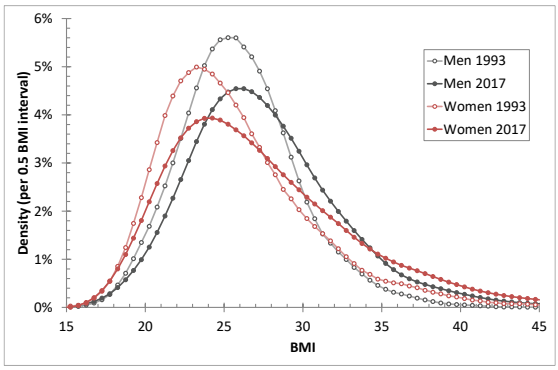
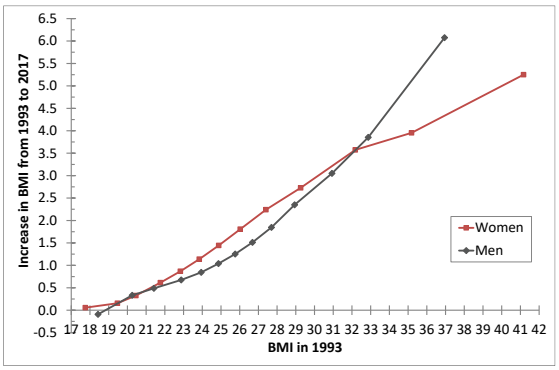
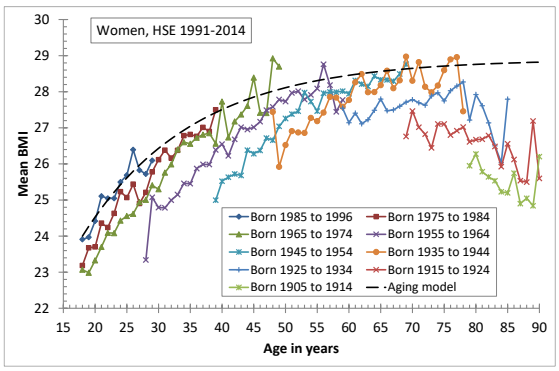
Lancaster University
Management School

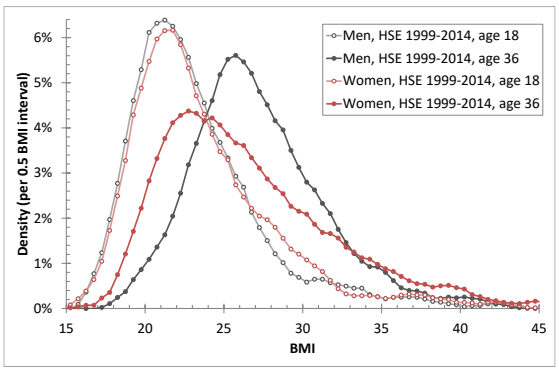
Appendices to the report: "The changes in BMI and obesity prevalence for adults in England since the early 1990s"

Roger J. Brooks









Appendices to the report: "The changes in BMI and obesity prevalence for adults in England since the early 1990s"

Roger J. Brooks

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About the author

Roger Brooks did a mathematics degree at Oxford University in the 1980s. He then worked as a Chartered Accountant before completing an MSc and a PhD in Operational Research at Birmingham University. After the PhD he worked for two years on the CLIVARA climate change and agriculture project at the Long Ashton Research Station in Bristol. From 1998 until 2021 he was a lecturer in the Department of Management Science at the Lancaster University Management School (LUMS). He is currently a visiting researcher in the Department of Management Science at LUMS.

Roger's general areas of research and expertise are data analytics and mathematical modelling. Past projects have included applications in health, sport, and business. His PhD and a lot of his subsequent research have been in computer simulation and he has co-authored a textbook with Professor Stewart Robinson on this topic. Other related research interests include agent-based modelling and complex adaptive systems. He has taught modules on simulation, spreadsheet modelling, operational research, statistics, accountancy, and project management. He has supervised several PhD students and many MSc summer projects, and has also carried out various consultancy assignments. Projects in the health area have included working with NHS England, the Department of Health, North West Air Ambulance, ScHARR, and hospital trusts.

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Introduction and numbering

This document is the supporting appendices to the main report called: “The changes in BMI and obesity prevalence for adults in England since the early 1990s” by Roger J. Brooks (Lancaster University Management School: Management Science Working Paper Series No. 2023:1).

The following pages contain the appendices. The appendices are numbered by the chapter in the main report that they relate to and then by capital Roman numerals. There are no appendices for Chapter 1. Hence the numbering starts for the appendices for Chapter 2 with these being 2.I, 2.II, 2.III, 2.IV. Chapter 3 has two appendices and so these are 3.I and 3.II. Similarly for the numbering of the appendices for the other chapters.

In the text in the appendices, references to chapters and sections mean the particular chapter or section in the main report.

Appendix 2.I HSE data analysis process

This appendix sets out the process that was used to extract the HSE data for each year and calculate some initial statistics. This data was then used for all the analysis set out in the chapters of the main report. For example, population BMI distributions were derived from groups of four years of HSE data, as explained in Chapter 3.

A general description of what was done is given in Section 2.2 of the main report. This appendix gives a more thorough description. This is intended to provide a detailed reference for what was done, to enable the analysis to be reproduced if desired, and to enable the work to be extended in future years by myself or by others through applying it to new HSE data as it becomes available. This appendix hopefully provides a clear guide for the procedure to follow.

A separate Excel spreadsheet was used for each different year. Some of the description here refers to the specific worksheet names used in the spreadsheet and the spreadsheet layout such as column names and colours. This is obviously only relevant for someone who is viewing the original spreadsheets.

Variables used

In the process that was used, the variables extracted from the HSE SPSS file into an Excel spreadsheet and used in the selection of valid BMI cases are:

- Sex
- Age
- BMI (SPSS field width widened to give more decimal places)
- bmiok (code for whether BMI is a valid value)
- BMIval (for 1997 onwards)
- BMIval2 (for 2012 onwards)
- Interview weight (this only exists for 2003 onwards and gives a non-response weighting for each case depending on demographics and other characteristics, discussed further on the next page)
- Sample type

Other variables were extracted to give additional information for possible further analysis (such as cases with a high weight value in Section 2.6 of the main report), and these are:

- Height and weight
- htok and wtok (codes for whether height and weight are valid values)
- Self reported weight values (WtSR)

The HSE year was also recorded in a column so as to keep track of the source for each case when several years data are combined in subsequent analysis.

The columns of data in the spreadsheet are therefore:
Year, Sex, Age, BMI, bmiok, BMIval, BMIval2, Height, htok, Weight, wtok, WtSR, Sample type, Interview weight. As explained above, only the later HSE years have the BMIval and BMIval2 variables.

For the specific analysis on deprivation categories in Chapter 15 the variable for this was also extracted, which is the quintile category for the “index of multiple deprivation” (QIMD).

Men and women

The BMI distributions are quite different for the populations of men and women. Therefore, all the analysis was done separately for the data for men and women. No combined statistics were calculated because the separate analysis is considered to be more meaningful.

Extracting annual data sets

Definition of valid cases

The aim here was to extract datasets for each year and for each sex that could be used in the subsequent analysis. The datasets need to consist of all valid cases. Valid cases are defined as those that meet all the following four criteria:

1. BMI value is valid, which means that either a. or b. below is true:
    a. BMIok = 1 (BMI is recorded and is defined as "valid")
    b. BMI = -1 (i.e., no BMI value recorded) and BMIval2 > 0 (for 2012 onwards) or BMIval > 0 (for 1997 – 2011). These are values that use an estimated weight, generally where the actual weight of the person exceeds the limit of the scales.
2. Age is 18 or over.
3. The case is from the main sample. Some years also have boost samples of people with specific characteristics. These are not sampled randomly from the population and so should not be included. As explained on the previous page, for 2003 onwards the HSE data has an interview weight variable. The interview weight values for the boost sample cases are all 0 and so these cases are excluded automatically by using the interview weight. For the years before 2003 the sample type variable is used to identify and exclude the boost sample. In many of the years the boost sample is for children and so they would be excluded anyway on the age criterion.
4. BMI ≥ 10. There are five cases in the HSE data used for 1991-2018 with extremely low BMI values of less than 10. These were excluded. These values are so low that they could be errors. Even if they are true values, they are very extreme values and the analysis here is not concerned with such extreme low BMI values. Hence it was decided to exclude them.

Weighting of each case

From 2003 onwards, the HSE data has various weighting values for each case (weight in this context referring to the amount of emphasis given to the case rather than the physical weight of the person). These are non-response variables designed to adjust for the effect of non-responses taking account of the demographics (Section 2.1.1 of the main report). The interview weight variable is the relevant one here since the BMI data is obtained from the HSE interviews rather than the nurse visit.

The data used here is just the valid BMI cases, as explained in the previous subsection. The case weighting used for each case was obtained by adjusting the interview weights so that the mean value for all the valid cases is 1 (Section 2.2.2 and Section 3.2 of the main report). Otherwise, the year would have more or less emphasis when several years are combined simply due to the mean case weight being different for each year. The adjustment was done simply by dividing each interview weight value by the mean weighting value for the valid cases for the year. Since the mean case weight equals 1, the total of the case weights equals the actual number of cases.

Prior to 2003 all cases just have a case weight of 1.

Spreadsheet process

The basic variables required for each case are age, BMI, and the case weight. The spreadsheet columns and the calculation process used to obtain the set of valid case values are as follows:

Data worksheet

The Data worksheet has columns of the data from the HSE SPSS file, as explained in "Variables used" subsection at the start of this appendix (in columns A to N where the data has both the BMIval and BMIval2 columns). The next column is a green shaded column, which is used to separate the data visually from the calculations. To the right of the green column, the worksheet has the following columns with calculations to extract the valid cases:

- BMIused. This has potentially useable BMI values. It has the HSE BMI value if BMIok = 1 ("valid"). If BMI = -1 and BMIval > 0 (for 1997 – 2011) or BMIval2 > 0 (for 2012 onwards), then the BMIval or BMIval2 value is selected by the cell formula. Otherwise the BMIused value is -1.
- wt18. This is a column of HSE interview weights for valid cases. This has the HSE interview weight value if BMIused ≥ 10 and age ≥ 18, and 0 otherwise. There are only five BMIused values that have an apparently valid BMI value of less than 10 and that are excluded as being extreme low values (as explained above). The original spreadsheet just has the condition that BMIused > 0, but this was adjusted to BMIused ≥ 10 in the spreadsheet if there are any values less than 10, which was checked in the Desc statistics worksheet.
- wt18 men and wt18 women. This just gives separate columns for the interview weights for men and women. Hence, for wt18 men the value is the wt18 value if the case is male and 0 otherwise. For wt18 women the value is the wt18 value if the case is female and 0 otherwise.
- std wt18 men and std wt18 women. This standardises the interview weights so that their mean is 1. The mean values of wt18 men and wt18 women are calculated in the "Data wts" worksheet. This is done by adding up the interview weight values and dividing by the number of values that are greater than 0. The standardised weight values for men, std wt18 men, are then the wt18 men values divided by the mean for men. Similarly, std wt18 women are the wt18 women values divided by the mean for women. These are then the final case weight values used in the analysis.
- wt16, wt16 men, wt16 women. These are the same calculations as for wt18, wt18 men, and wt18 women, except using BMIused > 0 and age ≥ 16. The purpose of these columns is to enable a check against the published Trend Table values, so as to give confidence that the correct data is being used (explained further in the "Comparison with Trend Table" subsection later in this appendix).

Note on the BMIok variable

The BMIok value is actually derived from variables for height and weight (htok and wtok) that indicate whether they are valid. BMIok is coded as valid in the HSE if both htok and wtok are coded as valid. The htok and wtok variables have other codes (2, 3, 4, 5 in recent HSE data sets) that represent "Not usable", "Refused", "Attempted but not obtained", "Not attempted". The last three of these imply that a measurement was not obtained and hence there is no BMI value given in the data. There are some cases where BMI is coded as "Not usable" because at least one of the height and weight variables is recorded as "Not usable". Some of these cases have a BMI value but these cases are not included in the analysis. I am not sure exactly what the circumstances are for these cases, but excluding them is consistent with the Trend Table values ("Comparison with Trend Table" subsection later in this appendix).

Data men and Data women worksheets

These worksheets contain the final data, which is then copied and used in the other analysis. The final data consists of four values for each case of: year, age, BMI, case weight. There are separate worksheets for the data for men and the data for women.

- Columns A – D. These are simply the values from the data worksheet that are needed to be extracted, so the formulae simply reference the relevant cells. These are year, age, BMI (BMIused), and the standardised interview weight (std wt18 men or std wt18 women).
- Columns F – I. The columns A – D are copied and the pasted as values (not formulae) into columns F to I. They are then sorted by interview weight value from large to small. All the zero interview weight cases at the bottom are then deleted. These columns are then the final set of values that are copied and used in the other analysis.
- As a check, the number of values, total case weight, mean, and standard deviation for the data in columns F – I are compared with the statistics calculated from the data on the Data worksheet so as to ensure that they are same.
- Columns R – U. These are just a copy of columns F – I sorted by BMI to allow a visual view of the way that the BMI values vary, particularly the extreme values. This data is not used in the analysis.

Statistics

Various descriptive statistics are calculated in the spreadsheets for the data for men and for women for each year. The values are summarised in the "Desc statistics" worksheet. Tables of the results for each year are given in Appendix 2.II. The statistics and calculations are as follows:

- Number of cases. Taken from the Data wts worksheet.
- Mean. Calculated directly from the data on the Data worksheet as the case weighted sum of the BMI values divided by the total case weight (= number of cases).
- Median. Cases here have a weighting and so this is the middle value by case weight when the cases are put in BMI order. This is defined as the case where the total weight of the cases before and the total weight of the cases after are both less than or equal to half the total case weight. If there are two cases satisfying this then the two BMI values are averaged - this is the usual median rule and will basically only happen before 2003, when all valid cases have a weight of 1, if there is an even number of cases. The calculation is done on the Median worksheet and requires some copying and sorting of the data.
- Standard deviation. Calculated using the case weights directly from the data on the Data worksheet. The usual sample version of the standard deviation formula is used.
- Skew. There are various formulae for skewness. The sample skewness calculation used is the moments version, which is a sample estimator of m_3 / σ^3 where m_3 is the third moment about the mean and σ is the standard deviation. This skewness version is sometimes denoted G1 and the equation used is $G1 = (n/(n-1)(n-2))\times(\sum w\times(B_i-m)^3)/s^3$, where w is the case weight, B_i are the BMI values, m is the mean, n is the sample size, s is the sample standard deviation. This is also the formula used for the SKEW function in Excel (although that applies for a set of data with no case weights).
- Category percentages. The total case weights are summed for each of the BMI categories and then the percentages calculated. This is done on the "Categories" worksheet using the data on the Data worksheet.

- Minimum and maximum BMI values. These are the minimum and maximum values for the valid cases used. The excluded cases with BMI < 10 are ignored. These are calculated using an Excel array formula, being the maximum and minimum BMIused values where the standard weight value (std wt18 men or std wt18 women) > 0.
- Number of BMI values less than 10. These are the number of valid BMI values less than 10 that are excluded. The number is counted from the original data using the criteria for valid cases (apart from the minimum value criterion).
- Percentage of high BMI cases, and percentage of cases with weight over 130 kg (see "High BMI and high weight values" subsection on page 8).

BMI data distribution shape and statistics

In order to see the shape of the BMI distribution for the data for the year, a data distribution is produced by calculating the percentages in each 0.5 BMI interval on the "BMI dist" worksheet. So as to be consistent with the BMI category definitions the intervals include the lower bound in the interval (e.g., 20.0 ≤ BMI < 20.5, 20.5 ≤ BMI < 21.0). The percentages are calculated simply by summing the case weights for each interval and then calculating the percentage compared to the total. The results are plotted in a scatter chart on the worksheet "Cht BMI".

Various statistics are calculated for the distribution data and are checked against the statistics for the actual data values. The category percentages and the total case weight should match exactly. The other statistics for the mean, median, standard deviation, and skewness use the mid-point of each interval and the percentage frequency. Hence, they are just approximations of the statistics for the actual data but they should be very close. They use population versions of the formulae although the effect of this rather than sample versions will be negligible. The median calculation uses linear interpolation within the interval containing the median. The comparison of the statistics provides a cross check of the data analysis particularly as alternative versions of the statistics formulae are used. An additional statistic calculated for the distribution data is the modal interval, although irregularities in the data makes this not particularly meaningful.

Putting the data into intervals provides some smoothing and so, to an extent, this makes the distribution a rough estimate or model of BMI for the population. However, there are considerable irregularities due to the data being a sample. The results are not included in the report as the focus of the work is on generating smoothed population distributions from four years of data, so as to use larger sample sizes and a smoothing method (main report Chapter 3).

Age profile and missing cases

The age profile of the data is calculated. This is partly to see what the age profile is and also how it is adjusted by the case weighting. In producing population BMI distributions a standard age profile is used, as explained in Section 3.3 of the main report.

The percentage of missing cases is calculated by age so as to see the relationship with age. Missing values are discussed in Section 2.4 of the main report, with some results also given in Appendix 2.III.

The calculations are on the "Age profile & missing cases" worksheet. The data is analysed by age in individual years from 18 to 90 (with 90 being 90+ since the 2014 HSE age values are categorised in this way). As usual, the data for men and for women is analysed separately. The spreadsheet calculations are:

- The total number of cases is counted for each age for the main data sample (i.e., ignoring any boost samples). This is the total number of cases that could provide a valid BMI value.
- The total number of cases actually used with valid BMI values is counted for each age.
- The number of pregnant cases is counted for women for each age. For the more recent years the pregnant cases are identified from a specific code in the bmiok variable. For earlier years there was no bmiok code for this but there was a pregnancy variable (just indicating whether the person is pregnant, usually called "pregnowb") which is used.
- The age profile for the unweighted data of the cases used is calculated using the data from the second bullet point. For each year of age this is the number of cases used for that age divided by the total number of cases used for all ages.
- The total of the case weights used is summed for each age.
- The age profile percentages of the weighted data of the cases used is calculated using the data from the previous bullet point. For each year of age this is the total case weight for the age divided by the total cases weights for all ages (= sample size of the total number of cases used).
- Missing cases. The percentage of missing cases for each age is calculated, taking account that a BMI value is not possible for pregnant cases, as: (total cases – used cases – pregnant cases) / (total cases – pregnant cases). The overall percentage of missing cases is calculated using the same equation for the total sample. These equations use the unweighted number of cases.
- The age profile percentages are plotted for the raw data, the case weighted data, and the population values for 2011-2014 (Section 3.3 of the main report). The charts are the worksheets "Cht age men" and "Cht age women". The comparison of the raw data and case weighted data shows the effects of the case weights which are designed to adjust for differences between the age profile of the sample and the population, as well as other demographics. In the generation of the population BMI distributions the 2011-2014 population age profile is used to adjust and standardise the data (Section 3.3 of the main report). For the years well before 2011 the HSE sample age profile will tend to be noticeably different because of the population age profile being shifted (e.g., peaks in the profile shift by one year as each year passes).
- Chart of missing cases. The worksheet "Cht missing" plots the percentage of missing cases by age for men and for women.

High BMI and high weight values

High BMI and high weight statistics are calculated. This is to enable analysis to see the trend and to see if there is any indication of an effect of changes at certain points in time in the weighing scales and the recording of high weight values (Sections 2.6 and 2.7 of the main report). The high BMI values are defined in this particular analysis as BMI values of 40 and over for men, and 45 and over for women. The high weight values are those over 130 kg, being the limit of the scales up until 2010. The calculations are:

- The number of high BMI values are counted for each age as both the actual number and the total case weight.
- The main statistic used (included on the "Desc statistics" worksheet) is the overall percentage of high BMI values. This is the sum of the high BMI case weights divided by the total sample size.
- The weight values are counted in intervals of 10 kg ($0 < \text{weight} \leq 10$, $10 < \text{weight} \leq 20$, etc.). This requires counting the weight used for all the valid BMI values. In most cases this is the measured value recorded in the HSE weight variable, but for a few high weight values where no measured weight is recorded it is the self-reported weight variable. The actual number of cases are counted and the total case weight is also summed.
- The main statistics used (and included on the "Desc statistics" worksheet) is the total percentage of weight over 130 kg by case weight (the sum of these case weights divided by the total sample size).

Comparison with Trend Table

As discussed in Section 2.5 of the main report, calculations were done to reproduce the "Trend Table" or "Data Table" statistics published on the NHS Digital website. This provides a check of the data being used and how it is extracted. Detailed results are given in Appendix 2.IV.

The Trend Table adult figures are for age 16 and over, and so the calculations for comparison need to use the data with age 16 or more in the HSE data. The Trend Table has values for all adults, men, and women and these are given for age categories and overall ("All men", "All women", "All adults"). Calculations are done in the spreadsheet to match the overall Trend Table values for all adults, all men, and all women. The calculations and comparisons are:

- The values used are BMI (BMIused variable, the same as in my analysis), and case weight variables. The case weight variables here are wt16, wt16 men, wt16 women, as explained on the "Spreadsheet process" subsection in this appendix on page 4. These are the equivalent of the wt18 variables except using age 16 and over and including all BMI values even those less than 10.
- The total case weights are summed for the BMI categories. The percentages are calculated for each category and compared with the Trend Table.
- The mean is calculated as the weighted sum of the BMI values divided by the total case weight. This is compared with the Trend Table value.
- The number of cases and total case weight are also compared with the Trend Table values.
- The Trend Table also has a "standard error of the mean" value. I was not able to reproduce this value, even when all the other values matched. I am not sure what formula was used for this.

Appendix 2.II HSE statistics for each year

This appendix gives the descriptive statistics for the HSE data for each year, as explained in the "Statistics" subsection in Appendix 2.I. Charts of some of the values are in Section 2.3 of the main report.

Table 2.II.1 Descriptive statistics for the HSE data for men.

	1991	1992	1993	1994	1995	1996	1997	1998
Number of cases	1326	1678	7021	6600	6525	6751	3583	6382
Mean	25.77	25.92	26.05	26.15	26.24	26.48	26.60	26.67
Median	25.38	25.64	25.78	25.80	25.94	26.16	26.27	26.37
Standard deviation (sample)	4.08	3.79	3.79	3.87	3.86	3.95	4.12	4.06
Skewness (sample)	1.44	0.76	0.60	0.75	0.52	0.59	0.75	0.73
Underweight (BMI < 18.5)	1.2%	1.1%	1.1%	0.8%	1.0%	0.9%	0.8%	0.9%
Healthy (18.5 ≤ BMI < 25.0)	45.1%	42.0%	39.8%	39.8%	38.6%	36.4%	35.8%	34.8%
Overweight (25.0 ≤ BMI < 30.0)	40.8%	44.2%	45.5%	45.1%	44.9%	45.8%	46.1%	46.6%
Obese I (30.0 ≤ BMI < 35.0)	10.5%	10.7%	11.5%	11.8%	13.3%	13.9%	13.6%	14.5%
Obese II (35.0 ≤ BMI < 40.0)	2.1%	1.8%	1.8%	2.0%	2.0%	2.6%	2.8%	2.6%
Severely obese (BMI ≥ 40.0)	0.3%	0.2%	0.2%	0.4%	0.3%	0.4%	0.8%	0.7%

	1999	2000	2001	2002	2003	2004	2005	2006
Number of cases	3104	3143	6073	2861	5787	2365	2819	5359
Mean	26.69	27.03	27.14	27.14	27.12	27.27	27.18	27.41
Median	26.29	26.64	26.80	26.82	26.74	27.04	26.71	26.91
Standard deviation (sample)	4.22	4.21	4.25	4.45	4.46	4.42	4.42	4.58
Skewness (sample)	0.85	0.60	0.70	0.82	0.69	0.68	0.65	0.80
Underweight (BMI < 18.5)	1.1%	0.7%	0.9%	1.0%	1.2%	1.0%	0.8%	0.7%
Healthy (18.5 ≤ BMI < 25.0)	34.8%	31.9%	30.1%	31.6%	31.7%	30.4%	32.1%	30.2%
Overweight (25.0 ≤ BMI < 30.0)	44.9%	45.8%	47.6%	44.7%	44.4%	45.1%	44.1%	44.7%
Obese I (30.0 ≤ BMI < 35.0)	15.9%	17.5%	17.1%	17.7%	17.9%	18.7%	17.4%	18.5%
Obese II (35.0 ≤ BMI < 40.0)	2.5%	3.5%	3.8%	4.2%	3.8%	3.9%	4.6%	4.4%
Severely obese (BMI ≥ 40.0)	0.8%	0.6%	0.6%	0.8%	1.0%	0.8%	1.0%	1.5%

	2007	2008	2009	2010	2011	2012	2013	2014
Number of cases	2633	5660	1790	3046	3099	3032	3245	3056
Mean	27.32	27.38	27.12	27.69	27.35	27.48	27.62	27.42
Median	26.70	26.87	26.71	27.16	26.73	27.03	27.06	26.80
Standard deviation (sample)	4.72	4.65	4.60	4.76	4.82	4.75	4.91	4.86
Skewness (sample)	1.06	0.83	0.76	0.89	1.00	0.84	0.74	0.98
Underweight (BMI < 18.5)	1.0%	1.0%	1.7%	0.8%	1.0%	1.1%	1.2%	1.4%
Healthy (18.5 ≤ BMI < 25.0)	32.3%	30.9%	31.0%	29.0%	32.5%	30.5%	29.7%	31.4%
Overweight (25.0 ≤ BMI < 30.0)	42.3%	43.0%	44.6%	43.0%	42.2%	43.4%	42.2%	42.2%
Obese I (30.0 ≤ BMI < 35.0)	18.5%	18.9%	17.3%	20.7%	17.2%	17.9%	19.4%	18.5%
Obese II (35.0 ≤ BMI < 40.0)	4.7%	5.0%	4.2%	4.8%	5.4%	5.3%	5.7%	4.9%
Severely obese (BMI ≥ 40.0)	1.3%	1.2%	1.2%	1.7%	1.7%	1.8%	1.7%	1.8%

Table 2.II.2 Descriptive statistics for the HSE data for women.

	1991	1992	1993	1994	1995	1996	1997	1998
Number of cases	1492	1841	7824	7681	7497	7816	4126	7519
Mean	25.48	25.49	25.82	25.85	25.97	26.11	26.32	26.47
Median	24.45	24.56	24.94	24.94	25.16	25.31	25.34	25.52
Standard deviation (sample)	5.55	4.78	4.88	4.98	4.92	4.90	5.32	5.19
Skewness (sample)	2.51	1.24	1.23	1.18	1.10	0.97	1.23	1.03
Underweight (BMI < 18.5)	2.5%	2.4%	1.8%	2.0%	2.0%	1.8%	1.8%	1.9%
Healthy (18.5 ≤ BMI < 25.0)	52.6%	51.5%	48.8%	48.4%	46.6%	45.1%	44.8%	43.7%
Overweight (25.0 ≤ BMI < 30.0)	29.0%	29.6%	32.6%	32.0%	33.5%	34.2%	33.1%	32.7%
Obese I (30.0 ≤ BMI < 35.0)	10.5%	11.8%	11.5%	12.1%	12.3%	13.3%	13.4%	14.8%
Obese II (35.0 ≤ BMI < 40.0)	3.8%	3.7%	3.9%	3.9%	4.1%	4.2%	4.5%	4.9%
Severely obese (BMI ≥ 40.0)	1.7%	0.9%	1.4%	1.6%	1.4%	1.4%	2.4%	2.0%

	1999	2000	2001	2002	2003	2004	2005	2006
Number of cases	3574	3615	7218	3395	6882	3050	3312	6313
Mean	26.50	26.68	26.85	26.86	26.86	26.88	27.01	26.95
Median	25.64	25.71	25.86	25.86	25.82	25.85	25.92	25.98
Standard deviation (sample)	5.27	5.42	5.41	5.46	5.56	5.45	5.64	5.57
Skewness (sample)	1.07	1.24	1.03	0.98	1.12	1.05	1.14	0.98
Underweight (BMI < 18.5)	1.6%	1.5%	1.4%	1.8%	1.7%	1.4%	1.5%	1.8%
Healthy (18.5 ≤ BMI < 25.0)	43.4%	42.7%	41.3%	40.7%	41.6%	40.6%	40.8%	40.9%
Overweight (25.0 ≤ BMI < 30.0)	33.5%	34.1%	33.4%	34.1%	33.1%	34.2%	32.8%	32.5%
Obese I (30.0 ≤ BMI < 35.0)	14.2%	14.0%	15.8%	14.4%	15.3%	15.1%	15.7%	15.5%
Obese II (35.0 ≤ BMI < 40.0)	5.3%	5.4%	5.5%	6.3%	5.3%	6.2%	6.4%	6.6%
Severely obese (BMI ≥ 40.0)	2.0%	2.4%	2.6%	2.7%	2.9%	2.5%	2.8%	2.7%

	2007	2008	2009	2010	2011	2012	2013	2014
Number of cases	3132	6782	2061	3746	3779	3696	3893	3708
Mean	26.89	27.04	27.12	27.34	27.23	27.08	27.07	27.32
Median	25.87	26.02	26.04	26.24	26.16	26.10	26.00	26.07
Standard deviation (sample)	5.36	5.63	5.86	5.90	5.76	5.73	5.77	5.90
Skewness (sample)	0.92	1.00	1.35	1.24	1.02	1.02	1.13	1.10
Underweight (BMI < 18.5)	1.7%	1.7%	2.1%	1.5%	2.0%	2.0%	1.8%	1.3%
Healthy (18.5 ≤ BMI < 25.0)	40.9%	40.1%	40.5%	39.2%	38.7%	40.1%	39.9%	39.7%
Overweight (25.0 ≤ BMI < 30.0)	32.5%	32.7%	33.1%	32.3%	32.8%	32.2%	33.9%	31.7%
Obese I (30.0 ≤ BMI < 35.0)	16.3%	16.0%	14.2%	16.8%	16.1%	16.2%	15.2%	17.0%
Obese II (35.0 ≤ BMI < 40.0)	6.4%	6.7%	6.5%	6.3%	7.0%	6.2%	5.2%	6.7%
Severely obese (BMI ≥ 40.0)	2.3%	2.9%	3.6%	3.9%	3.3%	3.2%	4.0%	3.7%

Appendix 2.III Missing values

These charts show the age profile of missing values for each year from 1991 to 2014 using a 15 point simple moving average to smooth the data. For example, the first value of each series is the average for ages 18 to 32, plotted at the midpoint age of 25, and the last value is the average for ages 76 to 90, plotted at age 83. As discussed in Section 2.4.2, the general pattern of missing values is very similar for each year. The pattern for 1991 is slightly different (the yellow line with very high values for older ages, particularly for women) in having relatively low percentages for younger ages but high percentages for older ages. However, the sample sizes for 1991 are very small.

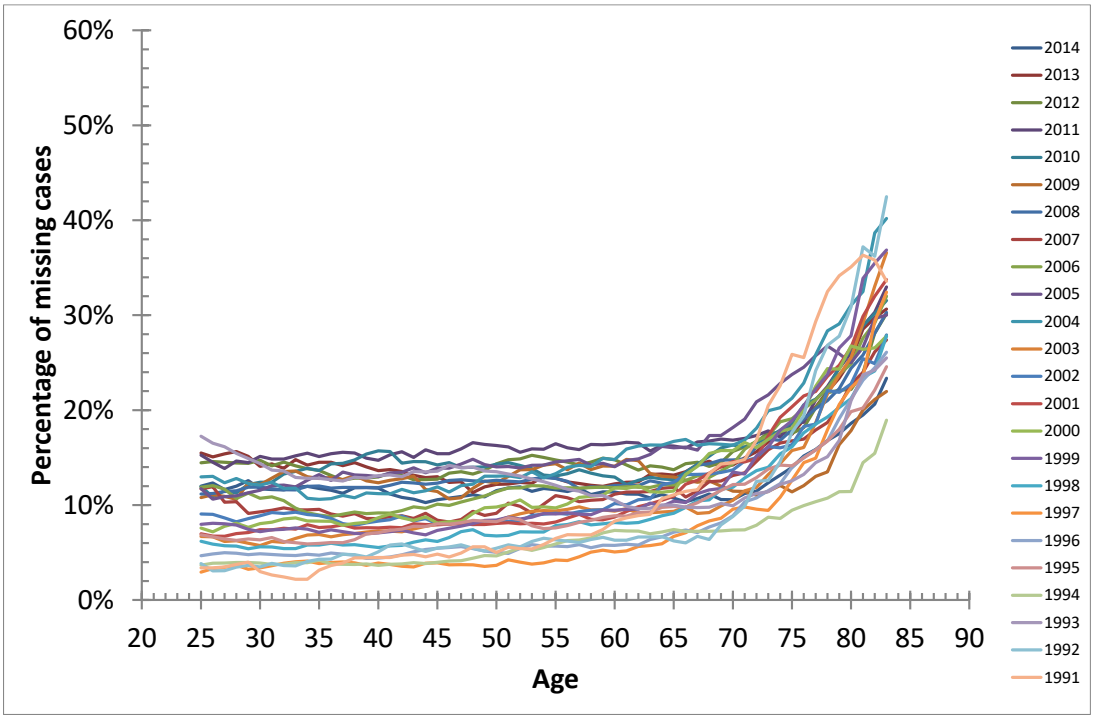

Figure 2.III.1 Moving average of missing value percentages for each year for men.

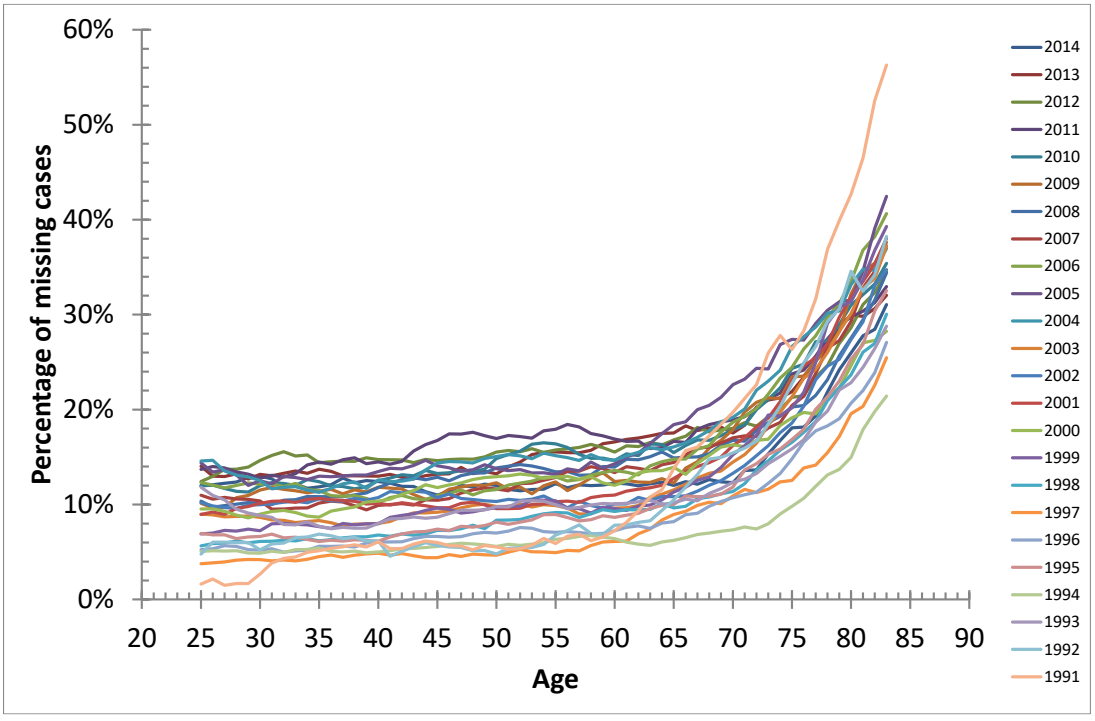

Figure 2.III.2 Moving average of missing value percentages for each year for women.

Appendix 2.IV Comparison with Trend Table

As explained in Section 2.5 of the main report, calculations were done to reproduce the Trend Table statistics that are published on the NHS Digital website. This gives a check that the correct data is being used in the work here and on the approach for identifying valid cases (Appendix 2.I). A very good match was obtained with only small negligible differences. This gives confidence in the method used for selecting the valid cases from the HSE data. The detailed results are presented in this appendix.

Summary of results

The Trend Table statistics used were those for all adults, all men, and all women. The statistics values compared were the number of cases, the total cases weighting, the mean, and the category percentages. The Trend Table gives category percentages for underweight, healthy (termed in the table as "normal"), overweight, all obese (i.e., BMI 30+), and severely obese (BMI 40+, termed in the table as "morbidly obese").

Table 2.IV.1 shows whether the statistics matched. A "Yes" in the "Matches" column indicates that all the statistics values matched between the Trend Table and my data. A "No" indicates that there was a difference in one or more of the statistics values. The brief reason for the difference is given in the three right hand columns, and these differences are explained further in the sections on the next two pages. The differences are all very minor. The Trend Table only gives statistics for1993 onwards and so no comparison could be done for 1991 and 1992.

Table 2.IV.1 Results and comments on the match with the Trend Table statistics.

Year	Matches?	Cases difference	Category classifications	Statistics calculations
1993	Yes			
1994	No	1 fewer in Trend Table		
1995	No	Shift 1 case	End points	
1996	No		End points	
1997	Yes			
1998	Yes			
1999	No			Means for men and women
2000	Yes			
2001	No			Small differences for men
2002	No	1 extra in Trend Table		
2003	Yes			
2004	Yes			
2005	Yes			
2006	No		Category for 1 case	
2007	Yes			
2008	No	4 extra in Trend Table		
2009	Yes			
2010	Yes			
2011	Yes			
2012	No	1 extra in Trend Table		
2013	Yes			
2014	Yes			

Rounding and precision of the comparisons

Most of the Trend Table values are given to many decimal places. For example, the mean for most years is given to at least four decimal places and often to 13 decimal places. Therefore, the statistics can be compared very precisely.

However, for 1993-1998 the values for the category percentages for men and for women for BMI 25-30, 30+, 40+, and for the mean are rounded to just one decimal place. Hence, the comparisons could only be made to that degree of precision and a match of the statistics means that they match to that level. The values for all adults are not rounded in this way and so these values were able to be compared very precisely for all the years.

For 2011-2013 the totals of the case weights are rounded to the nearest integer and so again those values could only be compared at that level.

Cases differences

As shown in Table 2.IV.1, five of the years have a small difference in the number of cases and this section gives the details. The statistics are compared for men and for women and for all adults. A difference in the number of cases shows as a difference in the number of cases for either men or women in some of the BMI categories as well as a difference in the total number of cases and the total case weighting. Hence, it is possible to identify which BMI category the extra cases are in. The number of cases match apart from the specific differences given in this section and any other differences given in the other sections that follow.

In 1994 there is one fewer case in the Trend Table for the data for men (and all adults). Looking in more detail at the Trend Table statistics, this must be a man aged 75+ with a BMI between 25 and 30. This fits the oldest male case in the data and temporarily taking out this case from the data then results in an exact match of all the statistics, including the mean for all adults to the full 13 decimal places provided. Hence, this case is presumably not included in the Trend Table data.

In 1995 the total number of cases match but there are small differences in the category percentages. As explained in the previous section, some of the statistics for men and for women are rounded. The mean for all adults, which is not rounded, gives a very close although not quite exact match being the same to five decimal places. A match for the category statistics can be obtained by altering all the category boundaries, as explained in the next section, and moving a case for men from BMI between 30 and 40 to BMI between 18.5 and 25. It is not clear exactly what the reason is for these small differences.

In 2002, 2008, and 2012 there are extra cases in the Trend Table. In 2002 there is one extra case for the data for women with a BMI between 25 and 30. In 2008 the extra cases are one case for the data for men with a BMI between 25 and 30, and three cases for the data for women being two with a BMI between 18.5 and 25, and one with a BMI between 25 and 30. In 2012 there is one extra case for the data for men with a BMI between 30 and 40. For 2008 and 2012 the cases have case weights. Where there is one extra case for the data for men for 2008 the weight of the extra case is just the difference in the total case weights. For the three extra cases for women for 2008 a solution was found using Excel solver for the case weights to add to each category to give a match of the statistics and that sum to the total difference in the case weights. For 2012 the total case weights are rounded (as explained in the previous section) and the case weight for the extra case to give a match of the statistics was found using Excel solver. The mean values naturally differ by a small amount in these situations where the number of cases are different. However, for each one the difference in the mean values is consistent with the categories for the extra cases (identified by comparing mean BMI × total case weight, and taking account of the deduced case weights of the extra cases). Hence, the differences in the statistics for 2002, 2008, and 2012 are all consistent with the Trend Table having a few extra cases included.

Given that there are over 200,000 valid cases these differences are very minor and such small differences in the number of cases used will not have any significant effect on the analysis.

Category classifications

In three of the years (Table 2.IV.1) some changes in the way cases are classified in the BMI categories are needed to get a match with the Trend Table statistics. These differences are as follows:

In 1995 and 1996 a match of the category statistics requires altering all the BMI categories slightly by including the top value rather than the bottom value in all the BMI intervals (e.g., healthy being $18.5 < BMI \leq 25$ rather than the usual definition of $18.5 \leq BMI < 25$). This applies to all the statistics for men, for women, and for all adults. Therefore, presumably the Trend Table statistics were calculated using intervals defined in this way.

In 2006, there is a small difference in the category statistics for women. The cases each have different case weights, and the difference was able to be identified as one specific case in the data with a BMI of exactly 25 that was put in the BMI interval of 18.5-25 for the Trend Table rather than 25-30 for my data.

These differences indicate that the same data is being used but with very minor differences in the classifications for these three years.

Statistics calculation differences

In 1999 the values for the mean BMI for men and for women do not quite match my calculations. The differences are very small with the Trend Table mean BMI values being 0.07 lower for men and 0.02 lower for women. All the other statistics match including the mean for all adults and so it is not clear why there is this difference.

In 2001 the percentages for the BMI categories for men in the Trend Table do not quite add to 100% even though they are each given to 14 or 15 decimal places. The total is 99.9892%. This presumably implies some very small calculation errors. The differences in the Trend Table compared to my values are the BMI categories of 25 to 30 and 30 to 40 having very slightly smaller percentages (by less than 0.01%) and the mean BMI being slightly smaller (the difference being only 0.004). The statistics for women and for all adults match exactly.

As with the differences described in previous sections, these are insignificant differences.

Other issues

The Trend Table includes a “standard error of the mean” value. I am not sure of the calculation that was done for this and so this value was not reproduced.

In 2004 the case weights in the HSE use a different scale and are much larger. The Trend Table values for the case weights have been revised in some way to make them consistent with other years and so could not be compared with my calculated case weight values from the HSE data. However, all the other statistics for that year match.

Appendix 3.I Age profile

The charts below show the age profile used for men and women. The profile used is the "Average" series, which is the average of the population percentages for 2011-2014 (shown as the other four series). Note that age 90 is actually the value for ages 90 and over, since that is how the data is provided.

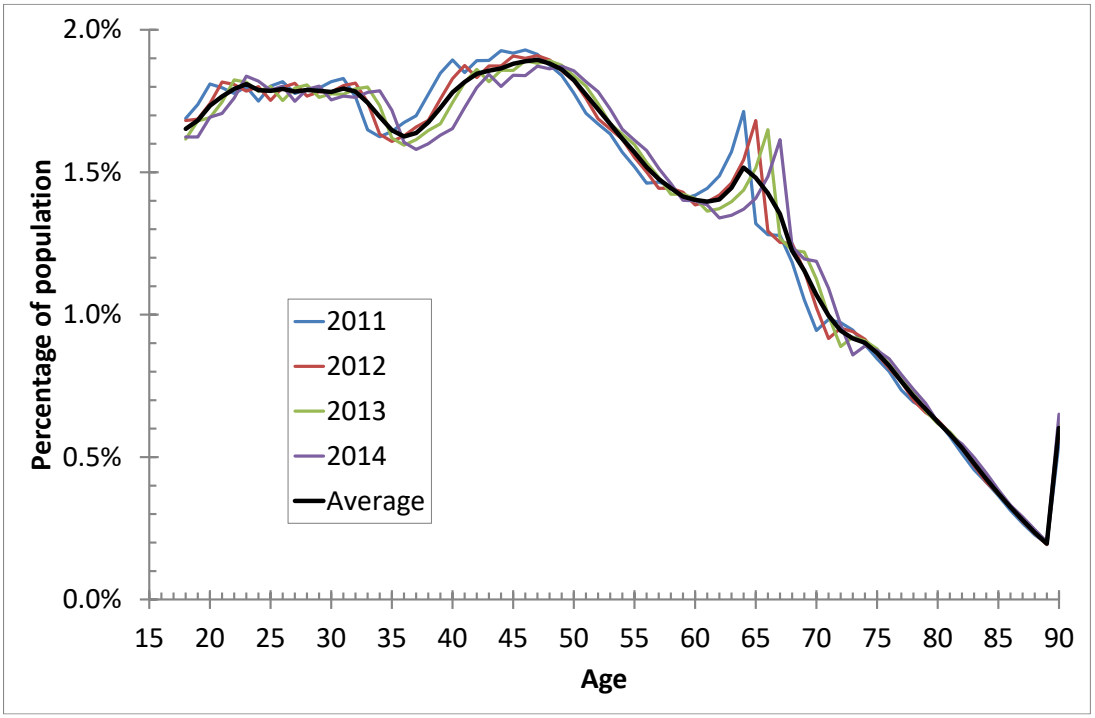

Figure 3.I.1 Age profile for men.

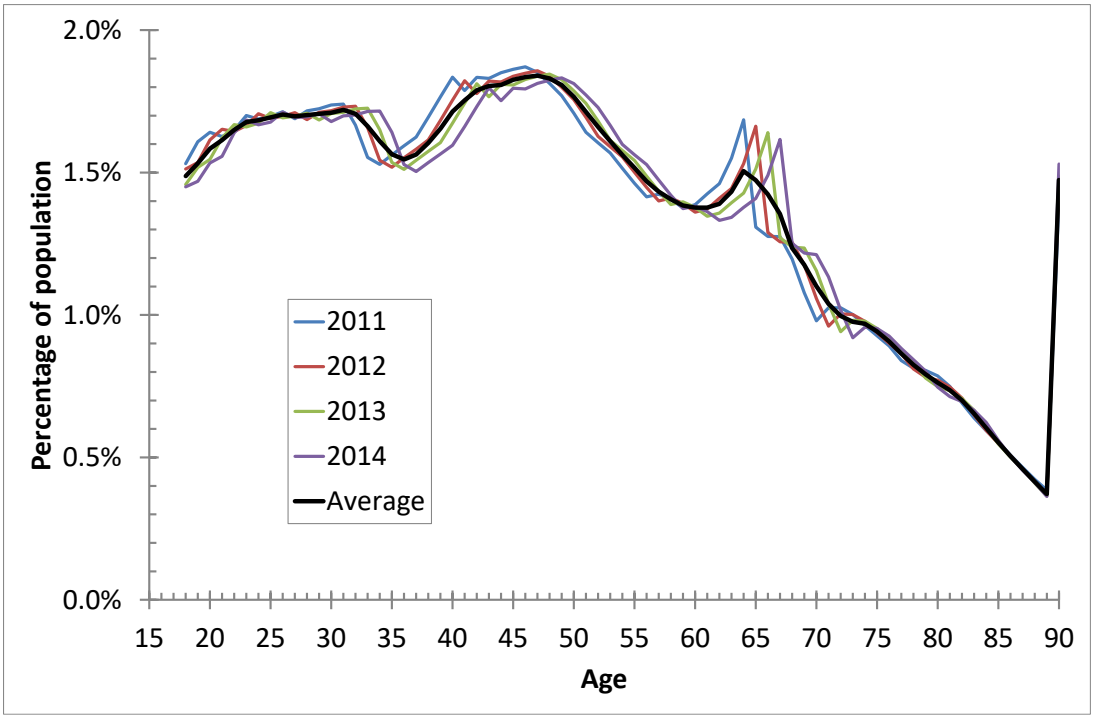

Figure 3.I.2 Age profile for women.

Appendix 3.II Data smoothing

These charts compare the data before and after the smoothing. For example, “Men 1993 data” is the data before smoothing and “Men 1993 smoothed” is the final distribution after smoothing. The charts for men and the charts for women keep the same axes ranges across the different years to enable comparison of the charts.

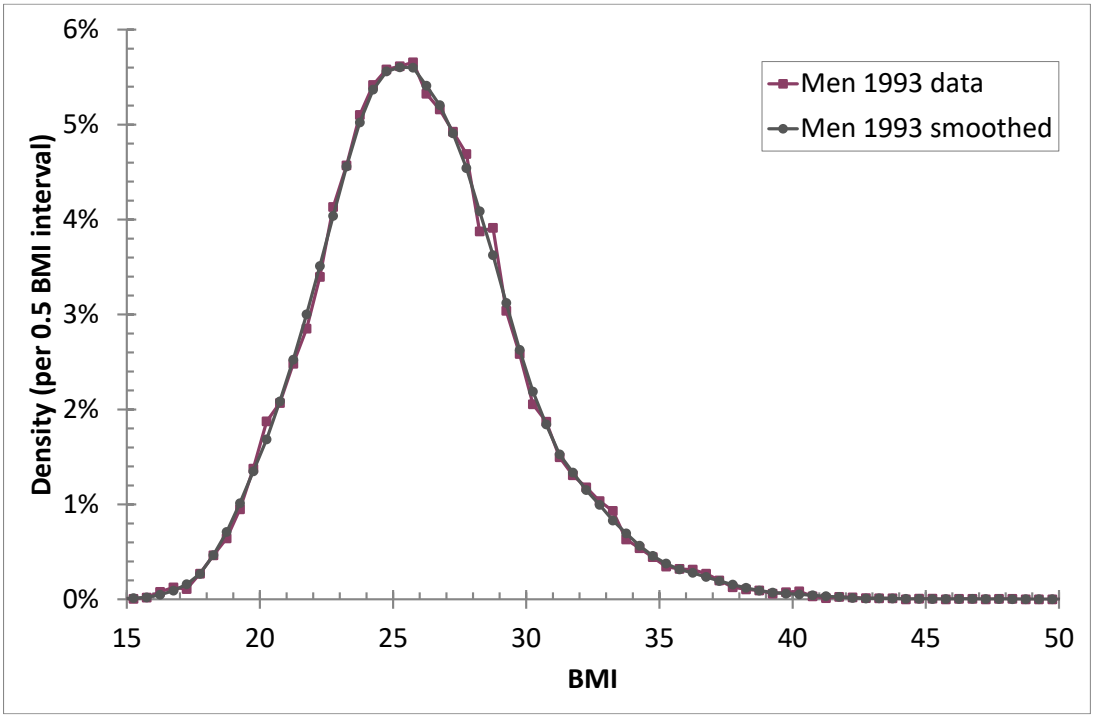

Figure 3.II.1 Data and smoothed distributions for men for 1993.

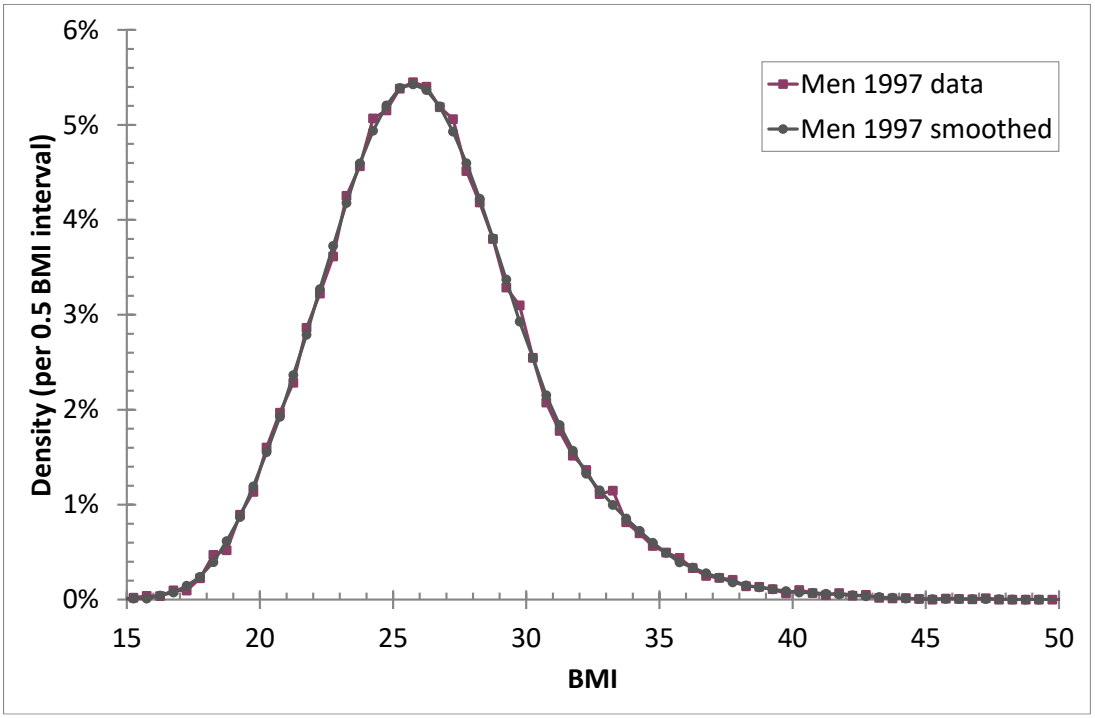

Figure 3.II.2 Data and smoothed distributions for men for 1997.

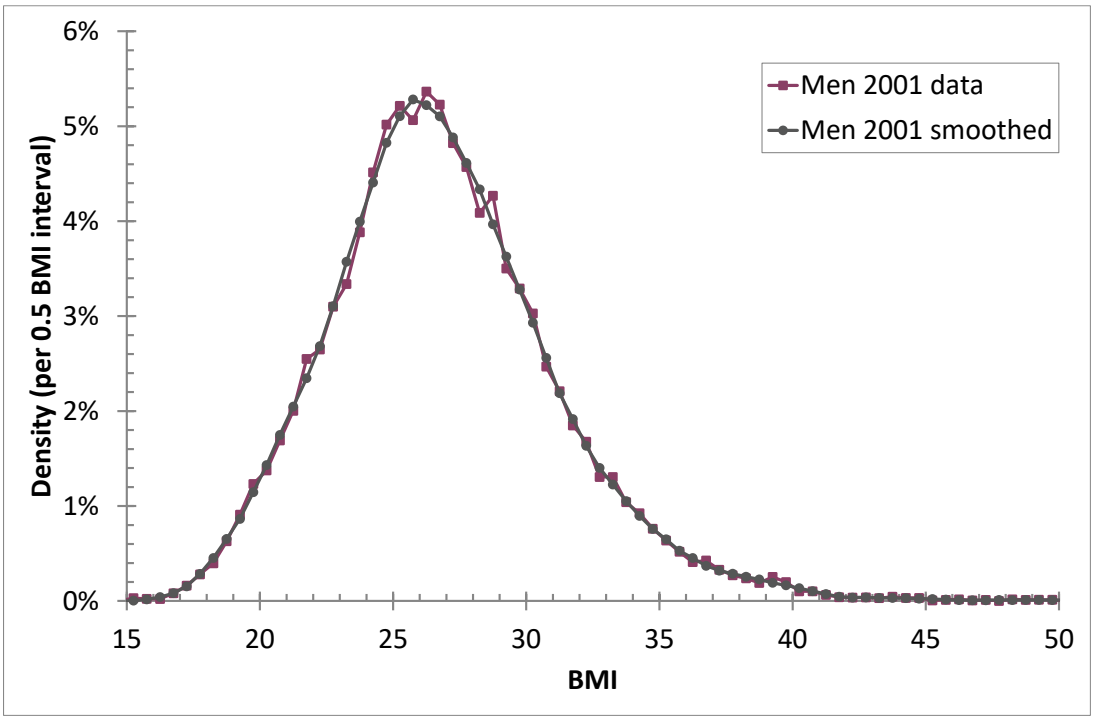

Figure 3.II.3 Data and smoothed distributions for men for 2001.

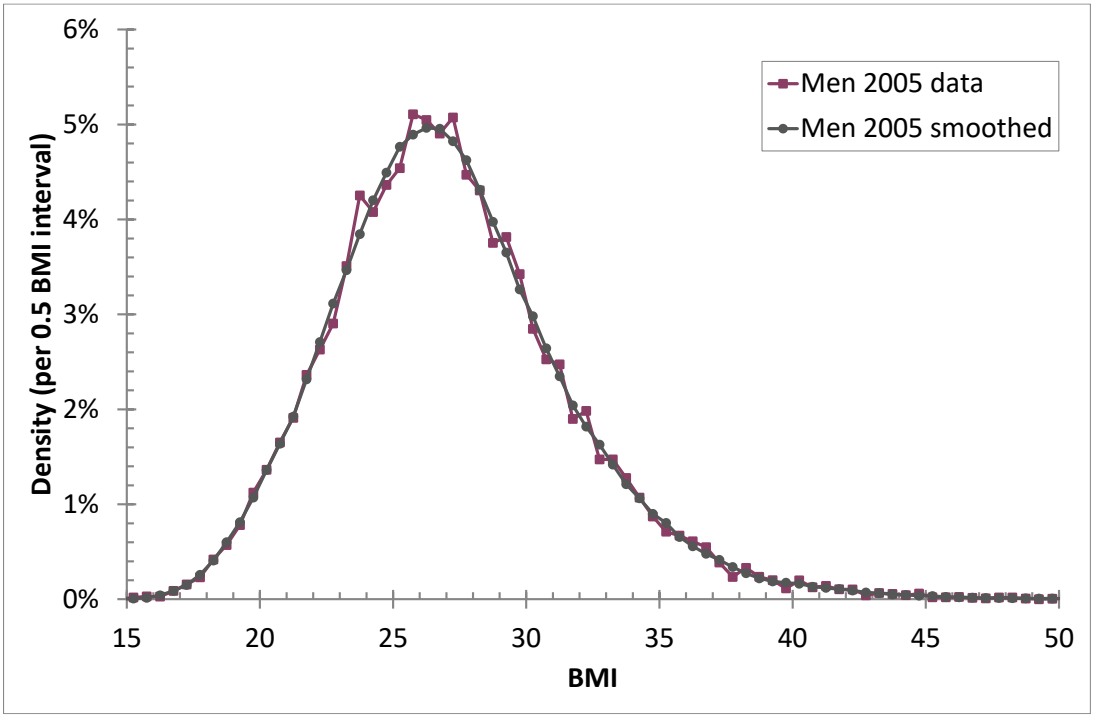

Figure 3.II.4 Data and smoothed distributions for men for 2005.

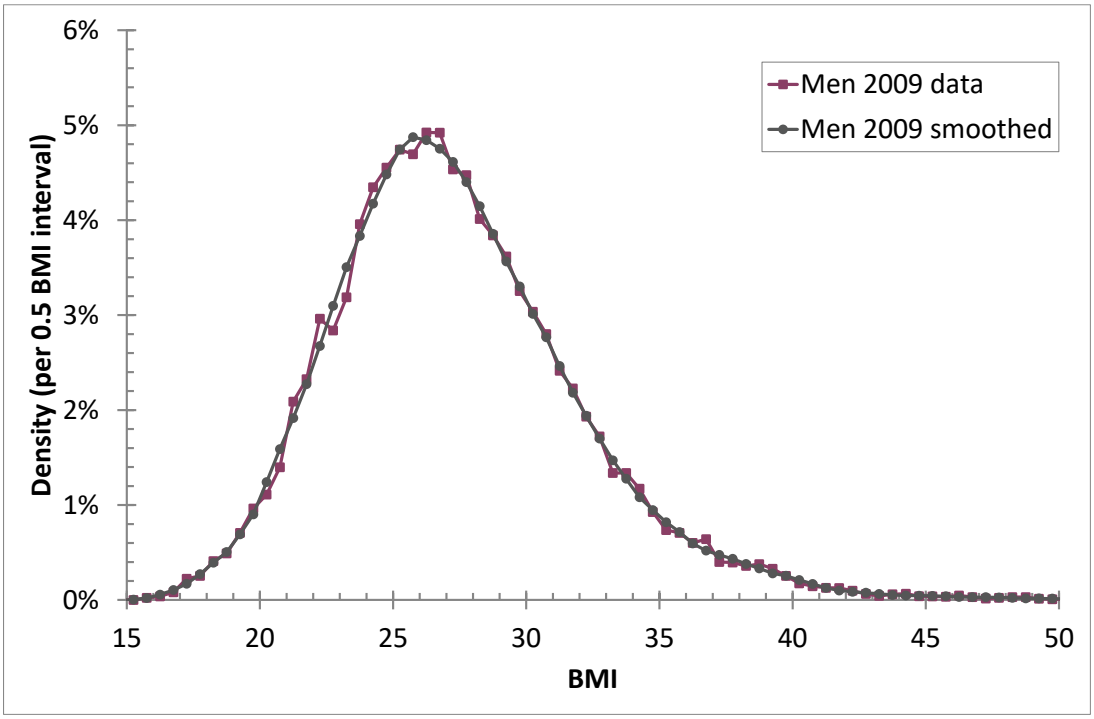

Figure 3.II.5 Data and smoothed distributions for men for 2009.

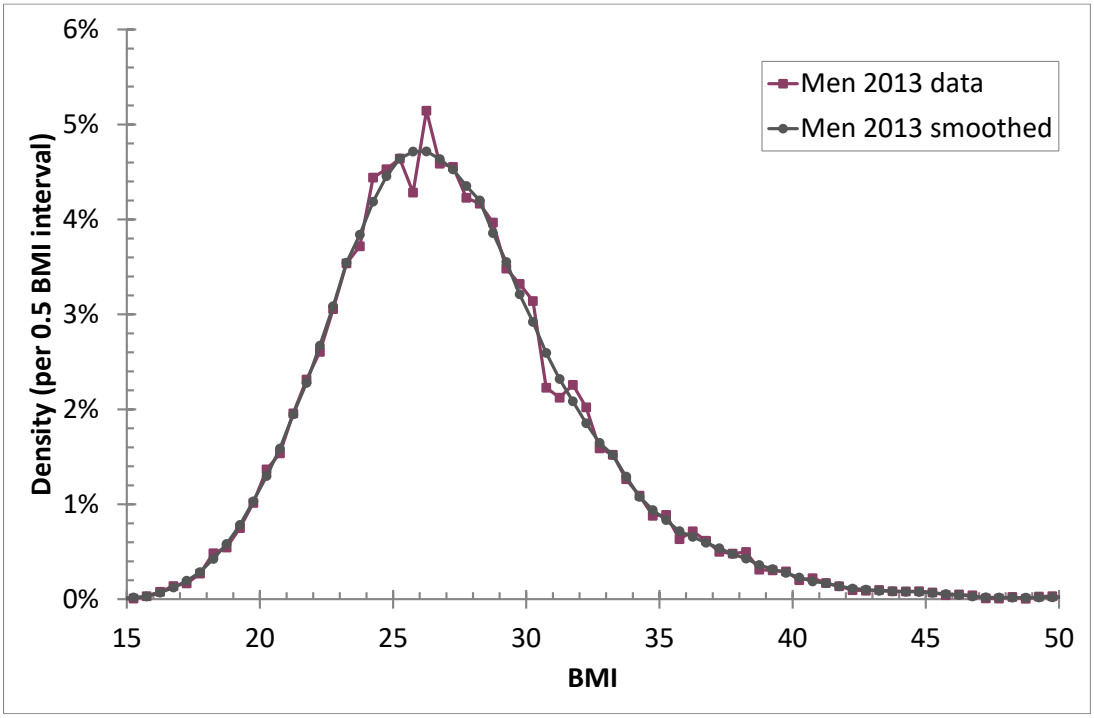

Figure 3.II.6 Data and smoothed distributions for men for 2013.

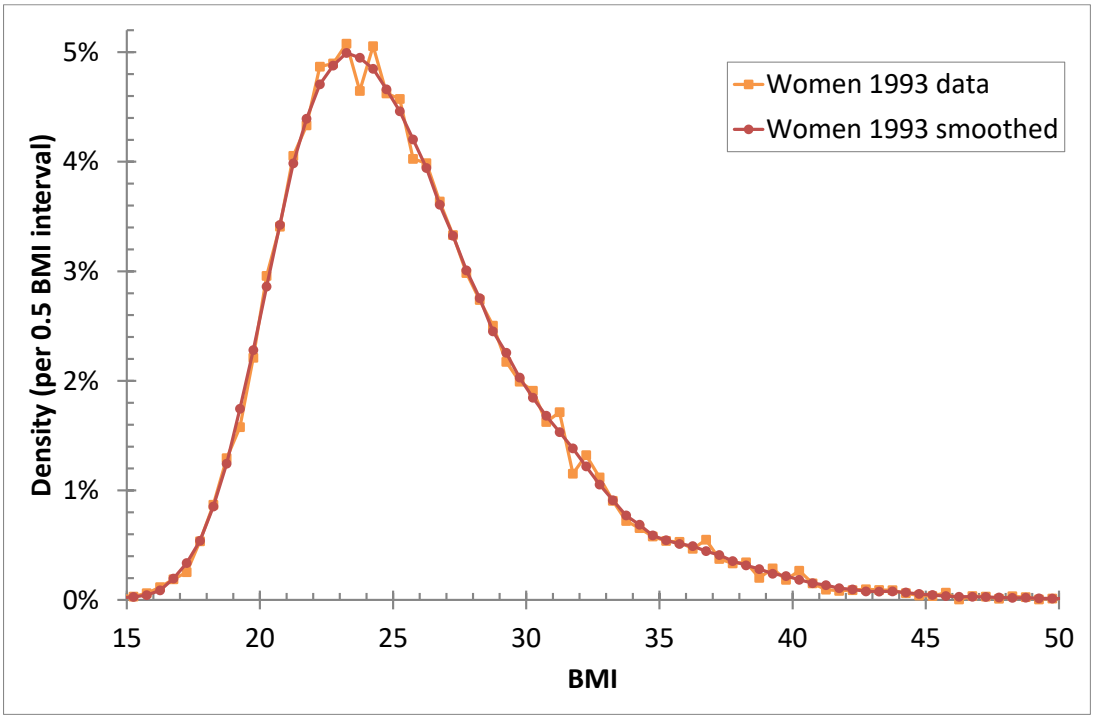

Figure 3.II.7 Data and smoothed distributions for women for 1993.

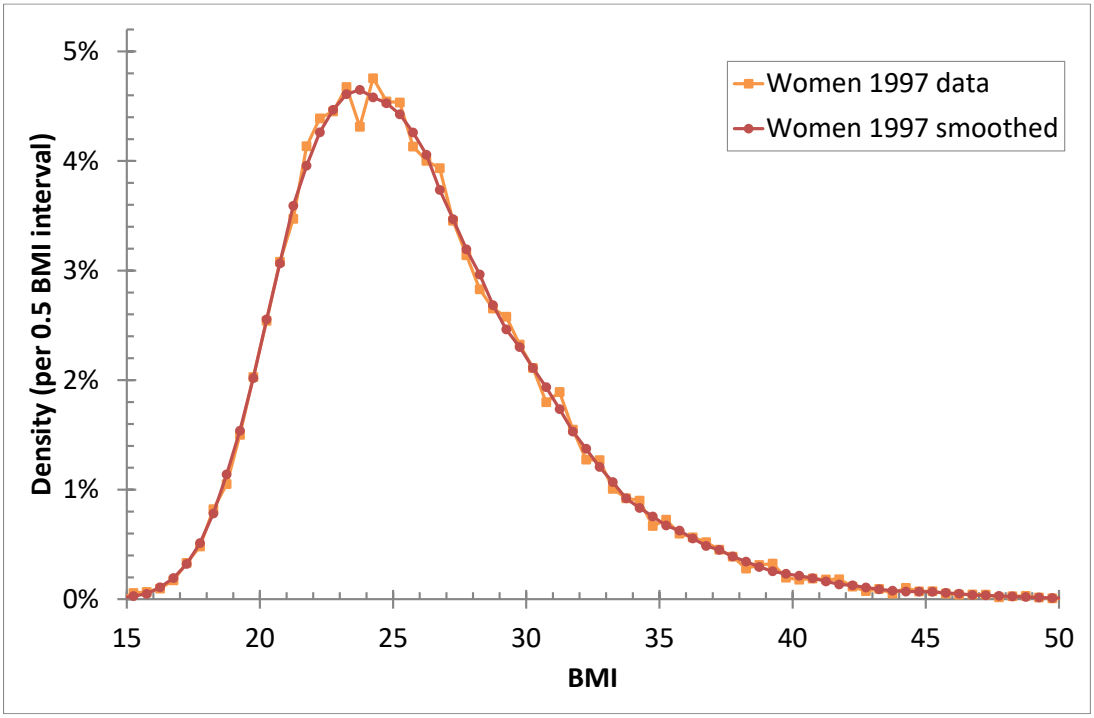

Figure 3.II.8 Data and smoothed distributions for women for 1997.

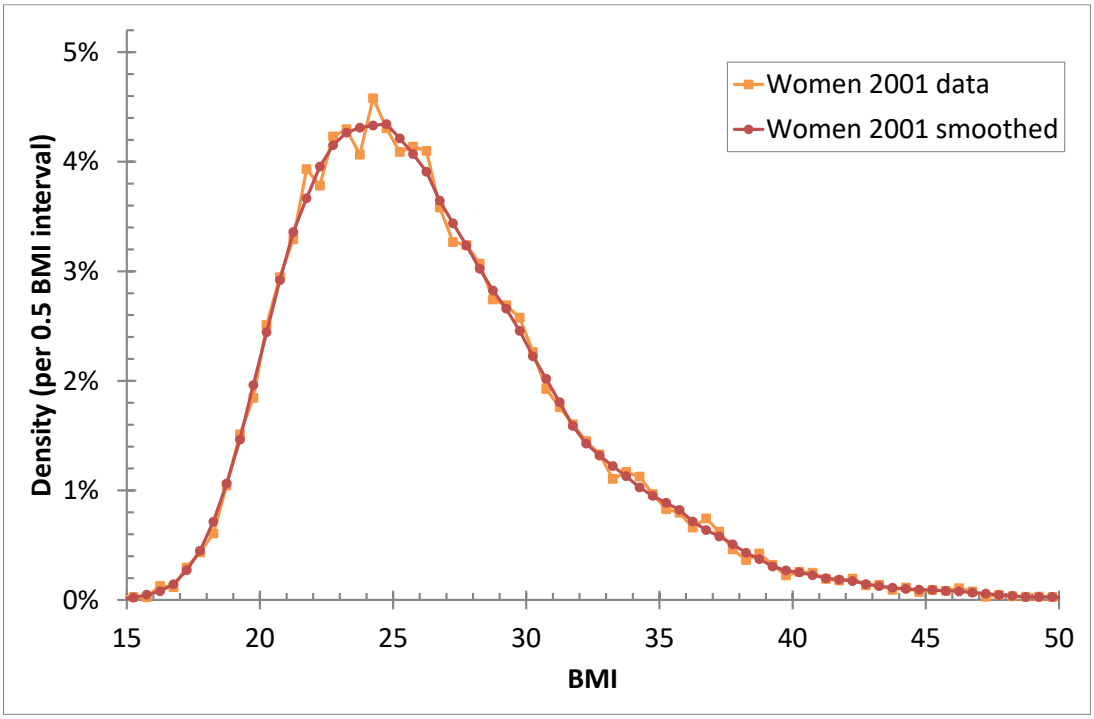

Figure 3.II.9 Data and smoothed distributions for women for 2001.

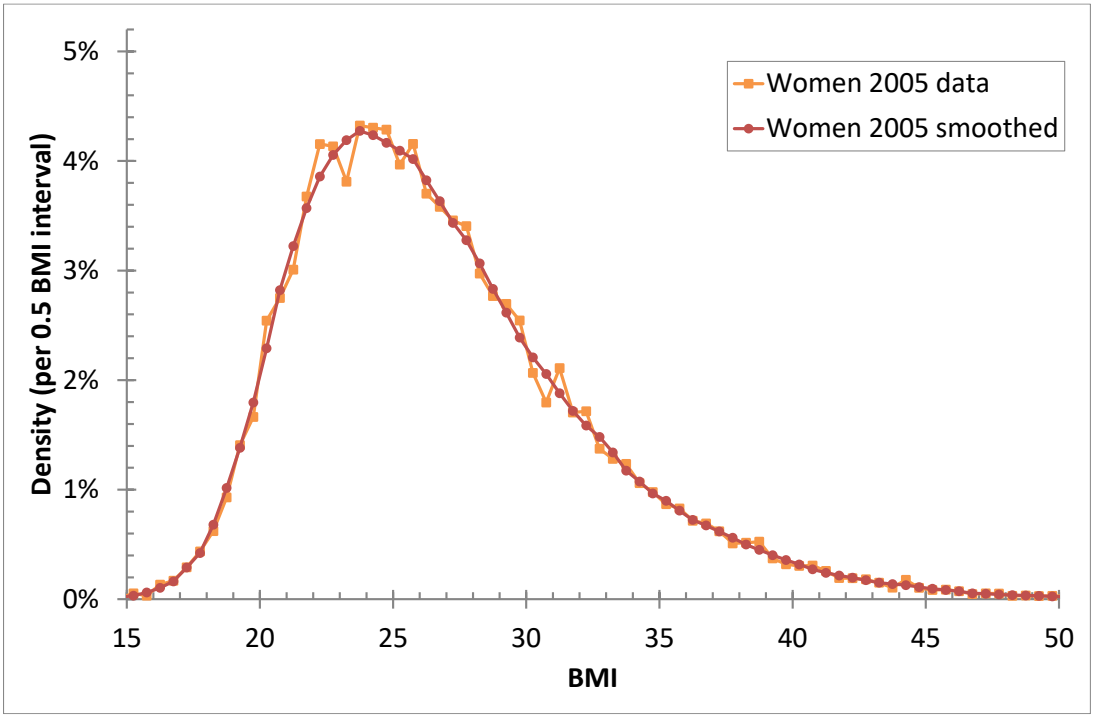

Figure 3.II.10 Data and smoothed distributions for women for 2005.

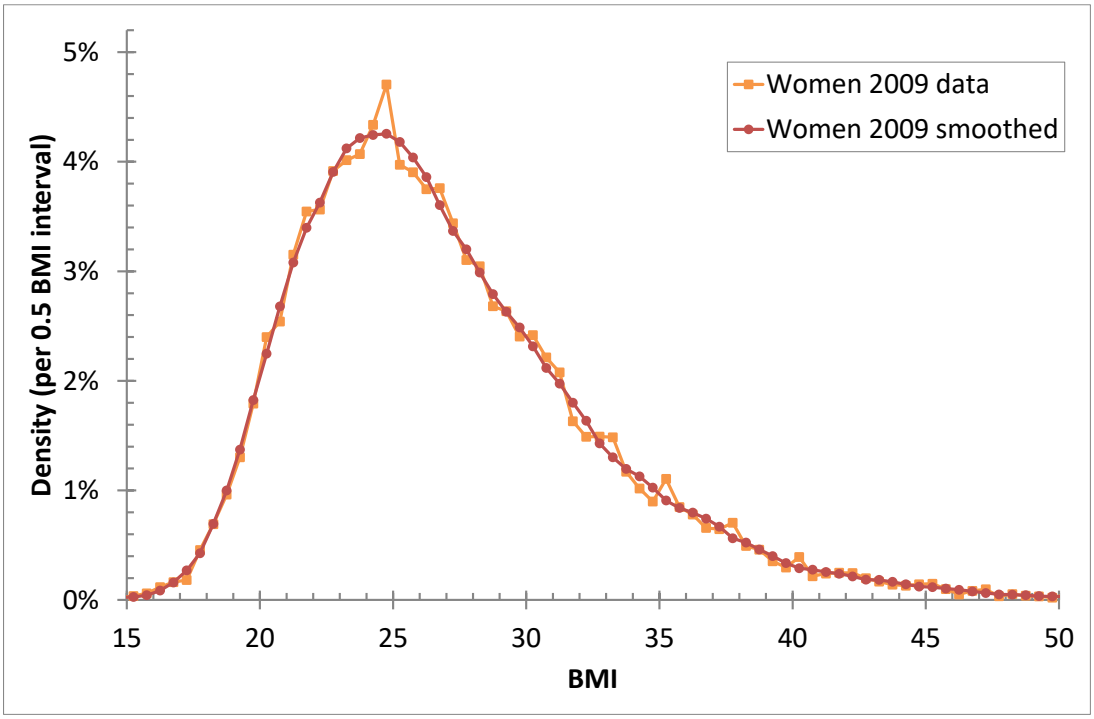

Figure 3.II.11 Data and smoothed distributions for women for 2009.

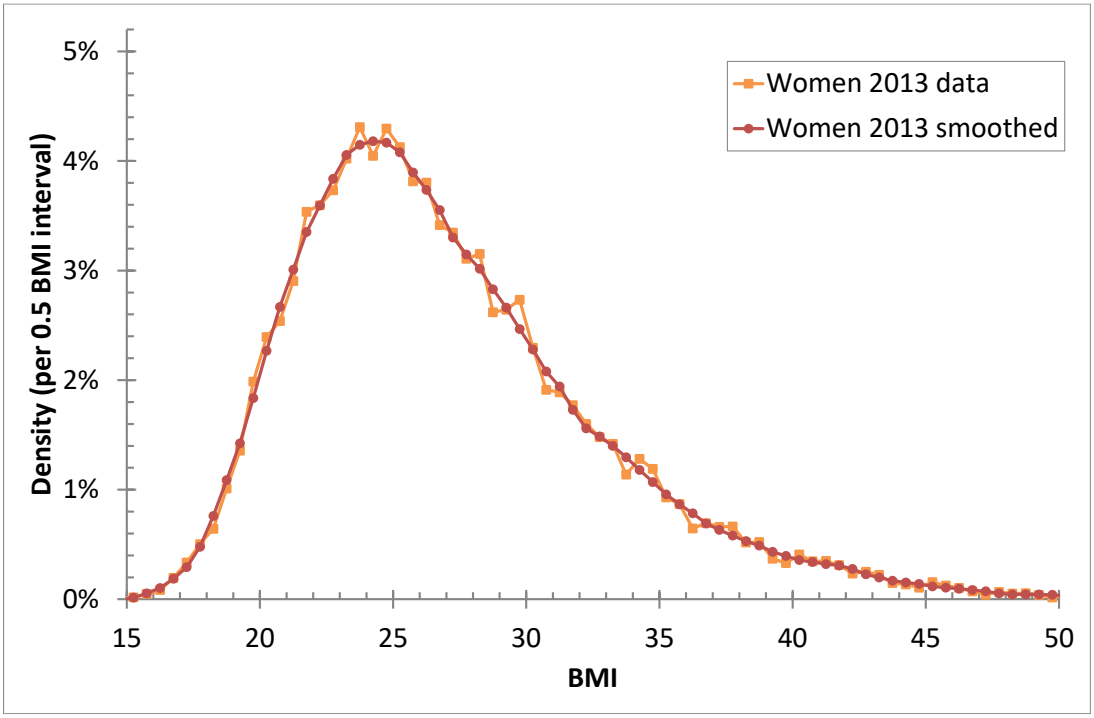

Figure 3.II.12 Data and smoothed distributions for women for 2013.

Appendix 4.I BMI distributions

These charts show slightly different views of the distributions in Figures 4.1 and 4.5 in Chapter 4 of the main report. The charts in Figure 4.I.1 and 4.I.2 have the x-axis going to a BMI value of 50 to show more of the right tail. The other charts are the distributions separately for up to 2005 and from 2005 onwards to see some of the detail obscured where the lines overlap in the charts in Chapter 4.

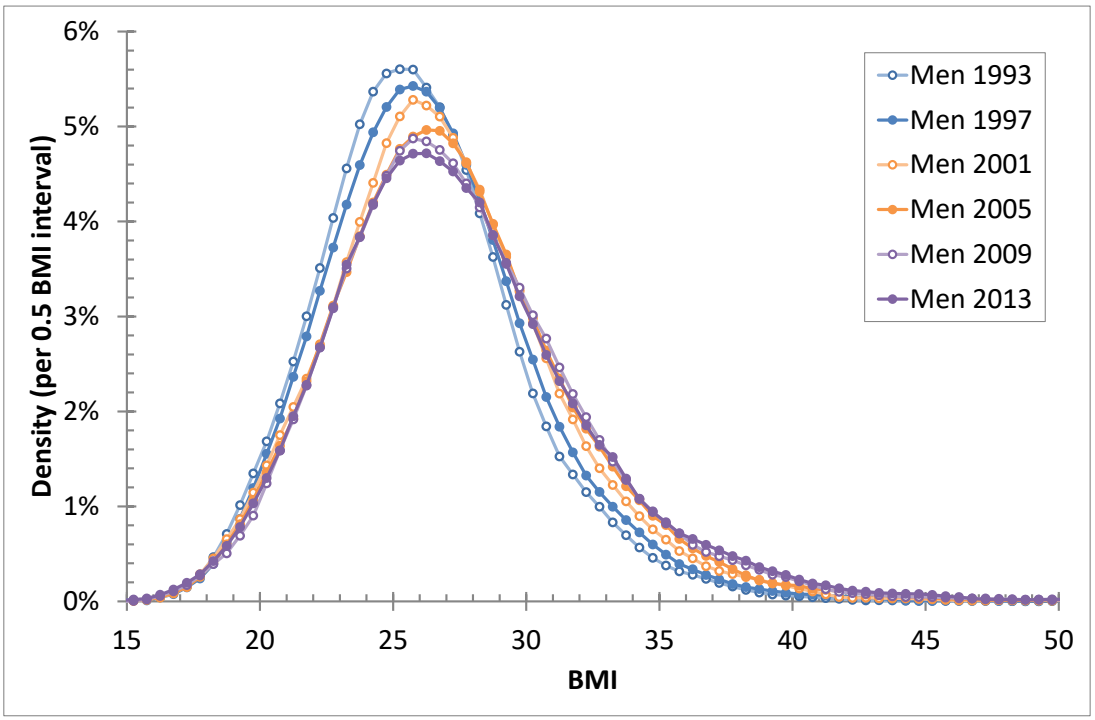

Figure 4.I.1 BMI distributions for men up to a BMI value of 50.

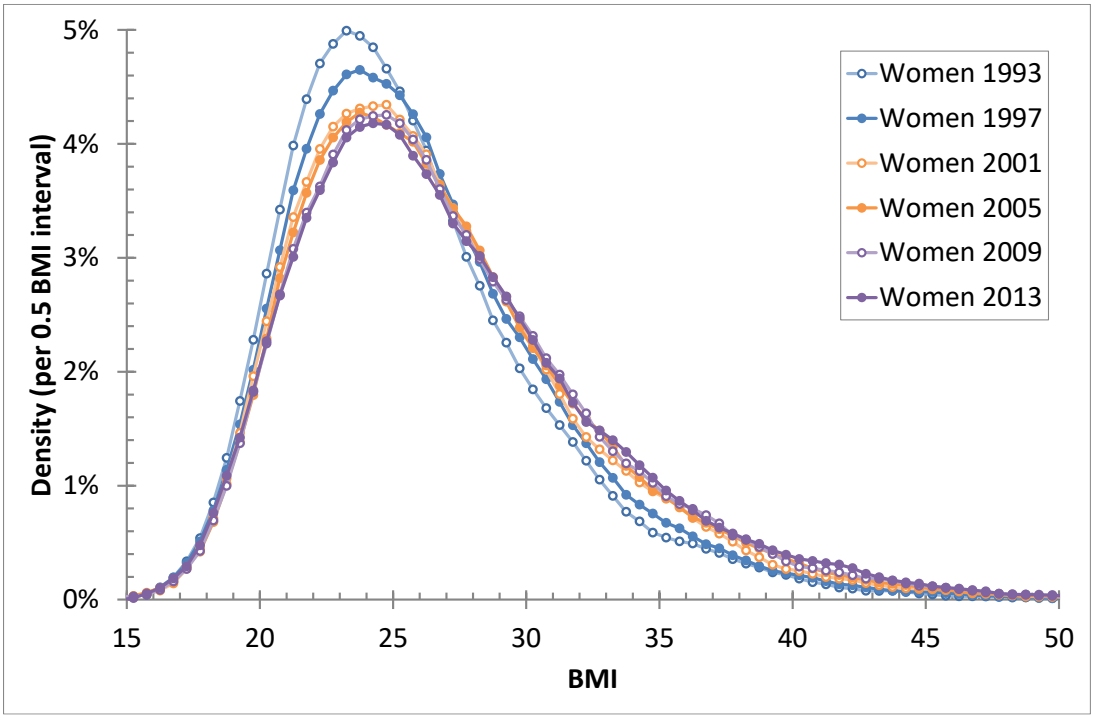

Figure 4.I.2 BMI distributions for women up to a BMI value of 50.

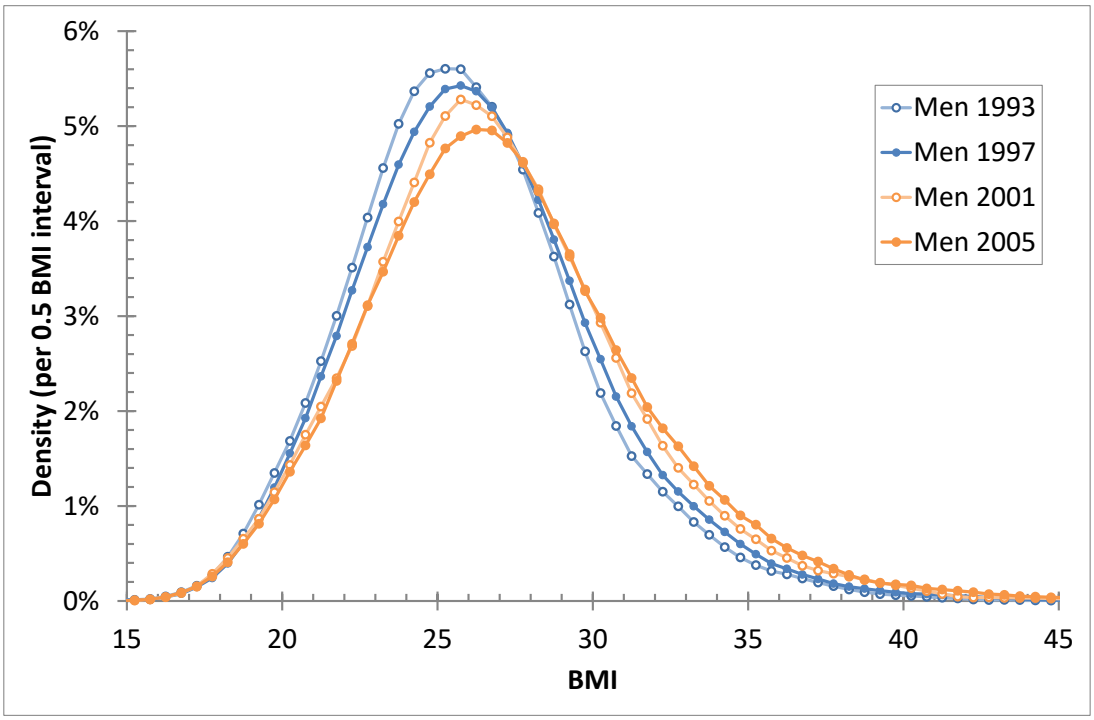

Figure 4.I.3 BMI distributions for men for 1993 to 2005.

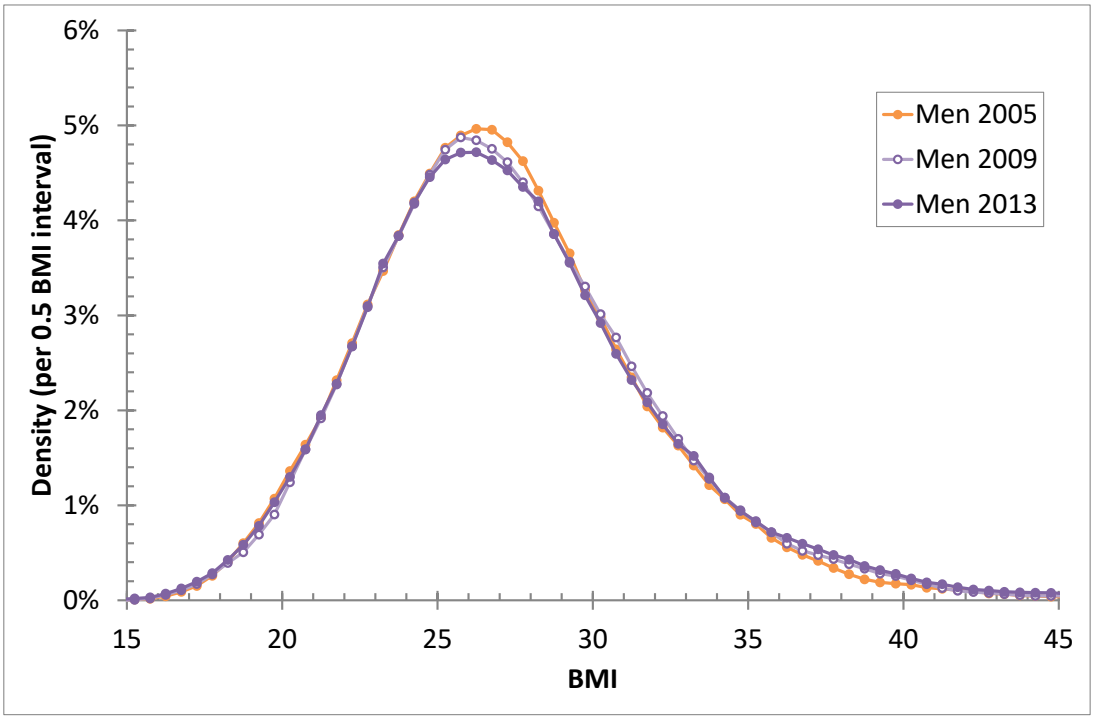

Figure 4.I.4 BMI distributions for men for 2005 to 2013.

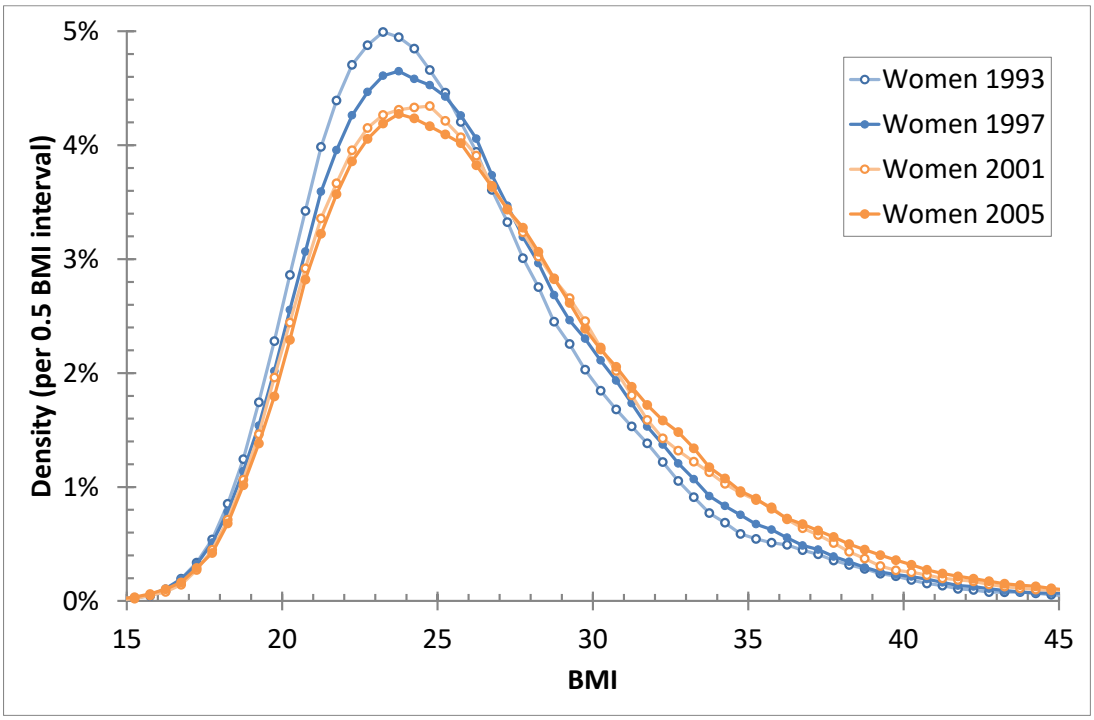

Figure 4.I.5 BMI distributions for women for 1993 to 2005.

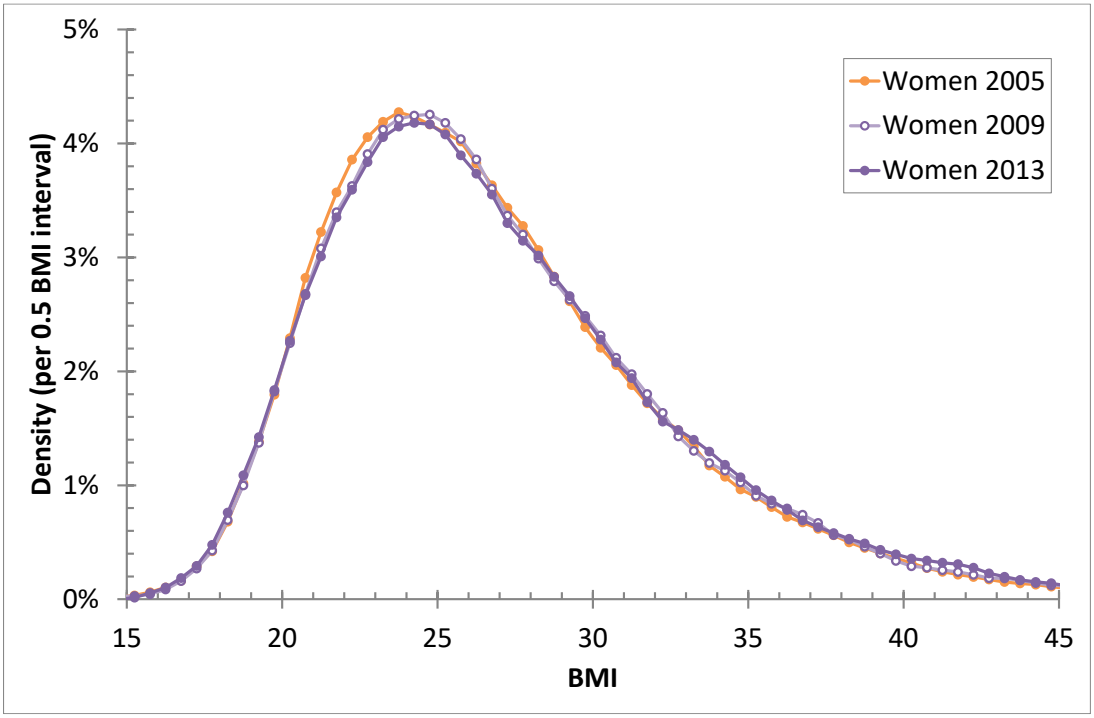

Figure 4.I.6 BMI distributions for women for 2005 to 2013.

Appendix 4.II BMI category percentages for the population distributions

These charts show the changes in each of the BMI category percentages over time for the population distributions. The values for men and for women are plotted on the same chart. This saves some space but also allows a comparison of the percentages.

There are differences in the levels. So, the data for men has higher percentages for overweight and obese I (except for obese I in 1993), but lower percentages for the other categories compared to the data for women. However, the patterns of the changes over time are generally very similar.

The charts include the total of the obese categories in Figure 4.II.7 and the total of the overweight and obese categories in Figure 4.II.8. Bar charts are also included at the end in Figures 4.II.9 and 4.II.10 of the changes from 1993 to 2013.

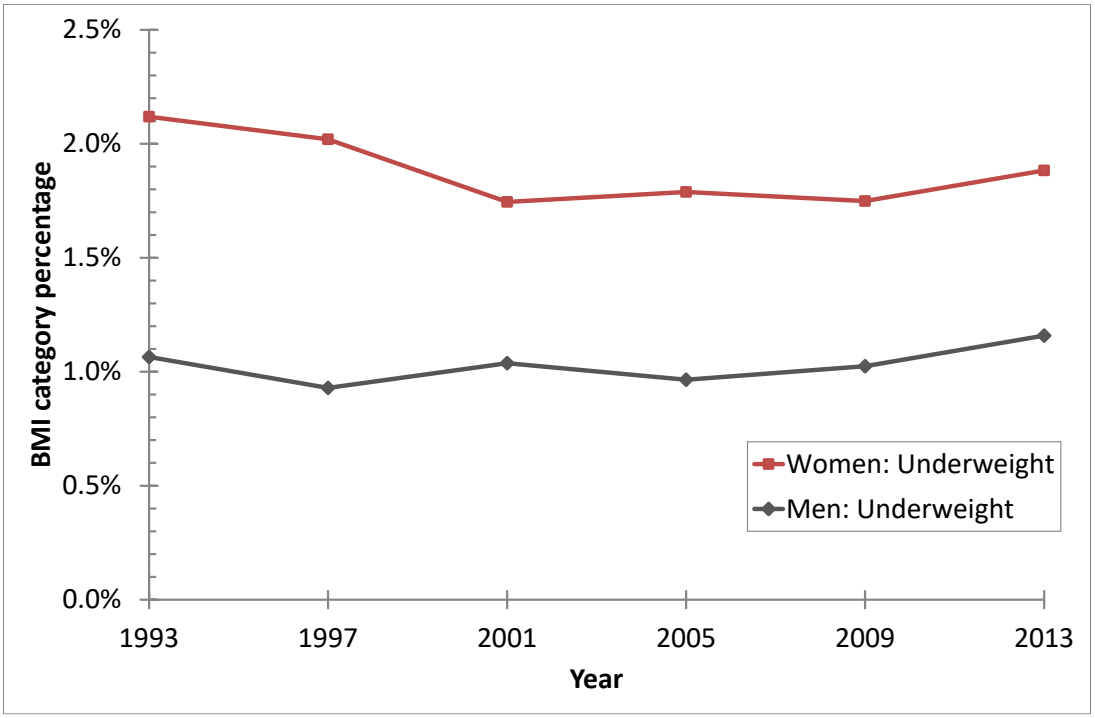

Figure 4.II.1 Underweight category percentages for the population distributions.

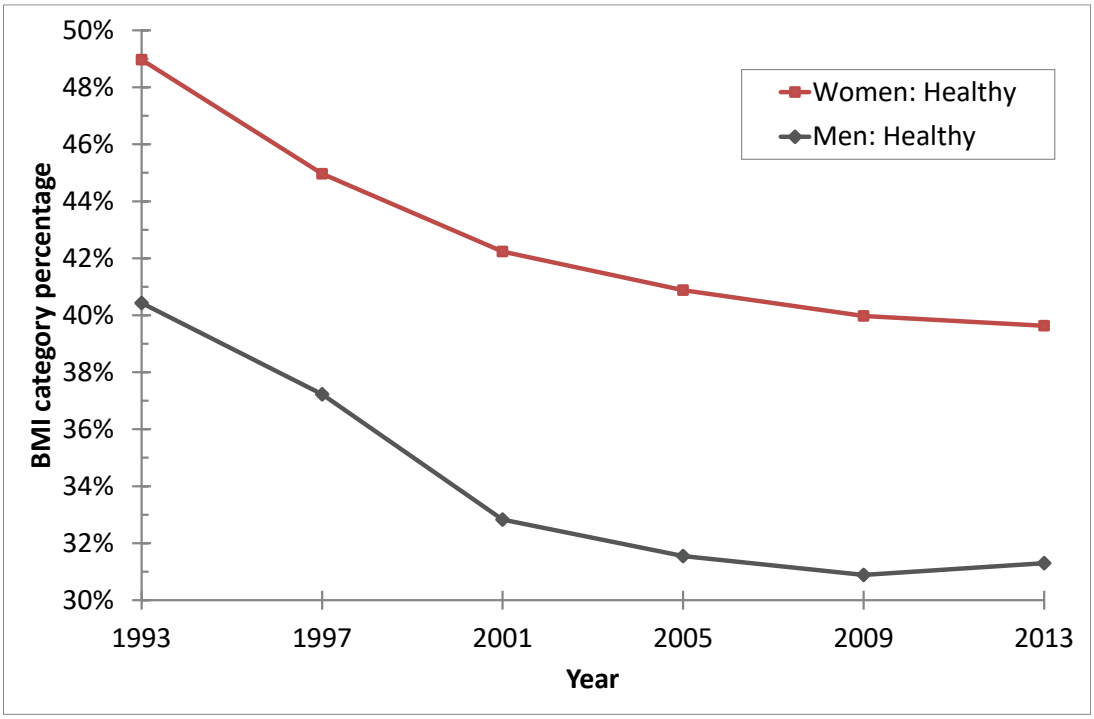

Figure 4.II.2 Healthy category percentages for the population distributions.

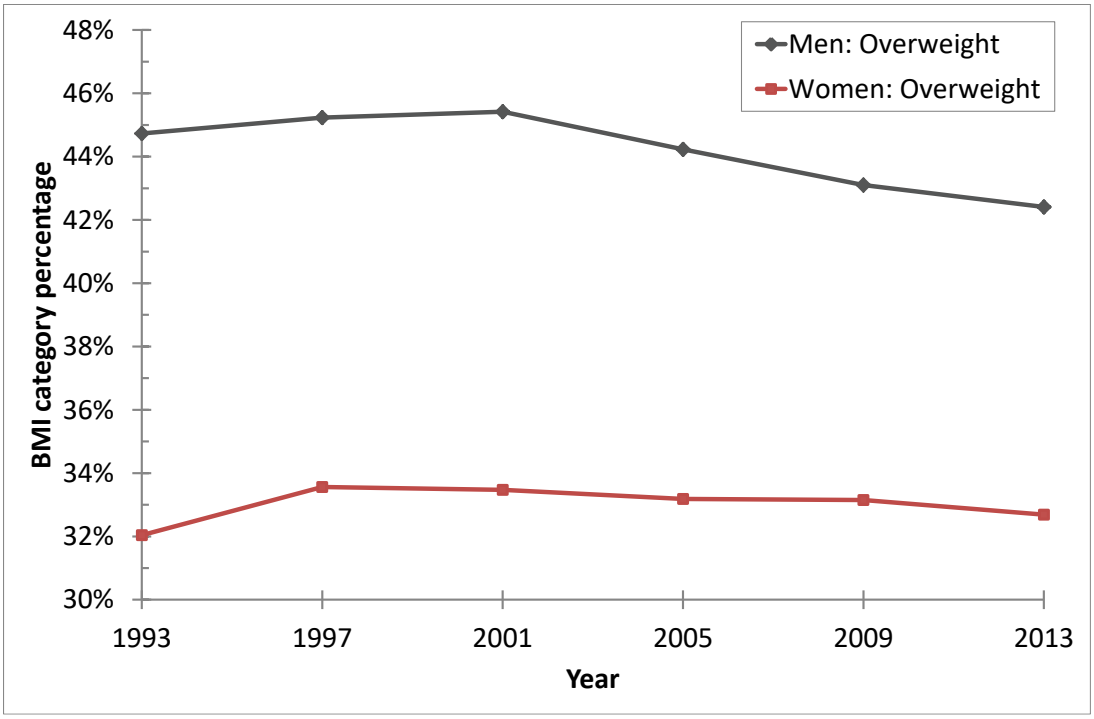

Figure 4.II.3 Overweight category percentages for the population distributions.

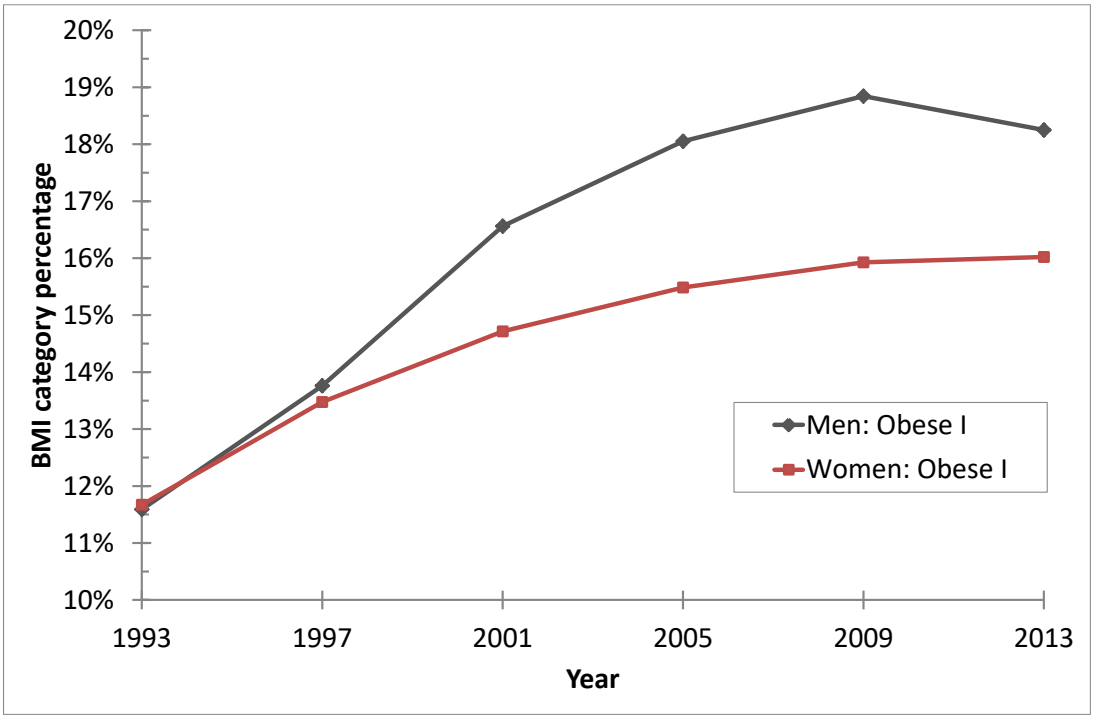

Figure 4.II.4 Obese I category percentages for the population distributions.

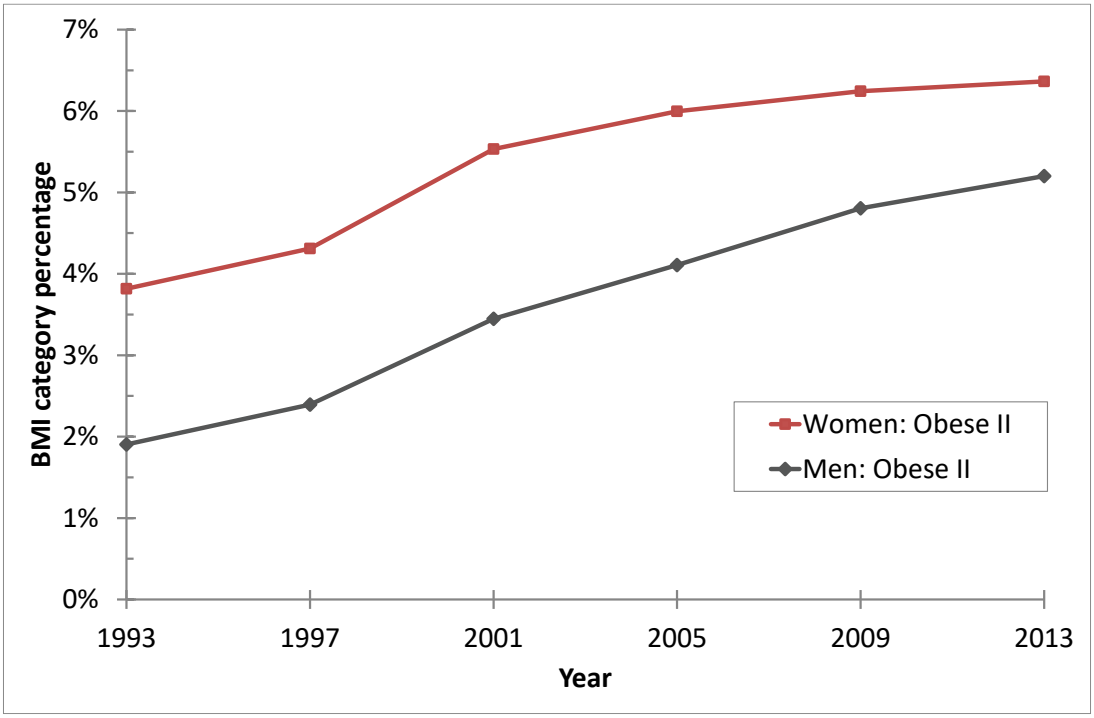

Figure 4.II.5 Obese II category percentages for the population distributions.

