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Thinness in the era of obesity: trends in children and adolescents in The Netherlands since 1980

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Background: Although children both at the upper and lower tail of the body mass index (BMI) distribution are at greater health risk, relatively little is known about the development of thinness prevalence rates in developed countries over time. We studied trends in childhood thinness and assessed changes in the BMI distribution since the onset of the obesity epidemic. **Methods:** Growth data from 54 814 children aged 2–18 years of Dutch, Turkish and Moroccan origin living in The Netherlands were used. Anthropometric measurements were performed during nationwide cross-sectional growth studies in 1980 (only Dutch), 1997 and 2009. Prevalence rates of thinness grades I, II and III were calculated according to international cut-offs. BMI distributions for 1980, 1997 and 2009 were compared. **Results:** Since 1980, thinness (all grades combined) reduced significantly from 14.0% to 9.8% in children of Dutch origin, but the proportion of extremely thin children (grade III) remained constant. Thinness in children of Moroccan origin decreased significantly from 8.8% to 6.2% between 1997 and 2009. No significant difference was observed in children of Turkish origin (5.4% in 1997 vs. 5.7% in 2009). Thinness occurred most often in children aged 2–5 years. There were no differences between boys and girls. The BMI distribution widened since 1980, mainly due to an upward shift of the upper centiles. **Conclusion:** Since the onset of the obesity epidemic, prevalence rates of thinness decreased. However, we found a small but persistent group of extremely thin children. More research is needed to gain insight into their health status.

Introduction

The last decades witnessed a rising trend in childhood overweight and obesity in many countries. Although children both at the upper and the lower tails of the body mass index (BMI) distribution are at greater health risk, relatively little is known about the prevalence rates of thinness over time. Thinness, i.e. low BMI for age, may have substantial consequences for child development, health and well-being. Thinness may reflect malnutrition and can result from poor feeding and eating practices or from underlying health conditions, such as coeliac disease or eating disorders.[1] Other health risks associated with (childhood) thinness include stunting, weakened or failing immune system, osteoporosis, anaemia and fertility problems later in life.[2–5]

Overweight and obesity have increased over the last decades, also in The Netherlands.[6] If the whole population experienced a similar upward shift in BMI, one would expect a reduction of the thinness prevalence. Alternatively, if only those who were already relatively heavy showed an upward shift, the thinness prevalence would remain stable. Finally, finding a higher prevalence rate of thinness would be counterintuitive in the current obesity era. Some have suggested, however, that programmes to prevent overweight and obesity in children may actually cause unintended harm.[7,8] A recent Dutch study found a negative body image and weight loss behaviour among a substantial proportion of normal weight children in primary and secondary schools.[9] This could manifest itself in a rising thinness prevalence. Each of these scenarios would have a different effect on the BMI distribution of the population; the distribution would move upwards as a whole in the first scenario, widen due to an upward shift at the upper end of the BMI distribution in the second scenario and widen as a result of upward and downward shifts of respectively, the upper and lower end of the BMI distribution in the third scenario.

Data on trends of thinness rates in developed countries are scarce, especially for severe grades of thinness. We hypothesized that thinness prevalence rates could be linked to overweight and obesity figures. Children of Turkish and Moroccan origin, the two main immigrant groups in The Netherlands, were found to be substantially shorter and more often overweight and obese than their peers of Dutch origin.[10–12] Therefore, comparison of thinness rates across ethnicity is of interest. The Dutch growth studies offer a unique opportunity to study thinness rates and its trend, covering also the time period before the worldwide obesity epidemic.

Our aims were to (i) study trends in thinness in The Netherlands among children of Dutch origin since 1980; (ii) study trends in thinness among children of Turkish and Moroccan origin since 1997 and (iii) assess how the BMI distribution has changed in the light of the obesity epidemic.

