

## Large heterogeneity of the obesity epidemic in Danish adults

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### Abstract

**Objective:** To examine to what extent the obesity epidemic is a general phenomenon in adults by assessing the secular change, by birth cohort and age, in the prevalence of obesity and median body mass index (BMI) in Danish men and women measured between 1964 and 1994.

**Design:** Multiple cross-sectional population surveys.

**Setting:** The greater Copenhagen area of Denmark.

**Subjects:** The study included 17 065 men (30 336 observations) and 13 417 women (24 065 observations), aged 20–84 years.

**Main outcome measures:** Trends in median BMI and prevalence of obesity estimated from measured height and weight in 10-year age groups.

**Results:** In general the prevalence of obesity was increasing, although in an irregular way: among men in two phases, during the 1970s and 1990s and among women only during the 1990s. Great heterogeneity was observed between birth cohorts and age groups. There was only little indication of an increasing trend in obesity prevalence for women, except for the 55–64-year-olds. In men, the prevalence of obesity was increasing in all age groups except in the youngest ones, and it was statistically significant only for men aged 35–74 years. There was no significant linear change in median BMI in any group, except for an increasing trend among men aged 50 years and above.

**Conclusion:** Although the overall Danish trend for obesity prevalence, similar to trends world-wide, showed a marked increase, the trend was very heterogeneous and generally neither uniform nor significantly positive; the changes were irregular, different among men and women, and different in the different age and birth cohorts. The obesity problem in middle-aged and older men of certain birth cohorts poses a specific public health challenge. Future studies of determinants behind the heterogeneity in the development of the obesity epidemic may provide clues to its causes.

**Keywords**  
Time trends  
Body mass index  
Obesity  
Prevalence  
Public health

Overall trends for obesity are increasing throughout the world and have prompted the World Health Organization to declare an epidemic of obesity: obesity is the second most important public health burden, exceeded only by the burden related to smoking<sup>1</sup>. In Denmark, a 30% increase in the prevalence of obesity apparently took place between the early 1980s and the early 1990s<sup>2,3</sup>. Similarly, data from the UK and the USA also suggest a

doubling in the prevalence over this time period<sup>1</sup>. Despite this apparent consistency, the obesity epidemic seems to manifest itself differently both between and within populations<sup>1</sup>. In Denmark, for instance, data from the Danish school health and draft board examinations showed a dramatic increase in the prevalence of obesity among schoolboys and young men, linked to specific birth cohorts only<sup>4–6</sup>, whereas data from men aged 30, 40, 50 and 60 years showed more modest trends<sup>2</sup>. However, all reported recent trends for Danes have been positive. On the other hand, exceptions showing no change or even a decrease in obesity prevalence have also been demonstrated in some population groups<sup>7–9</sup>. In Norway, while

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the obesity prevalence rate increased for large and representative groups of men aged 40–42 years, the prevalence in women of similar age decreased between the late 1960s and the early 1980s<sup>7</sup>. Also, 30–59-year-old Finnish women, but not men, examined at the National Public Health Institute, displayed decreasing obesity prevalence between 1972 and 1982, but after 1982 this trend was again reversed<sup>8</sup>. Similarly, Swedish women aged either 38 or 50 years displayed no increase in obesity prevalence between 1968 and 1992<sup>9</sup>, whereas other Swedish studies found increasing trends for both men and women<sup>10</sup>. Thus the pattern of the so-called epidemic may show both overall and local heterogeneity. However, the Danish population is thought to be fairly homogeneous and stable, with a relatively low ethnic admixture<sup>11</sup>, and hence large heterogeneity may not be present. Therefore the purpose of the present study was to examine secular changes in general, and by birth cohort and age, in the prevalence of obesity and median body mass index (BMI) in a large sample of Danish men and women aged 20–84 years. All were residents of the greater Copenhagen area, who had their heights and weights measured between 1964 and 1994.

### Populations and methods

The database of the Copenhagen Centre for Prospective Population Studies<sup>12</sup> includes information from three major population-based surveys in Copenhagen and its suburbs: The Copenhagen City Heart Study, The Glostrup Population Studies of The Research Centre for Prevention and Health, and The Copenhagen Male Study.