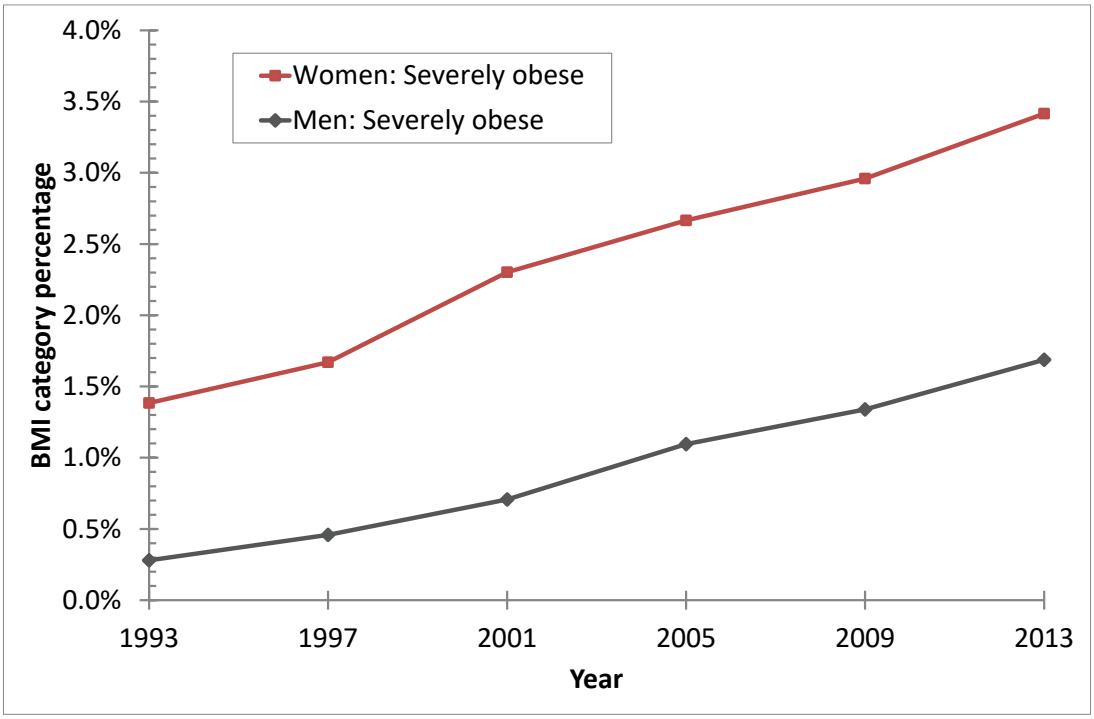

Figure 4.II.6 Severely obese category percentages for the population distributions.

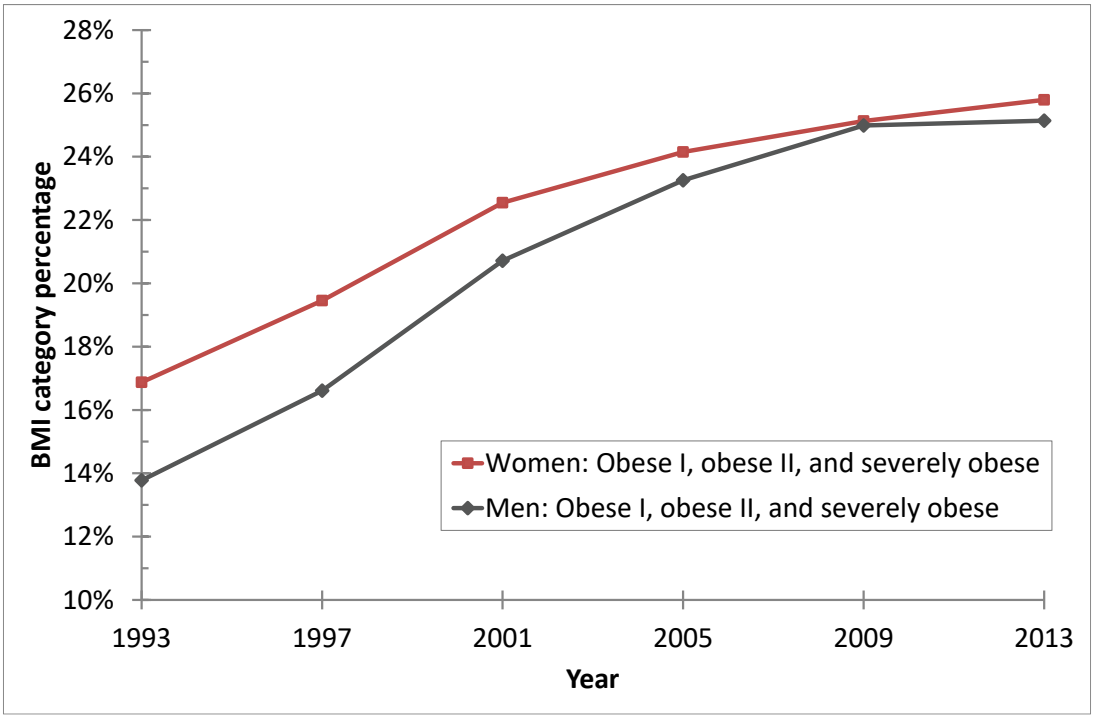

Figure 4.II.7 All obese category percentages for the population distributions.

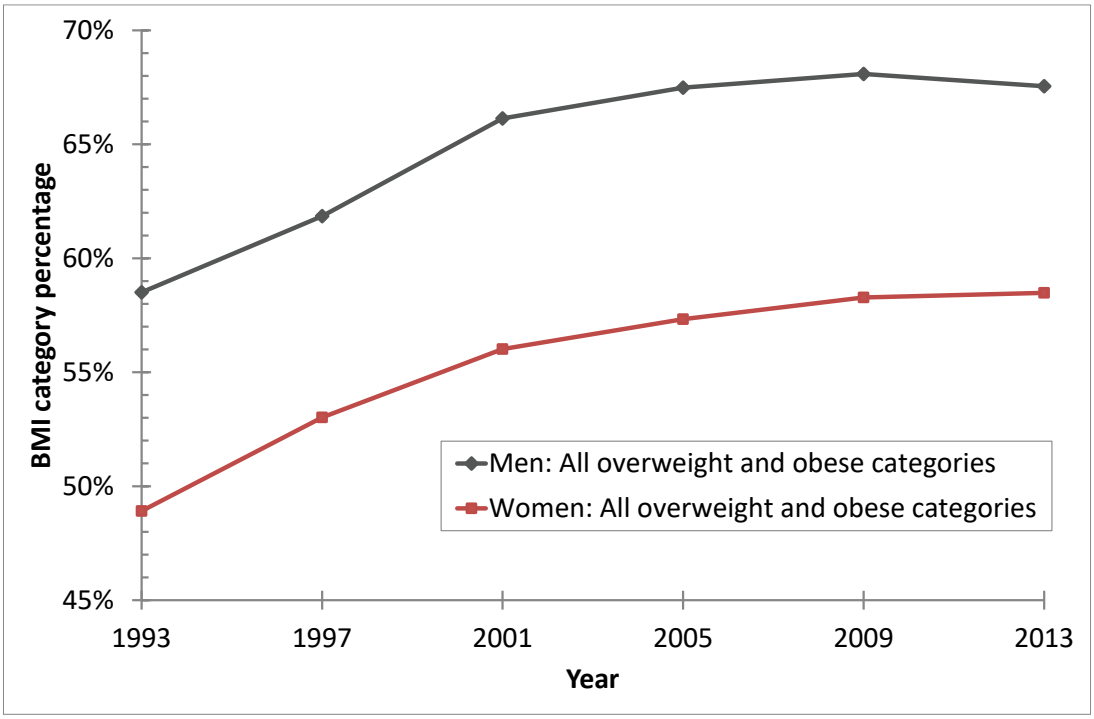

Figure 4.II.8 All overweight and obese category percentages for the population distributions.

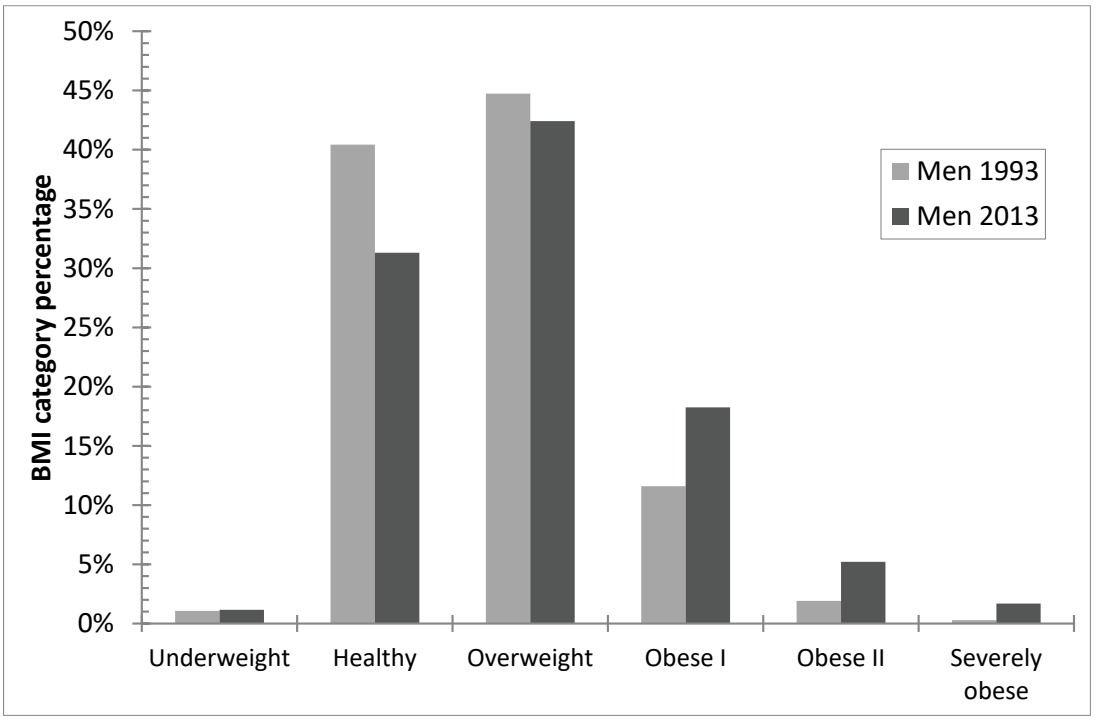

Figure 4.II.9 Bar chart of BMI categories for 1993 and 2013 for men.

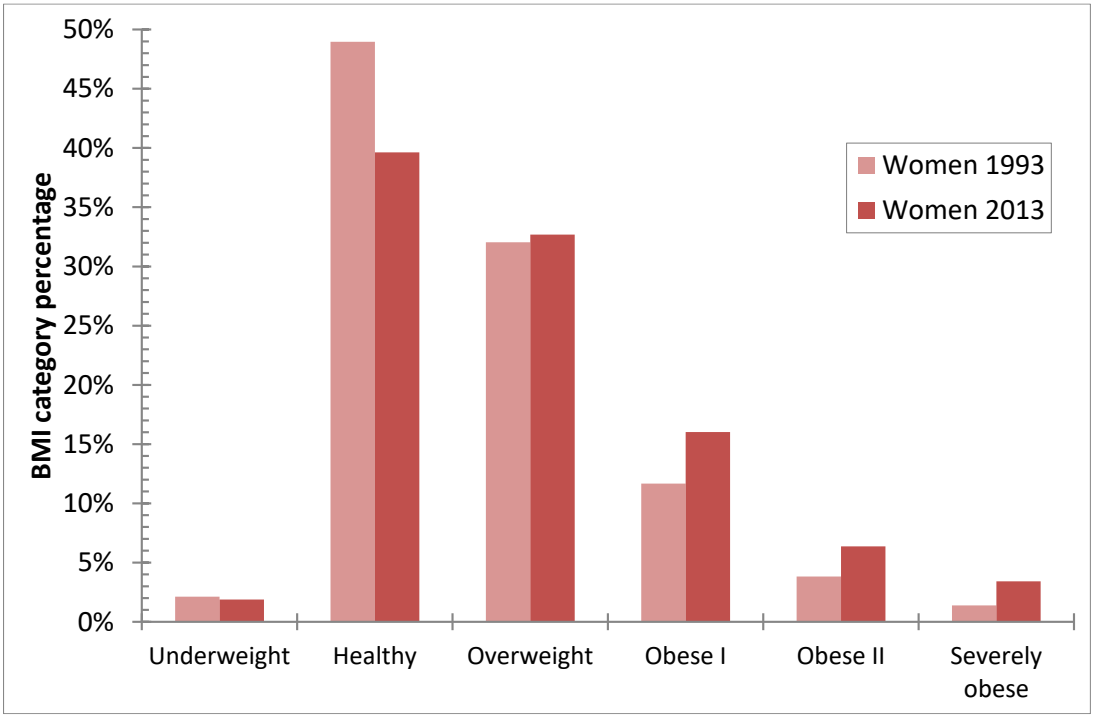

Figure 4.II.10 Bar chart of BMI categories for 1993 and 2013 for women.

Appendix 4.III Descriptive statistics for the data before smoothing

Tables 4.III.1 and 4.III.2 below show the statistics for the data distributions before smoothing. These are the distributions produced by combining the four years of data, adjusting for the population age distribution, and putting the data into 0.5 BMI intervals. These are the data values in the charts in Appendix 3.II. As discussed in Sections 4.4 and 4.5 in Chapter 4, the statistics are very similar to those for the smoothed population distributions, and in particular the smoothing process ensures that the mean, standard deviation and skewness are exactly the same.

For men, the median BMI values all differ from those of the smoothed distributions by at most 0.01. The category percentages differ by at most 0.2%, mainly being the same to 1 decimal place. There is some difference in the modal intervals due to irregularities in the data that are removed by the smoothing.

For women, the median BMI values all differ from those of the smoothed distributions by at most 0.01. The category percentages differ by at most 0.5% with about half being the same to 1 decimal place. Again, there is some difference in the modal intervals due to irregularities in the data that are removed by the smoothing.

Table 4.III.1 Descriptive statistics for the data distributions for men before smoothing.

	1993	1997	2001	2005	2009	2013
Mean	26.05	26.41	26.90	27.19	27.39	27.42
Median	25.75	26.10	26.55	26.79	26.87	26.87
Modal interval mid-point	25.75	25.75	26.25	25.75	26.25	26.25
Standard deviation	3.87	4.00	4.29	4.48	4.67	4.84
Skewness	0.75	0.63	0.71	0.72	0.87	0.89
Underweight (BMI < 18.5)	1.1%	1.0%	1.0%	1.0%	1.1%	1.2%
Healthy (18.5 ≤ BMI < 25.0)	40.4%	37.1%	32.9%	31.5%	30.9%	31.4%
Overweight (25.0 ≤ BMI < 30.0)	44.8%	45.4%	45.4%	44.4%	43.0%	42.4%
Obese I (30.0 ≤ BMI < 35.0)	11.5%	13.6%	16.6%	17.9%	18.9%	18.1%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	2.4%	3.5%	4.0%	4.8%	5.2%
Severely obese (BMI ≥ 40.0)	0.3%	0.5%	0.7%	1.1%	1.3%	1.7%

Table 4.III.2 Descriptive statistics for the data distributions for women before smoothing.

	1993	1997	2001	2005	2009	2013
Mean	25.76	26.18	26.65	26.88	27.03	27.13
Median	24.88	25.33	25.73	25.89	26.01	26.06
Modal interval mid-point	23.25	24.25	24.25	23.75	24.75	23.75
Standard deviation	4.95	5.04	5.38	5.54	5.63	5.77
Skewness	1.32	1.05	1.06	1.05	1.05	1.06
Underweight (BMI < 18.5)	2.1%	2.1%	1.7%	1.8%	1.8%	1.8%
Healthy (18.5 ≤ BMI < 25.0)	49.0%	44.9%	42.3%	41.0%	40.3%	39.7%
Overweight (25.0 ≤ BMI < 30.0)	31.9%	33.6%	33.5%	33.3%	32.7%	32.8%
Obese I (30.0 ≤ BMI < 35.0)	11.7%	13.4%	14.7%	15.3%	15.9%	16.0%
Obese II (35.0 ≤ BMI < 40.0)	3.8%	4.4%	5.4%	6.0%	6.3%	6.2%
Severely obese (BMI ≥ 40.0)	1.4%	1.7%	2.3%	2.7%	3.0%	3.5%

Appendix 4.IV Percentile values

Tables 4.IV.1 and 4.IV.2 give the percentile and quartile values calculated for the population distributions.

Table 4.IV.1 Percentile values for the population distributions for men.

	1993	1997	2001	2005	2009	2013
Percentiles						
1%	18.43	18.56	18.46	18.53	18.47	18.31
5%	20.26	20.45	20.45	20.56	20.70	20.55
10%	21.41	21.60	21.73	21.85	21.97	21.85
20%	22.88	23.09	23.41	23.50	23.58	23.50
30%	23.94	24.20	24.60	24.72	24.79	24.72
40%	24.87	25.17	25.60	25.78	25.84	25.81
50%	25.76	26.10	26.55	26.79	26.88	26.87
60%	26.68	27.05	27.56	27.83	27.98	28.00
70%	27.70	28.11	28.70	29.02	29.26	29.27
80%	28.93	29.43	30.12	30.55	30.86	30.93
90%	30.93	31.52	32.34	32.94	33.31	33.58
95%	32.87	33.52	34.45	35.13	35.73	36.26
99%	36.95	37.83	39.16	40.29	40.88	41.87
Quartiles						
25%	23.44	23.67	24.04	24.14	24.21	24.14
50%	25.76	26.10	26.55	26.79	26.88	26.87
75%	28.27	28.73	29.36	29.73	30.00	30.02

Table 4.IV.2 Percentile values for the population distributions for women.

	1993	1997	2001	2005	2009	2013
Percentiles						
1%	17.75	17.77	17.97	17.87	17.94	17.87
5%	19.47	19.57	19.69	19.73	19.74	19.66
10%	20.46	20.62	20.73	20.81	20.84	20.78
20%	21.77	22.01	22.17	22.27	22.37	22.34
30%	22.83	23.15	23.38	23.50	23.62	23.62
40%	23.84	24.23	24.54	24.68	24.80	24.82
50%	24.88	25.34	25.72	25.90	26.01	26.07
60%	26.03	26.54	27.03	27.26	27.39	27.49
70%	27.41	27.98	28.59	28.85	29.05	29.17
80%	29.26	29.88	30.58	30.97	31.18	31.37
90%	32.18	32.82	33.92	34.33	34.61	34.90
95%	35.18	35.74	36.82	37.45	37.72	38.25
99%	41.17	41.87	43.47	43.84	44.52	44.73
Quartiles						
25%	22.31	22.60	22.79	22.90	23.01	23.01
50%	24.88	25.34	25.72	25.90	26.01	26.07
75%	28.25	28.85	29.50	29.82	30.03	30.18

Increases in percentiles from 1993 to 2013 in percentage terms

A chart of the increases in the percentile values from 1993 to 2013 is given in the main report in Figure 4.33. The values are also converted to weight values, using average height, and the charts for this are Figures 4.38 and 4.39. The chart here in Figure 4.IV.1 gives the percentile increases as a percentage of the 1993 percentile value. Some of the percentage values are listed in Section 4.10 of the main report.

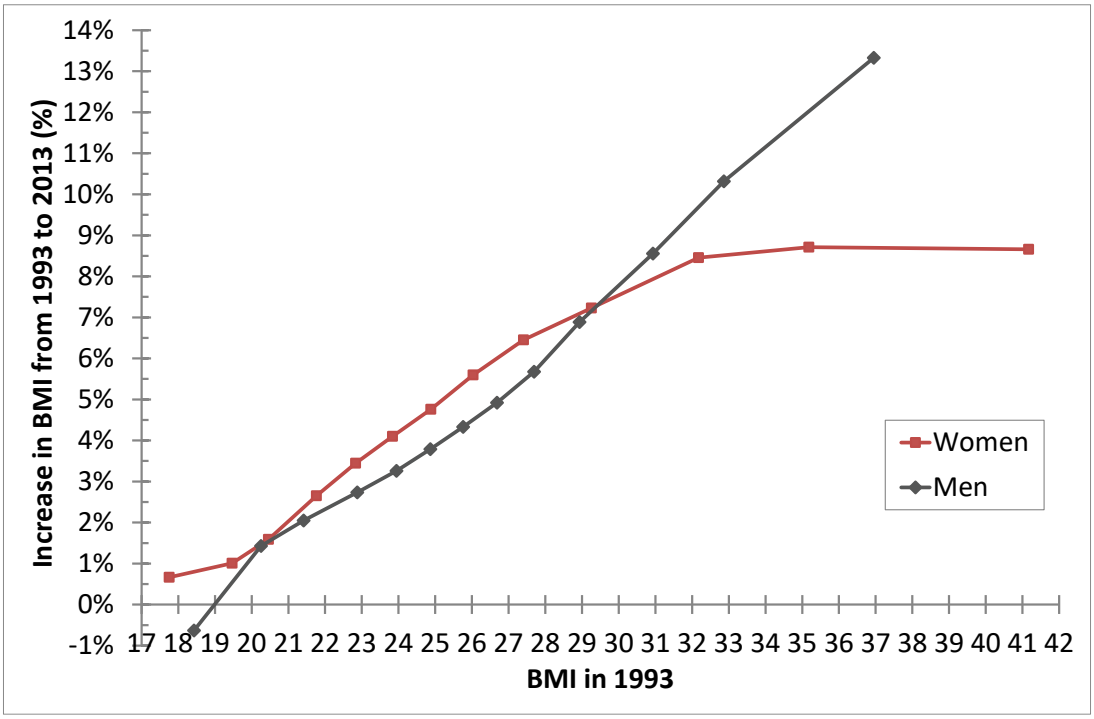

Figure 4.IV.1 Percentage increases in BMI for the percentile increases from 1993 to 2013.

Comparison with the results of Wardle and Boniface (2008)

Section 4.8.4 of the main report describes the paper of Wardle and Boniface (2008), who calculated percentile increases from the HSE data from 1993-1994 to 2002-2003. The charts in Figures 4.IV.2 and 4.IV.3 compare the results from the paper with the percentile increases from the 1993 distributions to the 2001 and 2005 distributions for the work in this report. As explained in Section 4.8.4, the Wardle and Boniface values were obtained by measuring the points from the charts in the paper and the x-axis values were adjusted to the format used in this report of the starting BMI value (rather than the mean of the starting and ending values used in Wardle and Boniface (2008)).

There are several differences in the details of the method and the data used, as explained in Section 4.8.4, but the results should be similar. Figures 4.IV.2 and 4.IV.3 show that this is the case, with the Wardle and Boniface values being closest to the increases from 1993 to 2005, particularly for the data for women. The general pattern of higher increases for higher BMI values in an approximate linear relationship is the same in both cases.

The reference for the paper is:

Wardle, J. and Boniface, D. (2008). Changes in the distributions of body mass index and waist circumference in English adults, 1993/1994 to 2002/2003, International Journal of Obesity, 32, 527–532.
https://doi.org/10.1038/sj.ijo.0803740

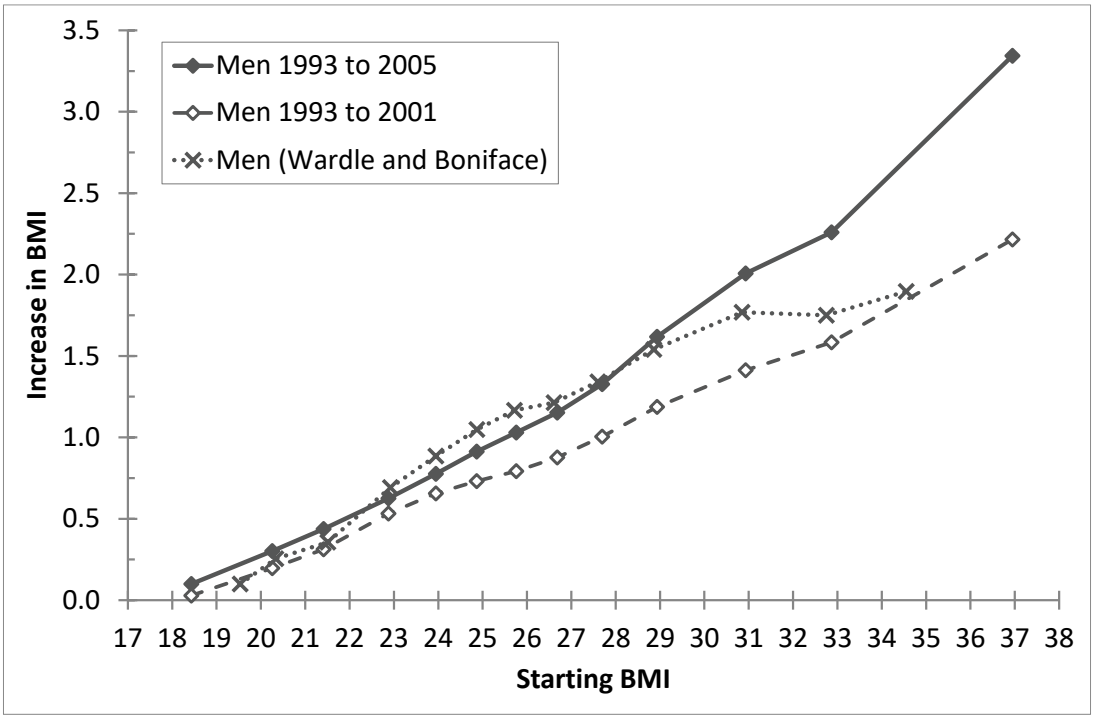

Figure 4.IV.2 Comparison of percentile increases with Wardle and Boniface (2008) for men.

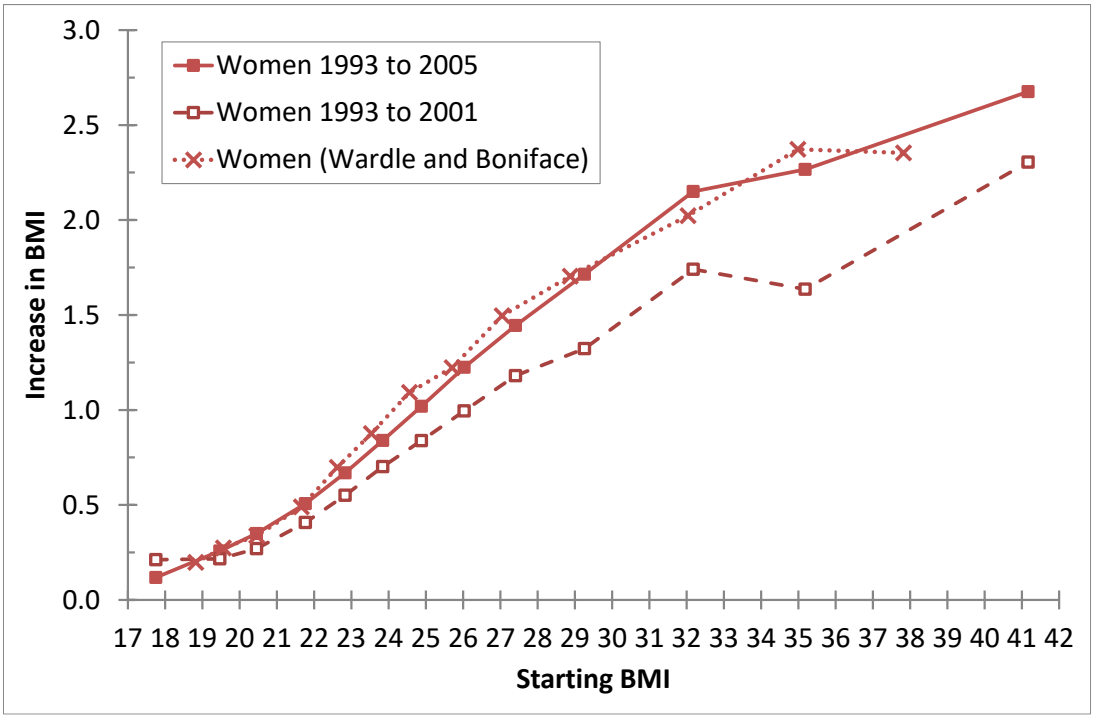

Figure 4.IV.3 Comparison of percentile increases with Wardle and Boniface (2008) for women.

Appendix 5.I Scaling model results

Charts of each scaling model

The charts here show the scaling models individually. These are the same results as in Figures 5.1 to 5.5 in Chapter 5, but showing the distributions for men and women separately gives a clearer view with less overlapping of the curves. These charts also have markers showing the interval mid-point values for the scaling models. The x-axis goes up to 50 to show more of the right tail.

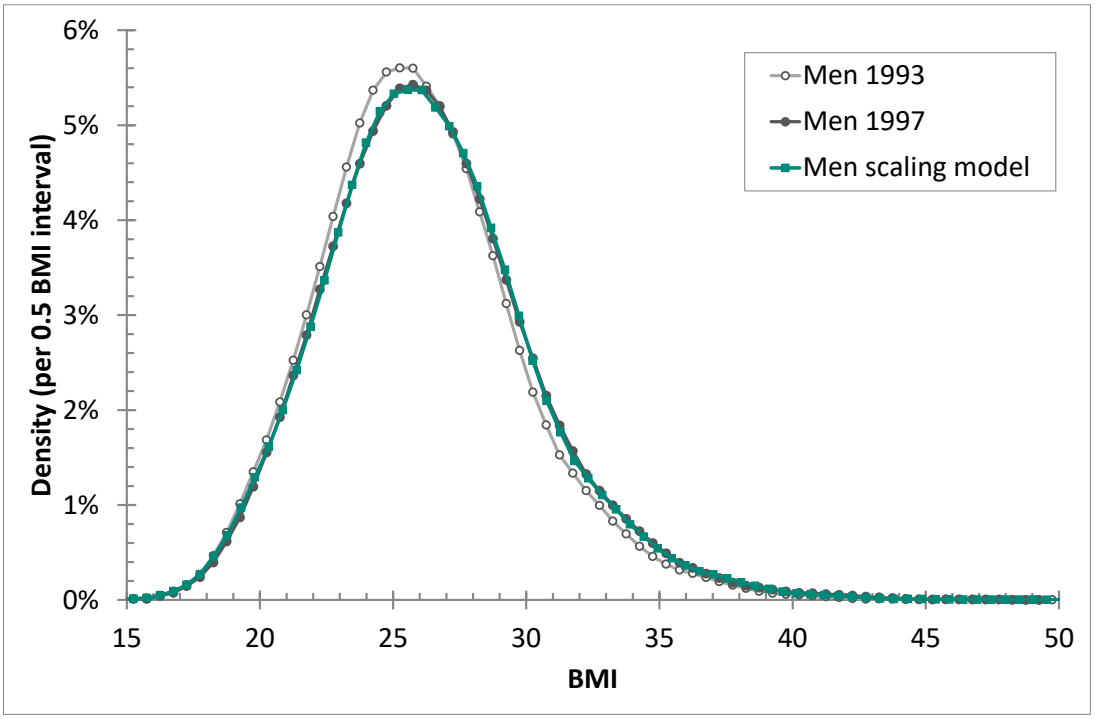

Figure 5.I.1 Scaling model for men for 1993 to 1997.

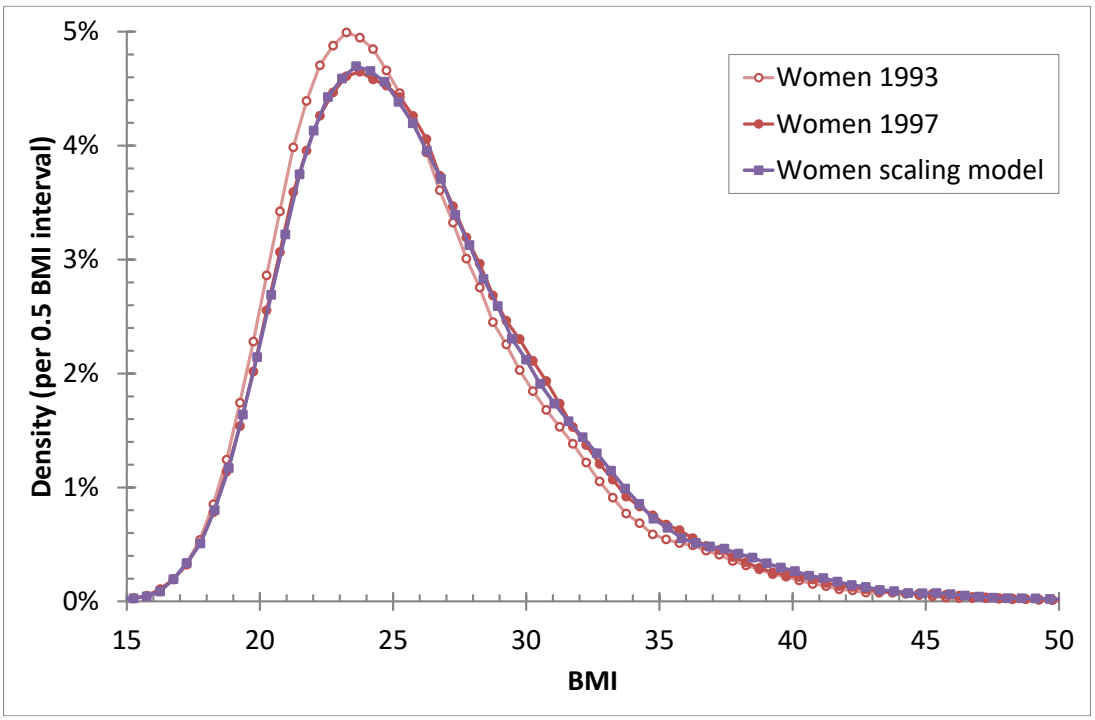

Figure 5.I.2 Scaling model for women for 1993 to 1997.

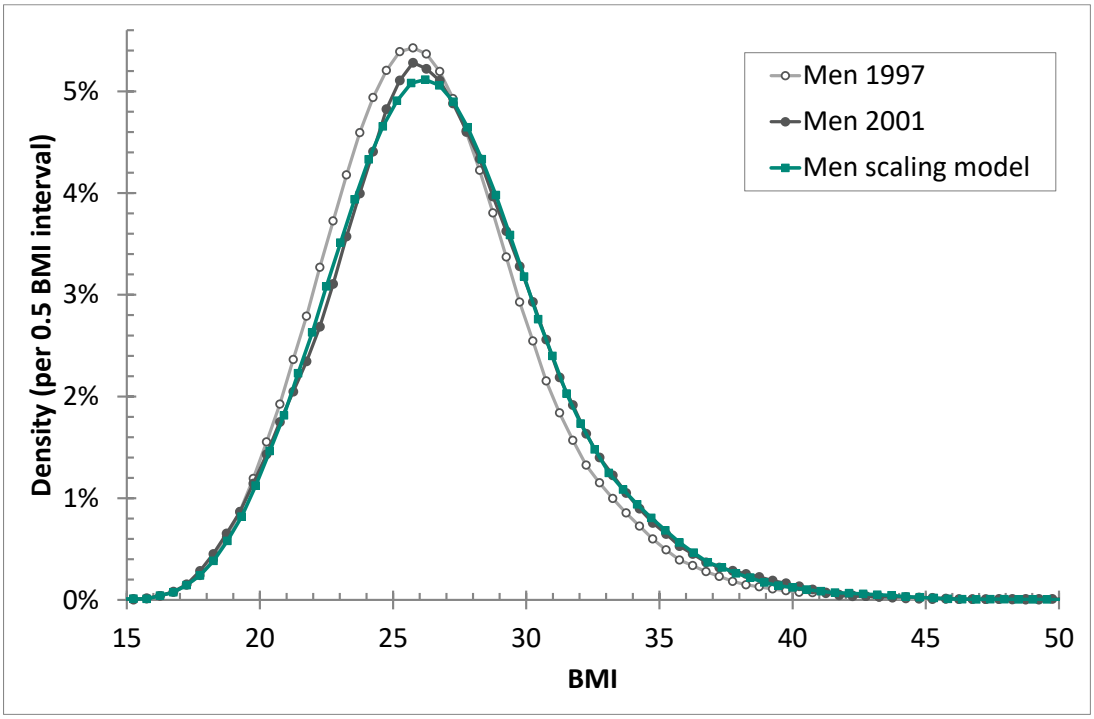

Figure 5.I.3 Scaling model for men for 1997 to 2001.

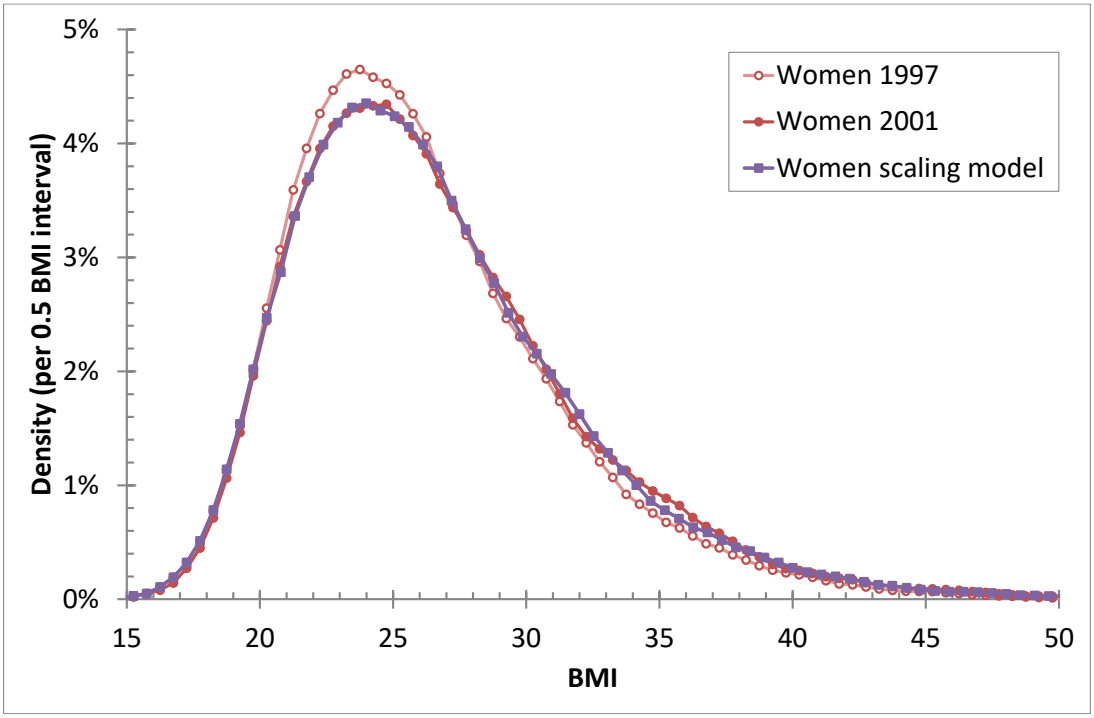

Figure 5.I.4 Scaling model for women for 1997 to 2001.

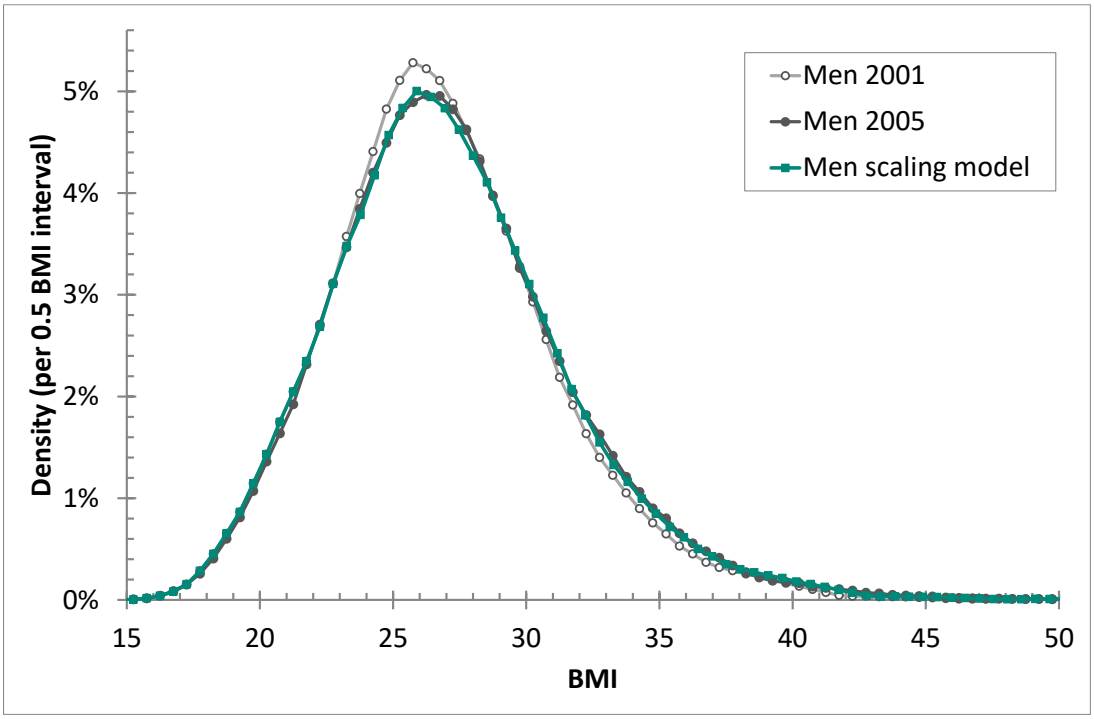

Figure 5.I.5 Scaling model for men for 2001 to 2005.

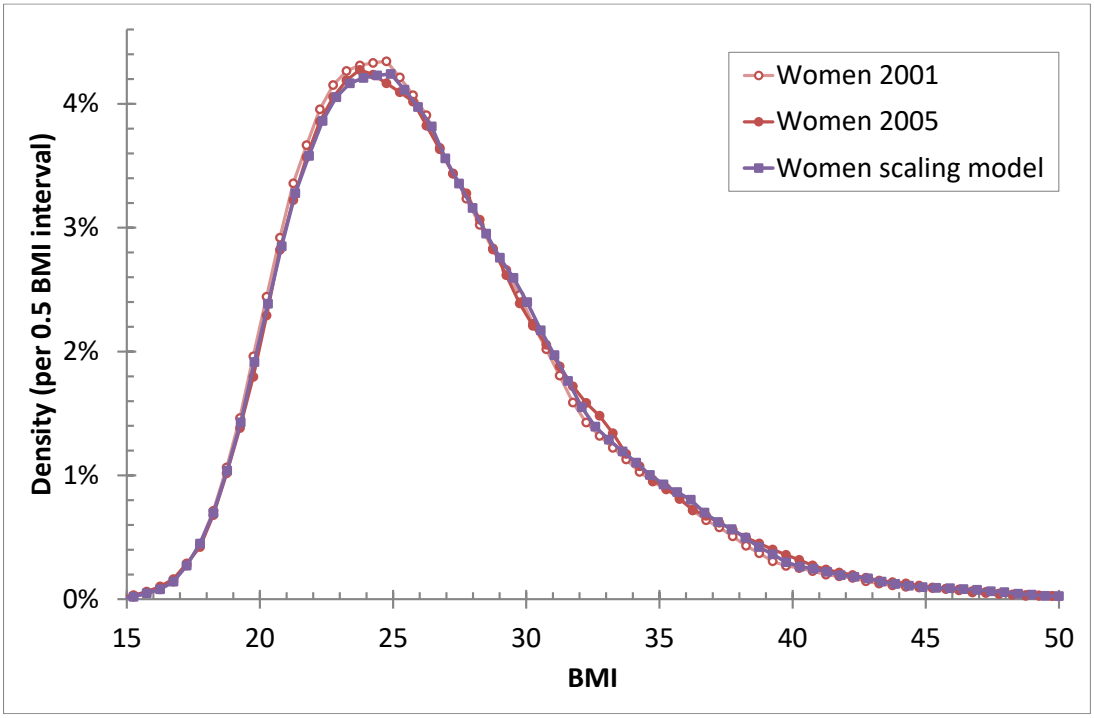

Figure 5.I.6 Scaling model for women for 2001 to 2005.

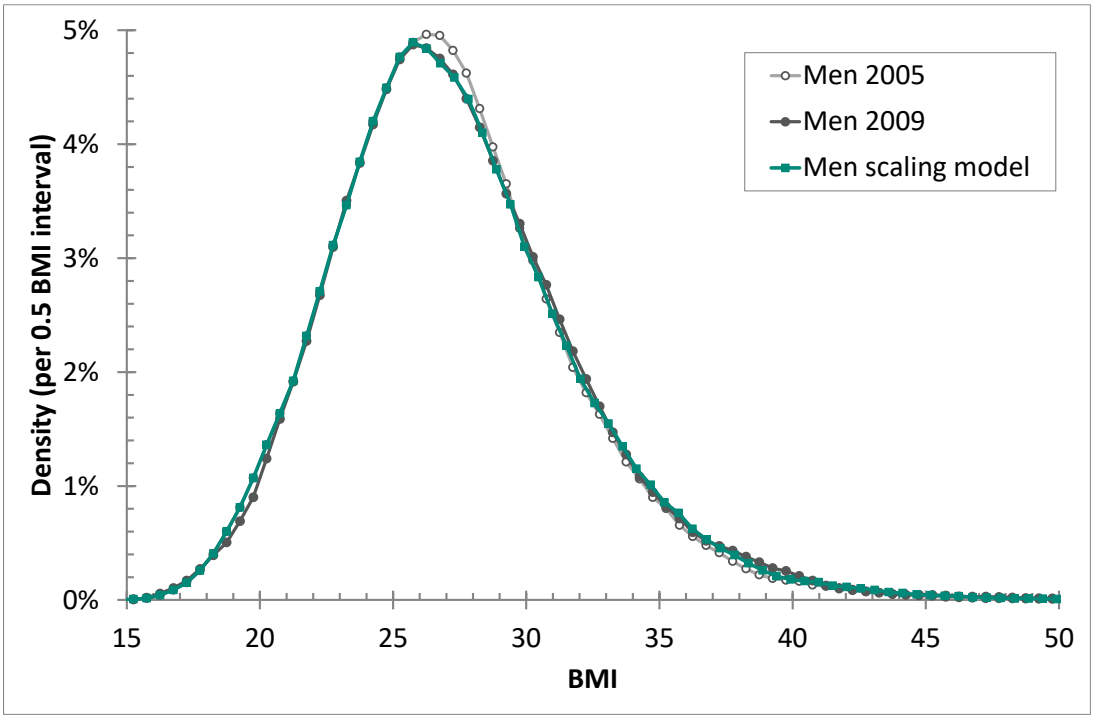

Figure 5.I.7 Scaling model for men for 2005 to 2009.

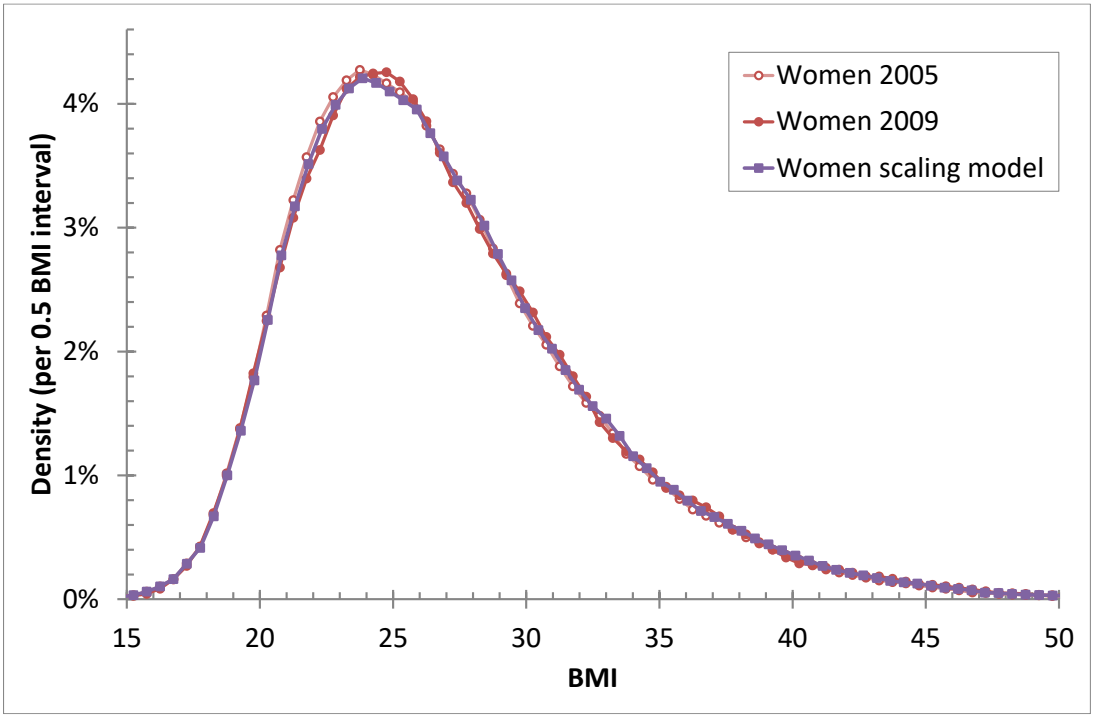

Figure 5.I.8 Scaling model for women for 2005 to 2009.

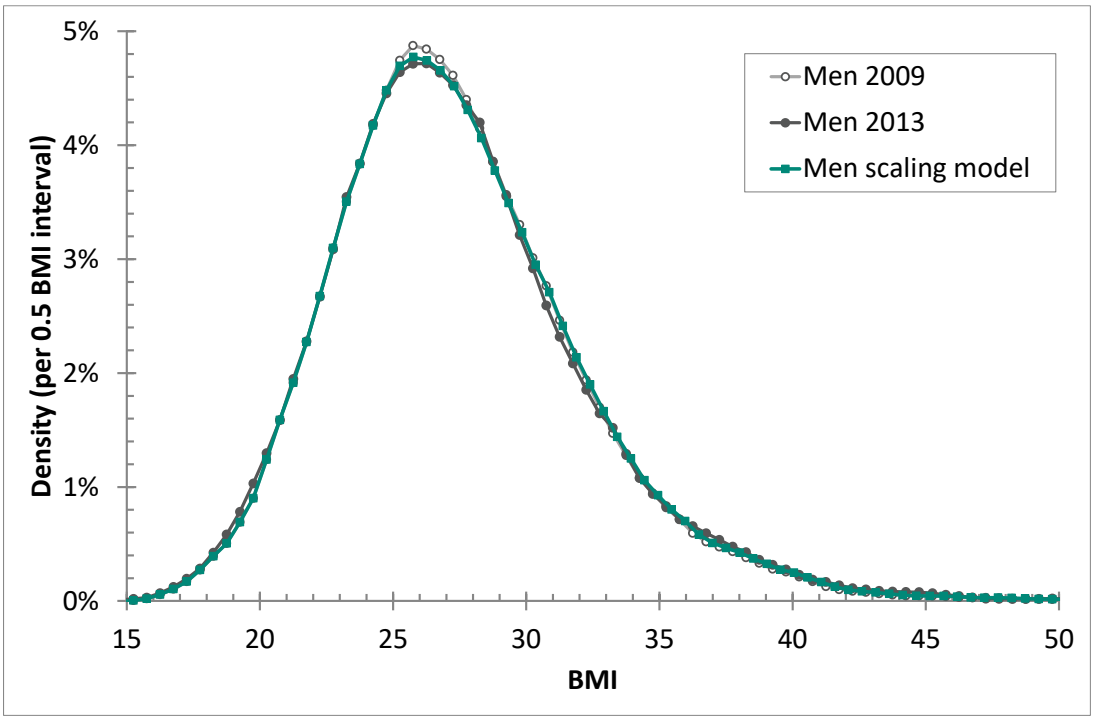

Figure 5.I.9 Scaling model for men for 2009 to 2013.

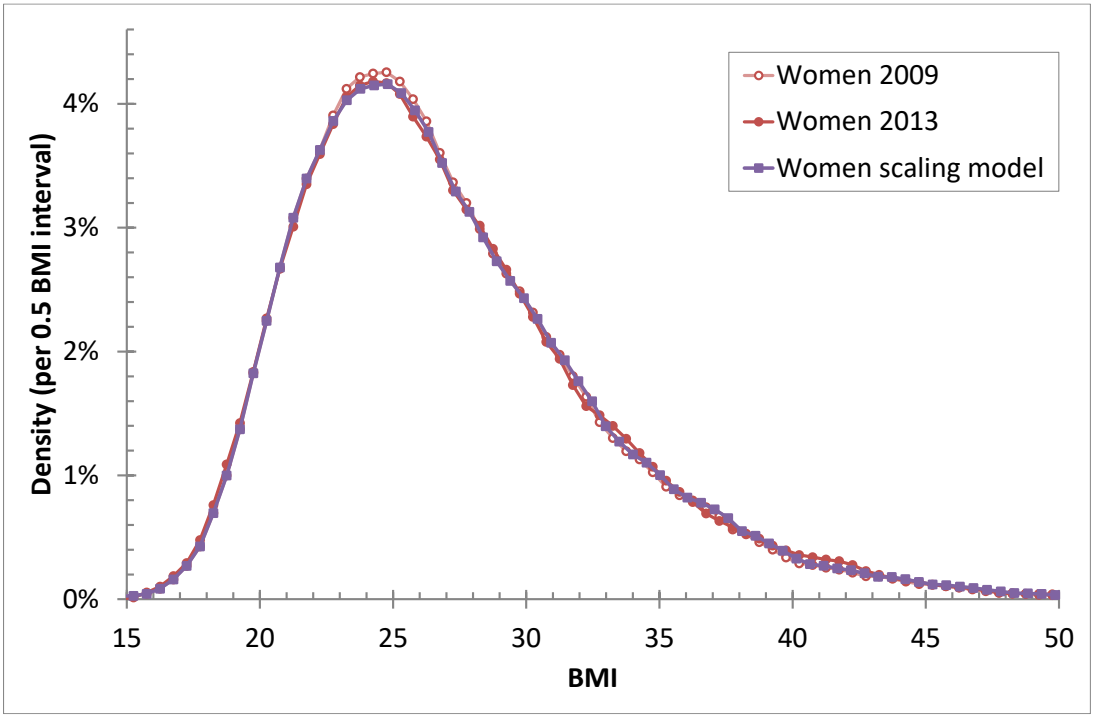

Figure 5.I.10 Scaling model for women for 2009 to 2013.

Charts of differences for the scaled model

These charts show the differences between the models and the target distributions, as shown in the previous charts in this appendix. There are two charts for each year with the first showing the differences and the second the cumulative differences.

The intervals and the mid-point x-axis values used are those for the scaling model. The scaling model y-axis values are therefore the values calculated for the model distribution. The y-axis values for the actual target distributions are linearly interpolated to the same x-axis point.

The difference charts show the differences between these y-axis values, which are the density values per 0.5 BMI interval. All differences are less than 0.2% in magnitude and so are small. The differences tend to oscillate and there are no long BMI intervals where the model is always higher or lower than the actual.

These differences are used in the fitness function, as explained in Section 5.3 in Chapter 5 of the main report. For the fitness function the difference values are squared and are multiplied by the interval width.

The cumulative difference charts show the cumulative sum of the differences. In calculating the cumulative difference, the differences are adjusted to the actual percentages in each interval. This requires dividing the density value by 0.5 and multiplying by the actual interval width. This ensures that the cumulative differences match the total percentages for the distributions up to the end of each interval. The values are plotted on the charts at the end points of the intervals. The cumulative differences also never get particularly large indicating a good match between the model and target distributions.

The linear interpolation process for the actual distribution values means that the total percentage differs very slightly from 100%. Hence, the final cumulative difference is not exactly zero but is very close to zero.

Overall, the charts here support the impression from the charts of the model distributions in Figures 5.I.1 – 5.I.10 that the models match the actual distributions well. Hence, a linear scaling transformation is a good model of the changes over time in the distributions.

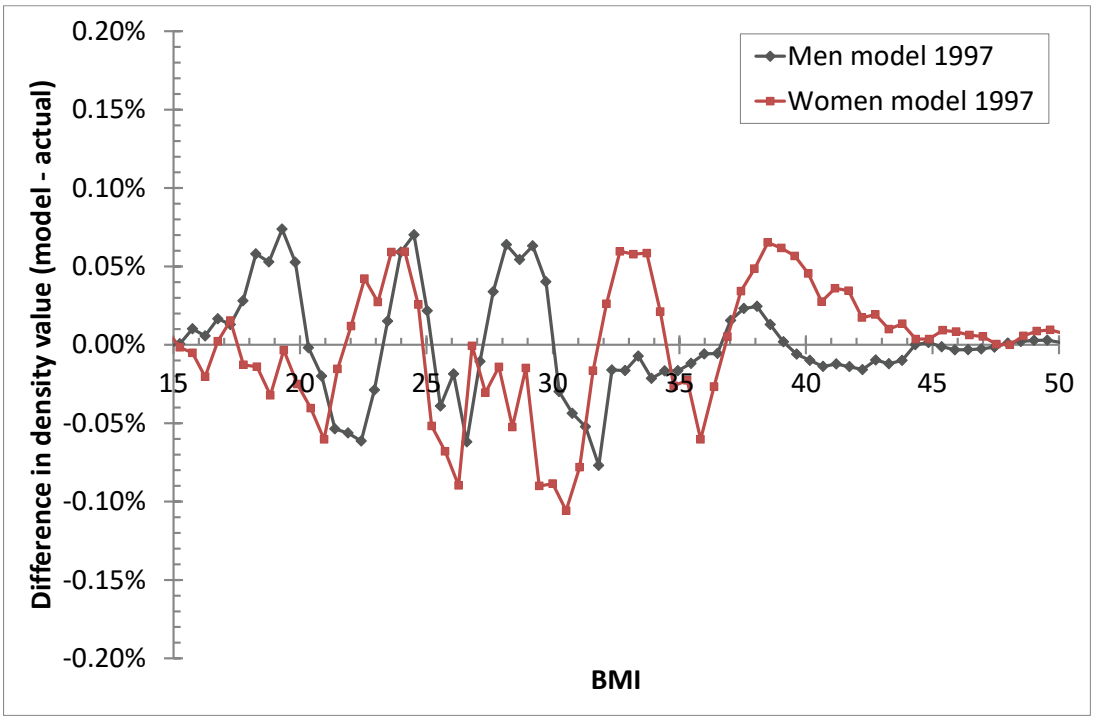

Figure 5.I.11 Scaling model differences for 1993 to 1997.

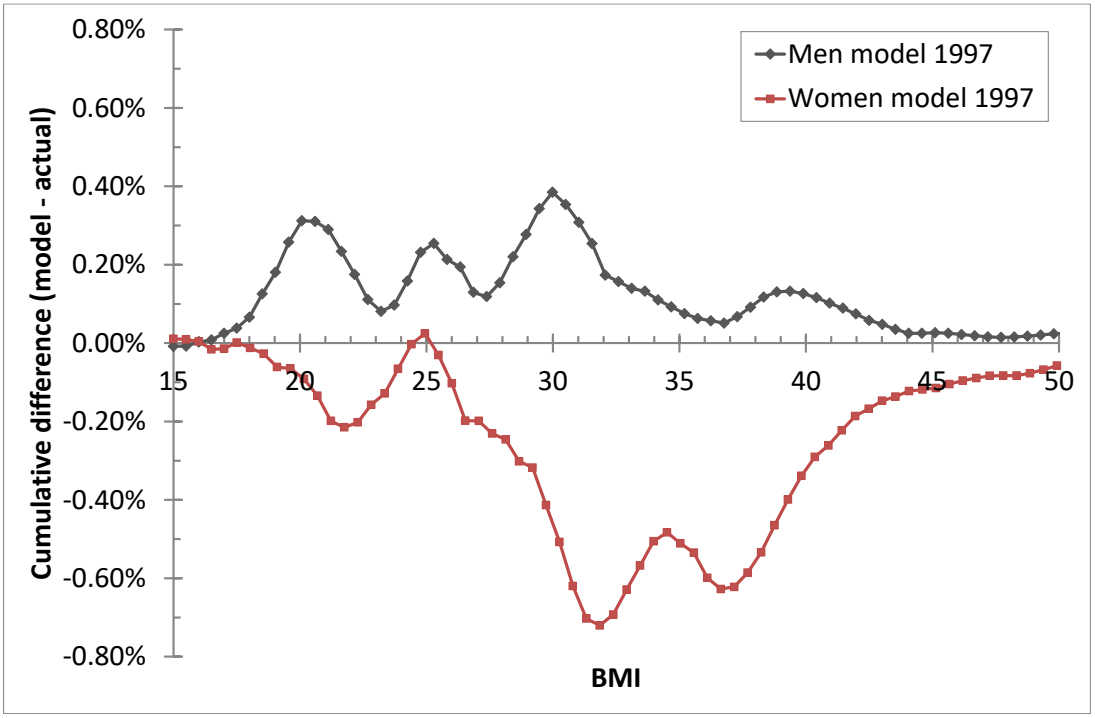

Figure 5.I.12 Scaling model cumulative differences for 1993 to 1997.

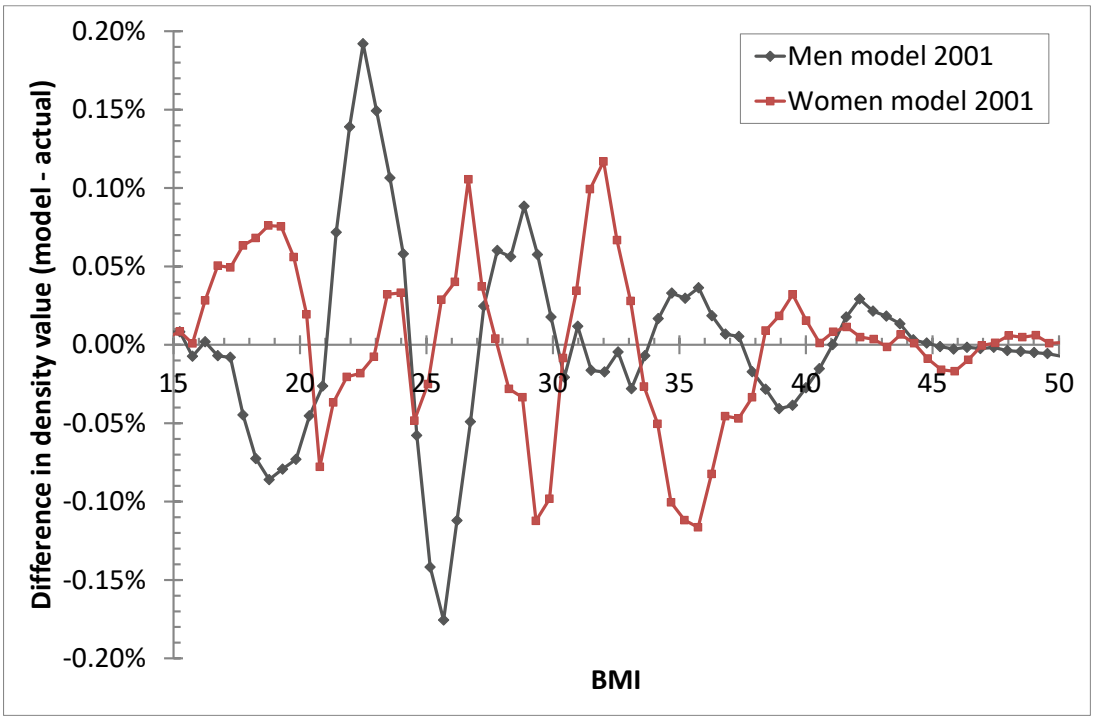

Figure 5.I.13 Scaling model differences for 1997 to 2001.

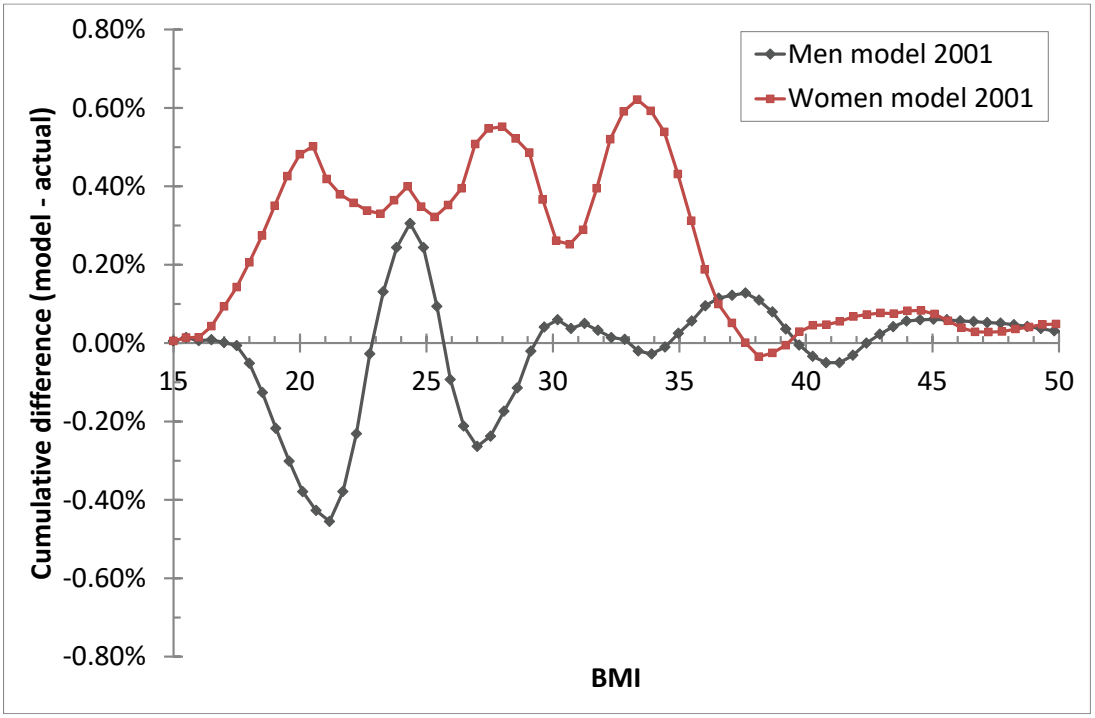

Figure 5.I.14 Scaling model cumulative differences for 1997 to 2001.

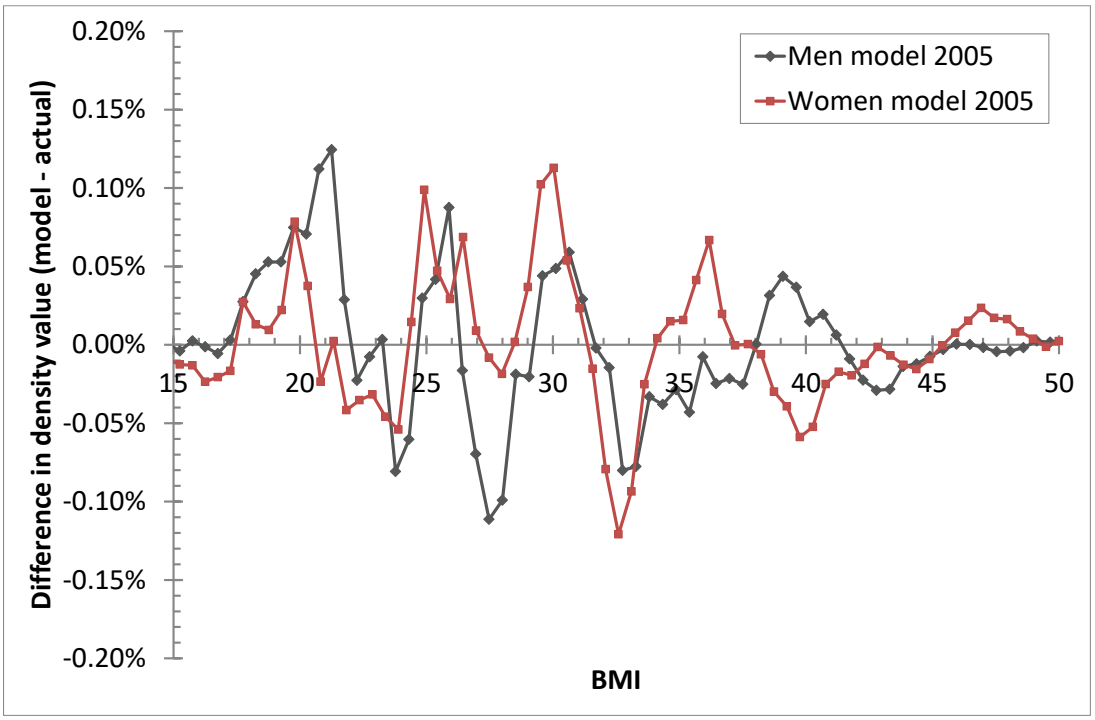

Figure 5.I.15 Scaling model differences for 2001 to 2005.

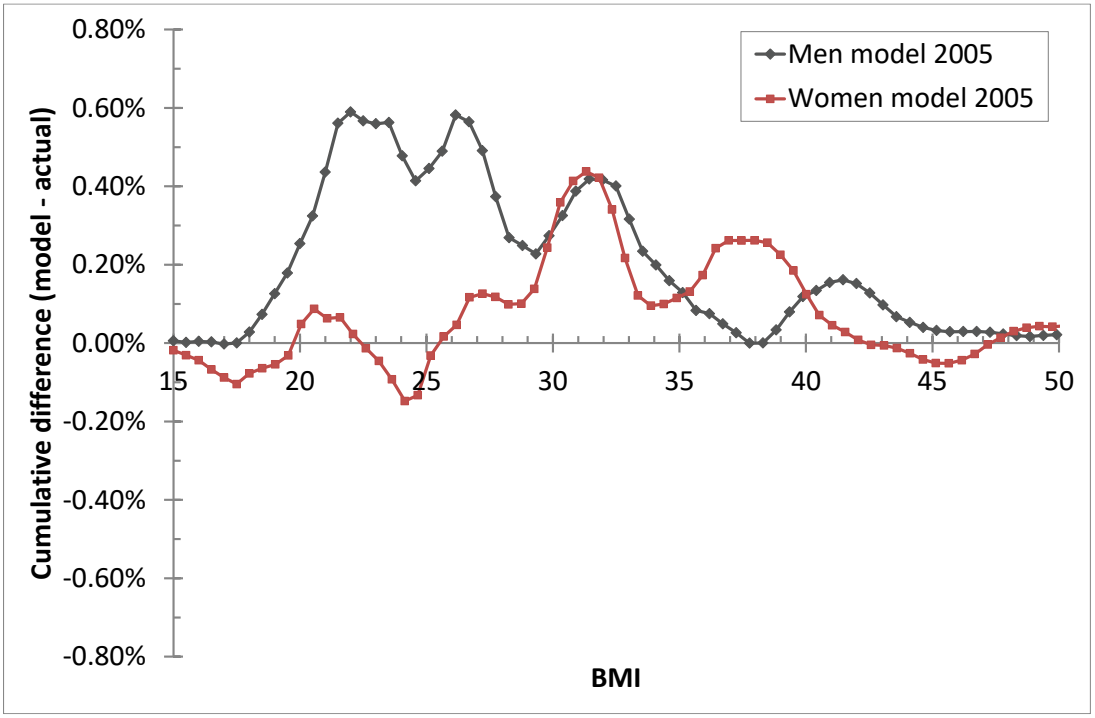

Figure 5.I.16 Scaling model cumulative differences for 2001 to 2005.

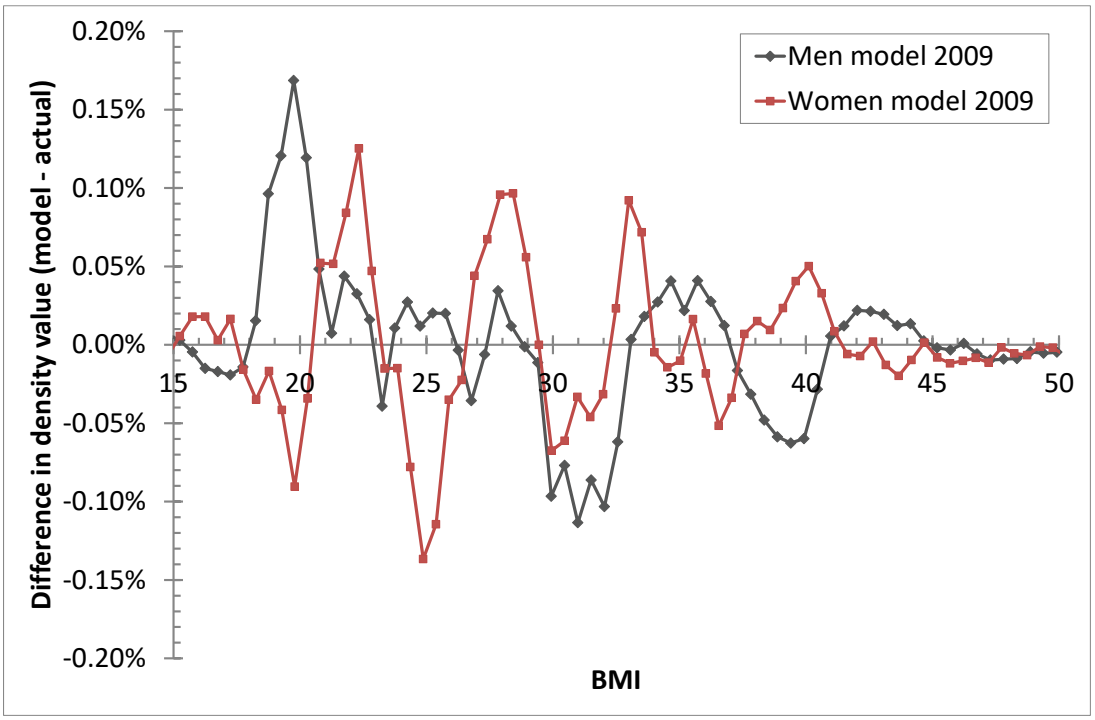

Figure 5.I.17 Scaling model differences for 2005 to 2009.

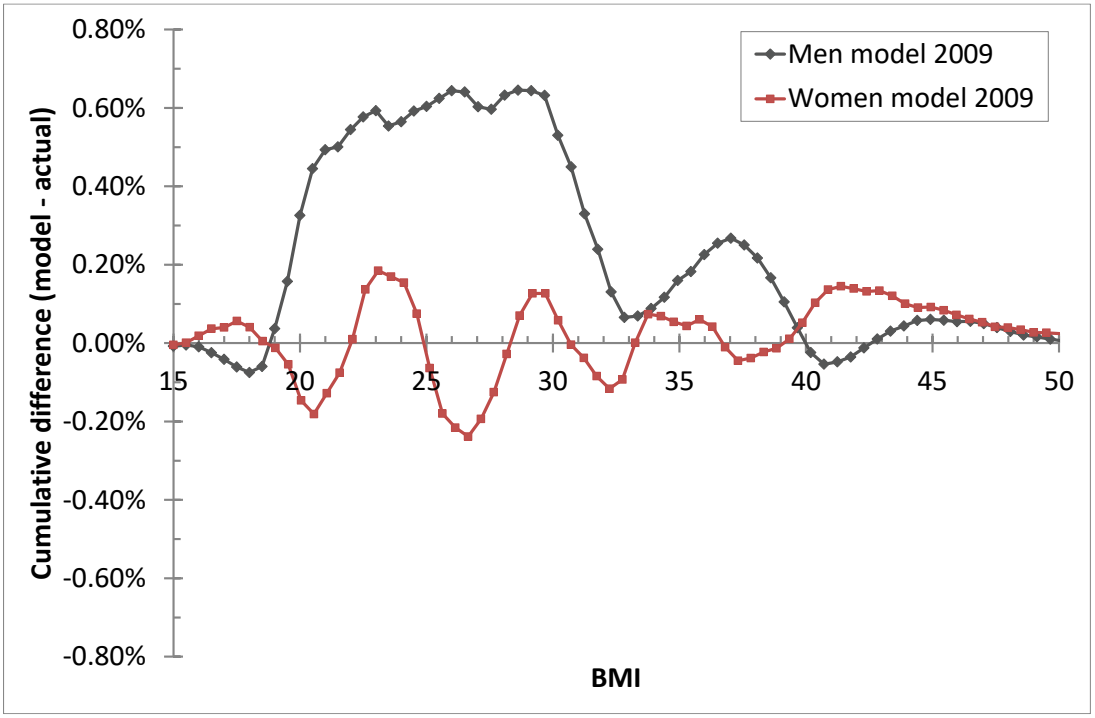

Figure 5.I.18 Scaling model cumulative differences for 2005 to 2009.

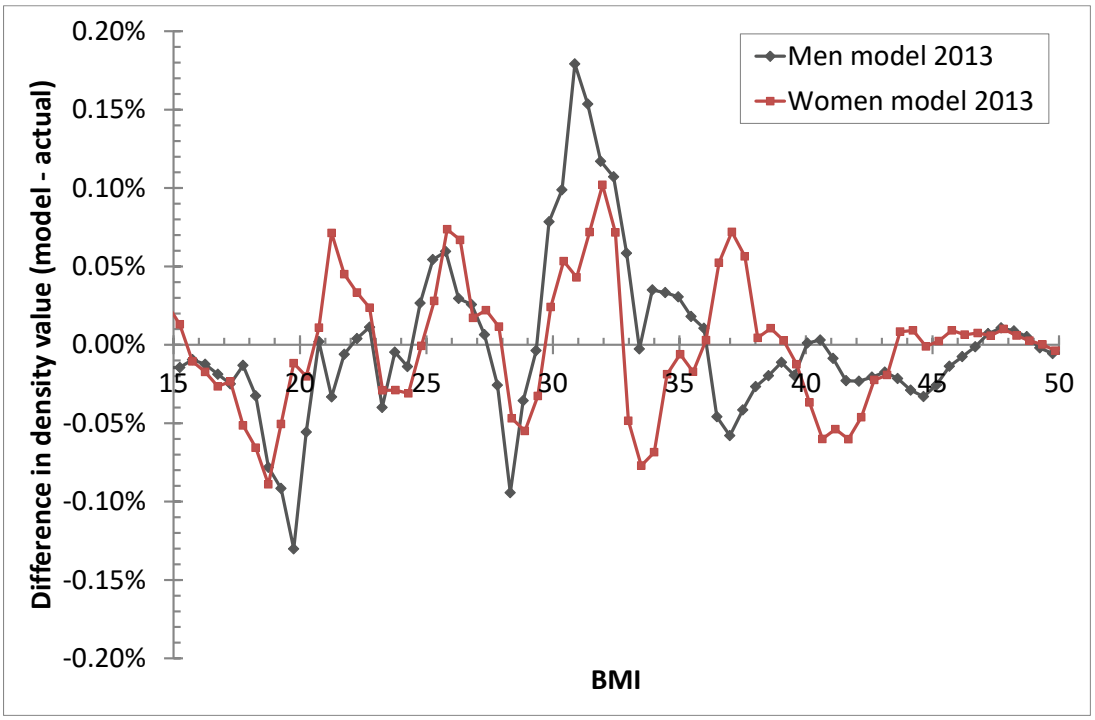

Figure 5.I.19 Scaling model differences for 2009 to 2013.

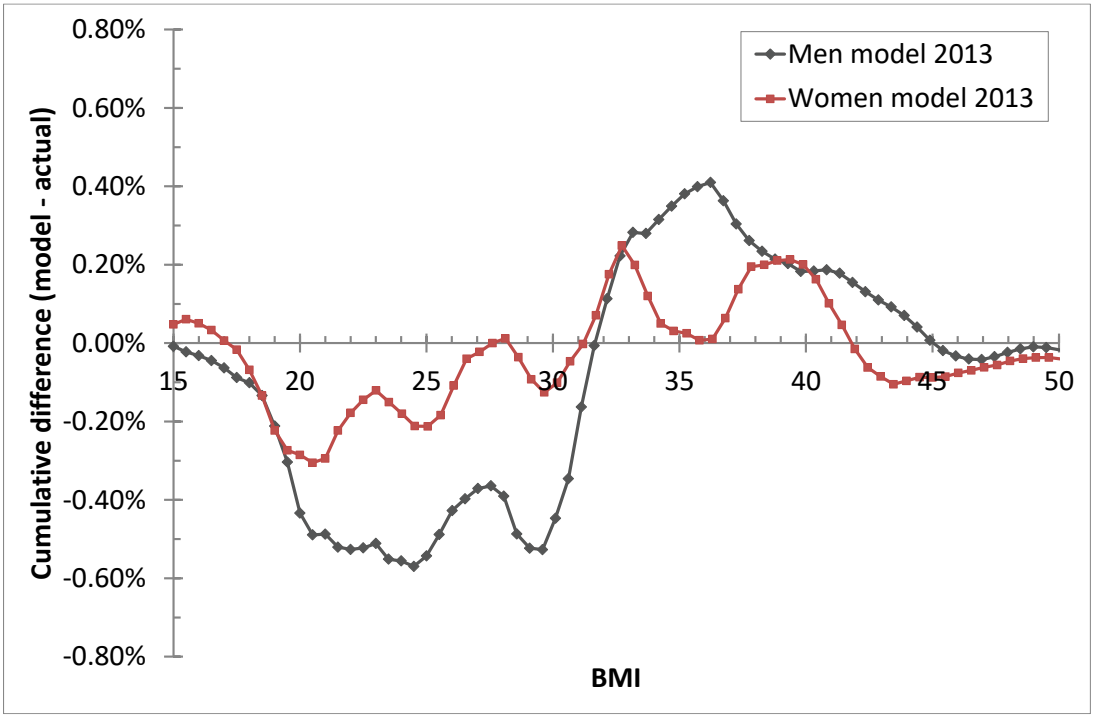

Figure 5.I.20 Scaling model cumulative differences for 2009 to 2013.

Appendix 5.II Alternative models for men for 2009 to 2013

Section 5.5 in the main report explains that there are two alternative models for men for 2009 to 2013 giving a similar fitness value. The model chosen has: scaling starting point 25.25, scaling factor 1.021, fitness value 9.06×10^{-6}. The chart for this model is Figure 5.II.1 (the same as Figure 5.I.9). The alternative model has: scaling starting point 30.25, scaling factor 1.077, fitness value 7.16×10^{-6}. This is shown in Figure 5.II.2. This model only scales the right end of the distribution, and fits the right tail well but not the peak. The model in Figure 5.II.1 was preferred as matching better across the whole distribution.

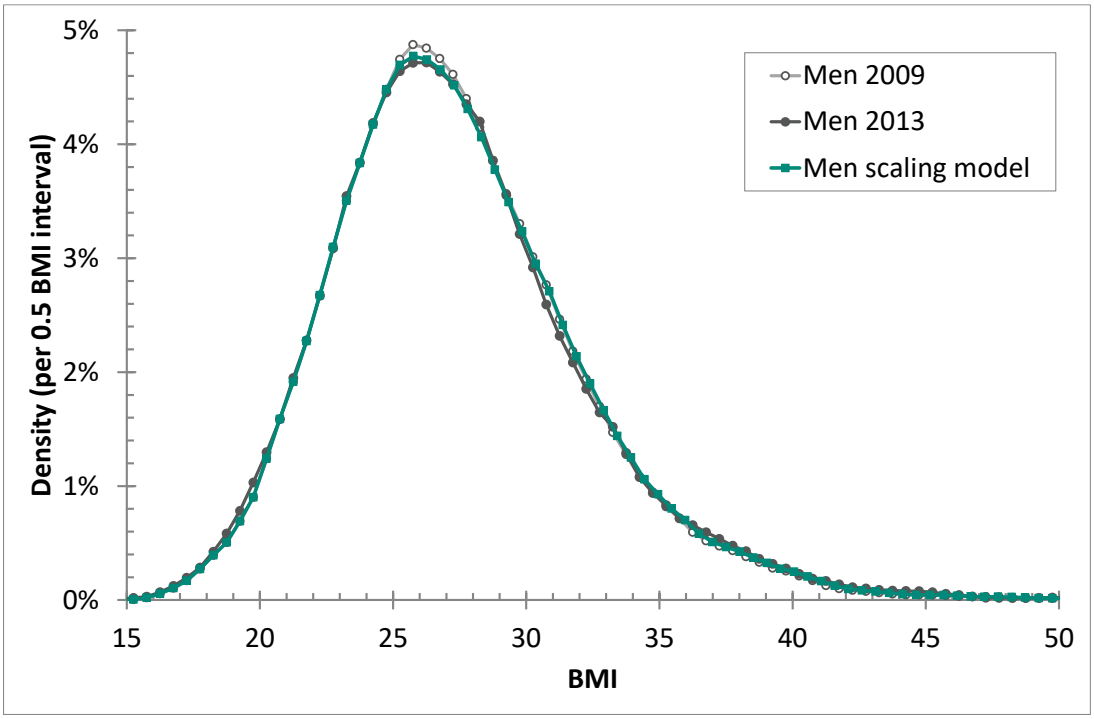

Figure 5.II.1 Chosen scaling model for men for 2009 to 2013.

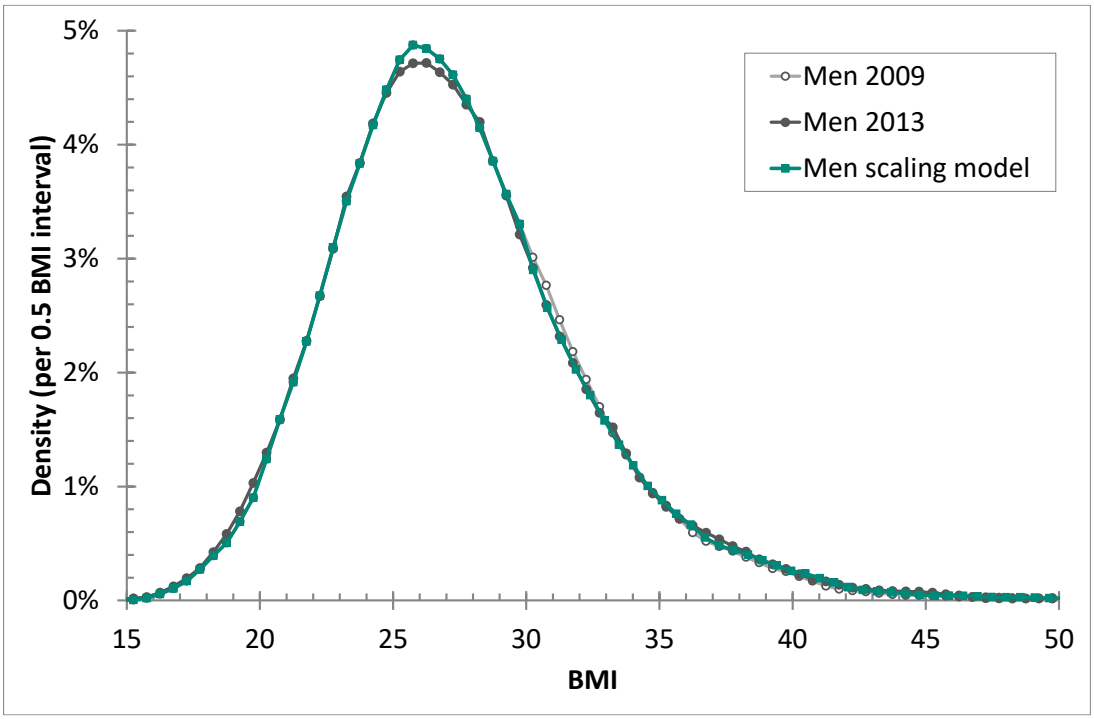

Figure 5.II.2 Alternative scaling model for men for 2009 to 2013.

Appendix 5.III BMI increases for the scaling models and percentiles

These charts compare the BMI increases for the scaling models (Section 5.6) with the BMI increases for the data percentiles (Section 4.4). Since the scaling models do well in modelling the BMI distributions there is naturally a close correspondence between values for the percentiles and the models. The BMI distributions have their peaks at around a BMI of 25 with most values between 20 and 35. As would be expected, the match is generally closer within this range where most of the data is situated.

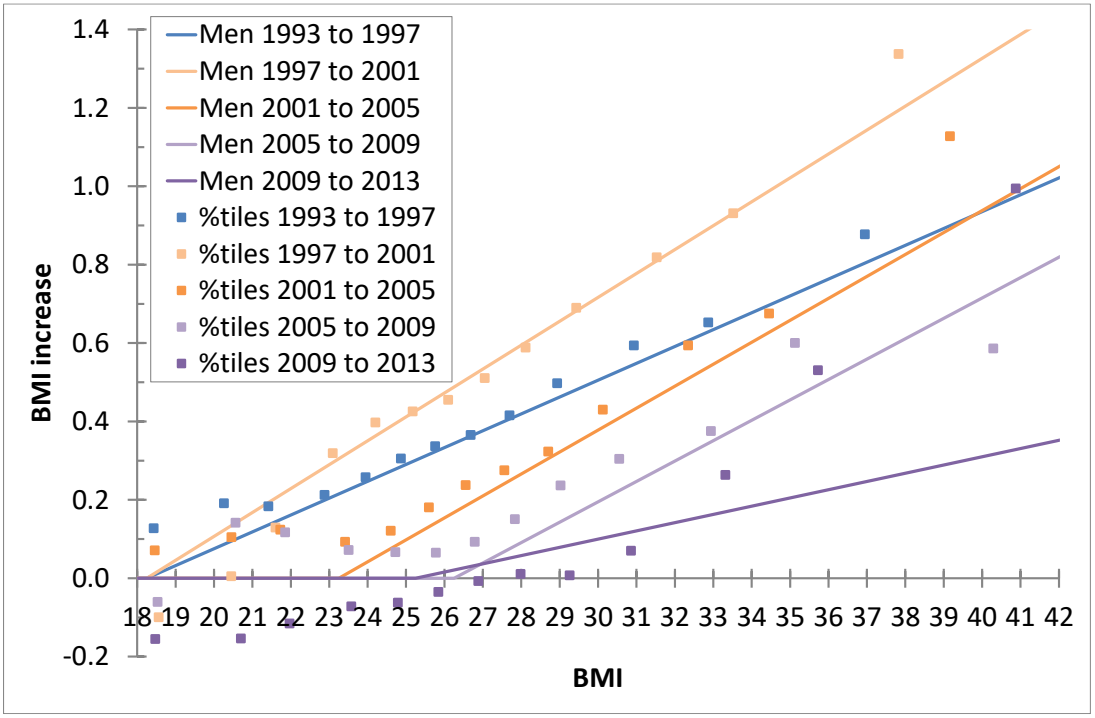

Figure 5.III.1 BMI increases for the scaling models and percentiles for men.

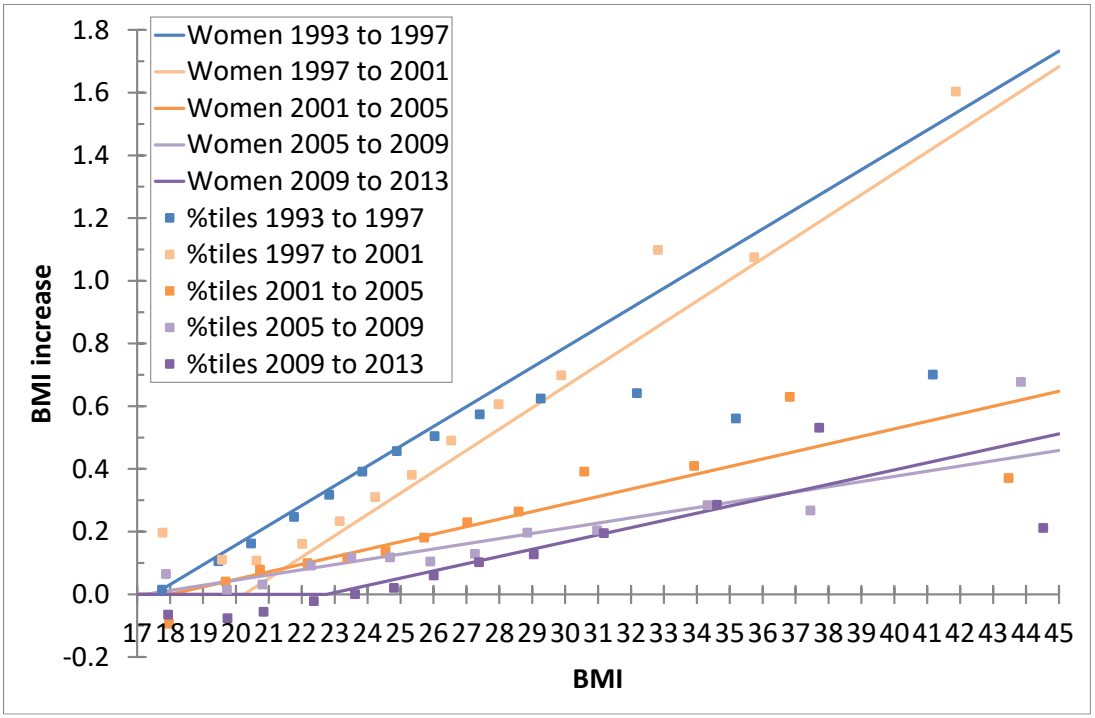

Figure 5.III.2 BMI increases for the scaling models and percentiles for women.

Appendix 5.IV Statistics for the scaling models

The tables here show the descriptive statistics for men and women for the scaling models. As discussed in Section 5.7, the scaling distributions model the change from the previous actual distribution, and the models each start with the actual distribution. This needs to be borne in mind when considering the statistics and comparing them with the actual values. Hence Section 5.7 in the main report focusses on comparing the changes from the previous actual distribution.

Table 5.IV.1 Descriptive statistics for the scaling model distributions for men.

	1997	2001	2005	2009	2013
Mean	26.39	26.91	27.13	27.30	27.45
Median	26.08	26.57	26.74	26.82	26.92
Modal interval mid-point	25.55	26.21	25.89	26.26	25.76
Standard deviation	4.03	4.24	4.50	4.64	4.75
Skewness	0.75	0.63	0.75	0.78	0.89
Underweight (BMI < 18.5)	1.1%	0.9%	1.0%	1.0%	1.0%
Healthy (18.5 ≤ BMI < 25.0)	37.3%	33.2%	31.9%	31.6%	30.9%
Overweight (25.0 ≤ BMI < 30.0)	45.3%	45.2%	44.0%	43.0%	42.5%
Obese I (30.0 ≤ BMI < 35.0)	13.5%	16.6%	17.9%	18.5%	19.1%
Obese II (35.0 ≤ BMI < 40.0)	2.5%	3.4%	4.1%	4.6%	5.0%
Severely obese (BMI ≥ 40.0)	0.4%	0.7%	1.0%	1.3%	1.5%

Table 5.IV.2 Descriptive statistics for the scaling model distributions for women.

	1997	2001	2005	2009	2013
Mean	26.28	26.59	26.86	27.03	27.14
Median	25.35	25.69	25.91	26.04	26.08
Modal interval mid-point	23.61	23.99	24.91	23.85	24.80
Standard deviation	5.26	5.38	5.51	5.62	5.75
Skewness	1.32	1.06	1.06	1.05	1.07
Underweight (BMI < 18.5)	2.0%	2.0%	1.7%	1.8%	1.7%
Healthy (18.5 ≤ BMI < 25.0)	44.9%	42.2%	40.8%	39.9%	39.5%
Overweight (25.0 ≤ BMI < 30.0)	33.1%	33.4%	33.5%	33.2%	32.8%
Obese I (30.0 ≤ BMI < 35.0)	13.5%	14.9%	15.3%	15.9%	16.2%
Obese II (35.0 ≤ BMI < 40.0)	4.5%	5.2%	6.0%	6.3%	6.5%
Severely obese (BMI ≥ 40.0)	2.0%	2.3%	2.6%	2.9%	3.2%

Appendix 5.V Other models for 1993 to 2013

This appendix shows the results for the other models of the changes in the BMI distributions from 1993 to 2013, as described in Section 5.8.3 of the main report. Figures 5.V.1 to 5.V.3 show the 2 piece linear scaling models, the binomial models, and the 2 piece binomial models. They all do well in being able to transform the 1993 distributions into the 2013 distributions.

Examples of the binomial distribution values are given in Figures 5.V.4 and 5.V.5 for a few BMI values (20, 25, 30, and high values). As explained in the main report in Section 5.8.3, the increase in the mean values has an upper limit in these models that is one of the fitted parameter values. For men the value is 35 and so all binomial distributions for a BMI of 35 and above are the same. For women the value is 34.5 and so again all binomial distributions for a BMI of 35 and above are the same. The binomial distributions for men and women in Figures 5.V.4 and 5.V.5 are pretty similar to each other because the changes in BMI from 1993 to 2013 are similar.

The BMI increases for all models are plotted in Figure 5.V.6 for men and Figure 5.V.7 for women, along with the percentile increases. For high BMI values above 35 there is a difference between the binomial model and the other models because of the upper limit in the model which means that the increase stays constant. However, there are not many people in the 1993 populations with a BMI above 35 and so this does not actually represent a big difference in the models. The models are similar to each other in their increases in the range 20 to 35 where most of the 1993 values are. Also, the increases for men and women are similar to each other.

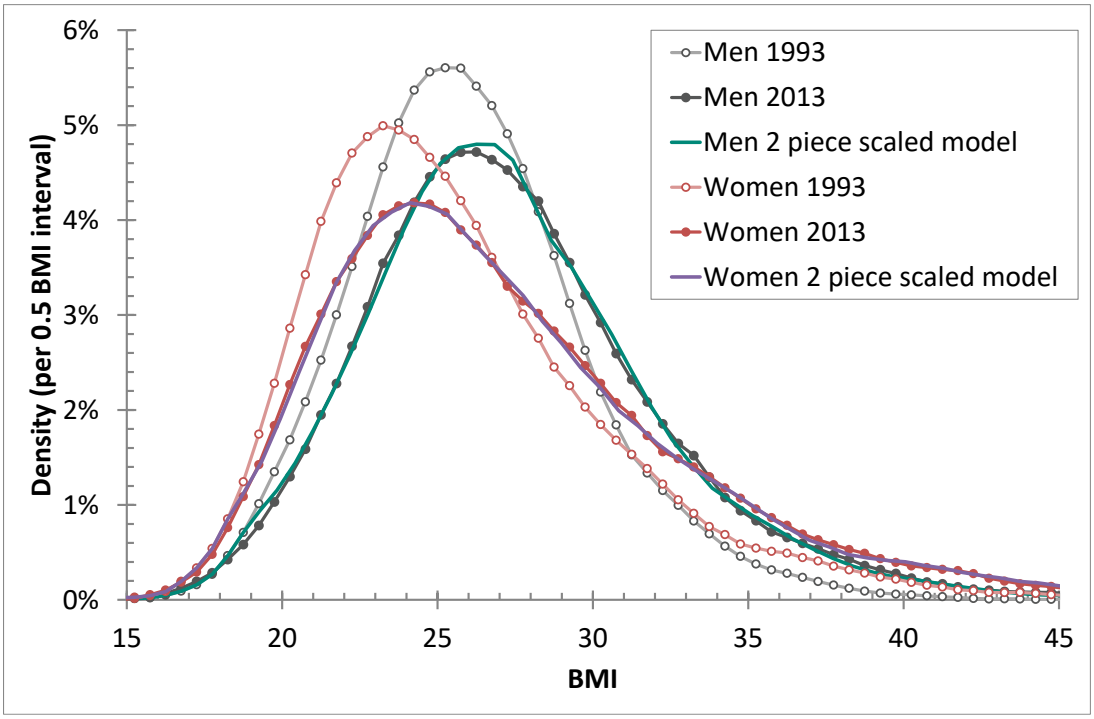

Figure 5.V.1 2 piece linear scaling models for men and women from 1993 to 2013.

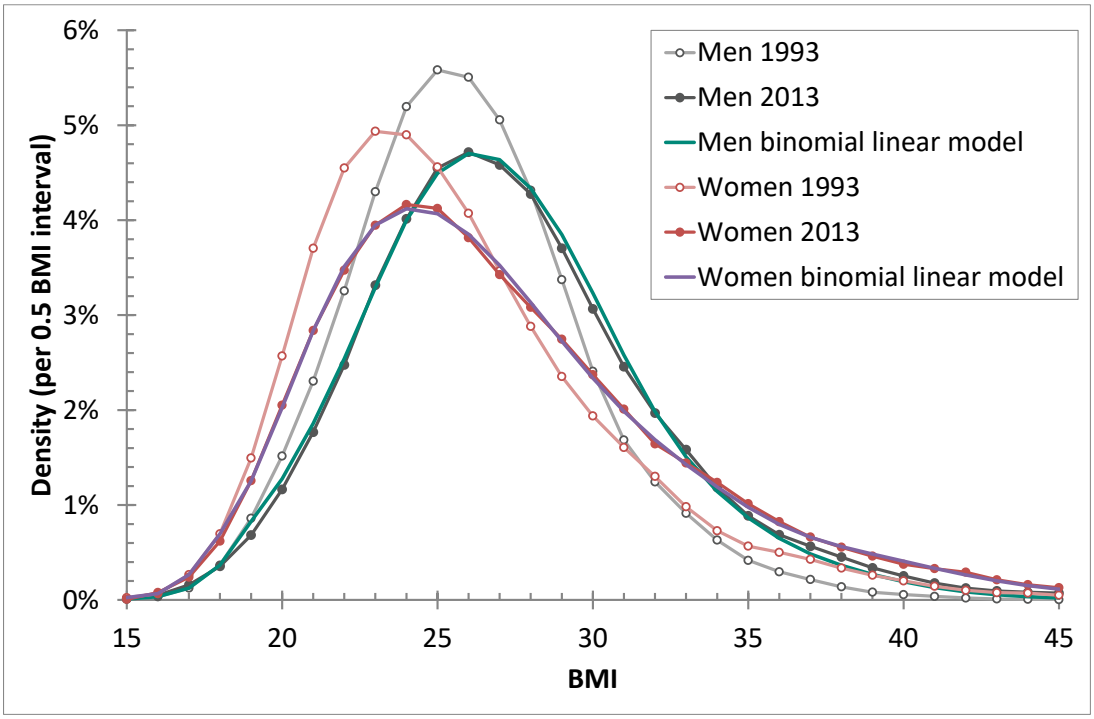

Figure 5.V.2 Binomial models for men and women from 1993 to 2013.

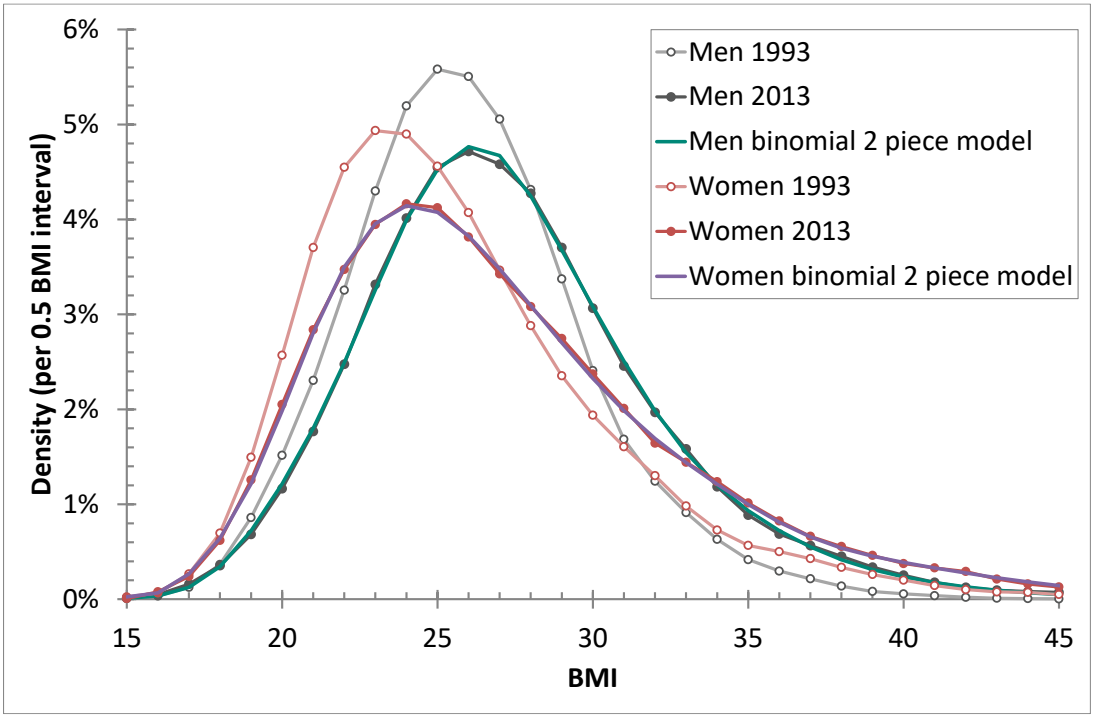

Figure 5.V.3 2 piece binomial models for men and women from 1993 to 2013.

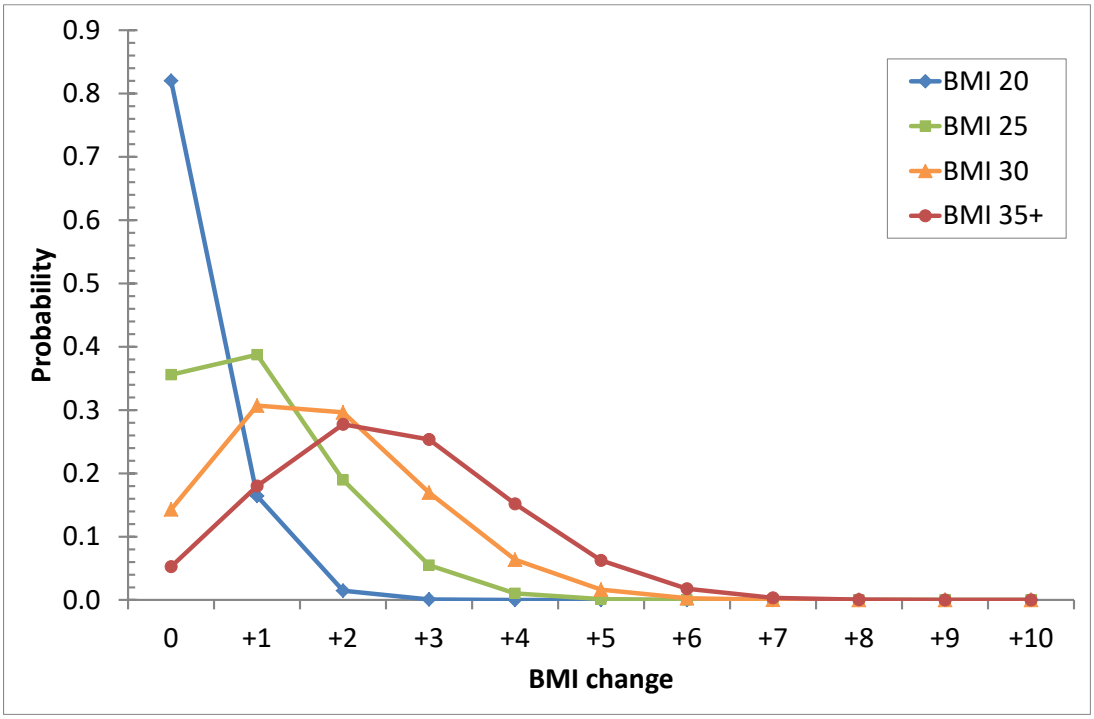

Figure 5.V.4 Examples of binomial distributions for the linear binomial model for men.