Methods

Data sources

Cross-sectional growth data of children aged 2–18 years of Dutch, Turkish and Moroccan origin were extracted from the 1980 (only Dutch origin), 1997 and 2009 Dutch Growth Studies. Measurements were performed across the country. The 1980 dataset was larger than the datasets in 1997 and 2009; with the knowledge from previous Dutch growth studies in 1955, 1965 and 1980 about the general shape of growth curves and expected variation within the population, it was calculated that smaller sample sizes (fewer

children per age group and fewer age groups) were needed in 1997 and 2009. The methodologies for the growth studies in 1997 and 2009 were similar. The study samples were stratified by age, sex, geographical region and educational level of the child. The distribution of geographical region and indicators for socio-economic status (SES) [parental occupation (1980) and educational level of the child (1997 and 2009)] of the three samples of children of Dutch origin were compared with national population distributions at the time of the studies to check for representativeness. All three samples were considered representative for the entire population of children of Dutch origin in The Netherlands. To obtain sufficient children of Turkish and Moroccan origin, we oversampled children from the four major cities (Amsterdam, Rotterdam, The Hague and Utrecht), where most children of Turkish and Moroccan origin in The Netherlands live. Details on the methodologies have been published before.[6,13,14]

Data collection for growth studies is one of the tasks of youth health care in the Netherlands. For these growth studies, written consent was not needed. Data were analysed anonymously. Before measurement, consent was obtained for each child. The study and the way consent was obtained were approved by the Medical Ethical Review Board of Leiden University Medical Centre.

Measurements

All anthropometric measurements were standardized and performed by trained healthcare professionals. Height was measured to the nearest 0.1 cm. Children were weighed, wearing underwear only, on calibrated mechanical or electronic step scales. Weight was rounded to the nearest 0.1 kg. A questionnaire, filled in by a health care professional, was used to collect demographic variables.

Variable definitions

Ethnic origin was defined according to the country of birth of the parents. Dutch: if both parents were born in The Netherlands; Turkish: if mother was born in Turkey, or if mother was born in The Netherlands and father was born in Turkey; Moroccan: if mother was born in Morocco, or if mother was born in The Netherlands and father was born in Morocco. BMI was calculated as weight (kg)/height^2 (m^2). For 1997 and 2009, SES was classified according to the highest educational level of the parents (low/middle/high). For 1980, no data on the educational level of the parents was available. When comparing SES across time, we used the 'highest' occupation of the parents in 1980 as a proxy for educational level. Occupation of the parents was coded into low/middle/high according to the prestige of the occupation. This classification was assessed by Statistics Netherlands.[15]

Exclusion criteria

Exclusion criteria were similar in all three Dutch Growth Studies. Children with diagnosed growth disorders and those on medication known to interfere with growth were excluded. As there are no international BMI cut-off values for thinness for children aged <2 years, these children were excluded. Children with an ethnic origin other than Dutch, Turkish or Moroccan were also excluded.

Statistical analysis

We used the age- and sex-specific cut-offs for thinness grades I, II and III as proposed by Cole and Lobstein,[16] which correspond to the following BMI ranges at the age of 18 years: 17.0–18.5 kg/m^2 (thinness grade I), 16.0–17.0 kg/m^2 (thinness grade II) and <16.0 kg/m^2 (thinness grade III). Each child was categorized as thinness grade I, grade II, grade III or no thinness. Thinness categories were exclusive, so, for example, the prevalence of thinness grade I did not include thinness grades II and III. Differences in the prevalence of thinness between groups and across time were tested using logistic regression analyses, correcting for age (in years), age squared (to include a potential U-shaped relation) and sex. *P*-values <0.05 (two-sided) were considered statistically significant. For the comparison of BMI distributions between 1980, 1997 and 2009, previously published BMI distributions were used.[6,13,14] Statistical analyses were performed in IBM SPSS Statistics version 20.0 for Windows and Microsoft Excel 2010 (version 14).