Participants from The Copenhagen City Heart Study<sup>13</sup> were randomly drawn from the Copenhagen Population Register among people living within 10 wards surrounding Rigshospitalet, one of the University Hospitals of Copenhagen. The sample was age-stratified within the entire range from 20 to 94 years of age. The first examination in The Copenhagen City Heart Study took place in 1976–1978. A total of 19 329 men and women above 20 years of age were invited, and 14 223 participated (response rate, 74%). Five years later, in 1981–1983, 11 135 of those attending the first examination were re-examined, whereas 1097 had died, 32 had emigrated and 1959 were non-responders (overall attrition rate, 22%). In 1991–1994 the cohort was re-examined and expanded by 1937 participants (3000 subjects invited) in the youngest age strata, 20–50 years old.

Participants from The Glostrup Population Studies<sup>14</sup> comprised men and women born in 1897, 1914 and 1936 who were examined in 1967, 1964 and 1976 as 70, 50 and 40 years old, respectively. As a part of the MONICA I surveys (MONItoring of trends and determinants in CArdiovascular diseases), 30-, 40-, 50- and 60-year-old men and women were examined in 1982–1983. Subjects

were selected at random among the people living in the Western part of greater Copenhagen County. Re-examination of the '1897' cohort took place 15 years later, and of the MONICA I cohort 5 and 11 years after the first examination. In total, 8210 were invited and 6631 attended at least one of these examinations (response rate, 81%). Subsequently, 4964 subjects attended at least one re-examination, whereas 436 had died before the re-examination, 14 had emigrated and 1217 were non-responders (overall attrition rate, 25%). The Glostrup Population Studies also include the MONICA II and MONICA III surveys, which were both cross-sectional. MONICA II (1986–1987) included 748 men (response rate, 78%) and 756 women (response rate, 76%) aged 30, 40, 50 and 60 years. MONICA III (1991–1992) included 1010 men (response rate, 70%) and 1017 women (response rate, 70%) aged 30, 40, 50, 60 and 70 years.

Finally, participants from The Copenhagen Male Study<sup>15</sup> comprised a total of 5246 male employees in the age group 40–59 years working in some selected companies and participating in the first study in 1970–1971 (response rate, 83%). Survivors were invited for re-examination in 1971–1972, 1976 and 1985–1986, and 4818, 4074 and 3355 men were examined, respectively.

For all persons (62 685 observations), BMI (weight/height<sup>2</sup>), date of birth, gender, age and date of investigation were extracted. Subsequently, data were stratified into seven 10-year age strata (20–24, 25–34, 35–44, etc. to 75–84 years) and eight 10-year birth year strata (1895–1904, 1905–1914, 1915–1924, etc. to 1965–1974). The majority of the participants had been examined more than once, with approximately 3–10 years between the measurements. Requiring that each person can appear only once in each age group resulted in a total of 54 401 observations from 30 482 different persons: 17 065 men (30 336 observations) and 13 417 women (24 065 observations). In subsequent analyses data were stratified into 13 5-year age strata (20–24, 25–29, 30–34, etc. to 80–84 years) and 17 strata for each five birth years (1890–1894, 1895–1899, 1900–1904; etc. to 1970–1974). These results were essentially similar to the analysis based on 10-year groups, and the data are therefore not shown.

### Statistical analysis

Trends in general prevalence were calculated for men and women separately and for five examination periods (1964–1975, 1976–1980, 1981–1984, 1985–1990 and 1991–1994). To adjust for the different age distributions of the study sample during the examination periods, a direct standardisation to the general Danish age distribution in 1990 was applied and age was restricted to the 25–75-year-olds.

For each combination of age (age group), year of birth (birth cohort) and gender, the median BMI and the

prevalence of obesity ( $\text{BMI} \geq 30 \text{ kg m}^{-2}$ ) were calculated within each 10-year birth cohort and 10-year age group.

Trends in BMI of the birth cohorts of given gender and age were assessed by linear regression, with birth cohort as independent variable. Logistic regression was used in order to similarly assess trends in the prevalence of obesity. Deviation from straight linearity was deliberately ignored, since the purpose of the analysis was to obtain an overall indicator for trend.

## Results

### General trends

Table 1 gives the number and age distribution of the men and women in the various sub-populations.