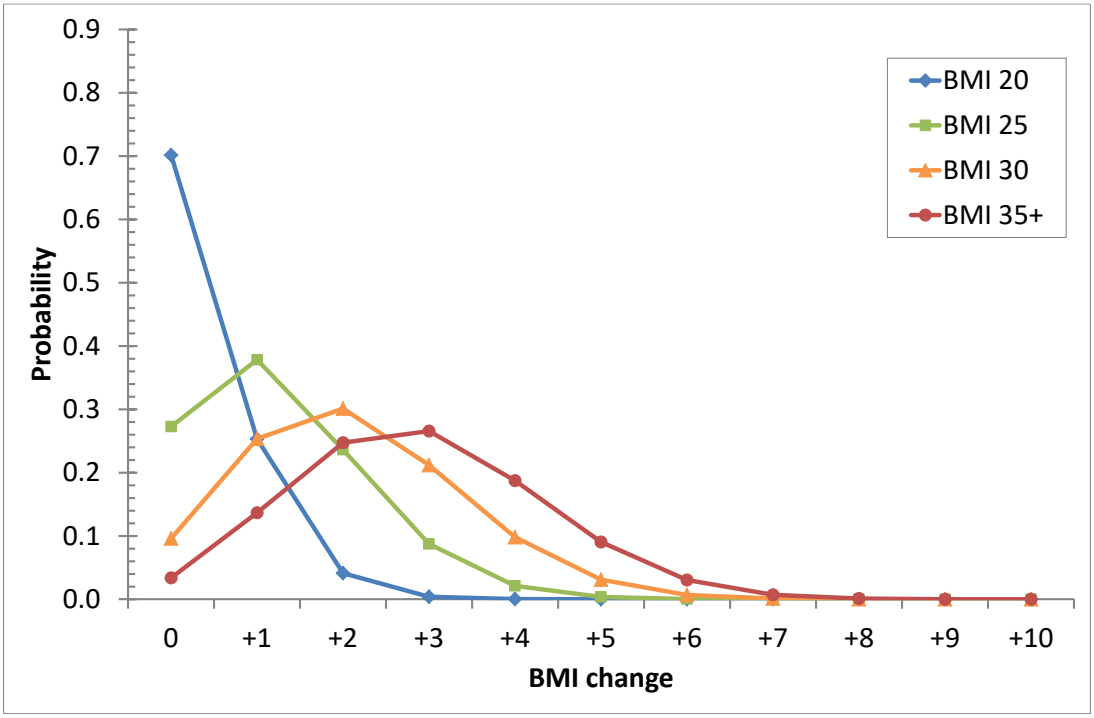

Figure 5.V.5 Examples of binomial distributions for the linear binomial model for women.

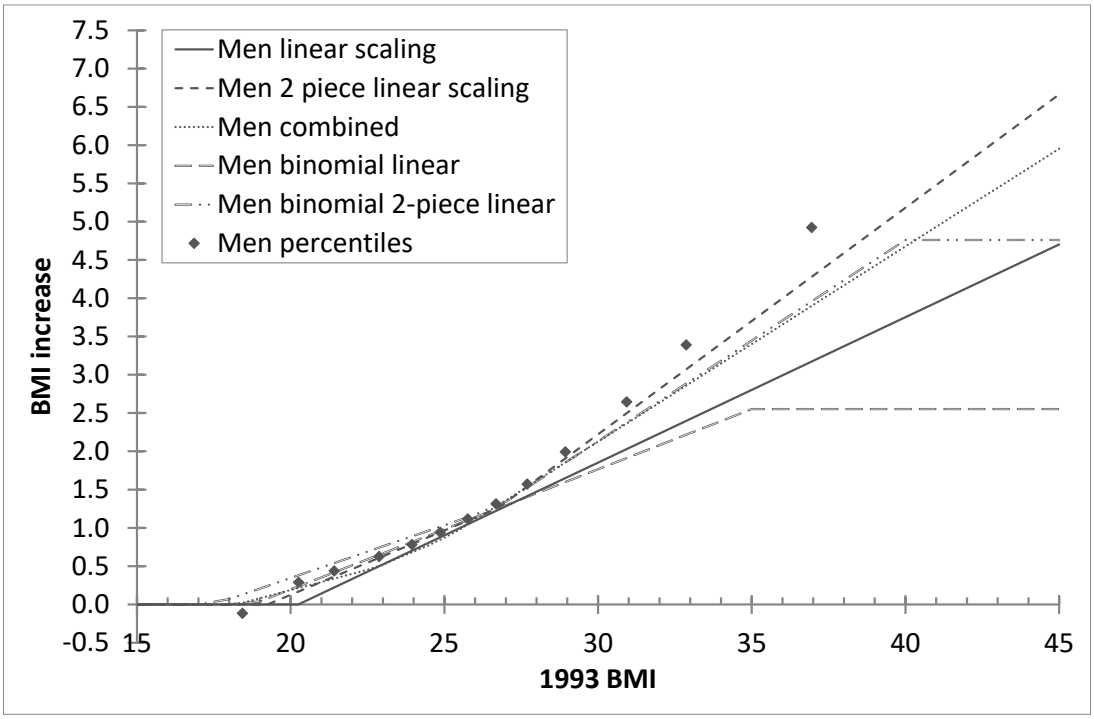

Figure 5.V.6 BMI increases for all the models for men.

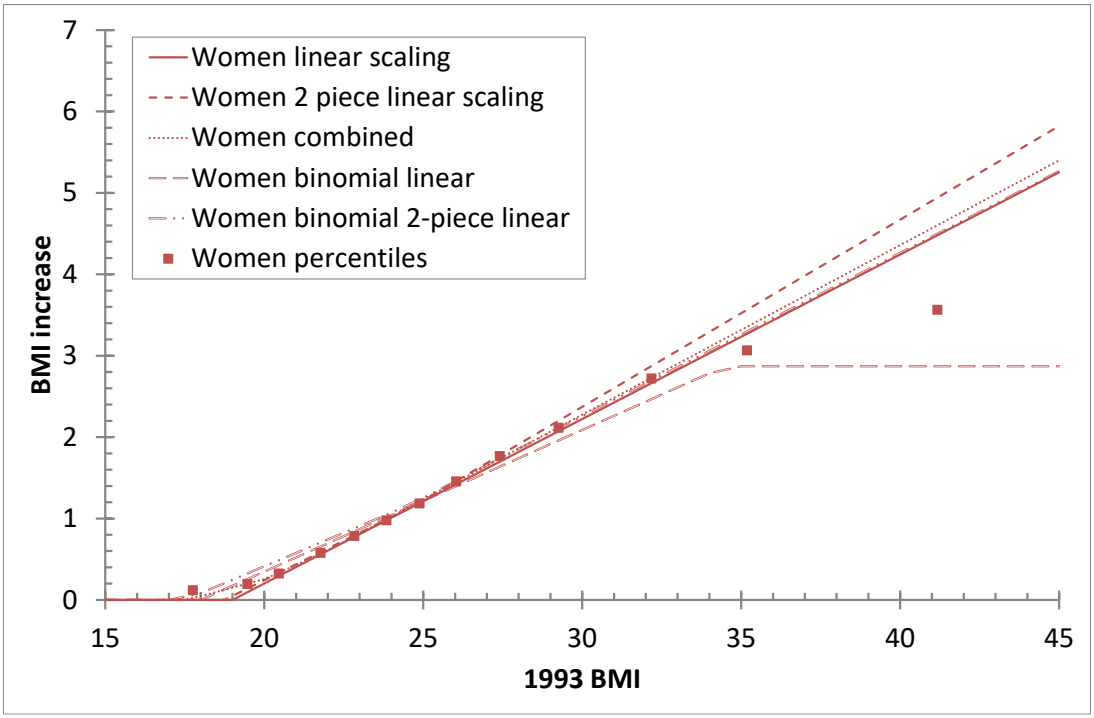

Figure 5.V.7 BMI increases for all the models for women.

Appendix 7.I Five year cohorts and wider age range

Section 7.4 of the main report examines the relationship between BMI and age by looking at how mean BMI varies with age within narrow birth cohorts. In a given cohort, everyone has lived a similar time period. The use of such cohorts helps to focus on the relationship between BMI and age without much of the confounding effect of having lived in different times.

The results in Section 7.4 use 10 year cohorts, with the results being shown in Figures 7.3 and 7.4. Other cohort lengths could be used and this appendix shows the results for five year cohorts. Figures 7.I.1 and 7.I.2 show the mean BMI values for the different ages within five year cohorts. Using five years has the advantage a narrower range of birth years but has the disadvantage that the sample sizes are smaller and so there are more irregularities. In each of Figures 7.I.1 and 7.I.2 the dashed line is the upper asymptotic curve from Section 7.5, which is the estimated current aging model, and the dotted line is the lower asymptotic curve from Section 7.5. These give a reference to compare the data with the charts in Chapter 7. They also give a further assessment of the suitability of the upper curve for the current aging model.

The general pattern is the same as for the 10 year cohorts, with the trends of BMI increasing with age within each cohort, the rate of increase getting less as age increases, and the older cohorts being at lower levels. Indeed, up to five points at either the start or end of each series (depending on the cohort dates) are exactly the same as the equivalent series for the 10 year cohorts. The upper asymptotic curve still looks reasonable in following the general trend of values for the younger cohorts and then continuing with the shape of the values for older cohorts (i.e., parallel to the general trends of the older cohorts).

Cohort charts were also produced for wider age categories rather than a single year of age to provide more smoothing of the data. These use the same 10 year cohorts as Figures 7.3 and 7.4 in the main report, but use ages in the categories of 18-19, and then five year age ranges of 20-24, 25-29, 30-34, etc. The whole HSE data was used for 1991-2014. This gives larger samples compared to the previous analysis of looking at single year ages. It therefore smooths out the data, although some details of the patterns are lost. The results are shown in Figures 7.I.3 and 7.I.4. As before, age is treated using the truncated integer values. The x-axis points used are the average for the interval of the age in truncated integer values, so averaging 18 and 19 to give 18.5, averaging each integer 20-24 to give 22, etc. Combining the data (i.e., effectively averaging across the age range interval) when the pattern is curved in the way that it is here will tend to underestimate slightly the BMI value for the mid-point. All four asymptotic curves from Section 7.5 are included on the charts. The smoothing provides an additional check of the suitability of the asymptotic curves, particularly the top line. The upper line looks suitable in each case in initially following the data of the most recent cohort and then continuing with the general pattern of the other cohorts. The charts perhaps show some evidence of a decline in mean BMI for people over 80, particularly for women.

The patterns here are similar to the charts in Chapter 7. Hence, the results do not alter the discussion and implications drawn in Chapter 7. The upper asymptotic curve is still considered a reasonable hypothesised model of the trajectory that the current youngest generation might follow if current conditions continue.

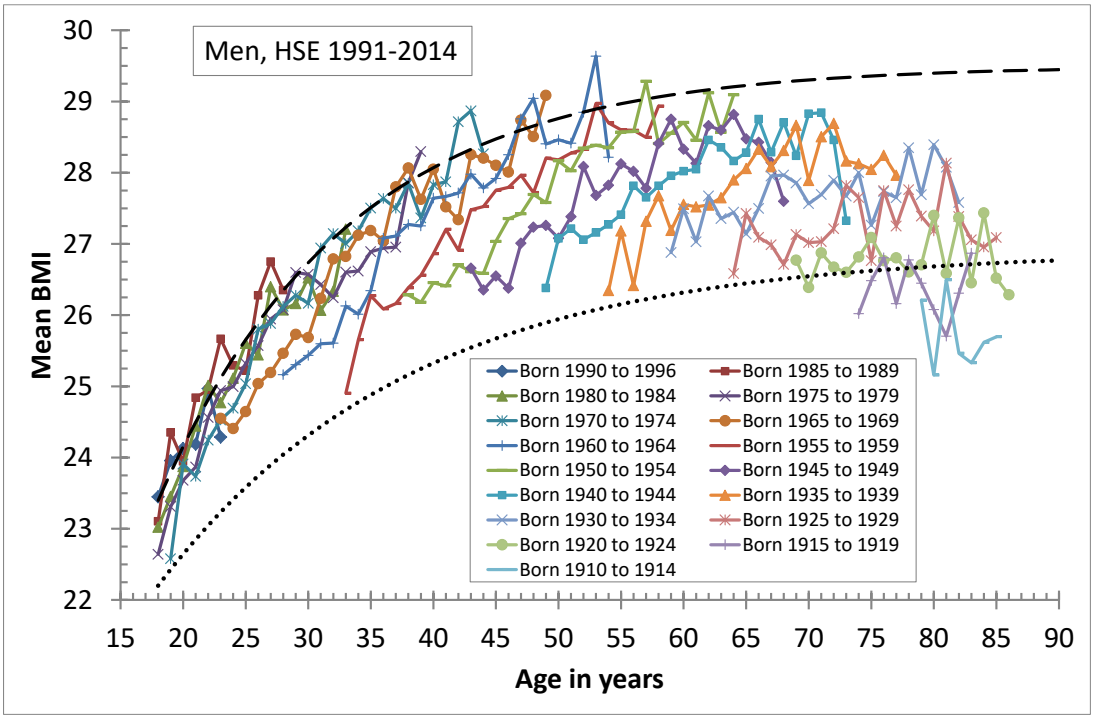

Figure 7.I.1 Mean BMI by age for five year cohorts for men.

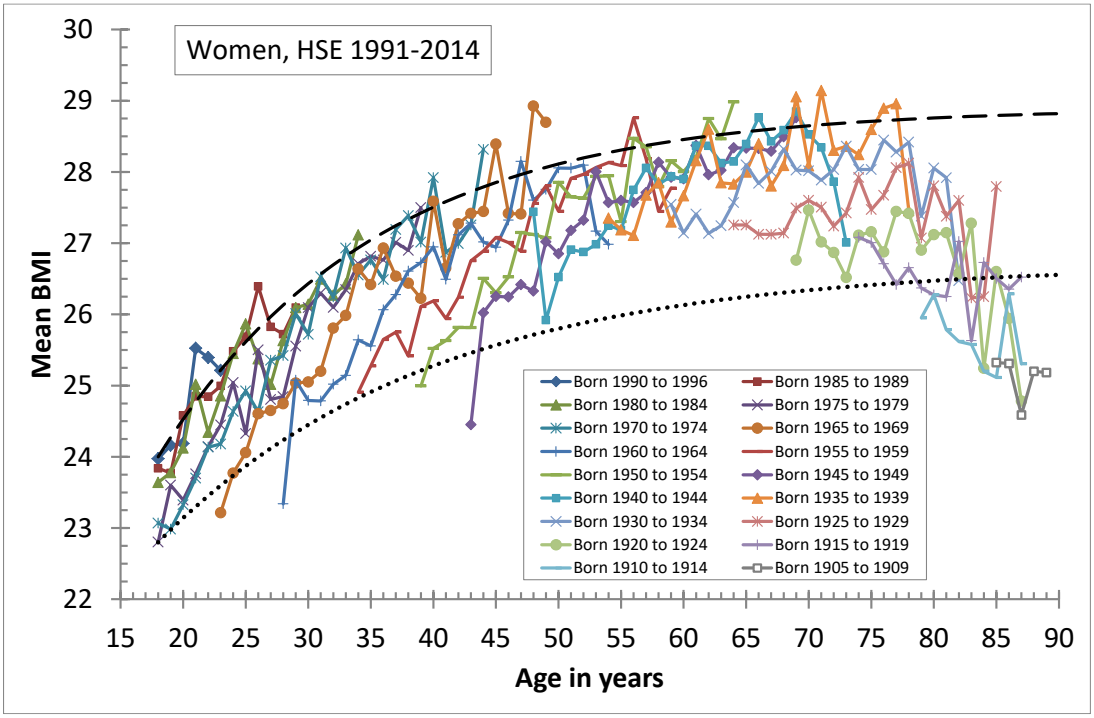

Figure 7.I.2 Mean BMI by age for five year cohorts for women.

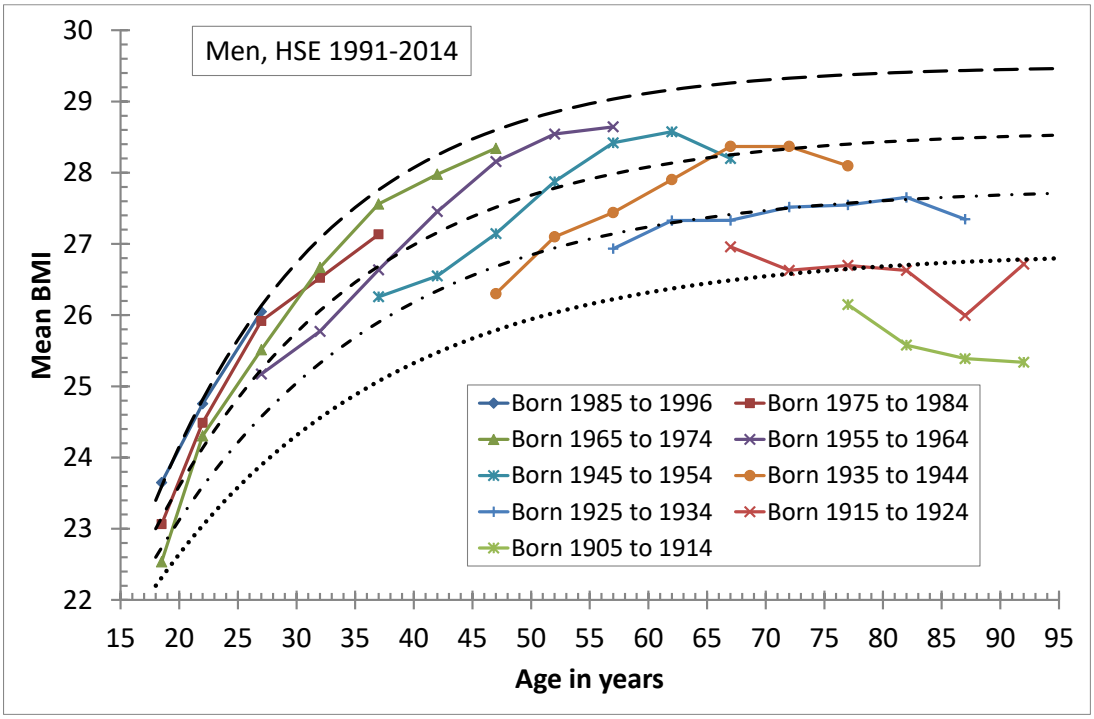

Figure 7.I.3 Mean BMI by age for 10 year birth cohorts for men in 5 year age groups.

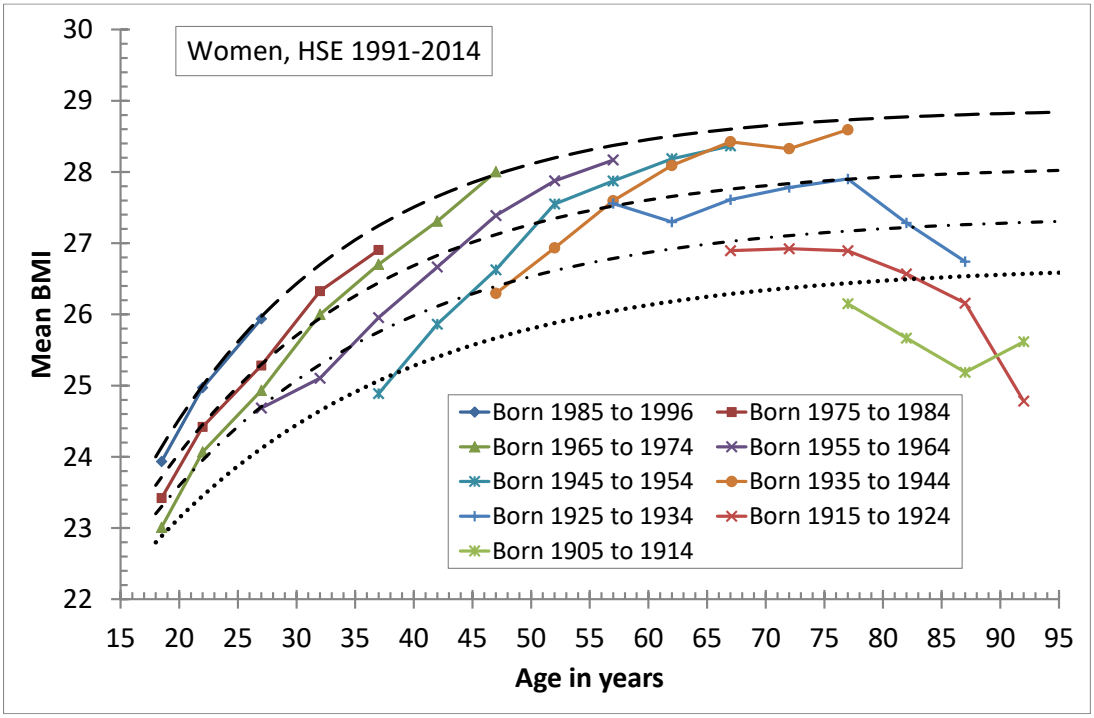

Figure 7.I.4 Mean BMI by age for 10 year birth cohorts for women in 5 year age groups.

Appendix 8.I Aging profile from the HSE data for men

Figure 8.I.1 shows the values for mean BMI for men for the three time intervals of eight years of the HSE data (1991-1998, 1999-2006, 2007-2014). A time interval length of eight years was used to give a reasonable amount of data, and the mean BMI values were only calculated and plotted where there are at least 30 values in the sample.

As discussed in Sections 7.3 and 8.1, the chart is limited in just showing how mean BMI varies with age for the whole data. The limitation is that it does not take account of the confounding effect of birth year with people born at different times experiencing very different conditions. Hence it does not show the true relationship of BMI with age. This is covered by the cohort analysis in Chapter 7 which shows BMI increasing with age within each cohort but also with older cohorts being at lower levels. This is the reason why mean BMI reduces with older ages in Figure 8.I.1, as is the case for Figure 7.1 in the main report. The proposed aging model from Chapter 7 is also shown on the chart as the dashed line in Figure 8.I.1. The main aspects of interest in Figure 8.I.1 are in seeing how the curves for mean BMI change from one HSE time interval to the next and also how they compare with the aging model curve.

As discussed in Section 7.5, the aging model curve is the hypothesised BMI aging pattern for the current conditions if they stay the same. The hypothesis is that as time passes the mean BMI for a given age will increase towards the aging model, since that age is then a more recent birth cohort and so their lifetime experience is closer to the current conditions. Older cohorts are also assumed to be increasing in level over time towards the aging model. Hence, the hypothesis that the overall population BMI curve will move towards the dashed line. The patterns in Figure 8.I.1 are consistent with this explanation. Mean BMI increases across the whole age range from 1991-1998 to 1999-2006. By 1999-2006 most ages up to about 45 are close to the aging model. From 1999-2006 to 2007-2014 there is little increase in mean BMI up to about age 45, but still significant increases above that.

To look at how the curves change between the time intervals in more detail, the changes between the series in Figure 8.I.1 were calculated. A seven point moving average was used to smooth the values and show the general patterns more clearly. The resulting values are plotted in Figure 8.I.2. The orange values show the changes between the first two time intervals from 1991-1998 to 1999-2006. The increase in BMI is fairly level across the ages with most of the moving average values between 0.6 and 1.1. The average of the increases for each year of age is 0.81. The purple values are the increase from the second to the third time interval, from 1999-2006 to 2007-2014. In the moving average differences, there is very little change in BMI up to age 43 with the values close to 0, and then there are BMI increases of around 0.6 at ages above that. There is actually a small decrease in BMI for ages of the early 30s. This is noted in the main report in Sections 7.4.1 and 7.6.1, and may indicate an improving situation for this age group cohort. The dashed purple line is the combined changes from 1991-1998 to 2007-2014, and these values are just the sum of the other two series values.

A chart of age curves for groups of four years of HSE data is given in Figure 8.I.3. The chart here divides the HSE data into six time intervals compared to the three of Figure 8.I.1 and so gives more detail of how the aging profile changes over time. However, the amount of data used for each series is less and so there is more sampling variation and irregularity in the values. The general trends and patterns of how the values change over time are the same.

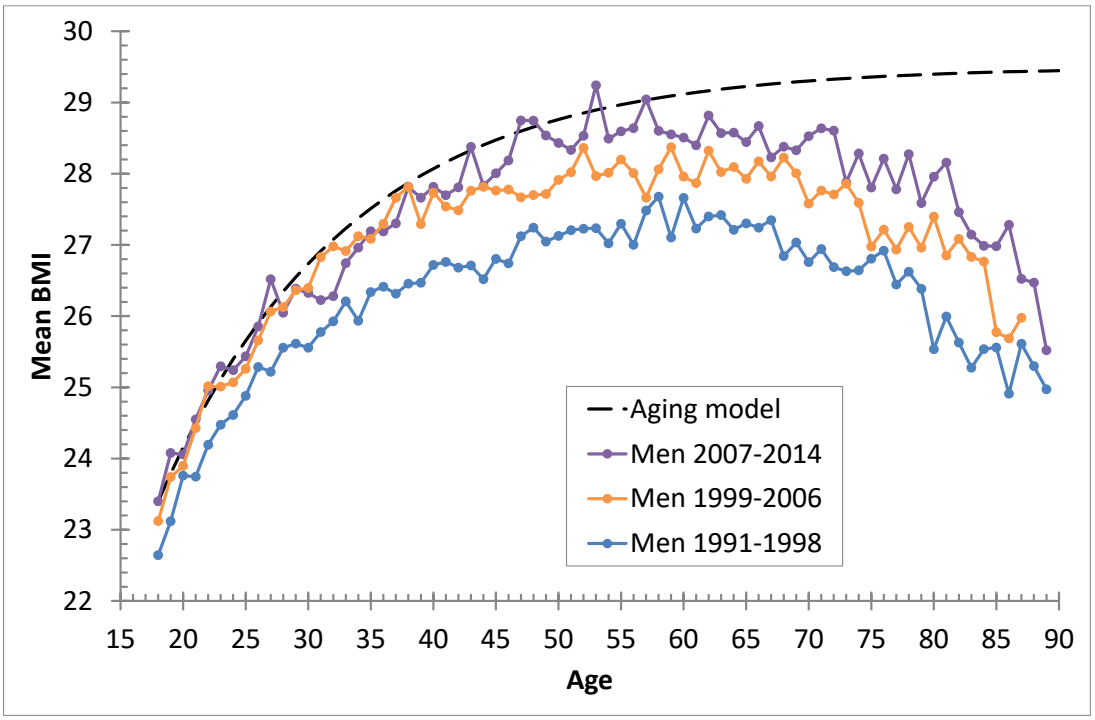

Figure 8.I.1 Mean BMI for men in eight year time intervals.

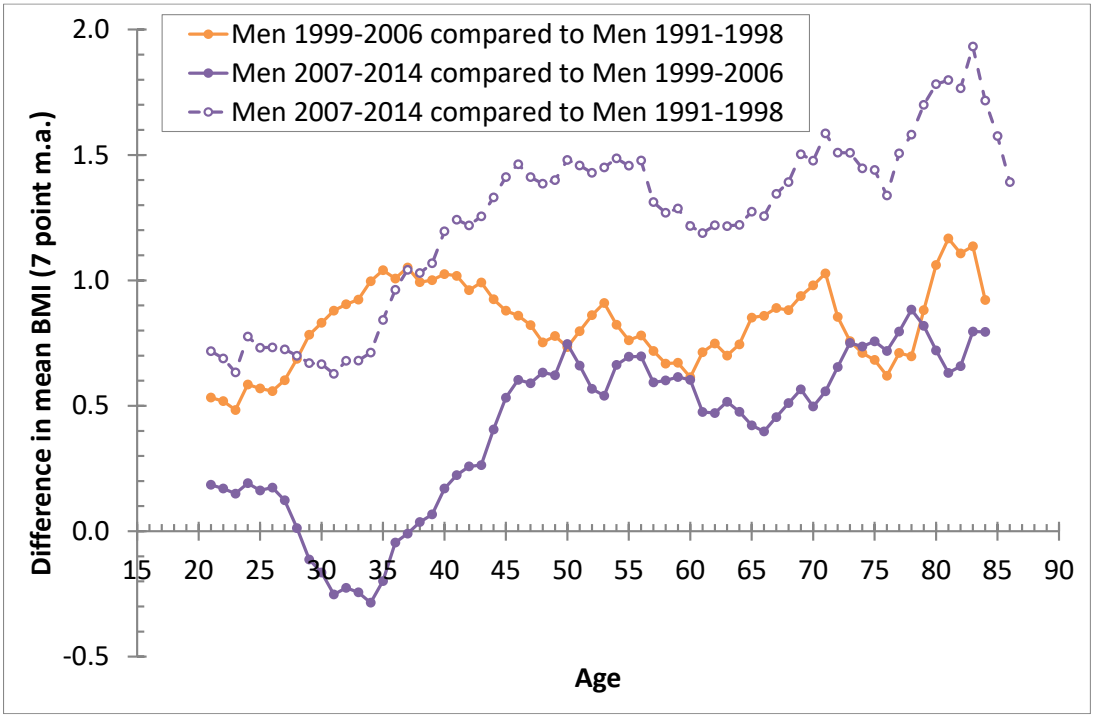

Figure 8.I.2 Differences over time in the mean BMI for men.

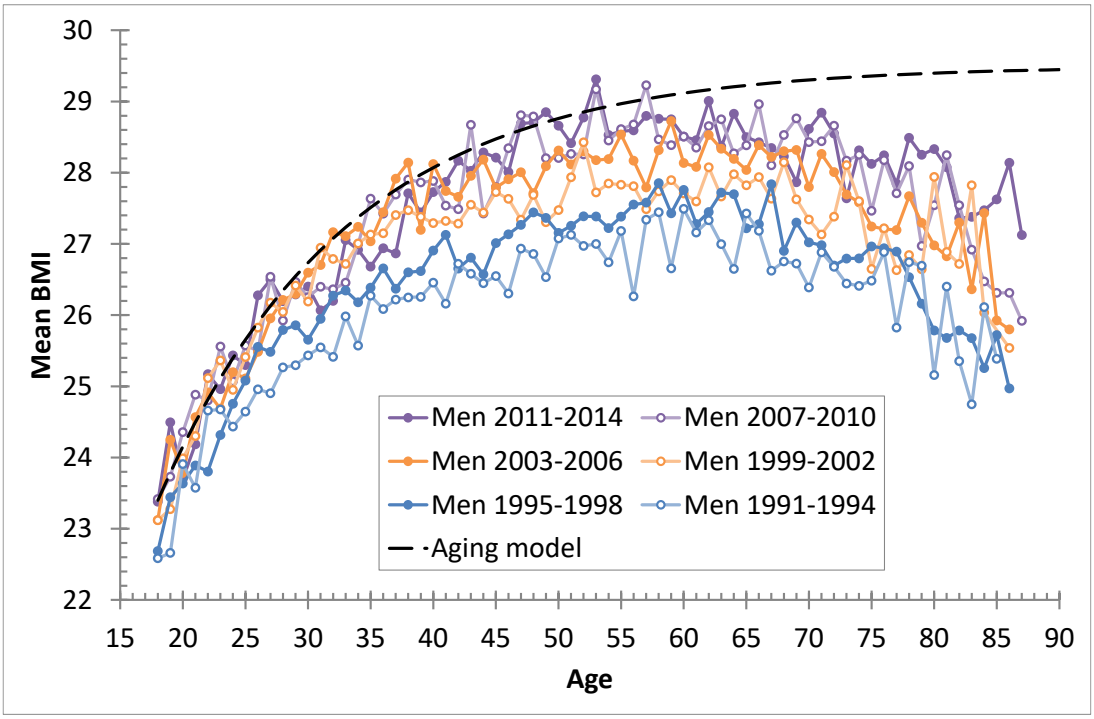

Figure 8.I.3 Mean BMI by age for four year HSE intervals for men.

Appendix 8.II Examples of smoothing of the age distributions for men

This appendix has two charts showing some examples of the data and the smoothed distributions for the age groups for men. These are given for a selection of three age groups (18-24, 25-34, 45-54) in 1991-1998 and 2007-2014.

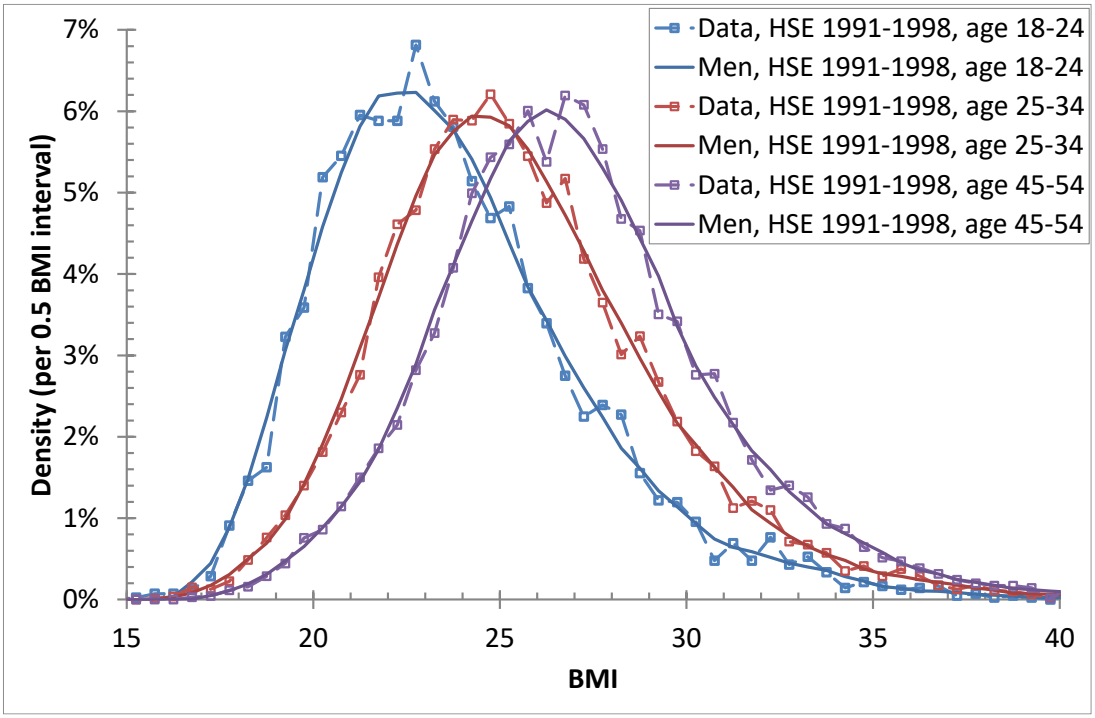

Figure 8.II.1 Smoothed distributions for three age groups for men for 1991-1998.

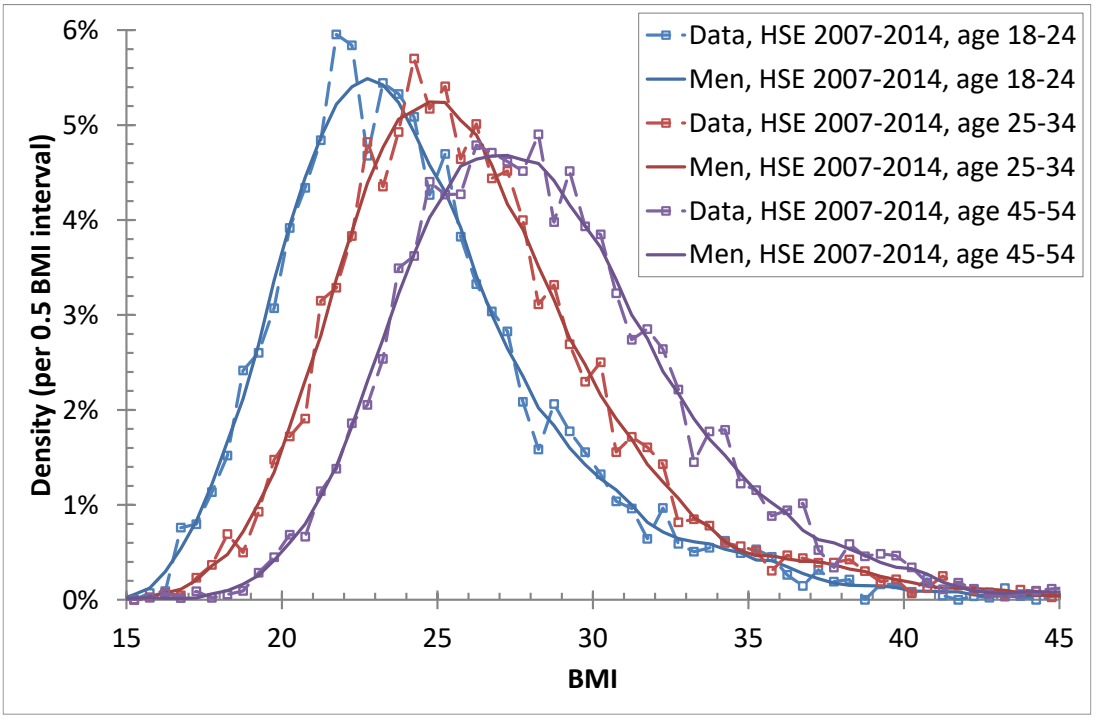

Figure 8.II.2 Smoothed distributions for three age groups for men for 2007-2014.

Appendix 8.III BMI distributions for each age group for men

This appendix compares the distributions and statistics for each age group for men across the three time intervals of 1991-1998, 1999-2006, 2007-2014. The changes between the distributions with time are discussed in Section 8.3.1 of the main report, and with age in Section 8.4.1.

Charts of population distributions for each age group

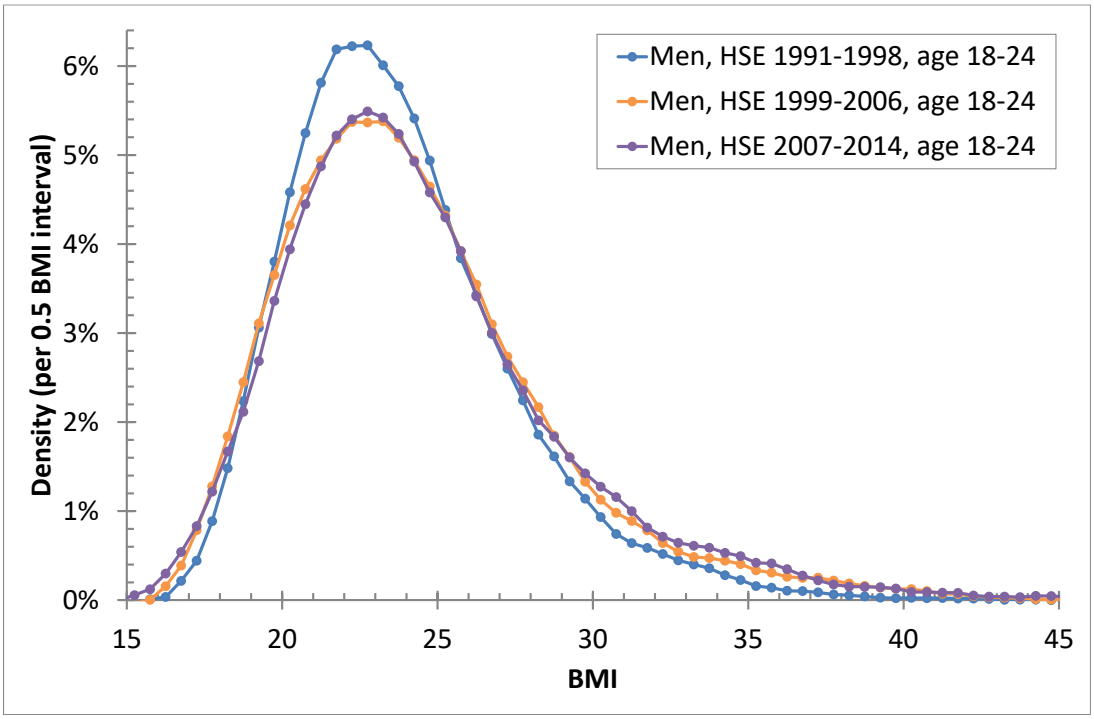

Figure 8.III.1 BMI distributions for men for age group 18-24.

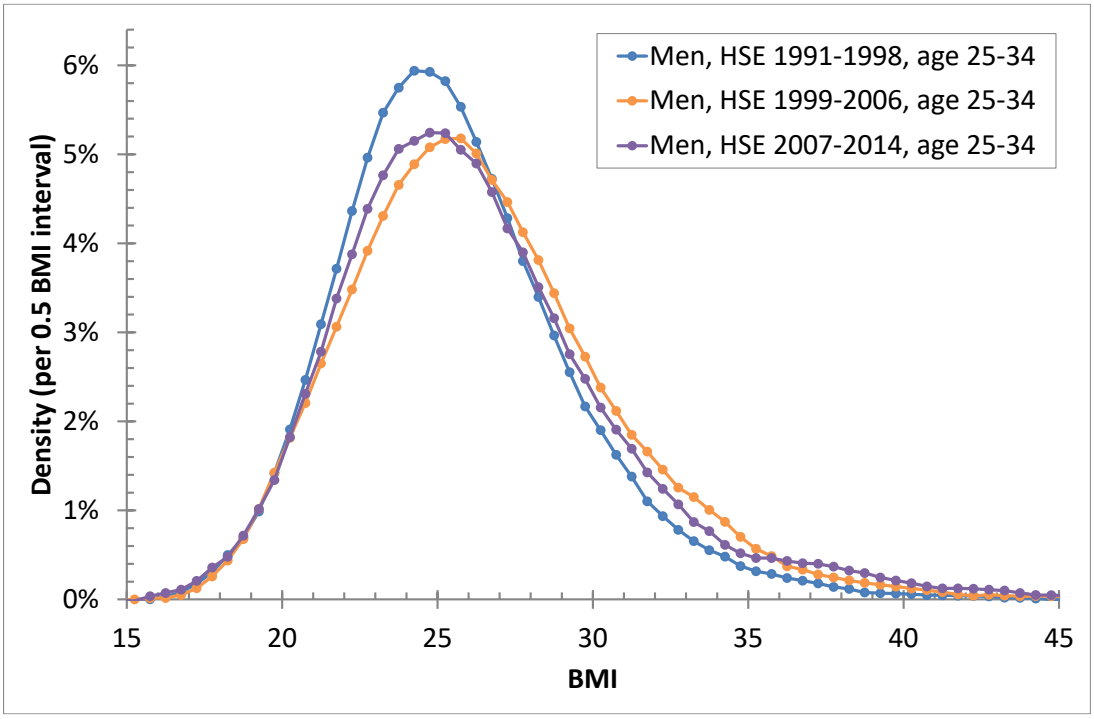

Figure 8.III.2 BMI distributions for men for age group 25-34.

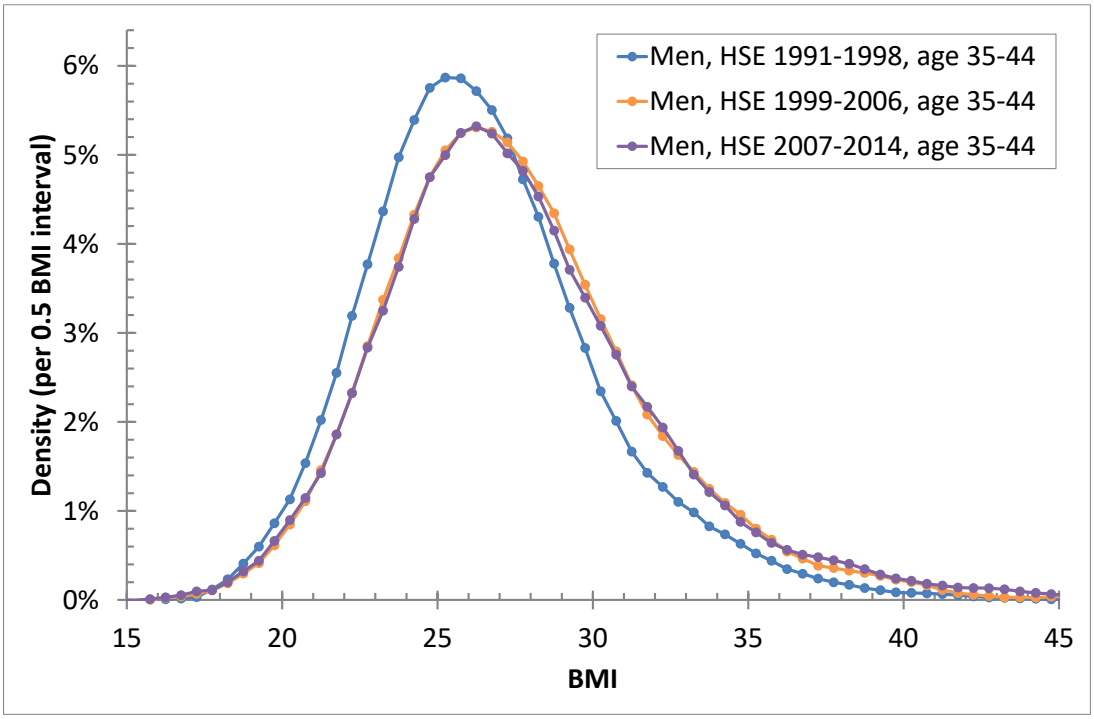

Figure 8.III.3 BMI distributions for men for age group 35-44.

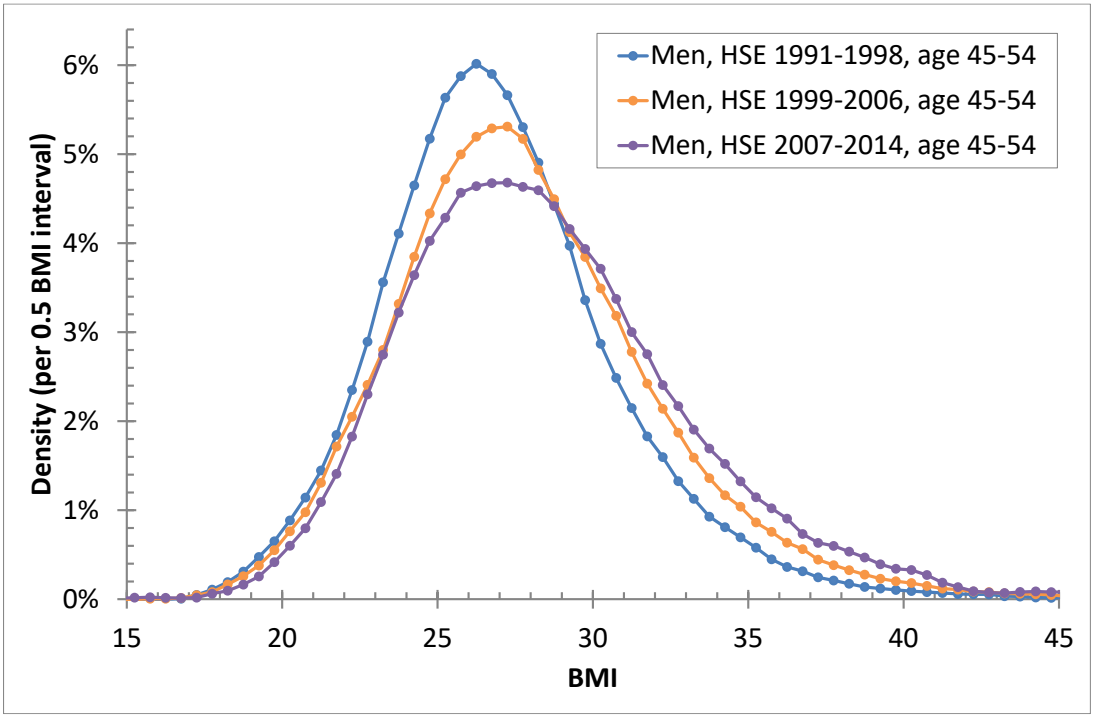

Figure 8.III.4 BMI distributions for men for age group 45-54.

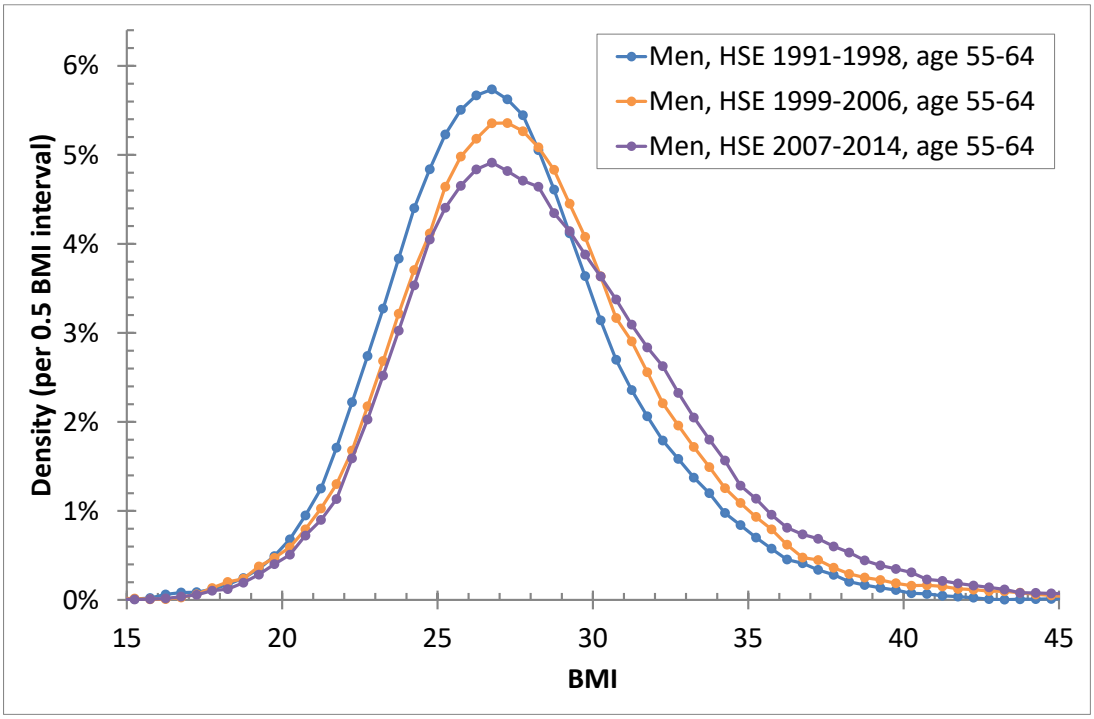

Figure 8.III.5 BMI distributions for men for age group 55-64.

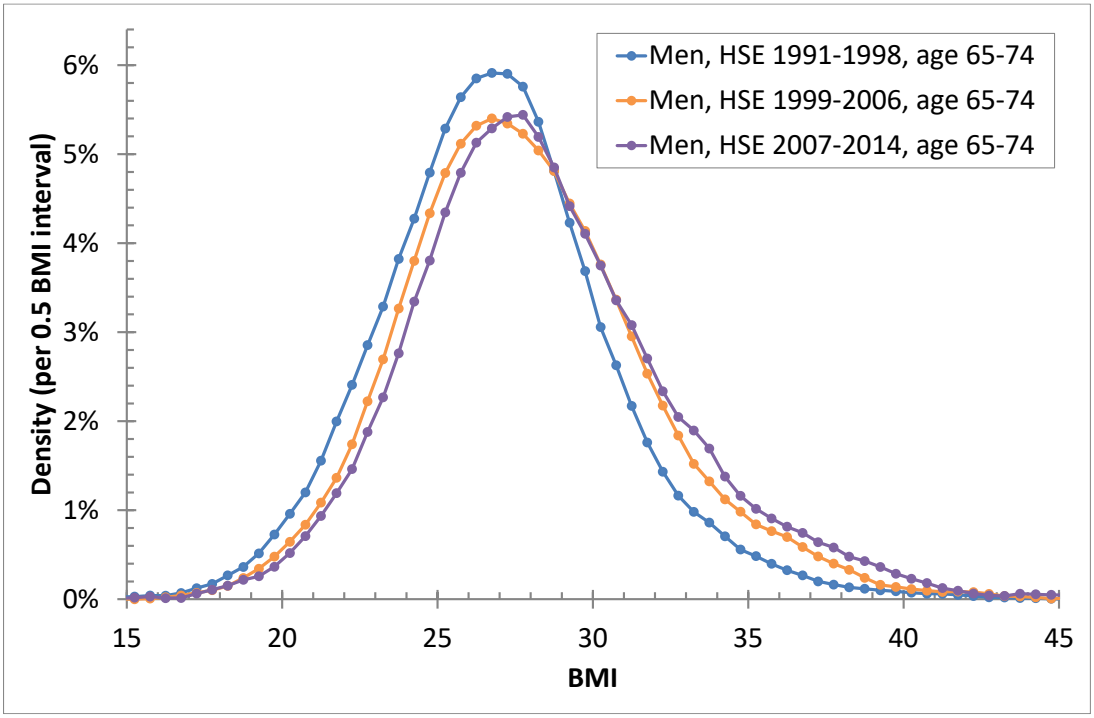

Figure 8.III.6 BMI distributions for men for age group 65-74.

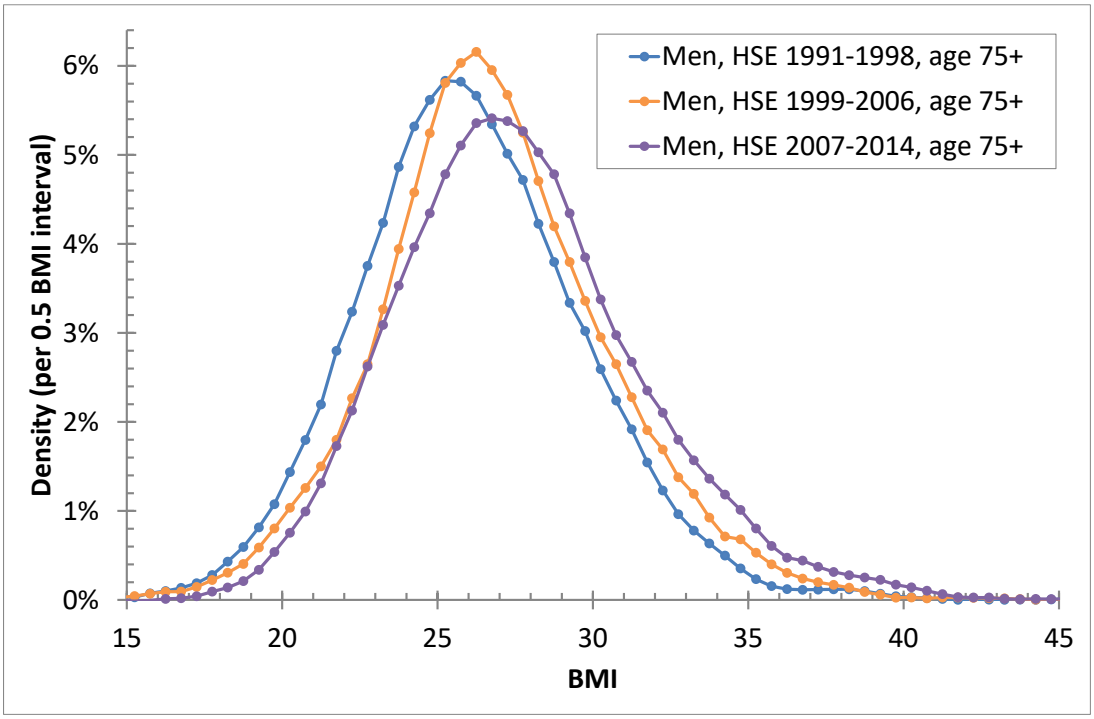

Figure 8.III.7 BMI distributions for men for age group 75+.

Descriptive statistics

Tables 8.III.1 – 8.III.3 give the descriptive statistics for the age group distributions. Charts of the values for the mean, median, standard deviation, skewness, and the category percentages are provided following the tables in Figures 8.III.8 – 8.III.21.

Table 8.III.1 Descriptive statistics for the age group distributions for men for 1991-1998.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	4182	8004	7779	6992	5634	4843	2432
Mean	23.83	25.62	26.53	27.07	27.35	26.96	26.17
Median	23.30	25.19	26.12	26.72	27.03	26.81	25.94
Modal interval mid-point	22.75	24.25	25.25	26.25	26.75	26.75	25.25
Standard deviation	3.61	3.79	3.86	3.82	3.87	3.76	3.81
Skewness	1.00	0.83	0.88	0.73	0.54	0.51	0.93
Underweight (BMI < 18.5)	3.0%	1.1%	0.4%	0.3%	0.6%	0.8%	1.3%
Healthy (18.5 ≤ BMI < 25.0)	65.5%	46.7%	36.6%	29.5%	27.0%	28.8%	37.7%
Overweight (25.0 ≤ BMI < 30.0)	25.4%	40.4%	47.1%	51.1%	50.6%	52.4%	46.8%
Obese I (30.0 ≤ BMI < 35.0)	5.1%	9.8%	13.0%	15.8%	18.0%	15.3%	12.8%
Obese II (35.0 ≤ BMI < 40.0)	0.8%	1.7%	2.5%	2.7%	3.4%	2.3%	1.2%
Severely obese (BMI ≥ 40.0)	0.1%	0.3%	0.5%	0.6%	0.4%	0.4%	0.2%

Table 8.III.2 Descriptive statistics for the age group distributions for men for 1999-2006.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	2794	5247	6381	5559	5246	3999	2285
Mean	24.32	26.45	27.55	27.90	28.05	27.89	26.87
Median	23.63	25.96	27.06	27.45	27.65	27.56	26.64
Modal interval mid-point	23.25	25.75	26.25	27.25	27.25	26.75	26.25
Standard deviation	4.34	4.34	4.31	4.35	4.24	4.04	3.73
Skewness	1.17	0.90	0.89	0.91	0.72	0.55	0.30
Underweight (BMI < 18.5)	4.3%	0.9%	0.4%	0.3%	0.5%	0.4%	1.0%
Healthy (18.5 ≤ BMI < 25.0)	59.1%	39.2%	28.1%	24.7%	22.4%	23.1%	29.3%
Overweight (25.0 ≤ BMI < 30.0)	27.0%	41.7%	47.4%	48.0%	49.2%	49.6%	50.9%
Obese I (30.0 ≤ BMI < 35.0)	6.8%	14.5%	18.7%	21.0%	22.0%	21.6%	16.4%
Obese II (35.0 ≤ BMI < 40.0)	2.2%	3.0%	4.4%	4.7%	4.6%	4.6%	2.2%
Severely obese (BMI ≥ 40.0)	0.6%	0.8%	1.1%	1.3%	1.3%	0.7%	0.2%

Table 8.III.3 Descriptive statistics for the age group distributions for men for 2007-2014.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	2077	3656	4658	4552	4438	3777	2403
Mean	24.51	26.31	27.70	28.52	28.62	28.41	27.64
Median	23.72	25.67	27.08	27.98	28.04	27.95	27.33
Modal interval mid-point	22.75	24.75	26.25	27.25	26.75	27.75	26.75
Standard deviation	4.59	4.54	4.69	4.70	4.68	4.31	3.98
Skewness	1.29	1.05	1.28	0.90	0.92	0.67	0.53
Underweight (BMI < 18.5)	4.7%	1.2%	0.5%	0.3%	0.4%	0.4%	0.3%
Healthy (18.5 ≤ BMI < 25.0)	57.7%	41.9%	27.9%	22.5%	20.9%	19.7%	25.6%
Overweight (25.0 ≤ BMI < 30.0)	26.5%	39.7%	46.4%	44.6%	45.4%	49.0%	49.3%
Obese I (30.0 ≤ BMI < 35.0)	7.8%	12.3%	18.6%	23.9%	24.6%	23.4%	20.4%
Obese II (35.0 ≤ BMI < 40.0)	2.4%	3.6%	4.7%	6.8%	6.6%	6.3%	3.9%
Severely obese (BMI ≥ 40.0)	0.8%	1.3%	1.9%	2.0%	2.1%	1.2%	0.5%

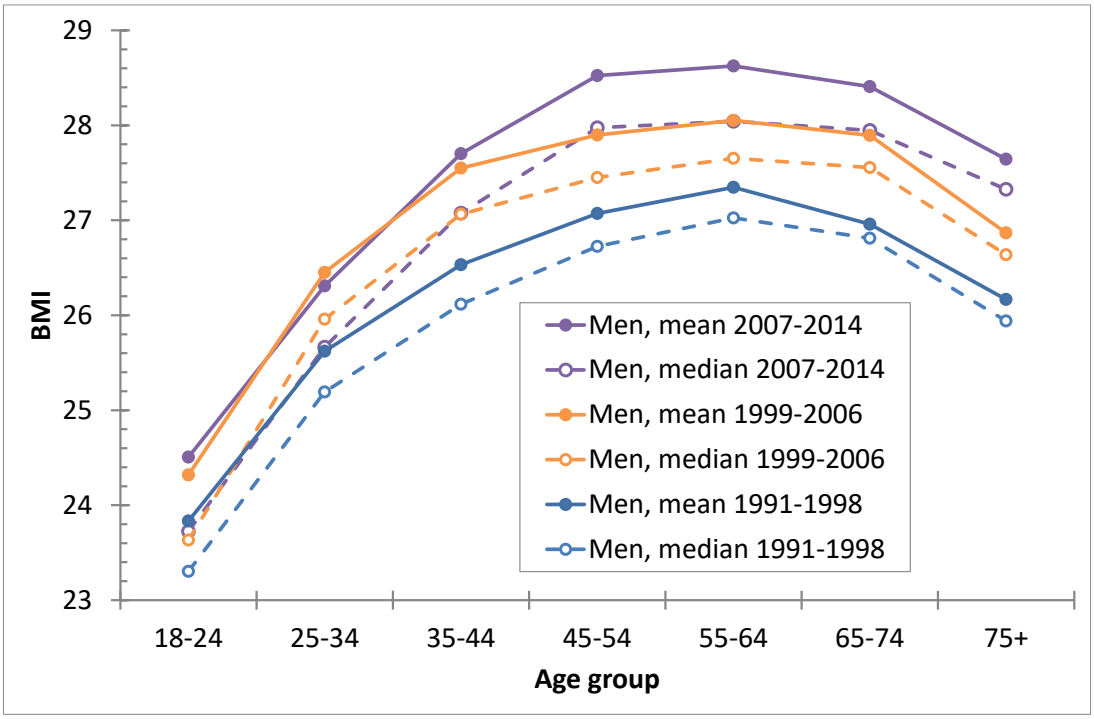

Figure 8.III.8 Mean and median values for each age group for men.

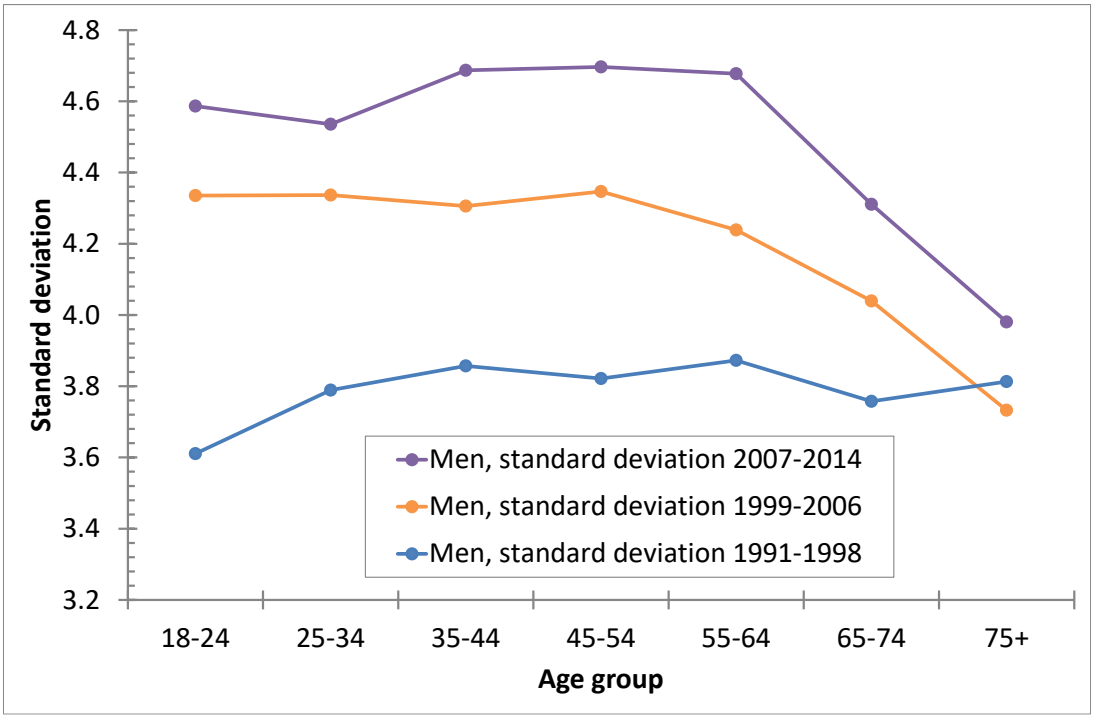

Figure 8.III.9 Standard deviation values for each age group for men.

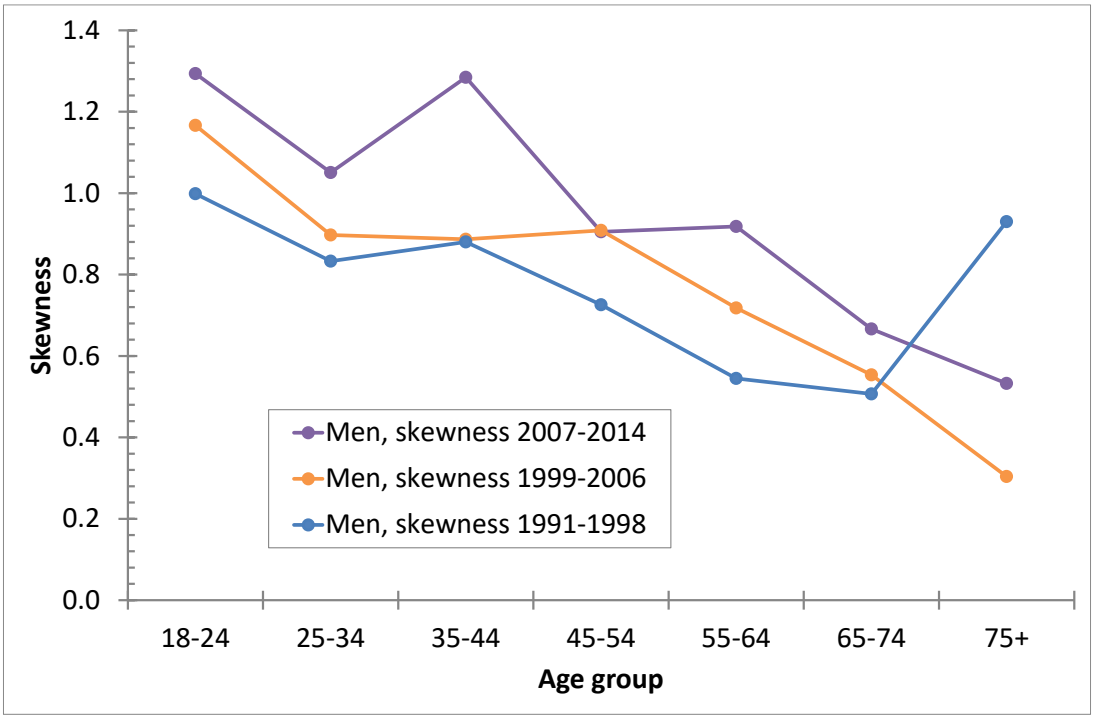

Figure 8.III.10 Skewness values for each age group for men.

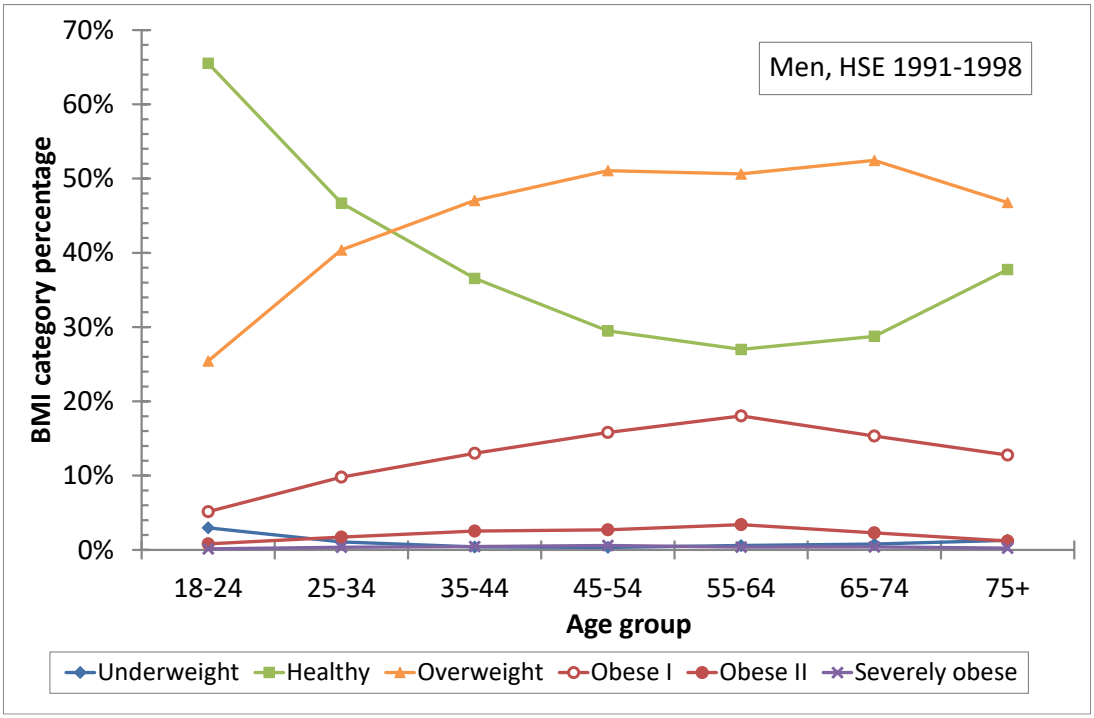

Figure 8.III.11 Age group category percentages for men for 1991-1998.

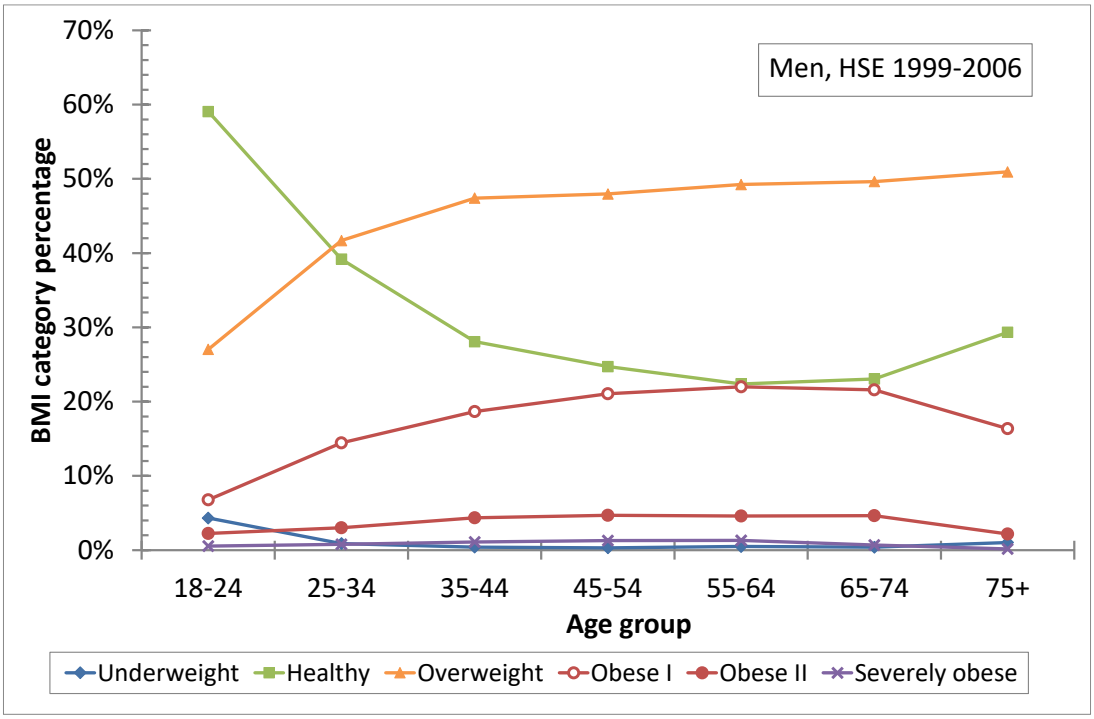

Figure 8.III.12 Age group category percentages for men for 1999-2006.

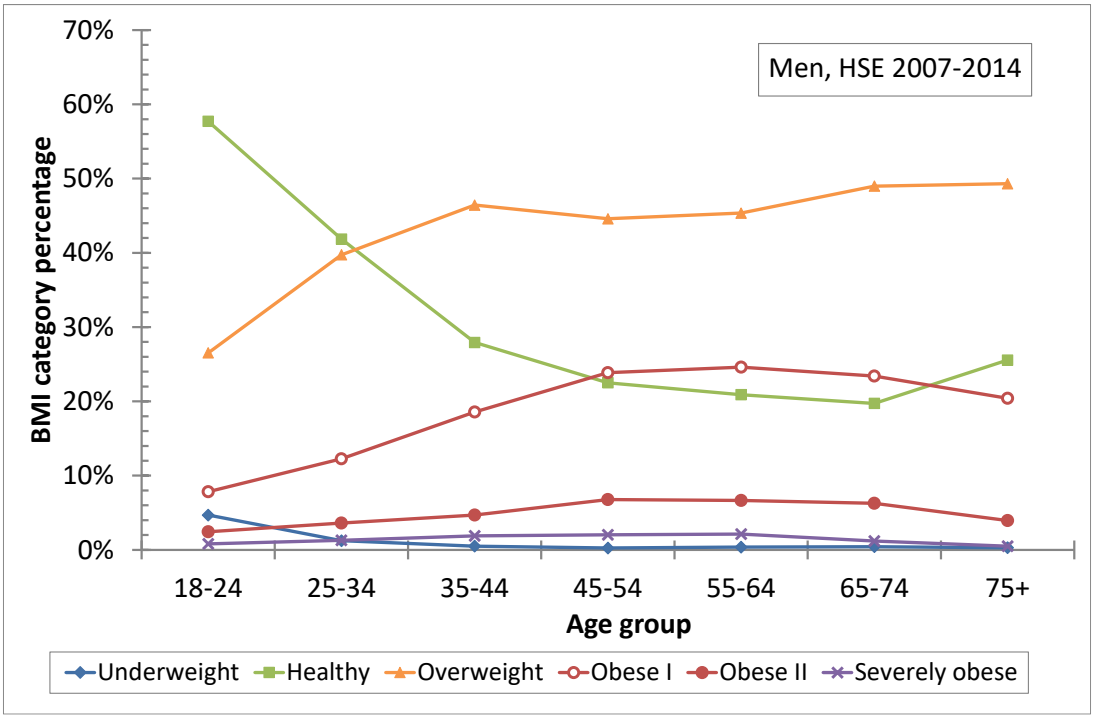

Figure 8.III.13 Age group category percentages for men for 2007-2014.

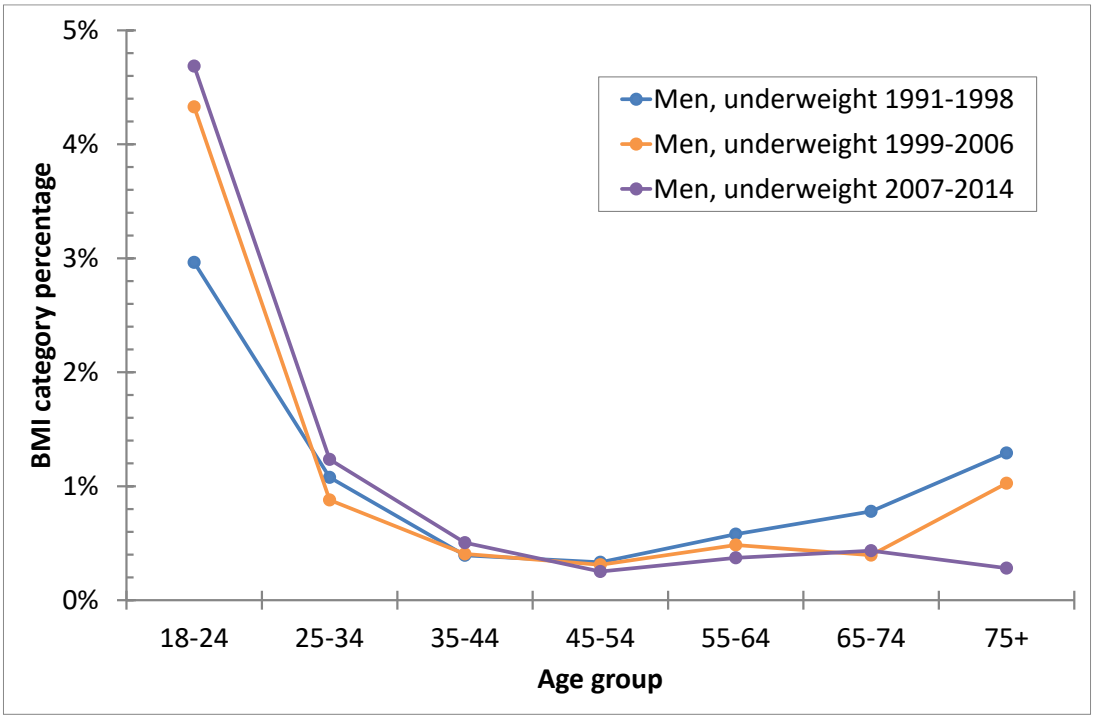

Figure 8.III.14 Underweight age group percentages for men.

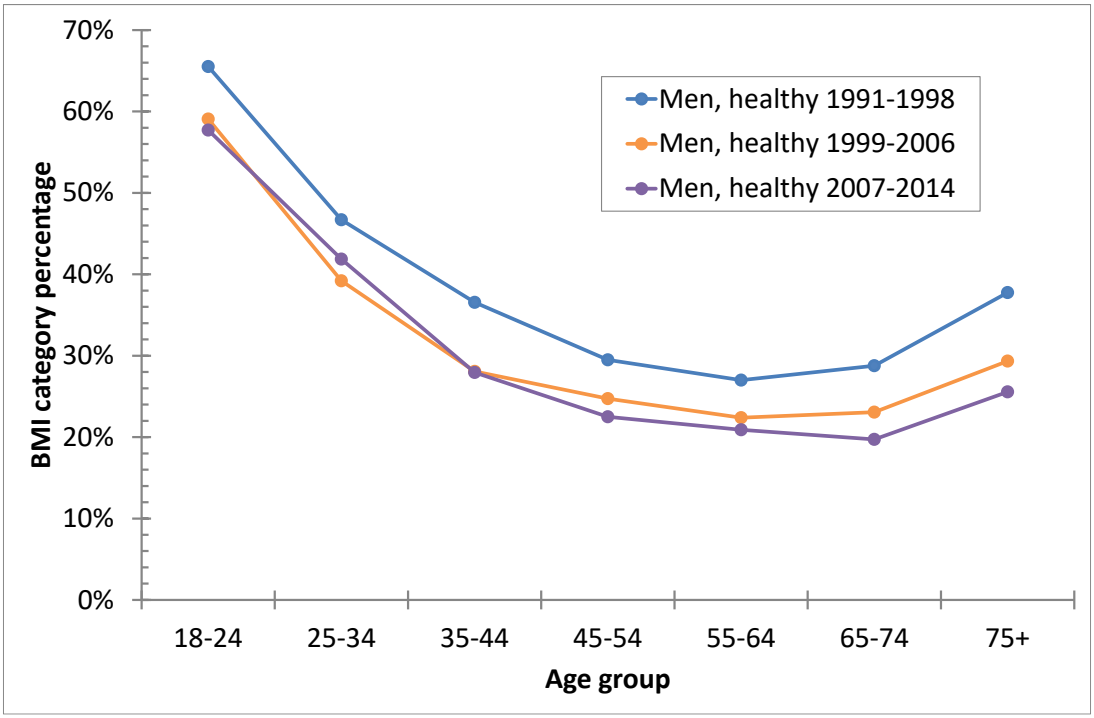

Figure 8.III.15 Healthy age group percentages for men.

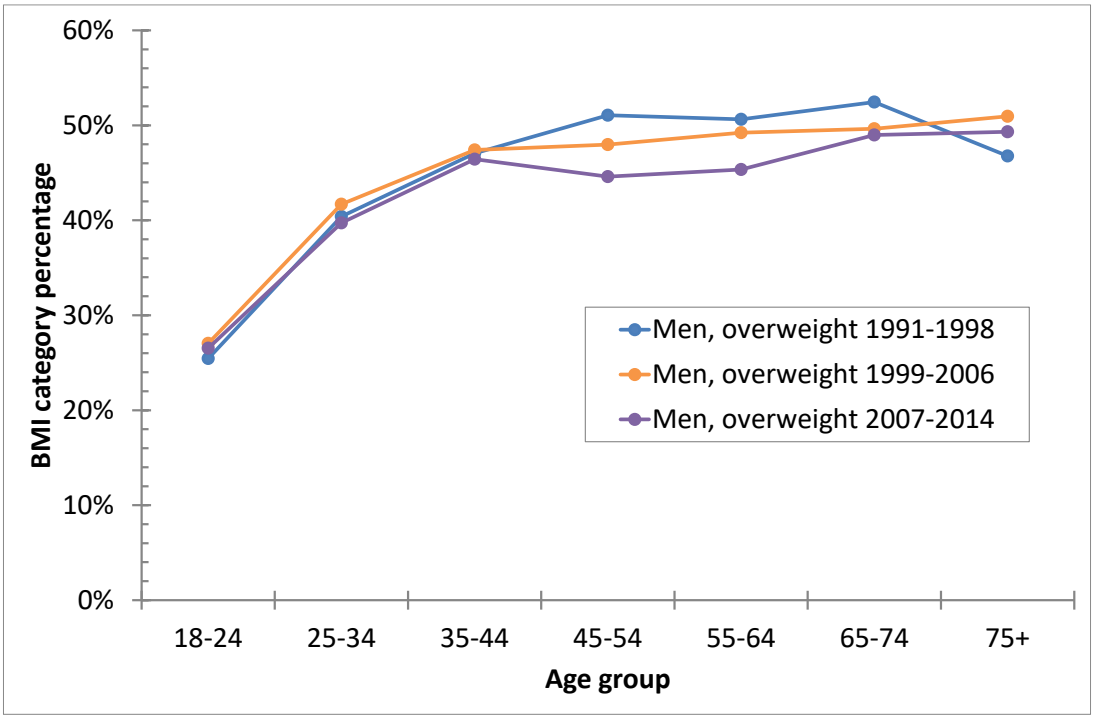

Figure 8.III.16 Overweight age group percentages for men.

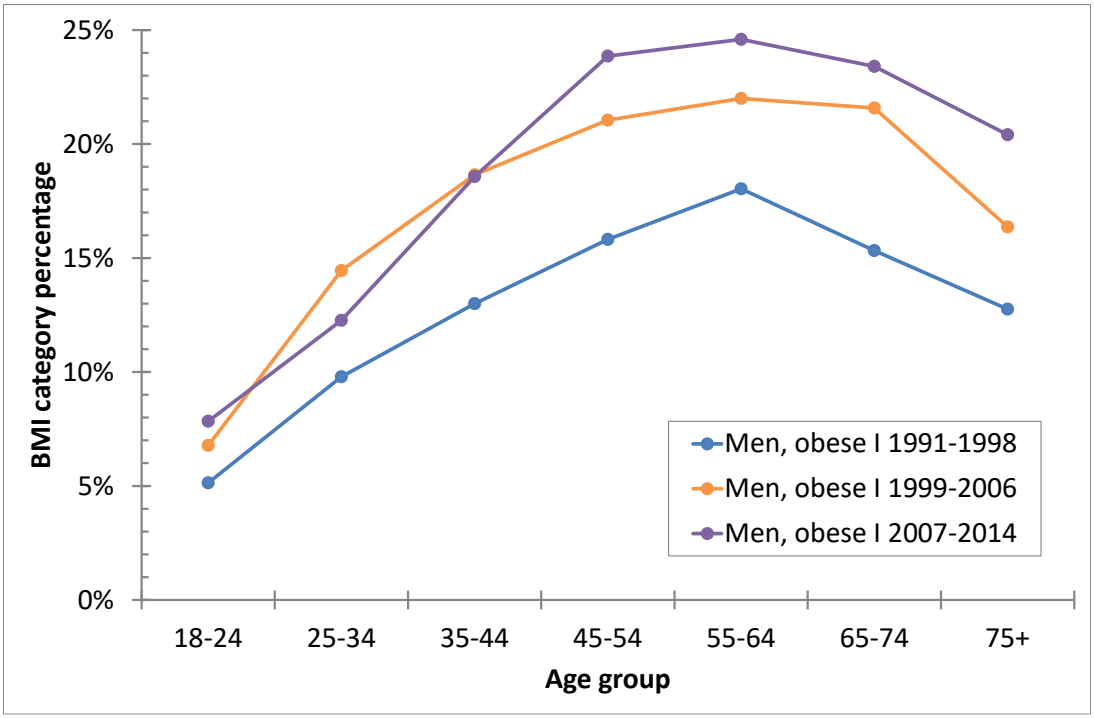

Figure 8.III.17 Obese I age group percentages for men.

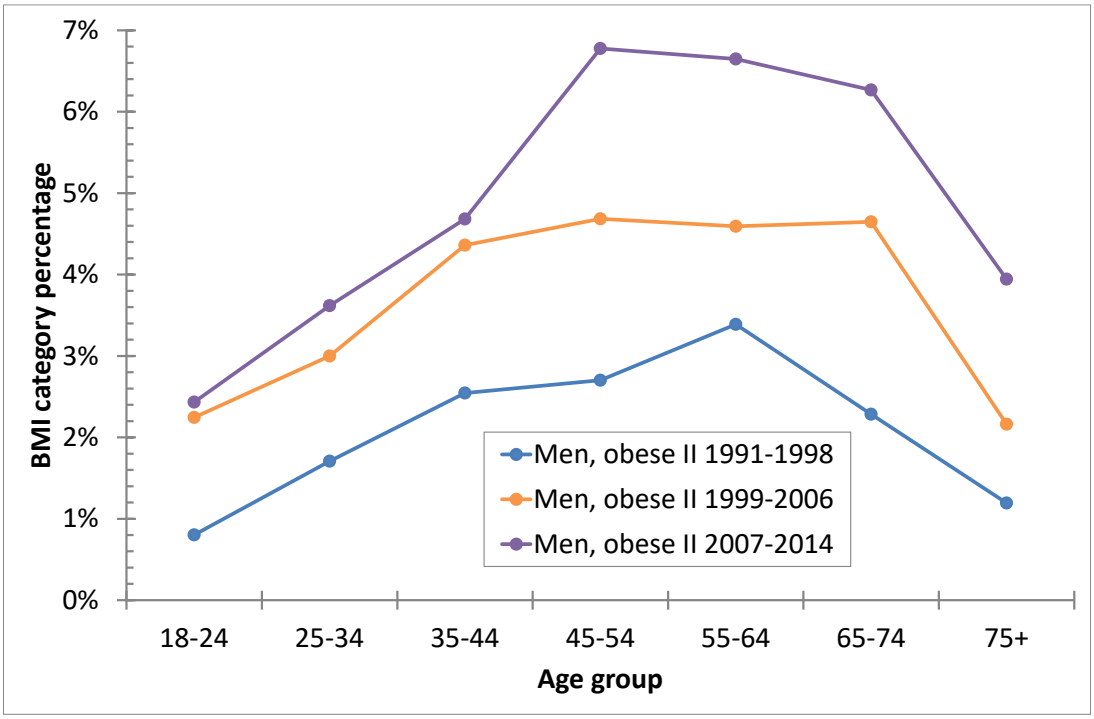

Figure 8.III.18 Obese II age group percentages for men.

Figure 8.III.19 Severely obese age group percentages for men.

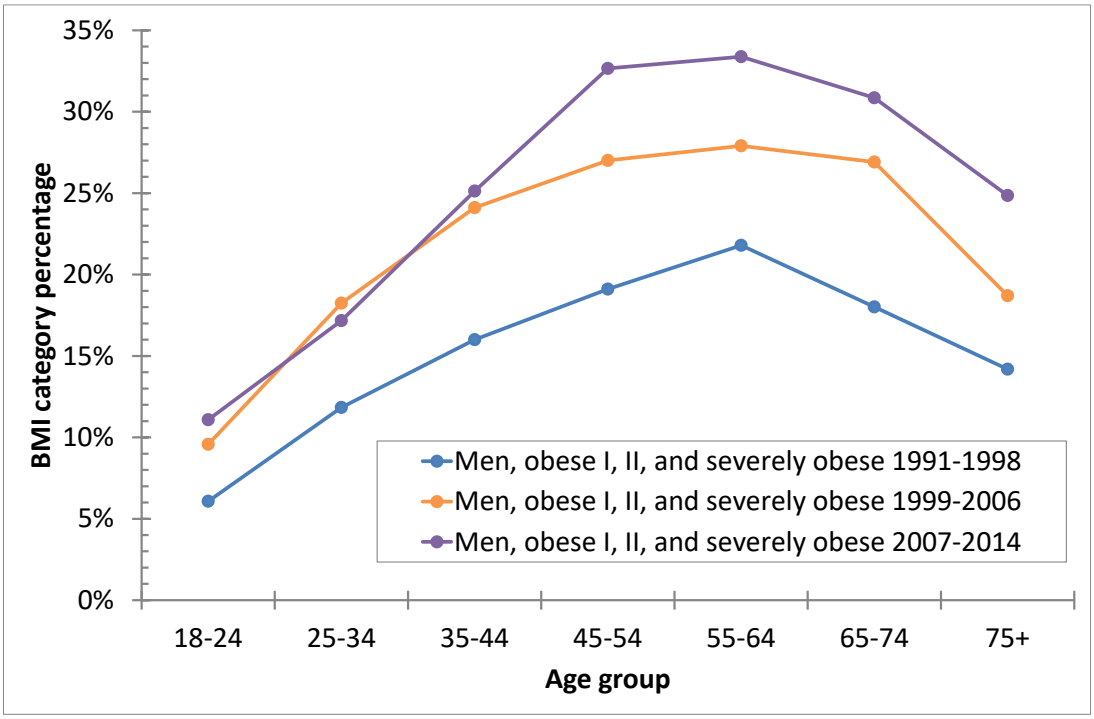

Figure 8.III.20 Combined all obese age group percentages for men.

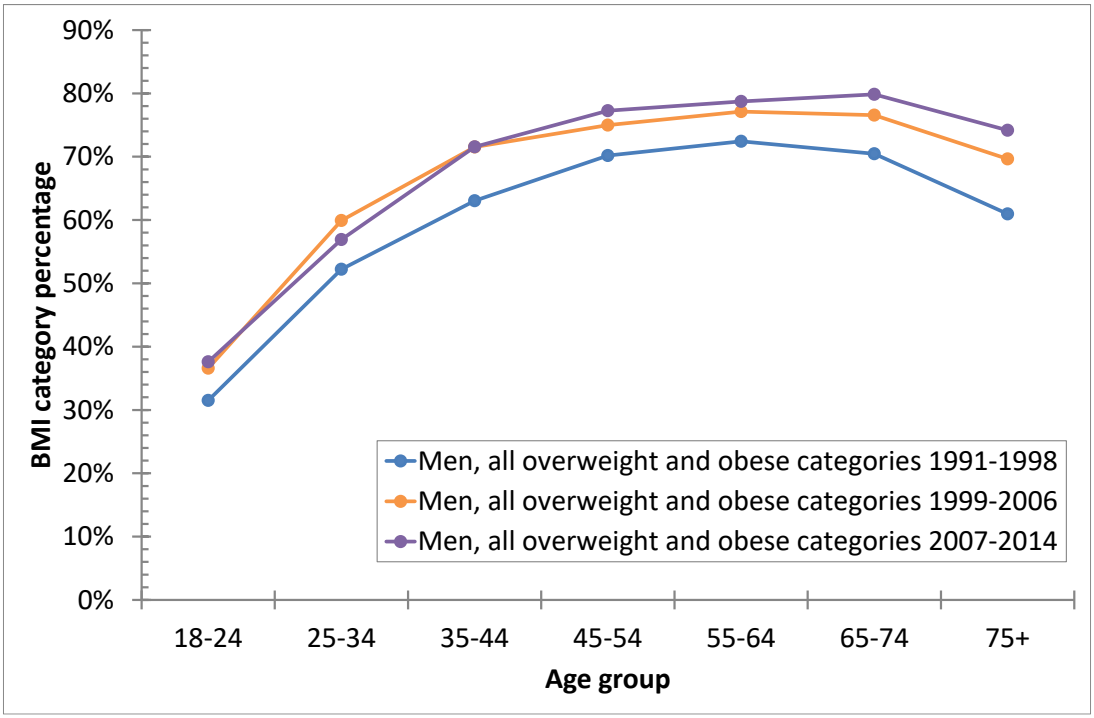

Figure 8.III.21 Combined all overweight and obese age group percentages for men.

Appendix 8.IV Men age group percentiles over time

These charts use all the percentile values (each 10% value and 1%, 5%, 95%, 99%) and plot the increases over time against the starting value. Figure 8.IV.1 (same data as Figure 8.6 but with different formatting) shows the changes for each age group from 1991-1998 to 2007-2014. Figures 8.IV.2 and 8.IV.3 show the changes from 1991-1998 to 1999-2006 and from 1999-2006 to 2007-2014. The latter chart has smaller changes with BMI often tending to only increase at higher BMI values. Figure 8.IV.4 shows the BMI increases for the scaling models from 1991-1998 to 2007-2014 along with the percentile values.

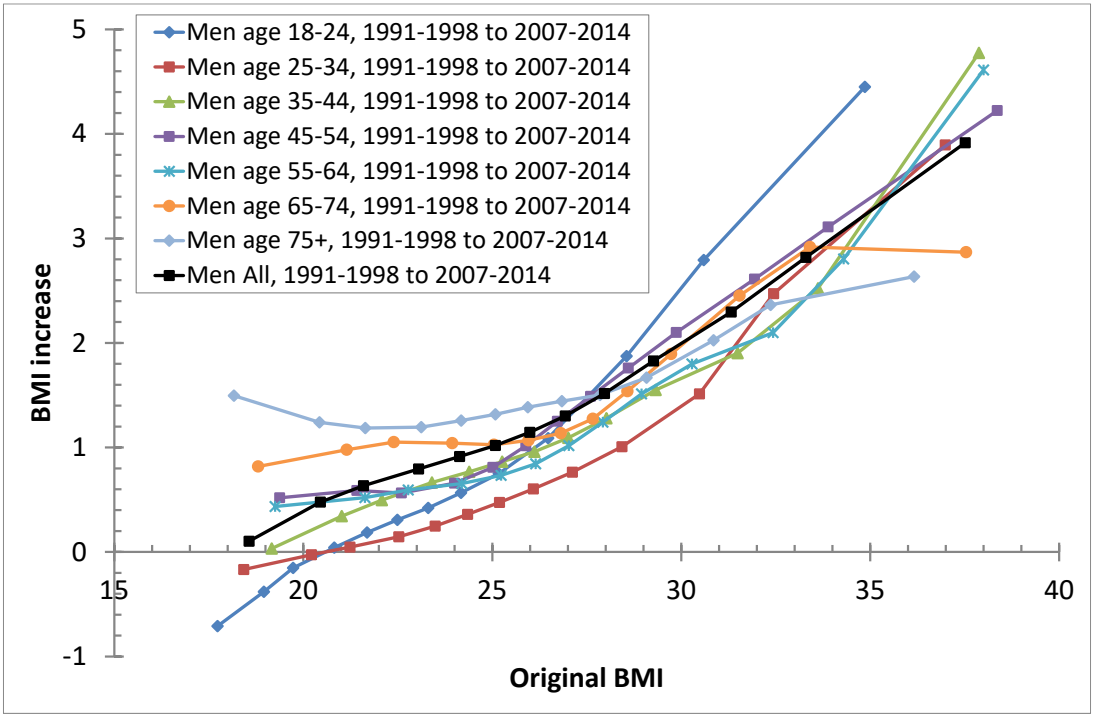

Figure 8.IV.1 Percentile increases for age groups for men from 1991-1998 to 2007-2014.

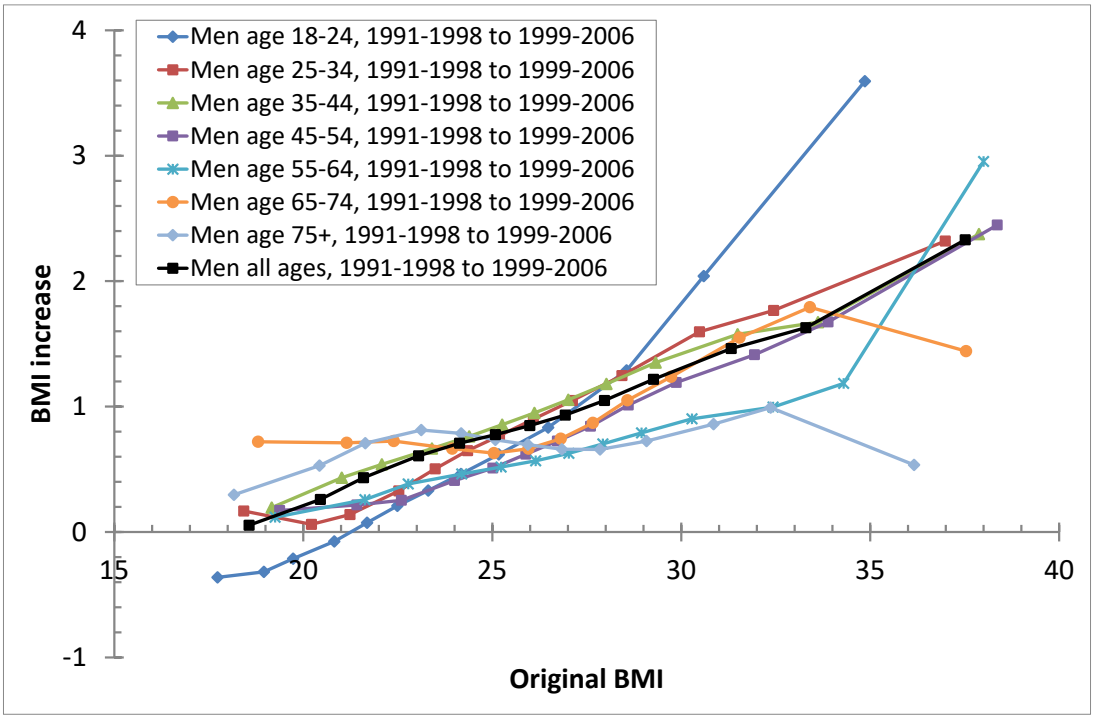

Figure 8.IV.2 Percentile increases for age groups for men from 1991-1998 to 1999-2006.

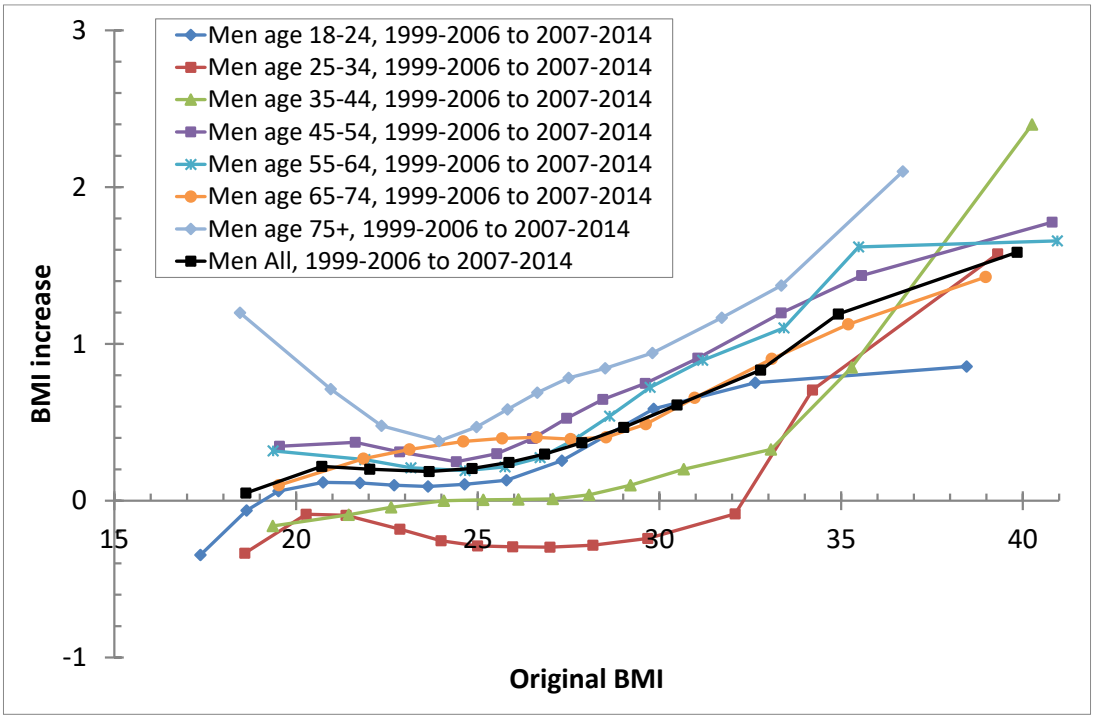

Figure 8.IV.3 Percentile increases for age groups for men from 1999-2006 to 2007-2014.

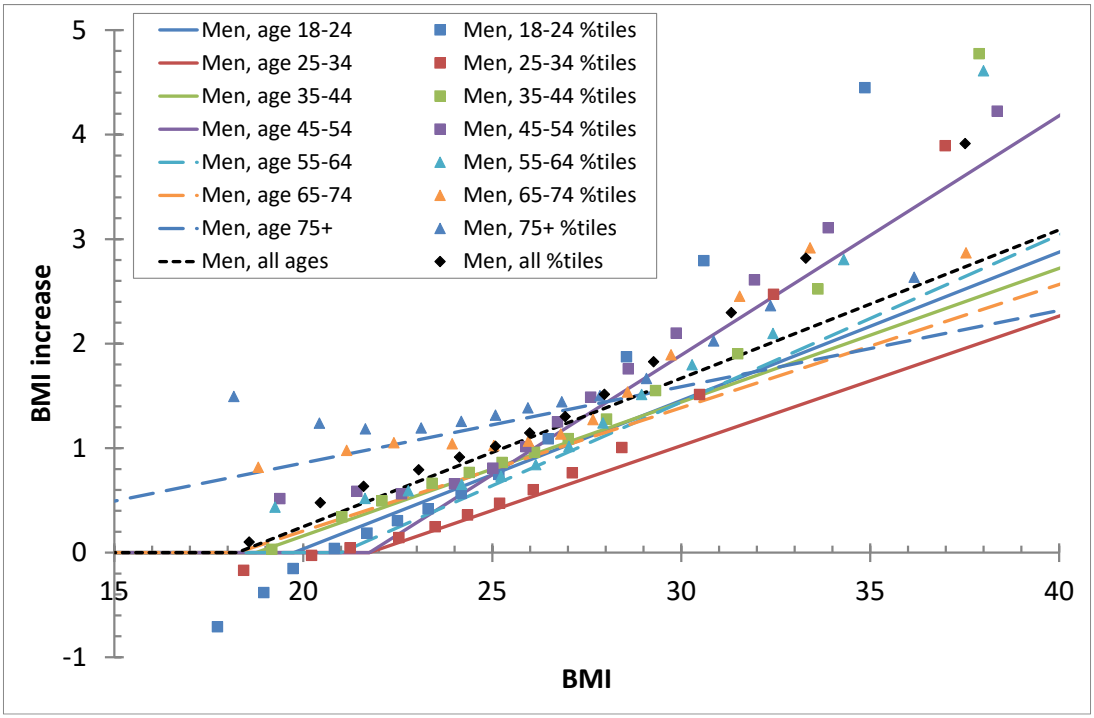

Figure 8.IV.4 Model and percentile increases for age groups for men 1991-1998 to 2007-2014.

Appendix 8.V Men age group models

Change with time: scaling models

These charts show the linear scaling model results for modelling the changes from 1991-1998 to 2007-2014 for each age group for men. For each age group the model does pretty well in matching the 2007-2014 distribution.

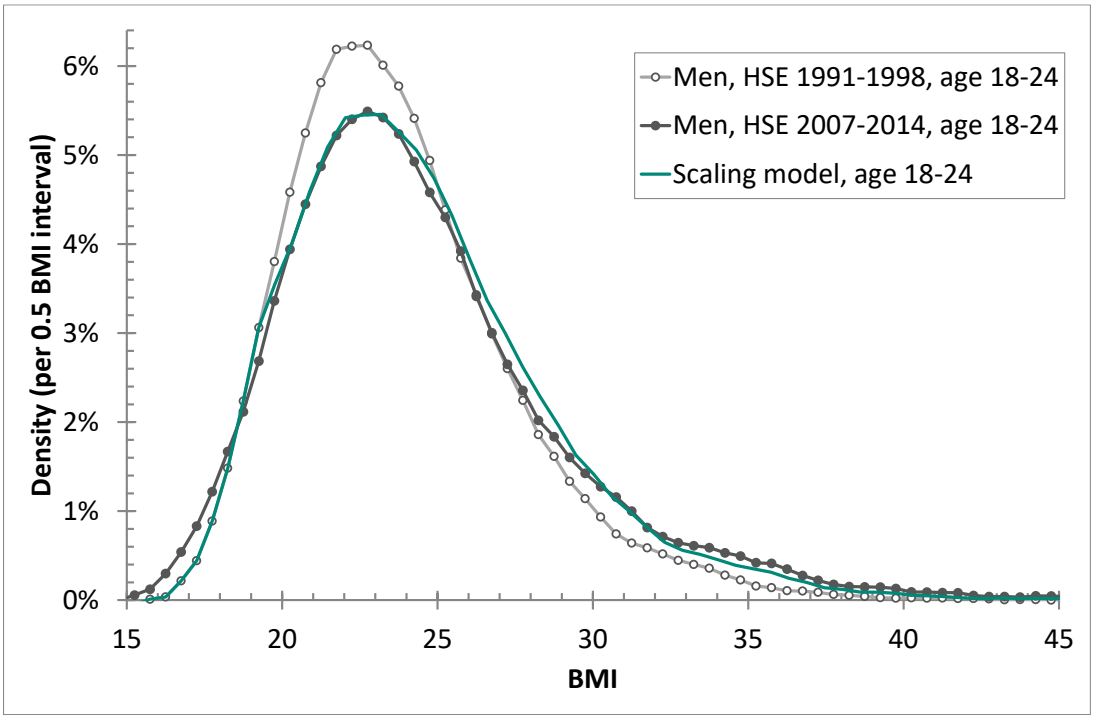

Figure 8.V.1 Scaling model for men age 18-24 from 1991-1998 to 2007-2014.

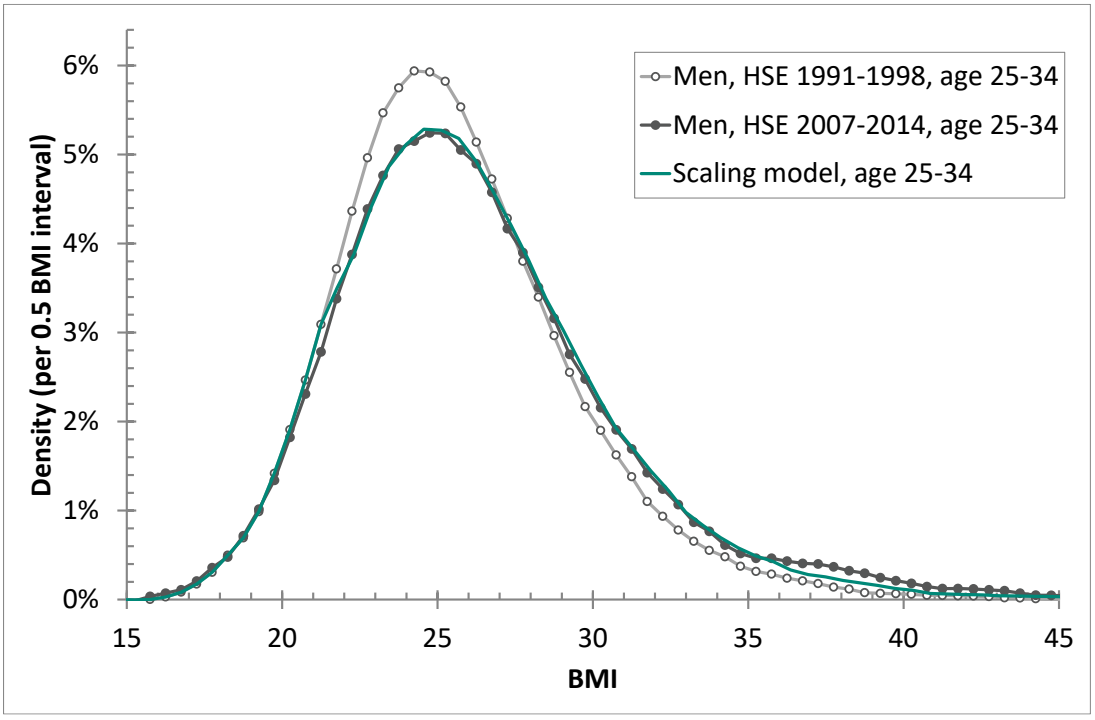

Figure 8.V.2 Scaling model for men age 25-34 from 1991-1998 to 2007-2014.

