. *Scand J Public Health. Suppl.* 2003;61:31–7.

29. **Eliasson M, Janlert U, Jansson JH, Stegmayr B.** Time trends in population cholesterol levels 1986–2004: influence of lipid-lowering drugs, obesity, smoking and educational level. The northern Sweden MONICA study. *J Intern Med.* 2006;260:551–9.

30. **Weinehall L, Hellsten G, Boman K, Hallmans G.** Prevention of cardiovascular disease in Sweden: the Norsjö community intervention programme – motives, methods and intervention components. *Scand J Public Health. Suppl.* 2001;56:13–20.

Legends to figures

Figure 1

Age-standardized percentages of men and women 25–64 years old in Norrbotten and Västerbotten counties in northern Sweden being overweight (BMI 25–29.9) and obese (BMI >30) at the times of different surveys. Age standardized to the populations in Norrbotten and Västerbotten as of 2004.

Figure 2

Age-standardized percentages of men and women 25–64 years old in Norrbotten and Västerbotten counties in northern Sweden having disadvantageous waist circumference (cut-offs for men ≥94 and >102 cm, respectively, and for women ≥80 and >88 cm, respectively) at the times of different surveys. Age standardized to the populations in Norrbotten and Västerbotten as of 2004.

Figure 1

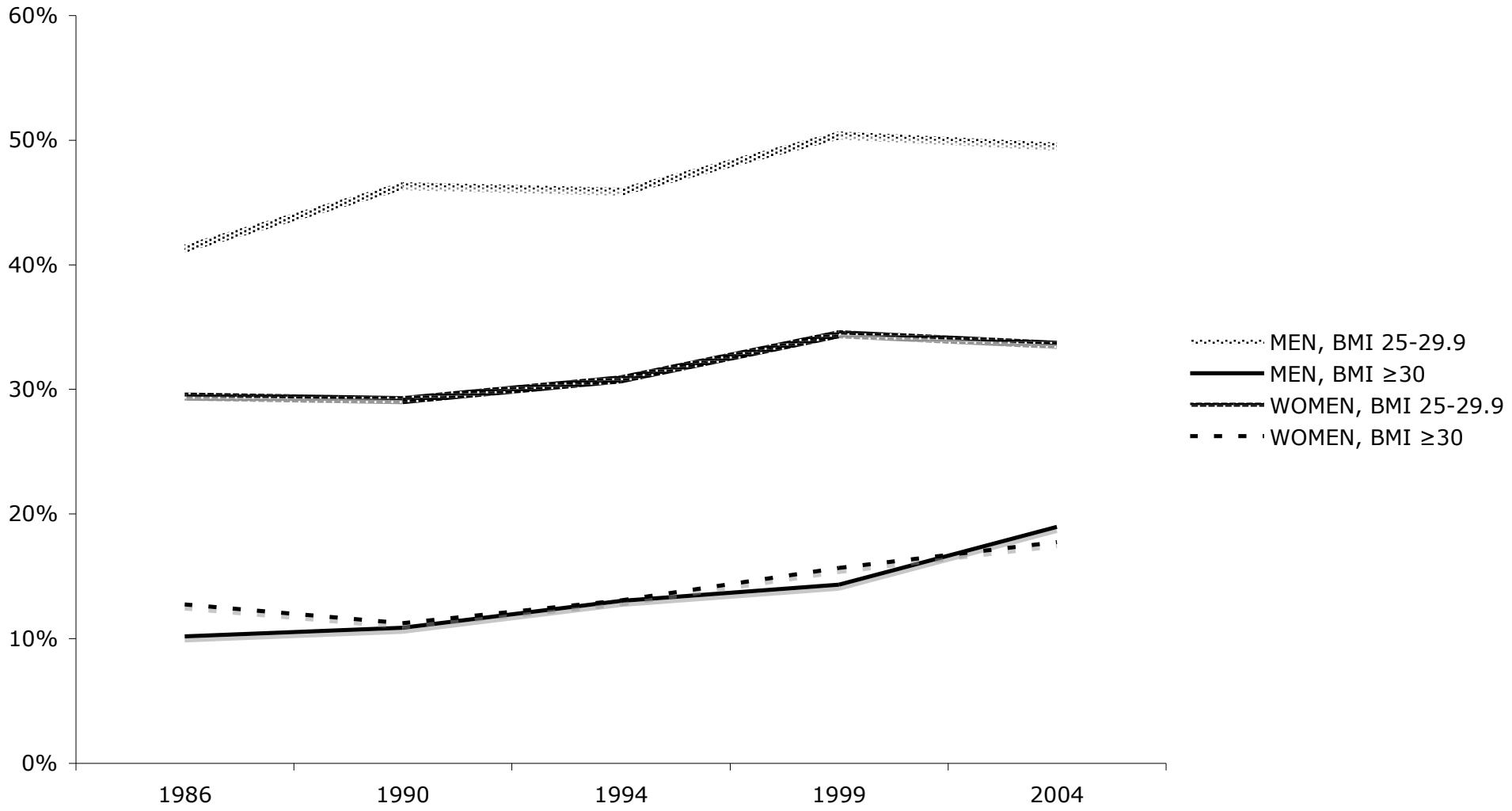
60%
50%
40%
30%
20%
10%
0%
1986
1990
1994
1999
2004
MEN, BMI 25-29.9
MEN, BMI ≥30
WOMEN, BMI 25-29.9
WOMEN, BMI ≥30