Figure 1 shows the prevalence of obesity among men and women. Trends were positive, but irregular. Since the curves were created after age-standardising the data from the 25–75-year-old men and women, the pattern of an overall increase is not dependent on differences in the age distribution at the different times. In men the increase occurred in two phases, in the 1970s and the 1990s, with a stable period in between. In women, the prevalence was stable until the 1990s, when an increase occurred similar to that in men. The prevalence was slightly higher in men than in women, except in the first examination period.

### Secular changes in median BMI

Figures 2 and 3 give the median BMI for men and women, respectively, by 10-year birth cohort. Each line represents the secular changes for same-aged individuals, using the 10-year age groups. There was little indication of a trend with birth cohort in median BMI for women, but for men median BMI was increasing with cohort in all age groups except in those younger than 45 years.

Table 2 gives regression coefficients for median BMI and obesity prevalence, the number of subjects participating and the range in number of participants from each birth cohort, by age. In women none of these regression lines had a slope significantly different from zero. For median BMI the trend was negative for 35-, 45- and 65-year-old women and positive for 20-, 25- and 55-year-old women. In contrast, there was a significant increasing trend for all men aged 45 years and older, and all estimated slopes

for median BMI were positive, except for the 25- and 35-year-old men.

### Secular changes in prevalence of obesity

Figures 4 and 5 show the prevalence of obesity for men and women, respectively, by 10-year birth cohort. Each line represents the secular changes for same-aged individuals, using 10-year age groups. There was little indication of a trend in obesity prevalence for women, except for the 55-year-olds in whom the prevalence was increasing significantly. For men, the prevalence was increasing in all age groups, and for men aged 35–74 years the increase was statistically significant.

For obesity prevalence, in general, none of the regression lines for women had a slope significantly different from zero (Table 2). The trend was negative for the 20-, 35-, 45- and the 65-year-old women, and positive for the 25- and 55-year-olds. For men trends were all positive, and significantly so for the men aged 35 years and older, except the very old (75-year-olds).

## Discussion

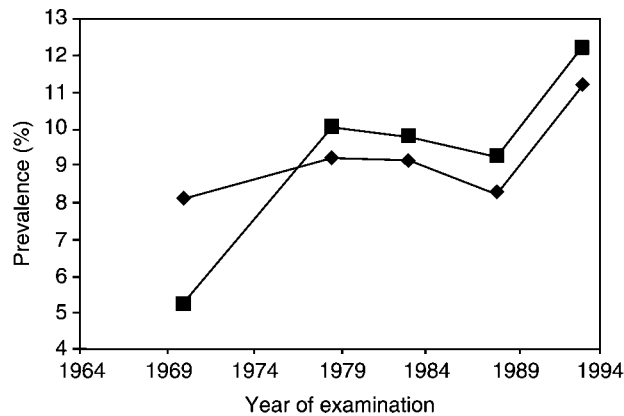
The present study of time changes in the prevalence of obesity and median BMI in a large sample of adult Danes has shown that the trend for obesity is not generally positive and uniform, but rather reveals a great heterogeneity for men and women of different ages and birth cohorts in the period between the mid-1960s and the mid-1990s.

The data showed that the trends for obesity were generally positive, although irregular, when all adult men and women aged 25–75 years were included in a pooled but age-standardised analysis. However, further gender- and age-specific analyses displayed an increasing obesity problem for men at certain, but not all, birth cohorts and age groups. In most age groups among women the occurrence of obesity was stable or declining. Hence, a general obesity epidemic was not apparent from the age-stratified data, except in these well-defined groups of men aged 45 years or older, born between 1915 and 1924.