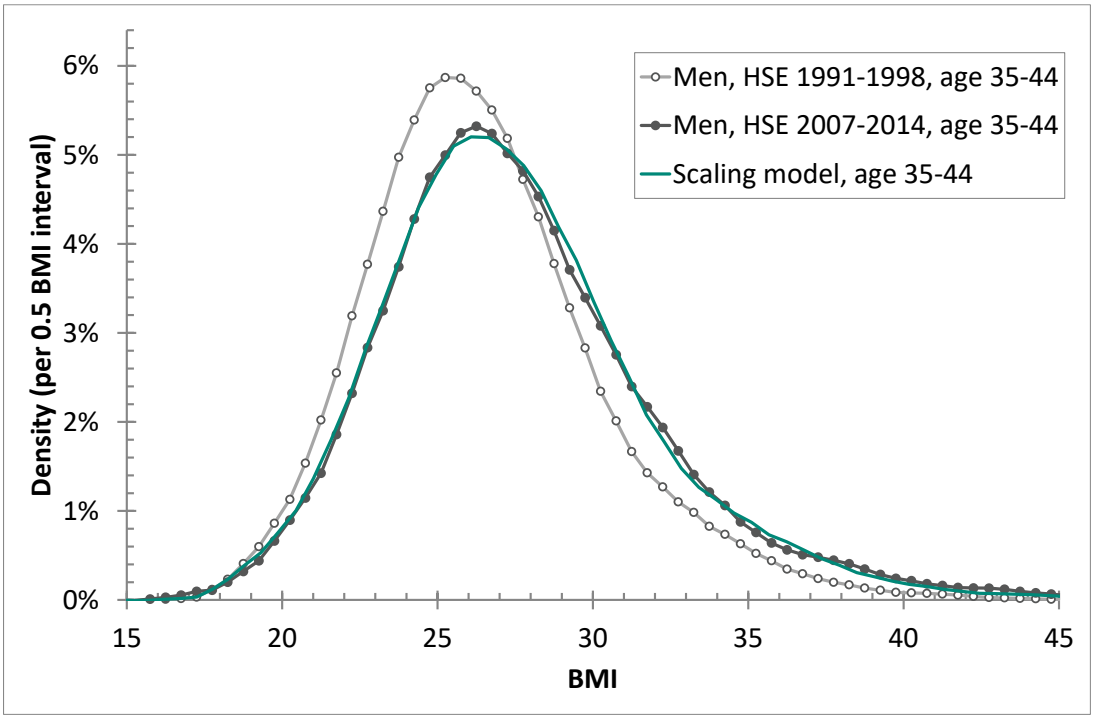

Figure 8.V.3 Scaling model for men age 35-44 from 1991-1998 to 2007-2014.

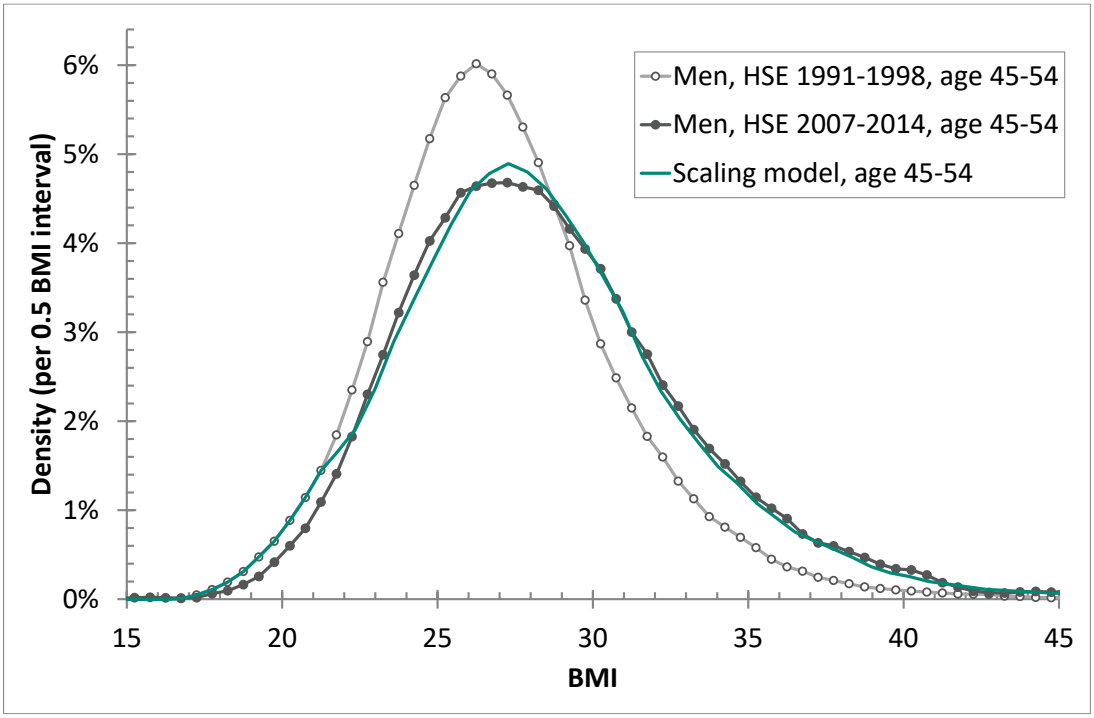

Figure 8.V.4 Scaling model for men age 45-54 from 1991-1998 to 2007-2014.

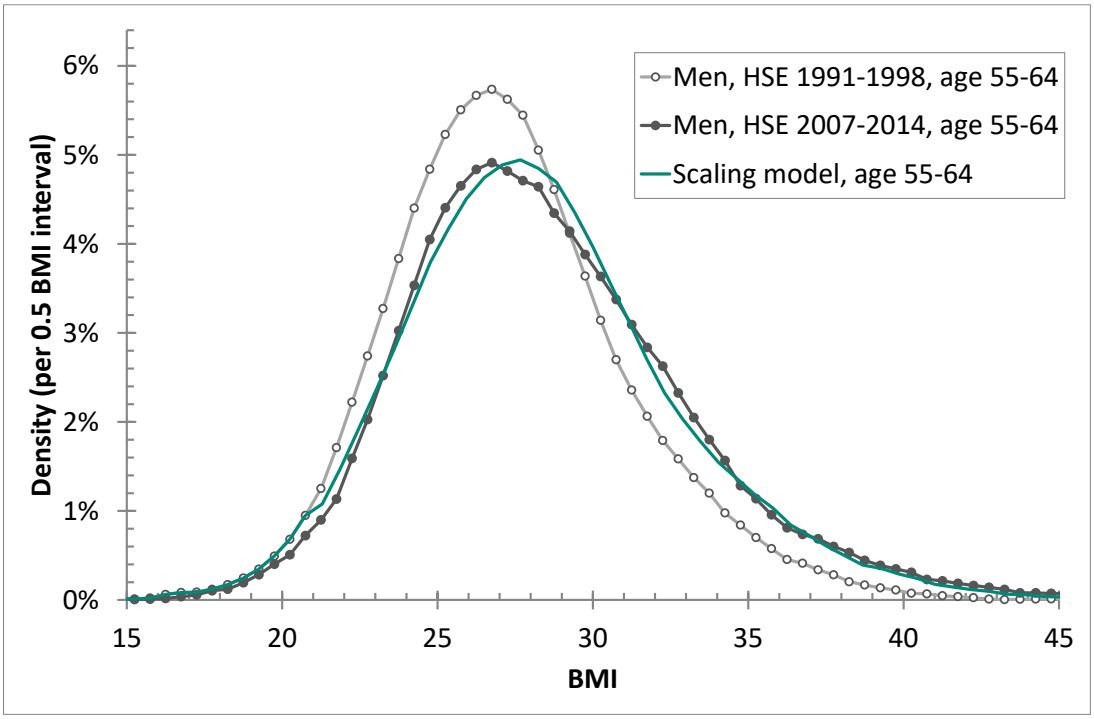

Figure 8.V.5 Scaling model for men age 55-64 from 1991-1998 to 2007-2014.

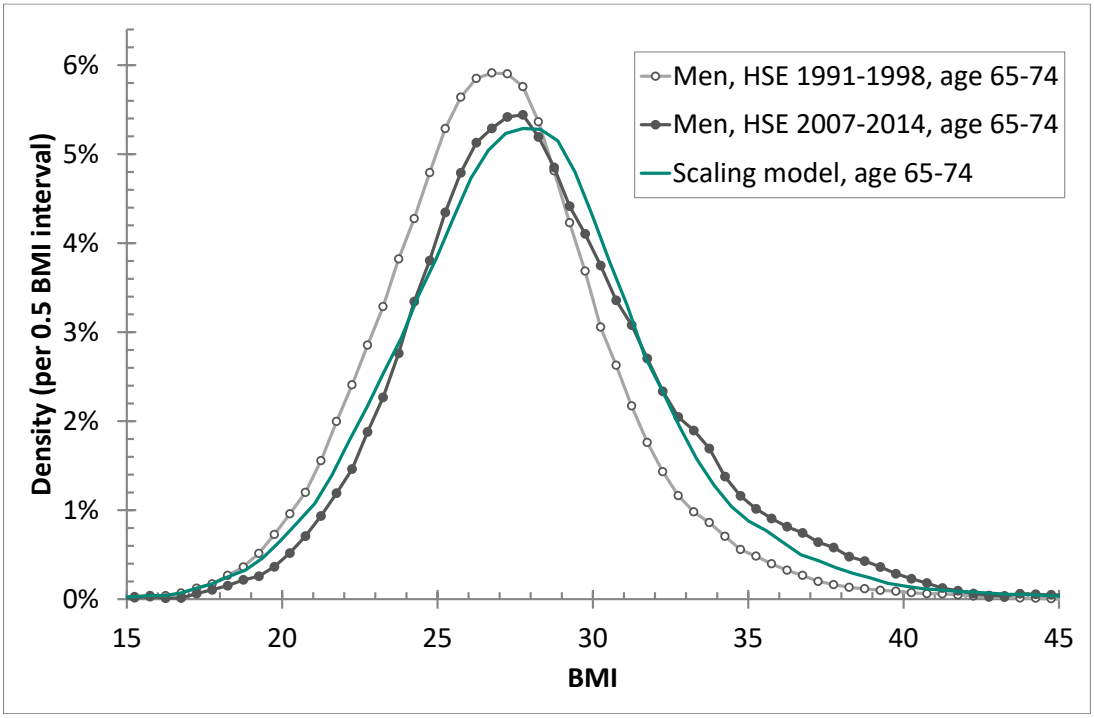

Figure 8.V.6 Scaling model for men age 65-74 from 1991-1998 to 2007-2014.

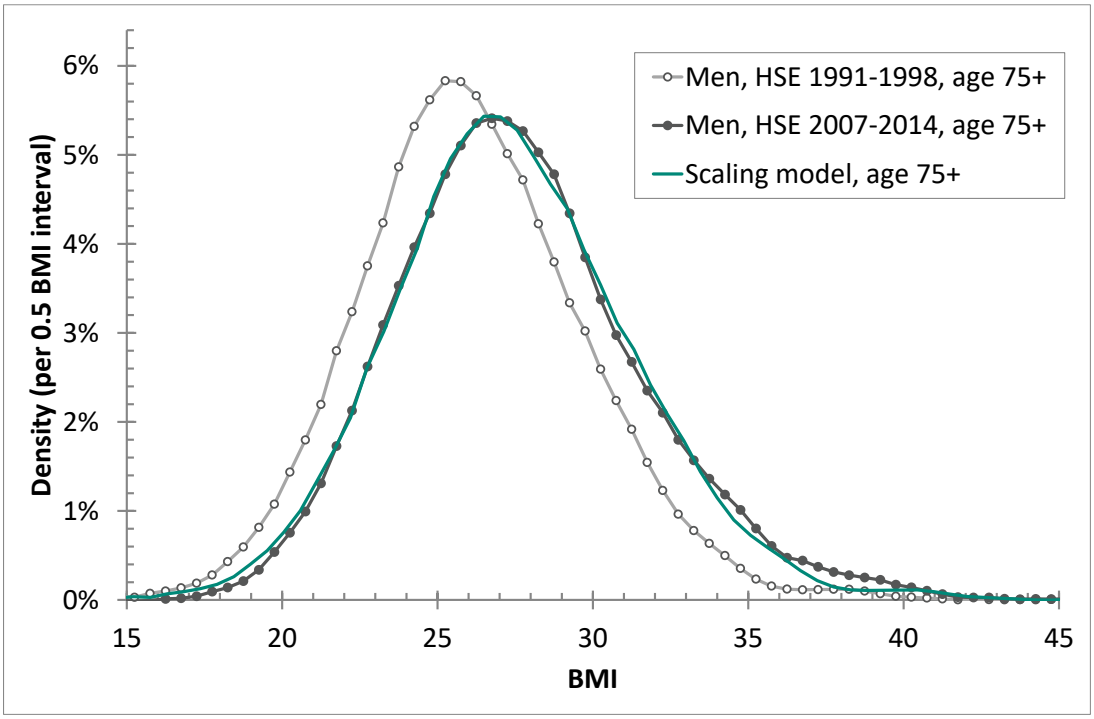

Figure 8.V.7 Scaling model for men age 75+ from 1991-1998 to 2007-2014.

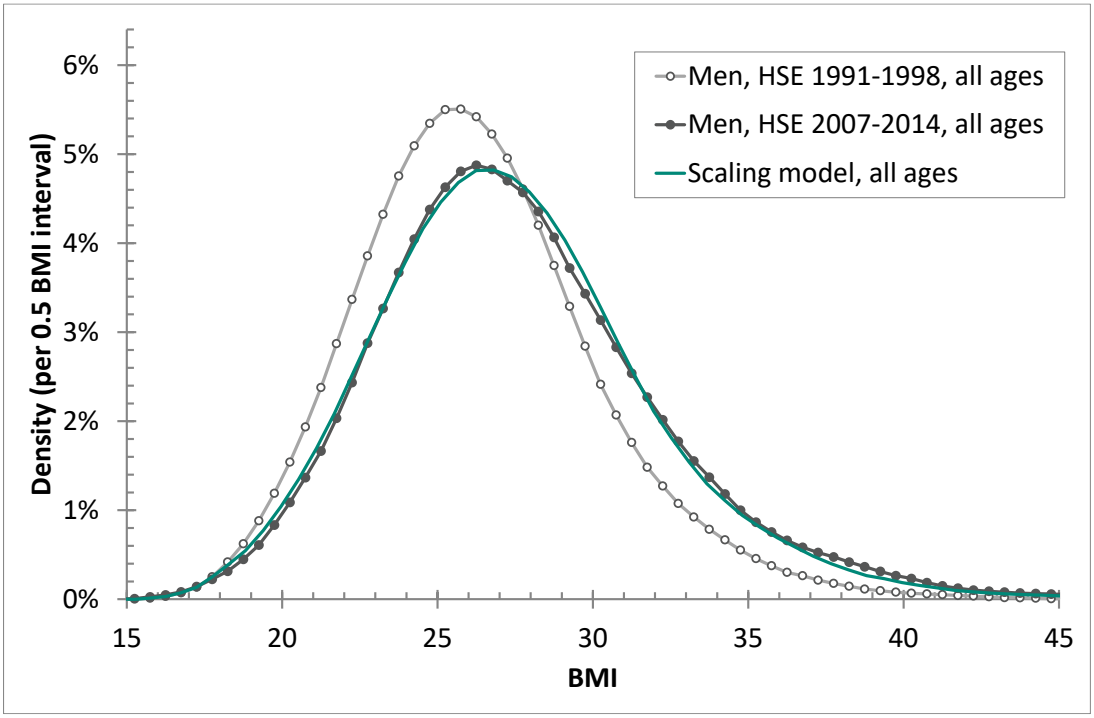

Figure 8.V.8 Scaling model for men all ages (i.e., 18+) from 1991-1998 to 2007-2014.

Change with age: shift models

These charts show the modelling of the changes with age for 2007-2014 from 18-24 to 25-34, and from 25-34 to 35-44 using a shift (translation). The shift value used was the change in mean and the transformation is able to model the changes well. The shift values used are 1.804 and 1.391. The resulting fitness values for the two models are 5.72×10^{-5} and 1.77×10^{-5}. Slightly better fitness values can be obtained by optimising the shift values although the difference in values used is small. Using the change in mean ensures that the model mean matches the mean for the target distribution.

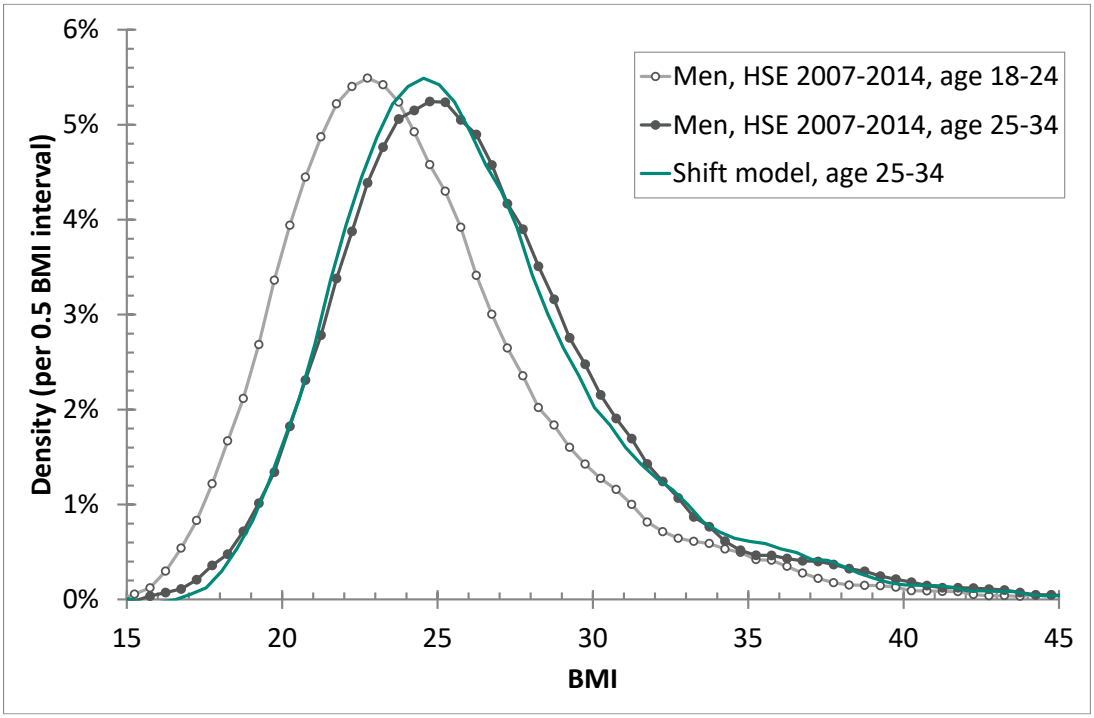

Figure 8.V.9 Shift model for men from age group 18-24 to 25-34.

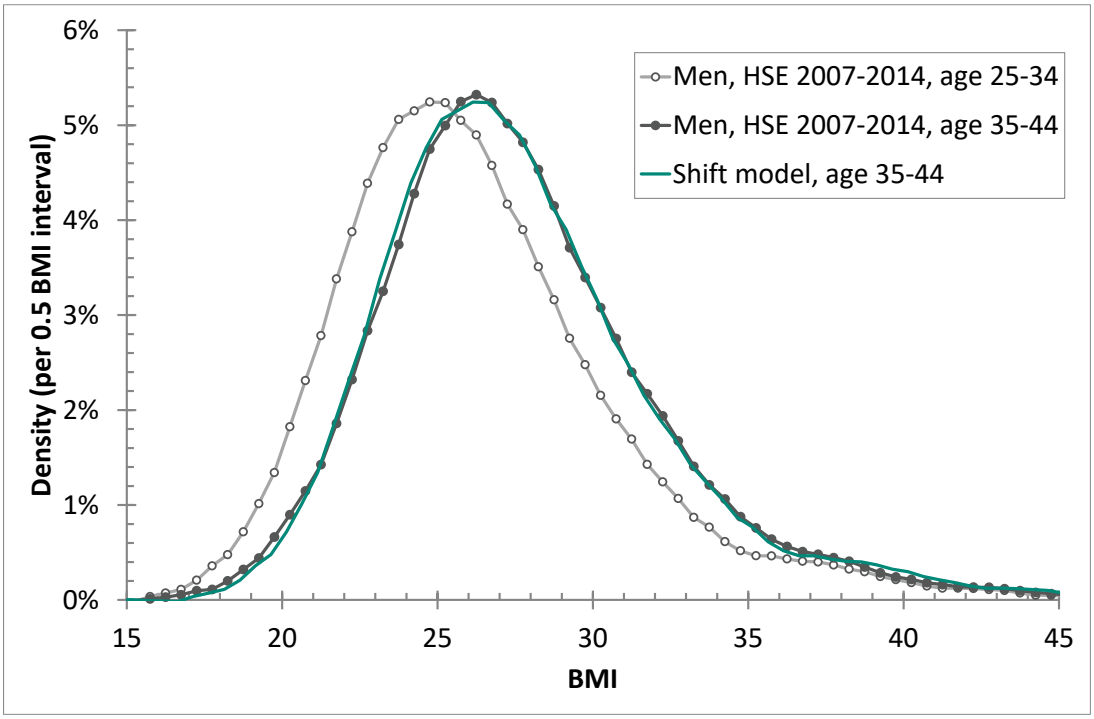

Figure 8.V.10 Shift model for men from age group 25-34 to 35-44.

Appendix 8.VI Analysis of single years of age from 18 to 54 for men

Charts of the population distributions

This appendix has the analysis of population distributions obtained for men for individual years of age from age 18 to 54 with gaps of 6 years. This is discussed in Section 8.5.1 of the main report. The time intervals used are 1991-1998 and 1999-2014. Figures 8.VI.1 and 8.VI.2 show the distributions for each of the time intervals.

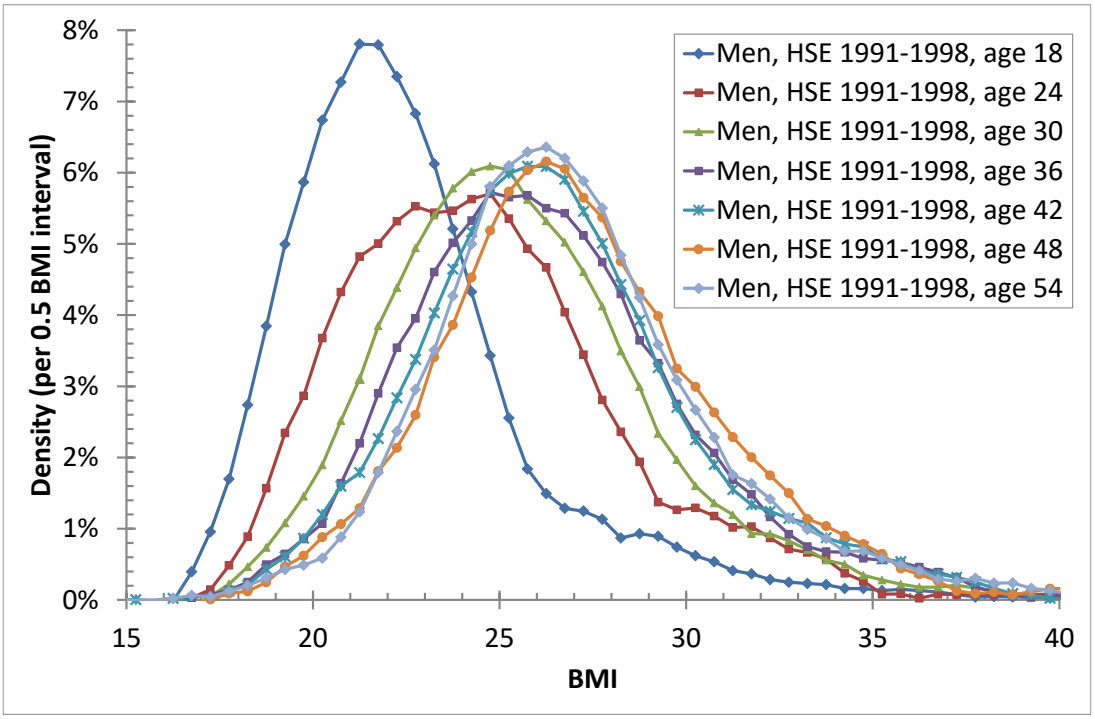

Figure 8.VI.1 Distributions for selected single age years from 18 to 54 for men for 1991-1998.

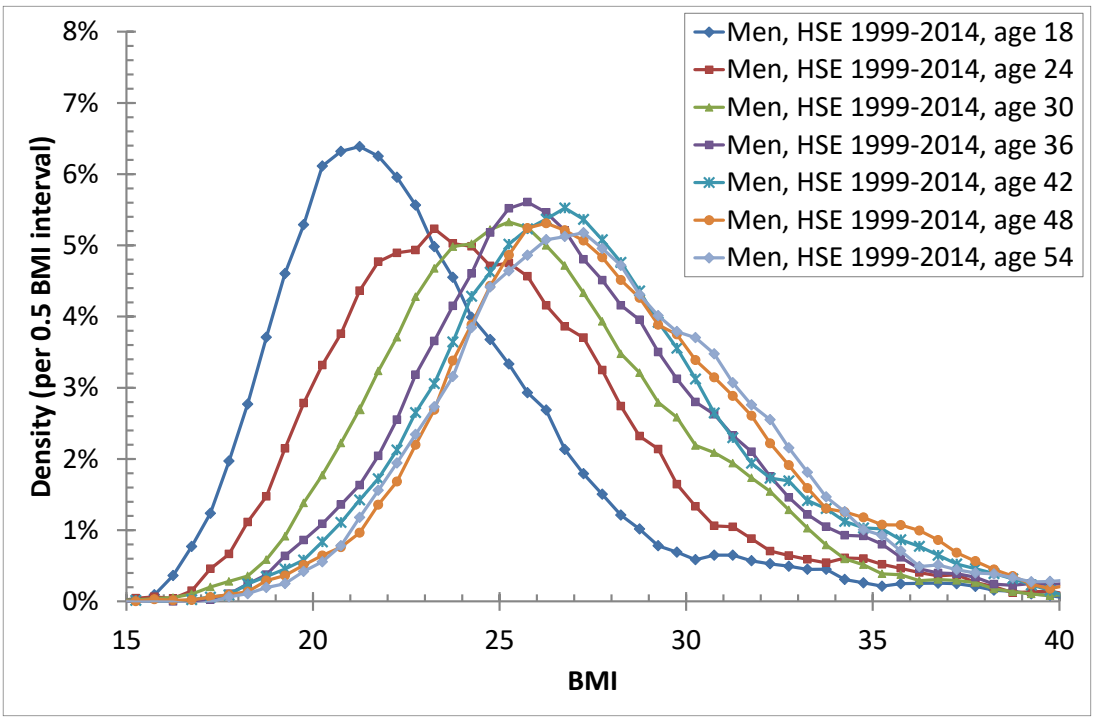

Figure 8.VI.2 Distributions for selected single age years from 18 to 54 for men for 1999-2014.

Percentiles

The percentiles were calculated for the changes over time and with age. The charts here show the BMI increases for 10% percentiles along with 5% and 95%. The 1% and 99% values are not shown. This is because they are sensitive to the small sample sizes and the 99% value particularly shows variability with some fairly large fluctuations compared to the pattern of the other percentiles. The increases with time are shown in Figure 8.VI.3 and the increases with age in Figure 8.VI.4.

Figure 8.VI.3 shows the percentile increases with time, from 1991-1998 to 1999-2014. The "all" category is the combined data from the seven ages. Each age shows a similar linear increase indicating approximately a linear scaling transformation. Age 18 has increases that are mostly a bit higher than the other ages. It also has some negative values at low BMI values indicating the left tail extending a little (i.e., an increase in underweight BMI prevalence) as well as the distribution stretching out further to the right.

Figure 8.IV.4 shows the percentile increases with age for each age compared to the previous younger age, for the 1999-2014 data. For example, the age 24 series shows the increases in the percentiles for the age 24 distribution compared to the distribution for age 18. The series are generally approximately a horizontal line indicating that the change is mainly a shift (translation) along the x-axis. Age 24 has some of the points as an increasing line indicating some change in shape from age 18 to 24 with some elements of a linear scaling.

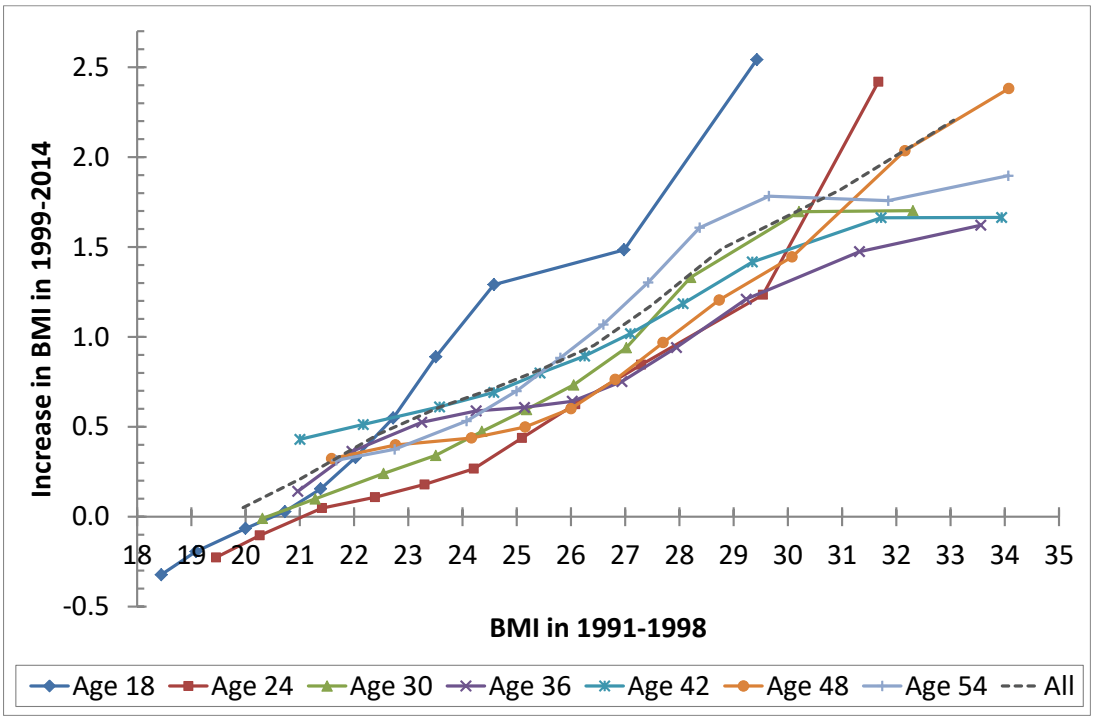

Figure 8.VI.3 Percentile increases with time for men single ages from 1991-1998 to 1999-2014.

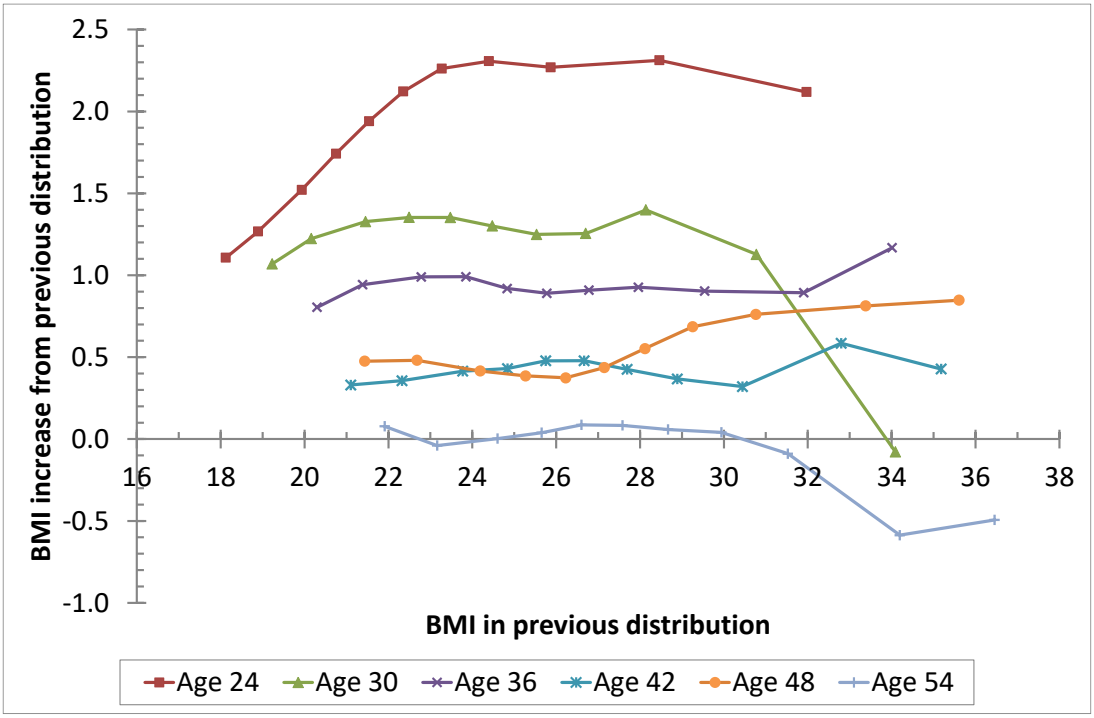

Figure 8.VI.4 Percentile increases with age for men single ages for 1999-2014.

Descriptive statistics

The descriptive statistics for the distributions are given below in Tables 8.VI.1 and 8.VI.2. Charts of the statistics follow in Figures 8.VI.5-17.

Figures 8.VI.5 and 8.VI.6 show all the category percentages together. The mean and median, standard deviation, and skewness are in Figures 8.VI.7-9.

Then, Figures 8.VI.10-15 are charts of each BMI category individually. These are included to show the trends with age, although sample sizes are small and so there are considerable irregularities for the categories with the smaller percentages (obese II and severely obese). Figures 8.VI.16 and 8.VI.17 are charts of all the obese categories and the total of the overweight and obese categories.

Table 8.VI.1 Descriptive statistics for men for selected ages from 18 to 54 for 1991-1998.

Age	18	24	30	36	42	48	54
Sample size of actual data	561	679	845	802	704	758	600
Mean	22.64	24.61	25.56	26.43	26.68	27.25	27.03
Median	22.03	24.21	25.18	26.02	26.25	26.82	26.60
Modal interval mid-point	21.25	24.75	24.75	24.75	25.75	26.25	26.25
Standard deviation	3.38	3.67	3.63	3.86	4.00	3.91	3.81
Skewness	1.53	0.84	0.80	0.87	1.26	0.93	0.88
Underweight (BMI < 18.5)	5.3%	1.3%	0.6%	0.4%	0.3%	0.1%	0.4%
Healthy (18.5 ≤ BMI < 25.0)	77.6%	57.7%	47.3%	38.0%	34.6%	28.1%	29.6%
Overweight (25.0 ≤ BMI < 30.0)	13.0%	32.2%	41.5%	46.1%	48.9%	51.3%	52.1%
Obese I (30.0 ≤ BMI < 35.0)	3.2%	8.0%	9.0%	12.3%	12.9%	17.0%	14.1%
Obese II (35.0 ≤ BMI < 40.0)	0.8%	0.7%	1.5%	2.7%	2.8%	2.4%	3.1%
Severely obese (BMI ≥ 40.0)	0.1%	0.1%	0.2%	0.5%	0.6%	1.1%	0.6%

Table 8.VI.2 Descriptive statistics for men for selected ages from 18 to 54 for 1999-2014.

Age	18	24	30	36	42	48	54
Sample size of actual data	769	712	909	1041	1113	1005	1012
Mean	23.24	25.14	26.36	27.26	27.64	28.20	28.21
Median	22.35	24.48	25.78	26.67	27.15	27.58	27.66
Modal interval mid-point	21.25	23.25	25.25	25.75	26.75	26.25	27.25
Standard deviation	4.26	4.51	4.46	4.36	4.34	4.52	4.48
Skewness	1.47	1.15	1.09	0.96	0.90	0.88	1.09
Underweight (BMI < 18.5)	7.1%	2.5%	1.1%	0.3%	0.4%	0.4%	0.1%
Healthy (18.5 ≤ BMI < 25.0)	67.4%	52.4%	40.7%	31.3%	26.9%	23.2%	23.4%
Overweight (25.0 ≤ BMI < 30.0)	18.1%	33.1%	40.6%	45.9%	48.2%	46.9%	46.7%
Obese I (30.0 ≤ BMI < 35.0)	4.9%	8.0%	13.7%	17.2%	18.3%	21.5%	23.3%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	3.0%	2.4%	4.0%	5.4%	6.5%	4.8%
Severely obese (BMI ≥ 40.0)	0.6%	0.9%	1.5%	1.3%	0.8%	1.6%	1.8%

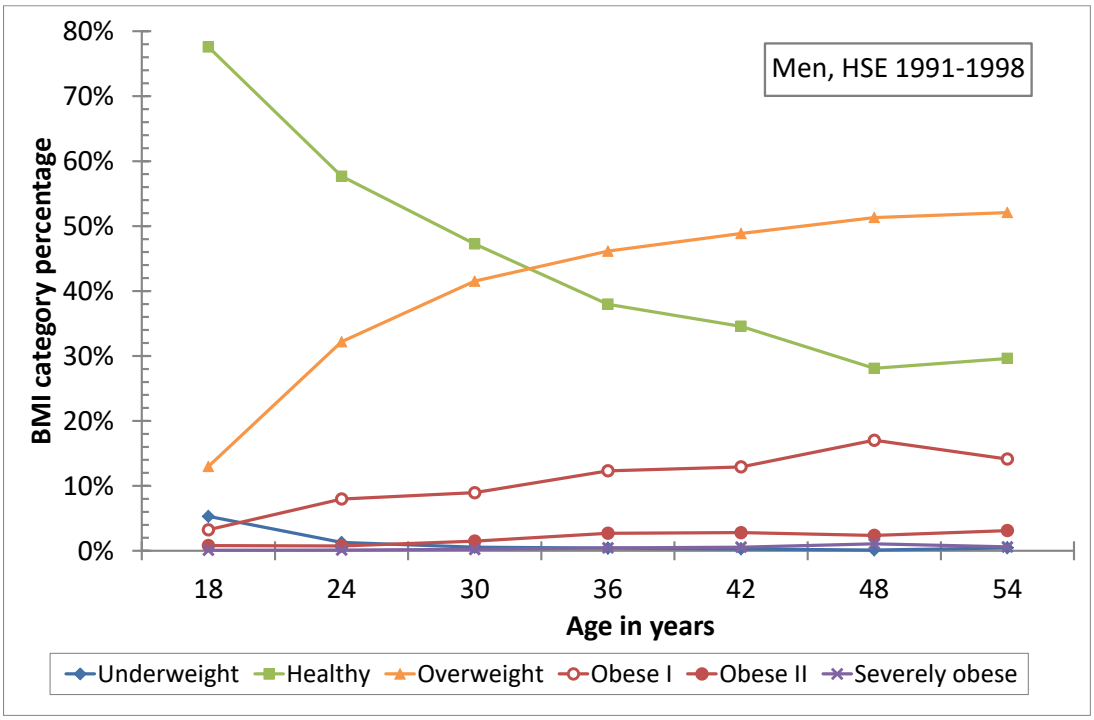

Figure 8.VI.5 Category percentages for selected ages from 18 to 54 for men for 1991-1998.

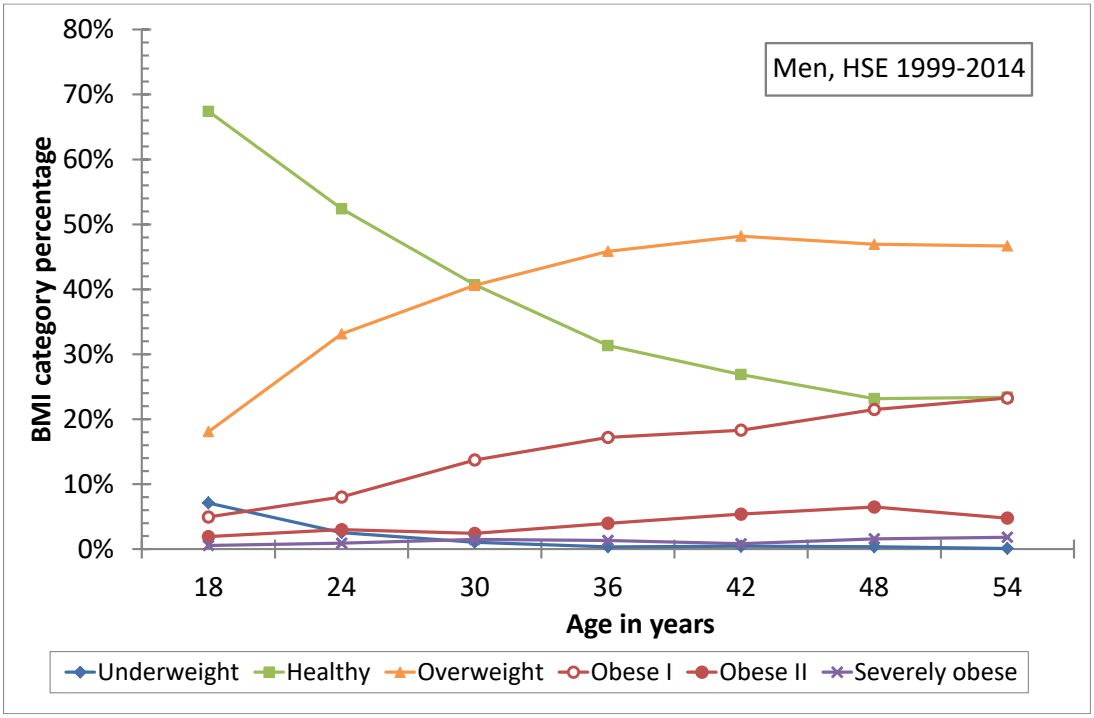

Figure 8.VI.6 Category percentages for selected ages from 18 to 54 for men for 1999-2014.

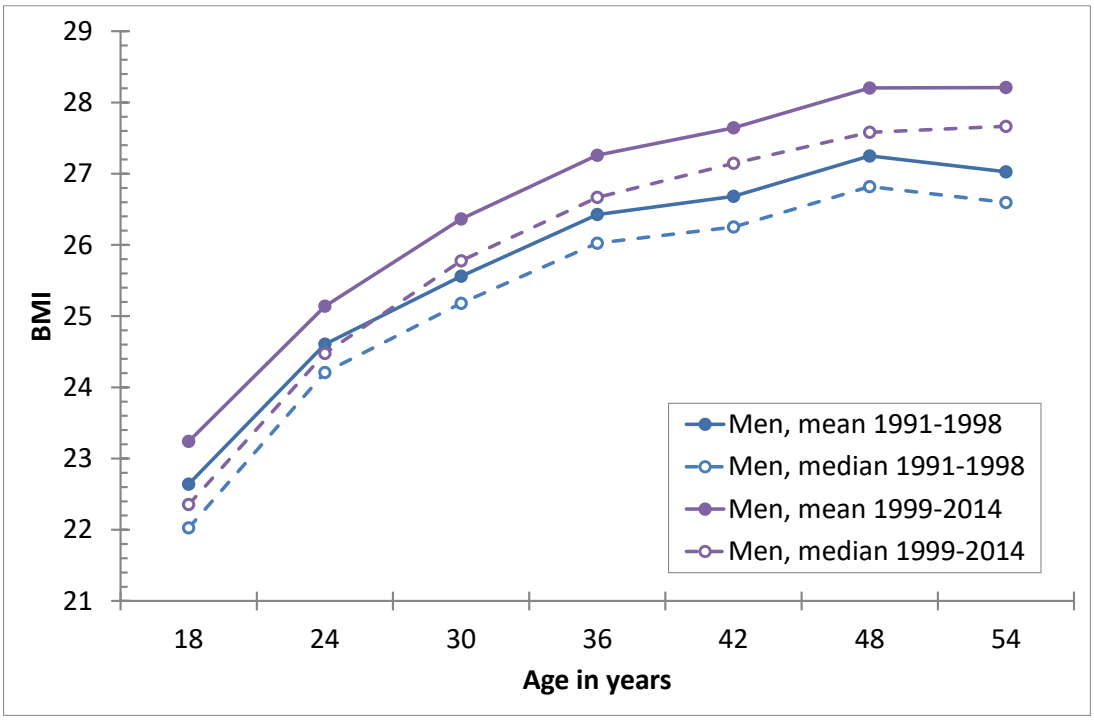

Figure 8.VI.7 Mean and median selected ages from 18 to 54 for men.

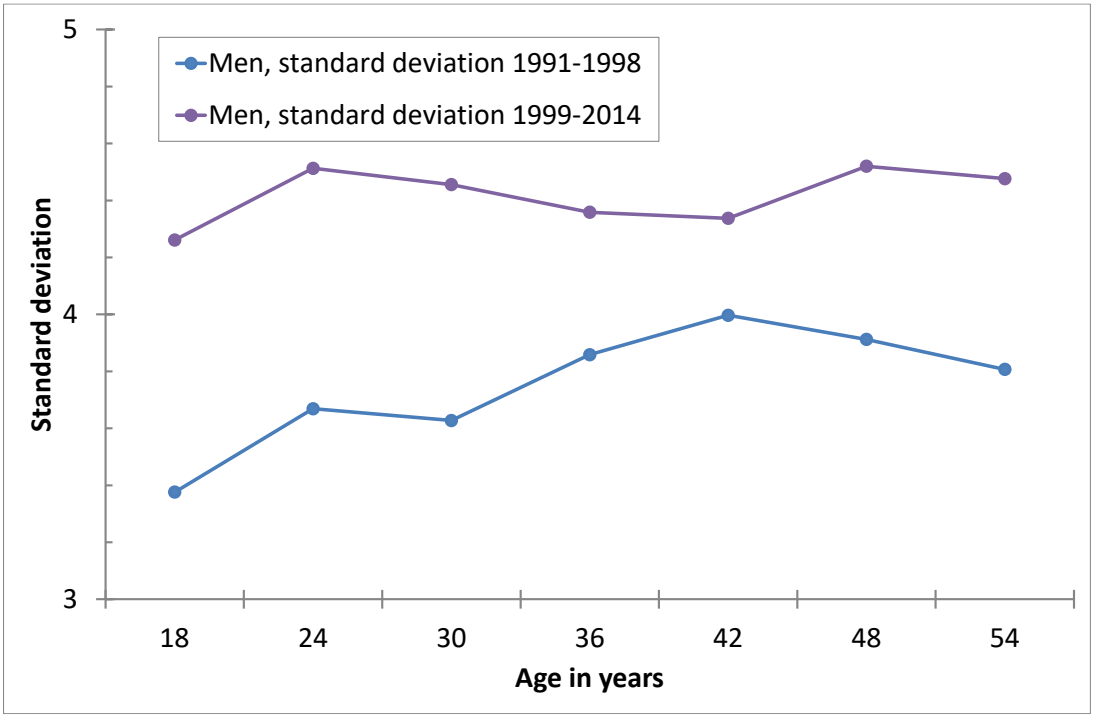

Figure 8.VI.8 Standard deviation for selected ages from 18 to 54 for men.

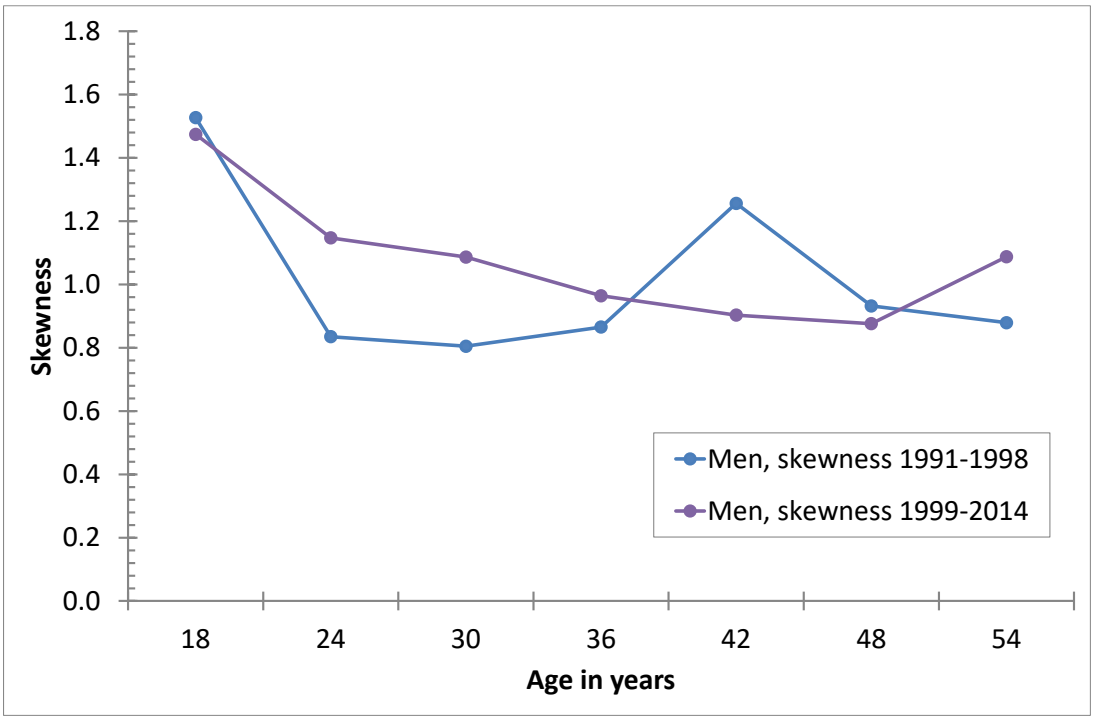

Figure 8.VI.9 Skewness for selected ages from 18 to 54 for men.

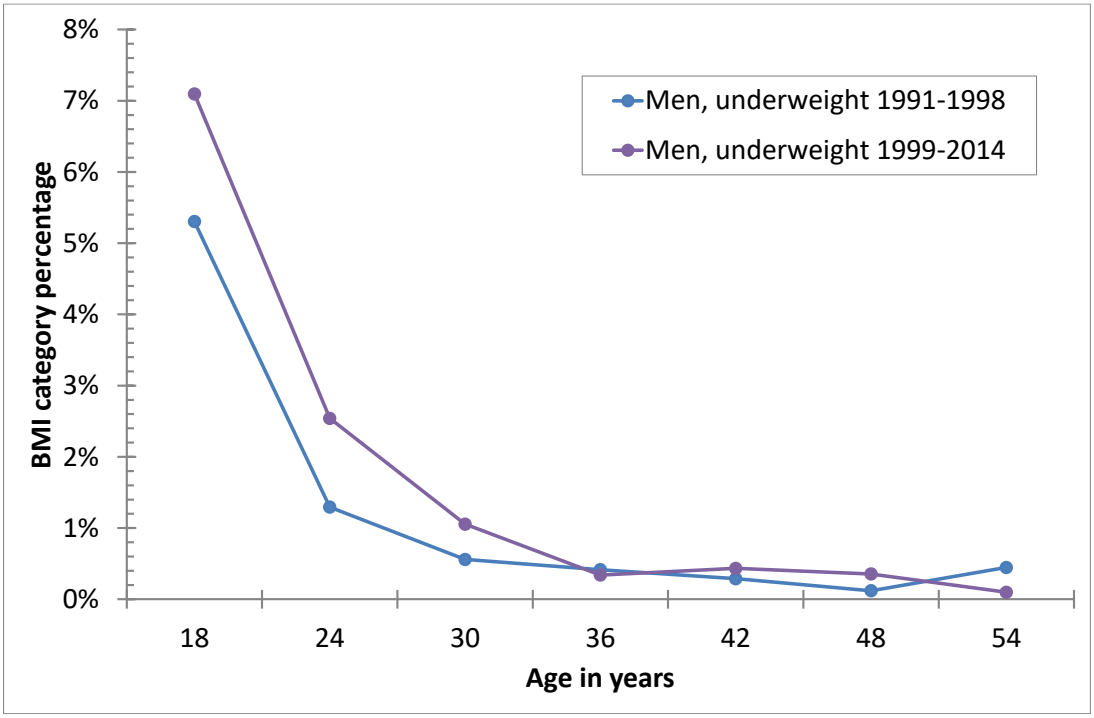

Figure 8.VI.10 Underweight percentages for selected ages from 18 to 54 for men.

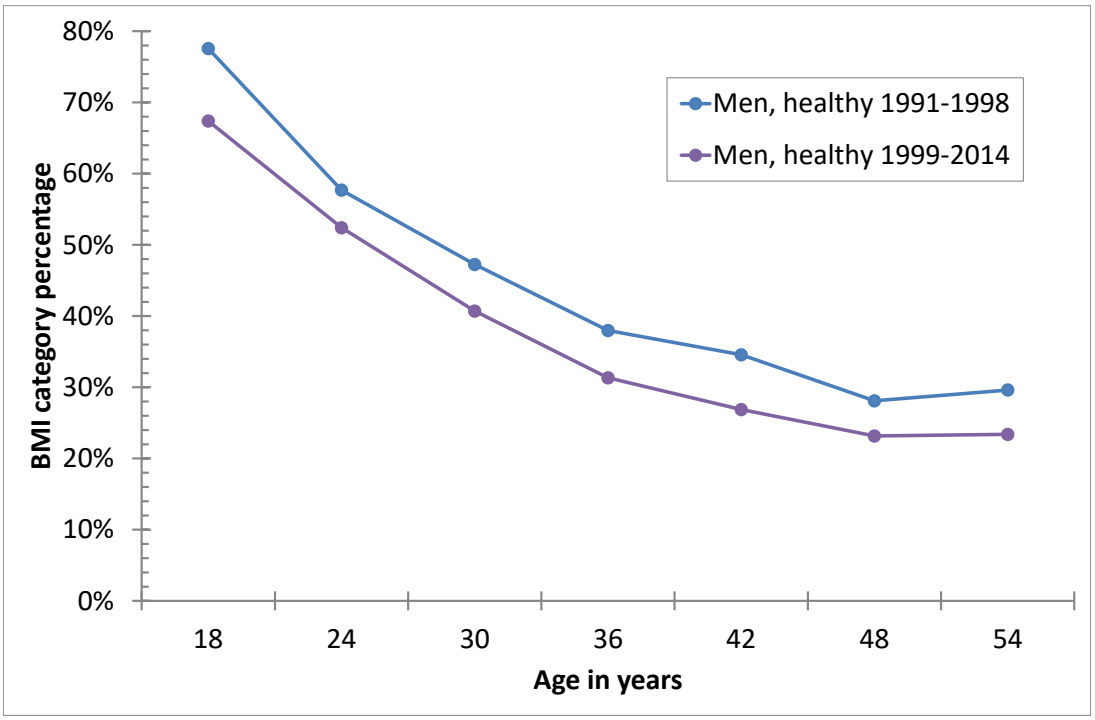

Figure 8.VI.11 Healthy percentages for selected ages from 18 to 54 for men.

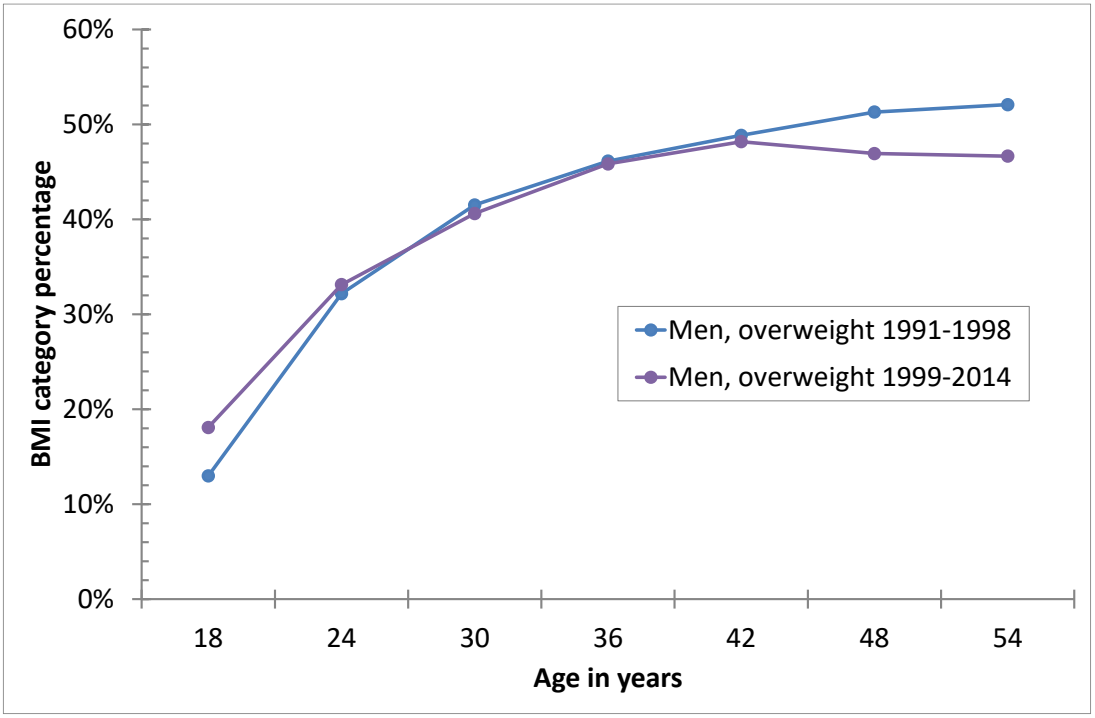

Figure 8.VI.12 Overweight percentages for selected ages from 18 to 54 for men.

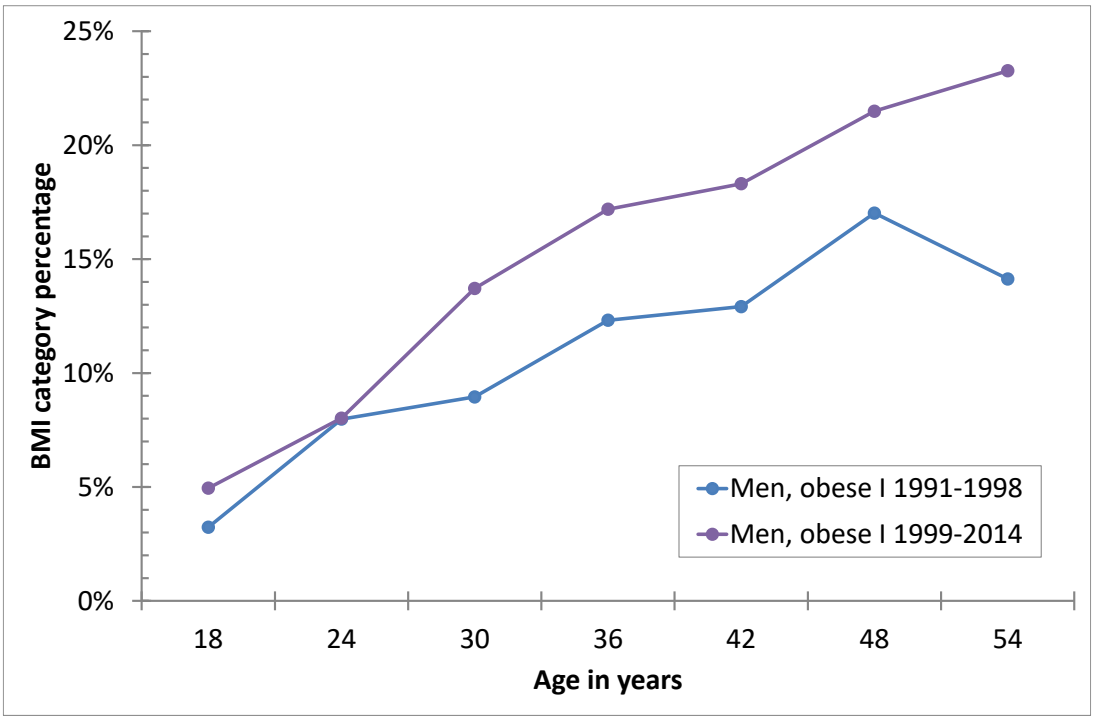

Figure 8.VI.13 Obese I percentages for selected ages from 18 to 54 for men.

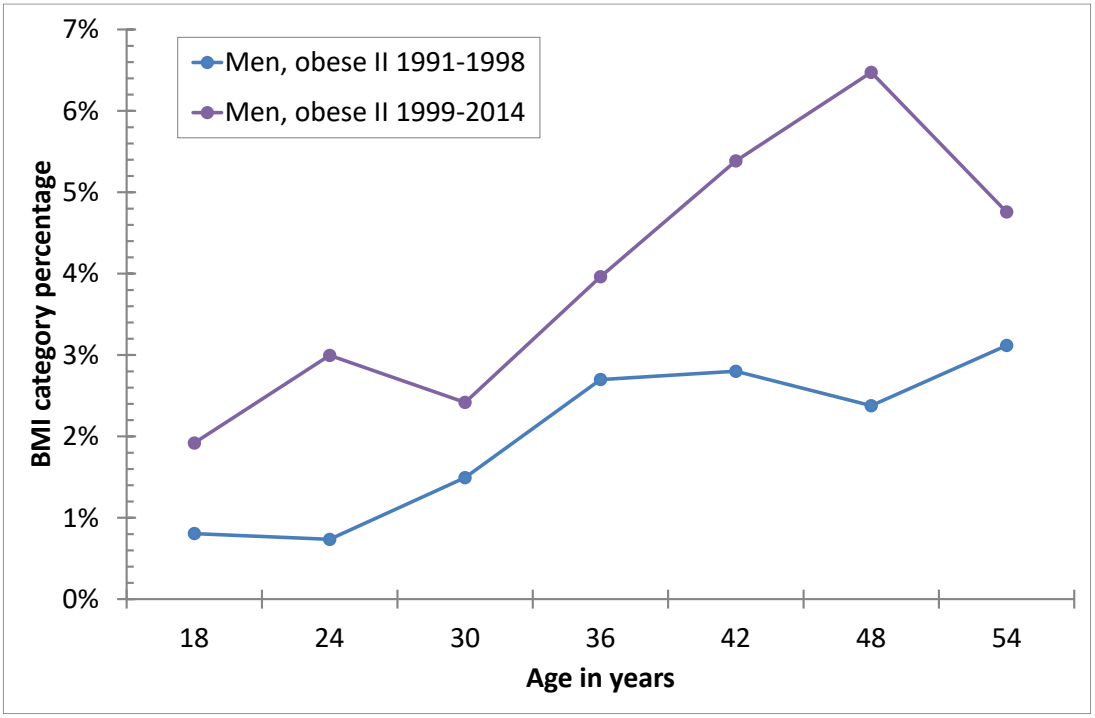

Figure 8.VI.14 Obese II percentages for selected ages from 18 to 54 for men.

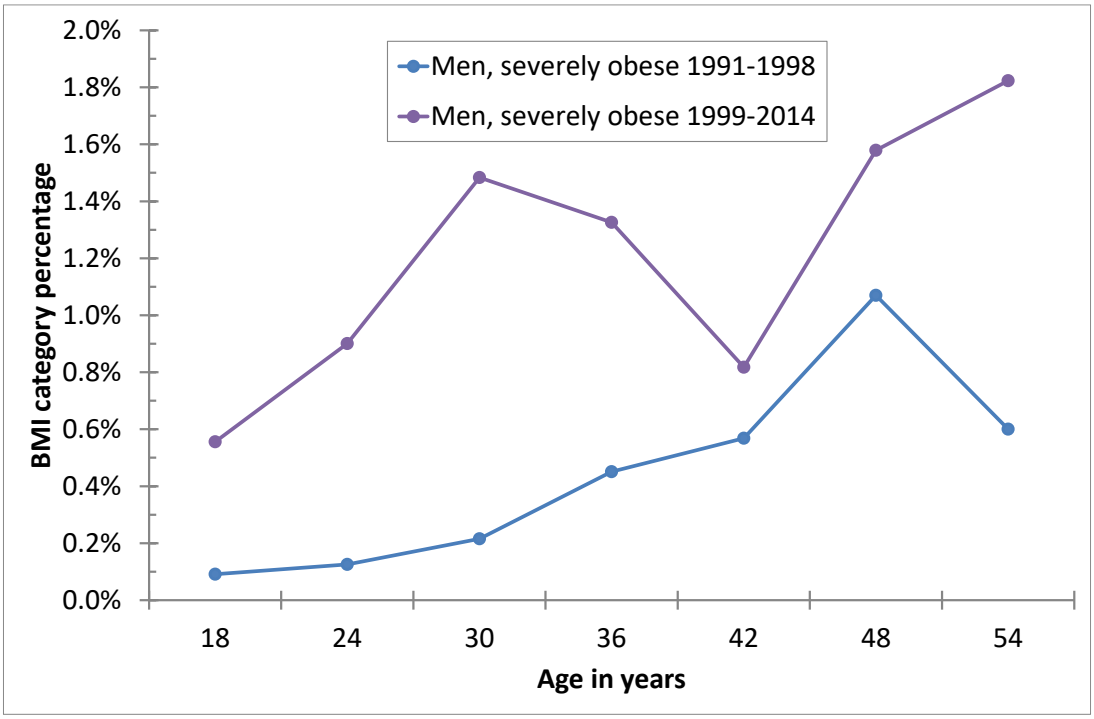

Figure 8.VI.15 Severely obese percentages for selected ages from 18 to 54 for men.

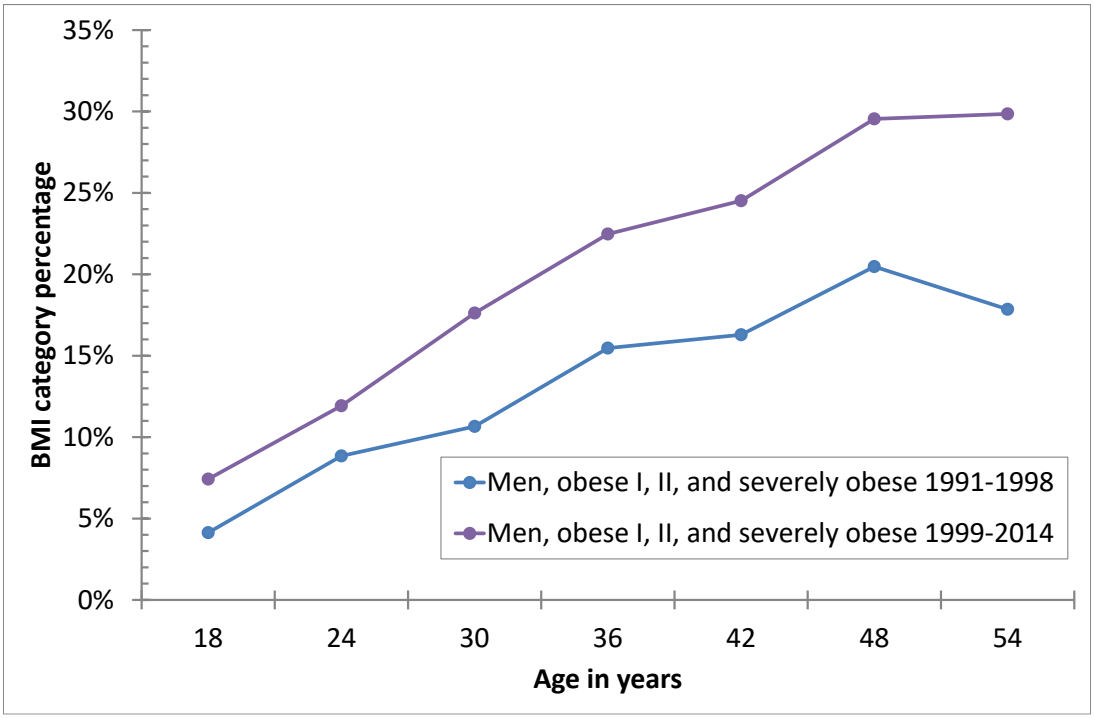

Figure 8.VI.16 All obese category percentages for selected ages from 18 to 54 for men.

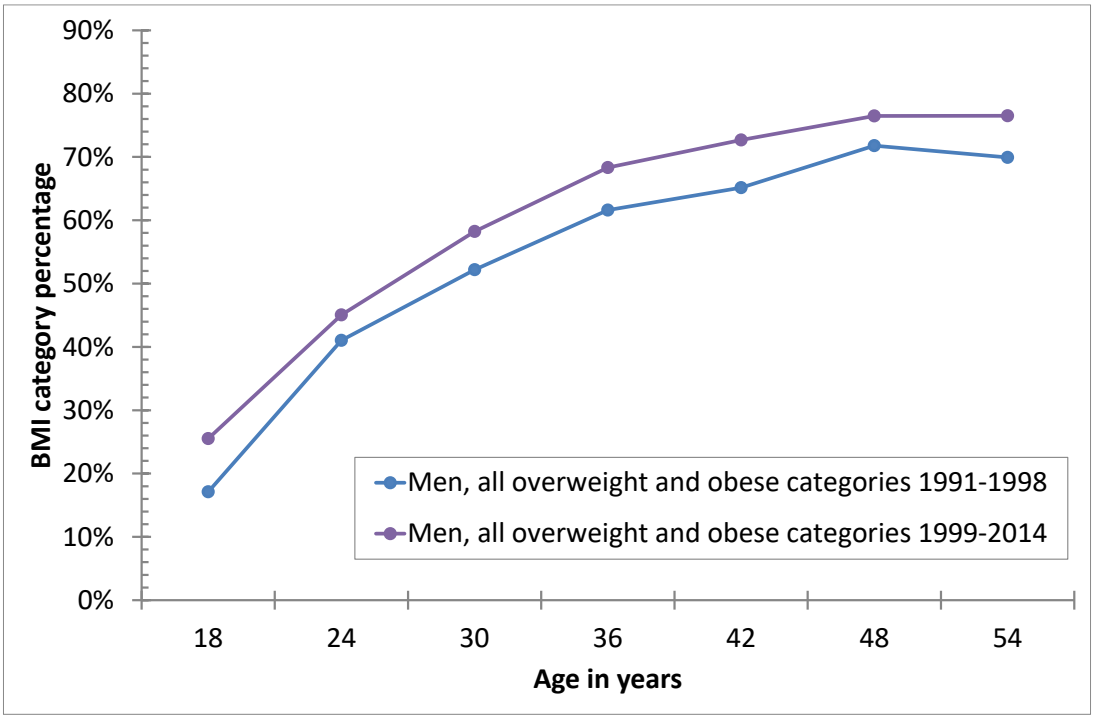

Figure 8.VI.17 All overweight and obese category percentages for selected ages 18 to 54 for men.

Changes with age: quartiles and shift model

Another way of looking at how BMI changes with age is to look at the changes in the quartile values with age. Figure 8.VI.18 shows the quartile values for each age along with the 5% and 95% percentiles for the data for 1999-2014. The 50% values are obviously the same as the median values given in Table 8.VI.1 and Figure 8.VI.7.

The increases are shown in Figure 8.VI.19. Apart from some irregularity with the 95% value, this shows that the increases in each value above age 24 are very similar.

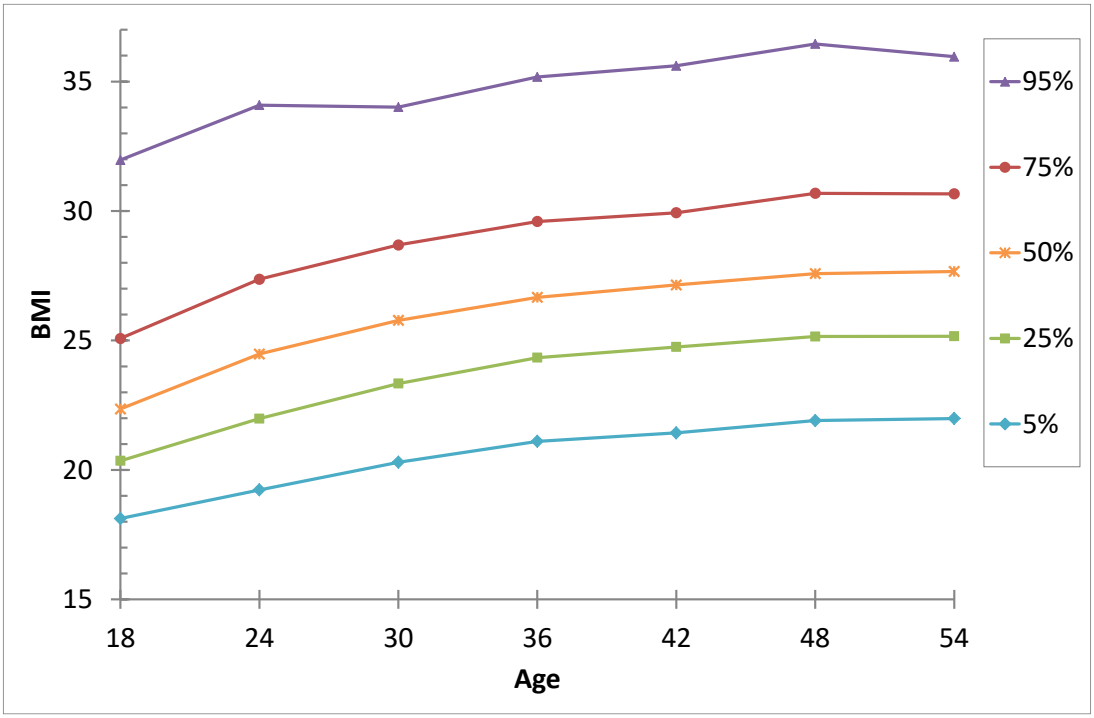

Figure 8.VI.18 Quartile and 5%, 95% values for men for ages 18 to 54 for 1999-2014.

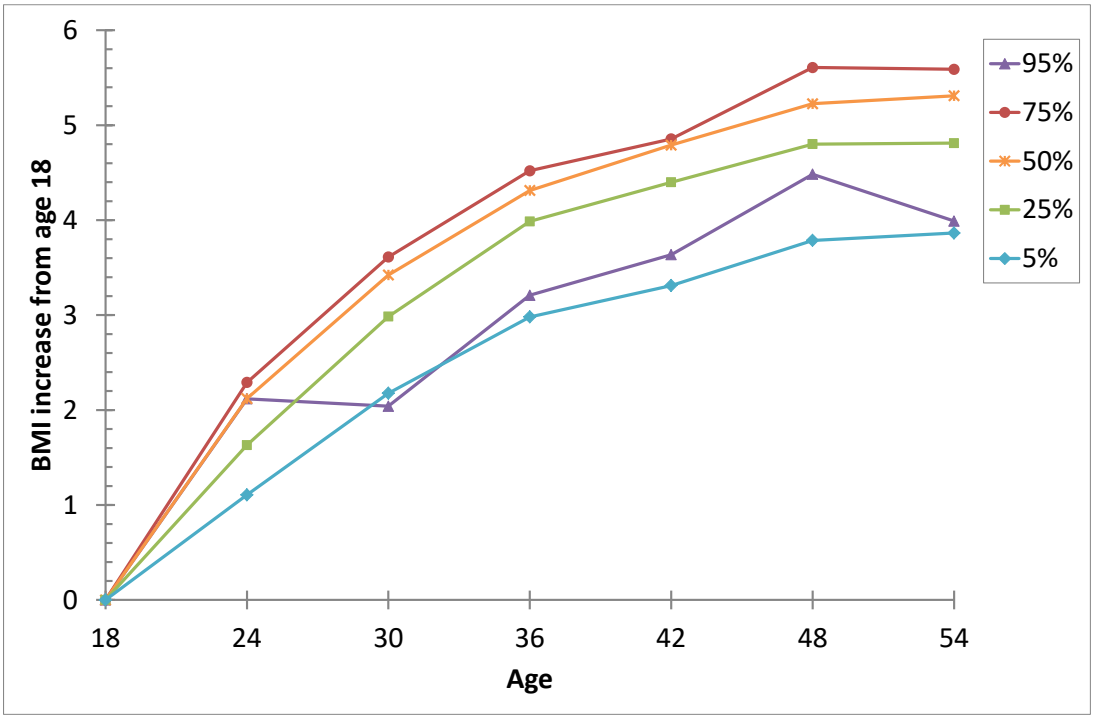

Figure 8.VI.19 Increases in quartile and 5%, 95% values for men for ages 18 to 54 for 1999-2014.

Based on the quartiles increase (Figure 8.VI.19), the percentiles (Figure 8.VI.4) and the chart of the distributions (Figure 8.VI.2), the increases with age above age 24 look to be mainly a shift of the distribution along the x-axis. The total BMI increase for the percentiles for each age from age 24 are shown in Figure 8.VI.20. The generally horizontal pattern again indicates a shift transformation. A shift was therefore applied for age 24 to 54 and fits well, as shown in Figure 8.VI.21 (included as Figure 8.12 in the main report). The shift amount used is the difference in the means of 3.070, and the fitness value is 13.81×10^{-5}.

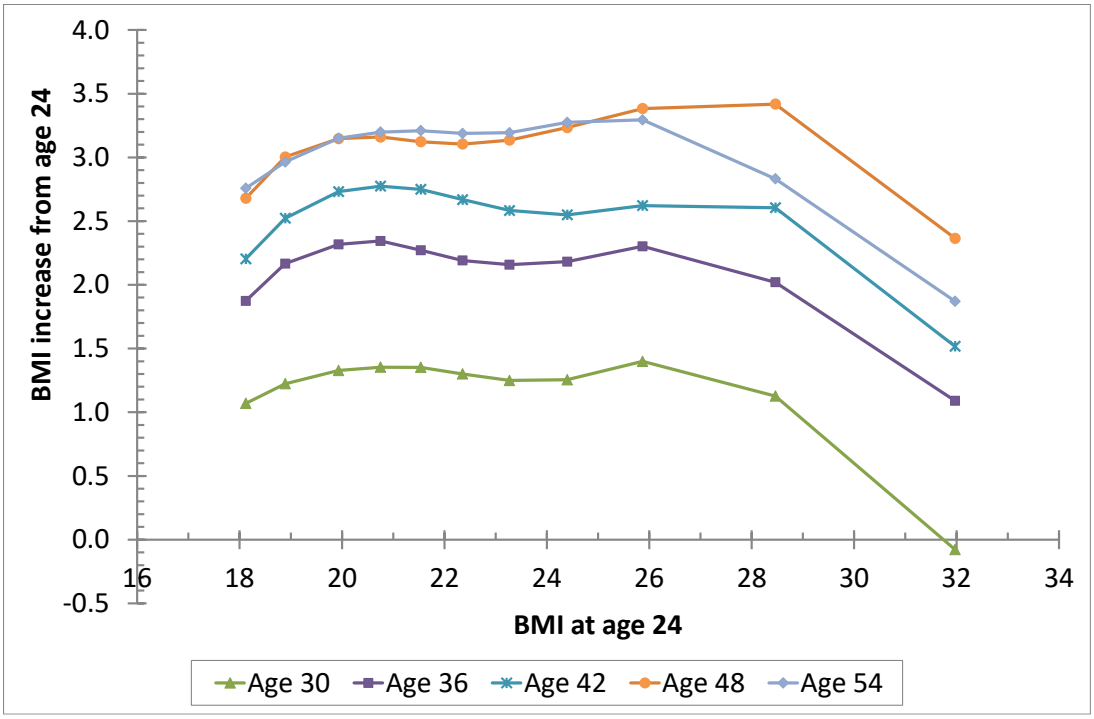

Figure 8.VI.20 Total change in the percentile values for men from age 24.

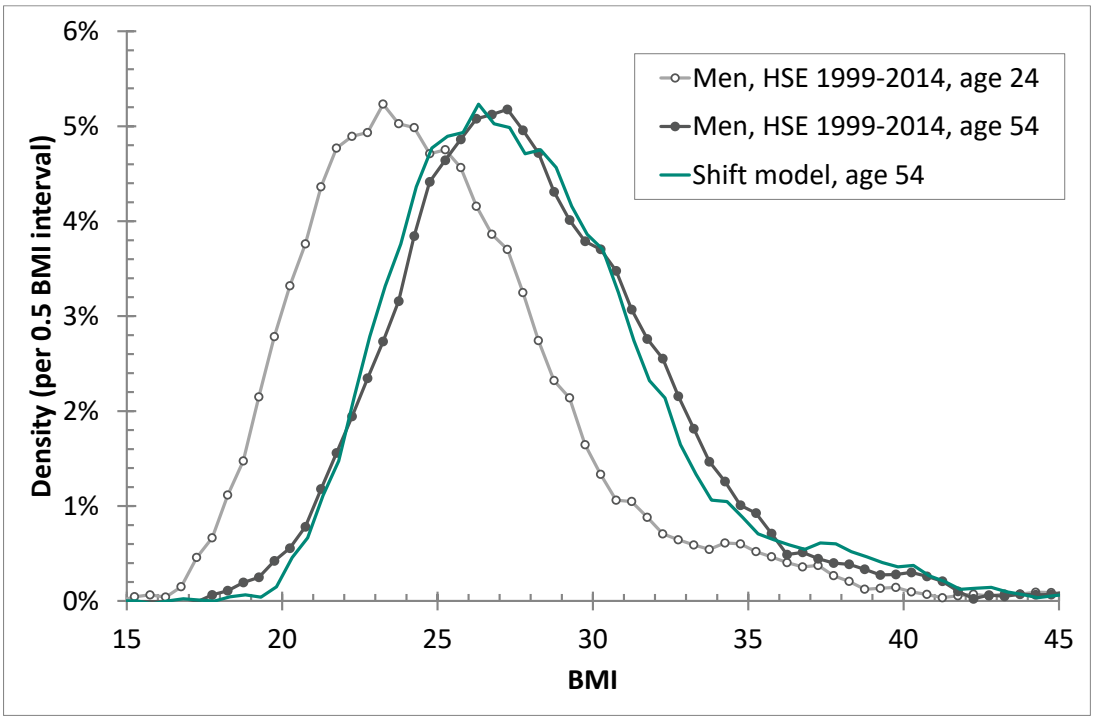

Figure 8.VI.21 Shift model for the change in the BMI distribution for men from age 24 to 54.

Appendix 8.VII Analysis of each year of age from 18 to 24 for men

Charts of the population distributions

This appendix looks at the distributions for each single year of age from 18 to 24, using the HSE time intervals of 1991-1998 and 1999-2014. Figures 8.VII.1 and 8.VII.2 show the smoothed population distributions. There is a strong trend of BMI increasing with each year of age. The age 18 distributions have a somewhat different shape to the others with a higher narrower peak and being more skewed.

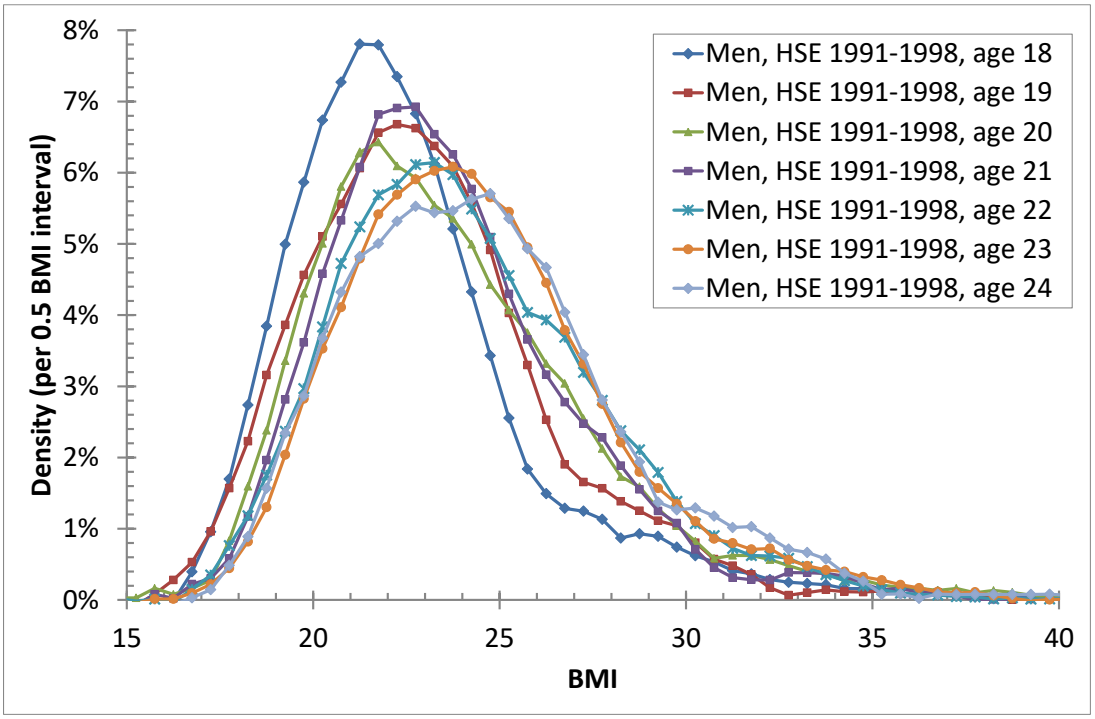

Figure 8.VII.1 Distributions for each age from 18 to 24 for men for 1991-1998.

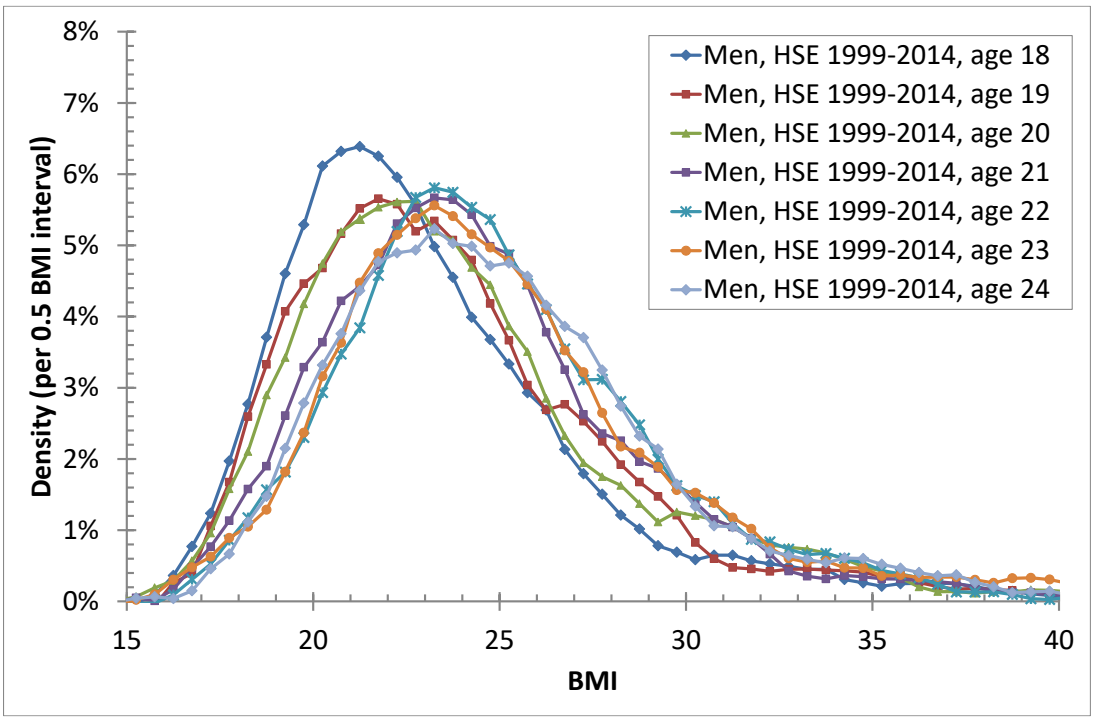

Figure 8.VII.2 Distributions for each age from 18 to 24 for men for 1999-2014.

Percentiles

The percentiles were calculated for the changes over time and with age. The increases with time are shown in Figure 8.VII.3 and with age in Figure 8.VII.4. The charts show the BMI increases for 10% percentiles along with 5% and 95%. The 1% and 99% values are not shown as it is considered that they are too affected by sampling irregularities due to the small sample sizes for single years.

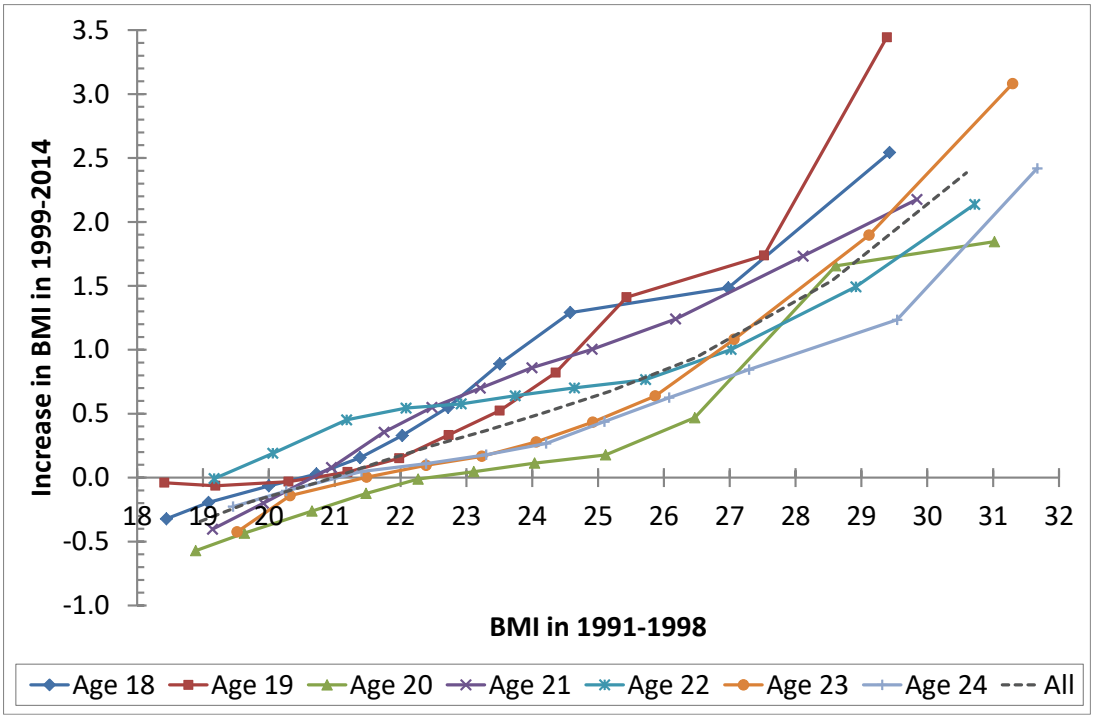

Figure 8.VII.3 Percentile changes over time for men for each age from 18 to 24.

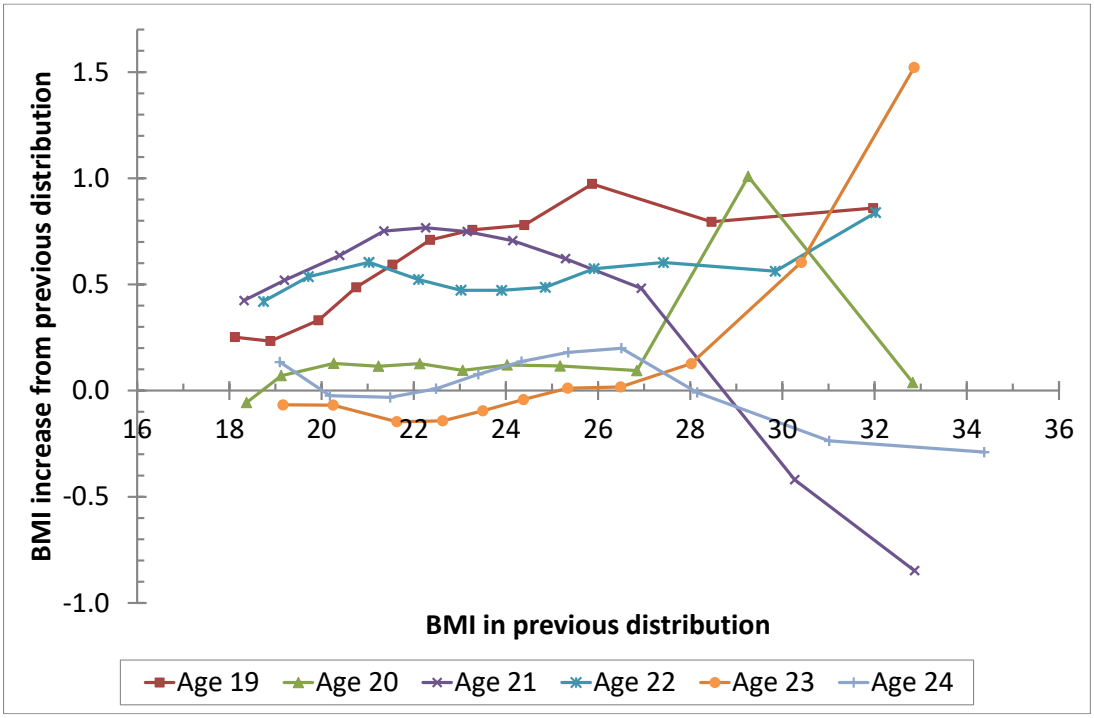

Figure 8.VII.4 Percentile changes with age for men for each age from 18 to 24 for 1999-2014.

The patterns for the percentiles are generally similar to those for the age groups in the main report Sections 8.2-8.4 and for the single years of age in Appendix 8.VI. The changes with time in Figure 8.VII.3 are roughly an increasing straight line starting from the x-axis, which is characteristic of a linear scaling. The changes with age in Figure 8.VII.4 are roughly a horizontal trend, albeit with significant variations likely due to the small samples. The increase in age 19 compared to age 18 has a trend between the 10% and 80% values (the 2nd to the 9th points of the red age 19 series) of higher BMI values having higher increases in BMI and so that change looks to have some aspects of a linear scaling.

Descriptive statistics

The two tables below show the descriptive statistics. The mean and median values are higher in 1999-2014 than 1991-1998. The standard deviation is also considerably higher for each age, reflecting the broader shape of the distributions in Figure 8.VII.2 compared to Figure 8.VII.1. There appears to be some tendency of the skewness to decrease with age, with age 18 having the highest value in both time intervals.

Table 8.VII.1 Descriptive statistics for men for ages 18 to 24 for 1991-1998.

Age	18	19	20	21	22	23	24
Sample size of actual data	561	559	578	558	598	649	679
Mean	22.64	23.12	23.76	23.74	24.21	24.47	24.61
Median	22.03	22.73	23.11	23.21	23.74	24.06	24.21
Modal interval mid-point	21.25	22.25	21.75	22.75	23.25	23.75	24.75
Standard deviation	3.38	3.39	3.77	3.49	3.55	3.54	3.67
Skewness	1.53	1.09	1.09	1.31	0.74	0.80	0.84
Underweight (BMI < 18.5)	5.3%	5.4%	3.1%	2.2%	2.4%	1.6%	1.3%
Healthy (18.5 ≤ BMI < 25.0)	77.6%	71.1%	65.9%	68.7%	61.2%	59.4%	57.7%
Overweight (25.0 ≤ BMI < 30.0)	13.0%	19.8%	24.5%	24.4%	29.9%	31.6%	32.2%
Obese I (30.0 ≤ BMI < 35.0)	3.2%	2.9%	5.0%	3.7%	5.8%	6.4%	8.0%
Obese II (35.0 ≤ BMI < 40.0)	0.8%	0.6%	1.3%	0.5%	0.5%	1.1%	0.7%
Severely obese (BMI ≥ 40.0)	0.1%	0.2%	0.1%	0.4%	0.1%	0.0%	0.1%

Table 8.VII.2 Descriptive statistics for men for ages 18 to 24 for 1999-2014.

Age	18	19	20	21	22	23	24
Sample size of actual data	769	616	658	739	719	658	712
Mean	23.24	23.88	23.96	24.48	24.99	25.13	25.14
Median	22.35	23.06	23.16	23.91	24.38	24.34	24.48
Modal interval mid-point	21.25	21.75	22.75	23.25	23.25	23.25	23.25
Standard deviation	4.26	4.48	4.39	4.25	4.21	4.68	4.51
Skewness	1.47	1.43	1.05	1.24	1.23	1.26	1.15
Underweight (BMI < 18.5)	7.1%	5.7%	5.8%	4.1%	2.8%	3.4%	2.5%
Healthy (18.5 ≤ BMI < 25.0)	67.4%	63.0%	62.0%	57.4%	53.8%	53.3%	52.4%
Overweight (25.0 ≤ BMI < 30.0)	18.1%	23.2%	21.6%	29.1%	32.1%	30.4%	33.1%
Obese I (30.0 ≤ BMI < 35.0)	4.9%	5.0%	8.3%	6.9%	8.9%	8.5%	8.0%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	2.1%	1.9%	2.2%	2.0%	3.3%	3.0%
Severely obese (BMI ≥ 40.0)	0.6%	1.0%	0.4%	0.4%	0.4%	1.1%	0.9%

The BMI category percentages from Tables 8.VII.1 and 8.VII.2 are plotted in Figures 8.VII.5 and 8.VII.6. From the tables and charts, the underweight and healthy category percentages decrease considerably with age. The overweight and obese I percentages increase by a large amount. For 1991-1998 there is not much change with age in obese II and severely obese with these percentages being small. For 1999-2014 these categories have larger percentages with obese II tending to increase with age.

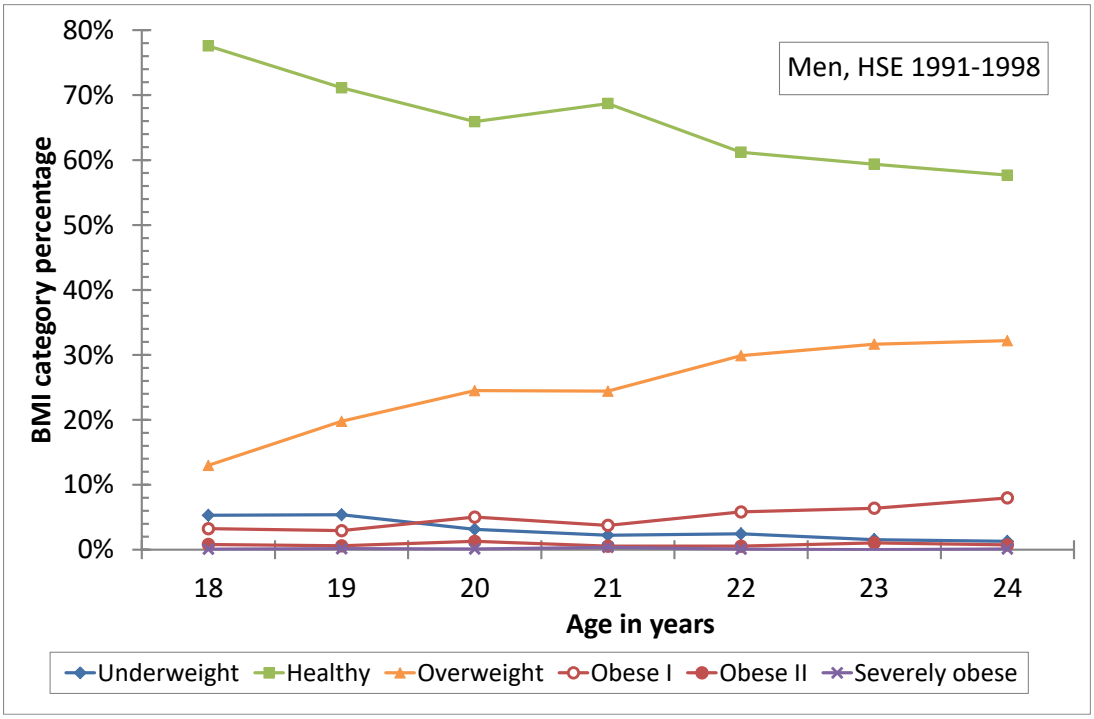

Figure 8.VII.5 Category percentages for each age from 18 to 24 for men for 1991-1998.

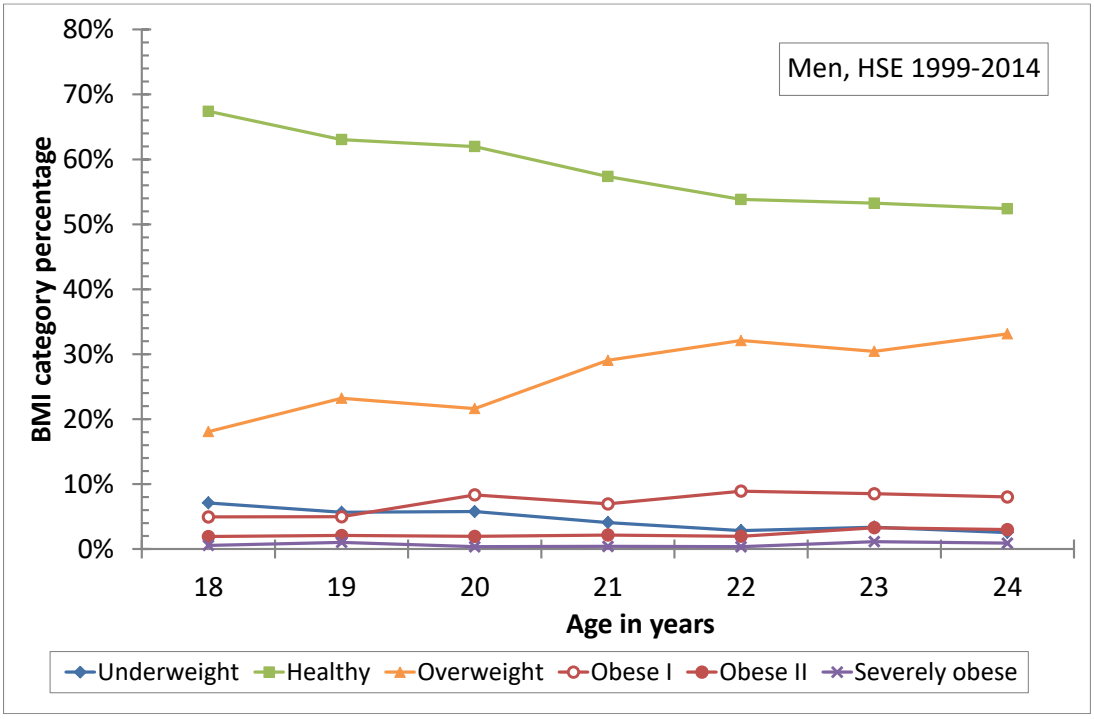

Figure 8.VII.6 Category percentages for each age from 18 to 24 for men for 1999-2014.

Changes over time for ages 18 and 24

The two charts in Figures 8.VII.7 and 8.VII.8 look at how the distributions have changed between the two time intervals for age 18 and age 24. The main changes in both cases are for the peak to become lower with longer left and right tails.

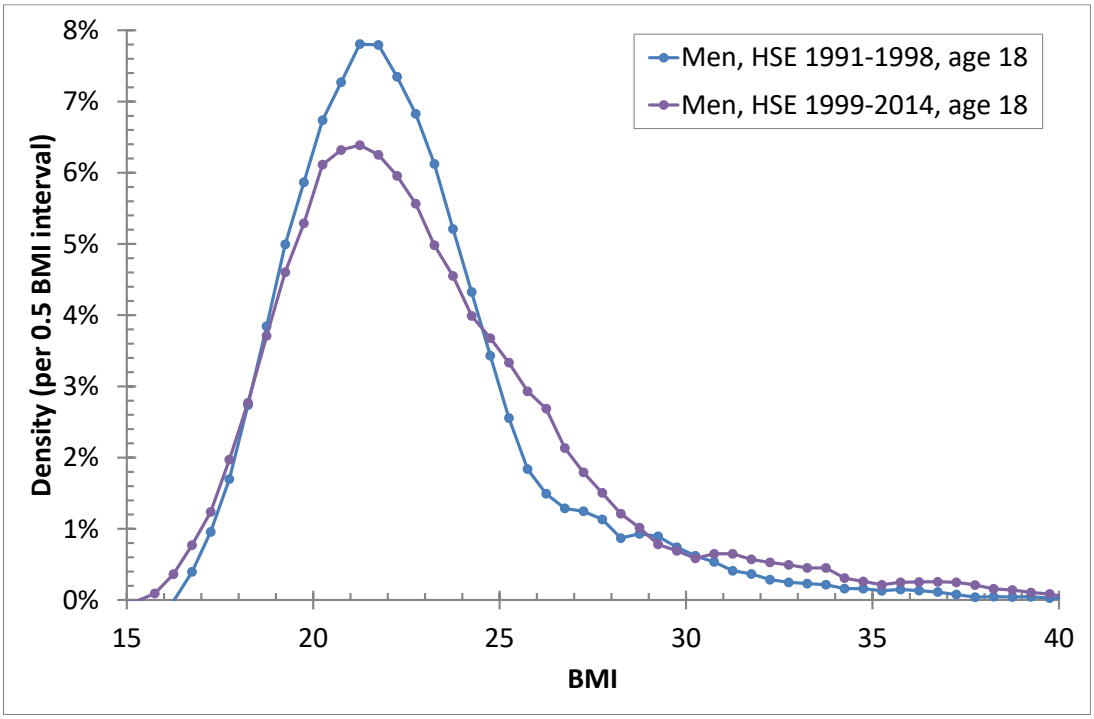

Figure 8.VII.7 Comparison of distributions for age 18 for men.

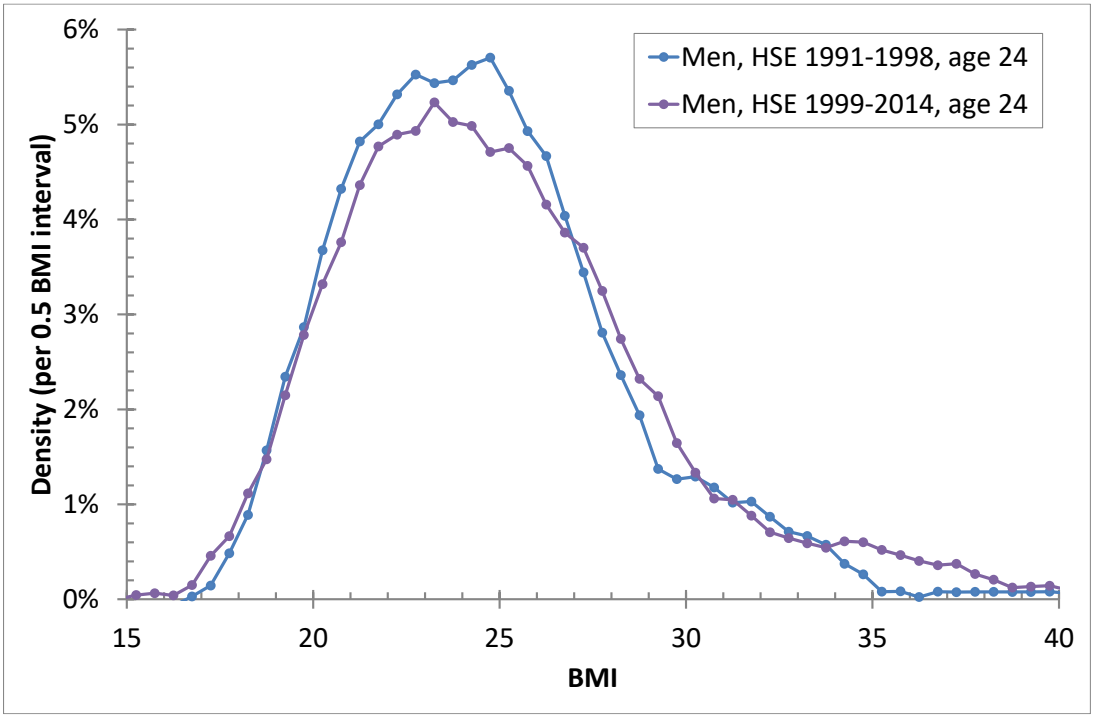

Figure 8.VII.8 Comparison of distributions for age 24 for men.

Selected statistics for three HSE time intervals

The two charts below show the mean BMI and healthy category percentage for the three HSE time intervals of 1991-1998, 1999-2006, 2007-2014. This demonstrates that the last two intervals are very similar and hence, as discussed in Section 8.5 of the main report, they were combined as 1999-2014 in the analysis to give larger sample sizes.