Results

Study population

In total, BMI data of 54 814 children aged 2–18 years were available. Table 1 presents the number of children per ethnic group and per study year. SES increased across the years. In 1980, the SES of 55% of the children of Dutch origin was classified as low, compared with 36% in 1997 and 18% in 2009. In children of Turkish origin, the

Table 1 Baseline characteristics of the study participants per ethnic group and study year

	Dutch			Turkish		Moroccan	
	1980 *n* (%)	1997 *n* (%)	2009 *n* (%)	1997 *n* (%)	2009 *n* (%)	1997 *n* (%)	2009 *n* (%)
Sex							
Boys	15 372 (51)	4995 (52)	3125 (47)	1119 (52)	1079 (51)	1076 (51)	1060 (49)
Girls	14 648 (49)	4633 (48)	3495 (53)	1024 (47)	1036 (49)	1053 (49)	1099 (51)
Age (years)							
2–5	9690 (32)	1940 (20)	1574 (24)	350 (16)	1044 (49)	366 (17)	929 (43)
6–11	9220 (31)	2728 (28)	2476 (37)	799 (37)	572 (27)	774 (36)	774 (36)
12–18	11 110 (37)	4959 (52)	2570 (39)	994 (46)	499 (24)	989 (47)	456 (21)
SES							
Low	15 235 (55)	3264 (36)	1039 (18)	1733 (90)	379 (58)	1821 (97)	355 (60)
Middle	10 334 (37)	2923 (32)	2141 (38)	165 (9)	184 (28)	43 (2)	148 (25)
High	2253 (8)	2849 (32)	2503 (44)	37 (2)	91 (14)	16 (1)	86 (15)
BMI (%)							
Overweight[a]							
Boys	4.6	8.7	12.3	23.5	32.3	15.6	24.5
Girls	7.1	11.5	14.7	29.4	31.1	23.2	28.2
Obesity							
Boys	0.3	0.9	1.7	5.0	8.5	3.0	5.6
Girls	0.5	1.5	2.2	6.8	7.8	5.1	7.1

a: including obesity

Table 2 Prevalence (percent) of thinness grades for Dutch boys and girls per age group in 2009

	Dutch boys				Dutch girls				Total			
	Thinness grade				Thinness grade				Thinness grade			
Age (years)	Total	I	II	III	Total	I	II	III	Total	I	II	III
2–5	13.0	11.3	1.3	0.37	12.5	9.9	1.9	0.79	12.8	10.6	1.6	0.58
6–11	7.5	6.8	0.6	0.14	8.2	6.7	1.2	0.35	7.9	6.7	0.9	0.24
12–18	9.1	7.8	1.0	0.30	10.4	8.8	1.2	0.38	9.8	8.3	1.1	0.34
Total	9.5	8.3	0.9	0.26	10.1	8.3	1.4	0.47	9.8	8.3	1.2	0.36

percentage of low SES decreased from 90% in 1997 to 58% in 2009 and in those of Moroccan origin from 97% to 60%.

Thinness in 2009 in children of Dutch origin

In 2009, the prevalence of thinness (all grades combined) in children and adolescents of Dutch origin aged 2–18 years was 9.8% (Table 2). There were no significant differences in the prevalence of thinness between boys and girls. Thinness occurred most often in children aged 2–5 years and least often in the age group of 6- to 11-year-olds. This was consistent across all grades of thinness. The prevalence of thinness in high SES children was 11.1% and 9.4% in low SES children, but these differences were not significant.

Thinness since 1980 in children of Dutch origin

Table 3 shows that between 1980 and 2009 there has been a downward trend in the prevalence of thinness grades I and II in both boys and girls of Dutch origin (both $P < 0.001$). This trend remained present after correction for SES. The prevalence of thinness grade III in boys and girls in 2009 was lower than in 1980, but this was not statistically significant.