This general heterogeneity for men of different ages, and in men compared with women, is of great potential interest to public health and may add to our understanding of the determinants behind the obesity epidemic,

**Table 1** Number and percentage of subjects in the various cohorts by age group

Cohort	Age (years)														Total <i>n</i>
	20–24		25–34		35–44		45–54		55–64		65–74		75–85		
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Copenhagen City Heart Study	600	2.0	1853	6.0	4323	14.1	7037	22.9	8792	28.7	6733	22.0	1334	4.4	30 672
Copenhagen Male Study	0	–	0	–	1494	17.6	2972	35.0	2928	34.5	1097	12.9	0	–	8491
Glostrup Population Study	0	–	1732	11.4	3621	23.8	3821	25.1	3111	20.4	2728	17.9	225	1.5	15 238
Total	600	1.1	3585	6.9	9438	18.1	13 830	25.4	14 831	27.3	10 558	26.5	1559	2.9	54 401



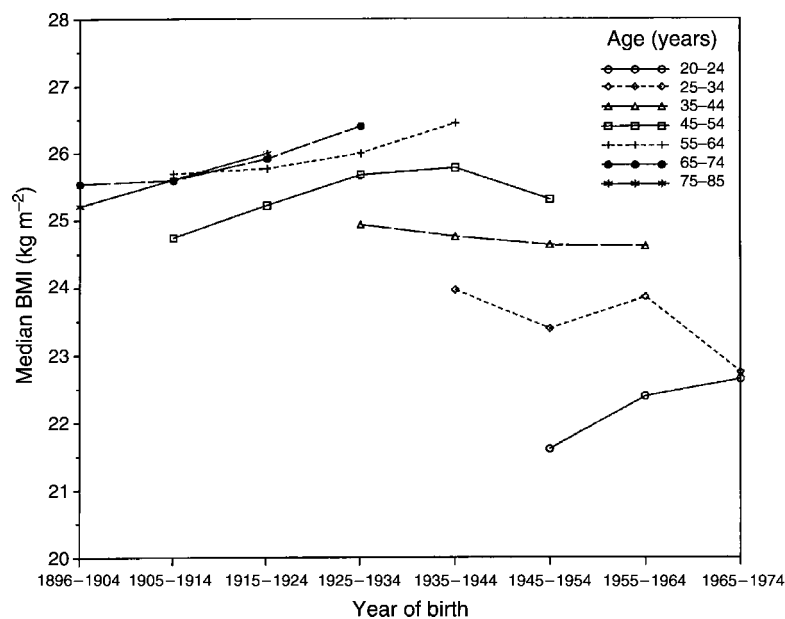
**Fig. 1** Prevalence of obesity (body mass index  $\geq 30 \text{ kg m}^{-2}$ ) among all men (■) and women (◆) aged 25–75 years in the period between 1964 and 1994, age-standardised to the Danish population in 1990

provided the conditions responsible can be identified. Indeed, heterogeneity may develop from previous or concurrent lifestyle changes in some but not other sub-populations, or from different responses by sub-populations to lifestyle changes. For instance, some but not other sub-populations may be genetically susceptible, or pre-programmed through pre- and/or postnatal conditions, to later obesity development, in response to a changing environment.

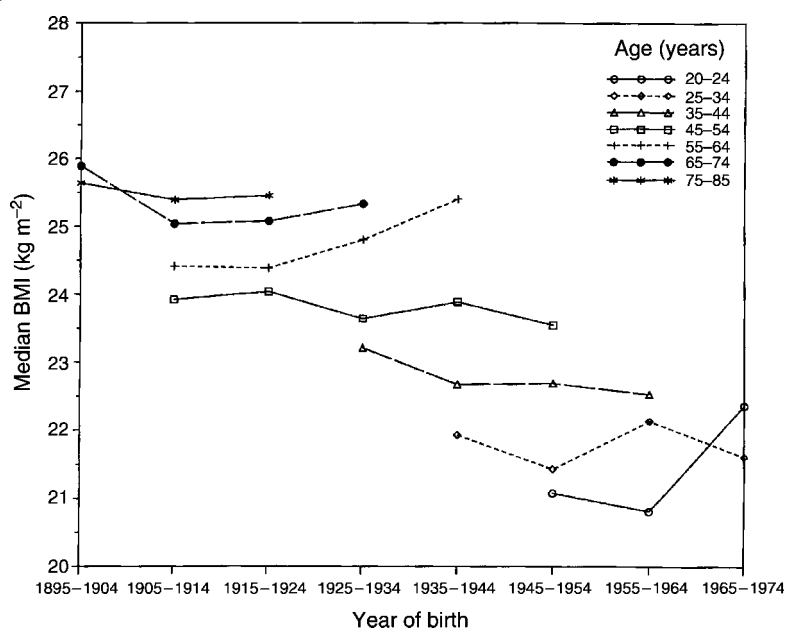
The present study did not address any of these issues, but examined the obesity trends among the different age and birth cohorts in the population sample. The results showing large heterogeneity raise the question of whether the general obesity trends reported for Denmark are valid. For instance, it is apparent from the present analyses that the underlying trends related to age-dependent effects are