Figure 2

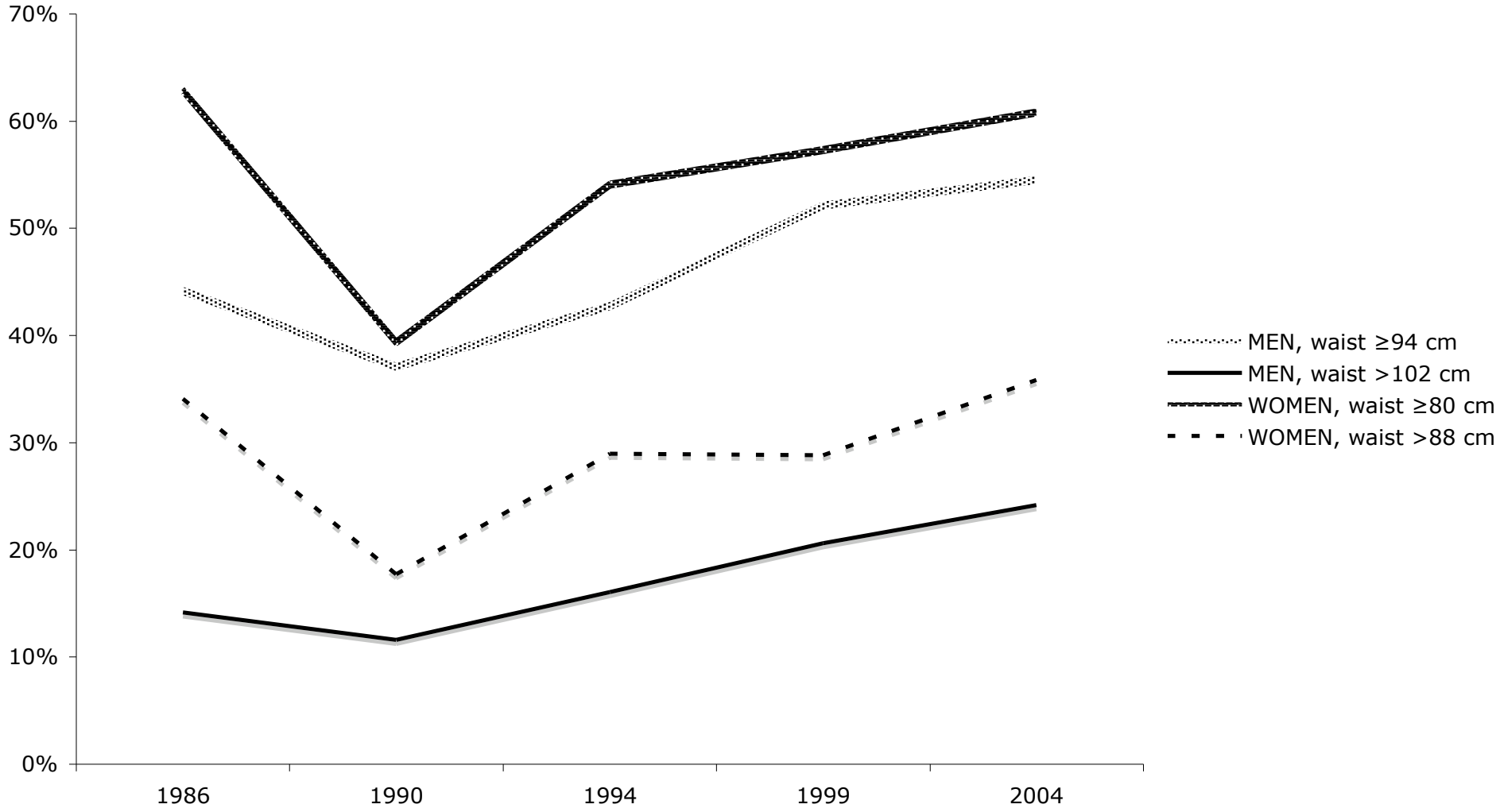
70%
60%
50%
40%
30%
20%
10%
0%
1986
1990
1994
1999
2004
MEN, waist ≥94 cm
MEN, waist >102 cm
WOMEN, waist ≥80 cm
WOMEN, waist >88 cm