Thinness in children of Turkish and Moroccan origin

In 2009, the prevalence of thinness (all grades combined) in children of Turkish and Moroccan origin was lower than in children of Dutch origin, also after correction for SES [5.7%; ($P < 0.01$), and 6.2% ($P < 0.05$) vs. 9.8%, respectively]. The thinness prevalence of children of Turkish origin did not differ significantly from that of Moroccan origin. There were no significant differences between boys and girls in any of the ethnic groups. The prevalence of thinness was significantly lower in 2009 compared with 1997 in children of Moroccan origin (−2.6%, $P = 0.002$), but not in those of Turkish origin (+0.3%, non-significant).

BMI distribution in 1980, 1997 and 2009

Figure 1 compares the BMI distributions of children of Dutch origin in 1980, 1997 and 2009. It shows that the BMI distribution has widened considerably since 1980, in both boys and girls. For example, in 18-year-old boys in 1980 the difference between +2 and −2 SD for BMI was 9.0 kg/m^2 (26.2 kg/m^2 to 17.2 kg/m^2). In 1997, this had expanded to 10.4 kg/m^2 and in 2009 it had grown to 12.6 kg/m^2, indicating that the BMI distribution for 18-year-old boys widened by >40% since 1980. In 18-year-old girls the BMI distribution in 1980 was already broader than in boys (10.5 kg/m^2), but had still increased by 16% in 2009 (12.2 kg/m^2). Figure 1 shows that while the 0 and +2 SD lines moved upwards substantially, no clear trend of the −2 SD line was observed since 1980.

Discussion

Thinness was present in about 10% of children and adolescents of Dutch origin in The Netherlands in 2009. Almost 2% was classified as having thinness grades II or III. Thinness was more prevalent in children <6 years. No significant differences were observed across levels of SES. Since 1980, the prevalence of thinness grades I and II decreased significantly, whereas there was no significant trend in the prevalence of extreme thinness (grade III). Over the same time period, prevalence rates of childhood overweight and obesity doubled or even tripled.[6] The BMI distribution in The Netherlands has thus widened over the period 1980–2009.[6,13,14] The increased spread in BMI is due to an upward shift of the upper SD lines, whereas at the same time a small group of constant size classified as thinness III keeps the lower SD lines in place.

Table 3 Prevalence (percent) of thinness grades for Dutch boys and girls aged 2–18 years in 1980, 1997 and 2009.

Thinness grade	Year	Dutch boys 2–18 years	Dutch girls 2–18 years	Total 2–18 years	Time trend total[a] OR (95% CI)[b]
Total	1980	13.5	14.5	14.0	1
	1997	12.4	11.1	11.8	0.84 (0.78–0.90)
	2009	9.5	10.1	9.8	0.70 (0.64;0.76)
I	1980	11.5	11.8	11.6	1
	1997	10.5	9.3	9.9	0.85 (0.79;0.92)
	2009	8.3	8.3	8.3	0.71 (0.64;0.78)
II	1980	1.6	2.1	1.9	1
	1997	1.7	1.4	1.5	0.80 (0.66;0.96)
	2009	0.92	1.4	1.2	0.66 (0.53;0.83)
III	1980	0.38	0.59	0.48	1
	1997	0.27	0.35	0.31	0.81 (0.55;1.15)
	2009	0.26	0.47	0.36	0.81 (0.54;1.23)

[a]Corrected for age, age squared and sex; [b]odds ratio (OR) with 95% confidence interval (CI).

The prevalence rates of thinness in children of Turkish and Moroccan origin were lower than in those of Dutch origin, also after correction for SES. Compared with 1997, thinness decreased in those of Moroccan origin, but not in those of Turkish origin. This is in line with the overweight and obesity prevalence rates in these groups, which were higher in children of Turkish and Moroccan origin compared with Dutch origin. Also, compared with 1997, overweight and obesity increased more in the Moroccan than in the Turkish group.[12]. However, while overweight and obesity in Turkish and Moroccan children tripled or quadrupled the prevalence in Dutch children, thinness prevalence rates in these groups were at most only half as high as in those of Dutch origin. This indicates that children of Turkish and Moroccan origin have a consistently higher BMI throughout the entire distribution.