fundamental and important for the general overall trends, and that these overall trends may not therefore be valid. It should be mentioned that we do not know if the trends observed among Danes residing in greater Copenhagen can be generalised to the total population of adult Danes. Indeed, no nation-wide data on adult BMI, based on measured heights and weights, are currently available for comparison. Self-reported national figures are, as shown in many other studies, much lower than those reported here<sup>3</sup>. Furthermore, in studies where information on obesity is based on self-reports of height and weight, bias in reporting may vary with time, or may even be dependent on the underlying obesity prevalence. This would not be of significance to the present study. On the other hand, a low or changing participation rate, as seen in many studies, may also invalidate trend analyses because sub-sets may be different from the background population they were sampled from. In particular, earlier studies have demonstrated that participation in health examination surveys declines with increasing degree of obesity<sup>16</sup>. The present study, however, showed high overall response rates of 70–90% between gender, age and birth cohorts, and differentiated response rates may not be a problem. Also, the limited change with respect to ethnic admixture during this time period is an advantage of this study<sup>11</sup>.

The generally stable or declining obesity occurrence among most groups of women was surprising, particularly in view of several recent reports suggesting that the obesity epidemic is occurring in both men and women<sup>1</sup>. However, the fact that similar findings for women have been made in Norway, Finland and Sweden<sup>7–9</sup> suggest some possible common conditions responsible for the Nordic women.



**Fig. 2** Median body mass index (BMI) of men by birth cohort for seven age groups. Each line shows the secular change in median BMI for groups of same-aged men between 1964 and 1994



**Fig. 3** Median body mass index (BMI) of women by birth cohort for seven age groups. Each line shows the secular change in median BMI for groups of same-aged women between 1964 and 1994

**Table 2** Linear regression of median body mass index (BMI) and prevalence of obesity (BMI  $\geq$  30 kg m<sup>-2</sup>) on birth cohort, for each age group: estimated slope with 95% confidence interval (CI). Within each of the gender and age groups are given the number of subjects and range of number of subjects in each birth cohort

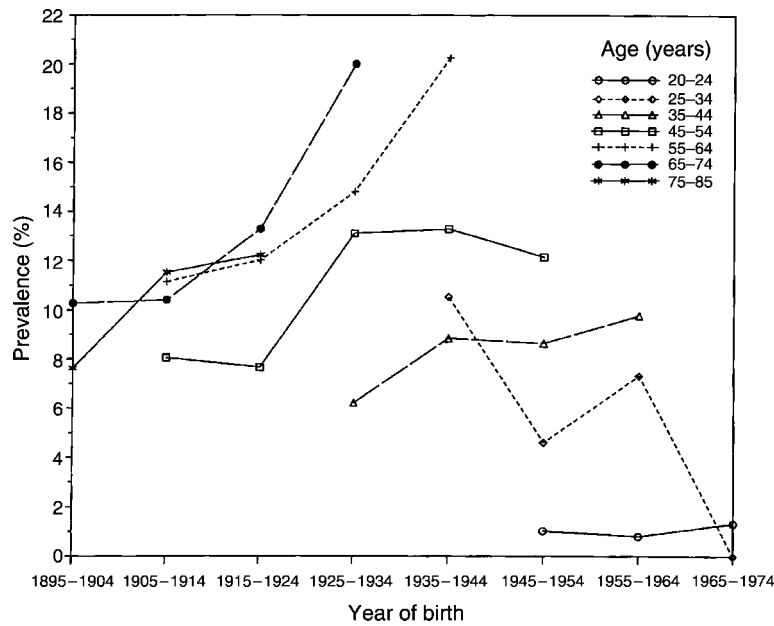
	Median BMI Slope (95% CI)	Prevalence of obesity Slope (95% CI)	n (range of birth cohort size)
<b>Females</b>			
20–24 years	0.53 (–2.12, 3.18)	–0.05 (–1.17, 1.07)	307 (62–140)
25–34 years	0.24 (–0.66, 1.14)	0.16 (–0.17, 0.47)	1850 (105–863)
35–44 years	–0.16 (–0.55, 0.23)	–0.10 (–0.26, 0.06)	4094 (189–432)
45–54 years	–0.05 (–0.31, 0.22)	–0.02 (–0.11, 0.07)	5481 (200–2383)
55–64 years	0.33 (–0.05, 0.71)	0.16 (0.07, 0.25)	6371 (374–3158)
65–74 years	–0.07 (–0.69, 0.55)	–0.06 (–0.17, 0.04)	4598 (301–2088)
75–85 years	–0.09 (–0.55, 0.38)	0.06 (–0.14, 0.25)	1364 (319–679)
<b>Males</b>			
20–24 years	0.53 (–0.20, 1.26)	0.12 (–1.37, 1.62)	293 (75–122)
25–34 years	–0.01 (–1.01, 1.03)	0.13 (–0.21, 0.48)	1735 (93–824)
35–44 years	–0.14 (–0.21, –0.07)	0.17 (0.05, 0.28)	5344 (174–2024)
45–54 years	0.26 (0.00, 0.53)	0.24 (0.17, 0.32)	8350 (214–3066)
55–64 years	0.20 (0.01, 0.38)	0.21 (0.13, 0.29)	8460 (316–3648)
65–74 years	0.30 (0.07, 0.53)	0.29 (0.17, 0.40)	5068 (330–2409)
75–85 years	0.39 (0.38, 0.40)	0.25 (–0.03, 0.54)	1086 (221–590)