Table 1. Study base.

Age group	25-34	35-44	45-54
MEN (n)			
1986	175	212	225
1990	167	199	203
1994	165	180	195
1999	157	160	170
2004	147	167	182
WOMEN (n)			
1986	187	206	211
1990	177	206	209
1994	173	202	209
1999	166	177	203
2004	165	195	197

Number of participants in the surveys 1986, 1990, 1994, 1999 and 2004 for men an
of 250 invited in each investigated age and gender group
(25-34, 35-44, 45-54, 55-64 and 65-74 years old) and the total. NI= Not investigate

55-64	65-74	Total
211	NI	823
207	NI	776
208	193	941
196	206	889
214	220	930
198	NI	802
215	NI	807
202	194	980
196	192	934
206	212	975

ıd women

:d.

Table 2. Weight, BMI, waist- and hip circumference and WHR in men and women.

	1986	1990	1994	1999
MEN				
Weight(kg)				
25-34 year	77.5 (10.7)	79.8 (12.7)	81.0 (12.9)	83.7 (13.6)
35-44 year	80.2 (10.7)	80.6 (11.5)	81.4 (13.3)	83.3 (11.1)
45-54 year	81.0 (13.4)	82.4 (11.1)	83.3 (11.5)	85.2 (12.0)
55-64 year	80.0 (11.1)	79.1 (10.3)	82.2 (13.5)	84.9 (12.4)
65-74 year	NI	NI	79.9 (11.0)	80.7 (11.3)
BMI (kg/m2)				
25-34 year	24.2 (3.0)	24.8 (3.5)	25.2 (3.5)	25.8 (3.8)
35-44 year	25.3 (3.1)	25.3 (3.2)	25.4 (3.6)	26.1 (3.2)
45-54 year	26.1 (3.8)	26.8 (3.1)	26.8 (3.4)	26.9 (3.2)
55-64 year	26.6 (3.3)	26.4 (3.3)	27.0 (3.9)	27.4 (3.4)
65-74 year	NI	NI	26.5 (3.3)	26.9 (3.6)
Waist circumference (cm)				
25-34 year	88.1 (8.0)	87.6 (9.5)	88.9 (10.0)	91.4 (10.2)
35-44 year	92.4 (8.0)	90.1 (8.7)	90.6 (10.3)	93.7 (8.8)
45-54 year	94.3 (10.0)	93.9 (8.5)	95.1 (9.0)	95.7 (9.0)
55-64 year	96.7 (9.1)	93.5 (8.7)	96.0 (9.9)	98.1 (9.8)
65-74 year	NI	NI	95.6 (8.8)	96.8 (9.4)
Hip circumference (cm)				
25-34 year	95.8 (5,5)	96.9 (6.9)	98.5 (6.8)	103.8 (7.6)
35-44 year	97.8 (5.5)	97.4 (5.8)	98.2 (6.5)	102.7 (5.7)
45-54 year	98.6 (6.5)	98.9 (5.9)	99.8 (6.2)	102.9 (5.8)
55-64 year	99.3 (6.1)	98.3 (5.4)	100.4 (7.1)	103.6 (6.0)