The datasets used in this study are large and cover the period during which the obesity epidemic emerged. This allowed us to study the trend in thinness during this interesting period and to estimate prevalence rates for the more severe and rare grades of thinness. Even in these large studies, analyses concerning subsets of the sample may be underpowered due to the relatively small numbers. A lack of power could be the reason why the difference

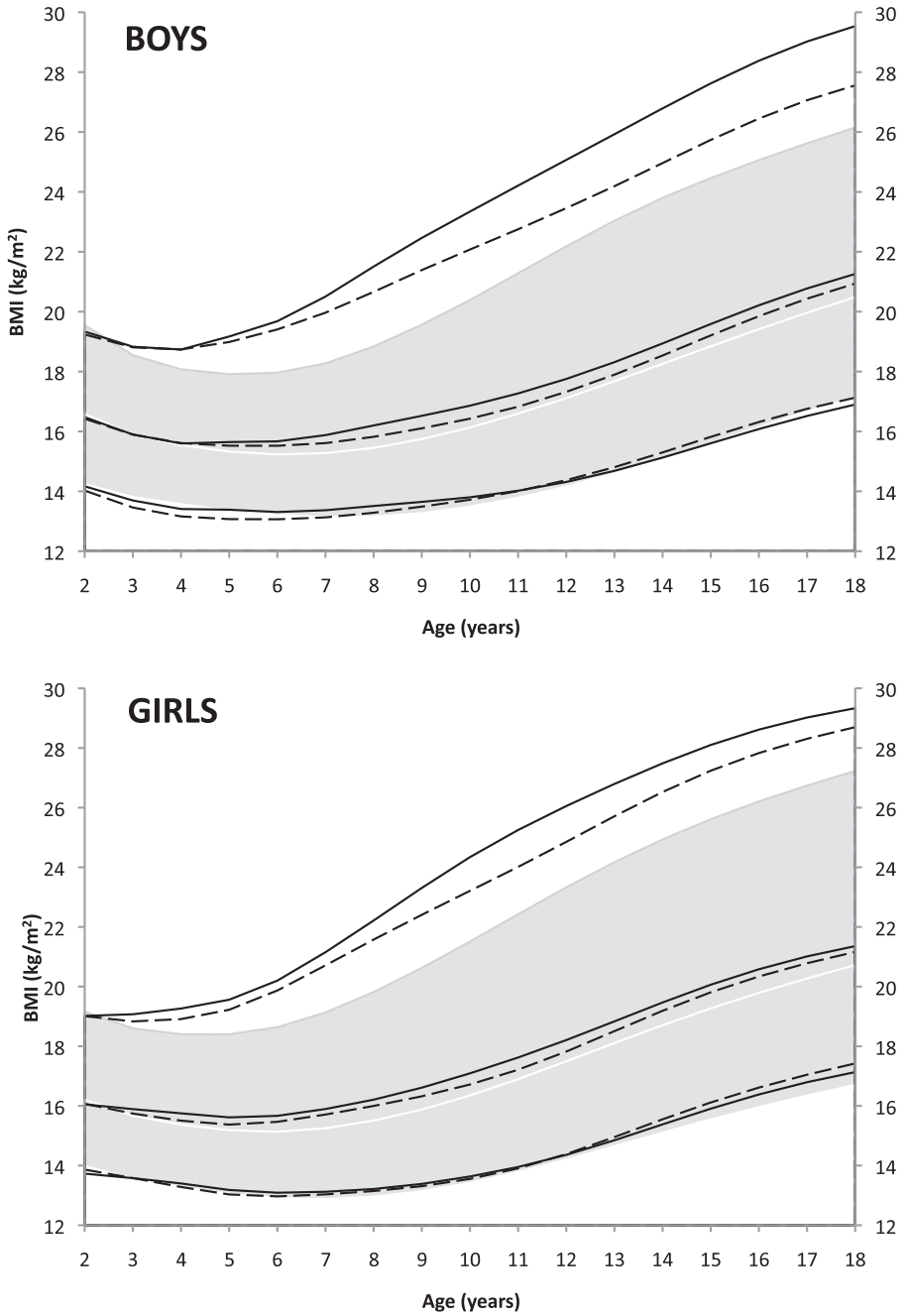

Figure 1 The −2, 0 and +2 BMI SD lines for boys (top) and girls (bottom) in 1980 (grey area, white line), 1997 (dotted lines) and 2009 (solid lines).[6,13,14]

in prevalence rates of thinness across SES was non-significant, and similarly for the difference in thinness grade III between 1980 and 1997 and 1980 and 2009. However, a decrease in the prevalence of thinness grade III since 1997 is unlikely to have occurred, as not even a non-significant downward trend was observed. Electronic health records for children were standardized in the year 2009, so we expect that future growth studies will be able to process larger samples using routinely collected data.

As stated in the method section, children with known growth disorders, or on medication known to interfere with growth were excluded. Some of these conditions, for example, coeliac disease, may be related to thinness. We therefore, cannot rule out a slight underestimation of the presented prevalence rates. As the exclusion criteria were the same across the study years, we do not expect this to affect the presented trends in thinness.

The downward trend we observed in thinness grade I is consistent with other studies in developed countries that use smaller age ranges and/or (slightly) different cut-offs to define thinness.[17–21] In the USA, the prevalence of thinness, defined as a BMI below the fifth percentile of the sex-specific BMI-for-age growth charts of the Centers for Disease Control and Prevention, has diminished from 5.3% to 3.5% since the early 1970s among 2- to 19-year-olds.[17] One study found a decrease of the thinness prevalence between 1994 and 2000 only in girls (aged 15–16 years).[23] Other studies found no statistically significant trends,[24–26] possibly due to small sample sizes or short time frames. A follow-up study in Gothenburg, Sweden, found an increase in the prevalence of underweight (all grades combined) in 18- to 19-year-olds between 1992–93 and 2008–09.