However, the trends for most of the common risk factors, like diet, smoking, physical activity and parity, are not necessarily of similar direction in the four Nordic countries. Food disappearance data in general support individual consumption data<sup>17–21</sup> and show that fat intake declined in Norway from the mid-1970s<sup>17,19</sup>, while in Denmark it increased until the late 1980s and dropped thereafter<sup>17,18,21</sup>. In Finland and Sweden declines were apparent from the early and mid-1980s, respectively<sup>17,20</sup>.

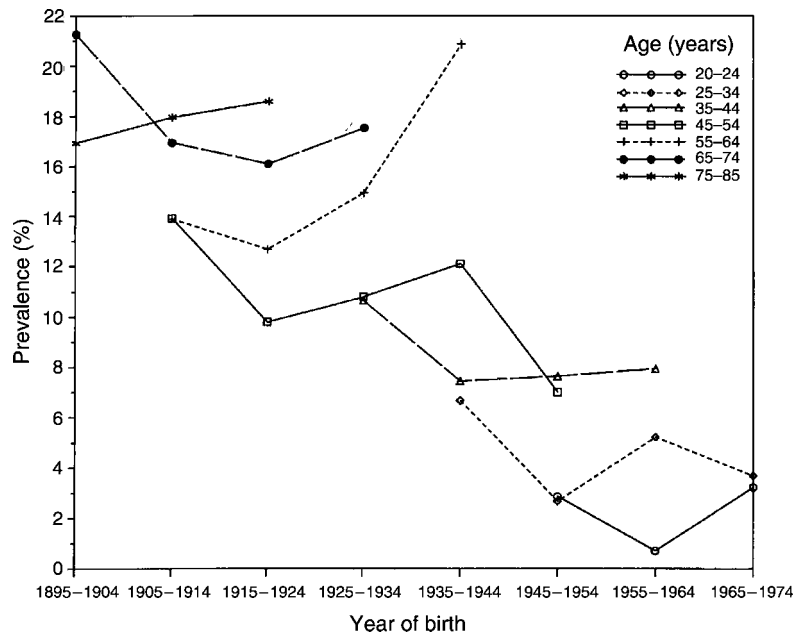
The proportion of women who smoke has been fairly high (around 40% of women) and stable in Denmark from the beginning of the 1950s to the 1990s<sup>22,23</sup>. Trends for

smoking among Finnish and Norwegian women have also been stable, but at a much lower prevalence (around 15 and 30% for Finnish<sup>24</sup> and Norwegian<sup>25</sup> women, respectively). Swedish women have reduced smoking since the beginning of the 1980s, and among middle-aged women about 20% smoke<sup>26,27</sup>.