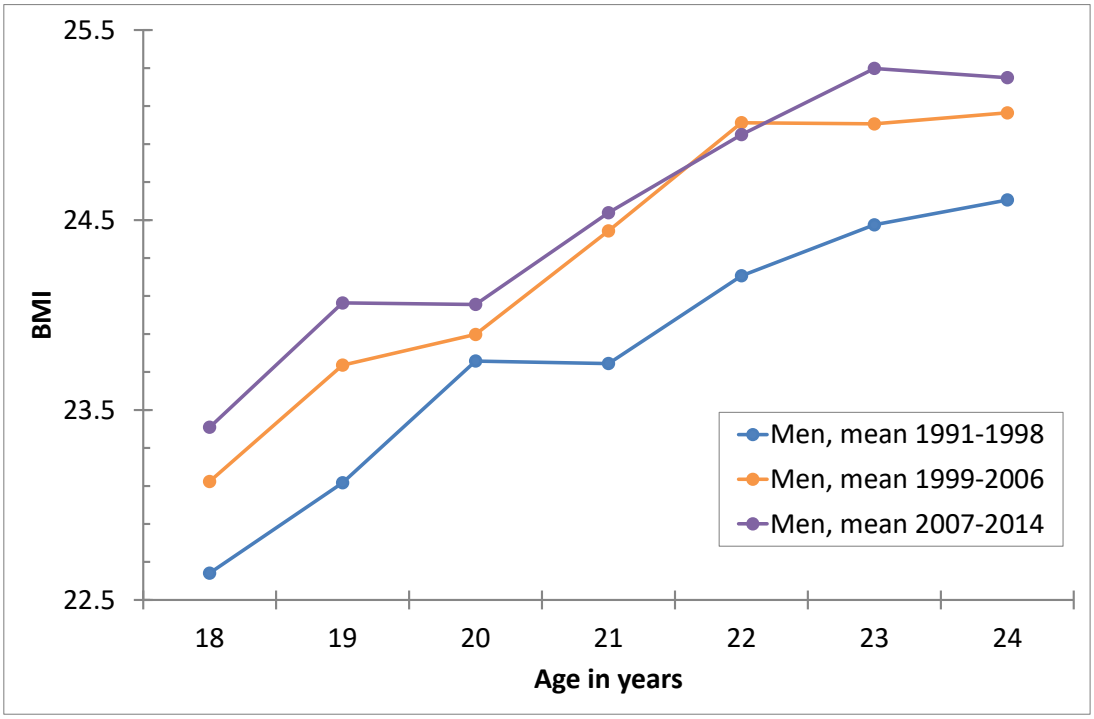

Figure 8.VII.9 Mean BMI for age 18 to 24 for men for the three time intervals.

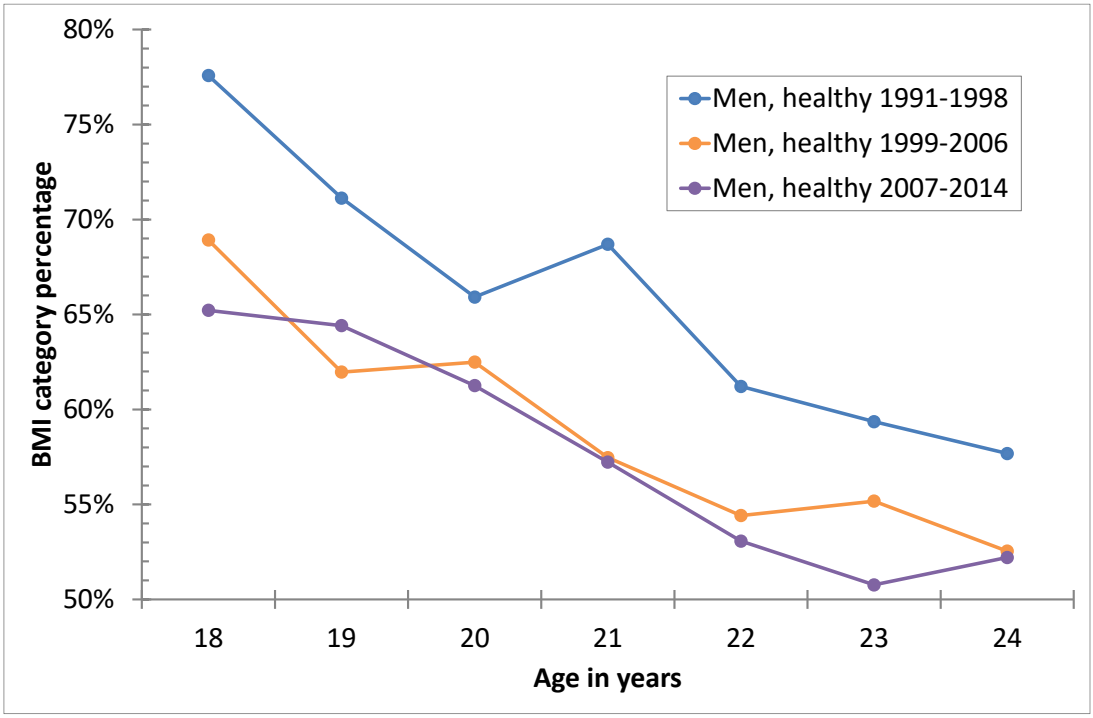

Figure 8.VII.10 Healthy category percentages for age 18 to 24 for men for the three time intervals.

Appendix 9.I Aging profile from the HSE data for women

Values for mean BMI were calculated for three time intervals of eight years of the HSE data: 1991-1998, 1999-2006, 2007-2014. As for the data for men in Appendix 8.I, a time interval length of eight years was used to give a reasonable amount of data and the mean values were only calculated where there were at least 30 values. The proposed aging model from Chapter 7 is shown as the dashed line in Figure 9.I.1. This is the hypothesised BMI aging curve for the current conditions.

As discussed in Sections 7.3, 8.1, and 9.1 of the main report, and in Appendix 8.I, the chart in Figure 9.I.1 is limited in just showing the simple relationship of mean BMI with age without accounting for birth year. As shown in Chapter 7, within narrow birth cohorts mean BMI tends to increase with age over all ages, although with a lower rate of increase at higher ages. The decreases in BMI at older ages in Figure 9.I.1 are because the older cohorts are at lower levels. The interest with Figure 9.I.1 is in seeing how the curves change over time and how close they are to the aging model curve. From the chart, BMI increases from 1991-1998 to 1999-2006 across all ages (except for ages 88 and 89) with the increases looking to be generally about the same across the ages. The increases are much less from 1999-2006 to 2007-2014. The curve for 2007-2014 is close to the aging model curve up to an age of about 75.

A seven point moving average of the differences between the curves was calculated and the results are in Figure 9.I.2. As for men in Appendix 8.I, the increases in BMI are much greater between the first two time intervals than between the second two. The increase is fairly similar across the ages in each case, although with some fluctuations. The average of the difference values for all the points from 1991-1998 to 1999-2006 is 0.78 with most of the moving average values in Figure 9.I.2 being between 0.5 and 1.1. From 1999-2006 to 2007-2014 most of the moving average difference values are between 0.0 and 0.6 and the average of the differences for all ages is 0.31.

The interpretation from Chapter 7 is that the cohorts are all moving towards an aging profile reflecting modern lifestyles and that recent cohorts are now at or close to that the level and so the changes over time have reduced. These changes are generally pretty similar to those in Appendix 8.I for men. One aspect in the data for men is that the change from 1999-2006 to 2007-2014 has little increase at ages up to the mid 40s with even a decrease in the early 30s, but then larger increases at older ages. In the moving average differences data for women in Figure 9.I.2 there are some low values between ages 30 and 36, but no negative values. There is no obvious change in the general level of the values across the ages which is different in this respect to the chart for men in Figure 8.I.2.

A chart of age curves for four year time intervals is given in Figure 9.I.3. That chart divides the HSE data into six time intervals compared to the three of Figure 9.I.1 and so gives more detail of how the aging profile changes over time. However, the amount of data used for each series is less and so there is more sampling irregularity in the values. The mean BMI values are not plotted where there are less than 30 values in the sample, although this only applies for a few points above age 85.

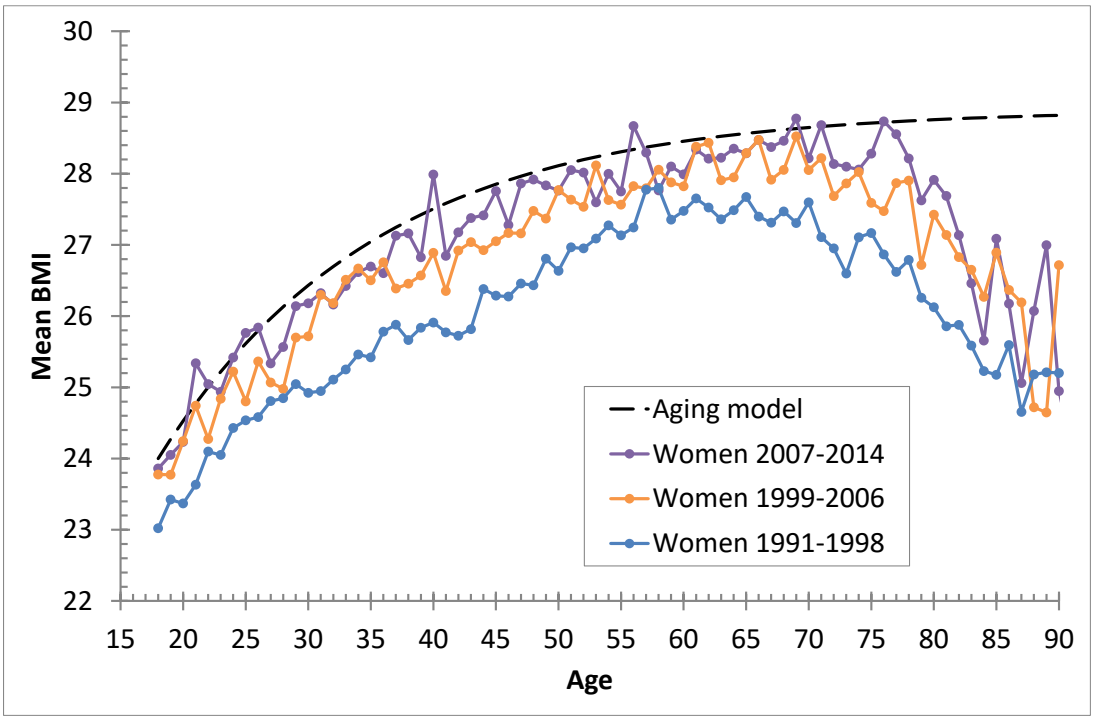

Figure 9.I.1 Mean BMI for women in eight year time intervals.

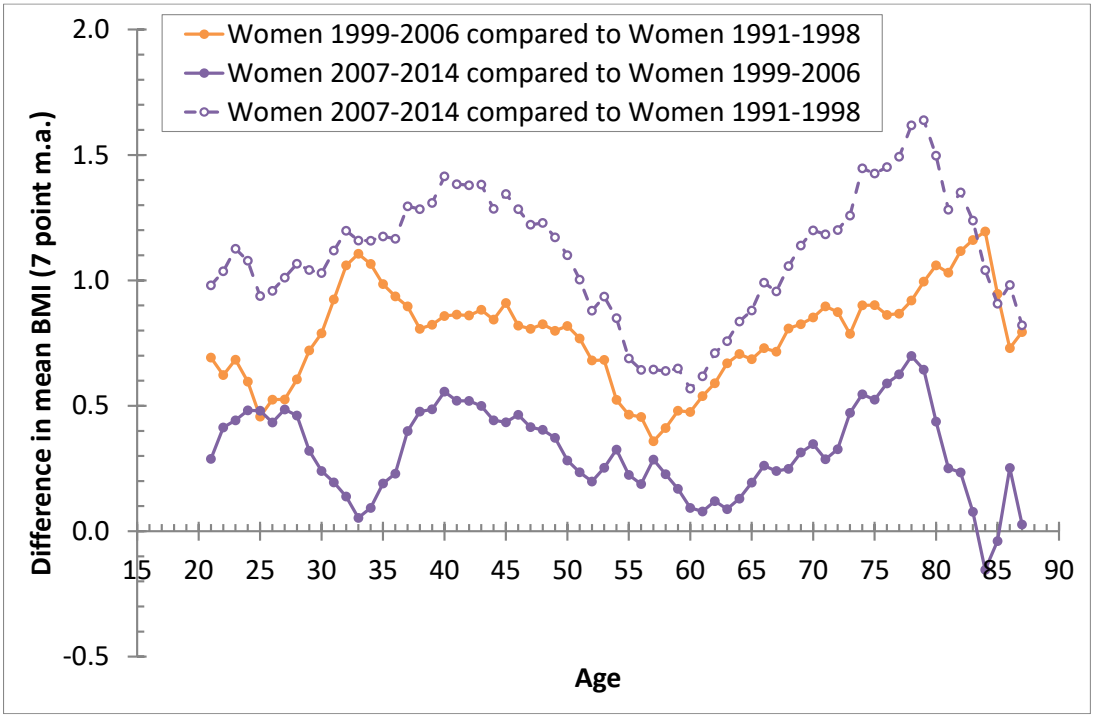

Figure 9.I.2 Differences over time in the mean BMI for women.

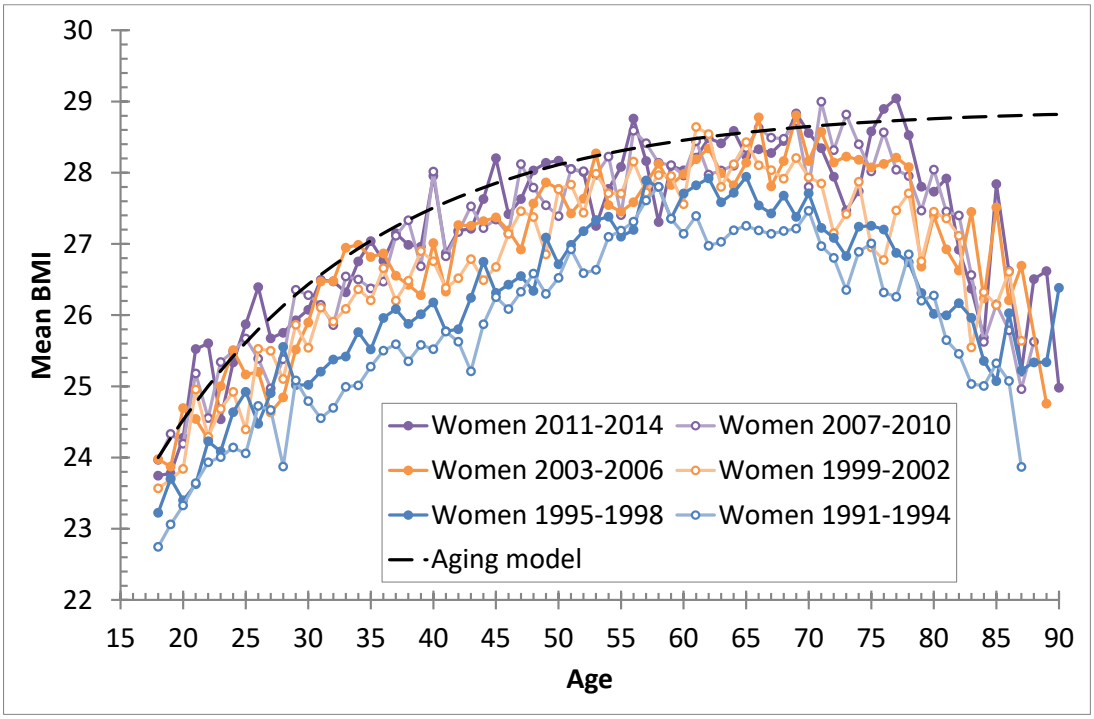

Figure 9.I.3 Mean BMI by age for four year HSE intervals for women.

Appendix 9.II Examples of smoothing of the age distributions for women

This appendix has charts showing examples of the data and the smoothed distributions for some of the age groups (18-24, 25-34, and 45-54) in 1991-1998 and 2007-2014.

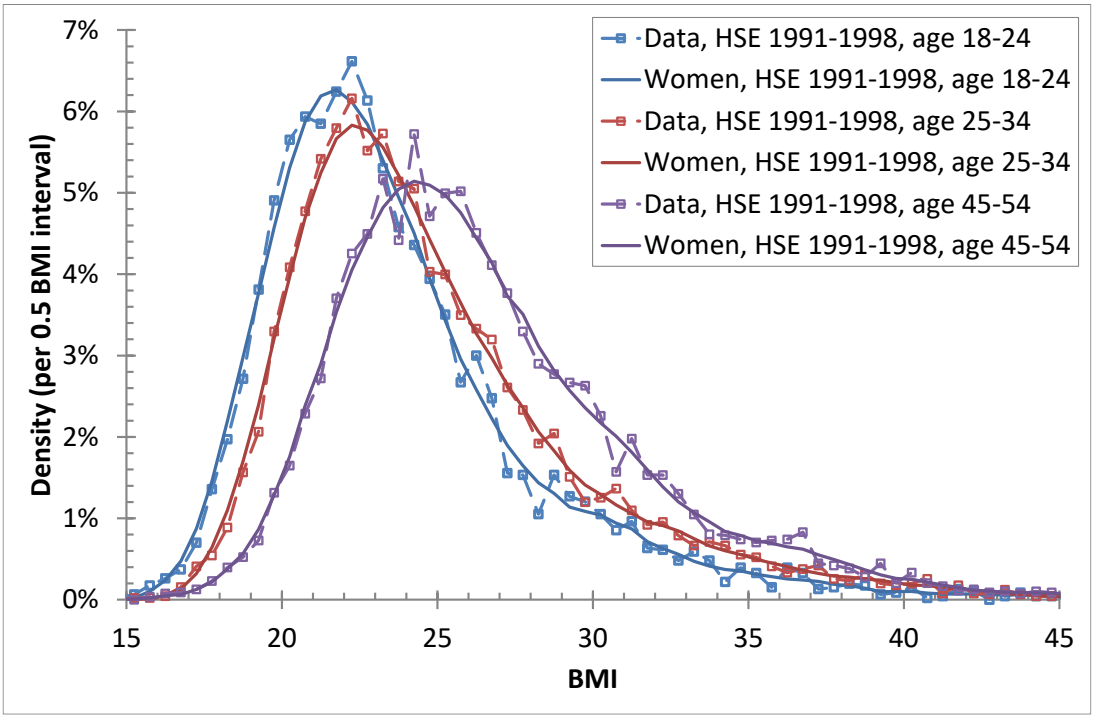

Figure 9.II.1 Smoothed distributions for three age groups for women for 1991-1998.

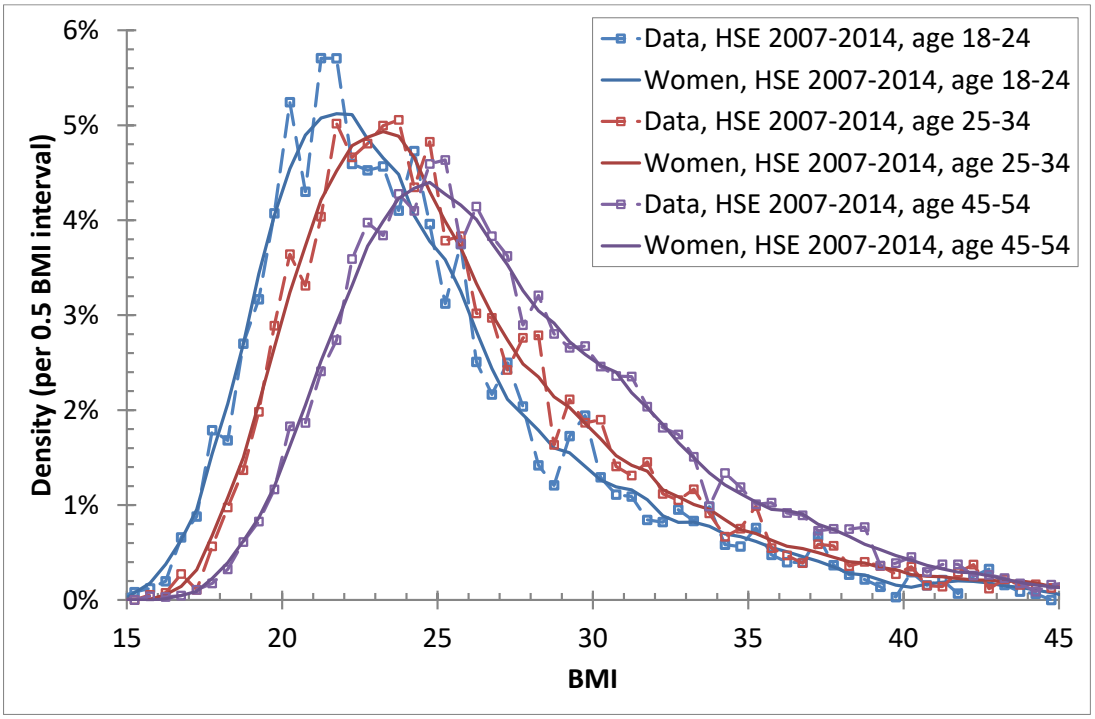

Figure 9.II.2 Smoothed distributions for three age groups for women for 2007-2014.

Appendix 9.III BMI distributions for each age group for women

This appendix compares the distributions and statistics for each age group across the three time intervals of 1991-1998, 1999-2006, 2007-2014. The changes between the distributions with time are discussed in Section 9.3.1 of the main report, and with age in Section 9.4.1.

Charts of population distributions for each age group

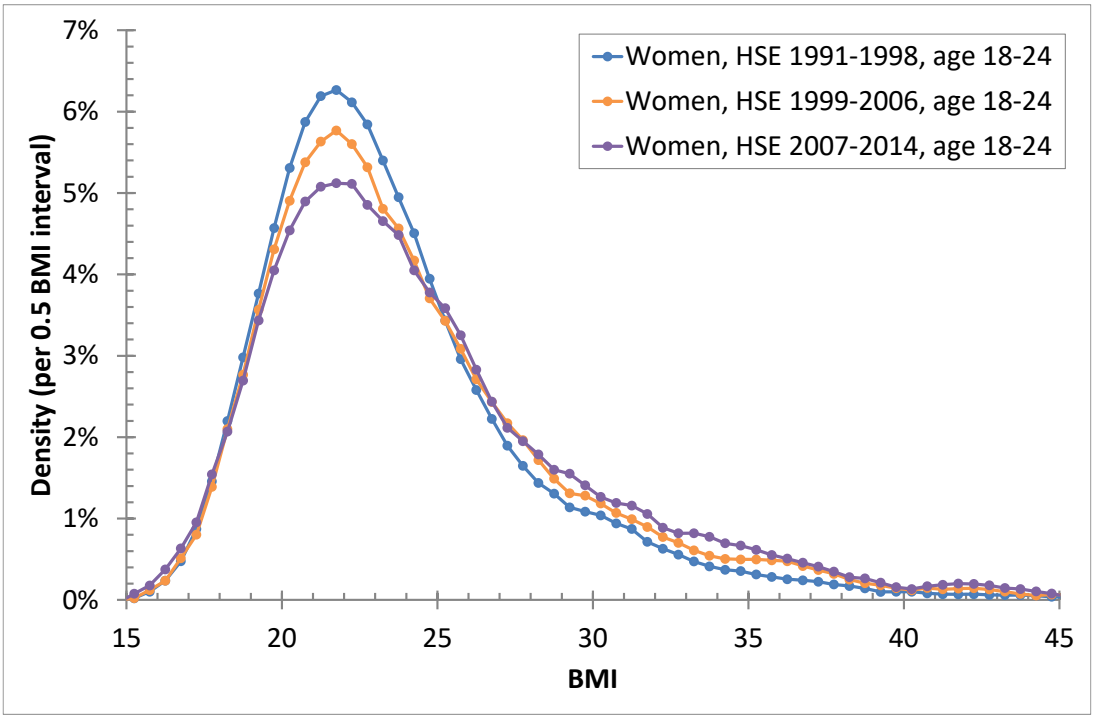

Figure 9.III.1 BMI distributions for women for age group 18-24.

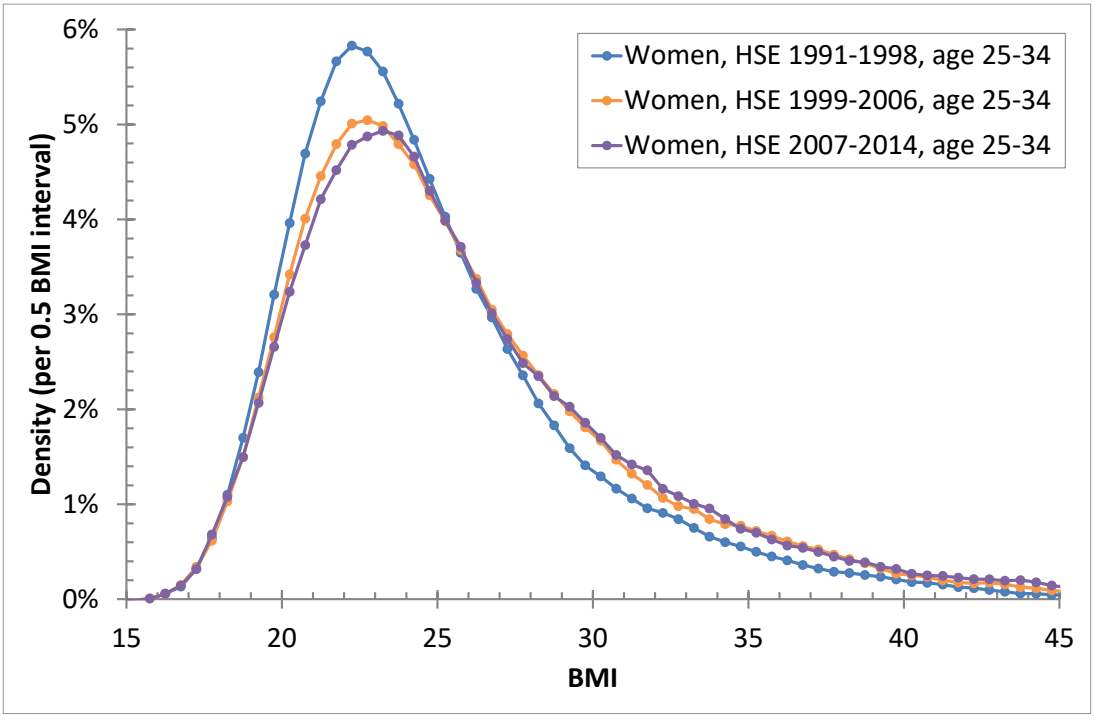

Figure 9.III.2 BMI distributions for women for age group 25-34.

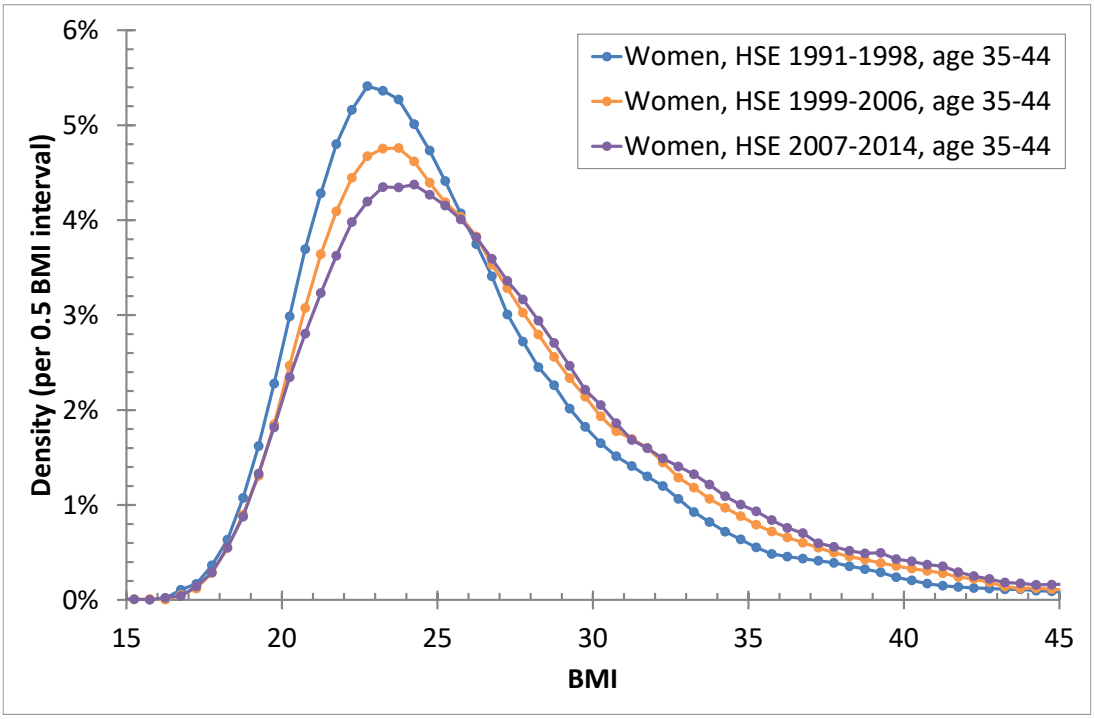

Figure 9.III.3 BMI distributions for women for age group 35-44.

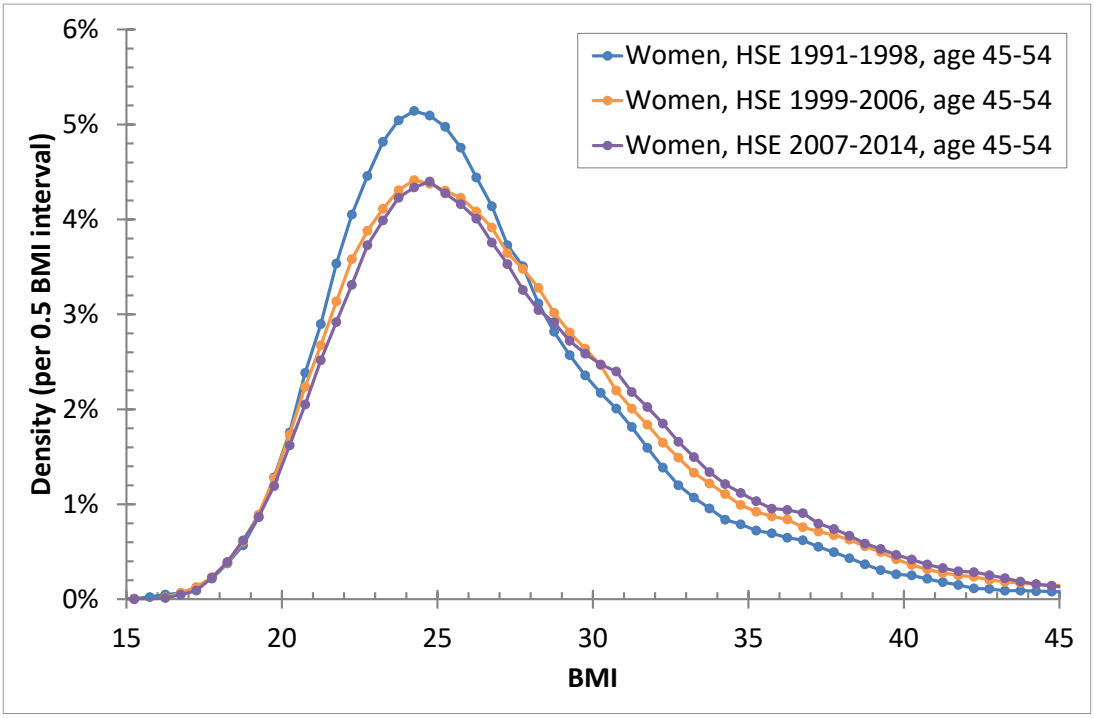

Figure 9.III.4 BMI distributions for women for age group 45-54.

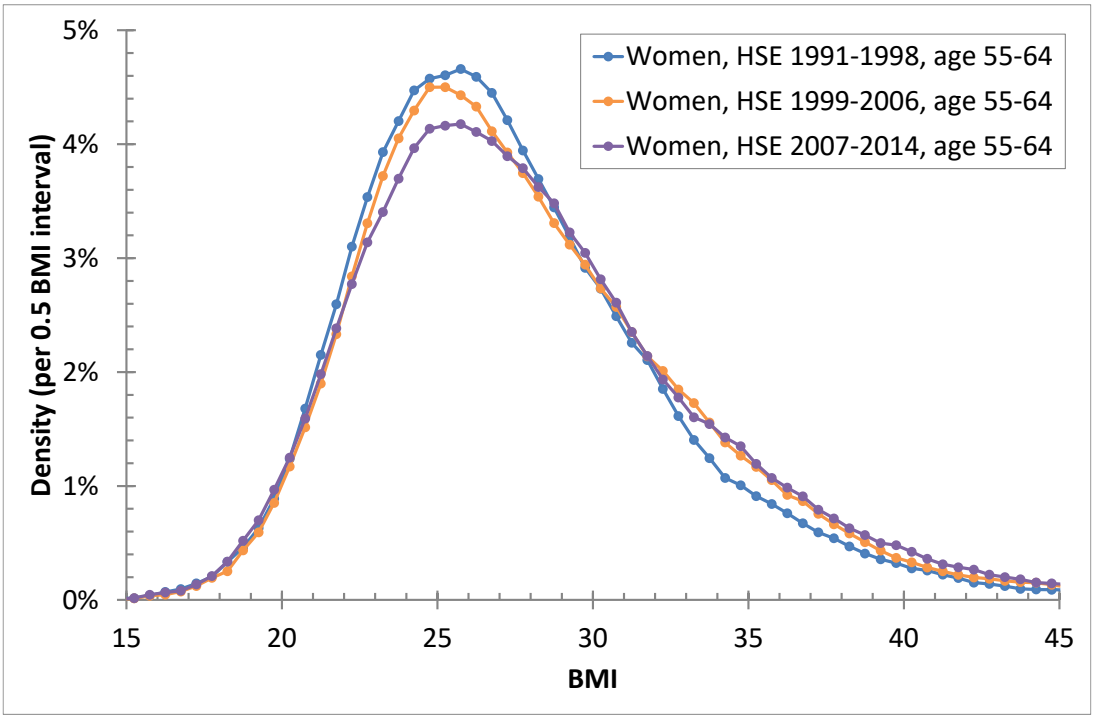

Figure 9.III.5 BMI distributions for women for age group 55-64.

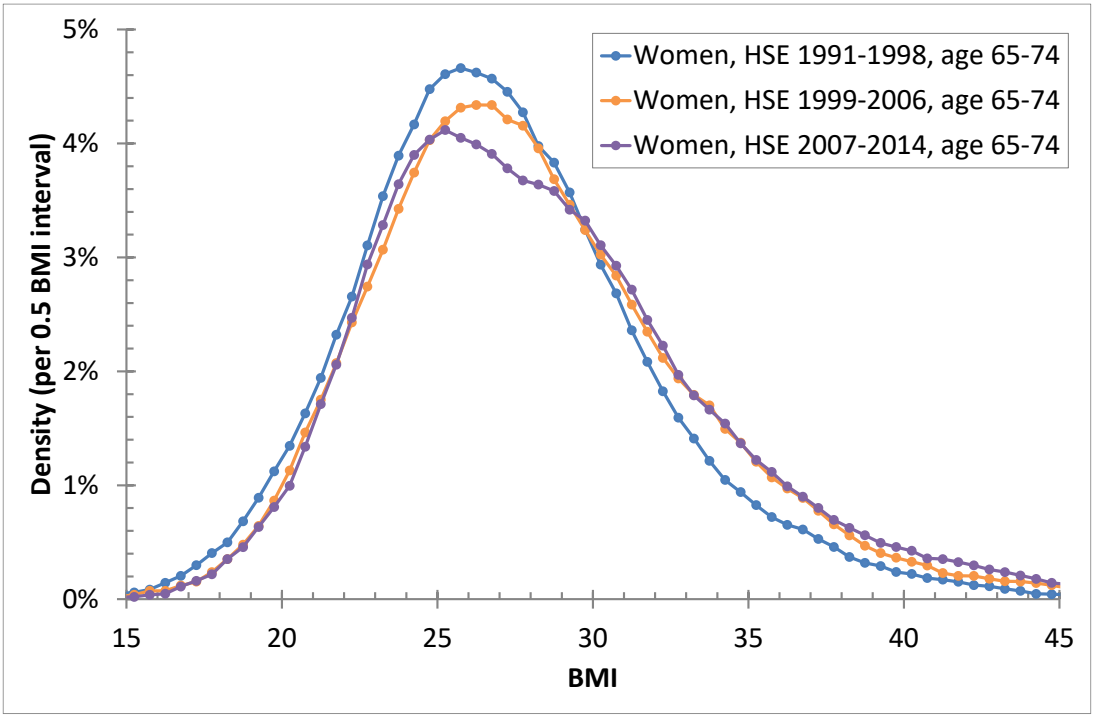

Figure 9.III.6 BMI distributions for women for age group 65-74.

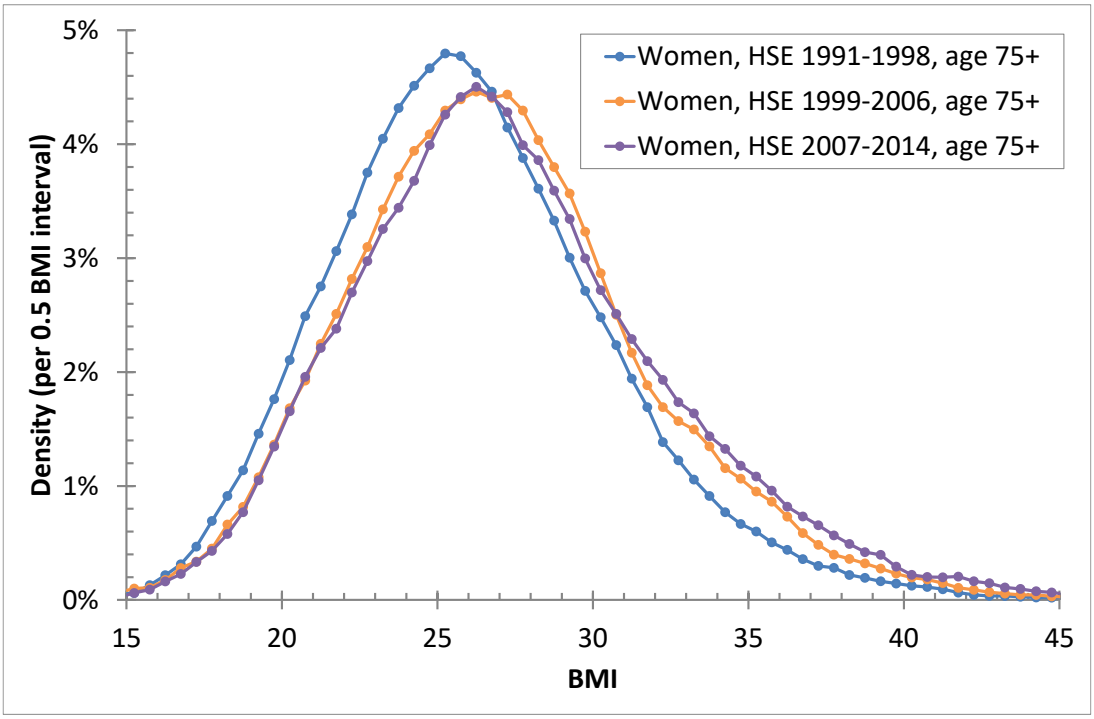

Figure 9.III.7 BMI distributions for women for age group 75+.

Descriptive statistics

Tables 9.III.1 – 9.III.3 give the descriptive statistics for the age group distributions. Charts of the values for the mean, median, standard deviation, skewness, and the category percentages are provided in Figures 9.III.8 – 9.III.21.

Table 9.III.1 Descriptive statistics for the age group distributions for women for 1991-1998.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	4565	9008	8636	7830	6149	5708	3900
Mean	23.77	24.96	25.81	26.69	27.48	27.26	26.17
Median	22.81	23.86	24.69	25.74	26.70	26.78	25.80
Modal interval mid-point	21.75	22.25	22.75	24.25	25.75	25.75	25.25
Standard deviation	4.49	4.84	5.09	4.99	5.09	4.86	4.62
Skewness	1.54	1.47	1.40	1.25	1.14	0.85	0.79
Underweight (BMI < 18.5)	5.3%	2.2%	1.3%	0.9%	0.9%	1.8%	2.9%
Healthy (18.5 ≤ BMI < 25.0)	65.7%	58.5%	51.7%	41.9%	33.5%	31.8%	39.5%
Overweight (25.0 ≤ BMI < 30.0)	19.7%	25.8%	29.9%	36.4%	39.7%	41.8%	39.3%
Obese I (30.0 ≤ BMI < 35.0)	6.4%	8.8%	11.2%	13.8%	17.8%	18.1%	14.4%
Obese II (35.0 ≤ BMI < 40.0)	2.0%	3.3%	3.9%	5.1%	5.9%	5.0%	3.2%
Severely obese (BMI ≥ 40.0)	0.9%	1.4%	1.9%	1.9%	2.2%	1.5%	0.7%

Table 9.III.2 Descriptive statistics for the age group distributions for women for 1999-2006.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	3168	6062	7848	6649	5957	4449	3226
Mean	24.42	25.81	26.67	27.49	27.95	28.12	27.07
Median	23.17	24.54	25.47	26.42	27.04	27.46	26.72
Modal interval mid-point	21.75	22.75	23.75	24.25	25.25	26.25	26.25
Standard deviation	5.21	5.44	5.53	5.60	5.32	5.19	4.85
Skewness	1.62	1.32	1.27	1.13	0.96	0.76	0.54
Underweight (BMI < 18.5)	5.1%	2.2%	1.0%	0.8%	0.8%	1.1%	2.2%
Healthy (18.5 ≤ BMI < 25.0)	60.5%	51.7%	45.0%	37.2%	31.5%	27.8%	32.7%
Overweight (25.0 ≤ BMI < 30.0)	21.6%	27.8%	31.7%	35.4%	38.0%	39.9%	40.9%
Obese I (30.0 ≤ BMI < 35.0)	7.8%	11.1%	13.8%	16.3%	19.6%	21.2%	17.8%
Obese II (35.0 ≤ BMI < 40.0)	3.3%	4.9%	5.5%	6.9%	7.3%	7.4%	5.2%
Severely obese (BMI ≥ 40.0)	1.7%	2.3%	3.0%	3.4%	2.9%	2.6%	1.2%

Table 9.III.3 Descriptive statistics for the age group distributions for women for 2007-2014.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	2497	4655	5787	5681	5086	4102	2989
Mean	24.72	26.06	27.14	27.79	28.16	28.37	27.42
Median	23.48	24.70	25.90	26.63	27.27	27.62	26.90
Modal interval mid-point	21.75	23.25	24.25	24.75	25.75	25.25	26.25
Standard deviation	5.40	5.71	5.85	5.76	5.61	5.45	5.08
Skewness	1.43	1.37	1.20	1.11	1.00	0.80	0.61
Underweight (BMI < 18.5)	5.8%	2.2%	1.1%	0.8%	0.9%	1.0%	1.9%
Healthy (18.5 ≤ BMI < 25.0)	56.7%	50.4%	41.5%	35.8%	30.5%	28.3%	31.4%
Overweight (25.0 ≤ BMI < 30.0)	22.5%	27.6%	32.4%	34.3%	37.5%	37.5%	39.7%
Obese I (30.0 ≤ BMI < 35.0)	9.3%	11.8%	14.7%	17.8%	19.6%	21.8%	18.9%
Obese II (35.0 ≤ BMI < 40.0)	3.8%	4.8%	6.3%	7.6%	7.8%	7.9%	6.4%
Severely obese (BMI ≥ 40.0)	1.8%	3.1%	3.9%	3.8%	3.6%	3.6%	1.7%

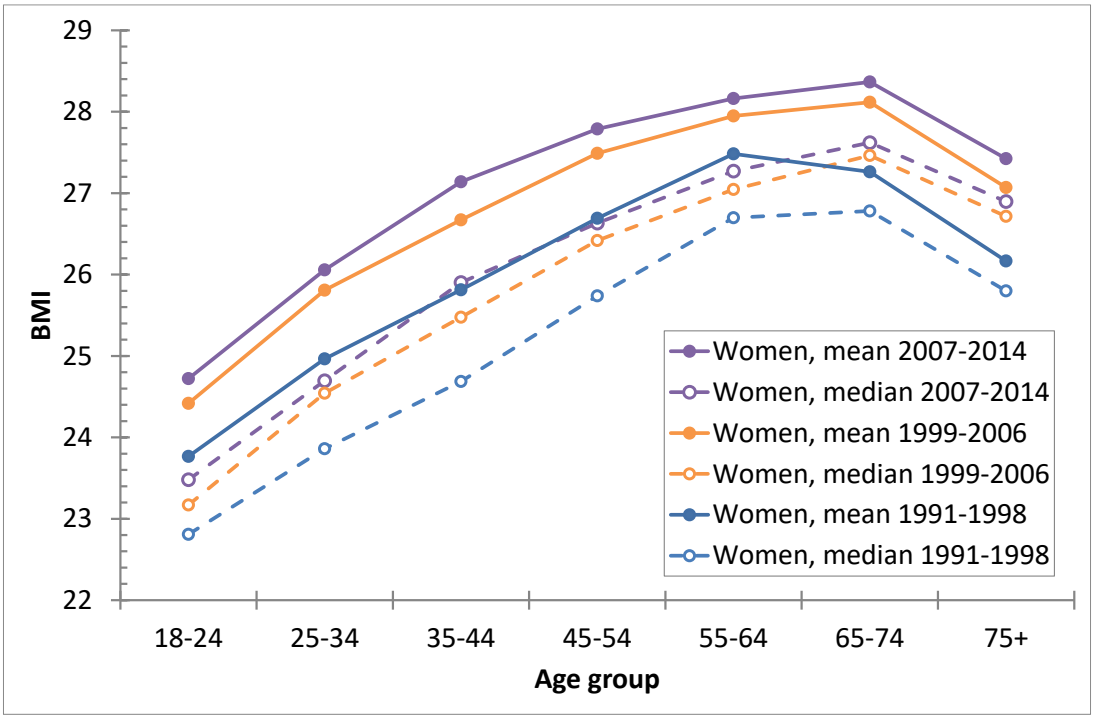

Figure 9.III.8 Mean and median values for each age group for women.

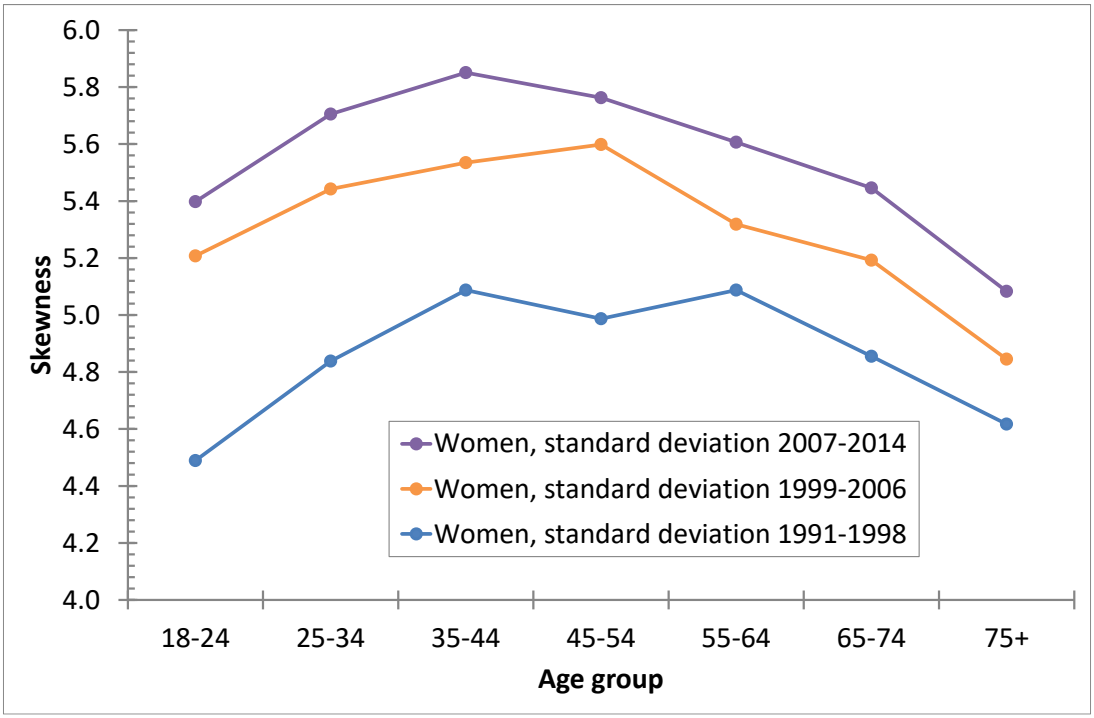

Figure 9.III.9 Standard deviation values for each age group for women.

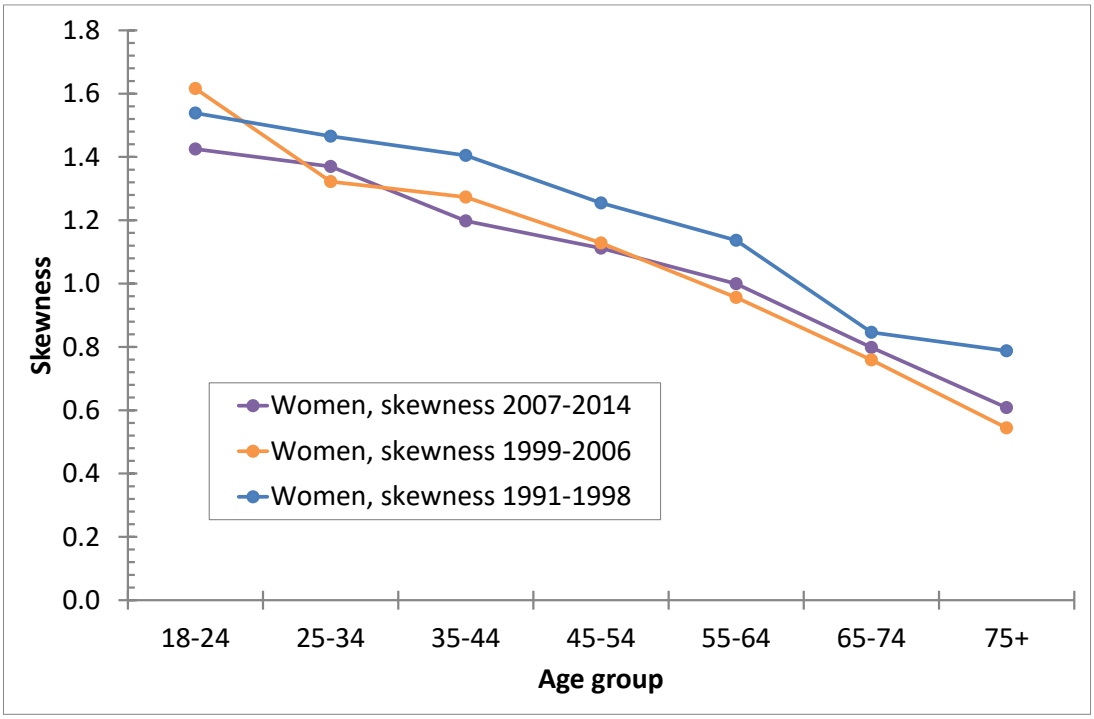

Figure 9.III.10 Skewness values for each age group for women.

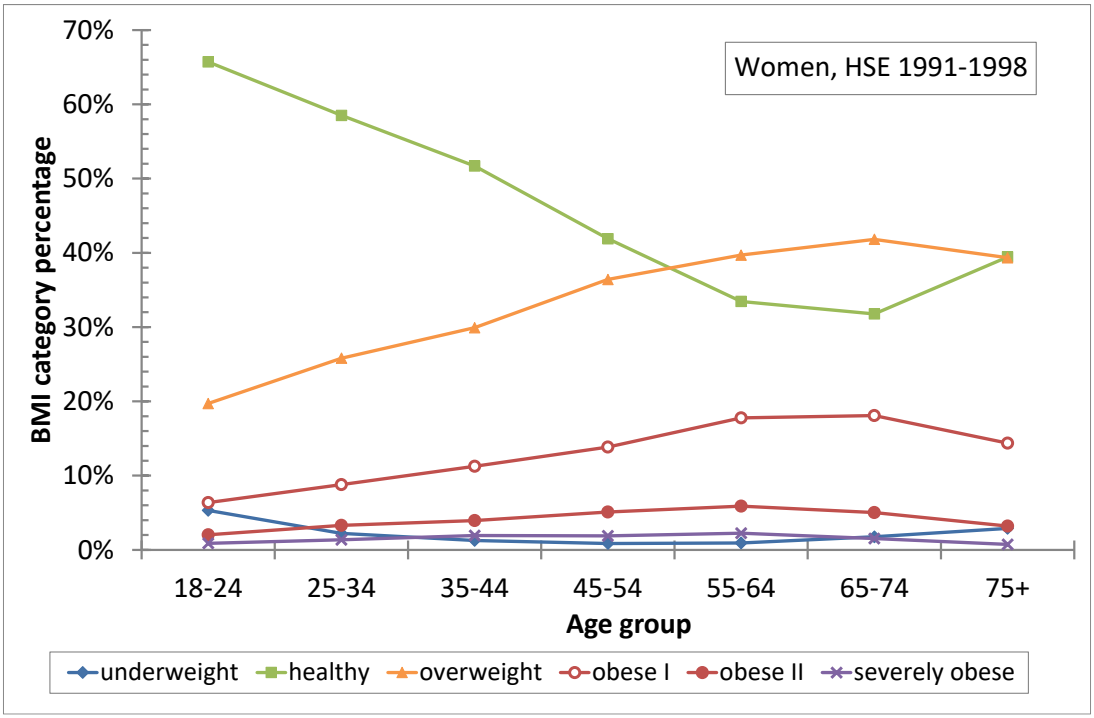

Figure 9.III.11 Age group category percentages for women for 1991-1998.

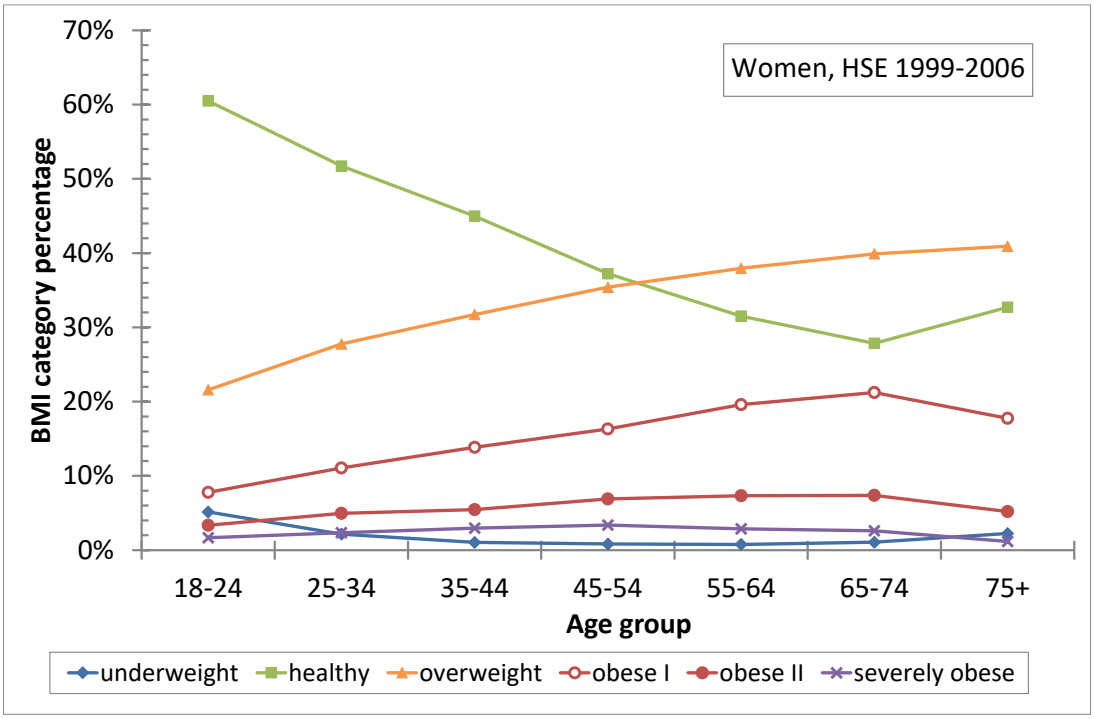

Figure 9.III.12 Age group category percentages for women for 1999-2006.

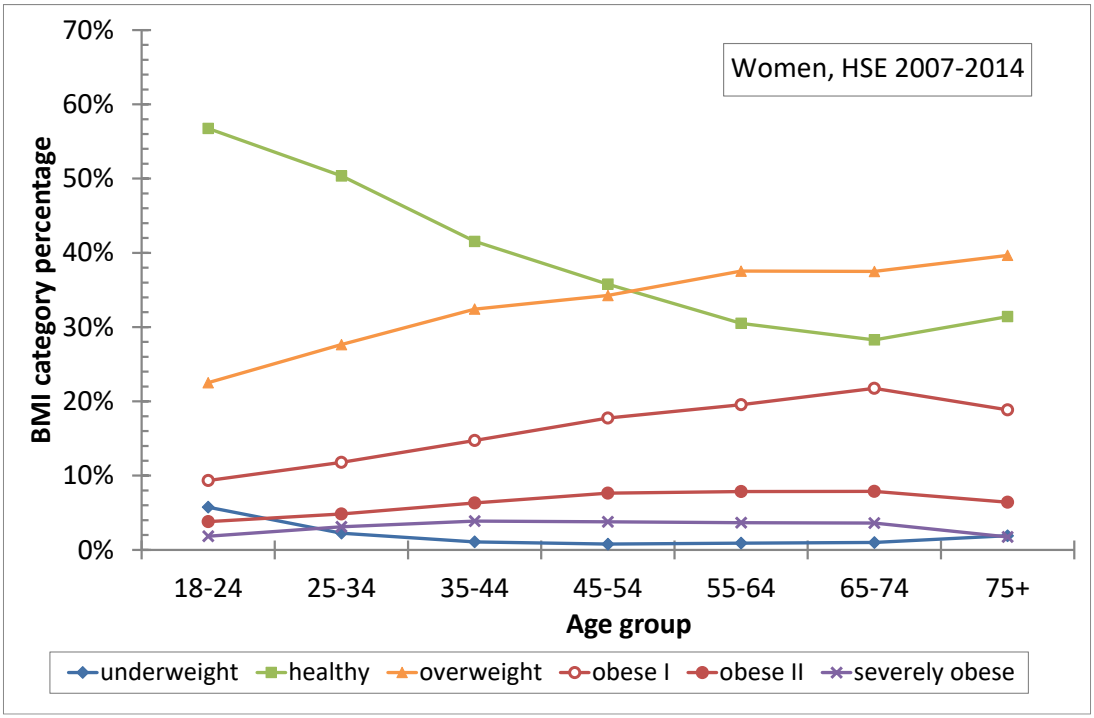

Figure 9.III.13 Age group category percentages for women for 2007-2014.

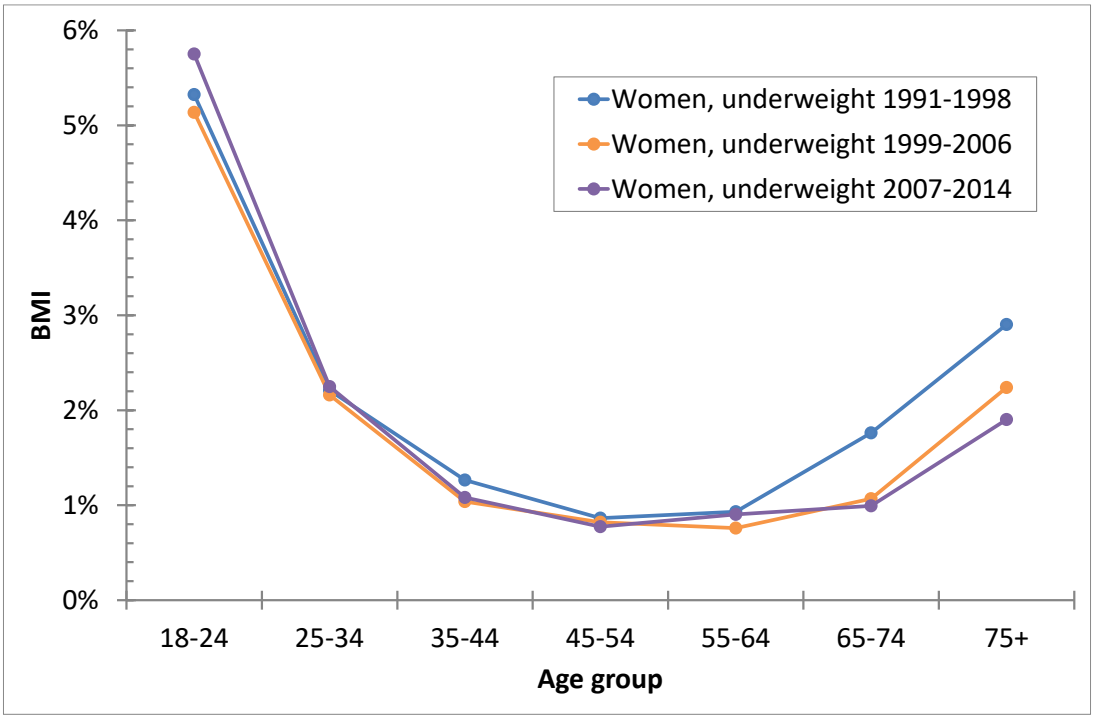

Figure 9.III.14 Underweight age group percentages for women.

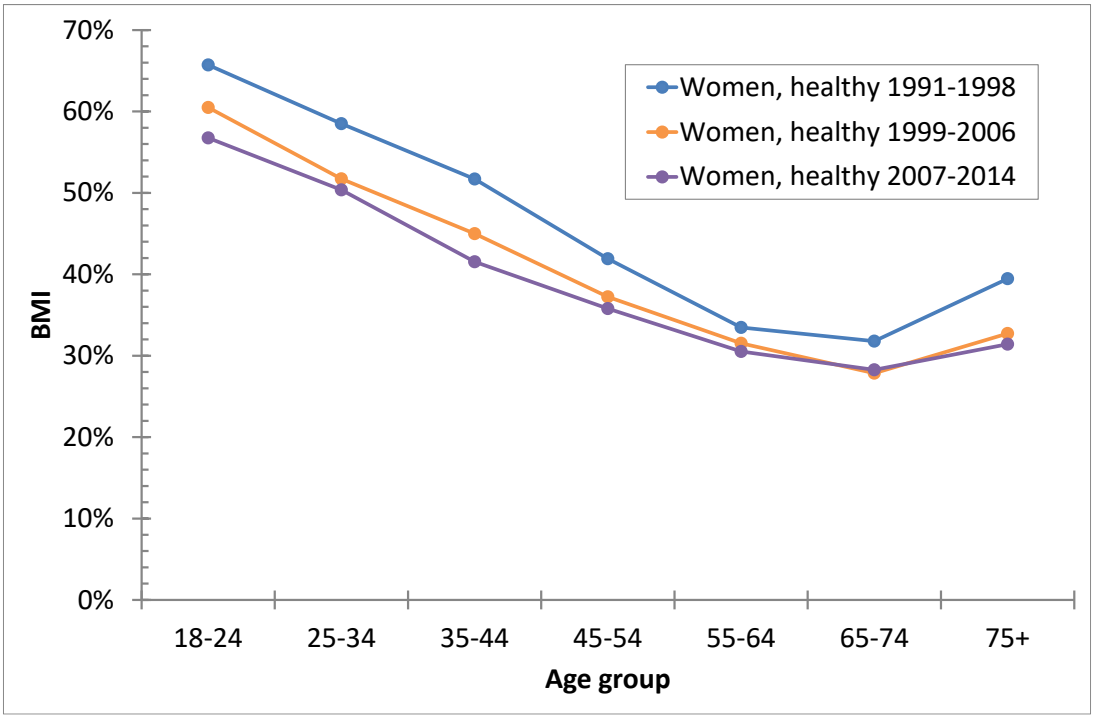

Figure 9.III.15 Healthy age group percentages for women.

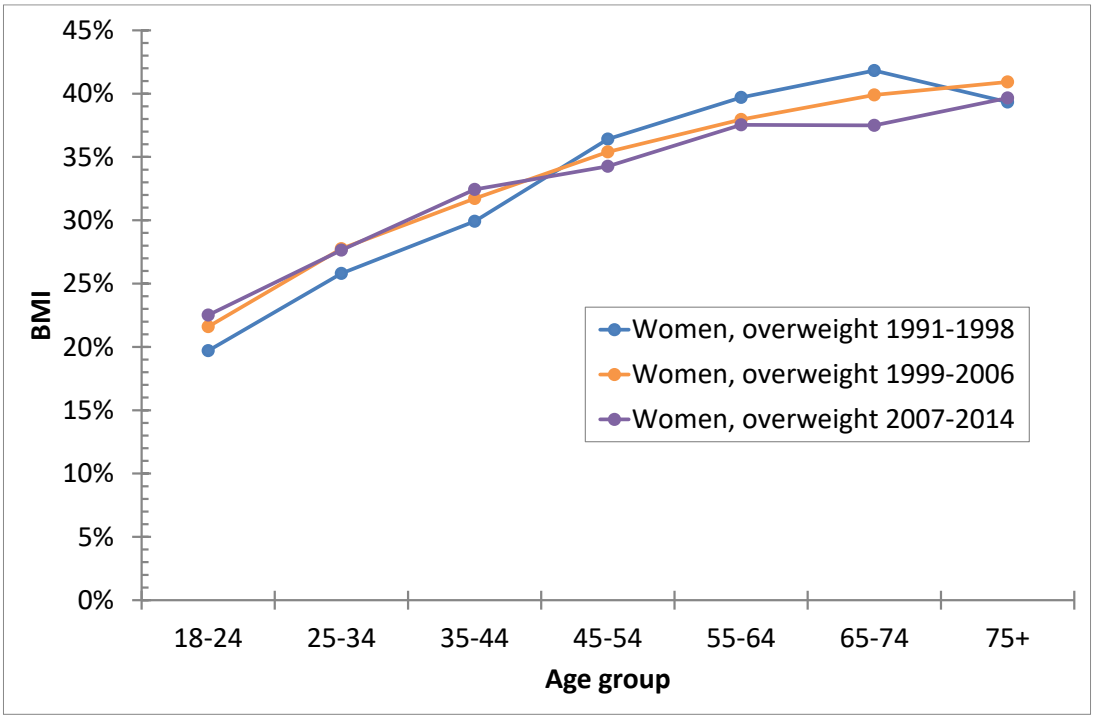

Figure 9.III.16 Overweight age group percentages for women.

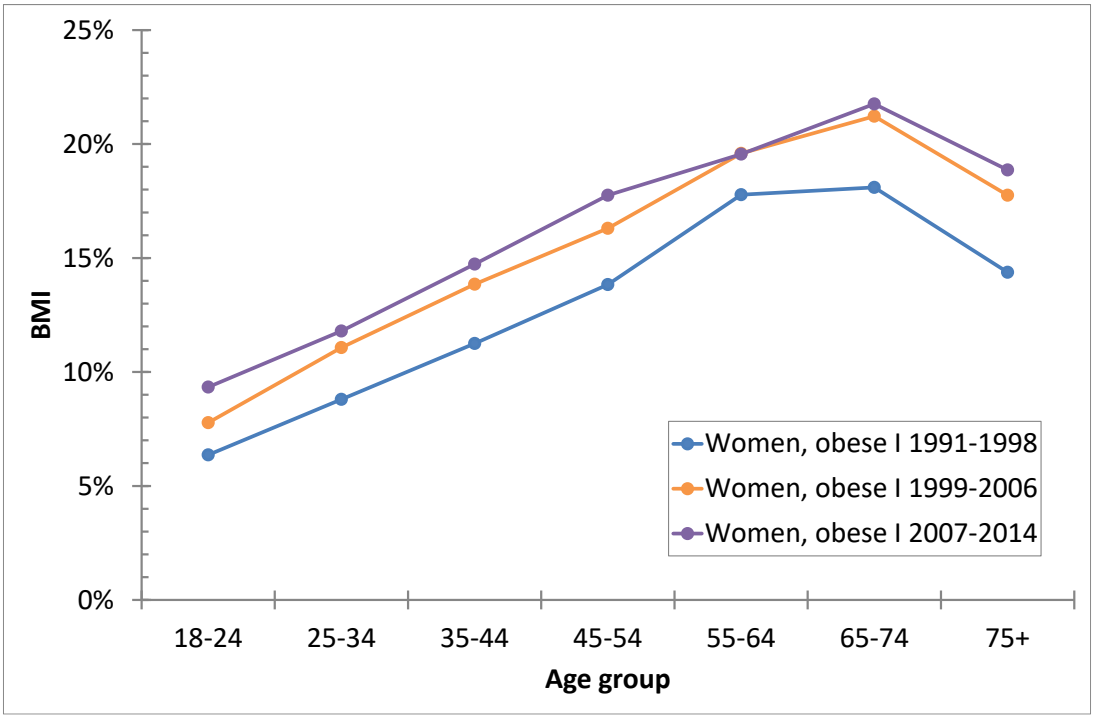

Figure 9.III.17 Obese I age group percentages for women.

Figure 9.III.18 Obese II age group percentages for women.

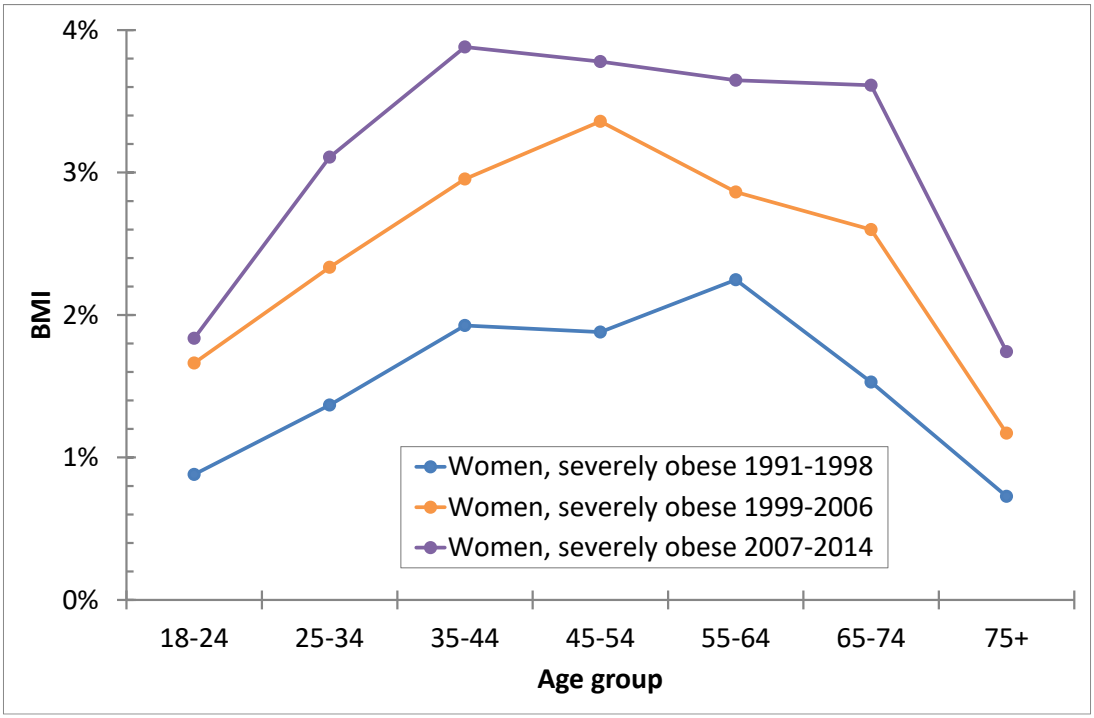

Figure 9.III.19 Severely obese age group percentages for women.

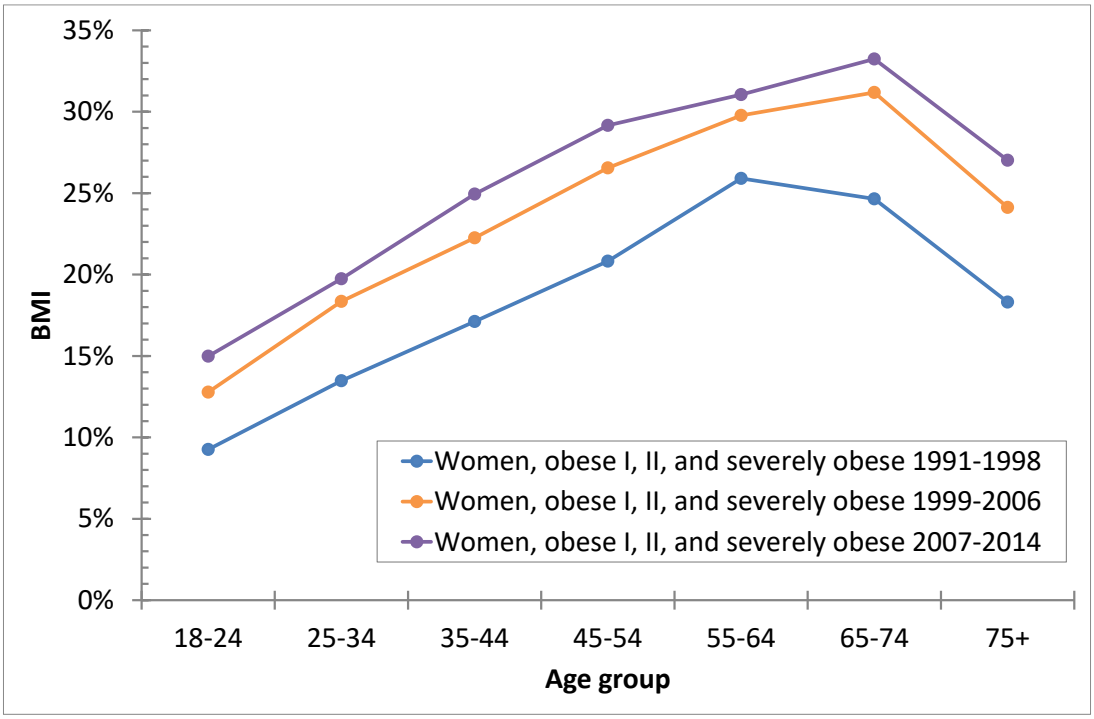

Figure 9.III.20 Combined all obese age group percentages for women.

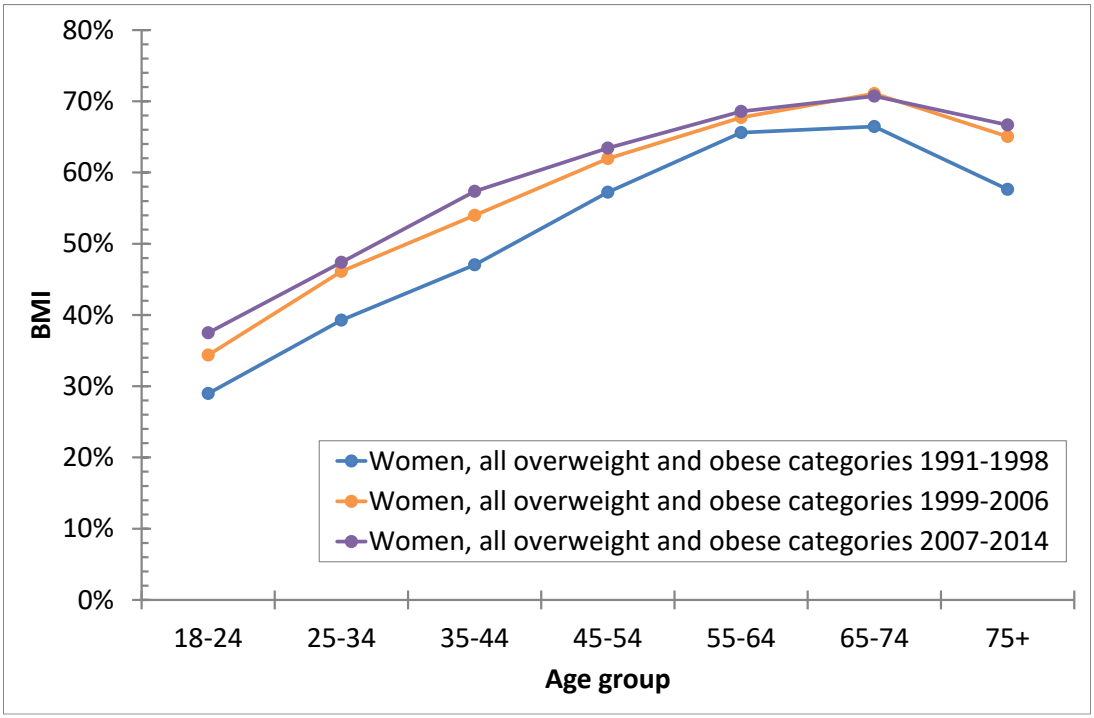

Figure 9.III.21 Combined all overweight and obese age group percentages for women.

Appendix 9.IV Women age group percentiles

These charts use all the percentile values calculated (each 10% value and 1%, 5%, 95%, 99%) and plot the increases against the starting value. Figure 9.IV.1 shows the changes from 1991-1998 to 2007-2014 (same as Figure 9.6 in the main report but with different formatting). Figures 9.IV.2 and 9.IV.3 show the changes from 1991-1998 to 1999-2006 and then 1999-2006 to 2007-2014. Figure 9.IV.3 has smaller changes and more irregularities but still roughly a general linear pattern. Figure 9.IV.4 shows the scaling model increases along with the percentile values for 1991-1998 to 2007-2014.

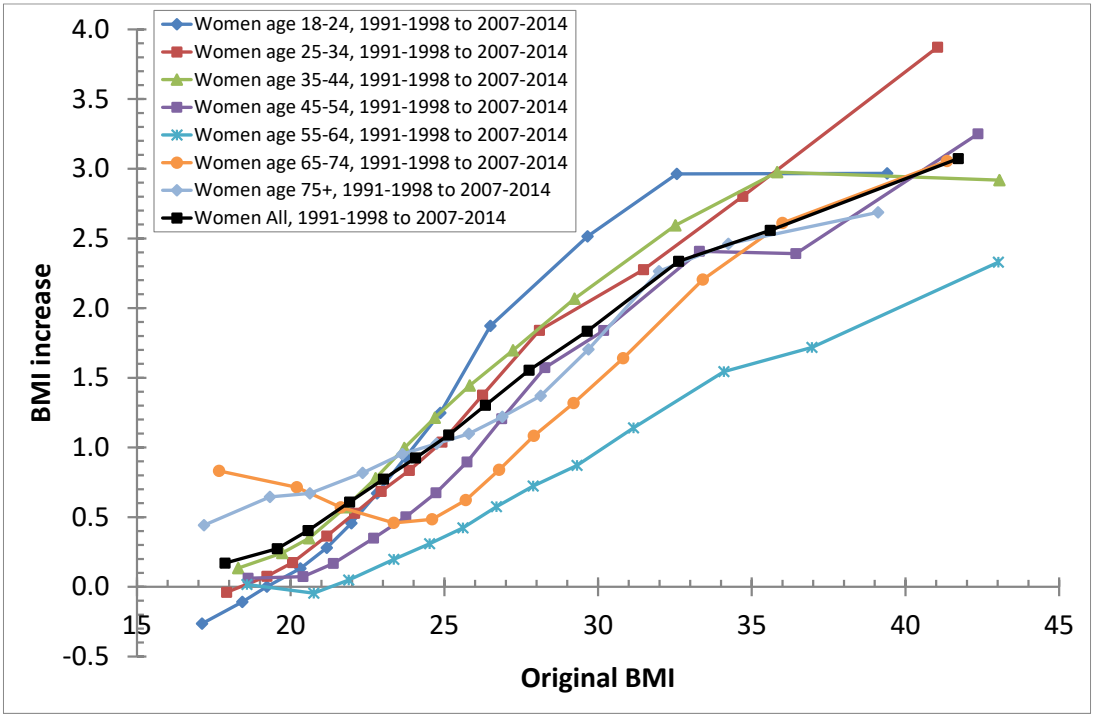

Figure 9.IV.1 Percentile increases for age groups for women from 1991-1998 to 2007-2014.

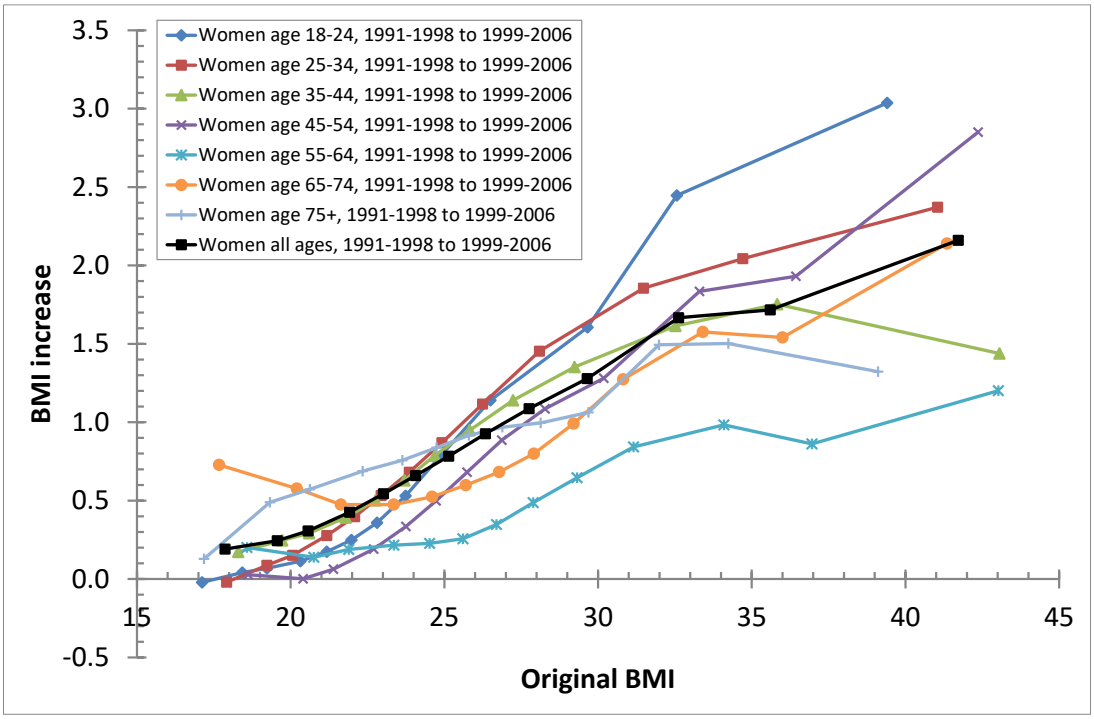

Figure 9.IV.2 Percentile increases for age groups for women from 1991-1998 to 1999-2006.

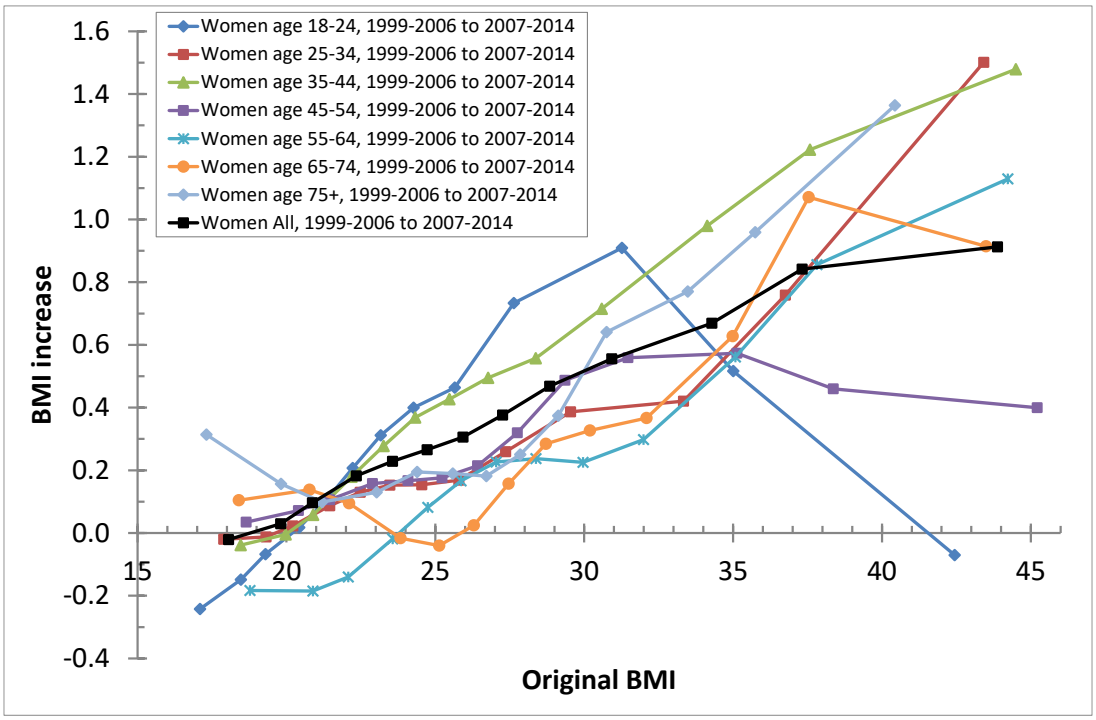

Figure 9.IV.3 Percentile increases for age groups for women from 1999-2006 to 2007-2014.

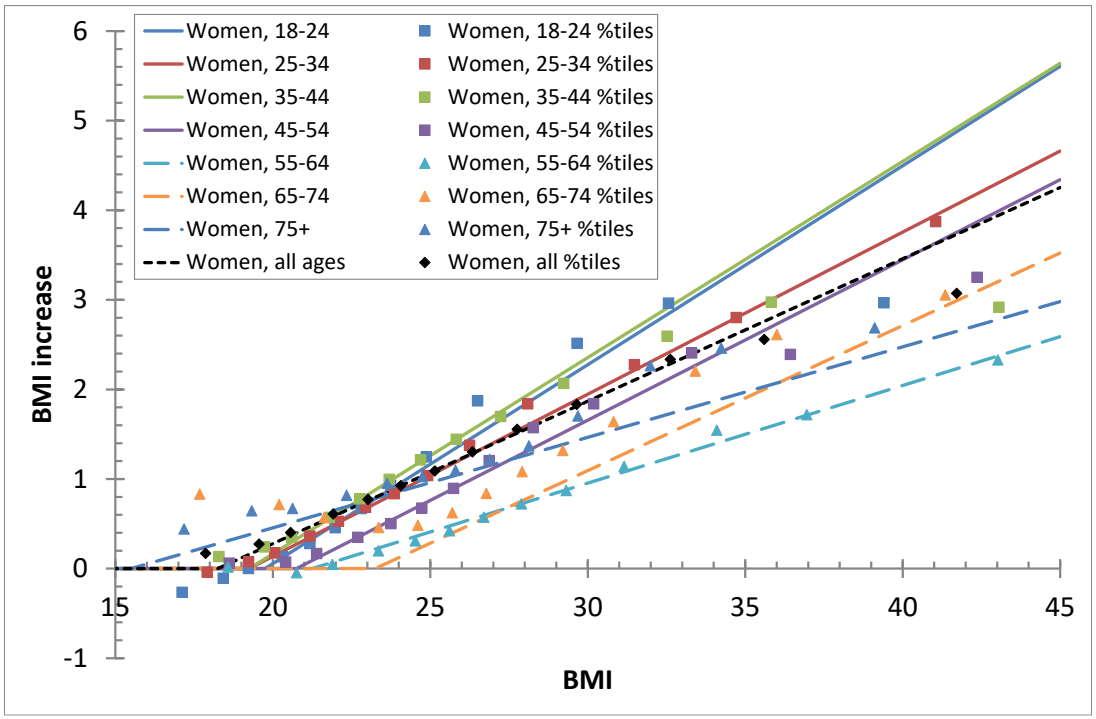

Figure 9.IV.4 Model and percentile increases for age groups for women 1991-1998 to 2007-2014.

Appendix 9.V Women age group models

Change with time: scaling models

These charts show the scaling model results for modelling the changes from 1991-1998 to 2007-2014 for each age group for women. For each age group the model does pretty well in matching the 2007-2014 distribution.

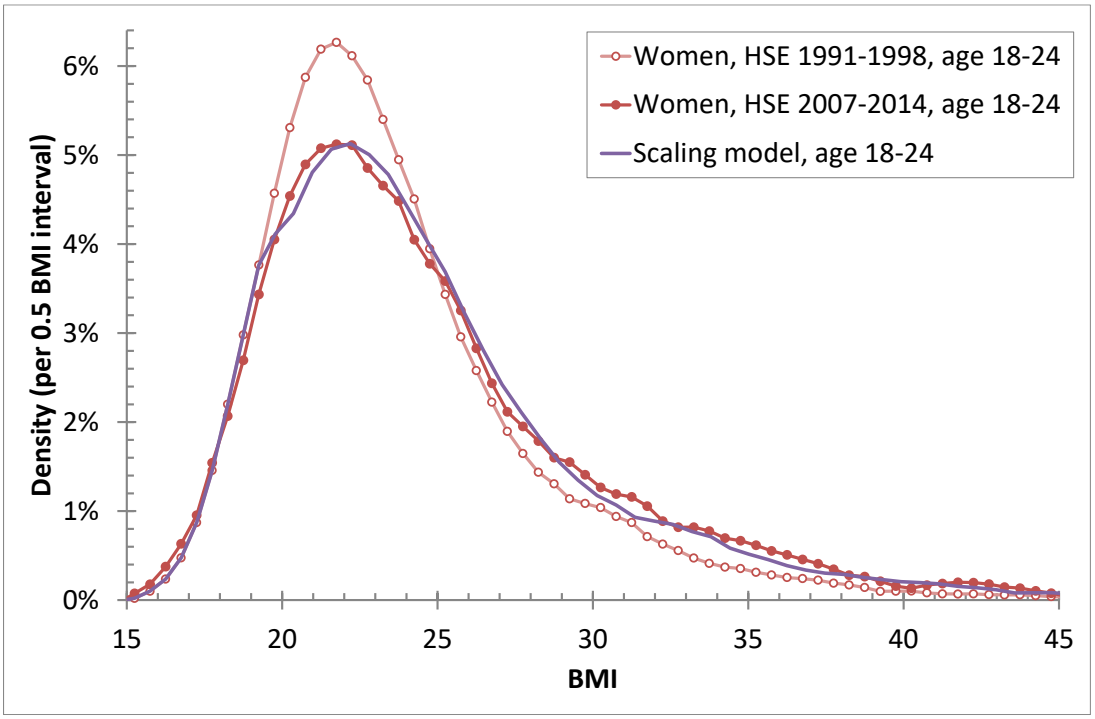

Figure 9.V.1 Scaling model for women age 18-24 from 1991-1998 to 2007-2014.

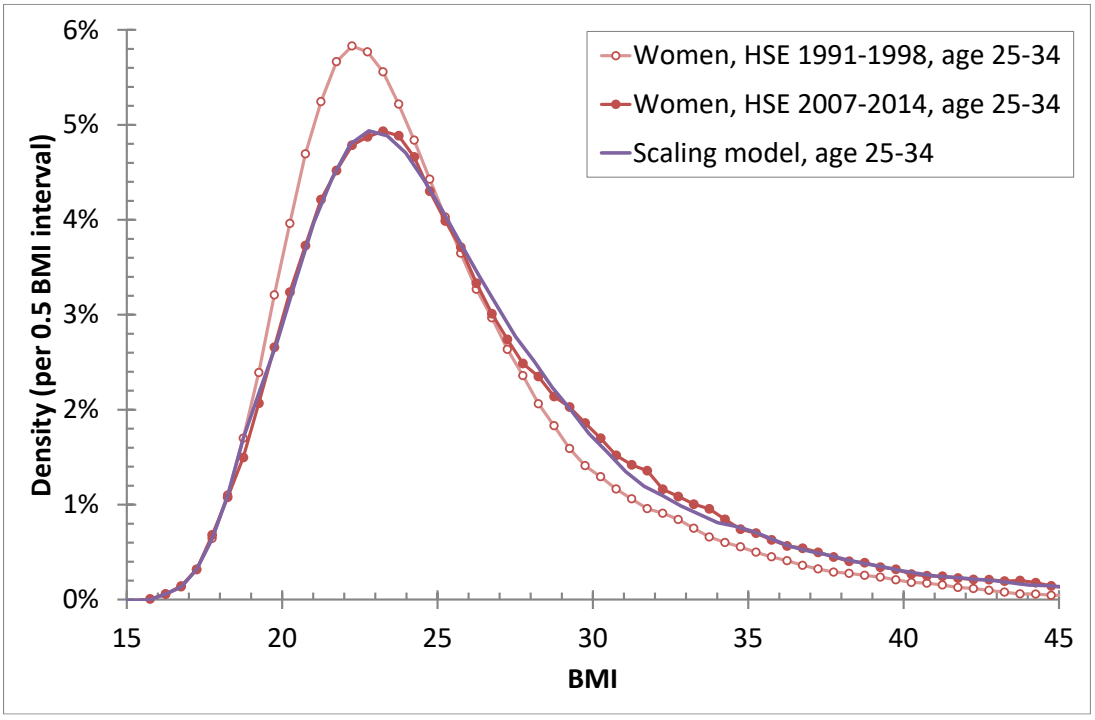

Figure 9.V.2 Scaling model for women age 25-34 from 1991-1998 to 2007-2014.

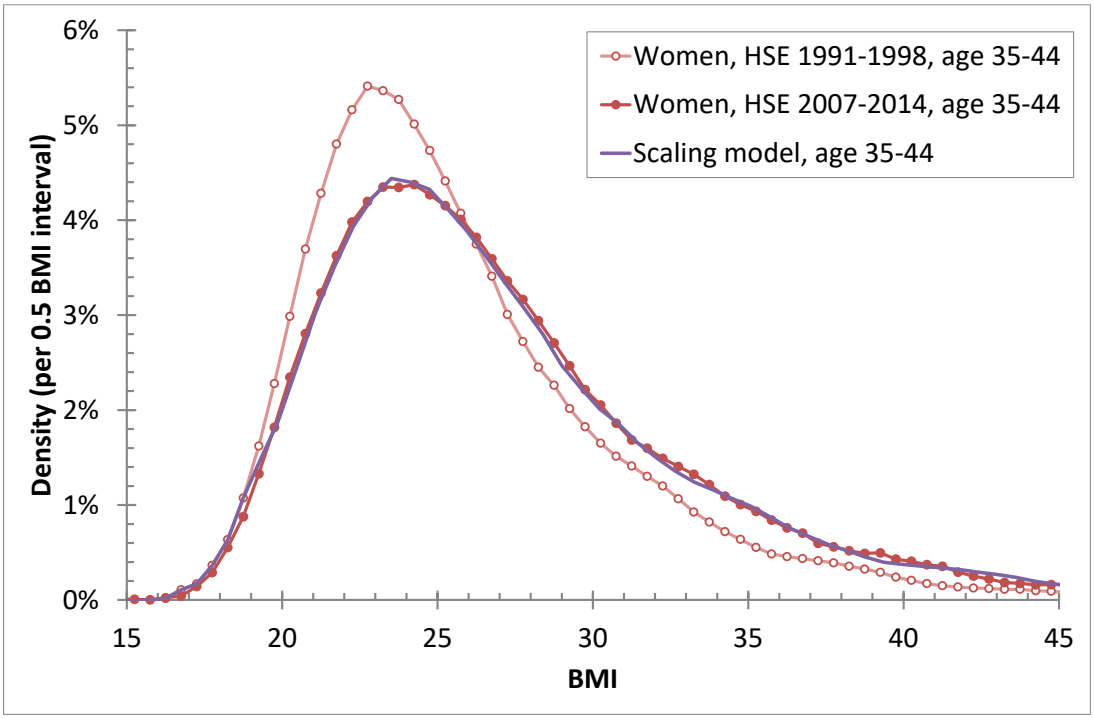

Figure 9.V.3 Scaling model for women age 35-44 from 1991-1998 to 2007-2014.

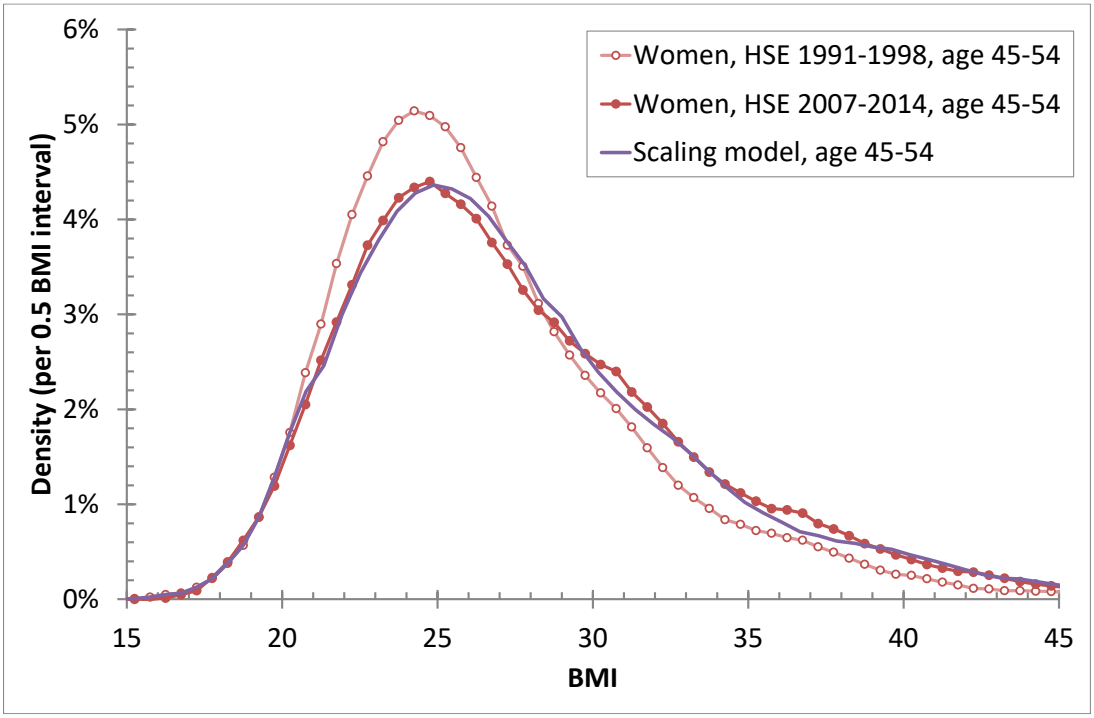

Figure 9.V.4 Scaling model for women age 45-54 from 1991-1998 to 2007-2014.

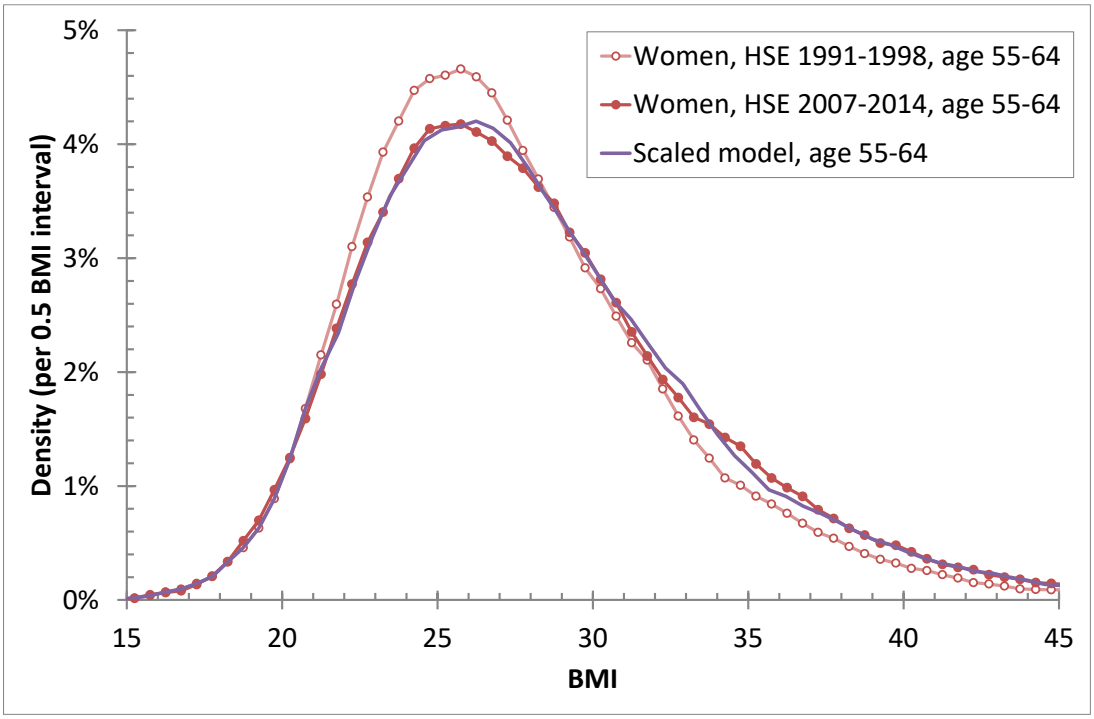

Figure 9.V.5 Scaling model for women age 55-64 from 1991-1998 to 2007-2014.

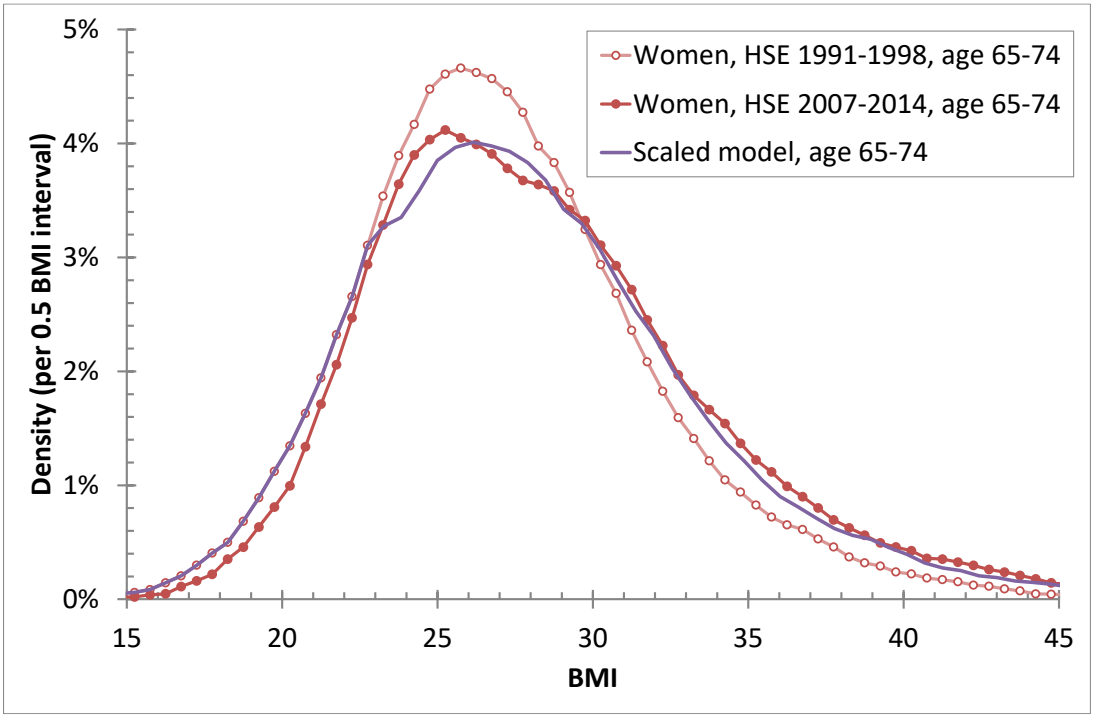

Figure 9.V.6 Scaling model for women age 65-74 from 1991-1998 to 2007-2014.

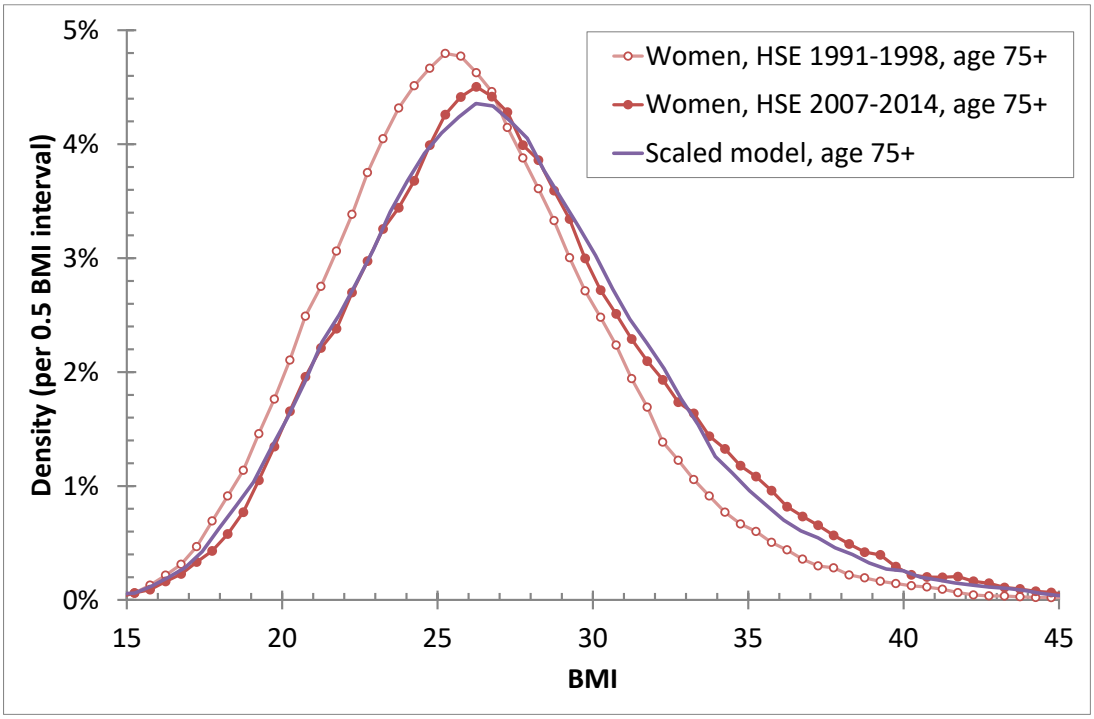

Figure 9.V.7 Scaling model for women age 75+ from 1991-1998 to 2007-2014.

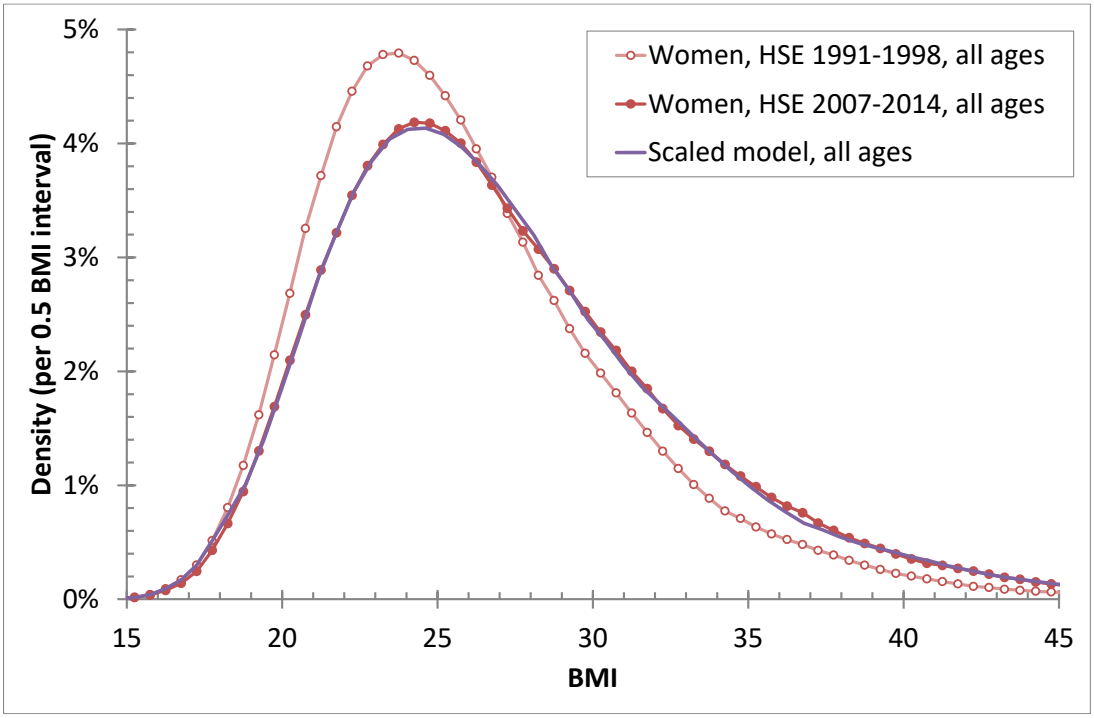

Figure 9.V.8 Scaling model for women all ages (i.e., 18+) from 1991-1998 to 2007-2014.