[22] A large study in 6- to 16-year-olds in Australia and a large study in 5-year-olds in the UK showed stable prevalence rates of <2% for thinness grades II and III combined since 1985,[20,27] which does not match the decrease that we found in the prevalence of grade II thinness. Furthermore, in this study from the UK, a significant interaction was found between birth year and

SES. In our study, SES was not significantly associated with thinness in any of the study years and no significant interaction was found with SES and the year of study. On the other hand, the more important finding is that in both studies, like in ours, no rising prevalence rates were found, despite the concerns about the unintended effects of current obesity programmes. Of course, results for one country may not apply to another, but when taken together, the data contain no evidence for unwanted side effects of obesity prevention programmes.

The prevalence rates presented in this article were based on new international cut-offs, which were developed to enable comparison of thinness prevalence across countries and across time. According to these criteria, almost 10% of the Dutch youth is thin. Not all of these children are malnourished or need treatment. Cole *et al.*[28] proposed that 'a BMI of 17 at the age of 18 [thinness grade II] is a suitable cut-off to use as a basis for an international definition of thinness in children and adolescents'. In the Dutch growth charts, cut-offs for thinness grades II and III are displayed.[28,29] The choice for these lower cut-offs is supported by findings obtained by using the 2007 WHO growth reference for BMI-for-age for children aged 6–18 years.[30] Applying the −2 SD and −3 SD lines from this reference as cut-offs results in an even more stringent definition of thinness and severe thinness. Of the children classified as thinness grade II, 71% had a BMI below the −2 SD line of the WHO reference and none below the −3 SD line. Among those classified as thinness grade III, 100% had a BMI below the −2 SD line and 46% below the −3SD line of the WHO BMI-for-age reference. The Dutch growth charts, together with the professional's clinical view and the child's background information, can help to identify children at increased health risk. The growth charts can also be used to monitor the development of a child's BMI over time.