65-74 year	NI	NI	100.5 (6.1)	102.7 (6.8)
WHR (ratio)				
25-34 year	0.92 (0.05)	0.90 (0.05)	0.90 (0.06)	0.88 (0.06)
35-44 year	0.94 (0.05)	0.92 (0.05)	0.92 (0.06)	0.91 (0.06)
45-54 year	0.96 (0.06)	0.95 (0.05)	0.95 (0.06)	0.93 (0.06)
55-64 year	0.97 (0.05)	0.95 (0.06)	0.95 (0.05)	0.95 (0.06)
65-74 year	NI	NI	0.95 (0.06)	0.94 (0.06)
WOMEN				
Weight (kg)				
25-34 year	62.3 (10.1)	64.4 (12.3)	64.7 (11.0)	66.4 (12.9)
35-44 year	65.3 (12.3)	64.5 (9.9)	67.9 (12.6)	69.8 (13.1)
45-54 year	68.2 (12.3)	68.3 (12.8)	68.3 (10.4)	69.7 (12.7)
55-64 year	69.4 (12.0)	68.7 (11.6)	69.2 (13.3)	72.2 (10.9)
65-74 year	NI	NI	71.3 (13.6)	71.4 (12.6)

BMI (kg/m^2)				
25-34 year	22.9 (3.3)	23.5 (4.2)	23.7 (3.7)	24.2 (4.3)
35-44 year	24.0 (4.1)	24.1 (3.7)	25.0 (4.6)	25.6 (4.5)
45-54 year	25.9 (4.5)	25.7 (4.6)	25.5 (3.9)	26.0 (4.4)
55-64 year	26.9 (4.4)	26.5 (4.5)	26.8 (4.9)	27.2 (4.0)
65-74 year	NI	NI	27.6 (4.9)	28.3 (4.8)
Waist circumference (cm)				
25-34 year	80.5 (9.5)	76.1 (10.9)	77.9 (11.2)	78.1 (10.4)
35-44 year	83.1 (11.6)	77.2 (9.0)	82.1 (11.8)	82.7 (11.6)
45-54 year	86.7 (12.0)	80.7 (11.4)	82.7 (10.0)	84.7 (12.2)
55-64 year	90.6 (13.3)	83.0 (11.2)	87.2 (12.6)	88.3 (11.0)
65-74 year	NI	NI	88.9 (12.7)	89.4 (10.4)
Hip circumference (cm)				
25-34 year	94.8 (7.0)	94.5 (8.7)	97.7 (7.6)	101.0 (8.5)
35-44 year	97.1 (8.6)	95.9 (7.3)	99.4 (9.3)	102.6 (9.0)
45-54 year	100.2 (8.5)	99.6 (9.6)	101.0 (7.4)	103.0 (8.4)
55-64 year	101.8 (9.1)	100.7 (8.6)	101.4 (9.8)	104.9 (7.8)
65-74 year	NI	NI	102.9 (9.6)	105.9 (9.8)
WHR (ratio)				
25-34 year	0.85 (0.07)	0.80 (0.06)	0.79 (0.08)	0.77 (0.06)
35-44 year	0.85 (0.07)	0.80 (0.05)	0.82 (0.07)	0.80 (0.07)
45-54 year	0.86 (0.07)	0.81 (0.06)	0.82 (0.07)	0.82 (0.07)
55-64 year	0.89 (0.08)	0.82 (0.06)	0.86 (0.08)	0.84 (0.07)
65-74 year	NI	NI	0.86 (0.08)	0.84 (0.05)