Change with age: scaling models

As discussed in Section 8.4 of the main report, scaling and shift models were used to model the change with age for 2007-2014 from 18-24 to 25-34, 25-34 to 35-44, and 35-44 to 45-54. The scaling models have considerably better fitness values, and the details of these models are in Table 9.V.1. By comparison, the shift models with an optimised shift value have fitness values ($\times 10^{-5}$) of 5.45, 11.67, and 3.76, respectively. Charts of the scaling models are in Figures 9.V.9 – 9.V.11. The models have a low start value for the scaling meaning that they are effectively a combination of a shift and a scaling over the BMI values for the distributions. Figure 9.V.12 shows the BMI increases for the models.

Table 9.V.1 Values for the scaling models for the changes with age in 2007-2014.

Age group	18-24 to 25-34	25-34 to 35-44	35-44 to 45-54
Start point	1.25	13.00	1.25
Scaling factor	1.055	1.104	1.034
Fitness value ($\times 10^{-5}$)	2.65	2.23	2.74

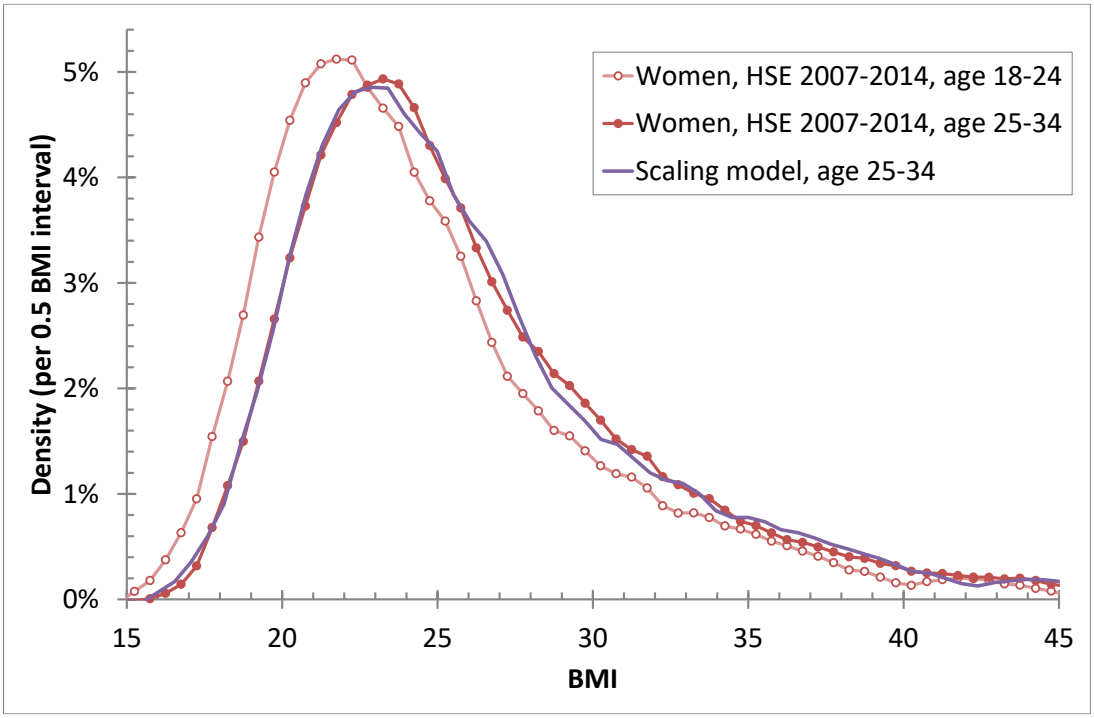

Figure 9.V.9 Scaling model for women from age 18-24 to 25-34.

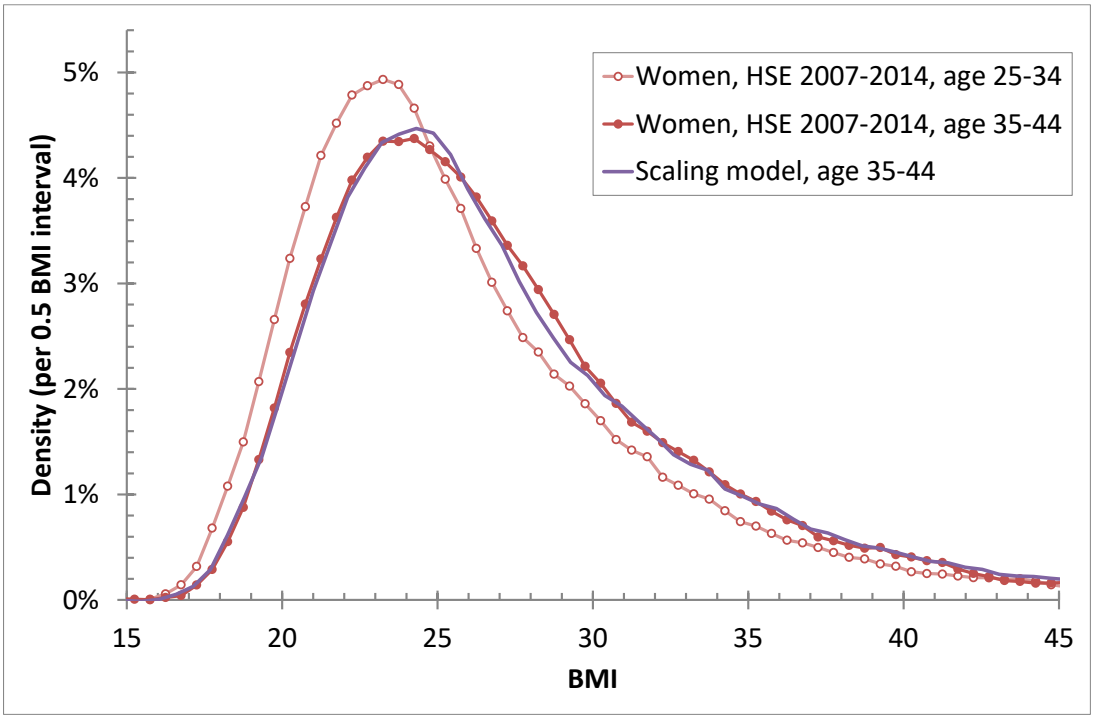

Figure 9.V.10 Scaling model for women from age 25-34 to 35-44.

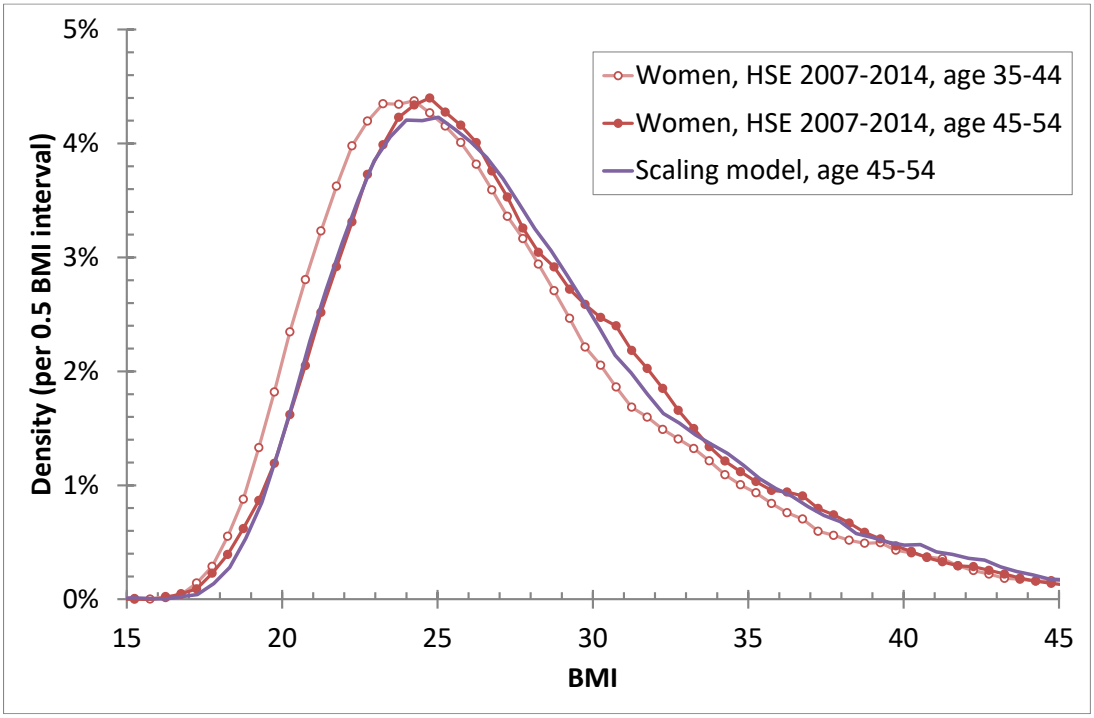

Figure 9.V.11 Scaling model for women from age 35-44 to 45-54.

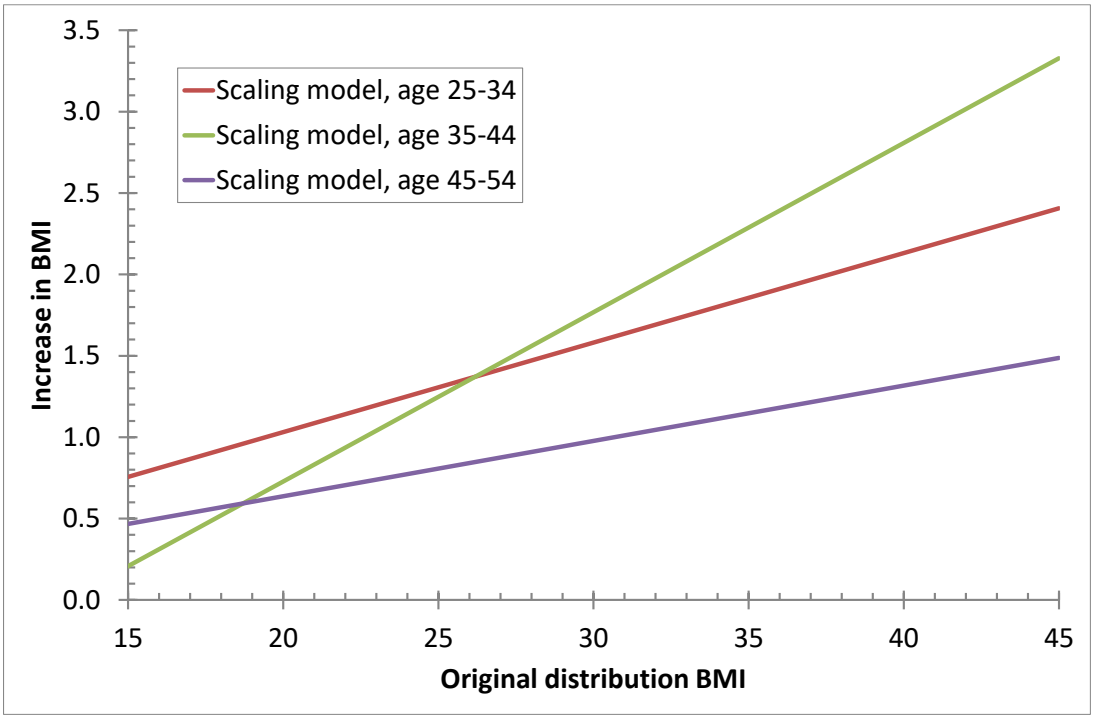

Figure 9.V.12 BMI increases for the age group scaling models for women.

Appendix 9.VI Analysis of single years of age from 18 to 54 for women

Charts of the population distributions

This appendix has the analysis of population distributions for women for individual years of age from age 18 to 54 in gaps of 6 years. This is discussed in Section 9.5.1 of the main report. The time intervals used are 1991-1998 and 1999-2014. Figures 9.VI.1 and 9.VI.2 show the distributions for each of the time intervals.

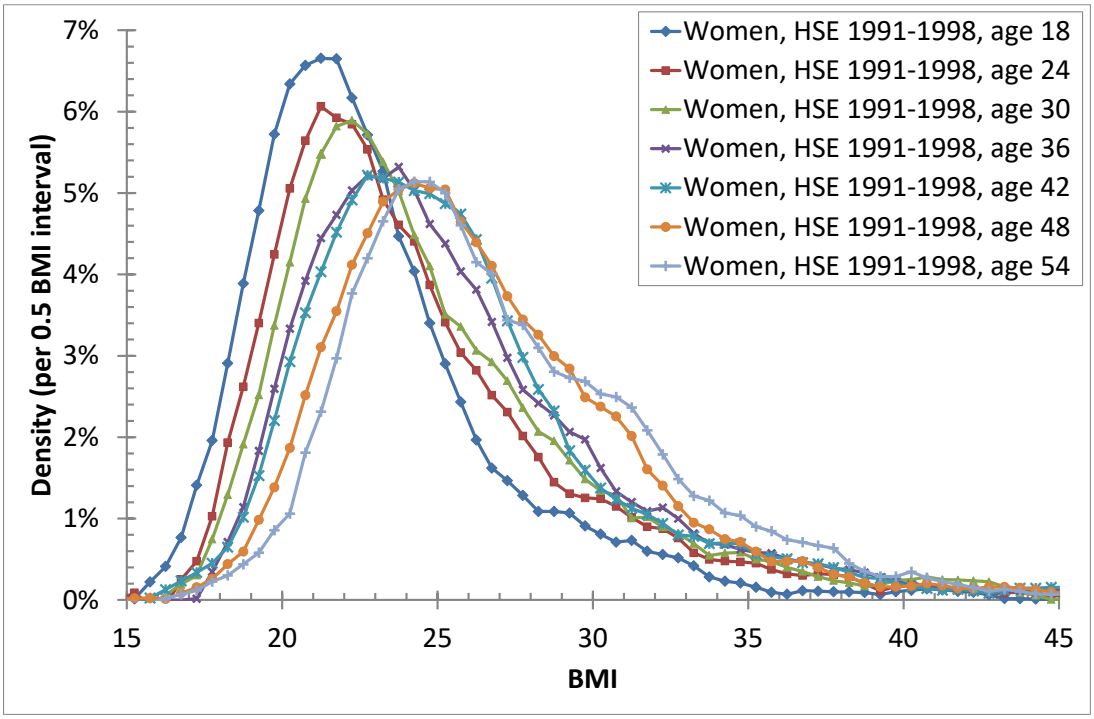

Figure 9.VI.1 Distributions for selected ages from 18 to 54 for women for 1991-1998.

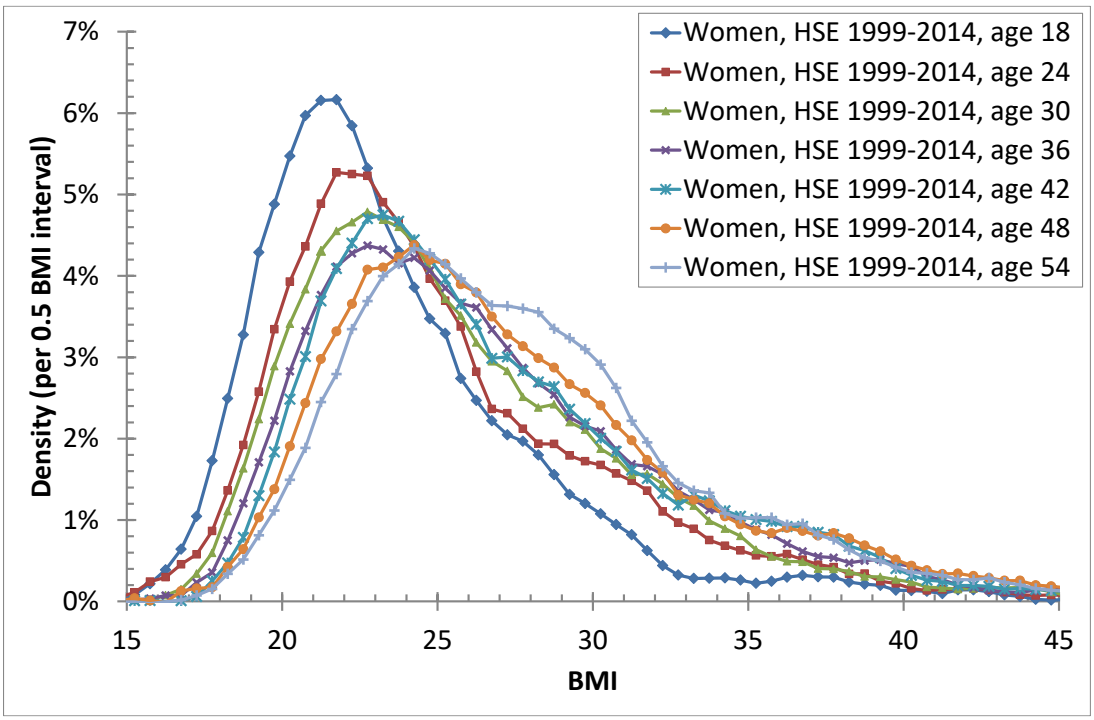

Figure 9.VI.2 Distributions for selected ages from 18 to 54 for women for 1999-2014.

Percentiles

The percentiles were calculated for the changes over time and with age. The charts here show the BMI increases for the 10% percentiles along with 5%, and 95%. The 1% and 99% values are not shown. This is because they are sensitive to the small sample sizes and the 99% value particularly shows variability with some fairly large fluctuations compared to the pattern of the other percentiles. The increases with time are shown in Figure 9.VI.3 and with age in Figure 9.VI.4.

Figure 9.VI.3 shows the percentile increases with time, from 1991-1998 to 1999-2014. The "all" category is the combined data from the seven ages. Each age shows approximately a linear increase in values with the increases being quite similar, particularly up to age 42. This indicates approximately a linear scaling.

Figure 9.IV.4 shows the percentile increases with age for each age compared to the previous younger one, for the 1999-2014 data. For example, the age 24 series shows the increases in the percentiles for the age 24 distribution compared to the percentiles for age 18. The largest changes are for this series from age 18 to 24. This series has greater increases in percentile values for higher BMI than lower BMI but with the series not starting from 0. This indicates a combination of a shift and a scaling transformation. The percentile increases for age 36 also show this type of pattern, although the increases are much less. The series for ages 30 and 48 have a slight upward trend for the lower BMI values up to about 26 or 27.

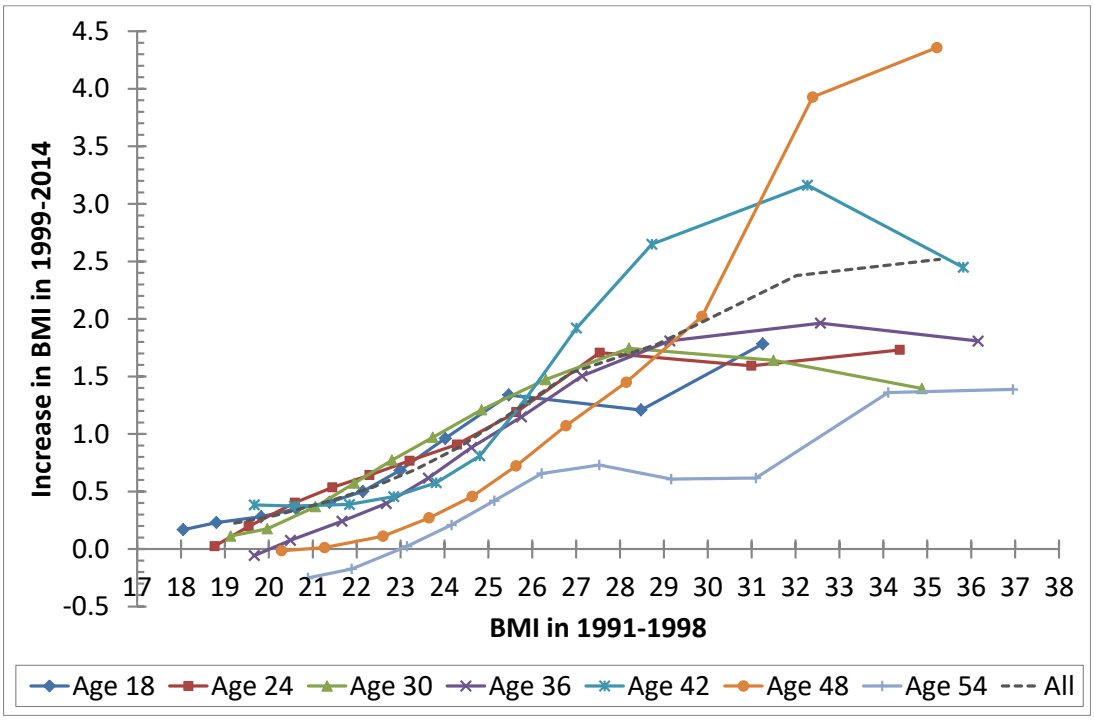

Figure 9.VI.3 Percentile increases with time for women single ages 1991-1998 to 1999-2014.

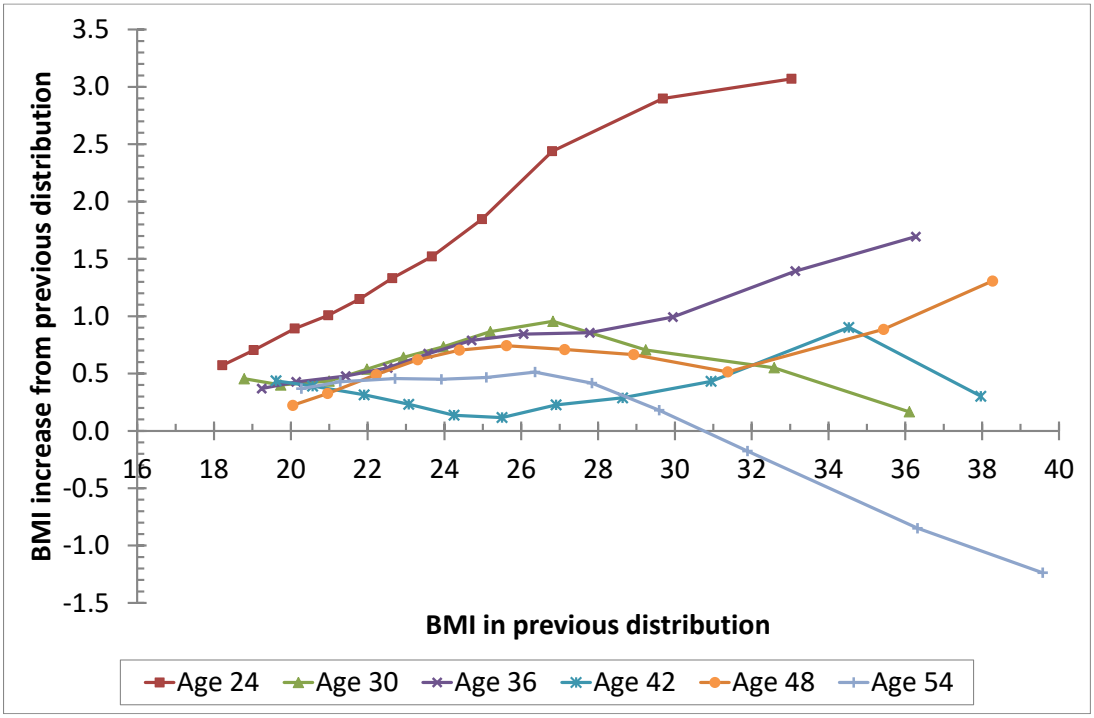

Figure 9.VI.4 Percentile increases with age for women single ages for 1999-2014.

Descriptive statistics

The descriptive statistics for the distributions are given below in Tables 9.VI.1 and 9.VI.2. Charts of the statistics follow in Figures 9.VI.5-17.

Figures 9.VI.5 and 9.VI.6 show all the category percentages together. The mean and median, standard deviation, and skewness are in Figures 9.VI.7-9.

Then, Figures 9.VI.10-15 are charts of each BMI category individually. These are included to show the trends with age, although sample sizes are small and so there are considerable irregularities for the categories with the smaller percentages, such as obese II and severely obese. Figures 9.VI.16 and 9.VI.17 are charts of all the obese categories and the total of the overweight and obese categories.

Table 9.VI.1 Descriptive statistics for women for selected ages from 18 to 54 for 1991-1998.

Age	18	24	30	36	42	48	54
Sample size of actual data	610	785	968	954	814	801	646
Mean	23.02	24.42	24.92	25.78	25.73	26.43	27.27
Median	22.14	23.21	23.74	24.62	24.80	25.63	26.21
Modal interval mid-point	21.25	21.25	22.25	23.75	22.75	24.25	24.25
Standard deviation	4.24	4.92	4.86	5.24	4.97	4.68	5.04
Skewness	1.74	1.49	1.31	1.53	1.35	1.03	1.07
Underweight (BMI < 18.5)	7.6%	3.6%	2.4%	1.2%	1.7%	1.0%	0.6%
Healthy (18.5 ≤ BMI < 25.0)	69.7%	62.1%	58.8%	52.4%	50.2%	42.7%	38.0%
Overweight (25.0 ≤ BMI < 30.0)	15.8%	21.9%	25.1%	29.9%	32.7%	37.0%	35.9%
Obese I (30.0 ≤ BMI < 35.0)	5.1%	8.0%	8.8%	10.2%	9.4%	14.1%	17.4%
Obese II (35.0 ≤ BMI < 40.0)	1.0%	2.8%	3.1%	4.2%	4.0%	3.5%	5.9%
Severely obese (BMI ≥ 40.0)	0.8%	1.6%	1.8%	2.2%	1.9%	1.7%	2.2%

Table 9.VI.2 Descriptive statistics for women for selected ages from 18 to 54 for 1999-2014.

Age	18	24	30	36	42	48	54
Sample size of actual data	855	856	1063	1297	1396	1231	1184
Mean	23.81	25.30	25.92	26.69	27.03	27.69	27.78
Median	22.64	23.98	24.71	25.50	25.61	26.36	26.87
Modal interval mid-point	21.75	21.75	22.75	22.75	23.25	24.25	24.25
Standard deviation	5.02	5.56	5.51	5.75	5.84	6.13	5.47
Skewness	2.12	1.51	1.35	1.14	1.20	1.26	0.97
Underweight (BMI < 18.5)	6.4%	3.9%	2.3%	1.6%	0.8%	0.9%	0.5%
Healthy (18.5 ≤ BMI < 25.0)	63.7%	54.7%	50.1%	44.6%	44.4%	38.3%	34.9%
Overweight (25.0 ≤ BMI < 30.0)	20.6%	24.1%	27.8%	30.1%	29.7%	32.8%	36.0%
Obese I (30.0 ≤ BMI < 35.0)	5.3%	11.1%	13.3%	14.7%	14.2%	15.6%	17.6%
Obese II (35.0 ≤ BMI < 40.0)	2.5%	4.2%	4.2%	6.1%	7.8%	7.7%	7.6%
Severely obese (BMI ≥ 40.0)	1.4%	2.0%	2.2%	3.0%	3.1%	4.6%	3.3%

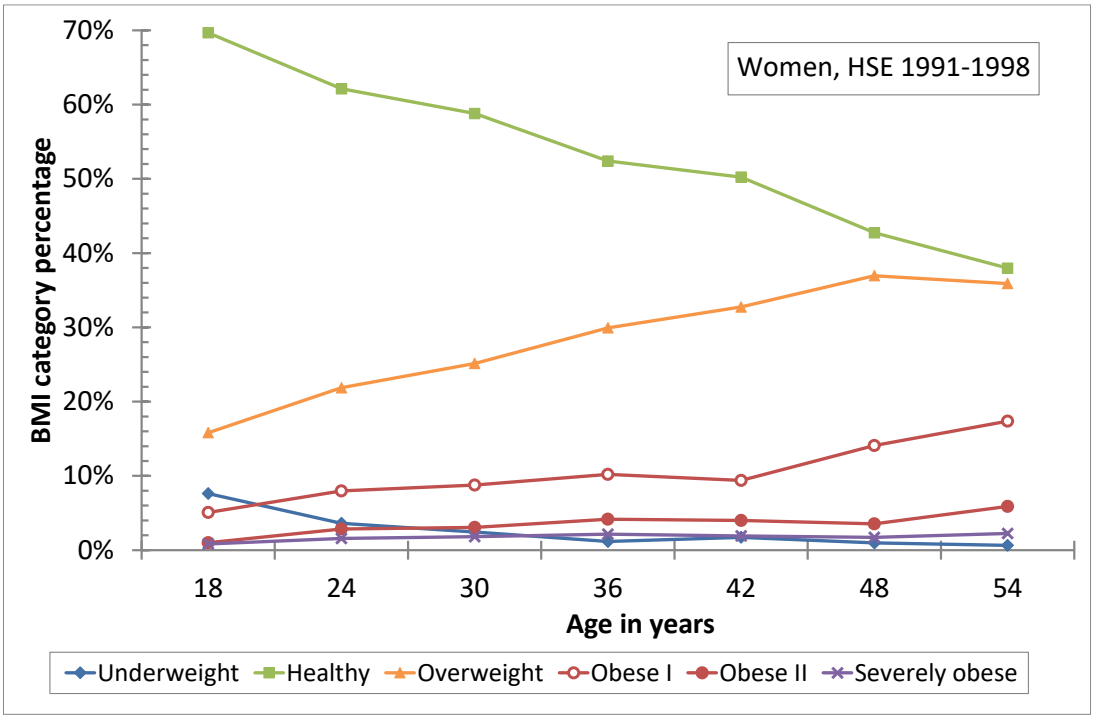

Figure 9.VI.5 Category percentages for selected ages from 18 to 54 for women for 1991-1998.

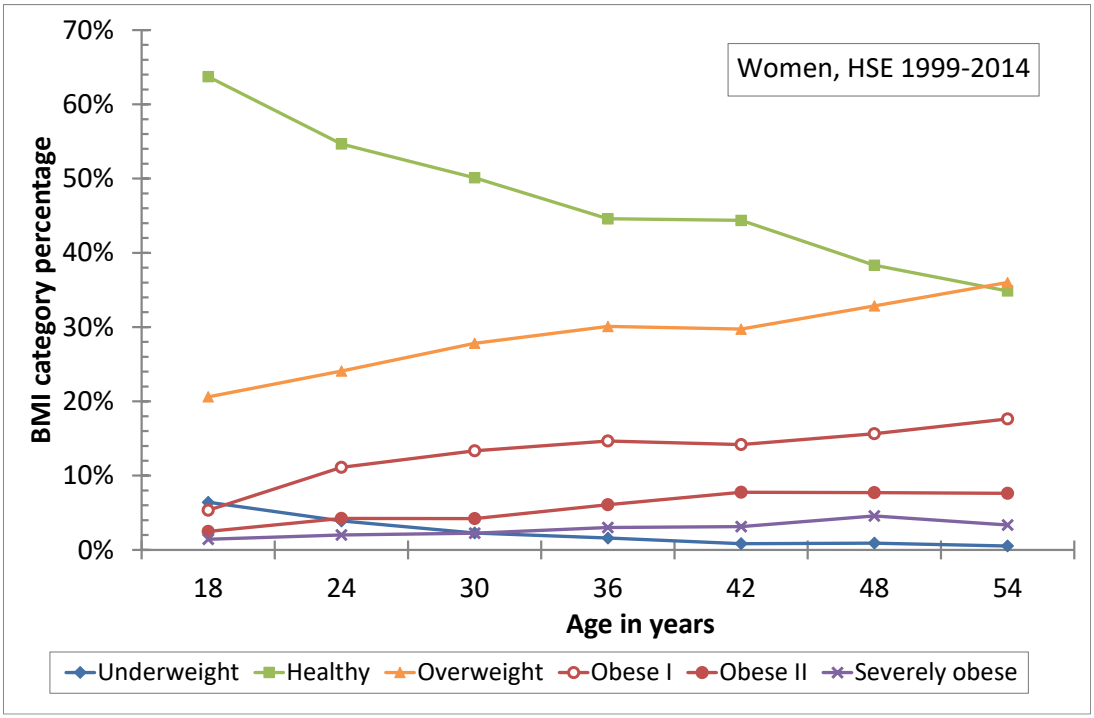

Figure 9.VI.6 Category percentages for selected ages from 18 to 54 for women for 1999-2014.

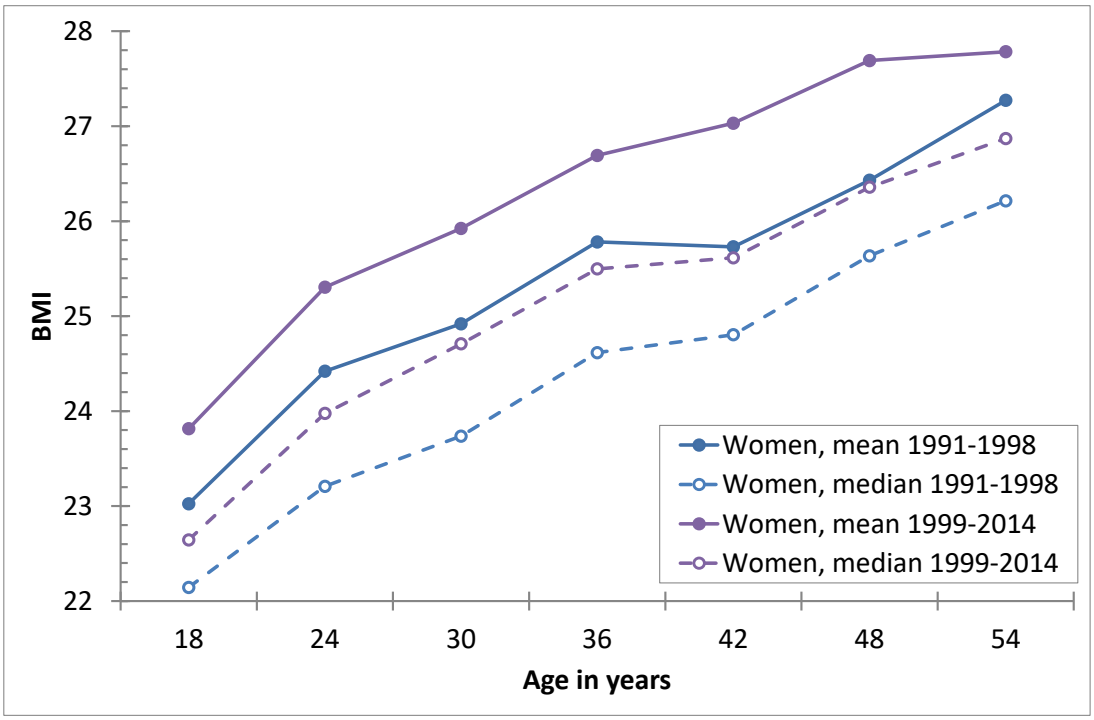

Figure 9.VI.7 Mean and median for selected ages from 18 to 54 for women.

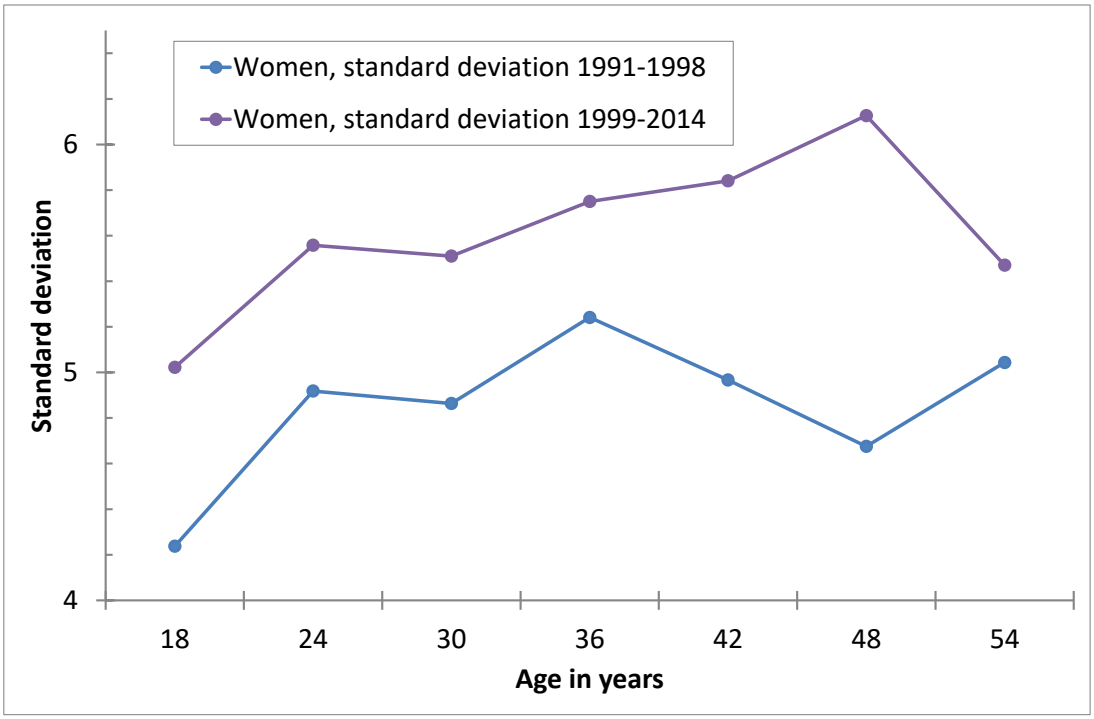

Figure 9.VI.8 Standard deviation for selected ages from 18 to 54 for women.

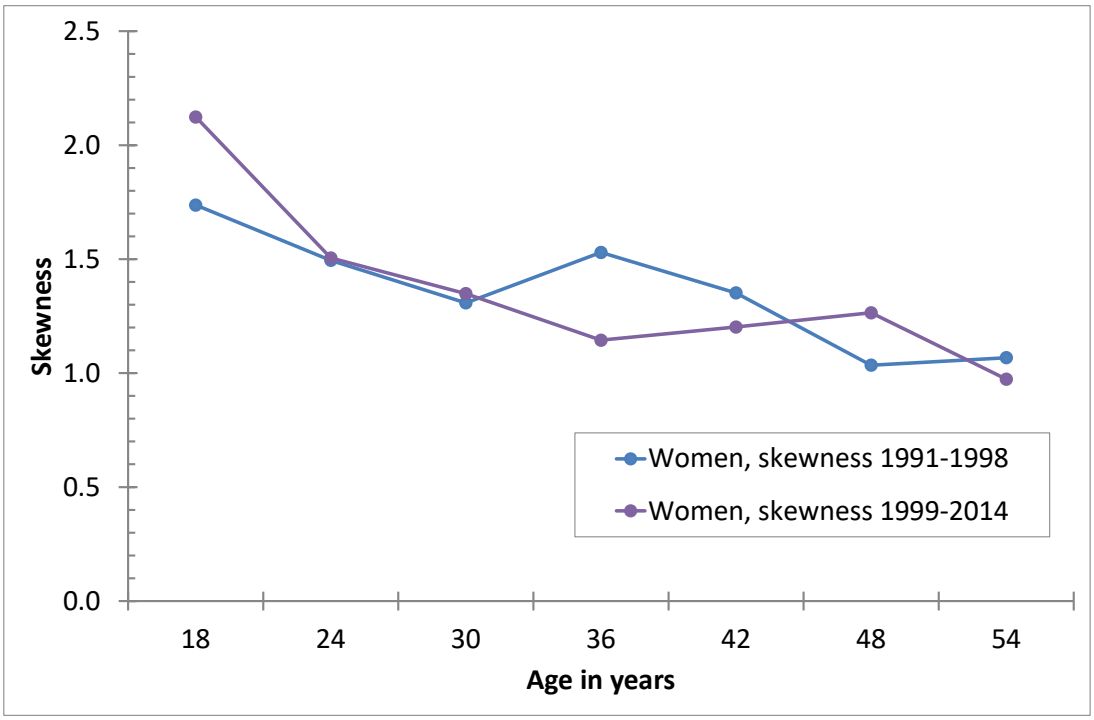

Figure 9.VI.9 Skewness for selected ages from 18 to 54 for women.

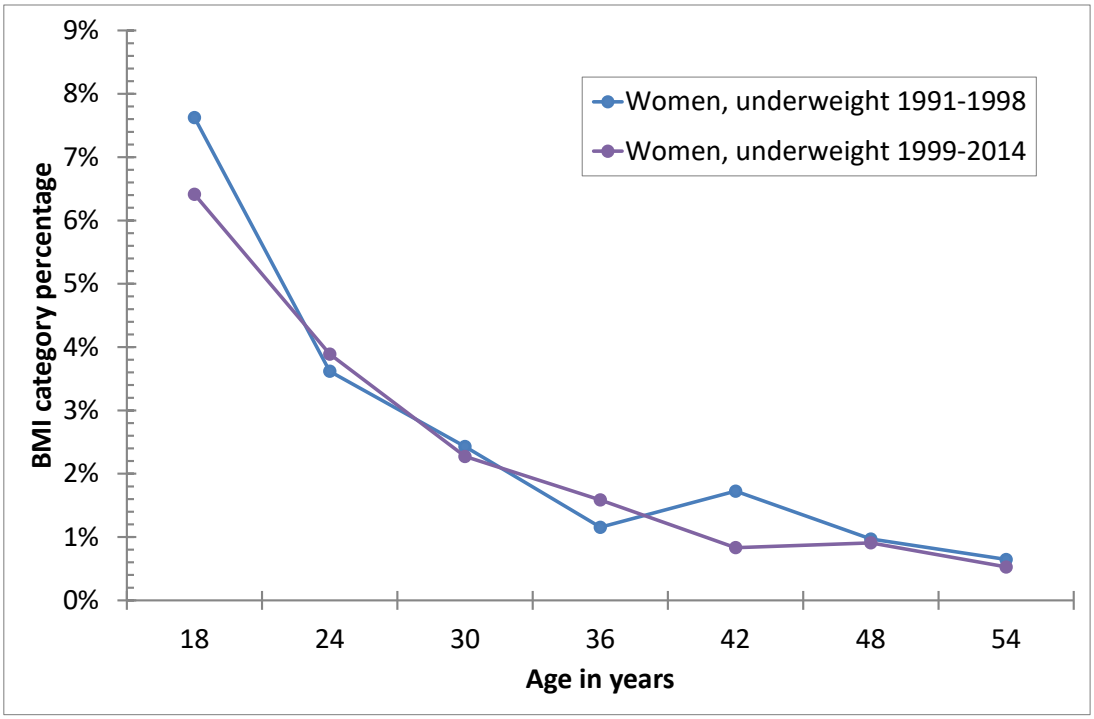

Figure 9.VI.10 Underweight percentages for selected ages from 18 to 54 for women.

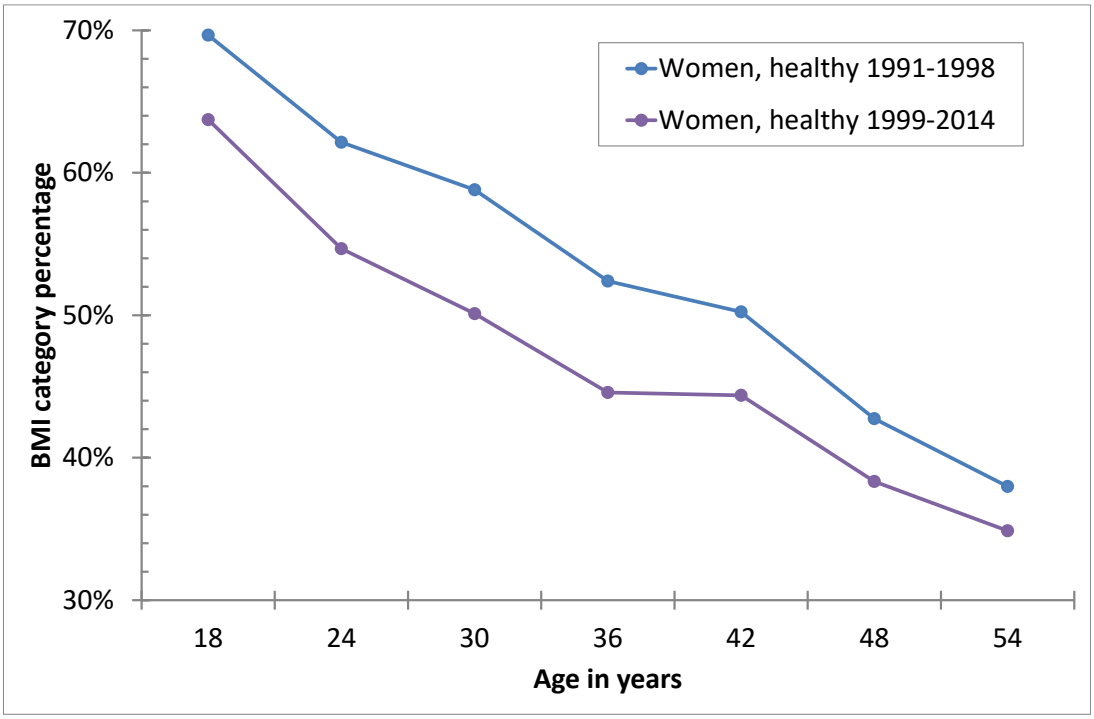

Figure 9.VI.11 Healthy percentages for selected ages from 18 to 54 for women.

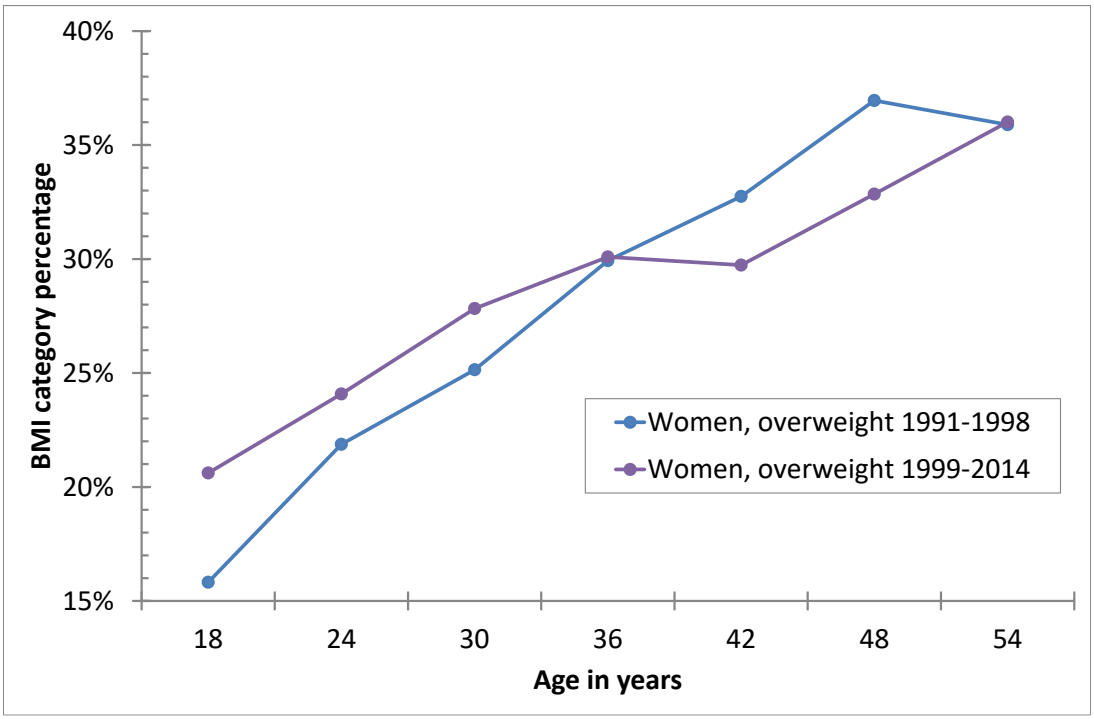

Figure 9.VI.12 Overweight percentages for selected ages from 18 to 54 for women.

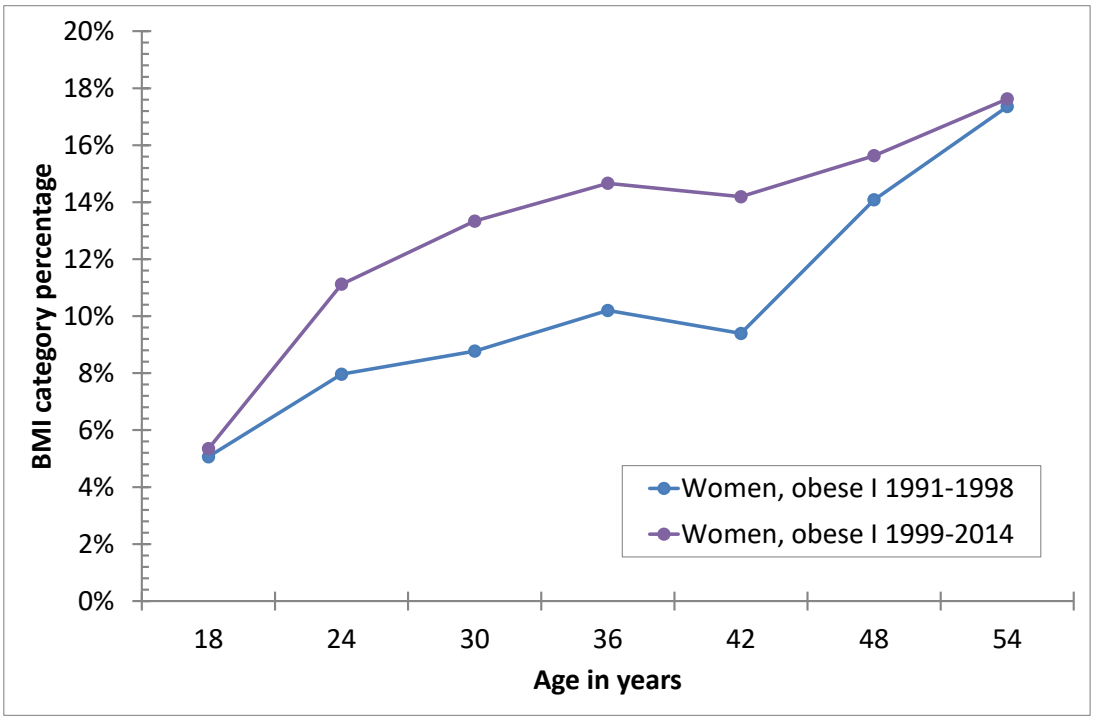

Figure 9.VI.13 Obese I percentages for selected ages from 18 to 54 for women.

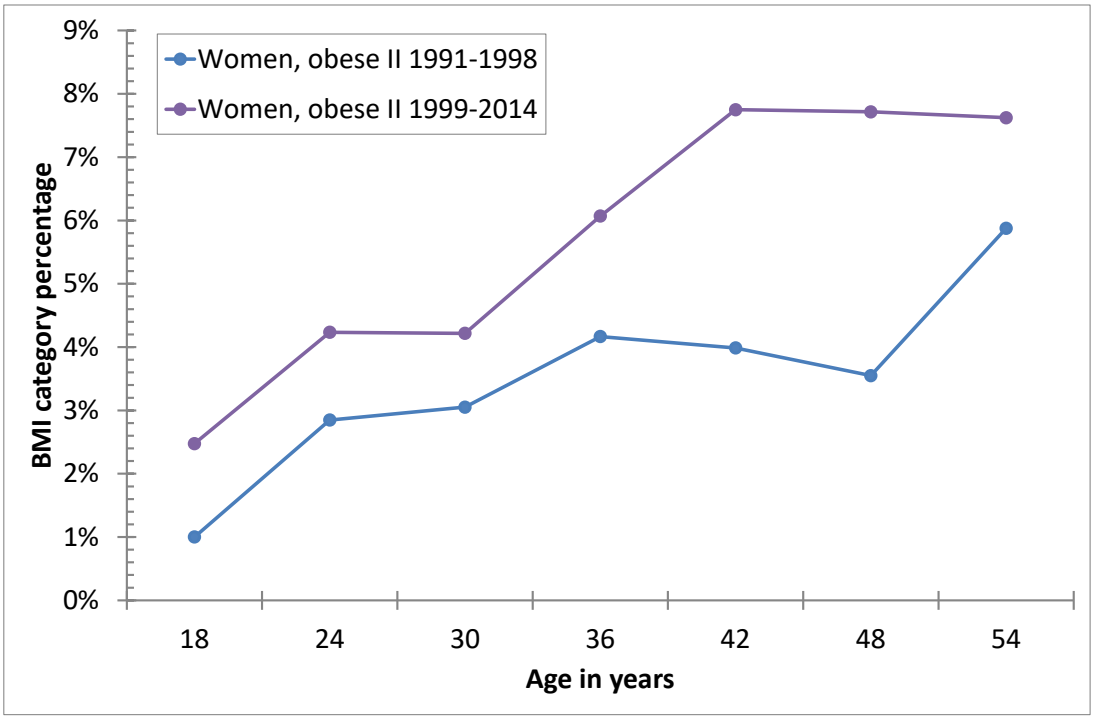

Figure 9.VI.14 Obese II percentages for selected ages from 18 to 54 for women.

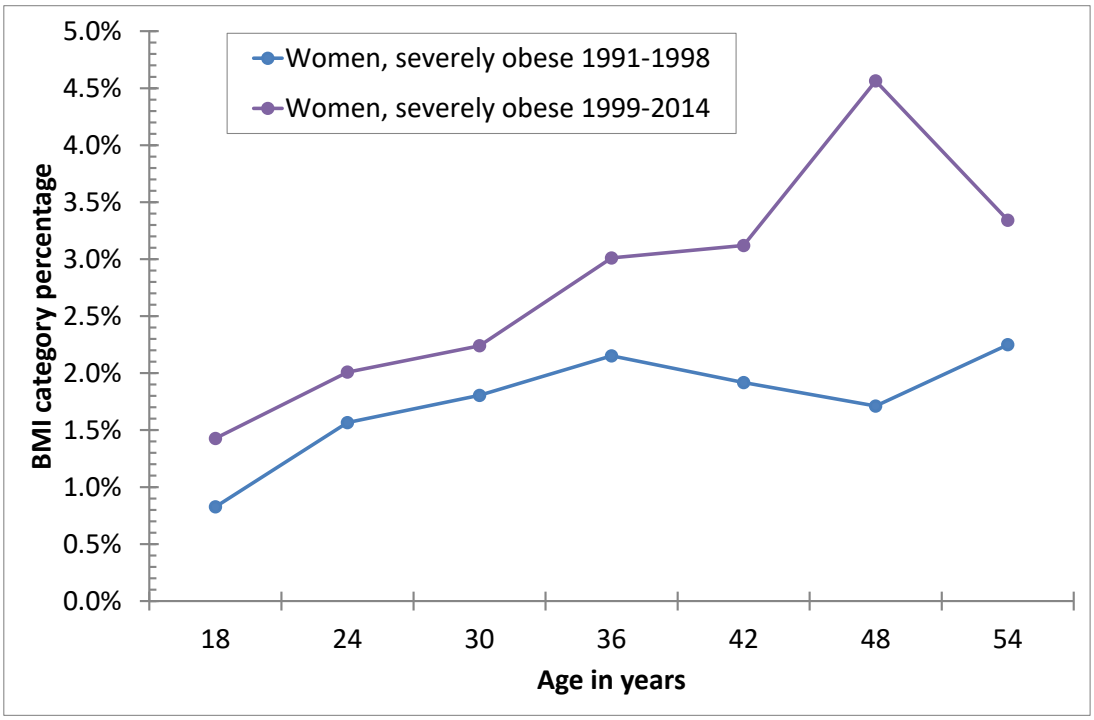

Figure 9.VI.15 Severely obese percentages for selected ages from 18 to 54 for women.

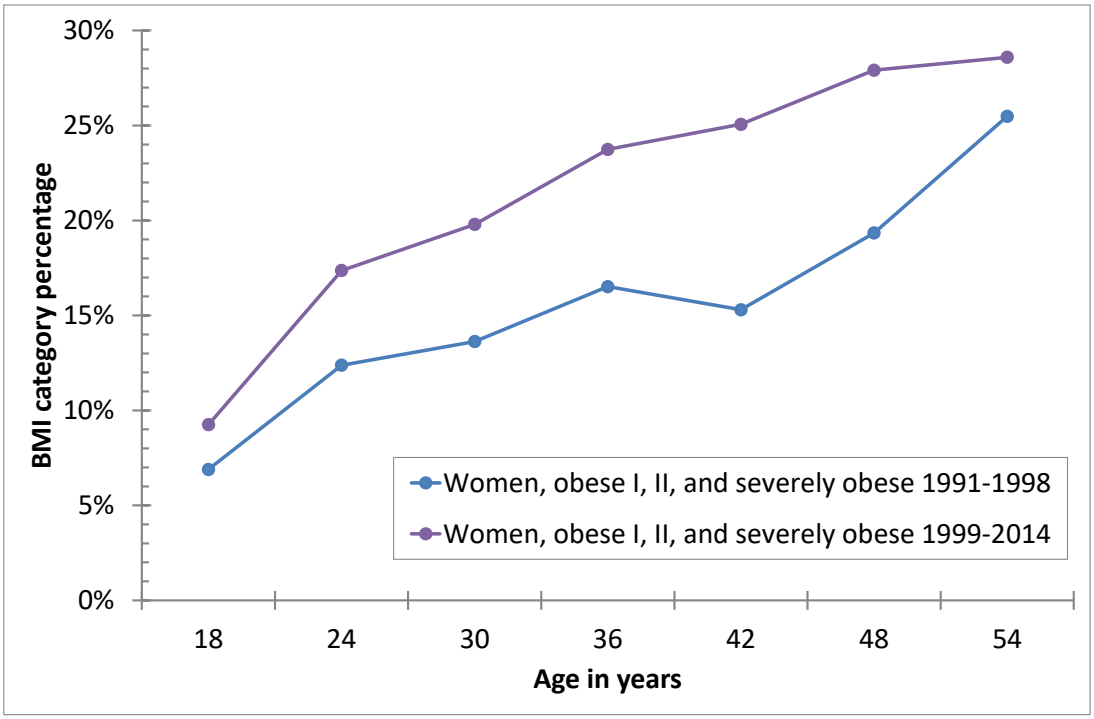

Figure 9.VI.16 All obese category percentages for selected ages from 18 to 54 for women.

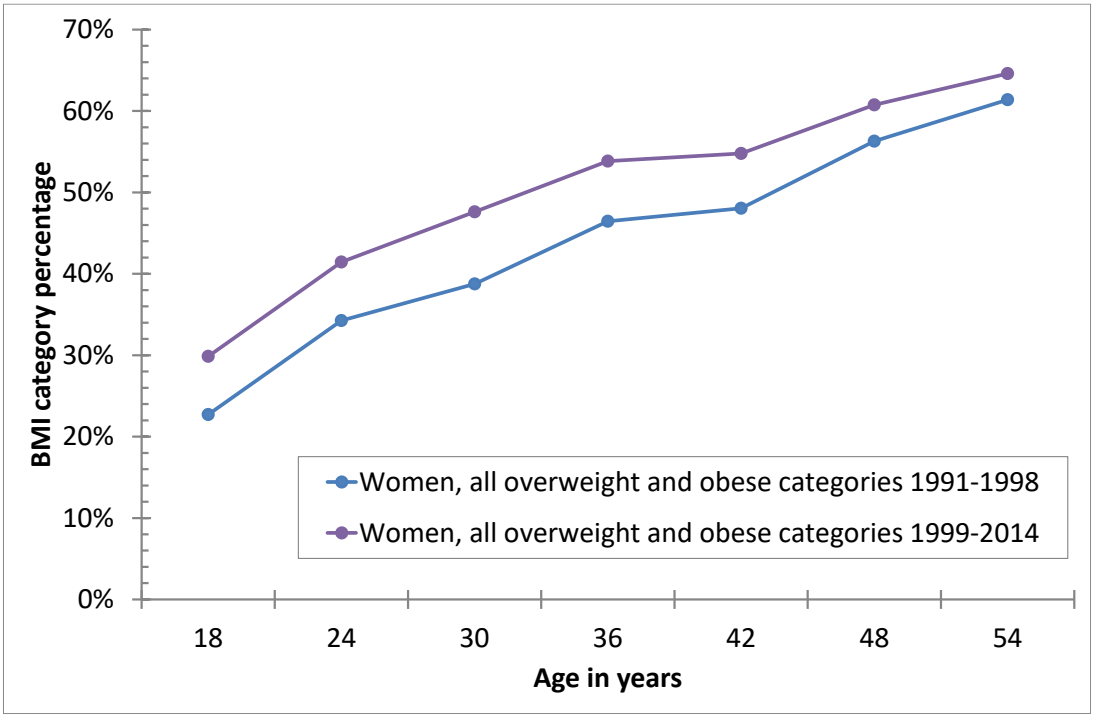

Figure 9.VI.17 All overweight & obese category percentages, selected ages 18 to 54 for women.

Changes with age: quartiles

Another way of looking at how BMI changes with age is to look at the changes in the quartile values with age. Figure 9.VI.18 shows the quartiles for each age along with the 5% and 95% percentiles.

The increases are shown in Figure 9.VI.19. There is some irregularity with the 95% values. The general patterns are for the higher values to increase more, particularly from 18 to 24 but also above 24. As also indicated from the percentiles in Figure 9.VI.4, this implies a changing in shape of the distribution with an element of a scaling as age increases.

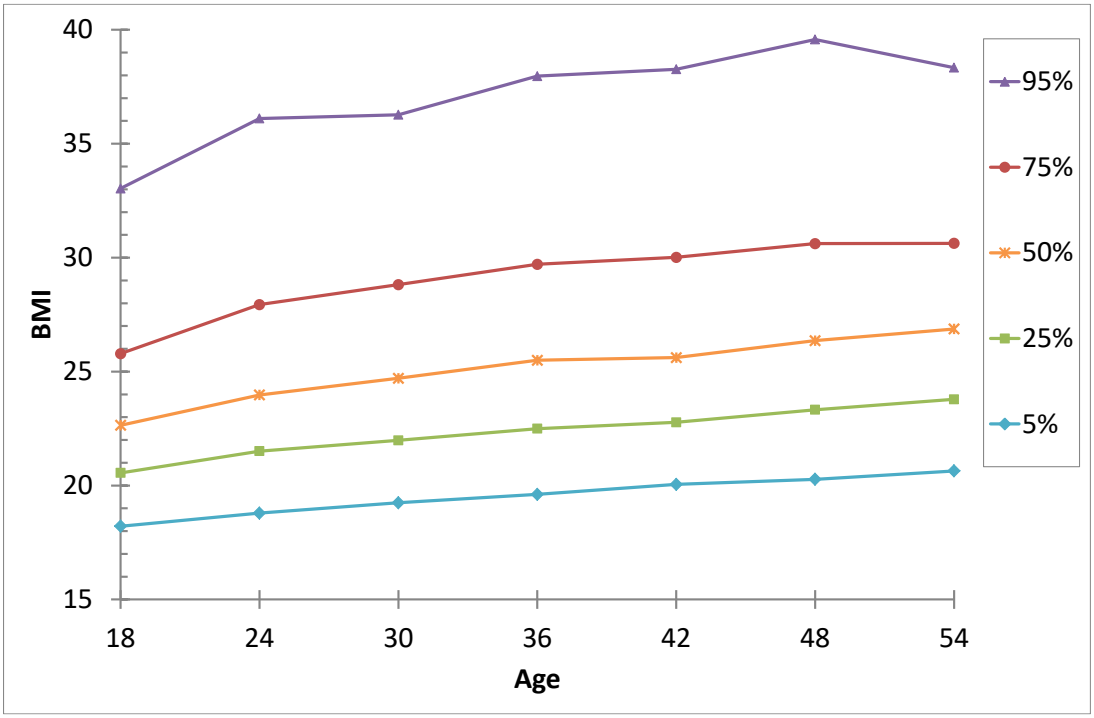

Figure 9.VI.18 Quartile and 5%, 95% values for women ages 18 to 54 for 1999-2014.

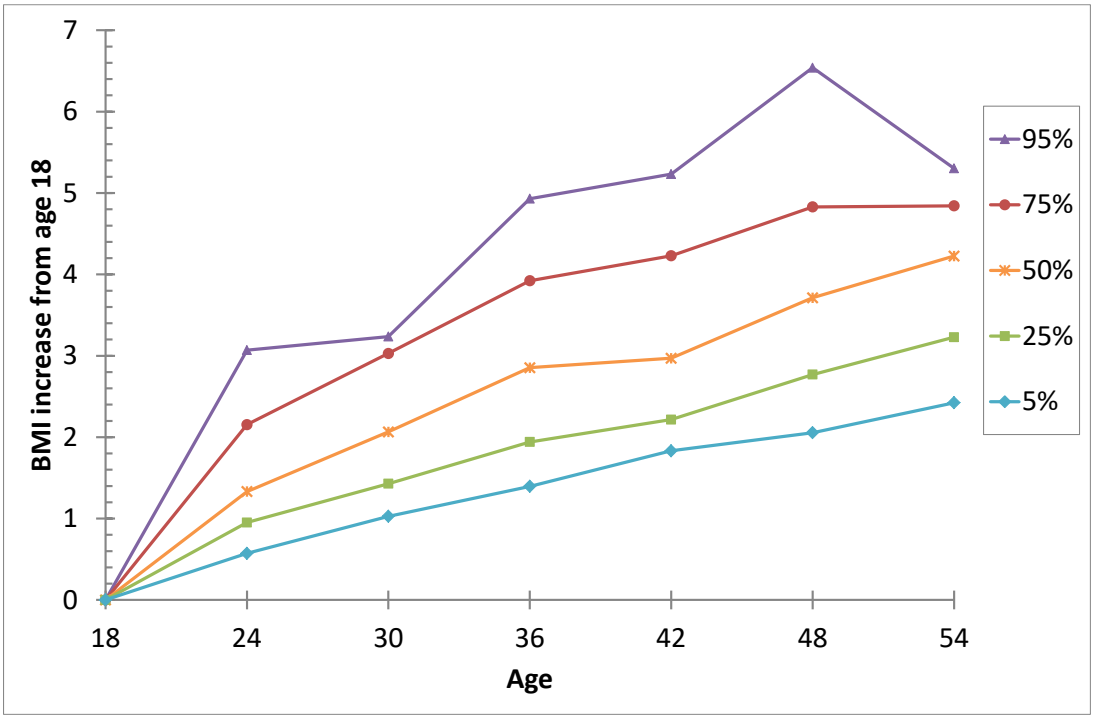

Figure 9.VI.19 Increases in quartile and 5%, 95% values for women ages 18 to 54 for 1999-2014.

Appendix 9.VII Analysis of each year of age from 18 to 24 for women

Charts of the population distributions

This appendix looks at the distributions for each year of age from 18 to 24, using the intervals of 1991-1998 and 1999-2014. Figures 9.VII.1 and 9.VII.2 show the smoothed population distributions. There is a trend of BMI increasing with each year of age, through the distributions shifting to the right with a lower peak and longer right tail.

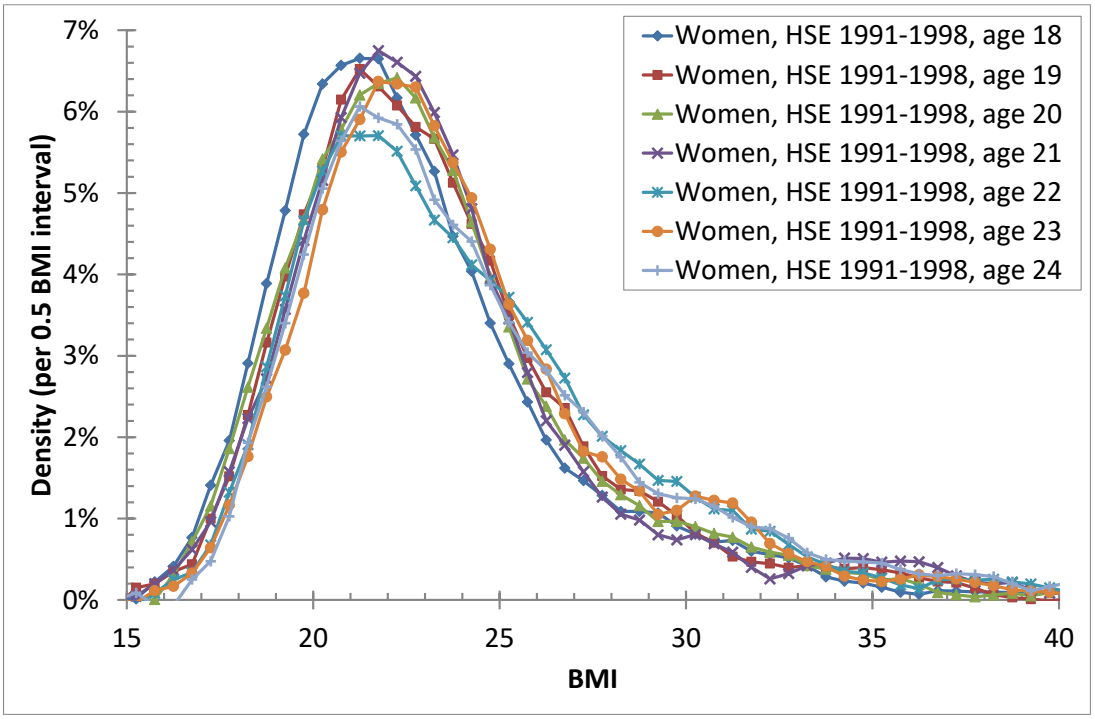

Figure 9.VII.1 Distributions for each age from 18 to 24 for women for 1991-1998.

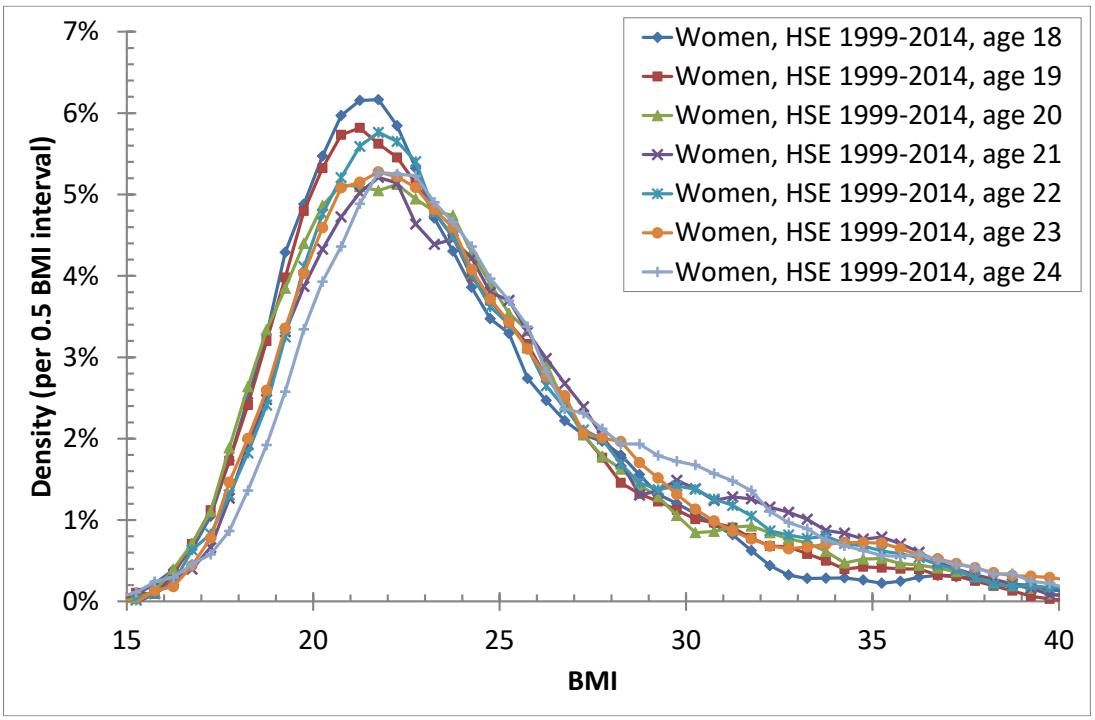

Figure 9.VII.2 Distributions for each age from 18 to 24 for women for 1999-2014.

Percentiles

The percentiles were calculated for the changes over time and with age. The charts here show the BMI increases for the 10% percentiles along with 5% and 95%. The increases with time are shown in Figure 9.VII.3 and with age in Figure 9.VII.4. The 1% and 99% values are not shown as it is considered that they are too affected by sampling irregularities due to the small sample sizes for single years.

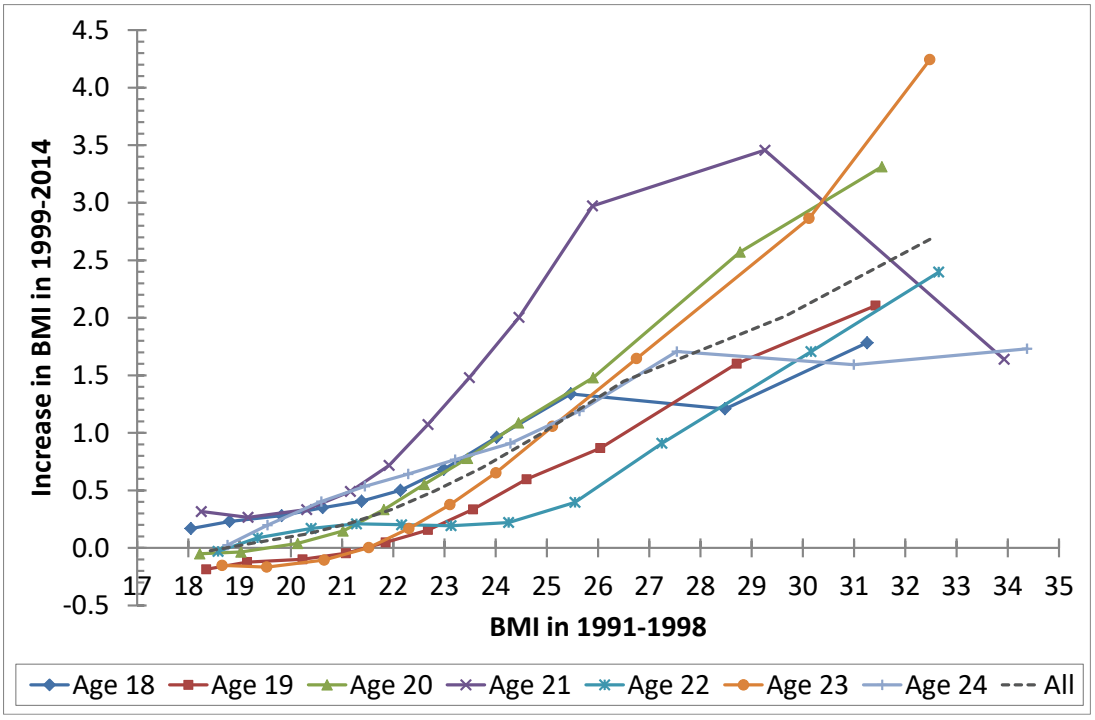

Figure 9.VII.3 Percentile changes over time for women for each age from 18 to 24.

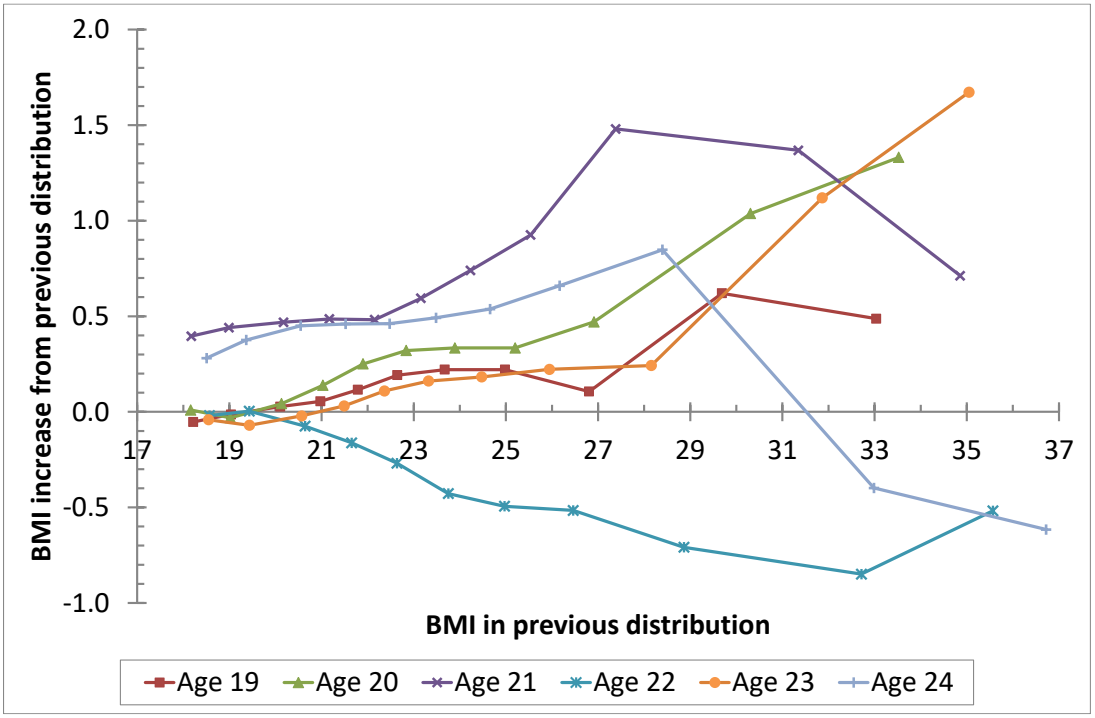

Figure 9.VII.4 Percentile changes with age for women for each age from 18 to 24 for 1999-2014.

The patterns for the percentiles are generally similar to those for the age groups in the main report in Sections 9.2-9.4 and for the single years in Appendix 9.VI. The changes with time in Figure 9.VII.3 are roughly an increasing straight line starting from the x-axis, characteristic of a linear scaling. The changes with age in Figure 9.VII.4 are more variable with less of a consistent pattern. The biggest changes for age 21 and 24 start above the x-axis and have a tendency of larger BMI values having greater increases. The smaller changes for the other ages are mostly a pattern of an increasing trend, although age 22 shows decreases. The interpretation is that this shows a mixture of shift and scaling types of transformation. The indication is that the variation due to the small sample sizes is quite large compared to the change from one year of age to the next, and hence the variety of patterns. Looking at larger changes across the 6 year age gaps in Appendix 9.VI therefore gives a clearer picture.

Descriptive statistics

The two tables below show the descriptive statistics for the single years of age from 18 to 24. A chart of the mean and median values is given as Figure 9.12 in Section 9.5.2 of the main report.

Table 9.VII.1 Descriptive statistics for women for ages 18 to 24 for 1991-1998.

Age	18	19	20	21	22	23	24
Sample size of actual data	610	588	575	576	699	732	785
Mean	23.02	23.43	23.37	23.63	24.10	24.05	24.42
Median	22.14	22.68	22.60	22.68	23.13	23.11	23.21
Modal interval mid-point	21.25	21.25	22.25	21.75	21.75	21.75	21.25
Standard deviation	4.24	4.05	4.12	4.61	4.60	4.47	4.92
Skewness	1.74	1.33	1.44	1.72	1.39	1.52	1.49
Underweight (BMI < 18.5)	7.6%	5.7%	6.4%	6.1%	4.5%	4.2%	3.6%
Healthy (18.5 ≤ BMI < 25.0)	69.7%	67.6%	68.0%	68.3%	61.4%	65.0%	62.1%
Overweight (25.0 ≤ BMI < 30.0)	15.8%	19.7%	18.0%	16.8%	23.6%	20.5%	21.9%
Obese I (30.0 ≤ BMI < 35.0)	5.1%	5.0%	5.7%	5.0%	7.5%	7.3%	8.0%
Obese II (35.0 ≤ BMI < 40.0)	1.0%	1.7%	1.2%	2.9%	2.2%	2.1%	2.8%
Severely obese (BMI ≥ 40.0)	0.8%	0.3%	0.6%	1.0%	0.7%	0.9%	1.6%

Table 9.VII.2 Descriptive statistics for women for ages 18 to 24 for 1999-2014.

Age	18	19	20	21	22	23	24
Sample size of actual data	855	748	772	794	792	848	856
Mean	23.81	23.90	24.25	25.02	24.62	24.88	25.30
Median	22.64	22.84	23.16	23.75	23.32	23.48	23.98
Modal interval mid-point	21.75	21.25	22.25	21.75	21.75	21.75	21.75
Standard deviation	5.02	4.88	5.13	5.50	5.16	5.53	5.56
Skewness	2.12	1.61	1.41	1.39	1.38	1.33	1.51
Underweight (BMI < 18.5)	6.4%	6.6%	6.7%	4.7%	4.8%	5.0%	3.9%
Healthy (18.5 ≤ BMI < 25.0)	63.7%	62.0%	59.5%	55.6%	59.1%	57.6%	54.7%
Overweight (25.0 ≤ BMI < 30.0)	20.6%	20.8%	21.4%	23.0%	21.6%	22.4%	24.1%
Obese I (30.0 ≤ BMI < 35.0)	5.3%	6.9%	7.5%	10.9%	9.5%	7.9%	11.1%
Obese II (35.0 ≤ BMI < 40.0)	2.5%	2.5%	3.2%	4.0%	3.6%	4.6%	4.2%
Severely obese (BMI ≥ 40.0)	1.4%	1.2%	1.7%	1.8%	1.4%	2.6%	2.0%

The BMI category percentages are plotted in Figures 9.VII.5 and 9.VII.6. From these charts and Tables 9.VII.1 and 9.VII.2, the healthy and underweight percentages tend to decrease with age whilst the overweight and each of the obese percentages tend to increase.

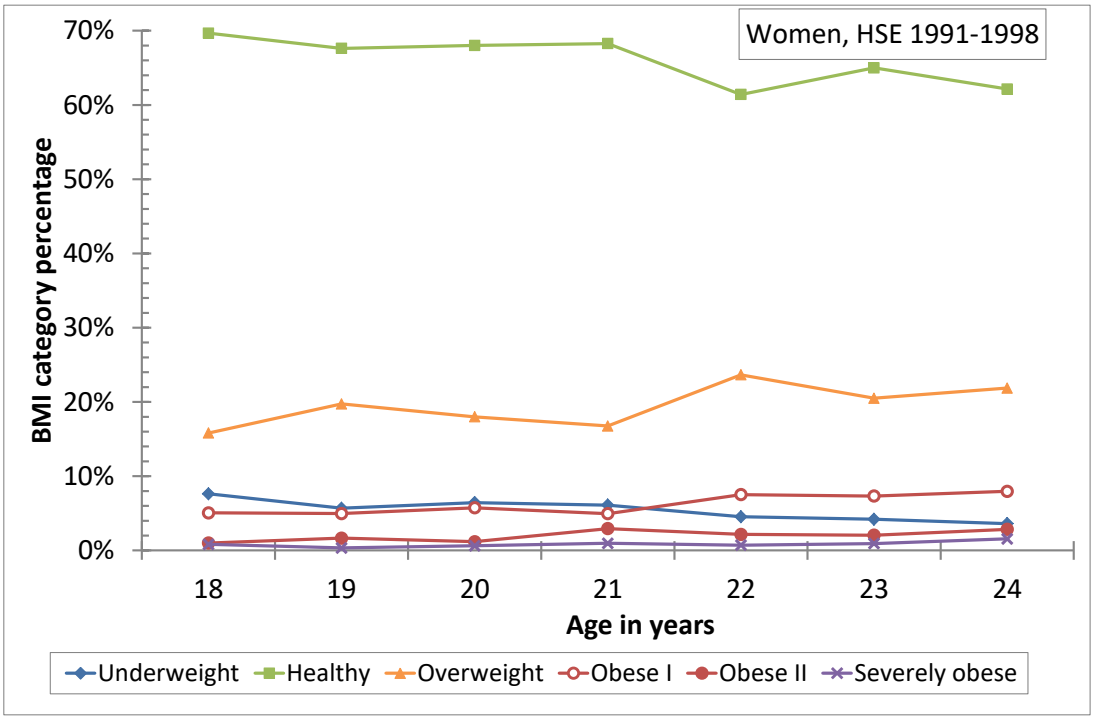

Figure 9.VII.5 Category percentages for each age from 18 to 24 for women for 1991-1998.

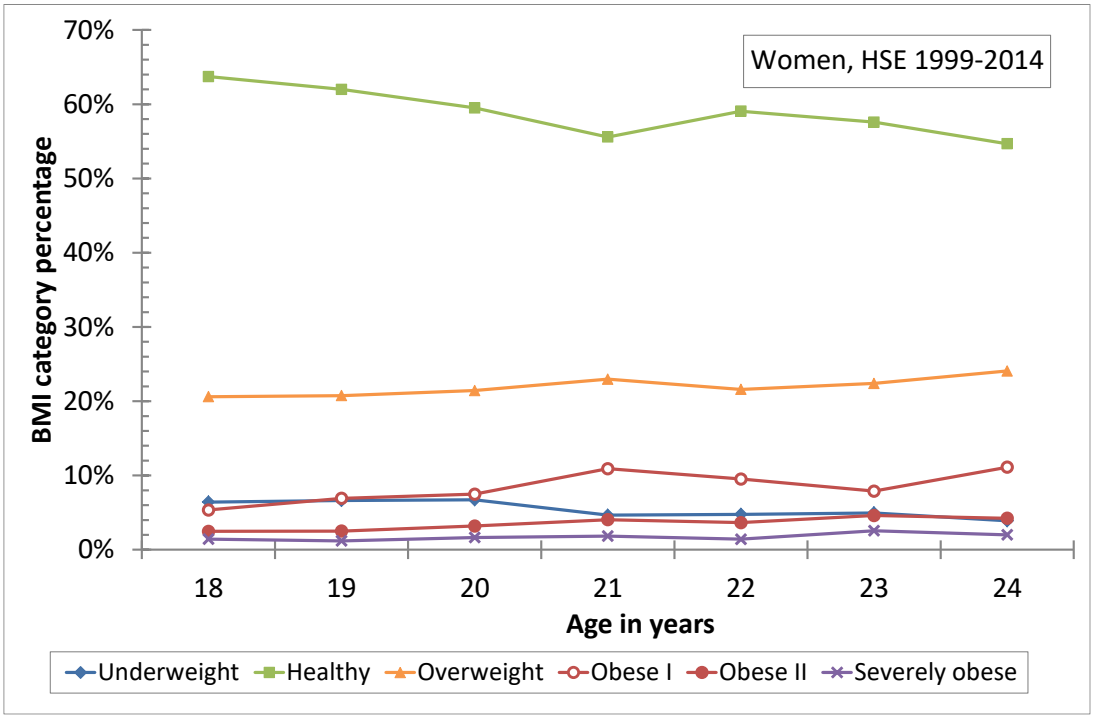

Figure 9.VII.6 Category percentages for each age from 18 to 24 for women for 1999-2014.

The standard deviation and skewness values can be considered as part of examining any changes in shapes of the distributions with age and over time. The chart in Figures 9.VII.7 shows the standard deviation being considerably higher for each age in 1999-2014 than 1991-1998 (reflecting the lower peak and broader shape of the distributions in Figure 9.VII.2 compared to Figure 9.VII.1). The trend is for the standard deviation to get slightly greater with increasing age. The skewness values in Figure 9.VII.8 are fairly similar for each age and for the two time intervals, although age 18 in 1999-2014 is the highest value.

Figure 9.VII.7 Standard deviation for each age from 18 to 24 for women.

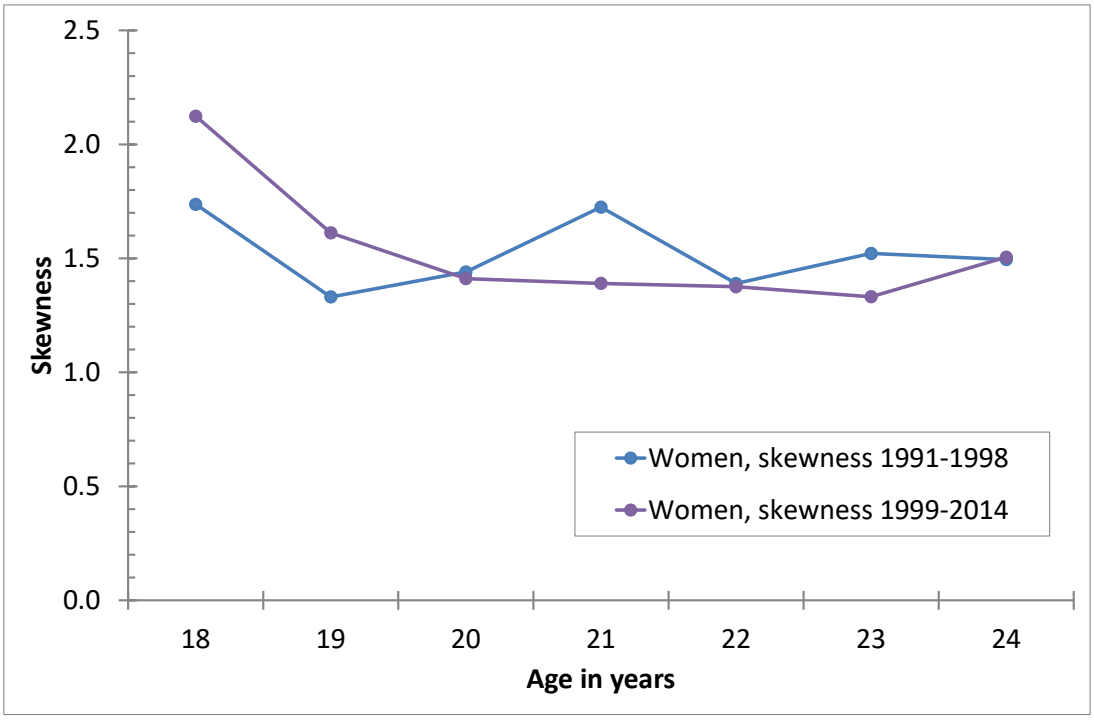

Figure 9.VII.8 Skewness value for each age from 18 to 24 for women.

Changes over time for ages 18 and 24

These two charts look at how the distributions have changed between the two time intervals for age 18 and age 24. The main changes with time in both cases are for the peak to become lower with a longer right tail.

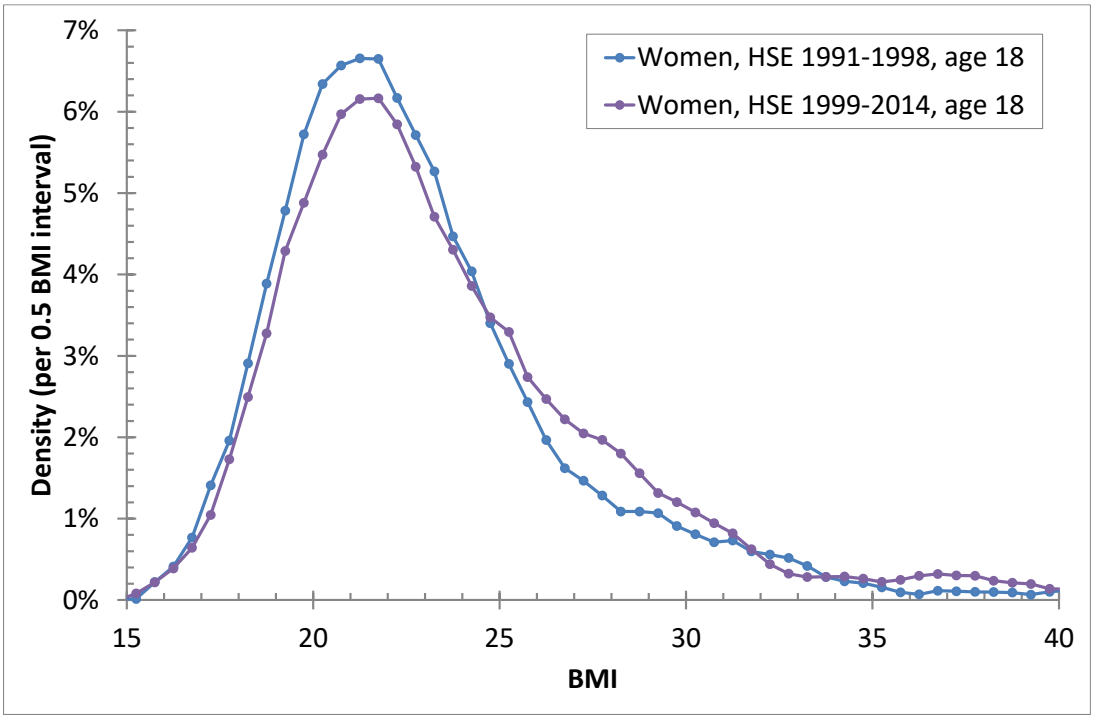

Figure 9.VII.9 Comparison of distributions for age 18 for women.

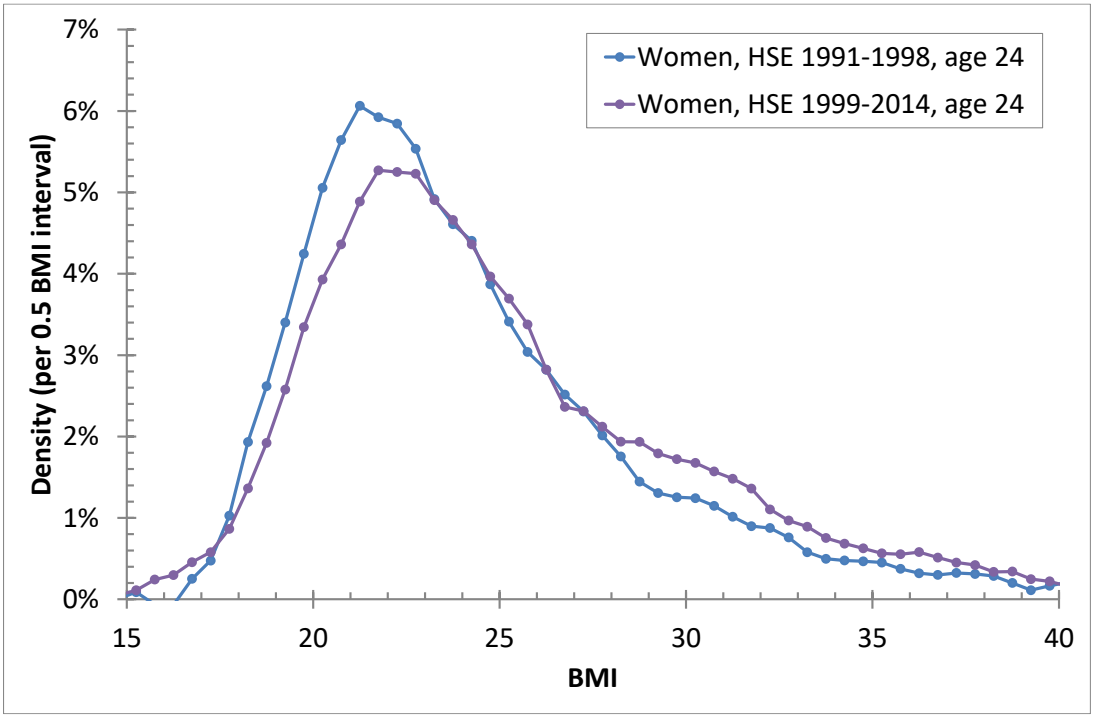

Figure 9.VII.10 Comparison of distributions for age 24 for women.

Appendix 10.I Comparison of category statistics for men and women

These results compare the BMI distributions for men and women for individual years of age with gaps of 6 years from age 18 to 54. The HSE time interval used is 1999-2014. Tables 10.I.1 and 10.I.2 are repeats of Table 8.VI.2 and Table 9.VI.2, but are shown here together for easy comparison. The charts that follow plot the statistics comparing the values for men and women.

As discussed in Chapter 10 of the main report, the distributions for men and women are very similar at age 18 but then differ considerably as age increases, as shown in Figures 10.1-10.9 in Chapter 10. The differences in the statistics at higher ages given here include the distributions for women having a smaller mean value and a much higher percentage in the healthy category, but also higher percentages in the obese II and severely obese categories.

Table 10.I.1 Descriptive statistics for men for selected ages from 18 to 54 for 1999-2014.

Age	18	24	30	36	42	48	54
Sample size of actual data	769	712	909	1041	1113	1005	1012
Mean	23.24	25.14	26.36	27.26	27.64	28.20	28.21
Median	22.35	24.48	25.78	26.67	27.15	27.58	27.66
Modal interval mid-point	21.25	23.25	25.25	25.75	26.75	26.25	27.25
Standard deviation	4.26	4.51	4.46	4.36	4.34	4.52	4.48
Skewness	1.47	1.15	1.09	0.96	0.90	0.88	1.09
Underweight (BMI < 18.5)	7.1%	2.5%	1.1%	0.3%	0.4%	0.4%	0.1%
Healthy (18.5 ≤ BMI < 25.0)	67.4%	52.4%	40.7%	31.3%	26.9%	23.2%	23.4%
Overweight (25.0 ≤ BMI < 30.0)	18.1%	33.1%	40.6%	45.9%	48.2%	46.9%	46.7%
Obese I (30.0 ≤ BMI < 35.0)	4.9%	8.0%	13.7%	17.2%	18.3%	21.5%	23.3%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	3.0%	2.4%	4.0%	5.4%	6.5%	4.8%
Severely obese (BMI ≥ 40.0)	0.6%	0.9%	1.5%	1.3%	0.8%	1.6%	1.8%

Table 10.I.2 Descriptive statistics for women for selected ages from 18 to 54 for 1999-2014.

Age	18	24	30	36	42	48	54
Sample size of actual data	855	856	1063	1297	1396	1231	1184
Mean	23.81	25.30	25.92	26.69	27.03	27.69	27.78
Median	22.64	23.98	24.71	25.50	25.61	26.36	26.87
Modal interval mid-point	21.75	21.75	22.75	22.75	23.25	24.25	24.25
Standard deviation	5.02	5.56	5.51	5.75	5.84	6.13	5.47
Skewness	2.12	1.51	1.35	1.14	1.20	1.26	0.97
Underweight (BMI < 18.5)	6.4%	3.9%	2.3%	1.6%	0.8%	0.9%	0.5%
Healthy (18.5 ≤ BMI < 25.0)	63.7%	54.7%	50.1%	44.6%	44.4%	38.3%	34.9%
Overweight (25.0 ≤ BMI < 30.0)	20.6%	24.1%	27.8%	30.1%	29.7%	32.8%	36.0%
Obese I (30.0 ≤ BMI < 35.0)	5.3%	11.1%	13.3%	14.7%	14.2%	15.6%	17.6%
Obese II (35.0 ≤ BMI < 40.0)	2.5%	4.2%	4.2%	6.1%	7.8%	7.7%	7.6%
Severely obese (BMI ≥ 40.0)	1.4%	2.0%	2.2%	3.0%	3.1%	4.6%	3.3%

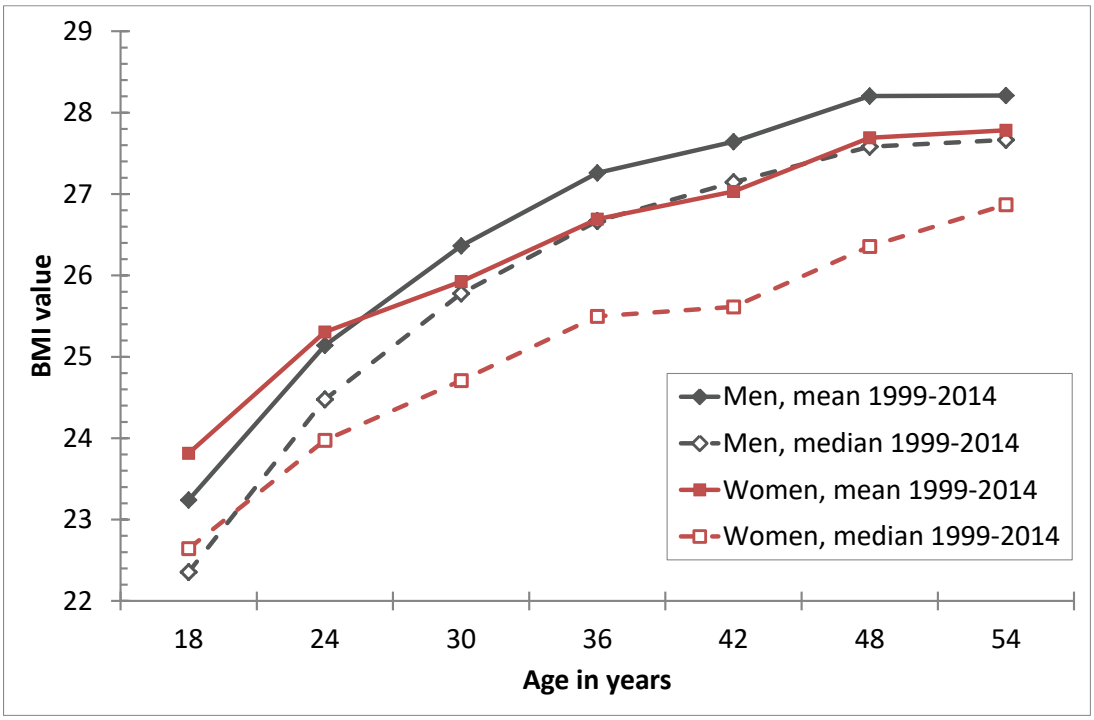

Figure 10.I.1 Mean and median for selected ages from 18 to 54 for men and women.

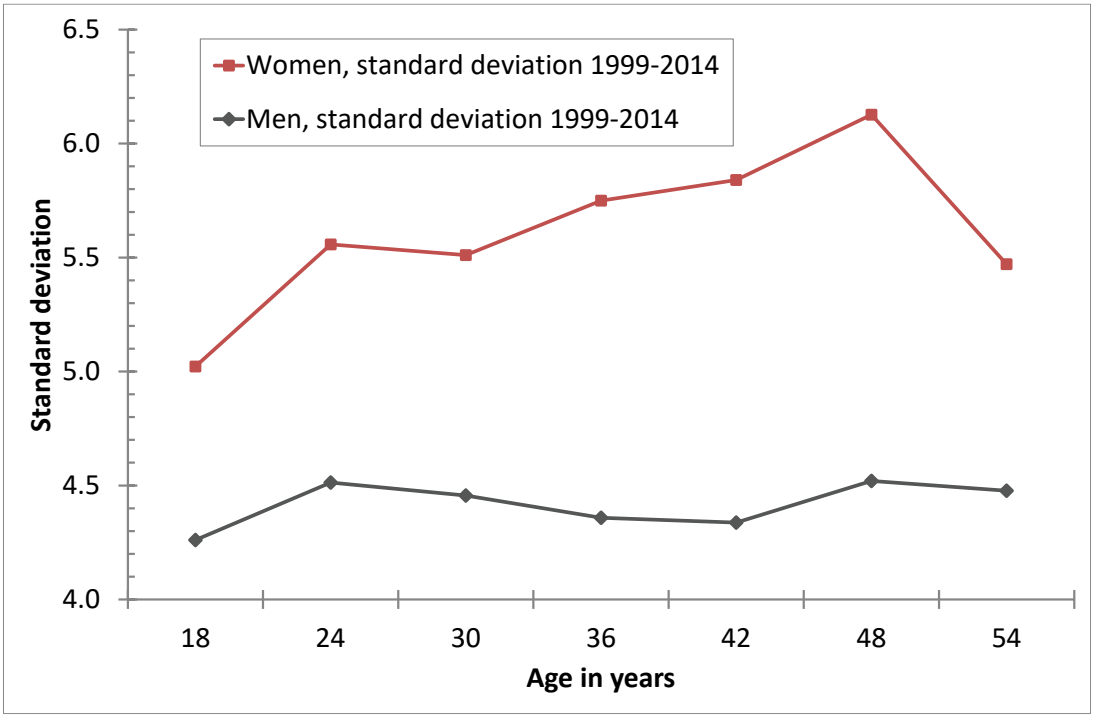

Figure 10.I.2 Standard deviation for selected ages from 18 to 54 for men and women.

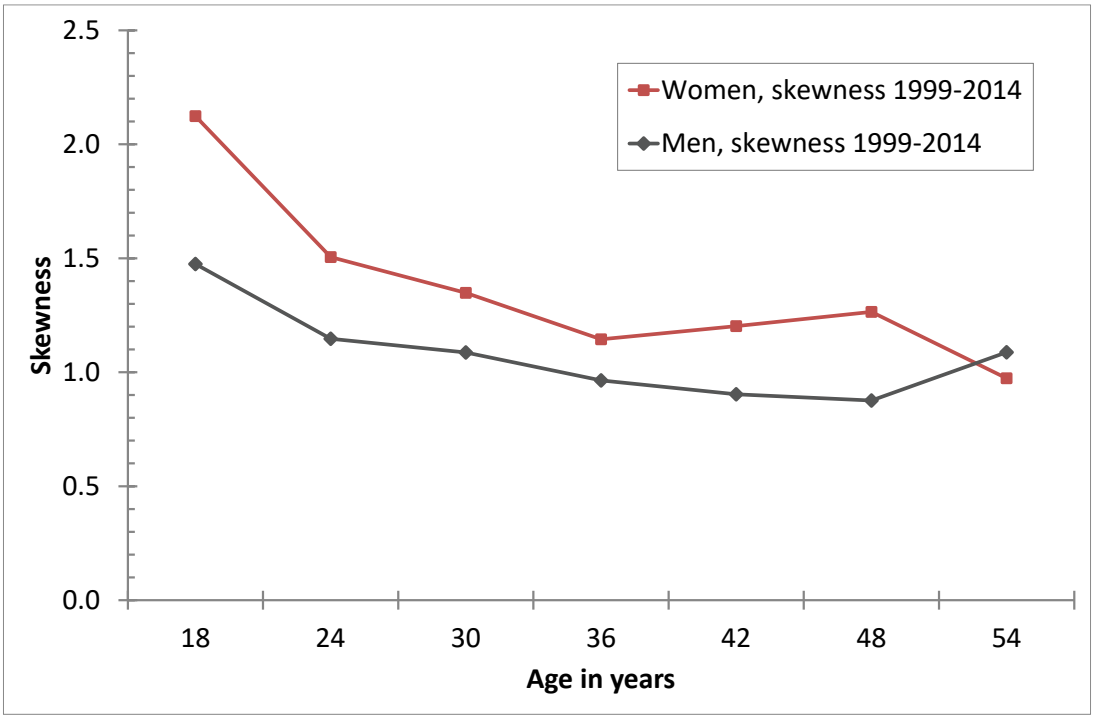

Figure 10.I.3 Skewness for selected ages from 18 to 54 for men and women.

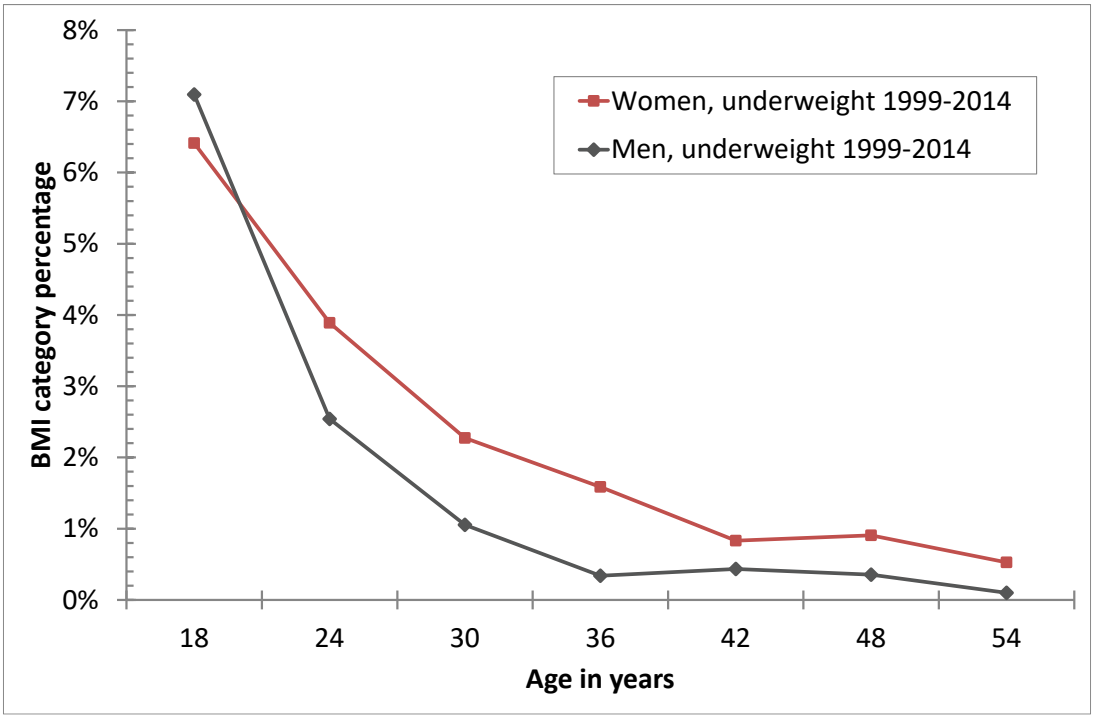

Figure 10.I.4 Underweight percentages for selected ages 18 to 54 for men and women.