We found a decrease in thinness since the onset of the obesity epidemic in children of Dutch origin, which means that fewer children run health risks due to a low BMI for age. The prevalence of thinness in children of Moroccan origin was also lower in 2009 than in 1997, which was not the case in those of Turkish origin. The BMI distribution has broadened due to an upward shift at the high end of the BMI distribution (due to increased obesity), combined with the presence of a small, but persistent group of extremely thin children. Our research suggests that this is a small hard core group whose size is relatively constant and cannot be reduced further. More research is needed to gain insight into the health status of these children.

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Conflicts of interest: None declared.

Key points

- Thinness in children and adolescents is a serious health condition with substantial consequences for their development, health, and well-being.
- Some have raised concerns that current overweight and obesity programmes may cause unintended harm in normal weight and thin children.
- Despite the concerns about the unintended effects of current obesity prevention programmes, we found that prevalence rates of thinness did not rise since 1980.
- We found evidence for the existence of a small but persistent group of extremely thin children.
- More research is needed to gain insight into the health status of this group of extremely thin children.

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The development in body mass index, overweight and obesity in three regions in Denmark

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Background: The prevalence of overweight and obesity has increased markedly the past decades. However, recent studies have indicated that the development differ between different socio-economic groups and different geographic regions. The aim of this study was to assess the development in prevalence of overweight and obesity from 2006/2007 to 2010 by age, gender, socio-economic factors and geographical regions. **Methods:** Two cross-sectional surveys in three regions in Denmark (The Capital Region of Denmark, The Central Denmark Region and The North Denmark Region) were performed in 2006/2007 and 2010. A random sample of citizens aged more than or equal to 25 years was invited to participate. The overall response rate was 57.5% ($n = 177\,076$). Data from questionnaire and central registers were included. **Results:** In 2006/2007, the prevalence of overweight, including obesity, was 54.3% and 36.8% among men and women, respectively. Of the overweight men 12.8% were obese and 11.8% women were obese. The prevalence was highest in the Northern region and among those who were older, had short education, was outside labour market, had low income and residents in rural areas. In 2010, the prevalence of overweight had increased to 56.3% and 39.6% in men and women, respectively ($P < 0.0001$). However, overweight increased the most in the Northern Region whereas no significant increase in body mass index was found among men in the Capital Region. Among women prevalence of overweight increased but not in those retired or above 60 years, and with high income. **Conclusion:** The prevalence of overweight and obesity was high and increased. The development, however, was heterogenic.

Introduction

Overweight and obesity are major risk factors for mortality and morbidity from a number of chronic diseases, including diabetes, cardiovascular diseases, musculoskeletal disorders and some cancers,[1,2] causing approximately 3 million deaths per year worldwide.[1,3]

Since the 18th century there has been an increasing trend in height, weight and body mass index (BMI) in many OECD countries, associated largely by the economic growth. However, since 1980 the increase in weight and thus BMI has accelerated and in many countries the obesity rates have doubled or tripled.[4,5] Today 50% or more of the population in almost half of the OECD countries are overweight.

In Denmark, a similar increase in both overweight and obesity has been found.[5,6] Although a recent small Danish study has indicated stagnation in the increasing BMI, and has found that this stagnation might especially have occurred in the eastern part of the country.[7] New data from OECD Health Division also suggest that the obesity epidemic might have slowed down in several countries during the last few years.[8] These trends need to be confirmed and understood better, and might be very different between different countries.[4] Further, earlier studies have indicated that the longitudinal shifts in overweight and obesity might not be equal among different segments of society.[9–12]

Investigating differences in trends between different populations and population groups is important to improve understanding of the obesity epidemic and can be valuable in the future development of public health policy, obesity management and prevention. This also includes geographical differences within countries, as a different trend between different regions could indicate a role of the different