Values shown are means and SD stratified for age groups and surveys and absolute and
Differences between surveys: a=1986-2004, b=1986-1999, c=1986-1994, d=1986-1990
f=1990-1999, g=1990-1994, h=1994-2004, i=1994-1999, and j=1999-2004.
Significance levels: *=p<0.05, †=p<0.005, ‡=p<0.0005, ns= non significant

2004	Absolute change 1986-2004	Absolute change 1990-2004	Relative change (%) 1986-2004	Relative change (%) 1990-2004	Significance surveys	Significance trend
83.9 (13.8)	6.4	4.1	8.3	5.1	‡ ab*e	‡
86.3 (14.4)	6.1	5.7	7.6	7.1	‡ae†h	‡
87.9 (13.7)	6.9	5.5	8.5	6.7	‡ae†h*b	‡
86.1 (13.5)	6.1	7.0	7.6	8.8	‡aef†b*h	‡
82.5 (12.9)	NI	2.6§	NI	3.3§	ns	*
26.0 (4.0)	1.8	1.2	7.4	4.8	‡ab*e	‡
26.9 (3.9)	1.6	1.6	6.3	6.3	‡ae†h	‡
27.6 (3.9)	1.5	0.8	5.7	3.0	‡a	‡
27.7 (4.1)	1.1	1.3	4.1	4.9	†e*a	‡
27.5 (3.8)	NI	1.0§	NI	3.8§	*h	†
91.7 (10.9)	3.6	4.1	4.1	4.7	†ef*ab	‡
95.5 (11.5)	3.1	5.4	3.4	6.0	‡eh†f*ai	‡
98.0 (10.2)	3.7	4.1	3.9	4.4	‡e†a*h	‡
98.6 (10.8)	1.9	5.1	2.0	5.5	‡ef*d	‡
97.9 (10.0)	NI	2.3§	NI	2.4§	*h	*
99.7 (7.1)	3.9	2.8	4.1	2.9	‡abfij†ce	‡
100.8 (7.5)	3.0	3.4	3.1	3.5	‡abefi†h	‡
101.0 (6.6)	2.4	2.1	2.4	2.1	‡bfi†a*ej	‡
101.0 (6.6)	1.7	2.7	1.7	2.7	‡befij*ag	‡
100.6 (6.5)	NI	0.1§	NI	00.00	†ij	ns
0.92 (0.06)	0.00	0.02	0.0	2.2	‡bj†f*ci	ns
0.94 (0.06)	0.00	0.02	0.0	2.2	‡bj†cdeh	ns
0.97 (0.05)	0.01	0.02	1.0	2.1	‡bj†ei*fh	ns
0.97 (0.06)	0.00	0.02	0.0	2.1	‡bdej†h*c	ns
0.97 (0.06)	NI	0.02§	NI	2.1§	‡j†h	‡
68.8 (15.0)	6.5	4.4	10.4	6.8	‡a*beh	‡
70.3 (13.3)	5.0	5.8	7.7	9.0	‡aef†b	‡
72.0 (13.6)	3.8	3.7	5.6	5.4	*aeh	†
72.8 (13.8)	3.4	4.1	4.9	6.0	*efh	‡
72.7 (13.5)	NI	1.4§	NI	2.0§	ns	ns