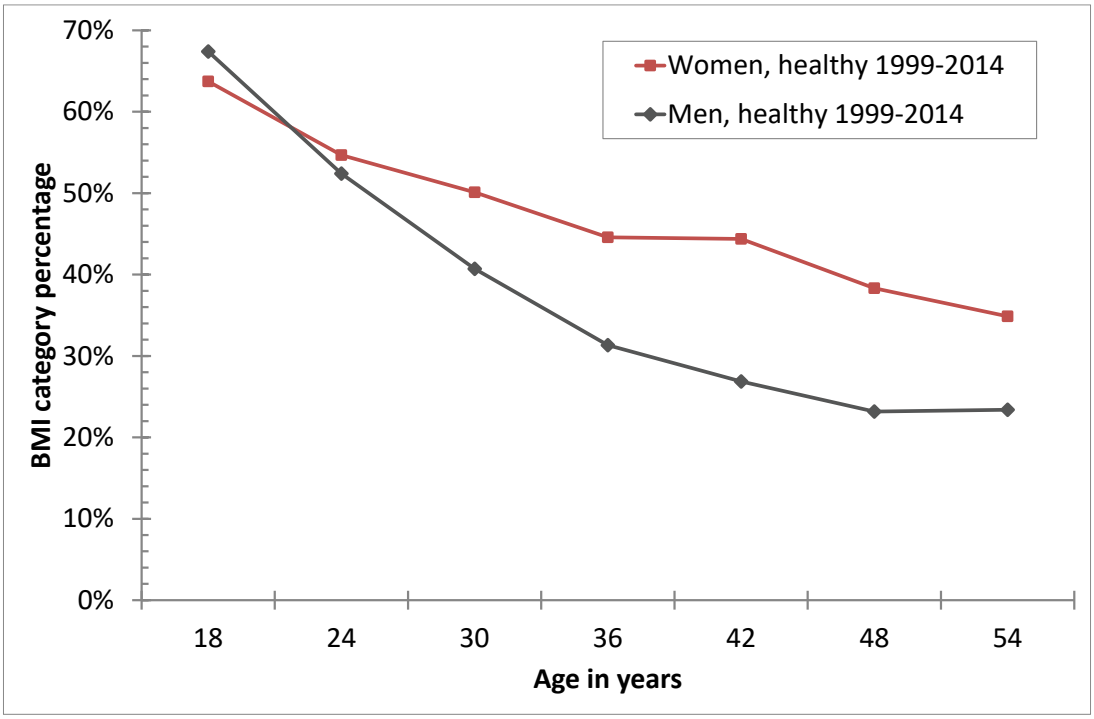

Figure 10.I.5 Healthy percentages for selected ages 18 to 54 for men and women.

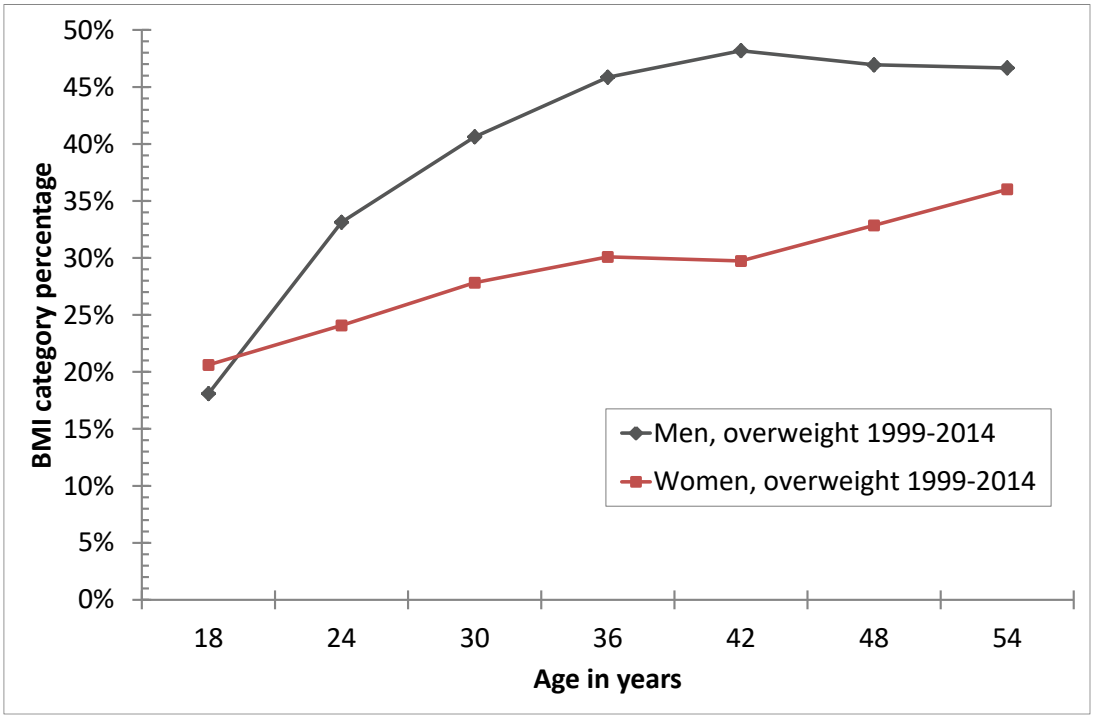

Figure 10.I.6 Overweight percentages for selected ages 18 to 54 for men and women.

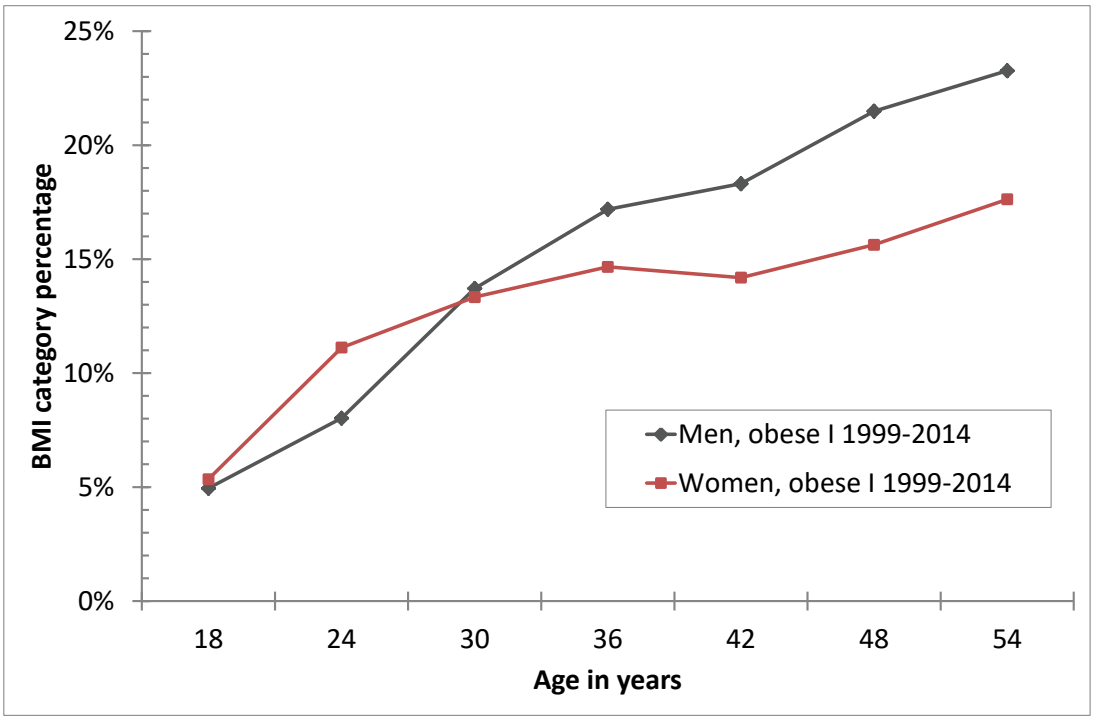

Figure 10.I.7 Obese I percentages for selected ages 18 to 54 for men and women.

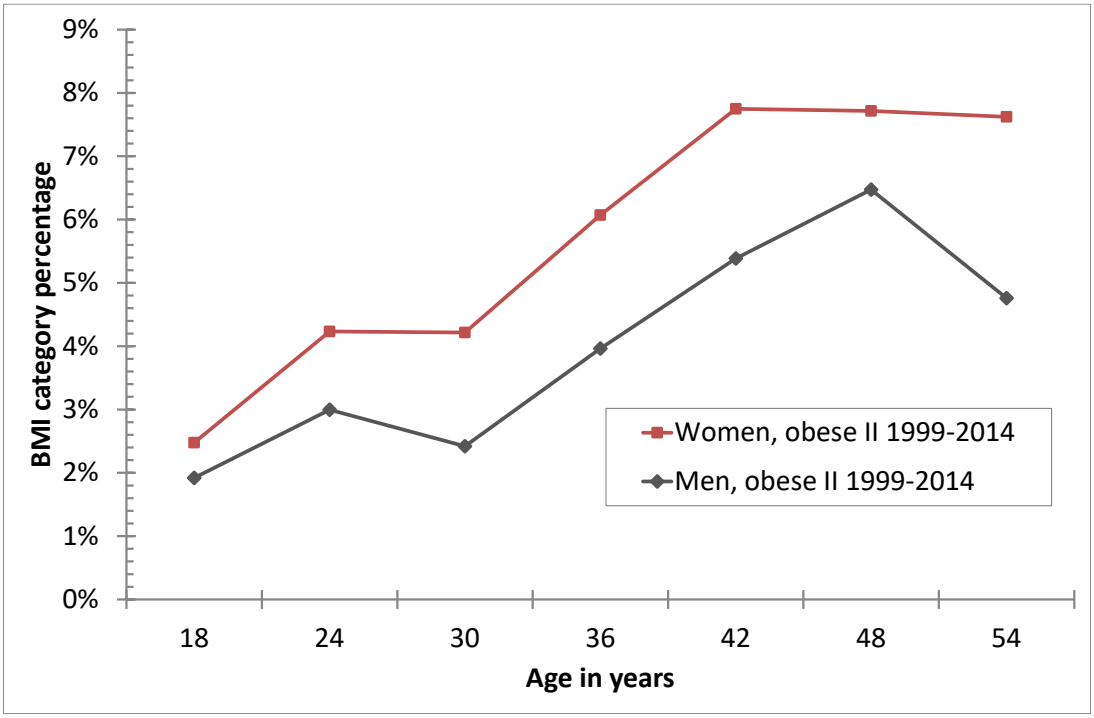

Figure 10.I.8 Obese II percentages for selected ages 18 to 54 for men and women.

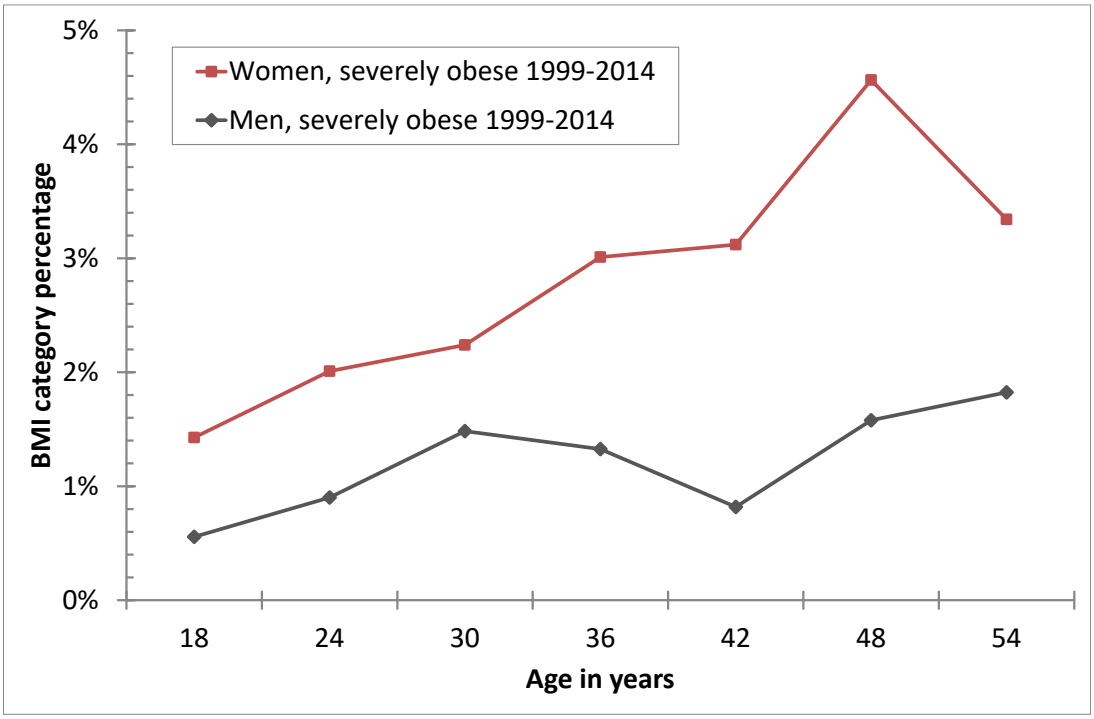

Figure 10.I.9 Severely obese percentages for selected ages 18 to 54 for men and women.

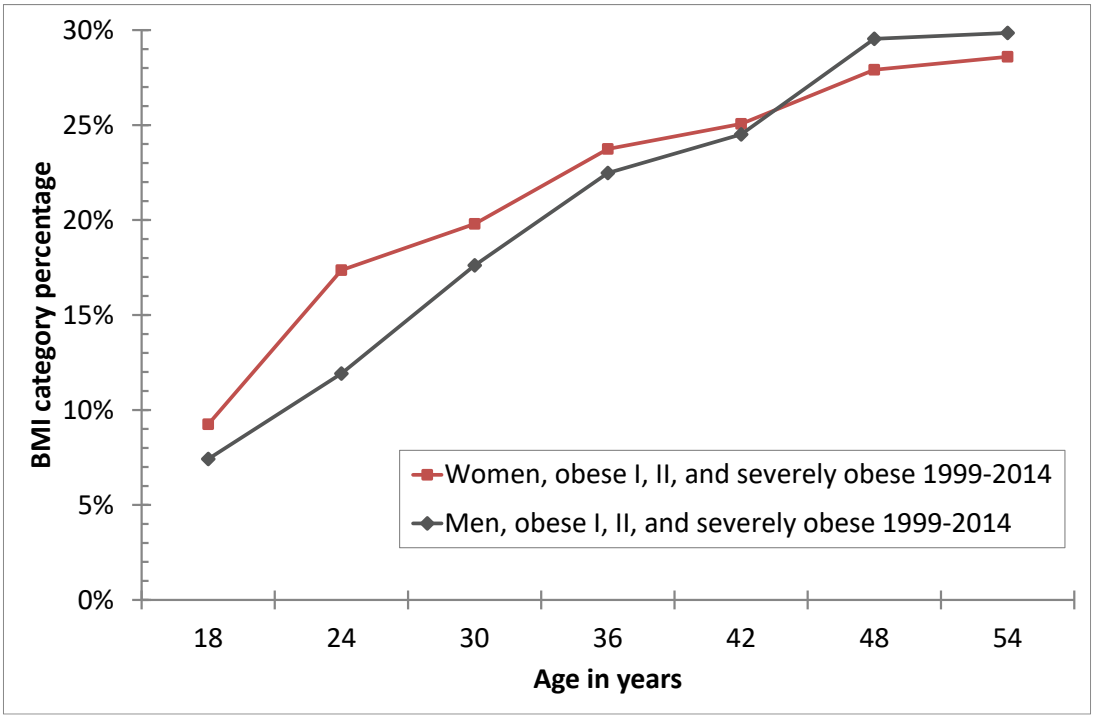

Figure 10.I.10 All obese percentages for selected ages 18 to 54 for men and women.

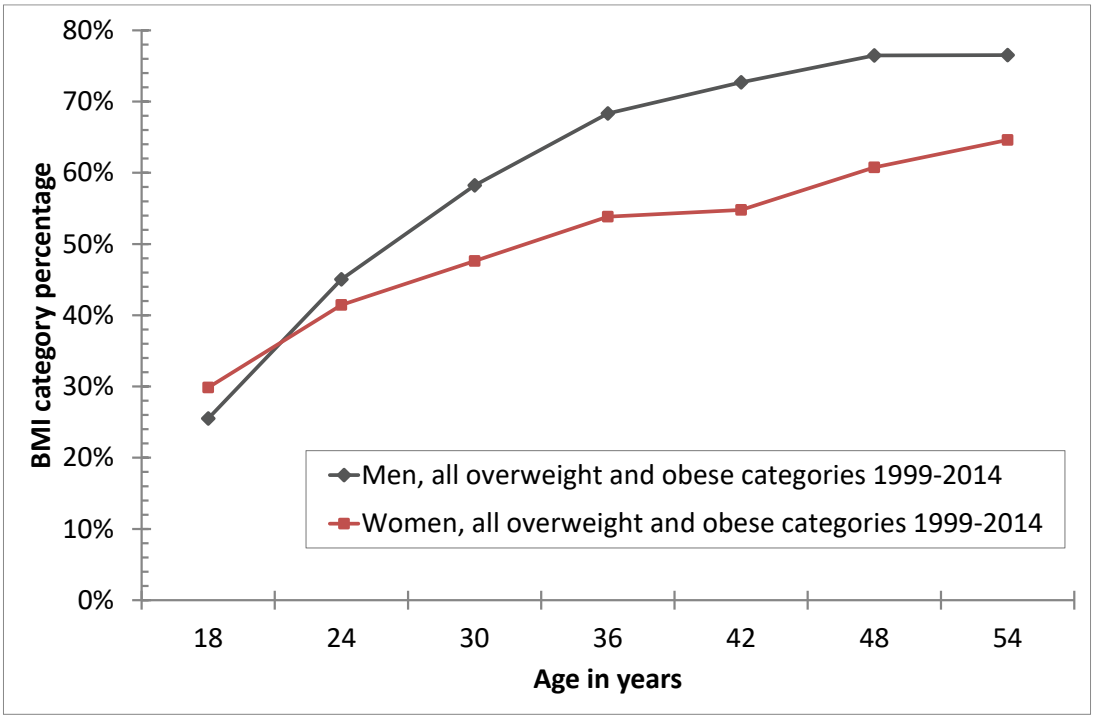

Figure 10.I.11 All overweight and obese percentages, selected ages 18 to 54 for men and women.

Changes with age: quartiles

Another way of looking at how BMI changes with age is to look at the changes in the quartile values with age. Figure 10.I.12 shows the quartiles for each age along with the 5% and 95% percentiles for 1999-2014. This combines the charts of Figure 8.VI.18 and Figure 9.VI.18. The increases are shown in Figure 10.I.13 combining Figure 8.VI.19 and Figure 9.VI.19. There is some irregularity with the 95% values.

The quartiles again show some of the differences between the changes with age for men and women. As age increases the values diverge much more for women than for men with greater differences between the values, as a result of the distribution for women becoming more spread out.

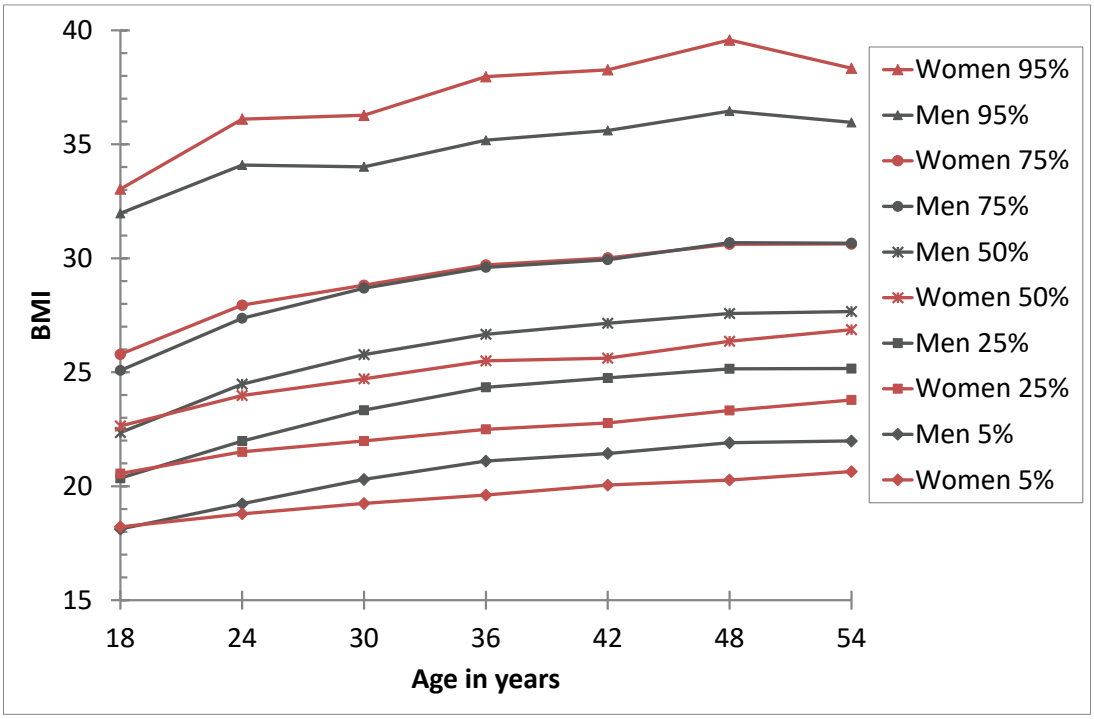

Figure 10.I.12 Quartile, 5%, 95% values for selected ages 18 to 54 for men and women.

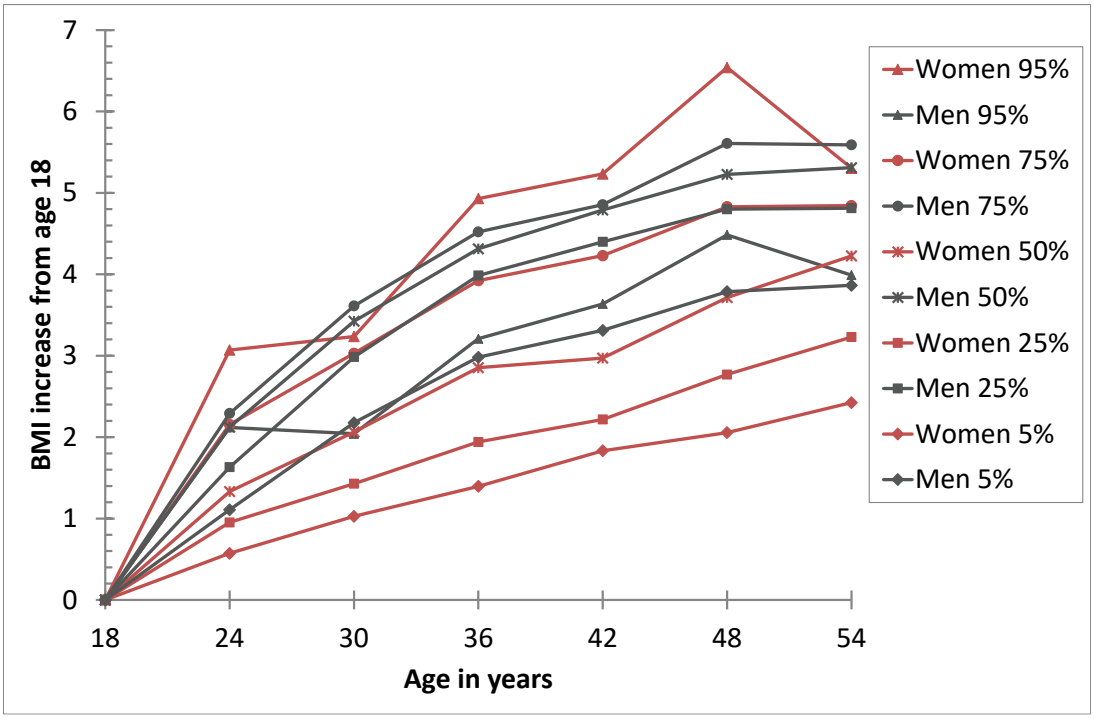

Figure 10.I.13 Increase in quartile, 5%, 95% values for selected ages 18 to 54 for men and women.

Appendix 11.I Comparison of population and models for men

This appendix gives the results of using the lognormal plus cosine modelling approach to model the historical distributions for men from Chapter 4 for 1993, 1997, 2001, 2005, 2009, and 2013. The charts and tables show comparisons of the distributions and statistics. The model matches the population BMI distribution very well in each case. The method ensures that the mean values are extremely close, and since the shape is modelled well all the statistics and category percentages also match well.

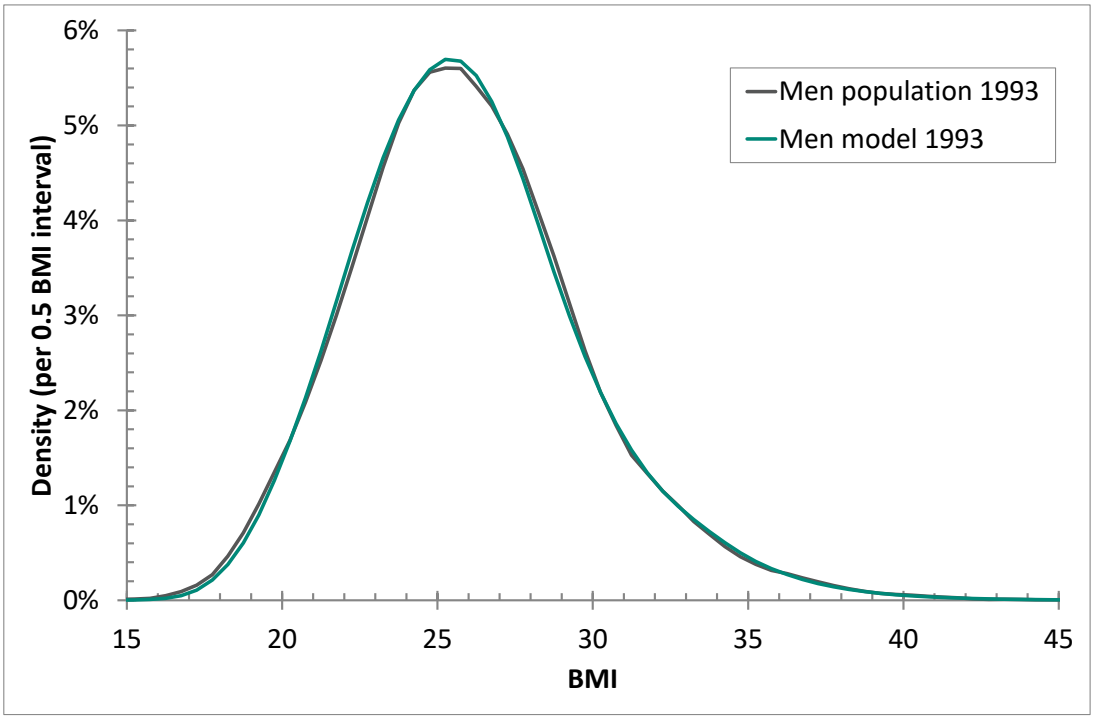

Figure 11.I.1 Population BMI distribution and modelled distribution for men for 1993.

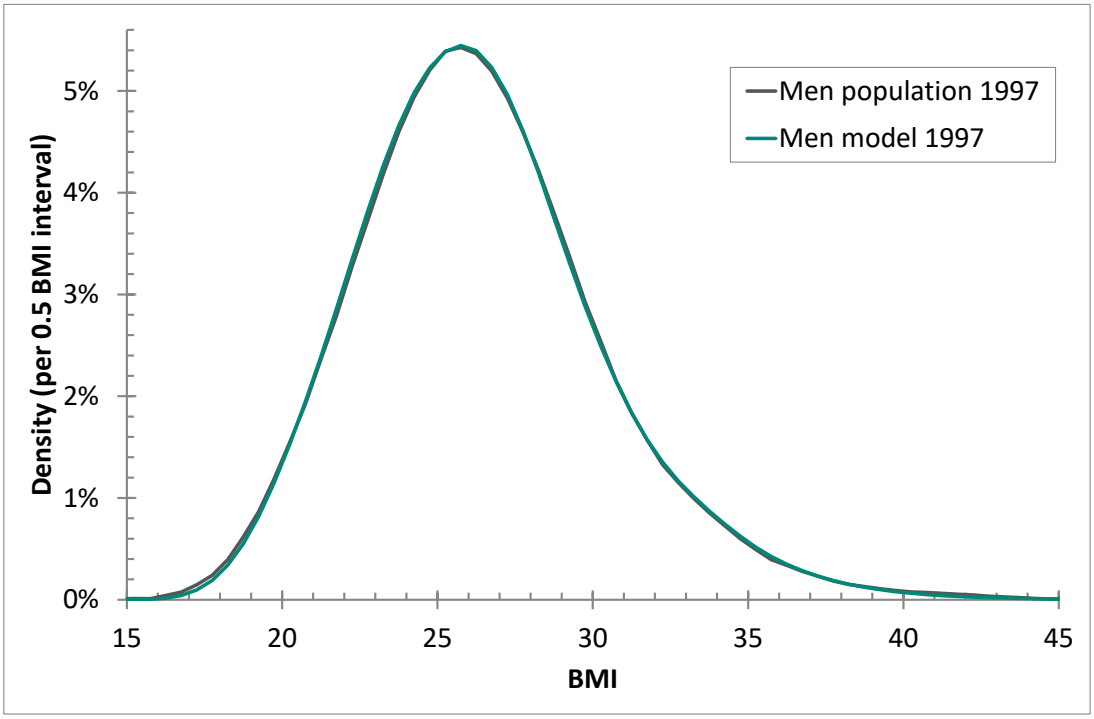

Figure 11.I.2 Population BMI distribution and modelled distribution for men for 1997.

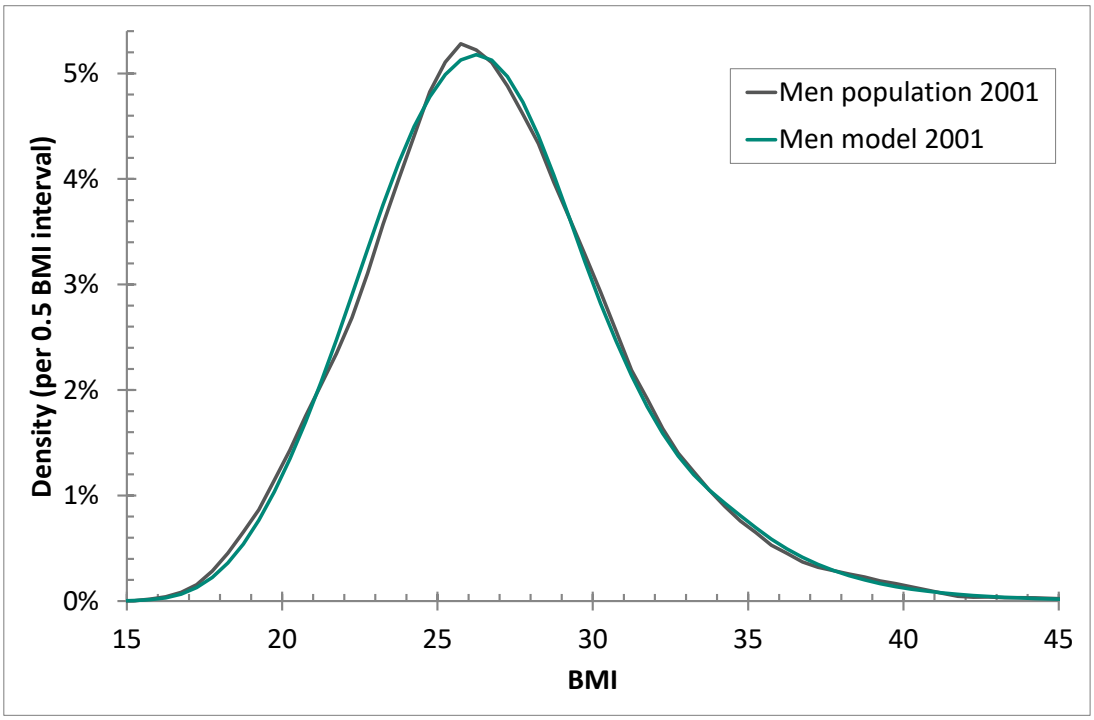

Figure 11.I.3 Population BMI distribution and modelled distribution for men for 2001.

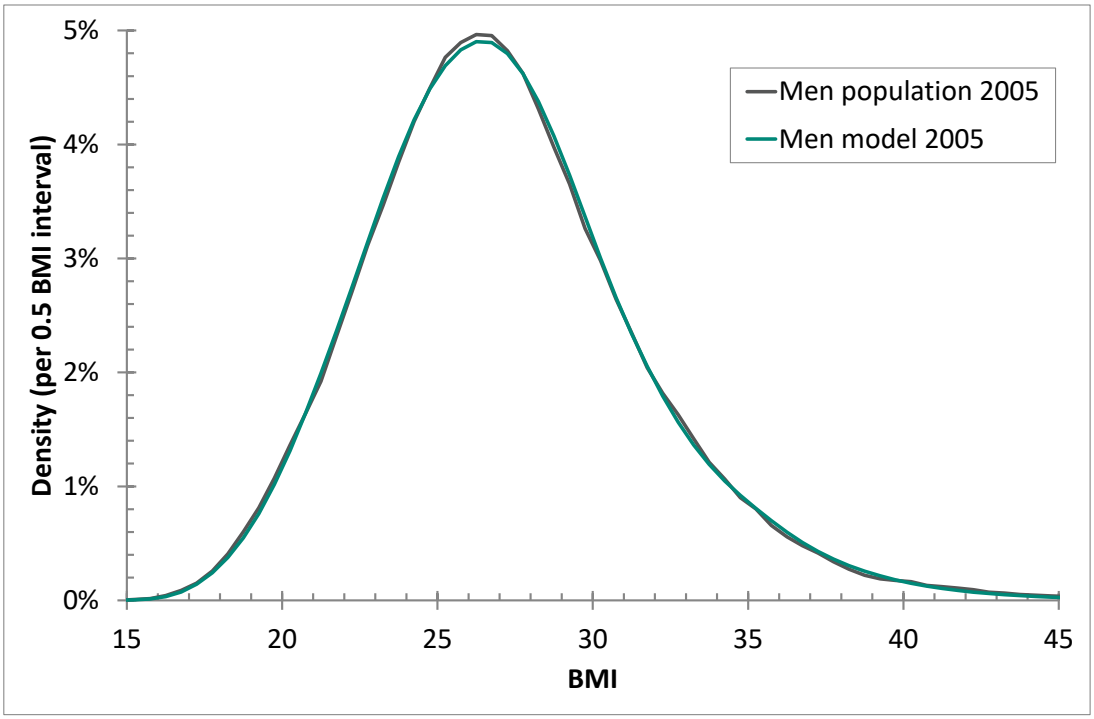

Figure 11.I.4 Population BMI distribution and modelled distribution for men for 2005.

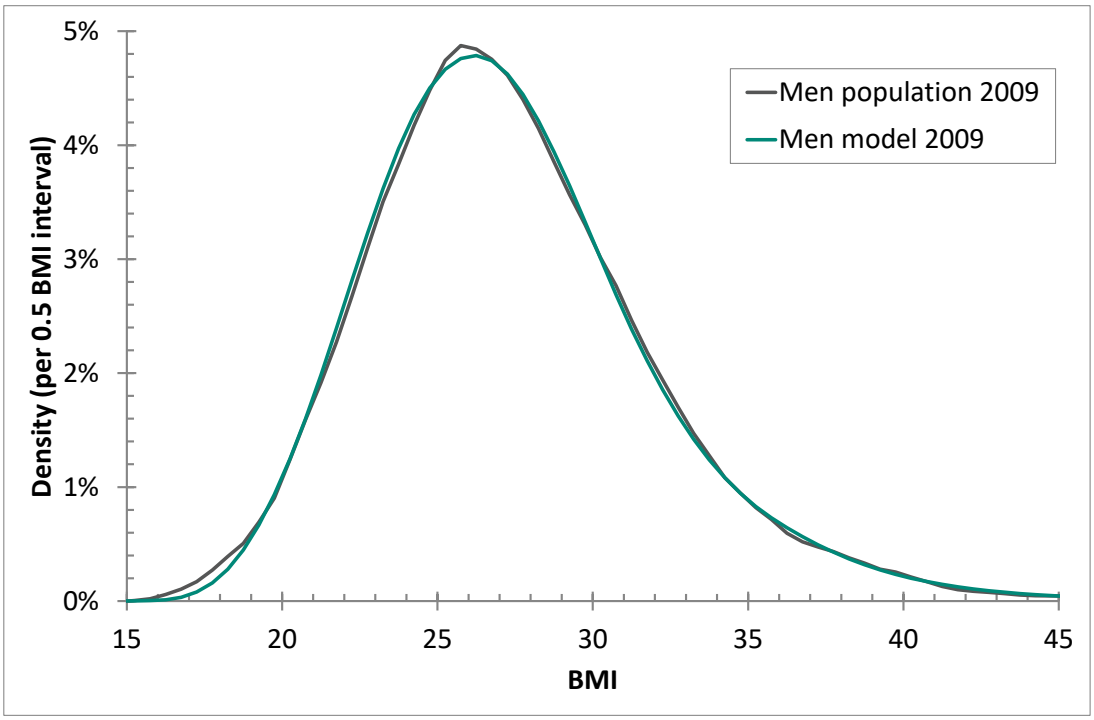

Figure 11.I.5 Population BMI distribution and modelled distribution for men for 2009.

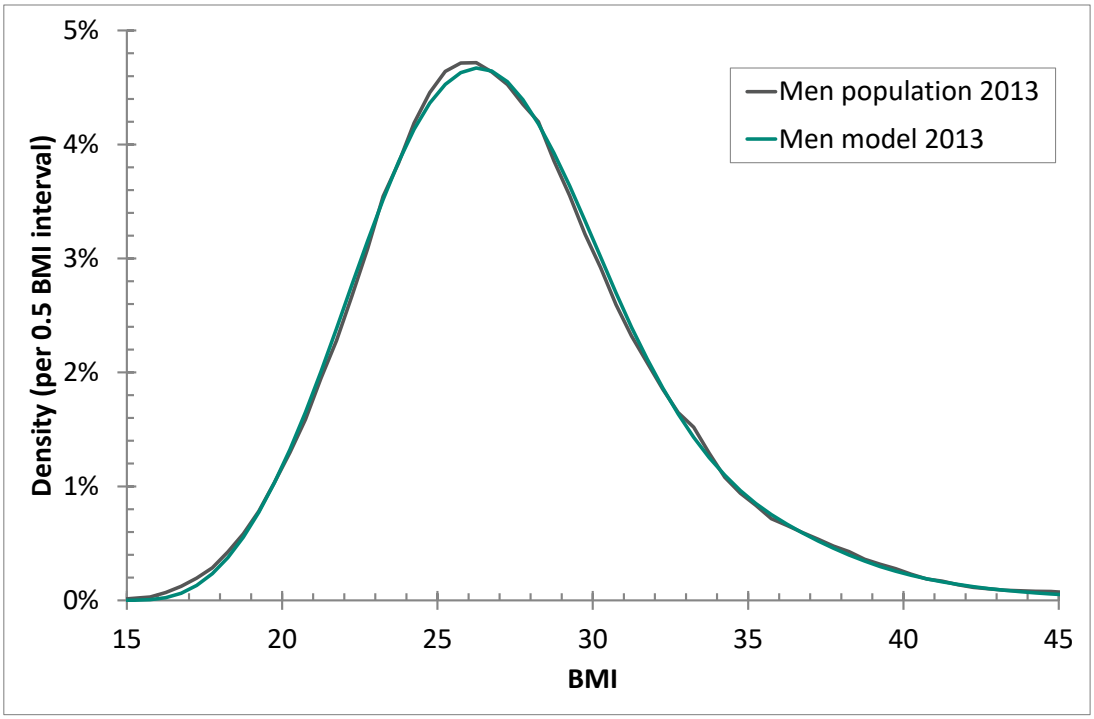

Figure 11.I.6 Population BMI distribution and modelled distribution for men for 2013.

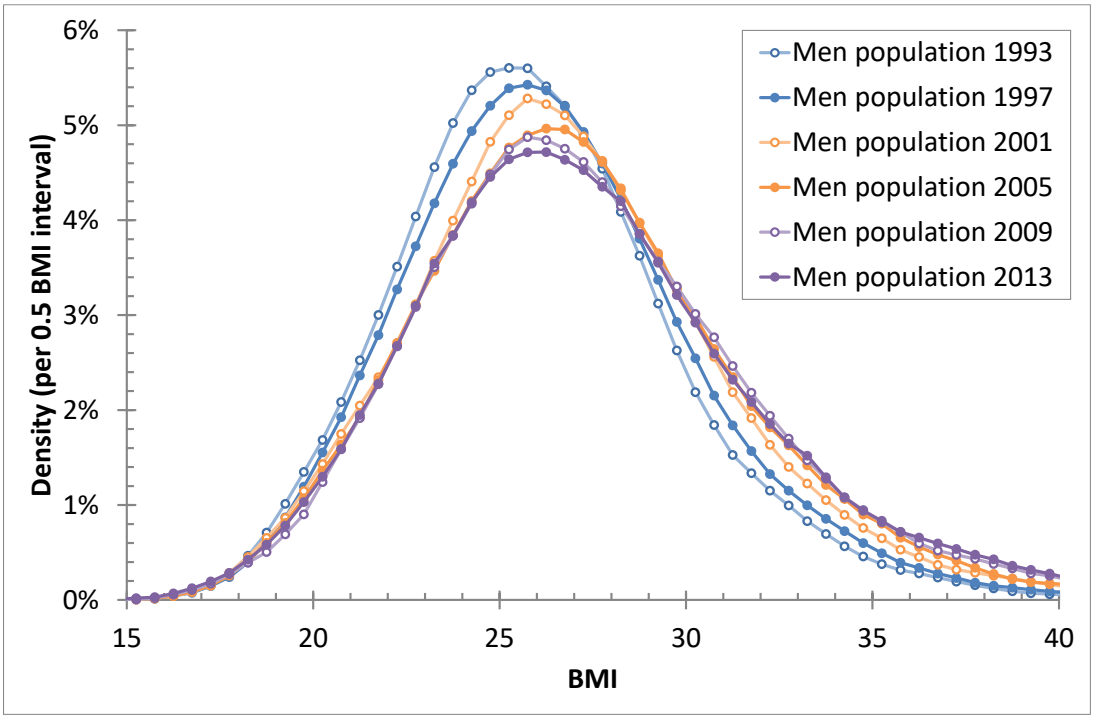

Figure 11.I.7 Population BMI distributions for men for 1993 to 2013.

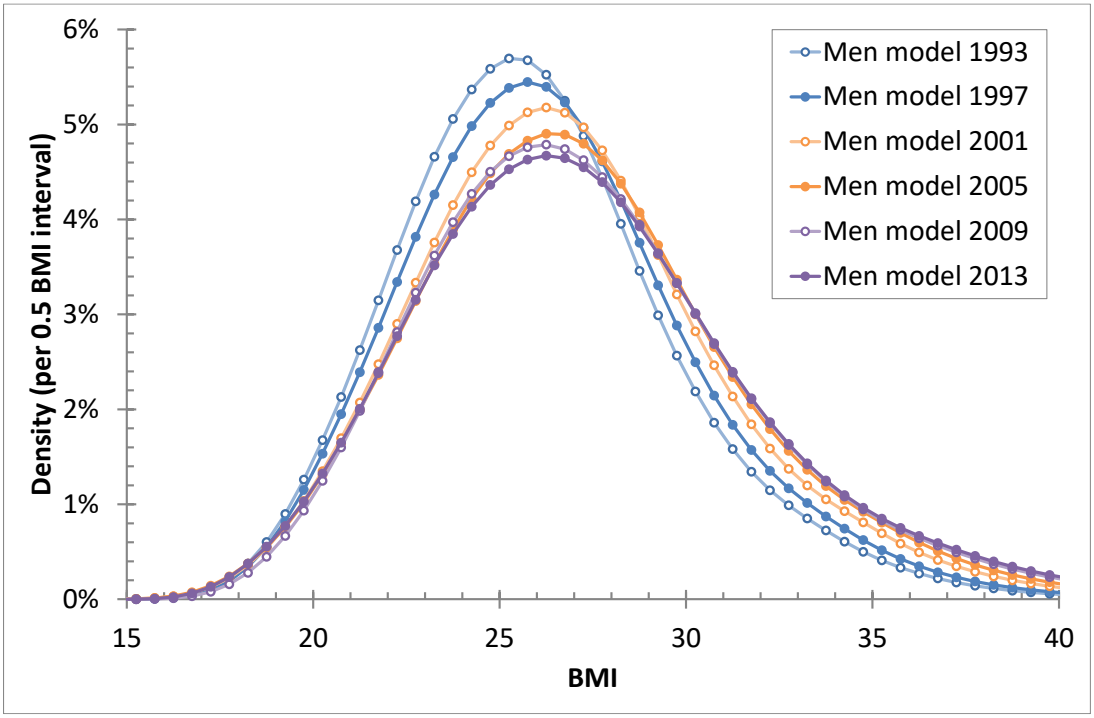

Figure 11.I.8 Model BMI distributions for men for 1993 to 2013.

Table 11.I.1 shows the statistics for the population distributions from Chapter 4 (the same as Table 4.1), and Table 11.I.2 shows the corresponding statistics for the model distributions. From the previous figures in this appendix the distributions are very similar, and so the statistics are also very similar. A chart comparing the healthy category percentages is given in Figure 11.6 in the main report.

Table 11.I.1 Descriptive statistics for the population distributions for men.

	1993	1997	2001	2005	2009	2013
Mean	26.05	26.41	26.90	27.19	27.39	27.42
Median	25.76	26.10	26.55	26.79	26.88	26.87
Modal interval mid-point	25.25	25.75	25.75	26.25	25.75	26.25
Standard deviation	3.87	4.00	4.29	4.48	4.67	4.84
Skewness	0.75	0.63	0.71	0.72	0.87	0.89
Underweight (BMI < 18.5)	1.1%	0.9%	1.0%	1.0%	1.0%	1.2%
Healthy (18.5 ≤ BMI < 25.0)	40.4%	37.2%	32.8%	31.6%	30.9%	31.3%
Overweight (25.0 ≤ BMI < 30.0)	44.7%	45.2%	45.4%	44.2%	43.1%	42.4%
Obese I (30.0 ≤ BMI < 35.0)	11.6%	13.8%	16.6%	18.1%	18.8%	18.2%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	2.4%	3.4%	4.1%	4.8%	5.2%
Severely obese (BMI ≥ 40.0)	0.3%	0.5%	0.7%	1.1%	1.3%	1.7%

Table 11.I.2 Descriptive statistics for the model distributions for men.

	1993	1997	2001	2005	2009	2013
Mean	26.05	26.41	26.90	27.19	27.39	27.42
Median	25.73	26.09	26.55	26.81	26.87	26.91
Modal interval mid-point	25.25	25.75	26.25	26.25	26.25	26.25
Standard deviation	3.79	3.93	4.22	4.42	4.60	4.75
Skewness	0.63	0.61	0.66	0.65	0.84	0.85
Underweight (BMI < 18.5)	0.8%	0.7%	0.8%	0.9%	0.6%	0.8%
Healthy (18.5 ≤ BMI < 25.0)	40.9%	37.5%	33.3%	31.6%	31.7%	31.5%
Overweight (25.0 ≤ BMI < 30.0)	44.4%	45.2%	45.4%	44.3%	43.2%	42.5%
Obese I (30.0 ≤ BMI < 35.0)	11.8%	13.8%	16.2%	17.9%	18.4%	18.5%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	2.4%	3.6%	4.4%	4.9%	5.1%
Severely obese (BMI ≥ 40.0)	0.2%	0.3%	0.6%	0.9%	1.4%	1.6%

Appendix 11.II Comparison of age group distributions and models for men

This analysis compares the age group distributions and statistics for men for the data for 2007-2014 with the models (Section 11.4.2). The data weightings used are those from Chapters 3 and 4. The first two charts show the distributions for the smoothed population distributions from the HSE data and for the lognormal plus cosine model. Then statistics and a couple of charts of the BMI categories are shown. These all show the close correspondence between the distributions of the model and the actual data.

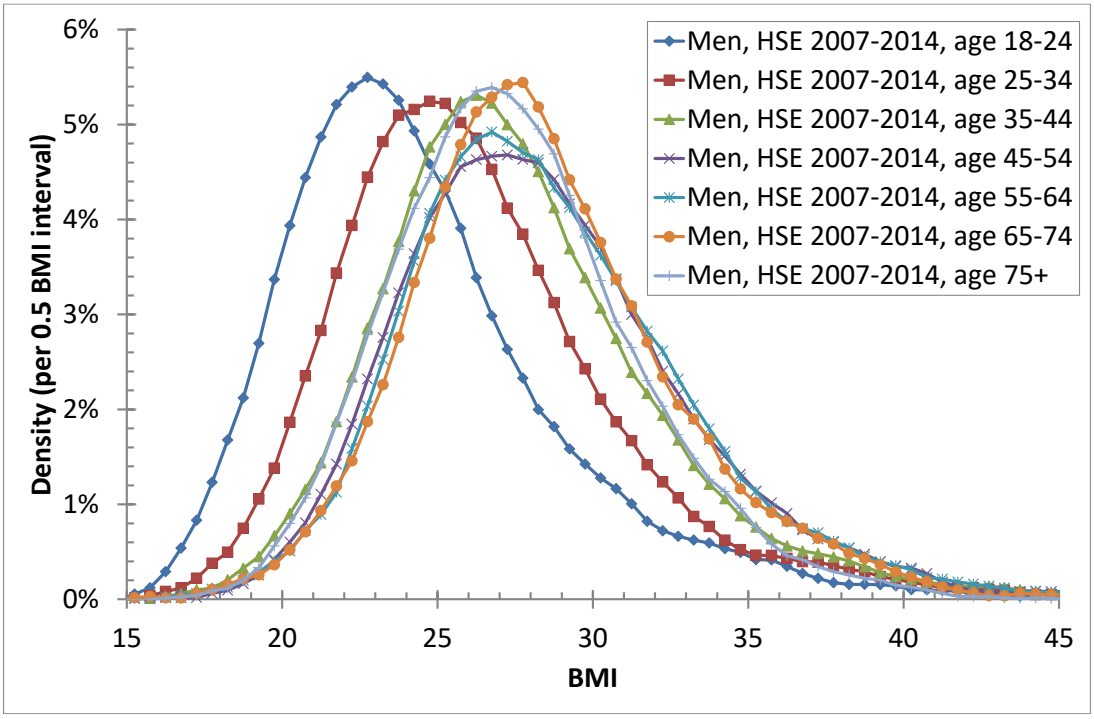

Figure 11.II.1 Age group distributions for men for the HSE data 2007-2014.

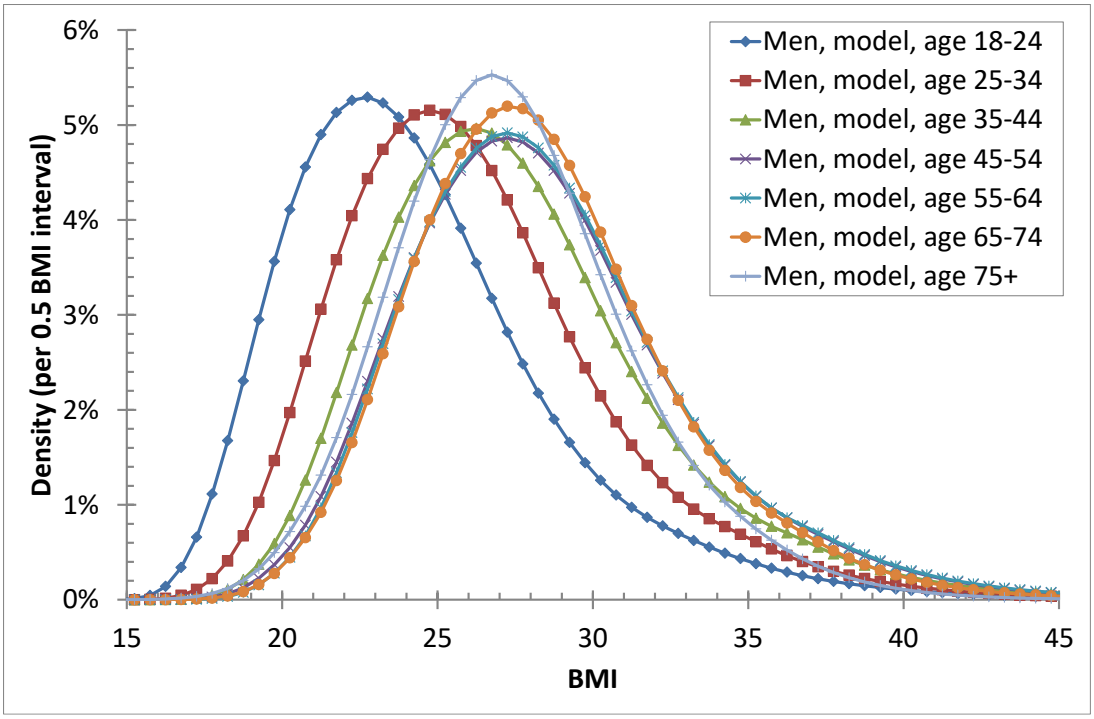

Figure 11.II.2 Age group distributions for men for the model.

Table 11.II.1 Descriptive statistics for the HSE age group distributions for men for 2007-2014.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Mean	24.52	26.26	27.69	28.52	28.62	28.41	27.52
Median	23.72	25.61	27.06	27.97	28.03	27.95	27.20
Modal interval mid-point	22.75	24.75	26.25	27.25	26.75	27.75	26.75
Standard deviation	4.61	4.55	4.69	4.70	4.69	4.31	3.95
Skewness	1.32	1.06	1.28	0.91	0.93	0.67	0.54
Underweight (BMI < 18.5)	4.7%	1.3%	0.5%	0.2%	0.4%	0.4%	0.3%
Healthy (18.5 ≤ BMI < 25.0)	57.7%	42.4%	28.1%	22.6%	20.9%	19.7%	26.8%
Overweight (25.0 ≤ BMI < 30.0)	26.4%	39.3%	46.3%	44.6%	45.3%	49.0%	49.0%
Obese I (30.0 ≤ BMI < 35.0)	7.9%	12.1%	18.5%	23.8%	24.5%	23.4%	19.8%
Obese II (35.0 ≤ BMI < 40.0)	2.5%	3.6%	4.7%	6.8%	6.7%	6.3%	3.7%
Severely obese (BMI ≥ 40.0)	0.9%	1.3%	1.9%	2.0%	2.1%	1.2%	0.5%

Table 11.II.2 Descriptive statistics for the model age group distributions for men for 2007-2014.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Mean	24.52	26.27	27.68	28.52	28.63	28.41	27.52
Median	23.52	25.39	26.80	27.71	27.78	27.71	26.95
Modal interval mid-point	22.75	24.75	26.25	27.25	27.25	27.25	26.75
Standard deviation	4.53	4.46	4.61	4.61	4.60	4.23	3.89
Skewness	1.31	1.07	1.02	0.88	0.95	0.76	0.56
Underweight (BMI < 18.5)	4.0%	0.8%	0.2%	0.1%	0.1%	0.1%	0.3%
Healthy (18.5 ≤ BMI < 25.0)	57.8%	42.7%	29.7%	22.3%	21.4%	20.8%	26.3%
Overweight (25.0 ≤ BMI < 30.0)	27.4%	39.3%	44.6%	45.5%	46.0%	48.2%	49.9%
Obese I (30.0 ≤ BMI < 35.0)	7.8%	12.6%	18.5%	23.3%	23.6%	23.6%	19.4%
Obese II (35.0 ≤ BMI < 40.0)	2.2%	3.5%	5.4%	6.7%	6.8%	6.0%	3.7%
Severely obese (BMI ≥ 40.0)	0.8%	1.0%	1.7%	2.0%	2.2%	1.3%	0.5%

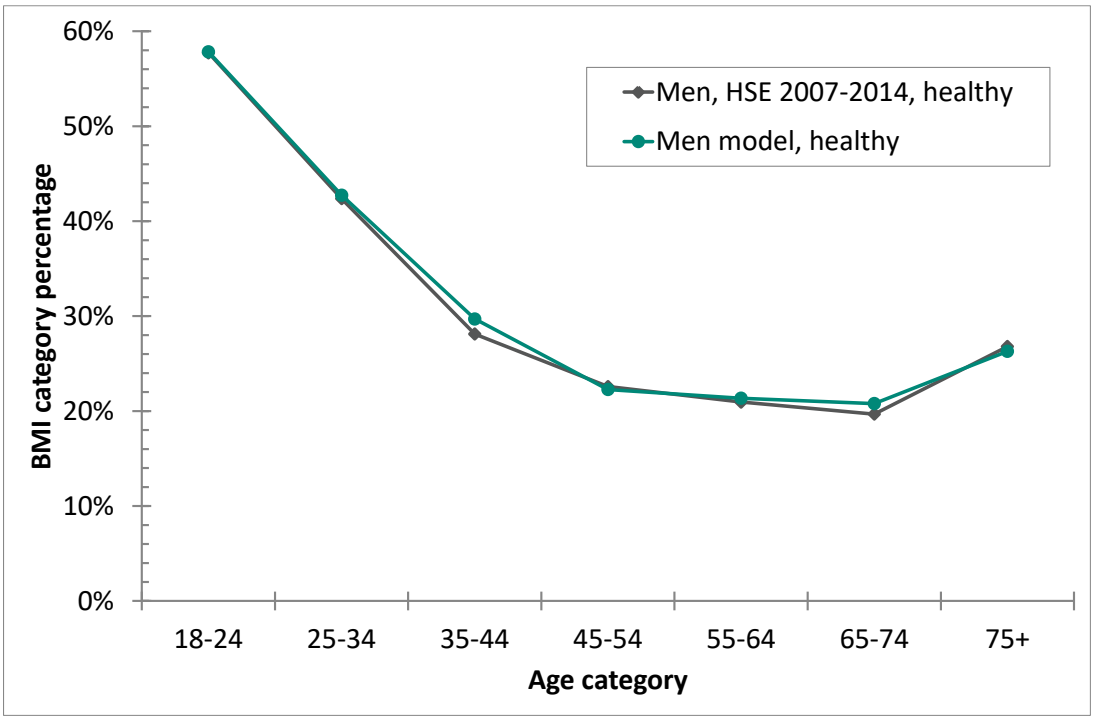

Figure 11.II.3 Model and actual healthy percentages for age group distributions for men.

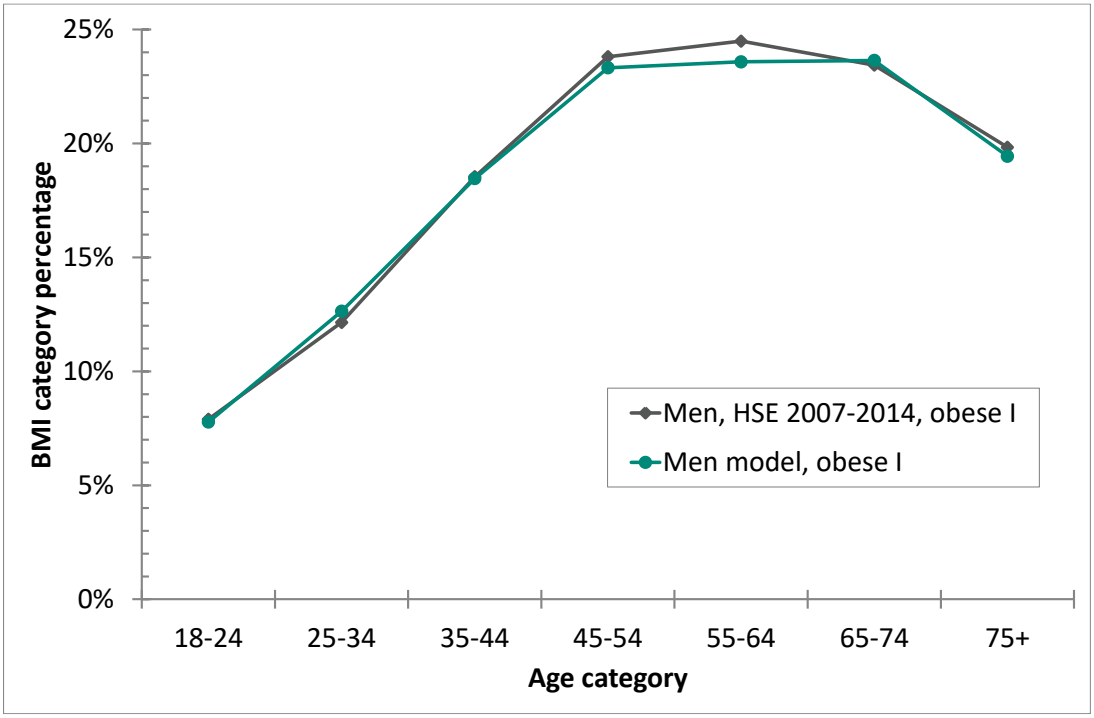

Figure 11.II.4 Model and actual obese I percentages for age group distributions for men.

Appendix 11.III Comparison of population and models for women

This appendix gives the results of using the lognormal modelling approach to model the historical distributions for women from Chapter 4 for 1993, 1997, 2001, 2005, 2009, and 2013. The charts and tables show the distributions and statistics. The model matches the shape of the population very well in each case. The method ensures that the mean values are extremely close, and since the shape is modelled well all the statistics and category percentages also match well.

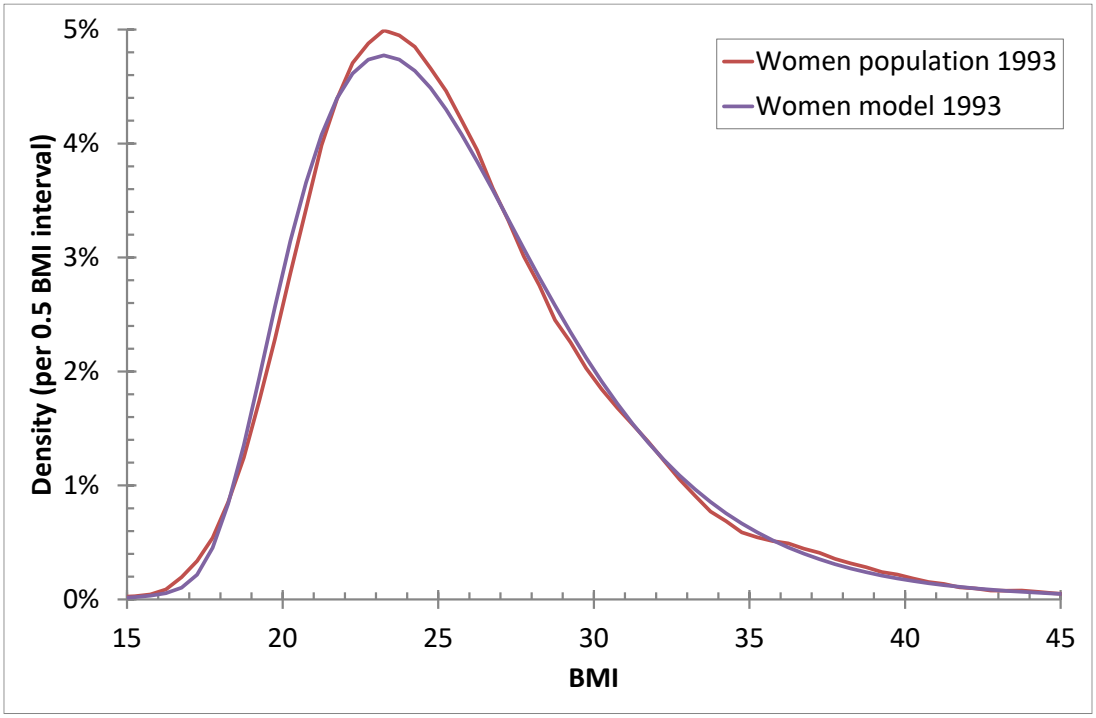

Figure 11.III.1 Population BMI distribution and modelled distribution for women for 1993.

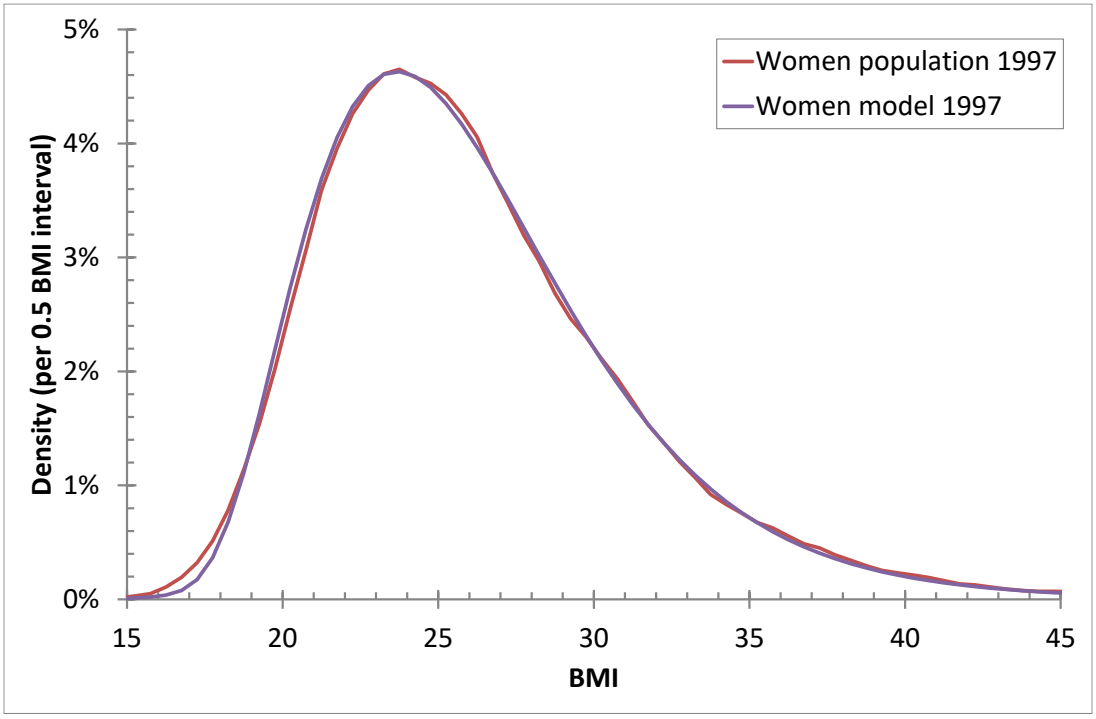

Figure 11.III.2 Population BMI distribution and modelled distribution for women for 1997.

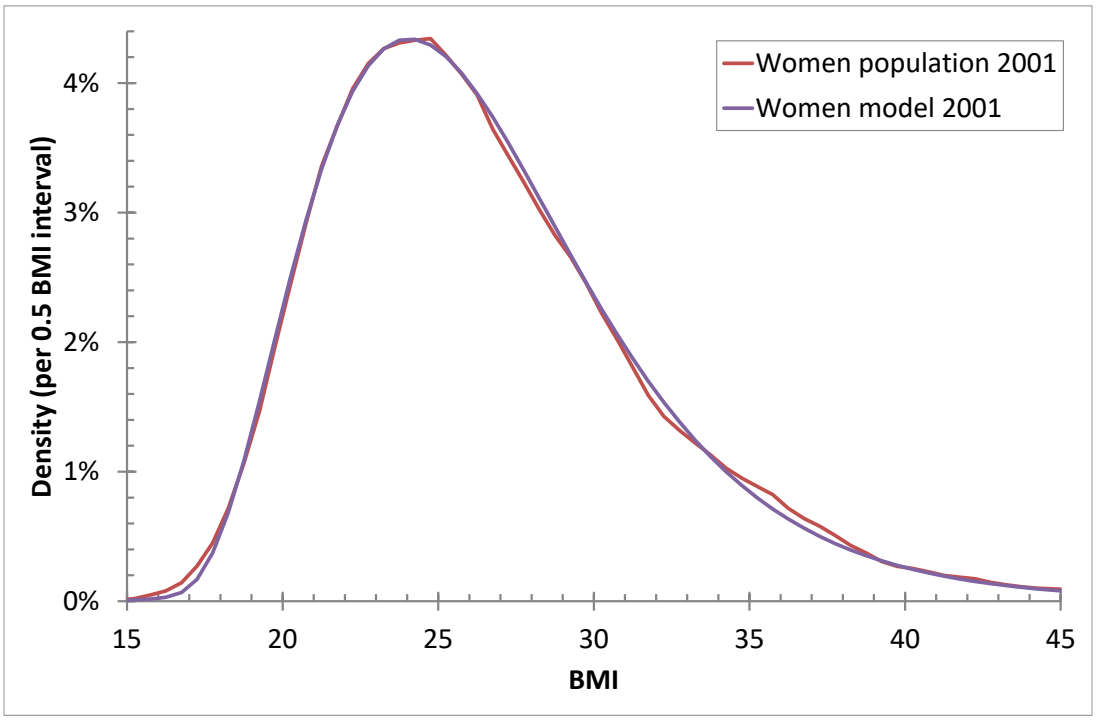

Figure 11.III.3 Population BMI distribution and modelled distribution for women for 2001.

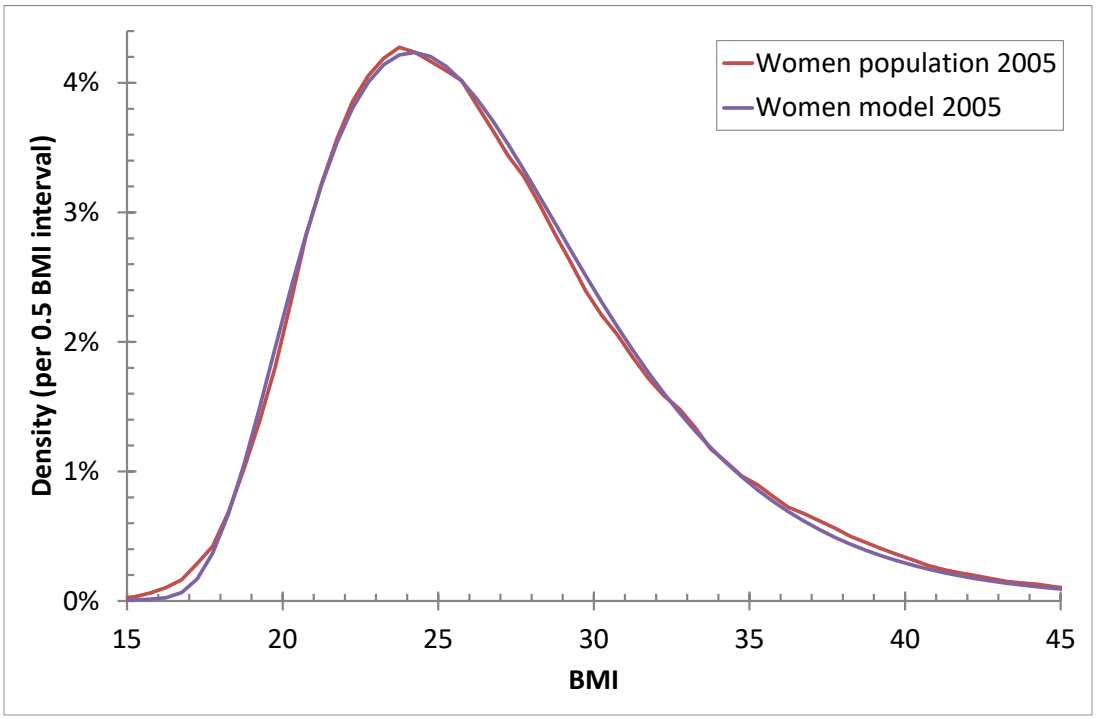

Figure 11.III.4 Population BMI distribution and modelled distribution for women for 2005.

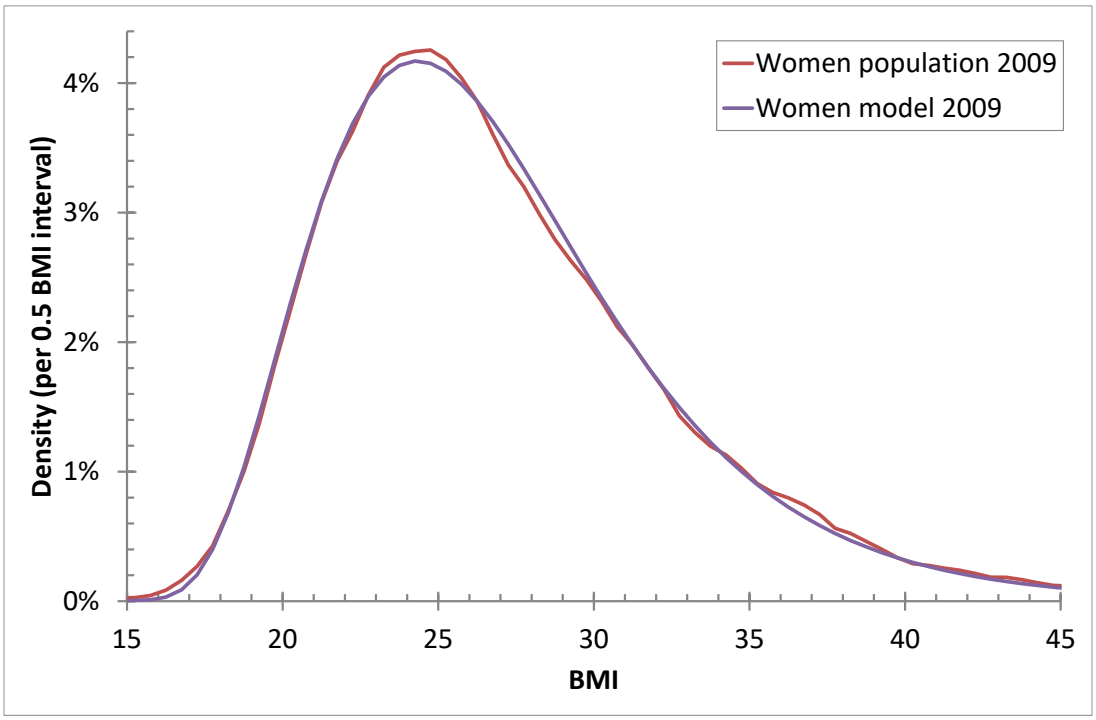

Figure 11.III.5 Population BMI distribution and modelled distribution for women for 2009.

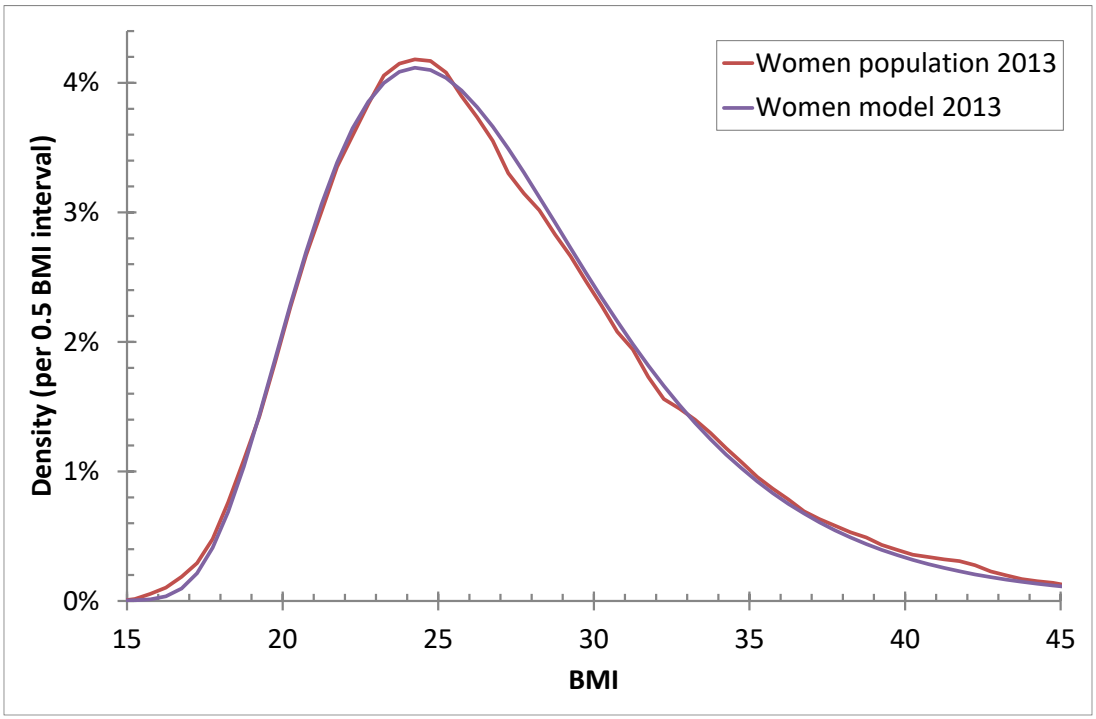

Figure 11.III.6 Population BMI distribution and modelled distribution for women for 2013.

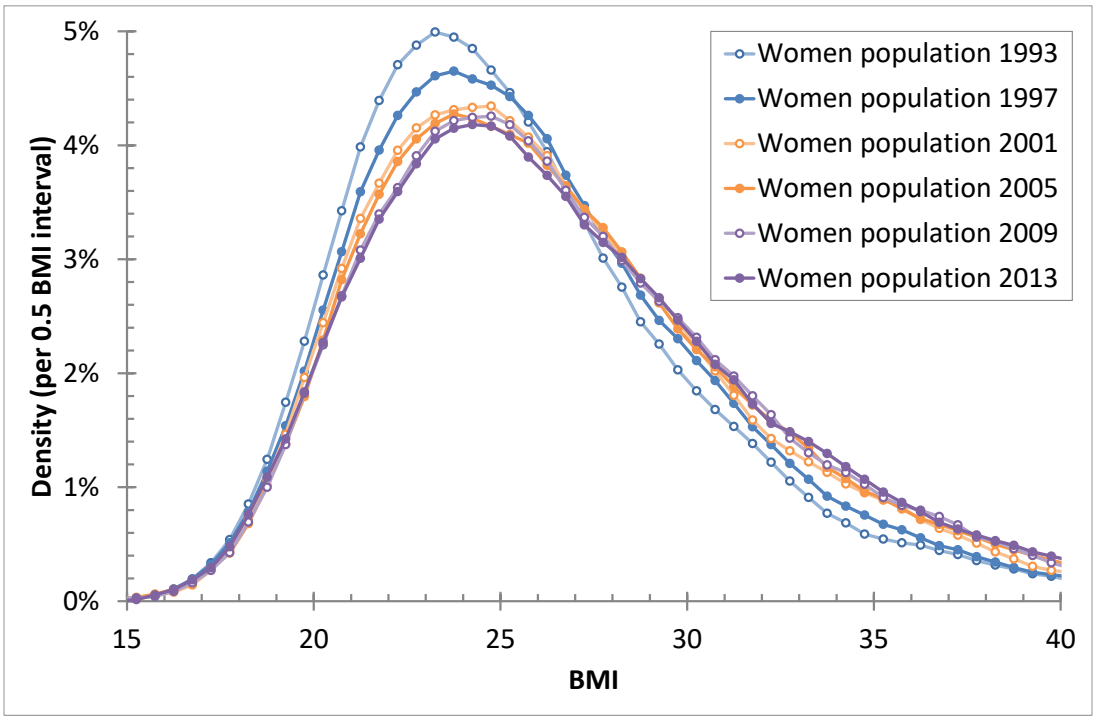

Figure 11.III.7 Population BMI distributions for women for 1993 to 2013.

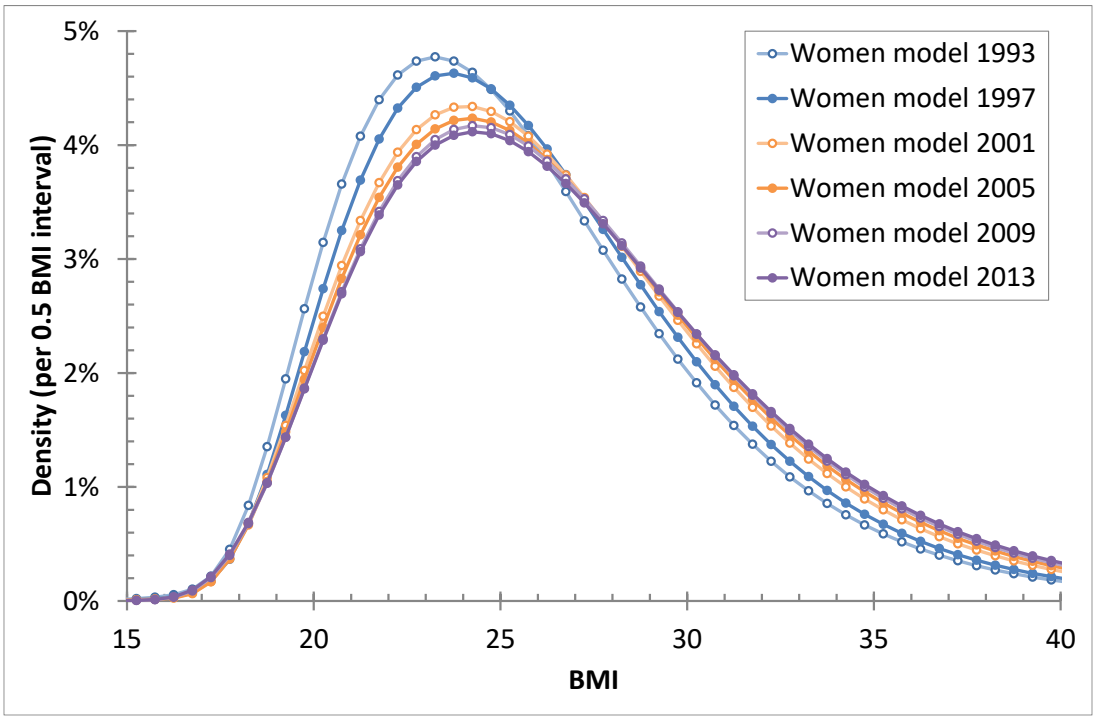

Figure 11.III.8 Model BMI distributions for women for 1993 to 2013.

Table 11.III.1 shows the statistics for the population distributions from Chapter 4 (the same as Table 4.2), and Table 11.III.2 shows the corresponding statistics for the model distributions. From the previous figures in this appendix the distributions are very similar, and so the statistics are also very similar. A chart comparing the healthy category percentages is given in Figure 11.11 in the main report.

Table 11.III.1 Descriptive statistics for the population distributions for women.

	1993	1997	2001	2005	2009	2013
Mean	25.76	26.18	26.65	26.88	27.03	27.13
Median	24.88	25.34	25.72	25.90	26.01	26.07
Modal interval mid-point	23.25	23.75	24.75	23.75	24.75	24.25
Standard deviation	4.95	5.04	5.38	5.54	5.63	5.77
Skewness	1.32	1.05	1.06	1.05	1.05	1.06
Underweight (BMI < 18.5)	2.1%	2.0%	1.7%	1.8%	1.7%	1.9%
Healthy (18.5 ≤ BMI < 25.0)	49.0%	45.0%	42.2%	40.9%	40.0%	39.6%
Overweight (25.0 ≤ BMI < 30.0)	32.0%	33.6%	33.5%	33.2%	33.1%	32.7%
Obese I (30.0 ≤ BMI < 35.0)	11.7%	13.5%	14.7%	15.5%	15.9%	16.0%
Obese II (35.0 ≤ BMI < 40.0)	3.8%	4.3%	5.5%	6.0%	6.2%	6.4%
Severely obese (BMI ≥ 40.0)	1.4%	1.7%	2.3%	2.7%	3.0%	3.4%

Table 11.III.2 Descriptive statistics for the model distributions for women.

	1993	1997	2001	2005	2009	2013
Mean	25.76	26.18	26.65	26.88	27.03	27.13
Median	24.90	25.32	25.75	25.93	26.07	26.13
Modal interval mid-point	23.25	23.75	24.25	24.25	24.25	24.25
Standard deviation	4.95	5.04	5.37	5.53	5.64	5.76
Skewness	1.26	1.22	1.24	1.25	1.24	1.27
Underweight (BMI < 18.5)	1.7%	1.4%	1.4%	1.3%	1.4%	1.5%
Healthy (18.5 ≤ BMI < 25.0)	49.1%	45.8%	42.4%	41.1%	39.9%	39.6%
Overweight (25.0 ≤ BMI < 30.0)	32.1%	33.6%	33.9%	33.8%	33.9%	33.6%
Obese I (30.0 ≤ BMI < 35.0)	12.1%	13.5%	15.1%	15.7%	16.1%	16.3%
Obese II (35.0 ≤ BMI < 40.0)	3.5%	4.1%	5.0%	5.5%	5.8%	6.0%
Severely obese (BMI ≥ 40.0)	1.4%	1.6%	2.3%	2.6%	2.9%	3.1%

Appendix 11.IV Comparison of age group distributions and models for women

This analysis compares the age group distributions and statistics for women for 2007-2014 (Section 11.7.2). The data weightings used are those from Chapters 3 and 4. The first two charts show the distributions for the smoothed population distributions from the HSE data and for the lognormal model. Then statistics and a couple of charts of the BMI categories are shown. This shows the close correspondence between the model results and the actual data.

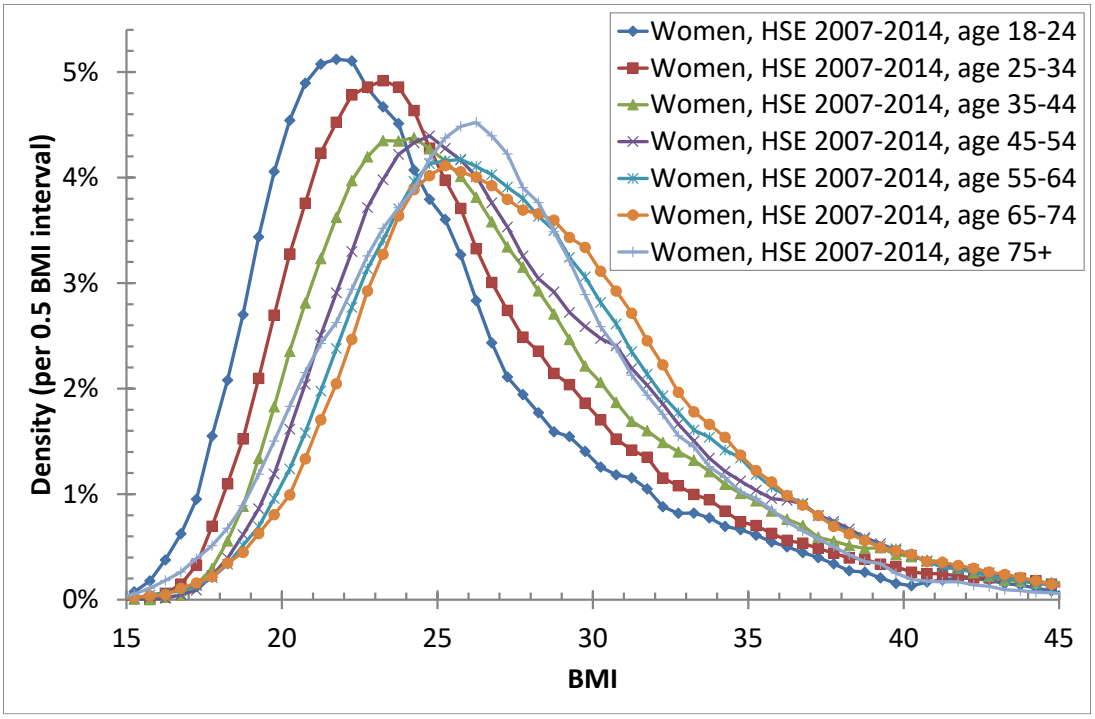

Figure 11.IV.1 Age group distributions for women for the HSE data 2007-2014.

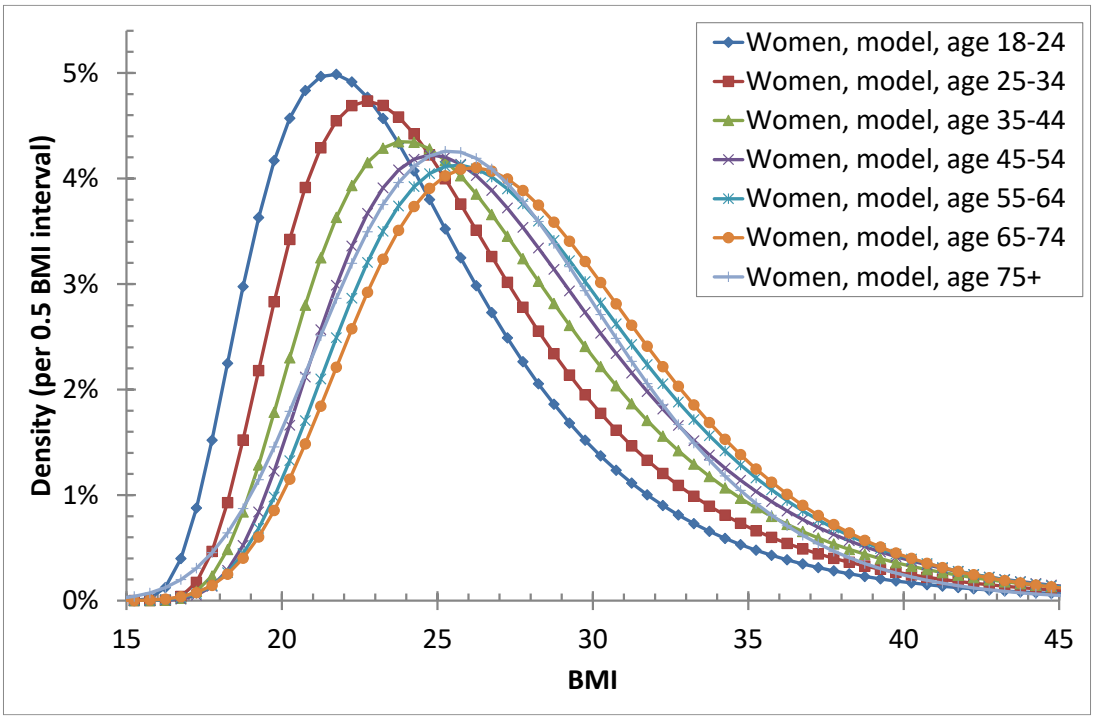

Figure 11.IV.2 Age group distributions for women for the model.

Table 11.IV.1 Descriptive statistics for the HSE age group distributions for women 2007-2014.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Mean	24.72	26.03	27.13	27.80	28.17	28.38	27.05
Median	23.48	24.68	25.89	26.65	27.28	27.63	26.53
Modal interval mid-point	21.75	23.25	24.25	24.75	25.75	25.25	26.25
Standard deviation	5.40	5.70	5.85	5.77	5.60	5.45	5.01
Skewness	1.43	1.37	1.20	1.11	1.00	0.81	0.65
Underweight (BMI < 18.5)	5.7%	2.3%	1.1%	0.8%	0.9%	1.0%	2.2%
Healthy (18.5 ≤ BMI < 25.0)	56.8%	50.4%	41.6%	35.7%	30.5%	28.2%	34.1%
Overweight (25.0 ≤ BMI < 30.0)	22.5%	27.6%	32.4%	34.3%	37.6%	37.6%	39.3%
Obese I (30.0 ≤ BMI < 35.0)	9.3%	11.7%	14.7%	17.8%	19.5%	21.7%	17.2%
Obese II (35.0 ≤ BMI < 40.0)	3.7%	4.8%	6.3%	7.6%	7.9%	7.9%	5.7%
Severely obese (BMI ≥ 40.0)	1.9%	3.1%	3.9%	3.8%	3.6%	3.7%	1.5%

Table 11.IV.2 Descriptive statistics for the model age group distributions for women 2007-2014.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Mean	24.72	26.03	27.13	27.81	28.17	28.38	27.05
Median	23.30	24.55	25.72	26.48	27.02	27.35	26.24
Modal interval mid-point	21.75	22.75	23.75	24.75	25.75	26.25	25.25
Standard deviation	5.39	5.68	5.84	5.80	5.60	5.46	5.01
Skewness	1.67	1.66	1.46	1.33	1.10	0.96	0.70
Underweight (BMI < 18.5)	5.2%	1.6%	0.8%	0.5%	0.5%	0.5%	1.9%
Healthy (18.5 ≤ BMI < 25.0)	56.6%	50.1%	41.2%	35.4%	31.0%	28.4%	35.5%
Overweight (25.0 ≤ BMI < 30.0)	24.4%	29.3%	33.3%	35.7%	37.3%	38.1%	37.6%
Obese I (30.0 ≤ BMI < 35.0)	8.9%	11.9%	15.3%	17.8%	20.0%	21.5%	18.1%
Obese II (35.0 ≤ BMI < 40.0)	3.1%	4.4%	5.9%	6.9%	7.6%	8.0%	5.4%
Severely obese (BMI ≥ 40.0)	1.8%	2.7%	3.5%	3.8%	3.6%	3.4%	1.5%

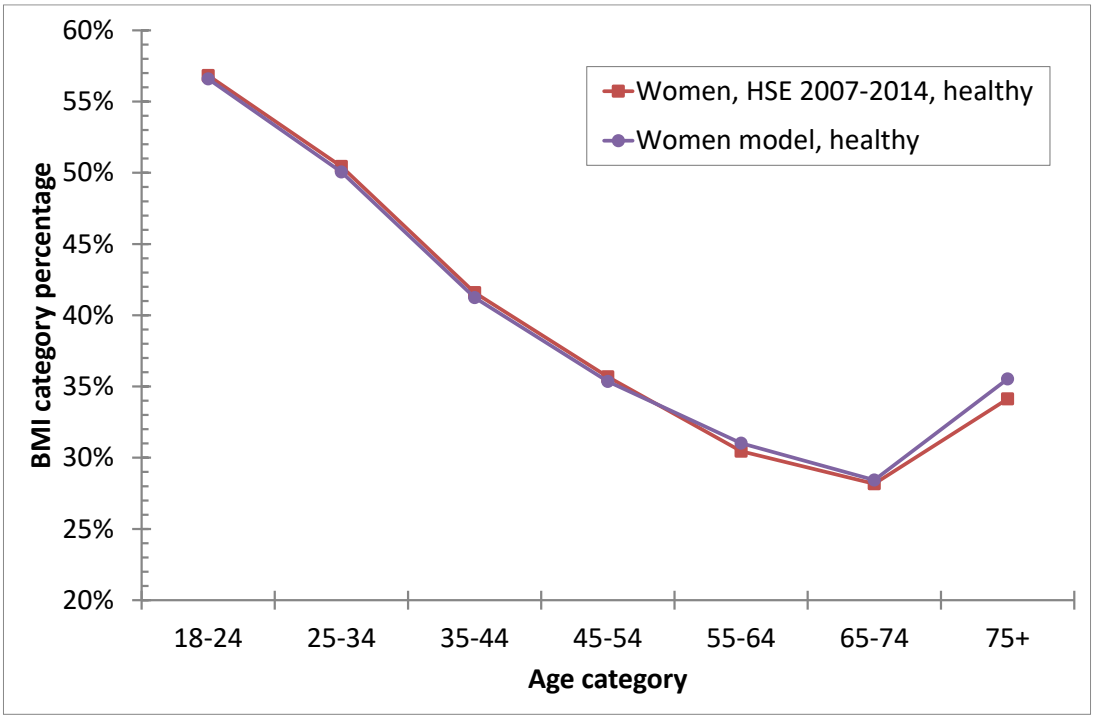

Figure 11.IV.3 Model and actual healthy percentages for age group distributions for women.

Figure 11.IV.4 Model and actual obese I percentages for age group distributions for women.

Appendix 14.I Analysis of the HSE data for 2015-2018

Descriptive statistics

Tables 14.I.1 and 14.I.2 show the statistics for the HSE data for each year for 2015-2018. Tables of the statistics for the HSE data for 1991-2014 are in Appendix 2.II. Charts of the mean and median, and the healthy category percentages for 1991-2018 are in Section 14.2.1 of the main report. As discussed in that section, the mean and median values for 2015-2018 are generally a bit higher than for previous years, and the values for 2017 for women show a particularly large increase compared to previous years. For 2017 for women the healthy percentage is also much lower than for the previous years and the obese percentages much higher. However, this is just initial analysis as the main focus of the work here is on the population distributions derived from four years of data with smoothing applied.

Table 14.I.1 Descriptive statistics for the HSE data for men.

	2015	2016	2017	2018
Number of cases	3004	2851	2842	2948
Mean	27.72	27.59	27.78	27.63
Median	27.06	26.94	27.18	27.01
Standard deviation (sample)	5.11	4.93	5.16	4.90
Skewness (sample)	1.13	0.92	0.93	0.82
Underweight (BMI < 18.5)	1.6%	1.1%	1.0%	0.8%
Healthy (18.5 ≤ BMI < 25.0)	29.3%	31.4%	30.3%	30.6%
Overweight (25.0 ≤ BMI < 30.0)	41.8%	41.2%	40.6%	41.8%
Obese I (30.0 ≤ BMI < 35.0)	19.7%	18.7%	20.0%	19.0%
Obese II (35.0 ≤ BMI < 40.0)	5.2%	5.6%	5.6%	5.8%
Severely obese (BMI ≥ 40.0)	2.3%	2.0%	2.6%	1.9%

Table 14.I.2 Descriptive statistics for the HSE data for women.

	2015	2016	2017	2018
Number of cases	3642	3489	3563	3603
Mean	27.31	27.33	27.88	27.65
Median	26.26	26.02	26.71	26.55
Standard deviation (sample)	5.92	6.13	6.30	6.24
Skewness (sample)	1.03	1.13	1.12	1.12
Underweight (BMI < 18.5)	2.0%	2.0%	1.6%	2.0%
Healthy (18.5 ≤ BMI < 25.0)	38.7%	40.0%	36.0%	37.3%
Overweight (25.0 ≤ BMI < 30.0)	31.9%	30.9%	31.7%	31.0%
Obese I (30.0 ≤ BMI < 35.0)	16.6%	15.5%	17.9%	18.1%
Obese II (35.0 ≤ BMI < 40.0)	7.2%	7.7%	8.1%	7.1%
Severely obese (BMI ≥ 40.0)	3.7%	4.0%	4.7%	4.6%

Missing values

Figure 14.I.1 shows the percentage of missing values for each year, extending Figure 2.3 in Section 2.4.1 of the main report to include 2015-2018. The percentage for the year is calculated as the weighted average of the missing value percentage for each age weighted by the standard 2011-2014 age profile used throughout the work. The HSE data for 2015-2018 only gives age in wider age categories and so the missing value calculations for 2015-2018 use the missing percentage for each of these categories weighted by the corresponding population age percentages for these categories from the 2011-2014 population age profiles. The general trend is for the percentage of missing cases to gradually increase over time.

Figure 14.I.2 shows the relationship between the missing percentages for men and women for each year, adding the values for 2015-2018 to Figure 2.4 in the main report. There is a very strong association with a correlation value of 0.94. The values for 2015-2018 continue to follow the pattern of this association from data for the previous years.

The age profile of the missing values is shown in Figure 14.I.3. The combined missing value percentage is calculated for the 1991-2014 data and for the 2015-2018 data. The age categories used are those for the 2015-2018 data. The values for each year of age for 1991-2014 are shown in Figure 2.5 of the main report and the values in Figure 14.I.3 are the same data combined into the wider age categories. The values are plotted at the mid-point of the integer values of the age categories (e.g., age 18-19 plotted at age 18.5, age 20-24 plotted at age 22, age 25-29 plotted at age 27). The pattern is for the percentage to be roughly constant up to about age 65 and then increase with age above that. This also applies to the 2015-2018 data although the level of missing cases up to age 65 is quite a bit higher than the overall average for 1991-2014. There are more fluctuations in the combined values for the 2015-2018 data with it being a much smaller sample of just four years compared to 24 years for the 1991-2014 data.

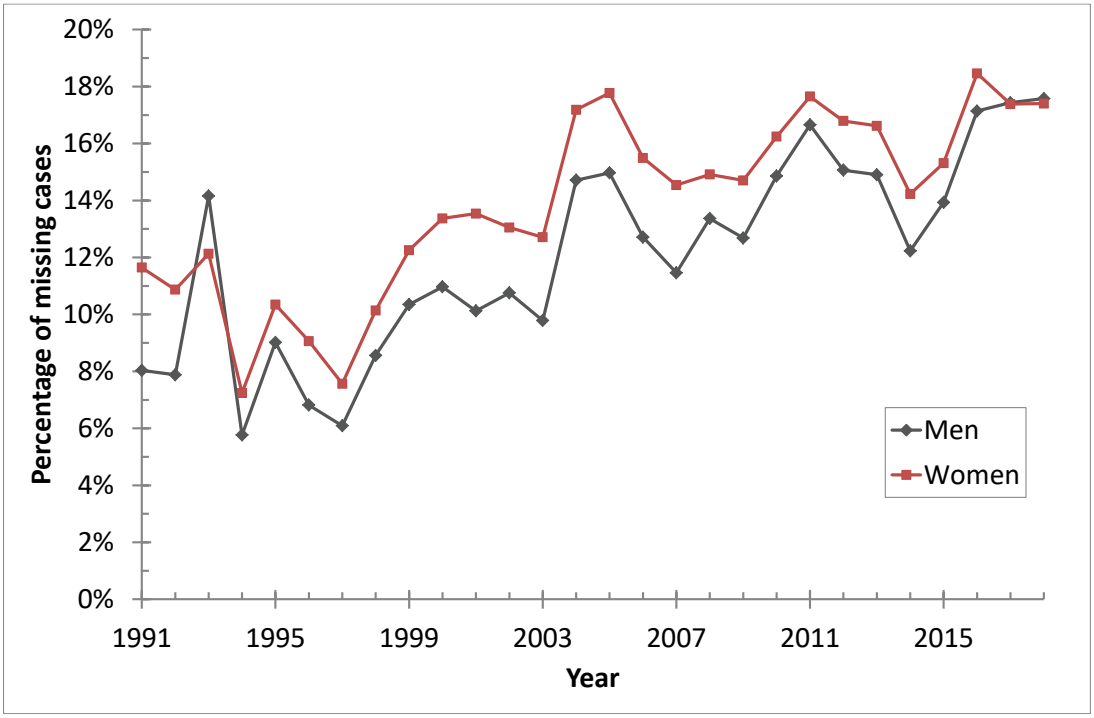

Figure 14.I.1 The percentage of missing values for each year.

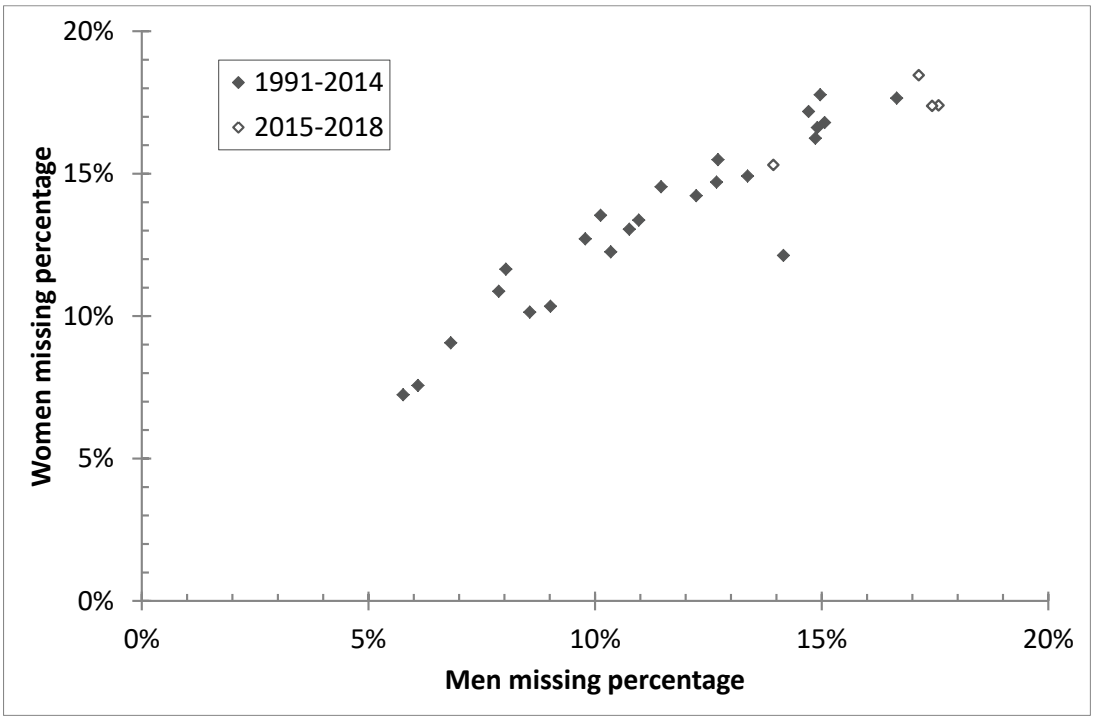

Figure 14.I.2 Relationship between the missing percentages for men and women for each year.

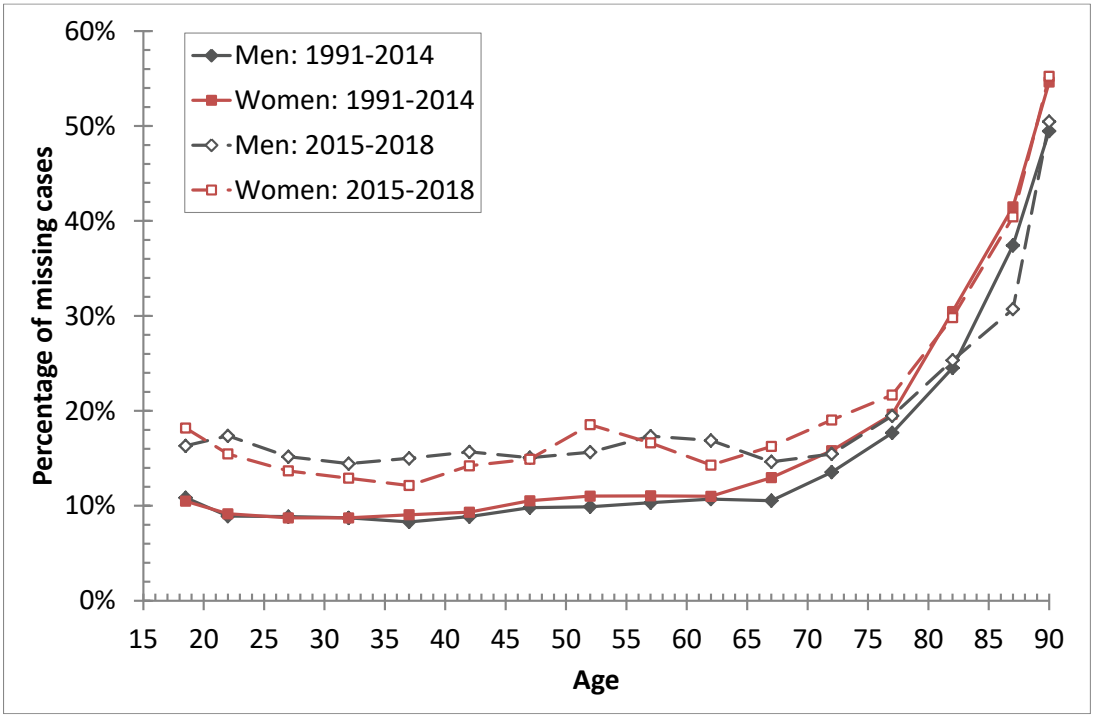

Figure 14.I.3 Overall missing percentages for each age category.

High weight and high BMI values

Figure 14.I.4 shows the percentage of cases above 130 kg (the old weight limit of the scales), while Figure 14.I.5 shows high BMI values in categories of 40 and over for men and 45 and over for women. Both charts show an increasing trend over time. The percentages of high BMI values look to be roughly a linear trend over this time interval for both men and women. The results are discussed in Section 14.2.4 of the main report.