Fertility rates were fairly low in Scandinavia 20–30 years ago but comparable to figures seen in other European countries, such as England<sup>17,28</sup>, where the prevalence of obesity in women has increased dramatically<sup>29</sup>. Data on physical activity trends are generally insufficient or lacking, and it cannot be excluded that trends for



**Fig. 4** Prevalence of obesity (body mass index  $\geq 30 \text{ kg m}^{-2}$ ) among men by birth cohort for seven age groups. Each line shows the secular change in obesity for groups of same-aged men between 1964 and 1994



**Fig. 5** Prevalence of obesity (body mass index  $\geq 30 \text{ kg m}^{-2}$ ) among women by birth cohort for seven age groups. Each line shows the secular change in obesity for groups of same-aged women between 1964 and 1994

Scandinavian middle-aged women are different from trends for middle-aged women elsewhere. However, indirect measures of inactivity, such as the number of cars and televisions, would suggest that inactivity is likely to have increased in the Nordic area like it has, for example, in the UK<sup>29</sup>. Thus, the identification of trends in the presumed and common risk factors for obesity may not provide sufficient explanations for the obesity trend pattern in Nordic countries. Moreover, such general

lifestyle trends would be expected to have had similar associations with obesity in men and women. However, in none of the four Nordic countries were trends for obesity prevalence rates declining in men, and in particular not in the middle-aged and older men<sup>1,7-9</sup>.

Differences in socio-economic conditions between Nordic women, and women elsewhere, may provide one explanation for the stable or declining occurrence of obesity in the Nordic area. One such condition may be the



participation of females in the labour force and the increase in the proportion of women entering the labour force in the Nordic countries, which was generally larger than in the rest of the Western world during the period between the mid-1960s and the mid-1990s<sup>30</sup>. Obesity carries a socio-economic disadvantage that seems to be particularly prevalent for women<sup>31</sup>. For example, obese women may face job discrimination<sup>32</sup> or lower income than thin women of similar socio-economic status<sup>33</sup>. Hence, the social pressure to stay thin, in relation to getting and keeping jobs and salaries, seems far greater among women than among men<sup>34–36</sup>.

In addition, some but not all studies have indicated that breast-feeding is associated with obesity<sup>37</sup>. Hence, differences in breast-feeding habits between Nordic and other women may be of importance, because some of the world's highest prevalences of breast-feeding are found among Nordic women<sup>38</sup>.

Finally, it cannot be excluded that middle-aged Nordic women previously experienced trends of weight gain, and that the present declining trends observed between the 1960s and the 1990s may be regression towards the mean. However, reliable trend data for middle-aged Nordic women obtained earlier are not available.

The fact that the trends for median BMI and obesity prevalence were discordant in many of the age–gender groups may be surprising given the strong relationship between the two measures reported from other populations. In fact, Rose<sup>39</sup> previously demonstrated that variations in the distribution of BMI could be predicted from the population mean BMI. However, this may not hold true for all populations<sup>4–6</sup>. For instance, while median BMI was constant among Danish draftees, an almost 10-fold increase in BMI above 31 kg m<sup>-2</sup> was found between 1960 and 1975<sup>4</sup>. Similarly, Danish data on schoolchildren showed increases in the upper percentiles of BMI but no change in the median of the population<sup>6</sup>. Hence, even associations between median BMI and obesity prevalence may display large heterogeneity.

In conclusion, trends for obesity apparent in the total population of adult Danes were irregular over time, differed between men and women, and did not translate into corresponding trends in all sub-populations. Great heterogeneity was found among different age and birth cohorts and in the relationship between median BMI and obesity prevalence, suggesting that the recent world-wide obesity epidemic does not seem to be occurring in this large subset of adult Danes. The expanding problem in middle-aged and older men of certain birth cohorts poses a specific public health problem. However, the fact that women at these ages, not only in Denmark but possibly also in other Nordic countries, may not be part of the present world-wide epidemic is of great potential interest, provided the conditions responsible for the declining or

stable occurrence can be identified. In general, a detailed search for the determinants of the various aspects of the heterogeneity of the obesity epidemic may provide clues to its causes, and hence to combating its further development.

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