24.9 (4.9)	2.0	1.4	8.7	6.0	‡a*be	‡
25.8 (5.1)	1.8	1.7	7.5	7.1	†ae*bf	‡
26.5 (4.8)	0.6	0.8	2.3	3.1	ns	ns
27.3 (4.9)	0.4	0.8	1.5	3.0	ns	ns
28.4 (5.0)	NI	0.8§	NI	2.9§	ns	ns
80.8 (12.8)	0.3	4.7	0.4	6.2	†de	ns
83.6 (12.5)	0.5	6.4	0.6	8.3	‡defg	*
87.1 (11.8)	0.4	6.4	0.5	7.9	‡de†cfh	*
89.4 (12.2)	-1.2	6.4	-1.3	7.7	‡def†g*c	ns
91.3 (12.5)	NI	2.4§	NI	2.7§	ns	*
98.8 (9.7)	4.0	4.3	4.2	4.6	‡abef†g*di	‡
99.6 (9.2)	2.5	3.7	2.6	3.9	‡bef†ig*j	‡
101.4 (8.9)	1.2	1.8	1.2	1.8	†f*b	†
102.8 (8.9)	1.0	2.1	1.0	2.1	‡f†bi	†
104.4 (9.4)	NI	1.5§	NI	1.5§	*i	ns
0.82 (0.07)	-0.03	0.02	-3.5	2.5	‡abcdfj*i	‡
0.84 (0.06)	-0.01	0.04	-1.2	5.0	‡bcdej*gi	ns
0.86 (0.07)	0.00	0.05	0.0	6.2	‡bcdfhj	ns
0.87 (0.06)	-0.02	0.05	-2.2	6.1	‡bcdeg†j*a	ns
0.87 (0.07)	NI	0.01§	NI	1.2§	‡j*i	ns

relative changes between 1986-2004, 1990-2004, and between 1994-2004 (§). NI=Not investigated.
), e=1990-2004,

Pregnant women not included.

Table 3. Trends in prevalence of overweight and obesity.

	1986	1990	1994	1999	2004	Absolute 1986-2004
MEN						
25-34 year						
Overweight	28.0	35.5	36.4	42.7	43.5	15.5
Obese	4.0	8.4	7.9	10.8	13.6	9.6
35-44 year						
Overweight	42.9	44.7	40.0	46.3	48.5	5.6
Obese	6.6	6.5	10.0	11.3	18.2	11.6
45-54 year						
Overweight	41.1	55.4	56.7	59.4	57.1	16.0
Obese	13.4	16.3	13.9	13.5	19.2	5.8
55-64 year						
Overweight	52.6	49.0	50.0	53.1	48.4	-4.2
Obese	16.1	11.7	19.7	21.4	24.4	8.3
65-74 year						
Overweight	NI	NI	52.8	49.0	47.5	NI
Obese	NI	NI	13.0	18.9	23.7	NI
WOMEN						
25-34 year						
Overweight	13.9	16.5	19.9	23.1	22.3	8.4
Obese	4.8	6.8	8.1	9.6	14.6	9.8
35-44 year						
Overweight	25.5	27.7	26.5	31.0	32.3	6.8
Obese	8.3	5.3	11.7	15.5	14.6	6.3
45-54 year						
Overweight	31.9	30.1	33.5	31.5	36.5	4.6
Obese	16.2	15.8	12.0	16.3	17.8	1.6
55-64 year						
Overweight	45.2	40.9	41.6	51.8	42.7	-2.5
Obese	20.3	16.3	19.8	20.5	23.3	3.0
65-74 year						
Overweight	NI	NI	40.4	44.3	41.0	NI
Obese	NI	NI	28.0	29.7	34.4	NI

Values shown are percentages of men and women being overweight (BMI 25–29.9) or obese (BMI ≥
and surveys with absolute and relative changes between 1986-2004, 1990-2004, and between 1994-2
Differences between surveys: a=1986-2004, b=1986-1999, c=1986-1994, d=1986-1990, e=1990-200
f=1990-1999, g=1990-1994, h=1994-2004, i=1994-1999, and j=1999-2004.
Significance levels: *=p<0.05, †=p<0.005, ‡=p<0.0005, ns= non significant

ɛ change	Relative change (%)		Significance	
1990-2004	1986-2004	1990-2004	surveys	trend
8.0	55.3	22.5	*a	†
5.2	240.0	61.9	*a	†
3.8	13.1	8.5	ns	ns
11.7	175.8	180.0	†ae	‡
1.7	38.9	3.1	†b*acd	†
2.9	43.3	17.8	ns	ns
-0.6	-8.0	-1.2	ns	ns
12.7	51.6	108.5	*e	†
-5.3§	NI	-10.0§	ns	ns
10.7§	NI	82.3§	*h	*
5.8	60.4	35.2	ns	*
7.8	204.2	114.7	*a	†
4.6	26.7	16.6	ns	ns
9.3	75.9	175.5	*ef	†
6.4	14.4	21.3	ns	ns
2.0	9.9	12.7	ns	ns
1.8	-5.5	4.4	ns	ns
7.0	14.8	42.9	ns	ns
0.6§	NI	1.5§	ns	ns
6.4§	NI	22.9§	ns	ns

≥ 30) stratified for age groups
2004 (§). NI=Not investigated. Pregnant women not included.
04,

Table 4. Trends in prevalence of abdominal obesity. Cut offs for waist circumferen

	1986	1990	1994	1999	2004
MEN					
25-34 year					
Waist ≥ 94 cm	23.4	21.7	24.8	36.9	34.9
Waist > 102 cm	3.4	7.2	8.5	14.6	15.8
35-44 year					
Waist ≥ 94 cm	41.2	30.2	34.4	45.6	50.0
Waist > 102 cm	10.9	9.0	10.6	17.5	22.3
45-54 year					
Waist ≥ 94 cm	45.8	48.8	54.9	59.4	66.5
Waist > 102 cm	20.0	16.3	20.5	21.2	25.8
55-64 year					
Waist ≥ 94 cm	64.9	46.8	55.6	65.8	64.9
Waist > 102 cm	21.3	13.2	23.7	28.6	31.8
65-74 year					
Waist ≥ 94 cm	NI	NI	59.9	62.1	63.6
Waist > 102 cm	NI	NI	20.8	24.8	29.1
WOMEN					
25-34 year					
Waist ≥ 80 cm	42.7	23.4	38.5	33.3	38.9
Waist > 88 cm	15.7	12.6	17.4	14.1	17.8
35-44 year					
Waist ≥ 80 cm	55.2	28.6	50.8	53.1	55.2
Waist > 88 cm	25.6	11.7	24.1	24.0	28.1
45-54 year					
Waist ≥ 80 cm	70.6	45.9	57.9	60.9	67.0
Waist > 88 cm	39.3	19.1	28.2	31.7	43.7
55-64 year					
Waist ≥ 80 cm	81.7	57.5	66.8	80.1	80.0
Waist > 88 cm	53.3	26.6	44.1	43.9	51.2
65-74 year					
Waist ≥ 80 cm	NI	NI	75.8	81.3	81.6
Waist > 88 cm	NI	NI	49.5	52.6	55.2

Values shown are percentages of men and women having disadvantegous waist accordi
(>102 and >88 in men and women, respectively) stratified for age groups and surveys a
relative changes between 1986-2004, 1990-2004, and 1994-2004 (§). NI=Not investigat
Differences between surveys: a=1986-2004, b=1986-1999, c=1986-1994, d=1986-1990
f=1990-1999, g=1990-1994, h=1994-2004, i=1994-1999, and j=1999-2004.
Significance levels: *=p<0.05, †=p<0.005, ‡=p<0.0005, ns= non significant

ıce according to NCEP ATP III and IDF.

Absolute change		Relative change (%)		Significance	
1986-2004	**1990-2004**	**1986-2004**	**1990-2004**	**surveys**	**trend**
11.5	13.2	49.1	60.8	*f	†
12.4	8.6	364.7	119.4	†ab	‡
8.8	19.8	21.4	65.6	†e*fh	†
11.4	13.3	104.6	147.8	†e*ah	‡
20.7	17.7	45.2	36.3	‡a†e	‡
5.8	9.5	29.0	58.3	ns	ns
0.0	18.1	0.0	38.7	†def	ns
10.5	18.6	49.3	140.9	‡e†f	‡
NI	3.7§	NI	6.2§	ns	ns
NI	8.3§	NI	39.9§	ns	ns
-3.8	15.5	-8.9	66.2	†d*eg	ns
2.1	5.2	13.4	41.3	ns	ns
0.0	26.6	0.0	93.0	‡defg	*
2.5	16.4	9.8	140.2	†e*dfg	ns
-3.6	21.1	-5.1	46.0	‡de*f	ns
4.4	24.6	11.2	128.8	‡de*h	*
-1.7	22.5	-2.1	39.1	‡def*chi	*
-2.1	24.6	-3.9	92.5	‡de†fg	ns
NI	5.8§	NI	7.7§	ns	ns
NI	5.7§	NI	11.5§	ns	ns

ng to IDF (≥94 and ≥80 in men and women, respectively) or NCEP ATPIII
and absolute and
ıted. Pregnant women not included.
), e=1990-2004,

Table 5. Self reported data for non-participants at each survey and average for non-p

	1986 men / women	1990 men / women
Respons rate %	52.3 / 60.8	40.9 / 62.3
BMI kg/m²	24.4 (3.2) / 24.2 (4.6)	24.5 (3.1) / 23.3 (4.4)
Married/cohabitant %	63.0 / 62.0	56.7 / 68.1
Elevated BP anytime %	18.2 / 22.3	11.5 / 12.1
Previous year control of:		
BP %	NQ	75.3 / 72.4
Cholesterol %	NQ	46.6 / 28.2
Highest educational level:		
University %	23.0 / 6.9	14.8 / 23.1
Secondary school %	24.1 / 24.1	30.7 / 37.6
Daily tobacco use:		
Snus (= moist snuff)%	NQ	24.4 / 6.0
Cigarettes %	30.7 / 33.1	24.6 / 29.4
Cigarettes/day if smoking	13.3 (8.5) / 11.1 (7.5)	11.2 (7.5) / 11.8 (5.9)

Values for surveys 1986, 1990, 1994, 1999 and 2004 are unadjusted means and SD stratifi
Data for groups with all participants and non-participants adjusted for covariates: sex, sur
Significance levels betwen group of all non-participants and all participants: *=p<0.05, †=
NQ=no questions at telephone inteview.
NA=not applicable.
Survey participants not asked wheather examined blood preasure (BP) or cholesterol level

participants and survey data for participants at all surveys.

1994 men / women	1999 men / women	2004 men / women
79.8 / 85.7	44.8 / 46.3	58.7 / 70.9
25.2 (3.2) / 24.1 (4.3)	25.4 (3.8) / 25.1 (4.5)	26.7 (4.3) / 25.2 (4.9)
65.7 / 64.4	62.0 / 67.3	62.4 / 61.3
13.9 / 21.6	15.5 / 21.8	24.6 / 24.7
63.7 / 76.4	64.1 / 71.8	62.9 / 68.6
29.1 / 25.9	33.8 / 33.6	41.9 / 32.6
14.3 / 18.2	22.7 / 20.7	18.2 / 26.6
32.8 / 28.6	32.6 / 27.9	37.4 / 32.3
25.3 / 3.1	34.5 / 9.1	36.0 / 14.4
24.6 / 33.3	21.8 / 27.3	18.5 / 24.6
14.4 (9.4) / 11.5 (5.7)	11.9 (6.2) / 9.3 (4.7)	12.0 (7.0) / 10.8 (5.8)

ied for gender. Adjusted values for non-participants and participants are presented a
vey year and age group.
=p<0.005, ‡=p<0.0005, ns= non significant

l previous year 1986.

1986-2004		
non-participants	**participants**	**Significance**
n=2639	n=8857	NA
25.0 (0.10)	26.1 (0.04)	‡
63.7 (0.011)	78.2 (0.005)	‡
20.7 (0.01)	23.4 (0.004)	*
70.2 (0.013)	60.3 (0.006)	‡
34.0 (0.012)	22.9 (0.005)	‡
17.3 (0.01)	19.1 (0.004)	ns
27.7 (0.010)	27.6 (0.004)	ns
17.2 (0.009)	13.9 (0.004)	†
27.0 (0.004)	19.6 (0.010)	‡
11.9 (0.32)	12.4 (0.15)	ns

as means and SE .