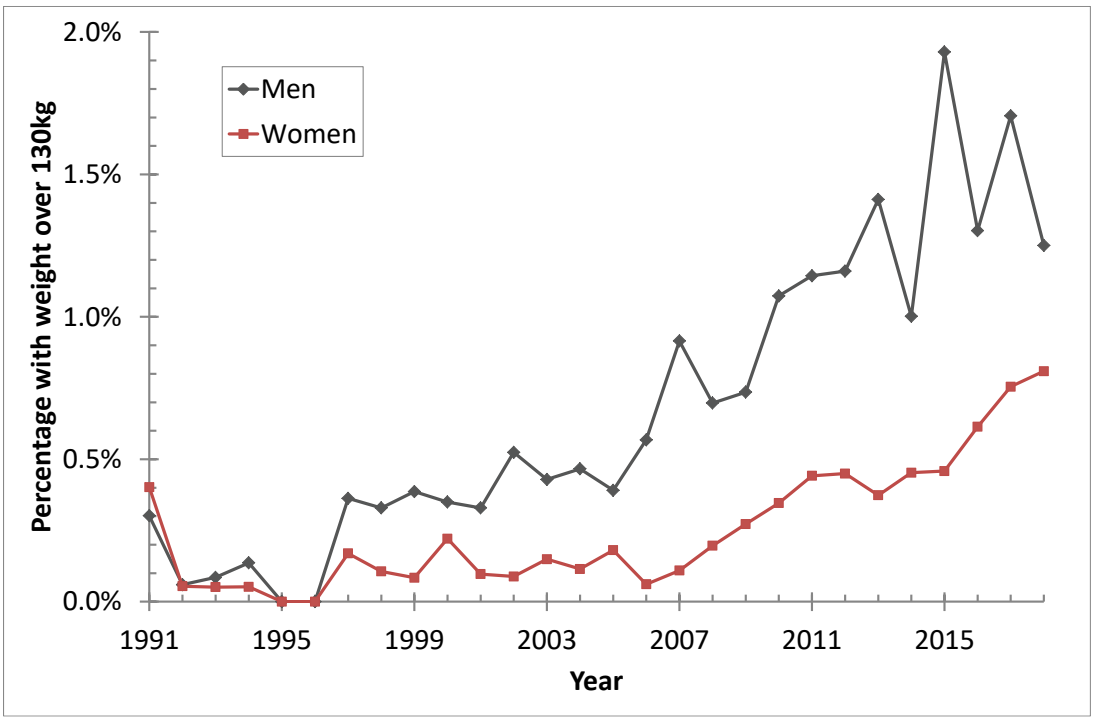

Figure 14.I.4 Percentage of cases with weight over 130 kg.

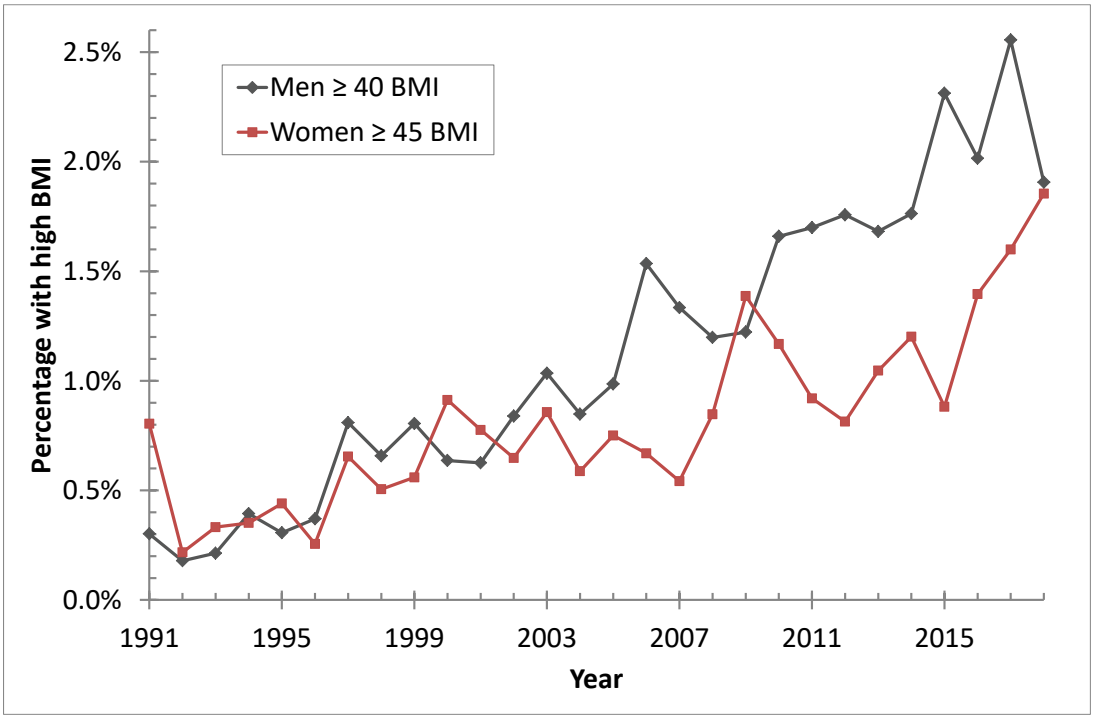

Figure 14.I.5 Percentage of high BMI values over time.

Appendix 14.II Smoothing for the 2017 distributions

Figures 14.II.1 and 14.II.2 show for 2017 the data distributions and the final smoothed distributions produced by the Savitzky-Golay smoothing method. As explained in Section 14.3 of the main report, the double smoothing version was used for 2017 where the data is smoothed first with the 11 point weights and then these values are smoothed again with the 13 point weights. The method does well in smoothing the data whilst following the general shape.

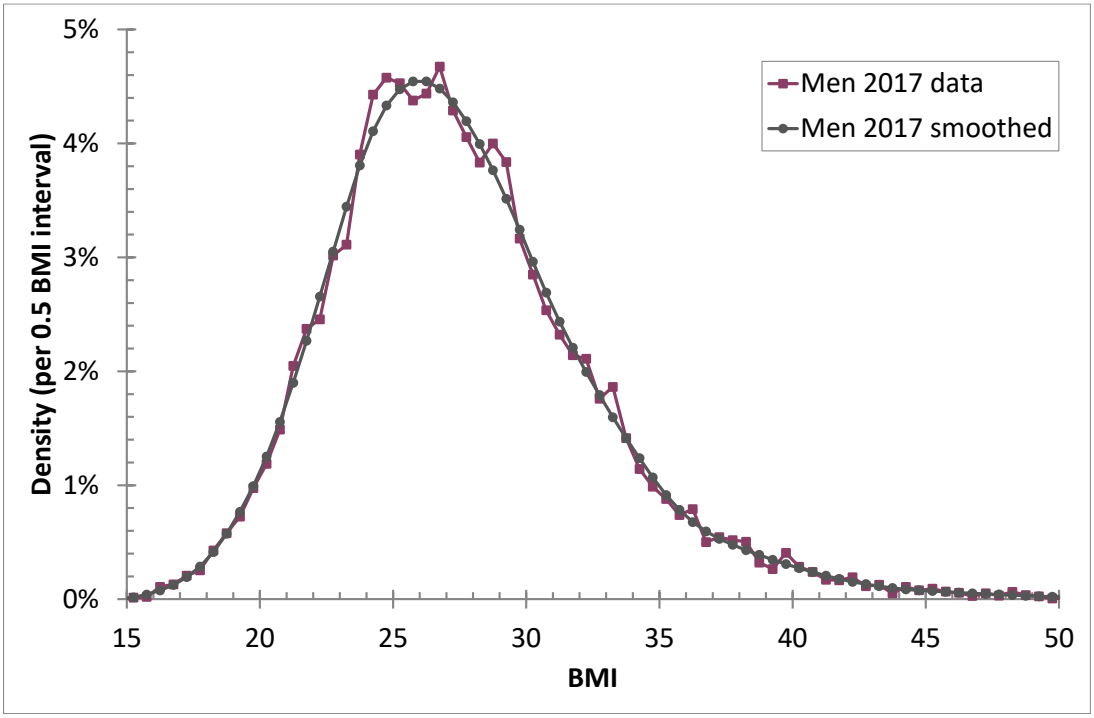

Figure 14.II.1 Data and smoothed distributions for men for 2017.

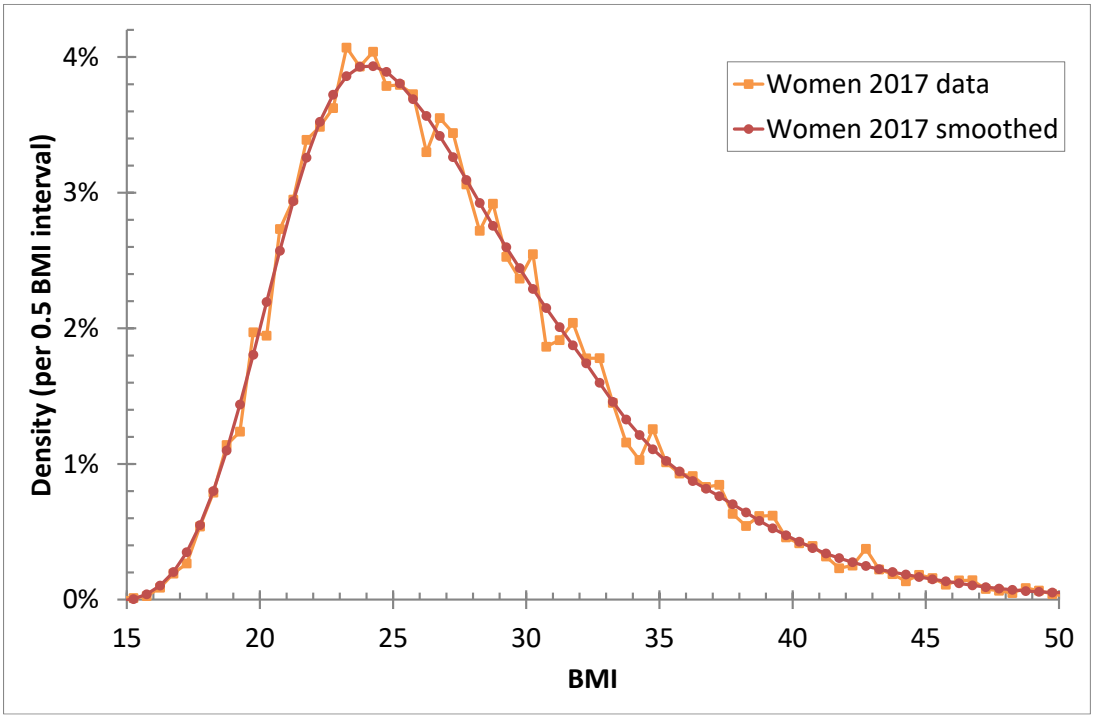

Figure 14.II.2 Data and smoothed distributions for women for 2017.

The double smoothing and the 11 point methods (used for earlier years) are compared in Figures 14.II.3 and 14.II.4. The differences are very small, particularly for the data for women, but the double smoothing was preferred as giving a smoother shape around the peak of the distribution for men. It is also slightly smoother in some parts of the right tails of the distributions.

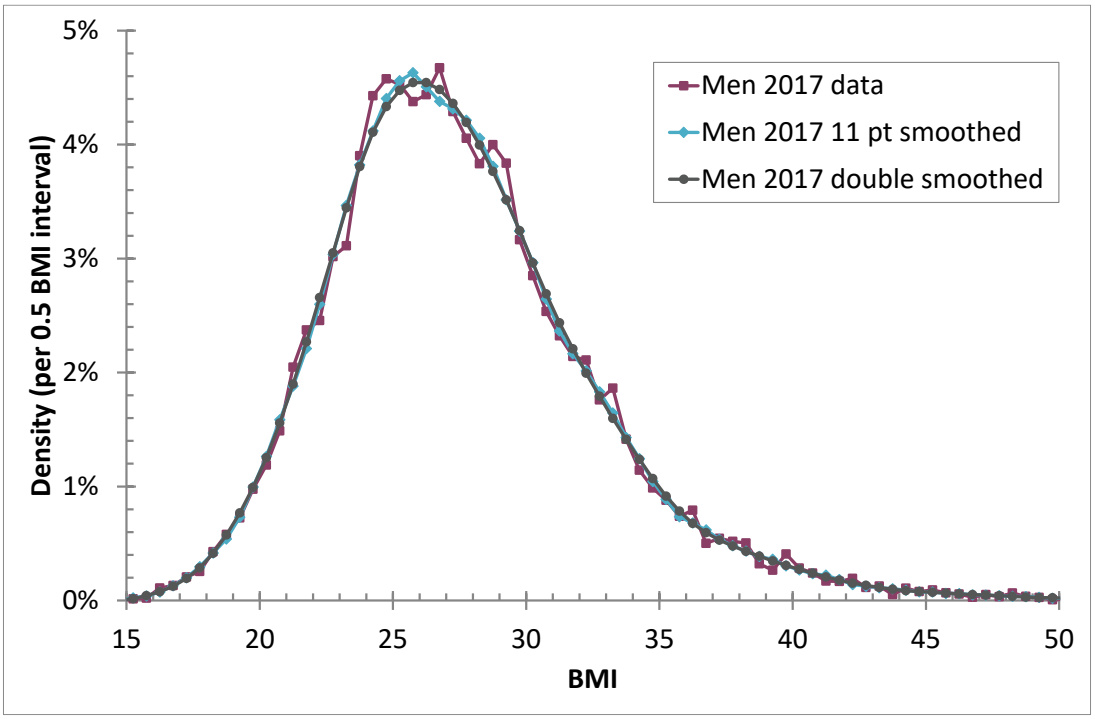

Figure 14.II.3 Data, 11 point smoothed and double smoothed distributions for men for 2017.

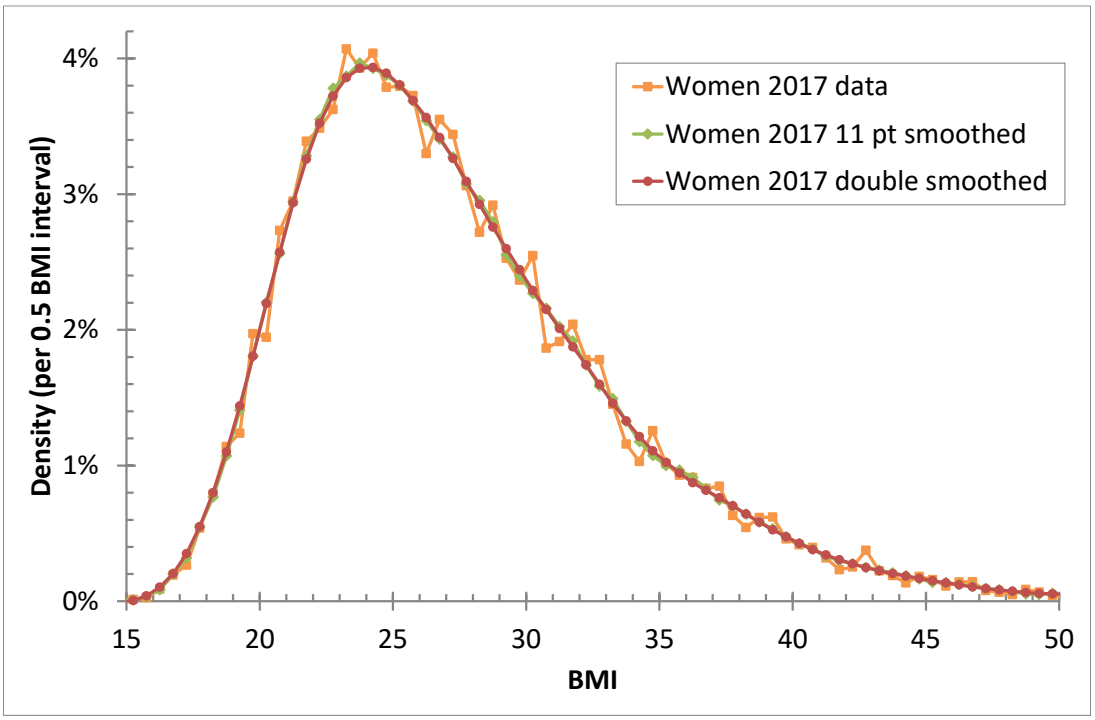

Figure 14.II.4 Data, 11 point smoothed and double smoothed distributions for women for 2017.

Appendix 14.III Analysis of the 2017 distributions

This appendix has charts and tables to accompany the analysis and discussion of the 2017 distributions in Section 14.4 of the main report. The sections in this appendix are:

- Frequency distributions and cumulative distributions
- Descriptive statistics
- Percentiles
- High BMI values
- Comparing the 1993 and 2017 distributions
- Comparing the distributions for men and women
- Tables of values for all the distributions

Frequency distributions and cumulative distributions

These charts in Figures 14.III.1-8 show the distributions, cumulative distributions, the differences between the distributions, and the difference between the cumulative distributions. These are discussed in Section 14.4.1 of the main report.

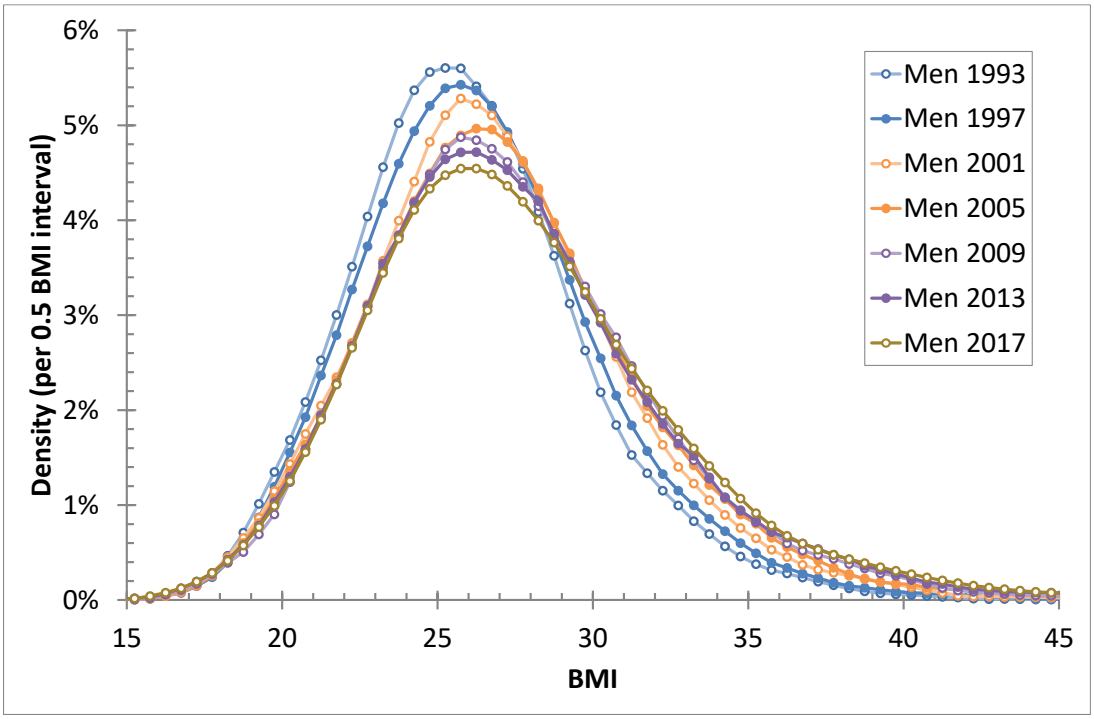

Figure 14.III.1 BMI population distributions for men for 1993 to 2017.

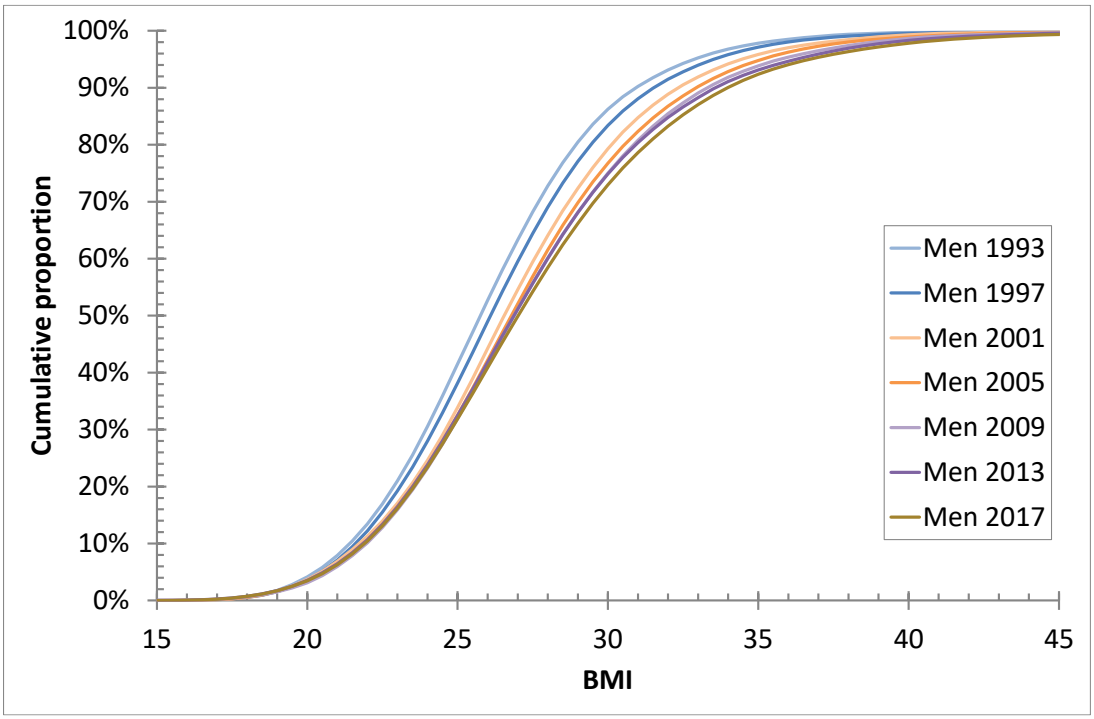

Figure 14.III.2 BMI cumulative frequency distributions for men.

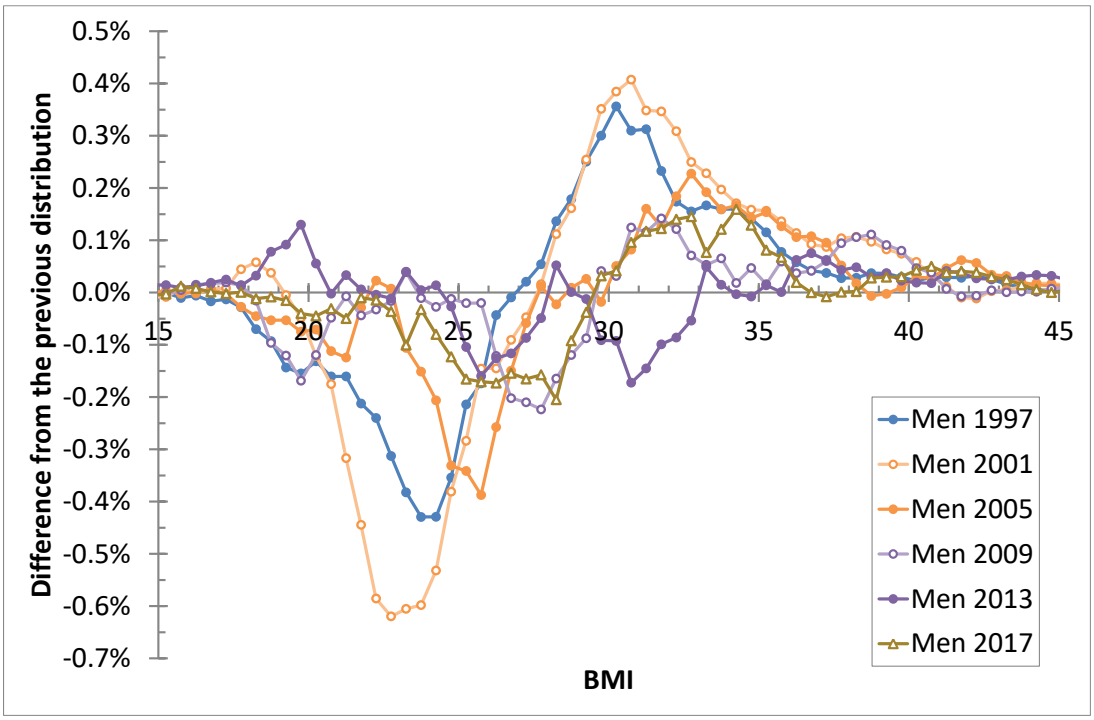

Figure 14.III.3 Difference from the previous for the distributions for men.

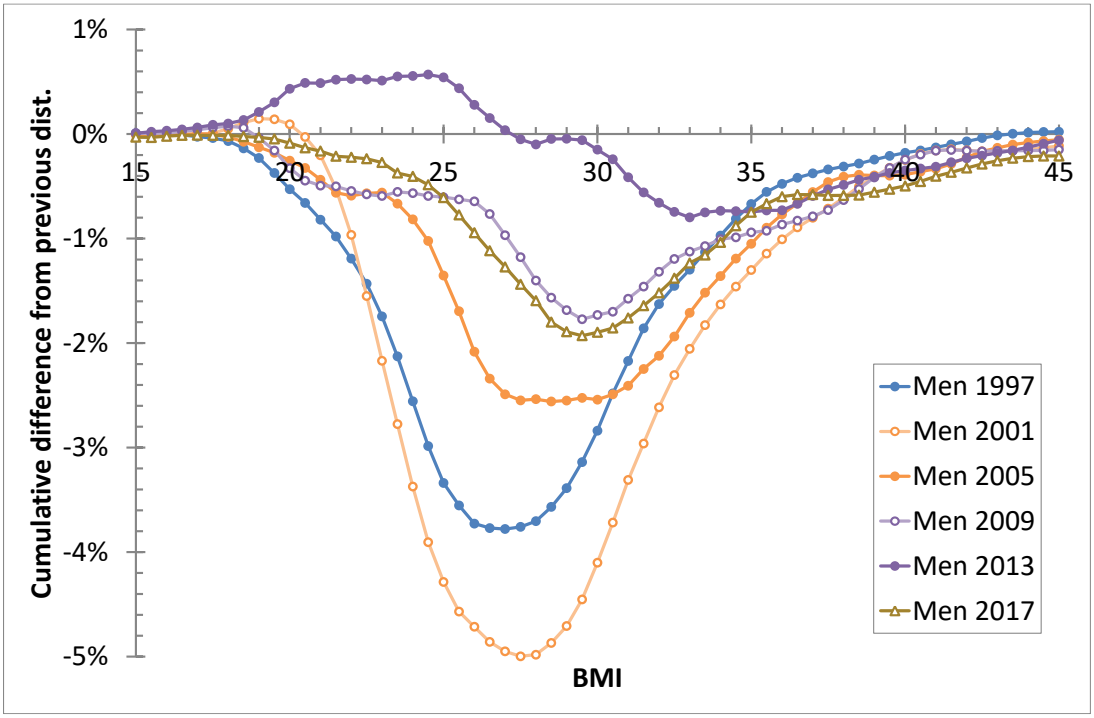

Figure 14.III.4 Difference from the previous for the cumulative distributions for men.

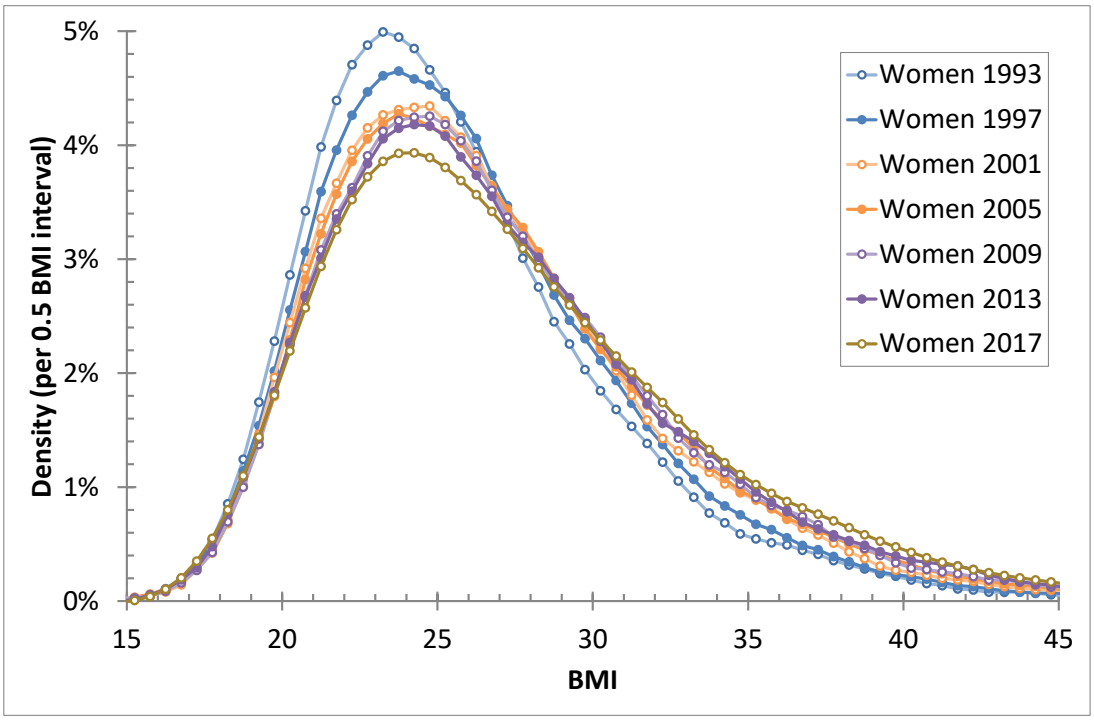

Figure 14.III.5 BMI population distributions for women for 1993 to 2017.

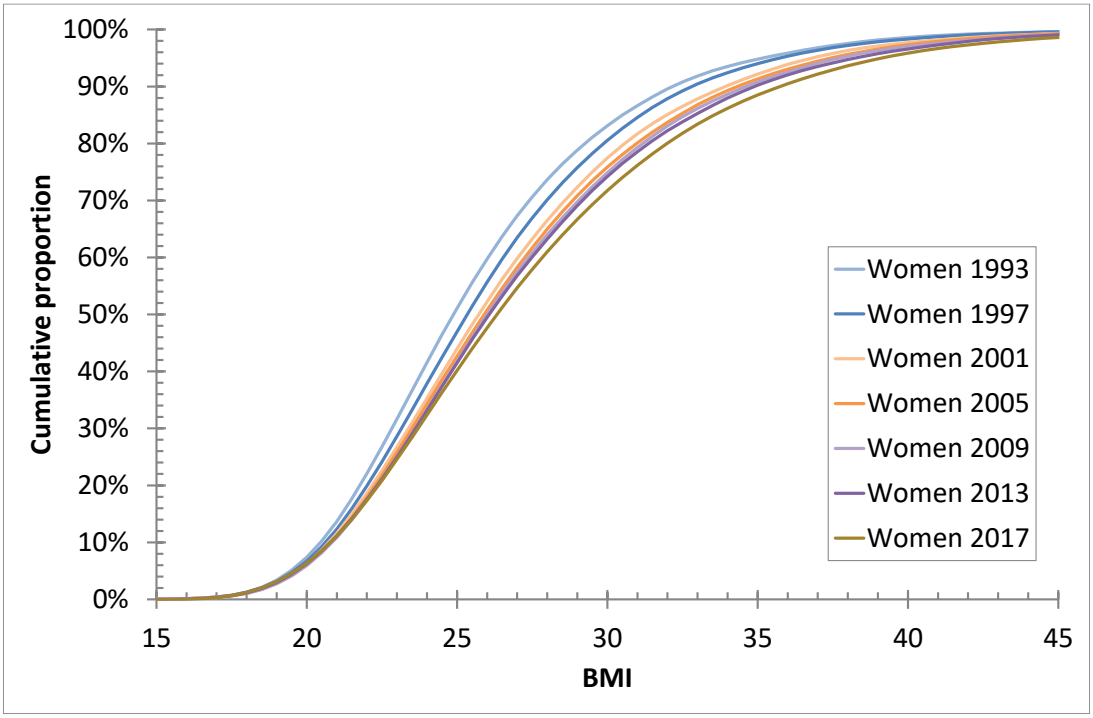

Figure 14.III.6 BMI cumulative frequency distributions for women.

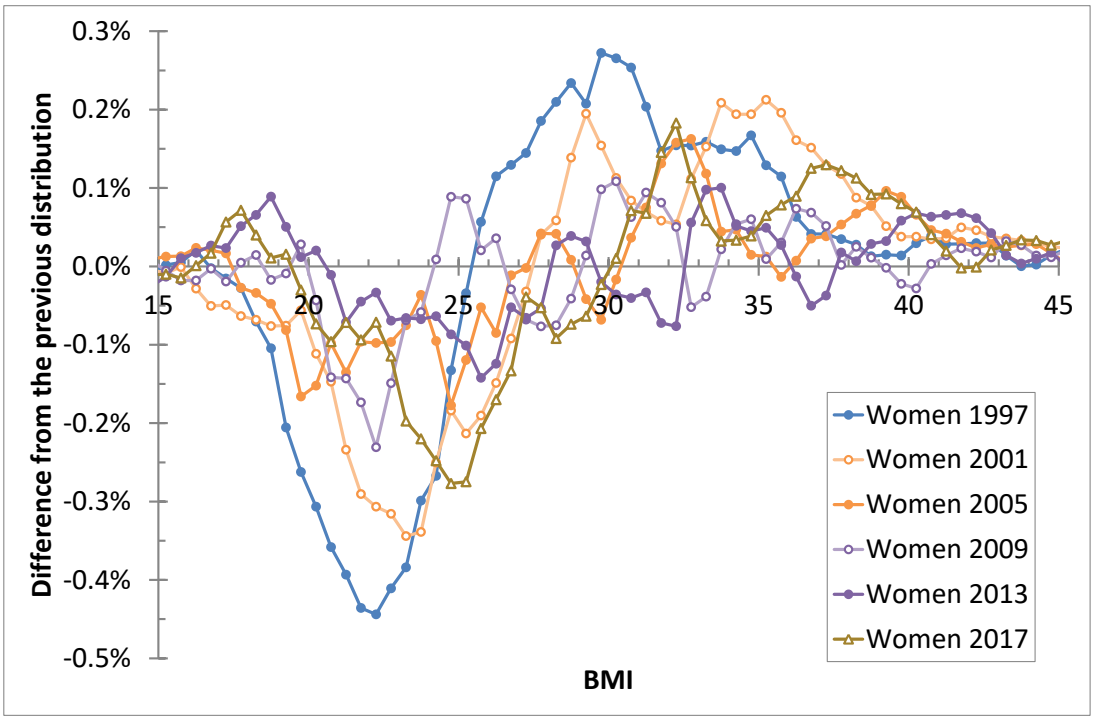

Figure 14.III.7 Difference from the previous for the distributions for women.

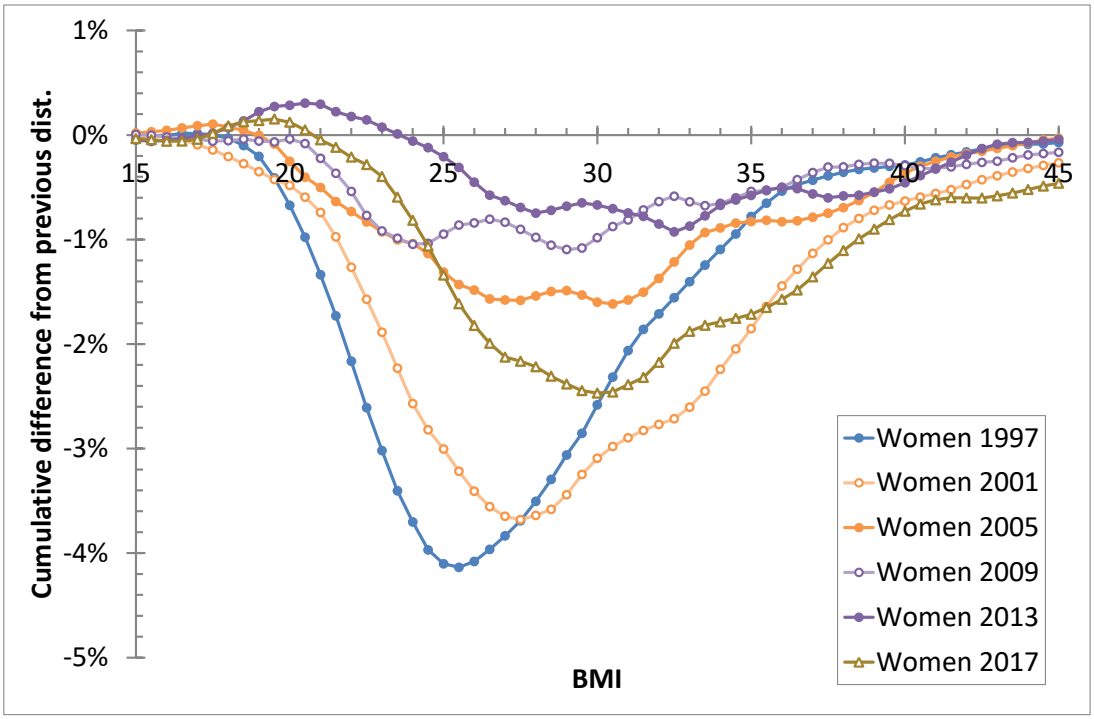

Figure 14.III.8 Difference from the previous for the cumulative distributions for women.

Descriptive statistics

The descriptive statistics are discussed in Section 14.4.2 of the main report. Tables 14.III.1 and 14.III.2 below (also given in the main report as Tables 14.2 and 14.3) show the statistics for the 2017 distributions along with those for the earlier distributions. Charts of the statistics follow the tables. Figure 14.III.9 is in the main report as Figure 14.5, but the other charts are additional to those in the report.

Table 14.III.1 Descriptive statistics for the population distributions for men.

	1993	1997	2001	2005	2009	2013	2017
Mean	26.05	26.41	26.90	27.19	27.39	27.42	27.63
Median	25.76	26.10	26.55	26.79	26.88	26.87	27.01
Modal interval mid-point	25.25	25.75	25.75	26.25	25.75	26.25	26.25
Standard deviation	3.87	4.00	4.29	4.48	4.67	4.84	5.04
Skewness	0.75	0.63	0.71	0.72	0.87	0.89	0.97
Underweight (BMI < 18.5)	1.1%	0.9%	1.0%	1.0%	1.0%	1.2%	1.1%
Healthy (18.5 ≤ BMI < 25.0)	40.4%	37.2%	32.8%	31.6%	30.9%	31.3%	30.7%
Overweight (25.0 ≤ BMI < 30.0)	44.7%	45.2%	45.4%	44.2%	43.1%	42.4%	41.1%
Obese I (30.0 ≤ BMI < 35.0)	11.6%	13.8%	16.6%	18.1%	18.8%	18.2%	19.4%
Obese II (35.0 ≤ BMI < 40.0)	1.9%	2.4%	3.4%	4.1%	4.8%	5.2%	5.5%
Severely obese (BMI ≥ 40.0)	0.3%	0.5%	0.7%	1.1%	1.3%	1.7%	2.2%

Table 14.III.2 Descriptive statistics for the population distributions for women.

	1993	1997	2001	2005	2009	2013	2017
Mean	25.76	26.18	26.65	26.88	27.03	27.13	27.47
Median	24.88	25.34	25.72	25.90	26.01	26.07	26.33
Modal interval mid-point	23.25	23.75	24.75	23.75	24.75	24.25	24.25
Standard deviation	4.95	5.04	5.38	5.54	5.63	5.77	6.13
Skewness	1.32	1.05	1.06	1.05	1.05	1.06	1.11
Underweight (BMI < 18.5)	2.1%	2.0%	1.7%	1.8%	1.7%	1.9%	2.0%
Healthy (18.5 ≤ BMI < 25.0)	49.0%	45.0%	42.2%	40.9%	40.0%	39.6%	38.2%
Overweight (25.0 ≤ BMI < 30.0)	32.0%	33.6%	33.5%	33.2%	33.1%	32.7%	31.6%
Obese I (30.0 ≤ BMI < 35.0)	11.7%	13.5%	14.7%	15.5%	15.9%	16.0%	16.8%
Obese II (35.0 ≤ BMI < 40.0)	3.8%	4.3%	5.5%	6.0%	6.2%	6.4%	7.3%
Severely obese (BMI ≥ 40.0)	1.4%	1.7%	2.3%	2.7%	3.0%	3.4%	4.1%

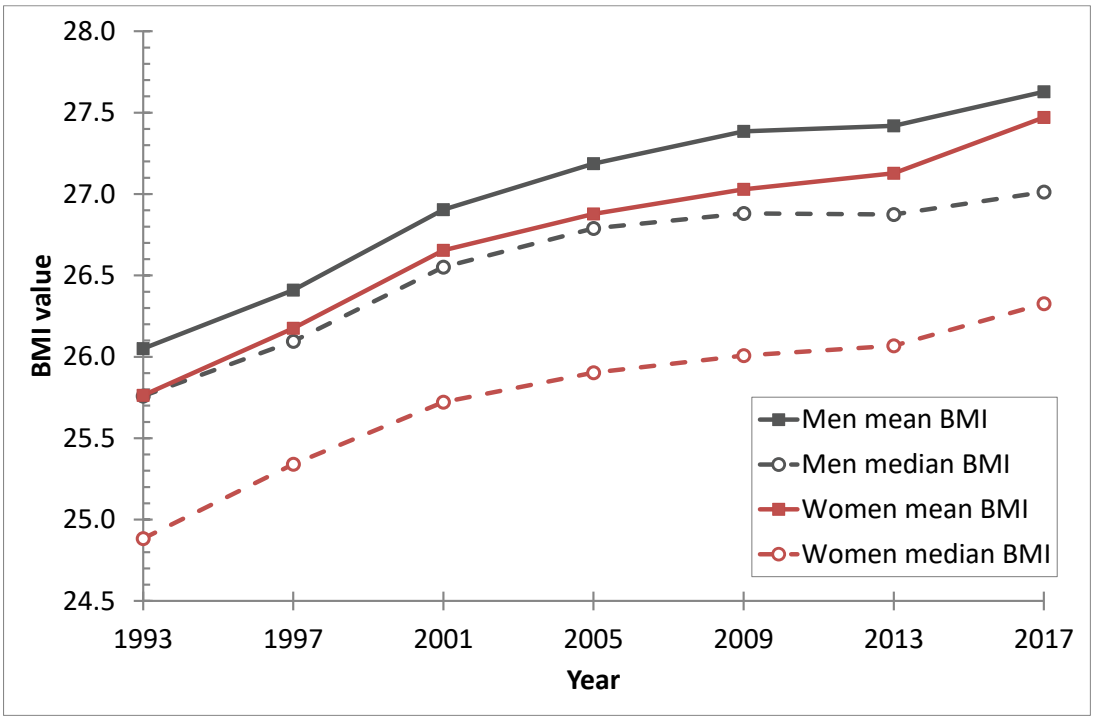

Figure 14.III.9 Mean and median values for the BMI distributions.

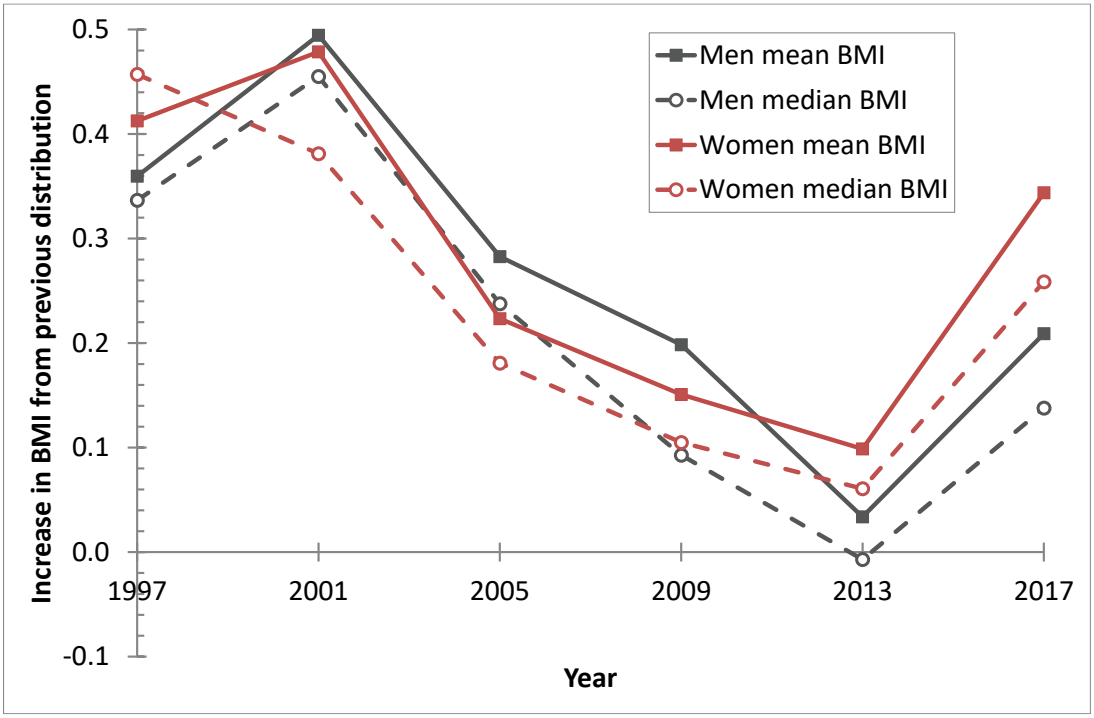

Figure 14.III.10 Increases in the mean and median values for the BMI distributions.

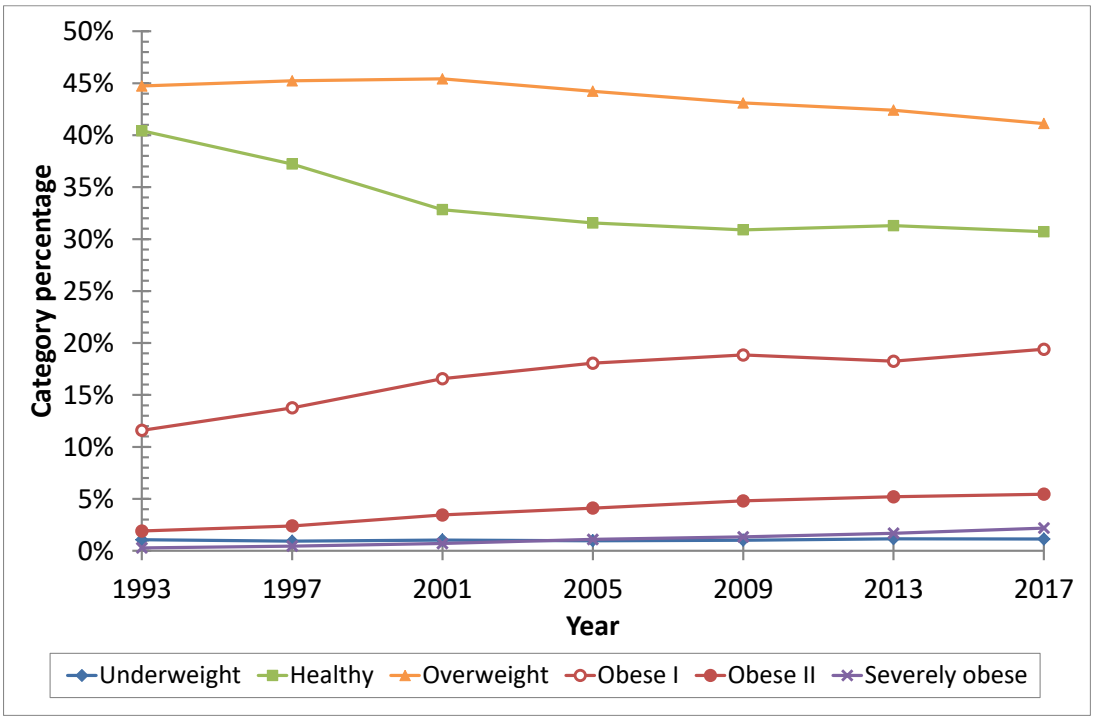

Figure 14.III.11 BMI category percentages for men for the BMI distributions.

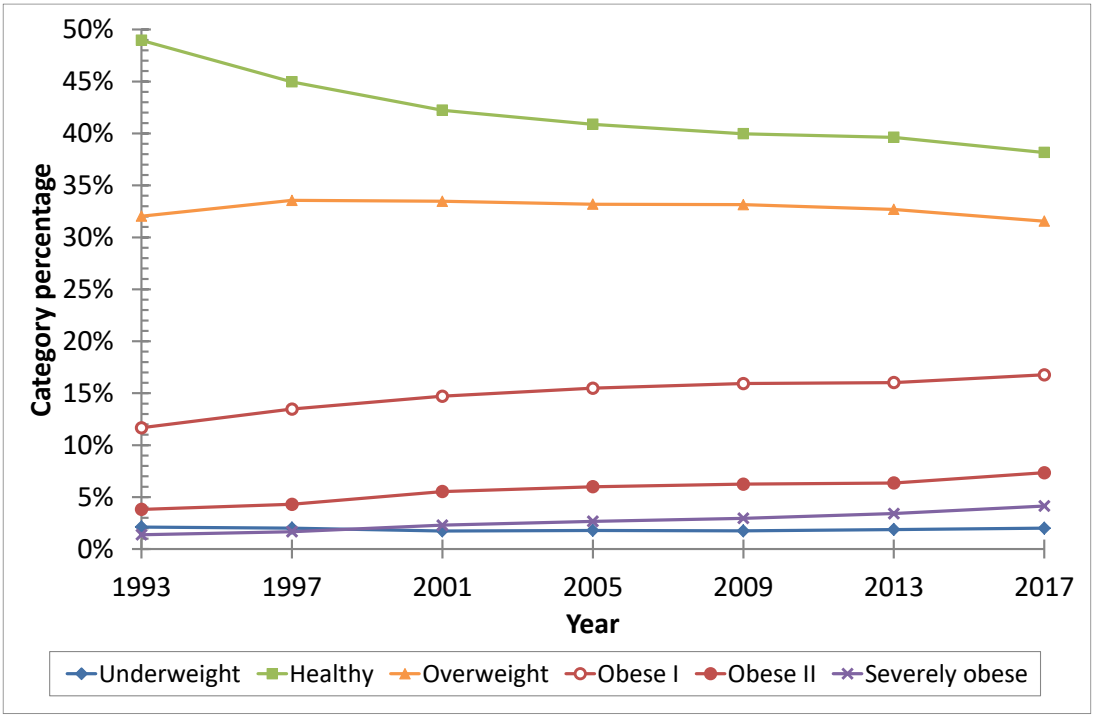

Figure 14.III.12 BMI category percentages for women for the BMI distributions.

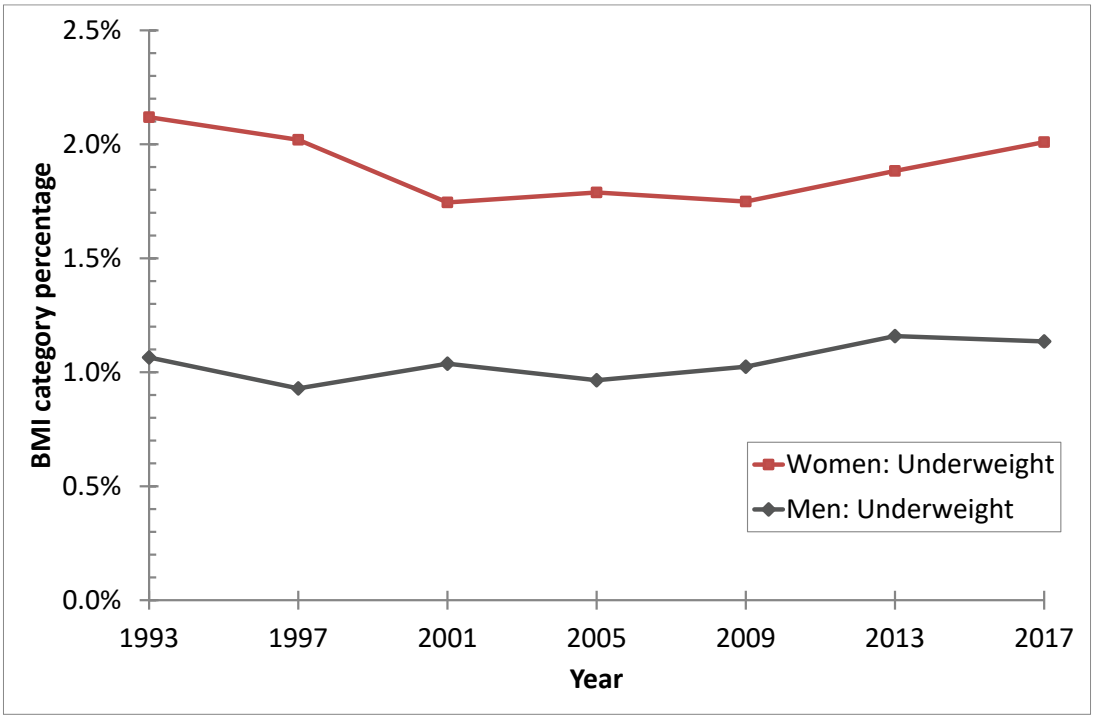

Figure 14.III.13 Underweight category percentages for the BMI distributions.

Figure 14.III.14 Healthy category percentages for the BMI distributions.

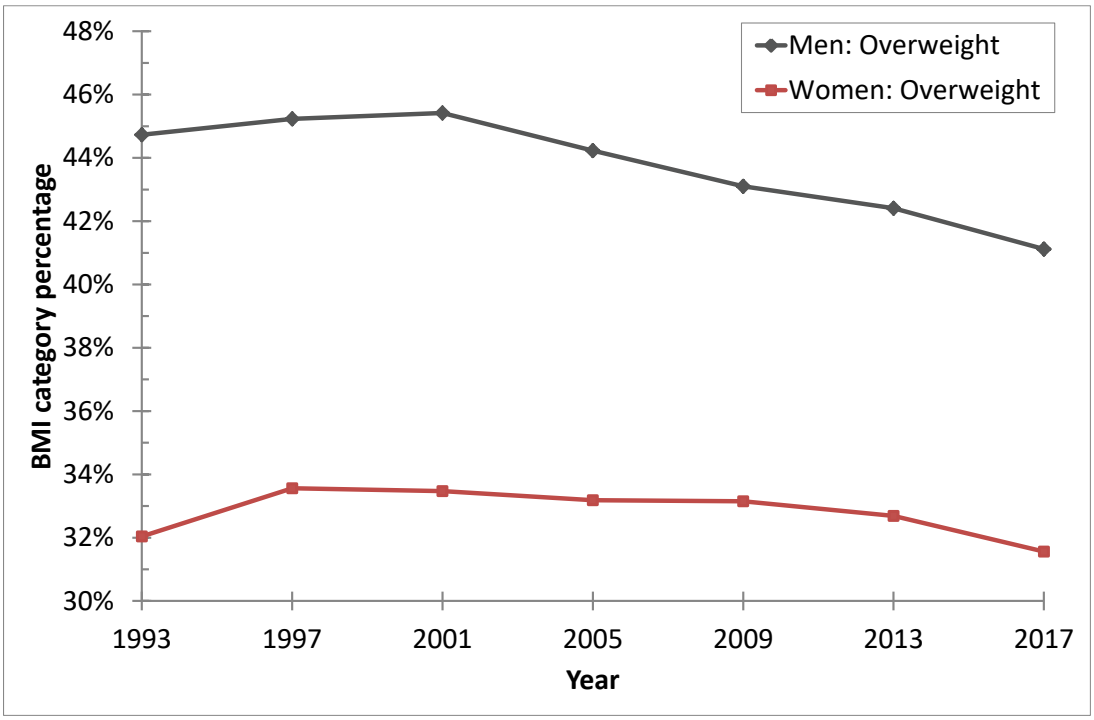

Figure 14.III.15 Overweight category percentages for the BMI distributions.

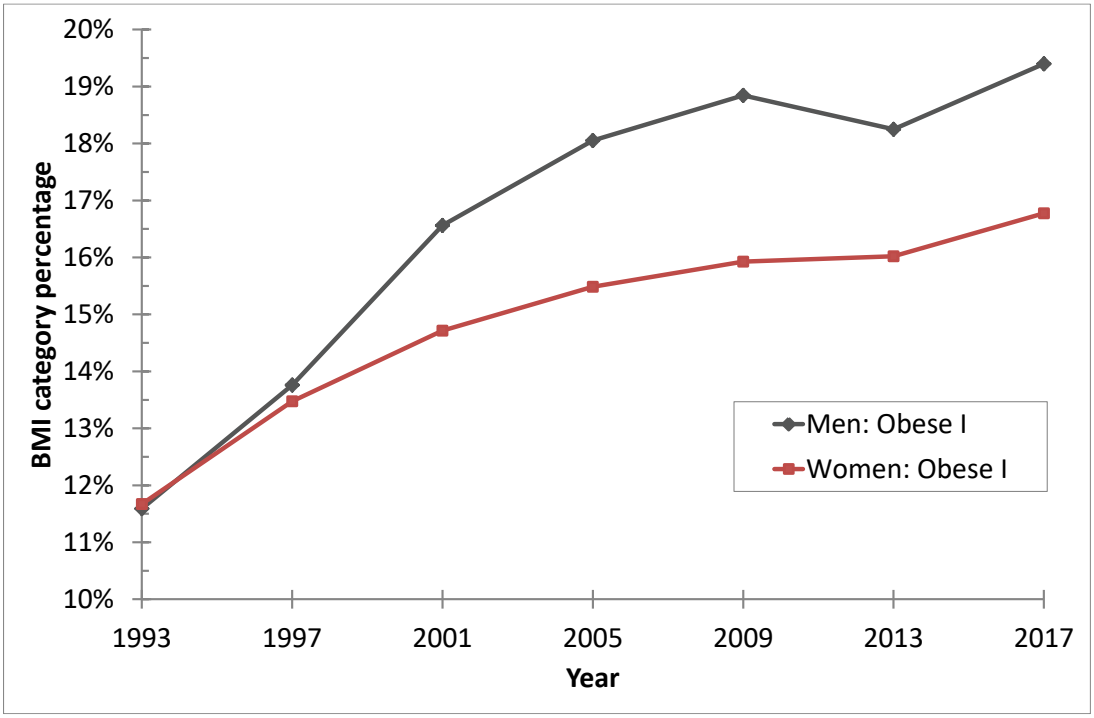

Figure 14.III.16 Obese I category percentages for the BMI distributions.

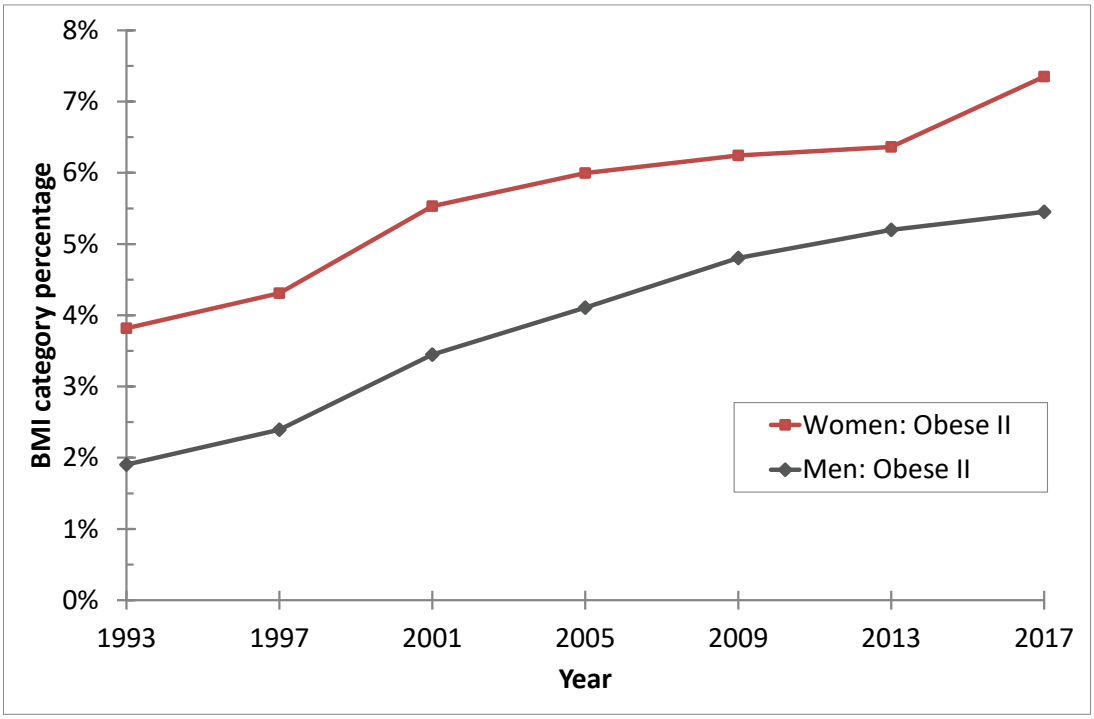

Figure 14.III.17 Obese II category percentages for the BMI distributions.

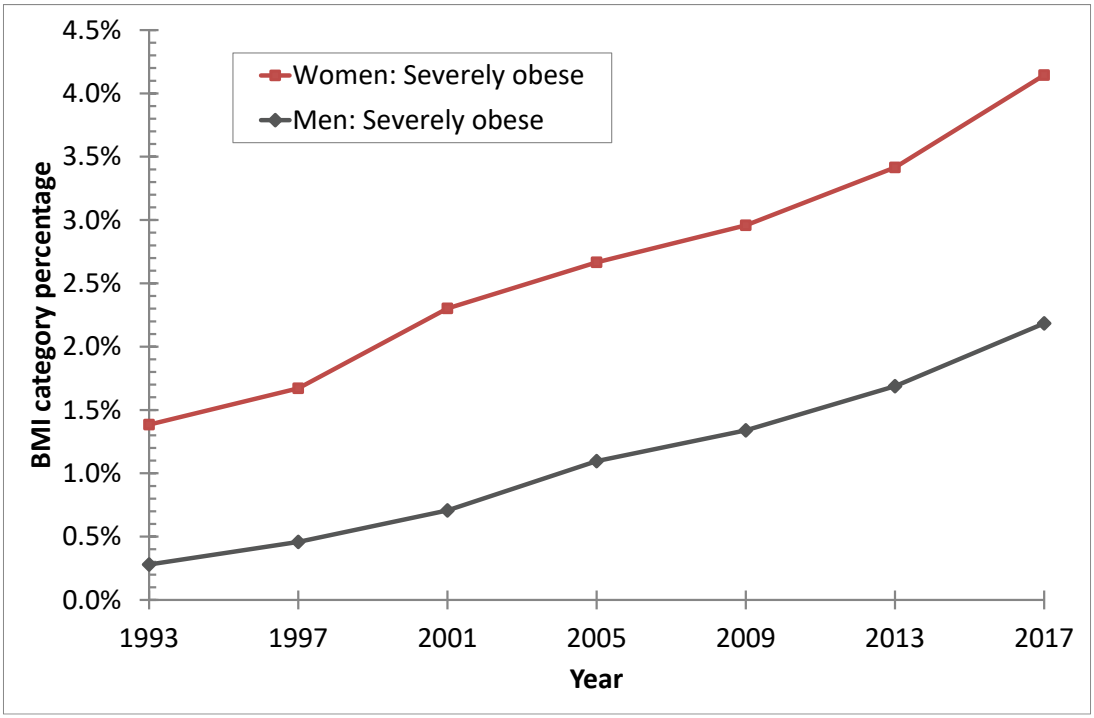

Figure 14.III.18 Severely obese category percentages for the BMI distributions.

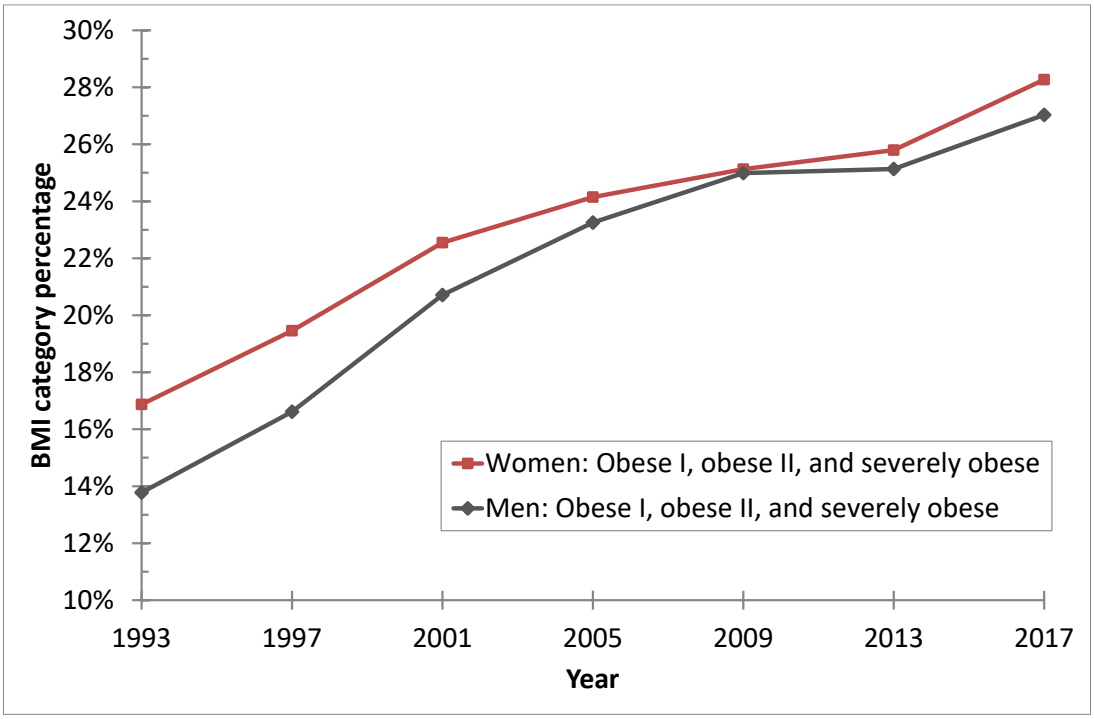

Figure 14.III.19 Total of the obese category percentages for the BMI distributions.

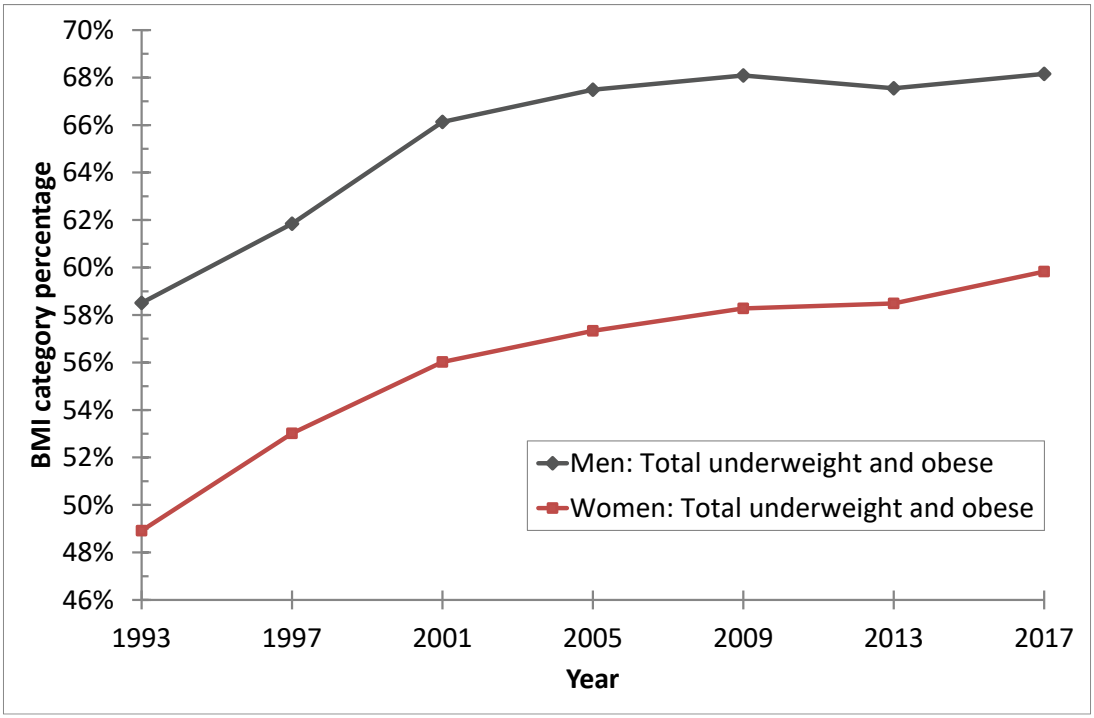

Figure 14.III.20 Total of underweight and obese category percentages for the BMI distributions.

Percentiles

These charts show the total increases in the percentile values for each year from the initial 1993 values. The lower percentiles change very little whereas the higher percentiles have progressively larger increases. The results for the percentiles are discussed in Section 14.4.3 of the main report.

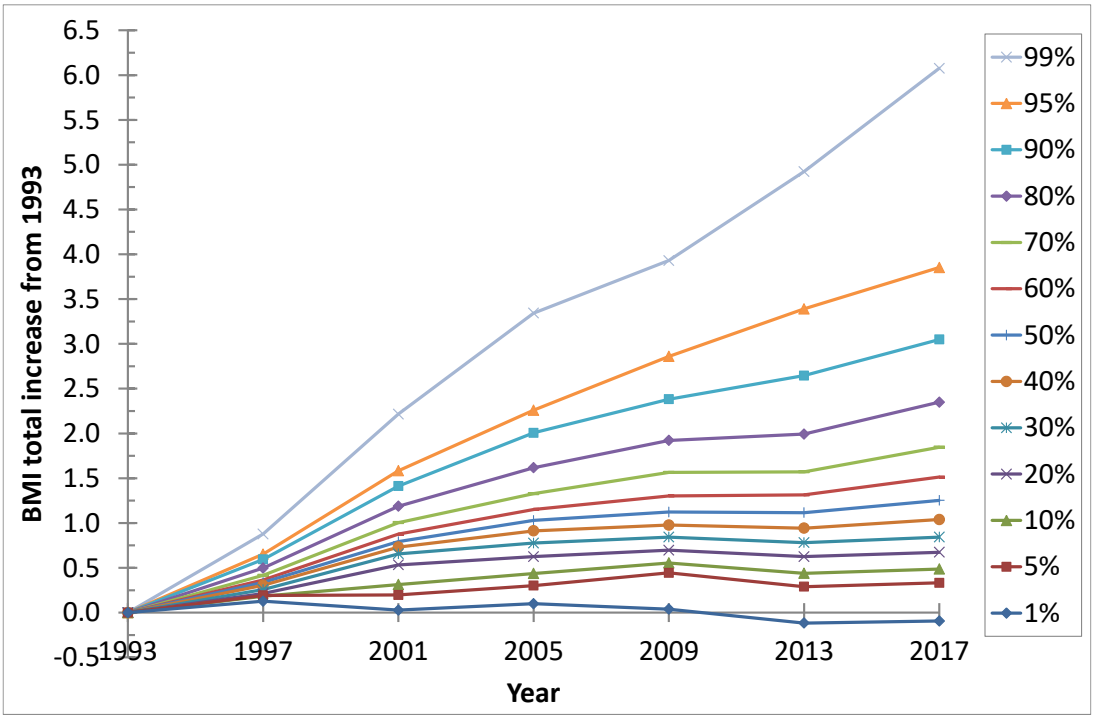

Figure 14.III.21 Total increases in BMI since 1993 for the percentile values for men.

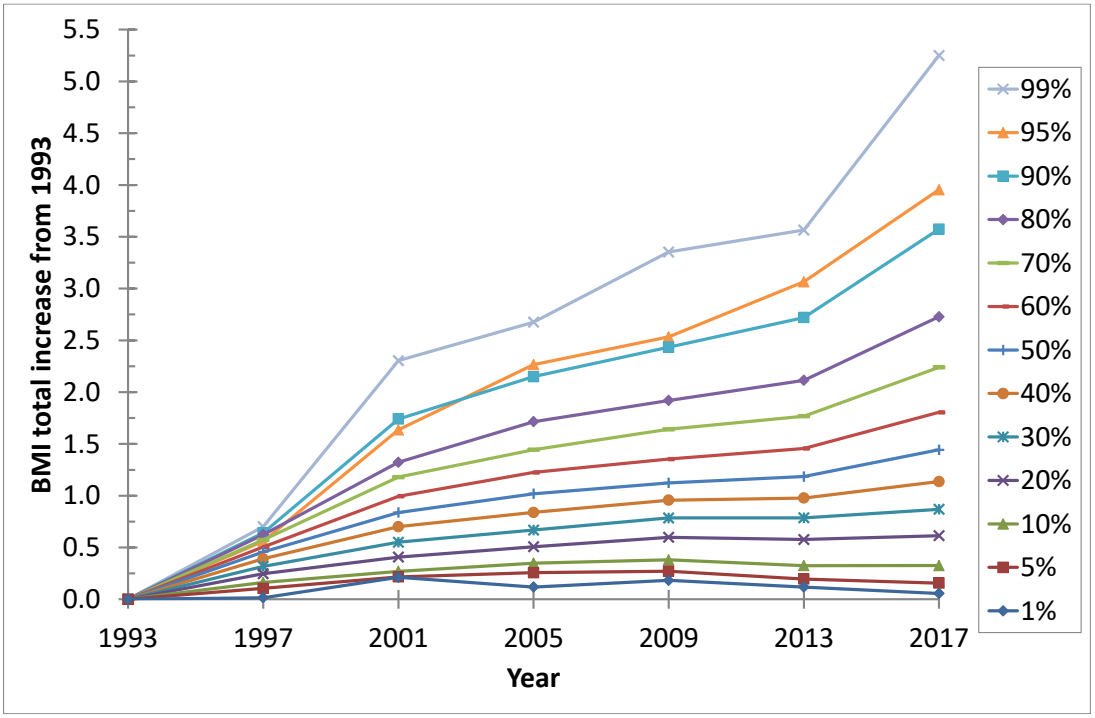

Figure 14.III.22 Total increases in BMI since 1993 for the percentile values for women.

High BMI values

High BMI values are discussed in Section 14.4.4 of the main report. The cut-off values used are 38.6 for men and 41.3 for women, giving about 2.5% prevalence in 2013. The charts here show the prevalence in age categories. The patterns are quite similar for each year and generally the high BMI values are most common for ages 40s, 50s and 60s. There are some irregularities with the fairly small sample sizes but the prevalence usually increases from one year to the next for the age categories, including for most of the age categories from 2013 to 2017.

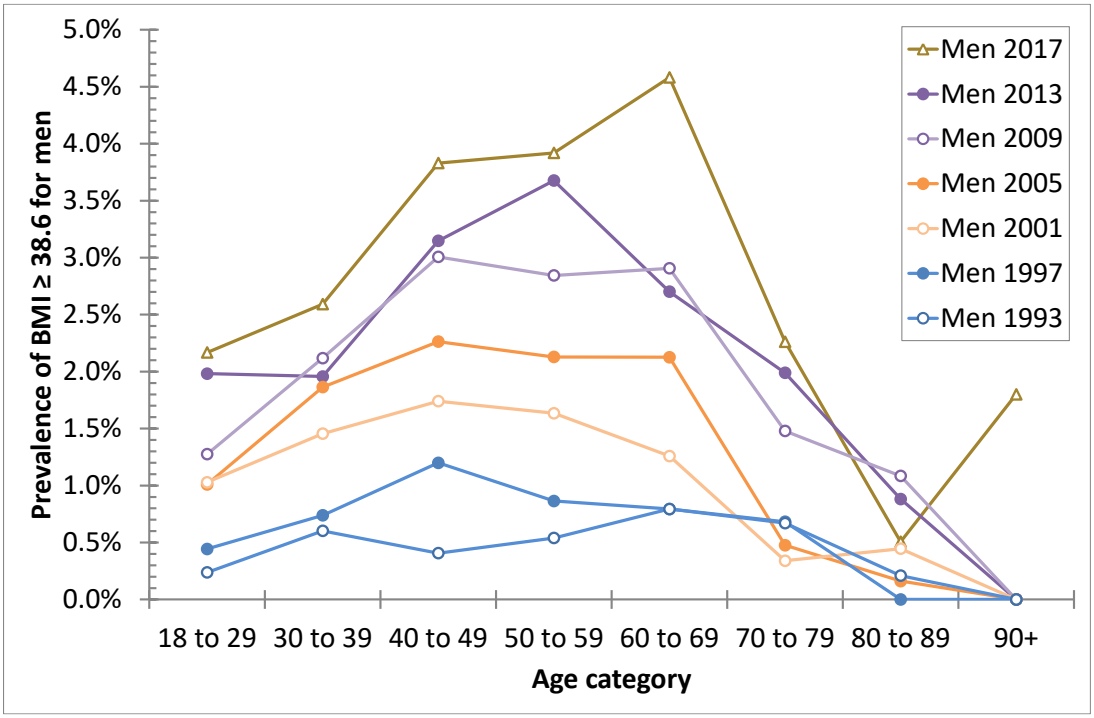

Figure 14.III.23 Percentage of high BMI values in different age groups for men.

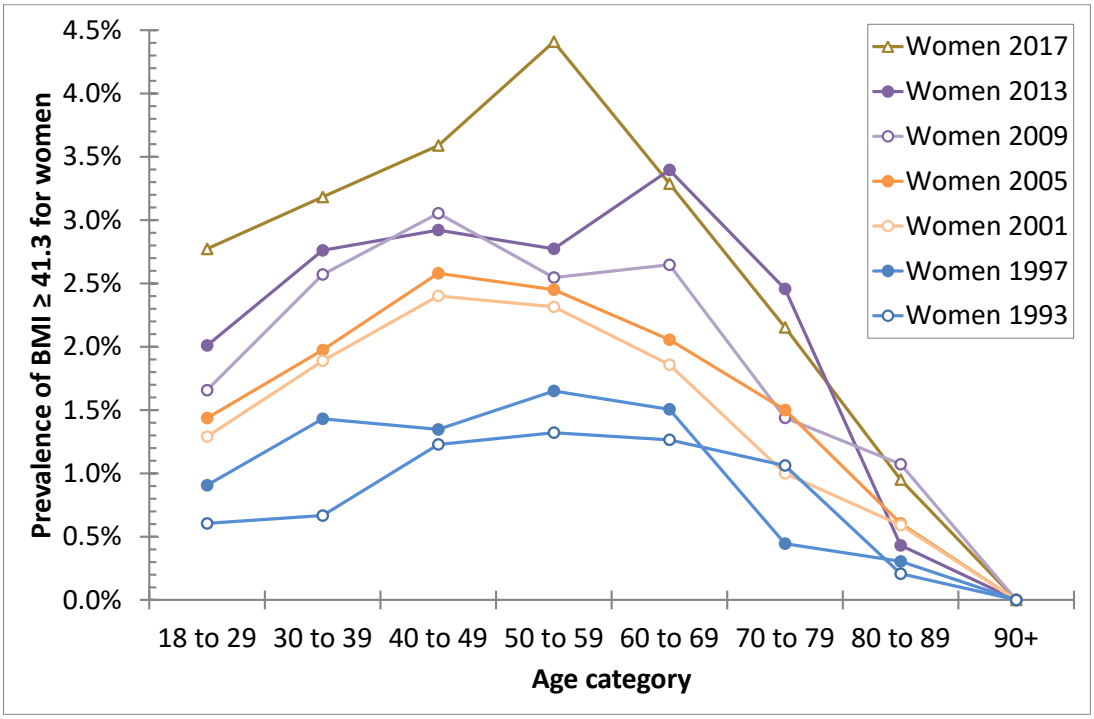

Figure 14.III.24 Percentage of high BMI values in different age groups for women.

Comparing the 1993 and 2017 distributions

This section contains charts on the comparison between the distributions for 1993 and 2017. This accompanies the analysis and discussion in Section 14.4.5 of the main report. Figure 14.III.25 plots the differences between 1993 and 2017 distributions. The percentile increases are given in Section 14.4.5 as BMI values and as weights (Figures 14.14-16). Figure 14.III.26 shows them as percentage increases.

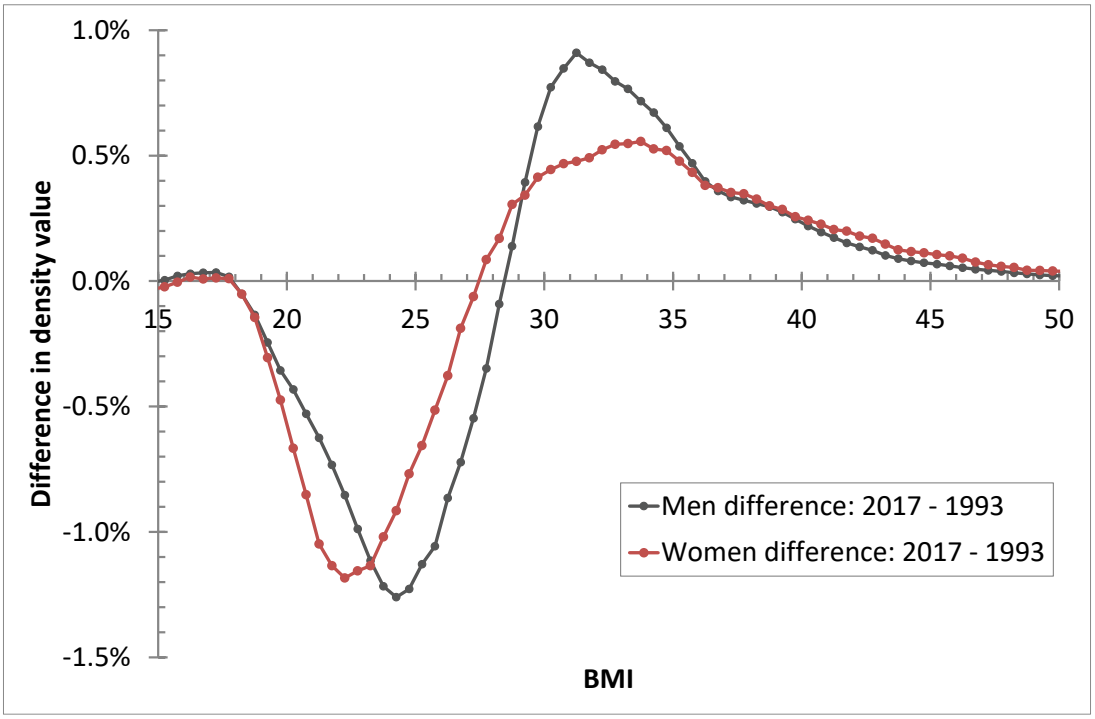

Figure 14.III.25 Differences in the distributions between 2017 and 1993.

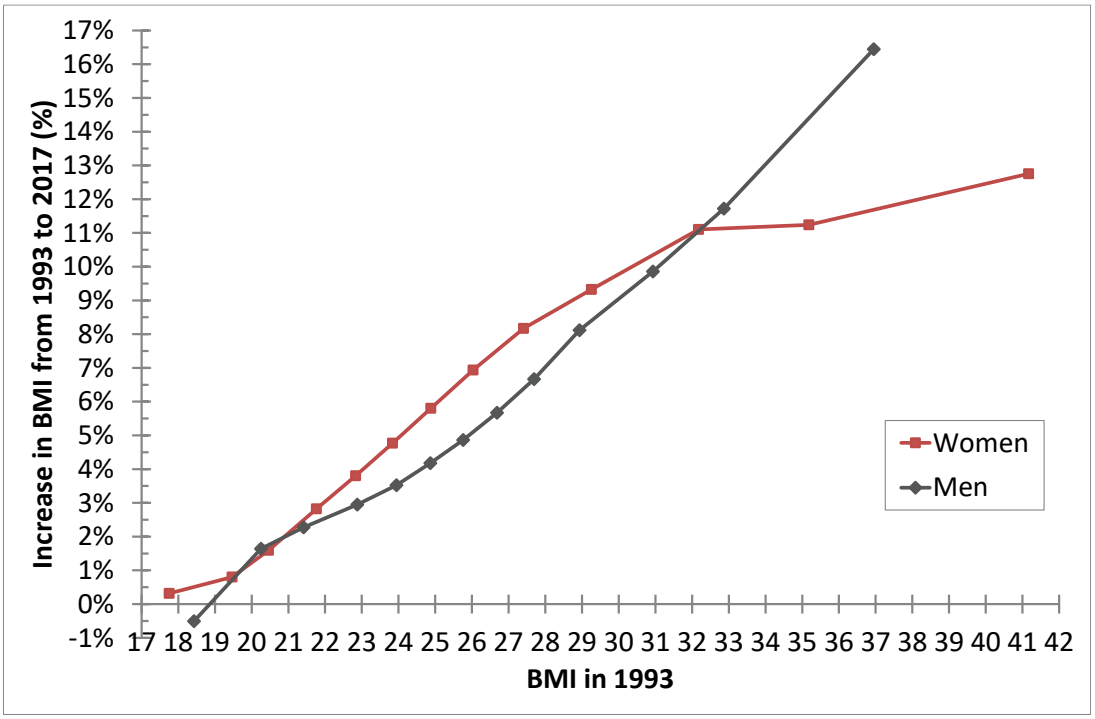

Figure 14.III.26 Percentage percentile increases from 1993 to 2017 for men and women.

Figures 14.III.27 and 14.III.28 are bar charts of the category percentages for 1993 and 2017, for men and women respectively. The values are in Tables 14.III.1 and 14.III.2 (and Tables 14.2 and 14.3 of the main report). Along with the charts of the actual distributions in Figure 14.13 of the main report this emphasises the large changes from 1993 to 2017. The differences in each category are given in Table 14.4 of the main report.

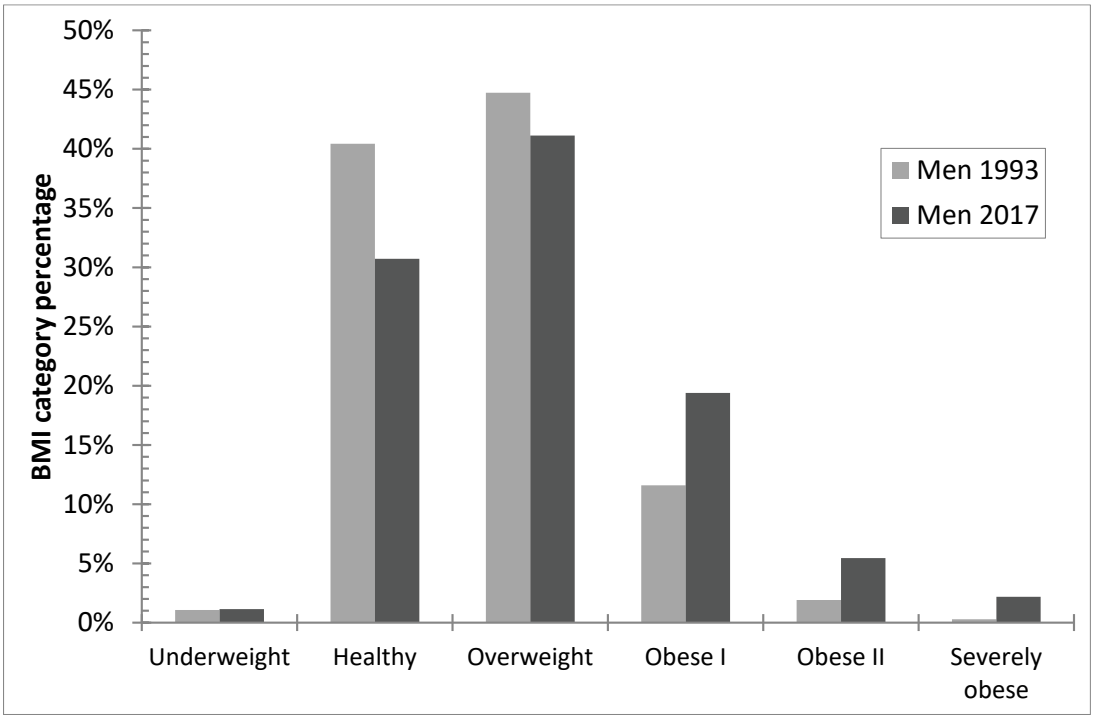

Figure 14.III.27 Bar chart of category percentages for the 1993 and 2017 distributions for men.

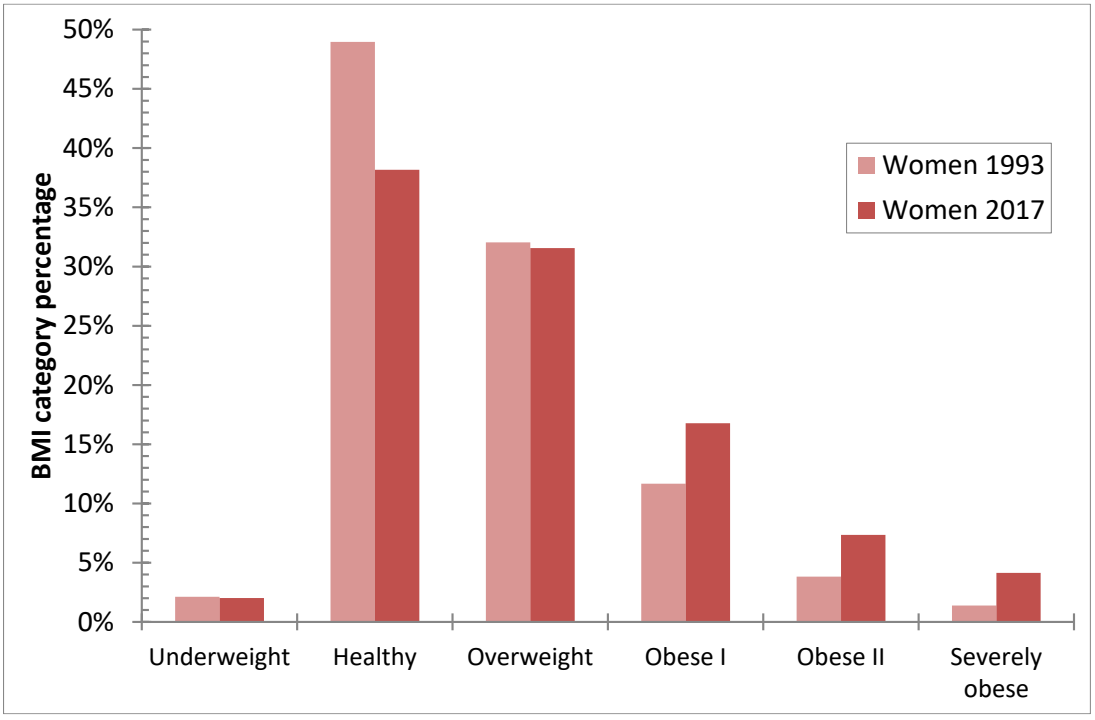

Figure 14.III.28 Bar chart of category percentages for the 1993 and 2017 distributions for women.

Comparing the distributions for men and women

The chart here looks at how the shapes of the BMI distributions differ for men and women, as discussed in Section 14.4.6 of the main report. The chart in Figure 14.III.29 plots the values for each 0.5 BMI interval of the distribution percentage for women minus the distribution percentage for men. This is done for the 1993 and the 2017 distributions. It is the differences between the distributions in Figure 14.13 of the main report. The differences are very similar for 1993 and 2017. The percentages are higher for women than for men for the lower BMI values up to a BMI of 23.5 for 1993 and 24.0 for 2017. The percentages are also higher in the right tail of the distributions above 31.0 for 1993 and 34.5 for 2017. In between the percentages are higher for the distributions for men. The total differences in the percentages within these intervals are given in Table 14.7 of the main report. As shown in Table 14.7, for 2017 the total percentage differences for the three intervals are 8.9%, -12.8%, and 3.9%.

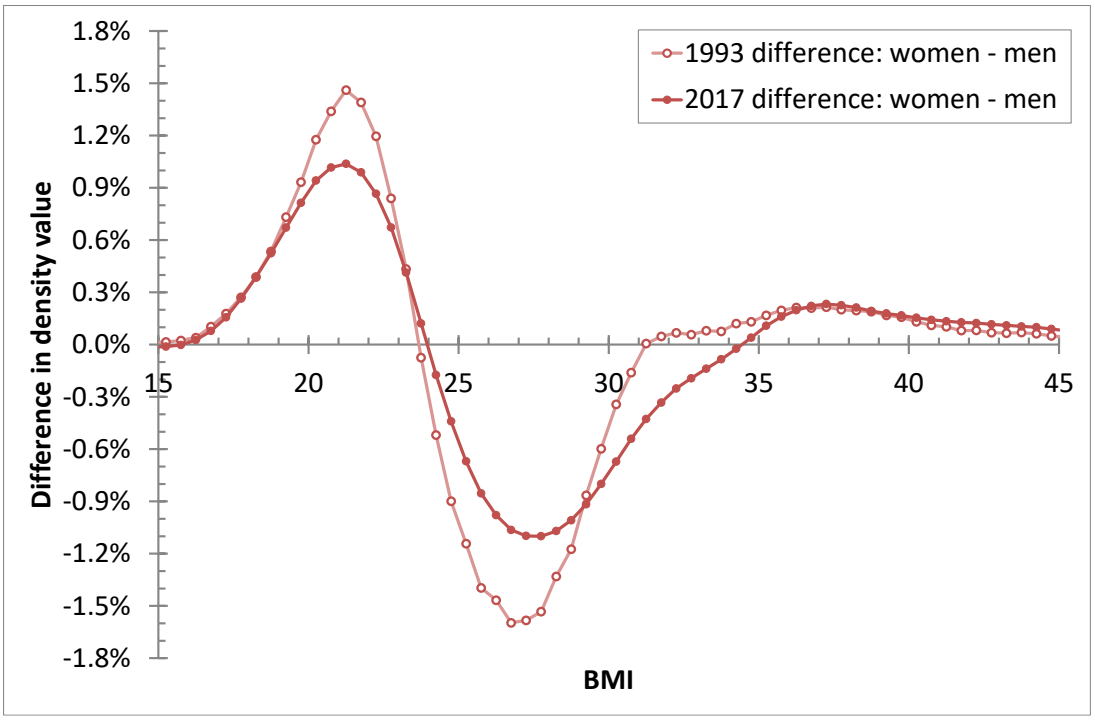

Figure 14.III.29 Differences between the distributions for women and men.

Tables of values for all the distributions

Tables 14.III.3 and 14.III.4 give the values for population BMI distributions for 1993, 1997, 2001, 2005, 2009, 2013, and 2017 for men and for women that are plotted in Figure 14.III.1 and Figure 14.III.5 (and Figure 14.3 and Figure 14.4 in the main report). These tables give each 0.5 BMI interval between BMI values of 10 and 70, and show the percentage frequency values to two decimal places. The method for producing the distributions is explained in Chapters 2 and 3 of the main report.

Table 14.III.3 Table of values for the population distributions for men.

BMI Interval	1993	1997	2001	2005	2009	2013	2017
10.0 ≤ BMI < 10.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10.5 ≤ BMI < 11.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11.0 ≤ BMI < 11.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11.5 ≤ BMI < 12.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12.0 ≤ BMI < 12.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12.5 ≤ BMI < 13.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13.0 ≤ BMI < 13.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13.5 ≤ BMI < 14.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
14.0 ≤ BMI < 14.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
14.5 ≤ BMI < 15.0	0.01%	0.01%	0.00%	0.00%	-0.01%	0.01%	0.00%
15.0 ≤ BMI < 15.5	0.01%	0.01%	0.00%	0.01%	0.00%	0.02%	0.02%
15.5 ≤ BMI < 16.0	0.02%	0.01%	0.02%	0.02%	0.02%	0.03%	0.04%
16.0 ≤ BMI < 16.5	0.05%	0.04%	0.04%	0.04%	0.06%	0.07%	0.08%
16.5 ≤ BMI < 17.0	0.09%	0.08%	0.08%	0.09%	0.10%	0.12%	0.12%
17.0 ≤ BMI < 17.5	0.16%	0.15%	0.15%	0.15%	0.17%	0.20%	0.19%
17.5 ≤ BMI < 18.0	0.27%	0.24%	0.29%	0.26%	0.27%	0.29%	0.29%
18.0 ≤ BMI < 18.5	0.47%	0.39%	0.45%	0.41%	0.39%	0.42%	0.41%
18.5 ≤ BMI < 19.0	0.71%	0.62%	0.65%	0.60%	0.51%	0.58%	0.57%
19.0 ≤ BMI < 19.5	1.01%	0.87%	0.86%	0.81%	0.69%	0.78%	0.77%
19.5 ≤ BMI < 20.0	1.35%	1.19%	1.15%	1.07%	0.90%	1.03%	0.99%
20.0 ≤ BMI < 20.5	1.68%	1.55%	1.43%	1.36%	1.24%	1.30%	1.25%
20.5 ≤ BMI < 21.0	2.09%	1.92%	1.75%	1.64%	1.59%	1.59%	1.56%
21.0 ≤ BMI < 21.5	2.52%	2.36%	2.05%	1.92%	1.92%	1.95%	1.90%
21.5 ≤ BMI < 22.0	3.00%	2.79%	2.35%	2.32%	2.27%	2.28%	2.27%
22.0 ≤ BMI < 22.5	3.51%	3.27%	2.69%	2.71%	2.68%	2.67%	2.66%
22.5 ≤ BMI < 23.0	4.04%	3.73%	3.11%	3.11%	3.10%	3.09%	3.05%
23.0 ≤ BMI < 23.5	4.56%	4.18%	3.57%	3.47%	3.51%	3.55%	3.45%
23.5 ≤ BMI < 24.0	5.02%	4.59%	4.00%	3.85%	3.83%	3.84%	3.81%
24.0 ≤ BMI < 24.5	5.37%	4.94%	4.41%	4.20%	4.17%	4.19%	4.11%
24.5 ≤ BMI < 25.0	5.56%	5.21%	4.82%	4.49%	4.48%	4.46%	4.33%
25.0 ≤ BMI < 25.5	5.60%	5.39%	5.11%	4.77%	4.74%	4.64%	4.48%
25.5 ≤ BMI < 26.0	5.60%	5.43%	5.28%	4.89%	4.87%	4.71%	4.54%
26.0 ≤ BMI < 26.5	5.41%	5.37%	5.22%	4.96%	4.84%	4.72%	4.54%
26.5 ≤ BMI < 27.0	5.20%	5.20%	5.10%	4.96%	4.75%	4.64%	4.48%
27.0 ≤ BMI < 27.5	4.91%	4.93%	4.88%	4.82%	4.61%	4.53%	4.36%
27.5 ≤ BMI < 28.0	4.54%	4.60%	4.61%	4.62%	4.40%	4.35%	4.19%
28.0 ≤ BMI < 28.5	4.09%	4.22%	4.33%	4.31%	4.15%	4.20%	4.00%
28.5 ≤ BMI < 29.0	3.63%	3.81%	3.97%	3.98%	3.86%	3.86%	3.77%

29.0 ≤ BMI < 29.5	3.12%	3.37%	3.63%	3.65%	3.57%	3.55%	3.51%
29.5 ≤ BMI < 30.0	2.63%	2.93%	3.28%	3.26%	3.30%	3.21%	3.24%
30.0 ≤ BMI < 30.5	2.19%	2.55%	2.93%	2.98%	3.01%	2.92%	2.96%
30.5 ≤ BMI < 31.0	1.84%	2.15%	2.56%	2.64%	2.77%	2.59%	2.69%
31.0 ≤ BMI < 31.5	1.53%	1.84%	2.19%	2.35%	2.46%	2.32%	2.44%
31.5 ≤ BMI < 32.0	1.34%	1.57%	1.92%	2.04%	2.18%	2.08%	2.21%
32.0 ≤ BMI < 32.5	1.15%	1.33%	1.63%	1.82%	1.94%	1.85%	1.99%
32.5 ≤ BMI < 33.0	1.00%	1.15%	1.40%	1.63%	1.70%	1.65%	1.79%
33.0 ≤ BMI < 33.5	0.83%	1.00%	1.23%	1.42%	1.47%	1.52%	1.60%
33.5 ≤ BMI < 34.0	0.70%	0.86%	1.05%	1.21%	1.28%	1.29%	1.41%
34.0 ≤ BMI < 34.5	0.57%	0.73%	0.90%	1.06%	1.08%	1.08%	1.24%
34.5 ≤ BMI < 35.0	0.46%	0.60%	0.76%	0.90%	0.95%	0.94%	1.07%
35.0 ≤ BMI < 35.5	0.38%	0.49%	0.65%	0.80%	0.82%	0.83%	0.91%
35.5 ≤ BMI < 36.0	0.32%	0.39%	0.53%	0.66%	0.72%	0.72%	0.78%
36.0 ≤ BMI < 36.5	0.28%	0.34%	0.45%	0.56%	0.59%	0.66%	0.68%
36.5 ≤ BMI < 37.0	0.24%	0.28%	0.37%	0.48%	0.52%	0.60%	0.60%
37.0 ≤ BMI < 37.5	0.19%	0.23%	0.32%	0.41%	0.47%	0.54%	0.53%
37.5 ≤ BMI < 38.0	0.16%	0.18%	0.29%	0.34%	0.43%	0.48%	0.48%
38.0 ≤ BMI < 38.5	0.12%	0.15%	0.26%	0.27%	0.38%	0.43%	0.43%
38.5 ≤ BMI < 39.0	0.09%	0.13%	0.23%	0.22%	0.33%	0.36%	0.39%
39.0 ≤ BMI < 39.5	0.07%	0.11%	0.19%	0.19%	0.28%	0.32%	0.35%
39.5 ≤ BMI < 40.0	0.06%	0.09%	0.16%	0.17%	0.25%	0.28%	0.31%
40.0 ≤ BMI < 40.5	0.05%	0.08%	0.13%	0.16%	0.21%	0.23%	0.27%
40.5 ≤ BMI < 41.0	0.04%	0.07%	0.10%	0.13%	0.17%	0.19%	0.24%
41.0 ≤ BMI < 41.5	0.03%	0.06%	0.07%	0.12%	0.13%	0.17%	0.21%
41.5 ≤ BMI < 42.0	0.03%	0.05%	0.04%	0.11%	0.10%	0.14%	0.18%
42.0 ≤ BMI < 42.5	0.02%	0.05%	0.04%	0.09%	0.09%	0.11%	0.15%
42.5 ≤ BMI < 43.0	0.01%	0.03%	0.04%	0.07%	0.08%	0.10%	0.13%
43.0 ≤ BMI < 43.5	0.01%	0.03%	0.03%	0.06%	0.06%	0.09%	0.11%
43.5 ≤ BMI < 44.0	0.01%	0.02%	0.03%	0.05%	0.05%	0.08%	0.10%
44.0 ≤ BMI < 44.5	0.01%	0.01%	0.03%	0.04%	0.05%	0.08%	0.09%
44.5 ≤ BMI < 45.0	0.00%	0.01%	0.02%	0.04%	0.05%	0.08%	0.08%
45.0 ≤ BMI < 45.5	0.00%	0.01%	0.02%	0.03%	0.04%	0.07%	0.07%
45.5 ≤ BMI < 46.0	0.00%	0.01%	0.01%	0.02%	0.04%	0.05%	0.06%
46.0 ≤ BMI < 46.5	0.00%	0.01%	0.01%	0.02%	0.03%	0.04%	0.06%
46.5 ≤ BMI < 47.0	0.00%	0.01%	0.01%	0.02%	0.03%	0.03%	0.05%
47.0 ≤ BMI < 47.5	0.00%	0.01%	0.01%	0.01%	0.03%	0.02%	0.05%
47.5 ≤ BMI < 48.0	0.00%	0.00%	0.01%	0.01%	0.03%	0.02%	0.04%
48.0 ≤ BMI < 48.5	0.00%	0.00%	0.01%	0.01%	0.02%	0.02%	0.04%
48.5 ≤ BMI < 49.0	0.00%	0.00%	0.01%	0.01%	0.02%	0.02%	0.03%
49.0 ≤ BMI < 49.5	0.00%	0.00%	0.01%	0.01%	0.02%	0.02%	0.03%
49.5 ≤ BMI < 50.0	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%
50.0 ≤ BMI < 50.5	0.00%	0.00%	0.01%	0.01%	0.01%	0.02%	0.02%
50.5 ≤ BMI < 51.0	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%
51.0 ≤ BMI < 51.5	0.00%	0.00%	0.00%	0.01%	0.00%	0.01%	0.02%
51.5 ≤ BMI < 52.0	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.02%
52.0 ≤ BMI < 52.5	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.02%

52.5 ≤ BMI < 53.0	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.02%
53.0 ≤ BMI < 53.5	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.02%
53.5 ≤ BMI < 54.0	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.01%
54.0 ≤ BMI < 54.5	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%
54.5 ≤ BMI < 55.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
55.0 ≤ BMI < 55.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
55.5 ≤ BMI < 56.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
56.0 ≤ BMI < 56.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
56.5 ≤ BMI < 57.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
57.0 ≤ BMI < 57.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
57.5 ≤ BMI < 58.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
58.0 ≤ BMI < 58.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
58.5 ≤ BMI < 59.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
59.0 ≤ BMI < 59.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
59.5 ≤ BMI < 60.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
60.0 ≤ BMI < 60.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
60.5 ≤ BMI < 61.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
61.0 ≤ BMI < 61.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
61.5 ≤ BMI < 62.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
62.0 ≤ BMI < 62.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
62.5 ≤ BMI < 63.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
63.0 ≤ BMI < 63.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
63.5 ≤ BMI < 64.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
64.0 ≤ BMI < 64.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
64.5 ≤ BMI < 65.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
65.0 ≤ BMI < 65.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
65.5 ≤ BMI < 66.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
66.0 ≤ BMI < 66.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
66.5 ≤ BMI < 67.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
67.0 ≤ BMI < 67.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
67.5 ≤ BMI < 68.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
68.0 ≤ BMI < 68.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
68.5 ≤ BMI < 69.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
69.0 ≤ BMI < 69.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
69.5 ≤ BMI < 70.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 14.III.4 Table of values for the population distributions for women.

Interval	1993	1997	2001	2005	2009	2013	2017
10.0 ≤ BMI < 10.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10.5 ≤ BMI < 11.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11.0 ≤ BMI < 11.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11.5 ≤ BMI < 12.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12.0 ≤ BMI < 12.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12.5 ≤ BMI < 13.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13.0 ≤ BMI < 13.5	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
13.5 ≤ BMI < 14.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%
14.0 ≤ BMI < 14.5	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	-0.01%
14.5 ≤ BMI < 15.0	0.02%	0.01%	0.01%	0.02%	0.03%	0.00%	-0.01%
15.0 ≤ BMI < 15.5	0.03%	0.03%	0.02%	0.03%	0.03%	0.01%	0.00%
15.5 ≤ BMI < 16.0	0.04%	0.05%	0.05%	0.06%	0.04%	0.05%	0.04%
16.0 ≤ BMI < 16.5	0.09%	0.11%	0.08%	0.10%	0.09%	0.10%	0.10%
16.5 ≤ BMI < 17.0	0.20%	0.19%	0.14%	0.16%	0.16%	0.19%	0.20%
17.0 ≤ BMI < 17.5	0.34%	0.32%	0.27%	0.29%	0.27%	0.29%	0.35%
17.5 ≤ BMI < 18.0	0.54%	0.51%	0.45%	0.42%	0.43%	0.48%	0.55%
18.0 ≤ BMI < 18.5	0.85%	0.78%	0.71%	0.68%	0.69%	0.76%	0.80%
18.5 ≤ BMI < 19.0	1.24%	1.14%	1.06%	1.02%	1.00%	1.09%	1.10%
19.0 ≤ BMI < 19.5	1.74%	1.54%	1.46%	1.38%	1.37%	1.42%	1.44%
19.5 ≤ BMI < 20.0	2.28%	2.02%	1.96%	1.80%	1.82%	1.84%	1.81%
20.0 ≤ BMI < 20.5	2.86%	2.55%	2.44%	2.29%	2.25%	2.27%	2.19%
20.5 ≤ BMI < 21.0	3.42%	3.07%	2.92%	2.82%	2.68%	2.67%	2.57%
21.0 ≤ BMI < 21.5	3.99%	3.59%	3.36%	3.22%	3.08%	3.01%	2.94%
21.5 ≤ BMI < 22.0	4.39%	3.96%	3.67%	3.57%	3.40%	3.35%	3.26%
22.0 ≤ BMI < 22.5	4.71%	4.26%	3.96%	3.86%	3.63%	3.59%	3.52%
22.5 ≤ BMI < 23.0	4.88%	4.47%	4.15%	4.06%	3.91%	3.84%	3.72%
23.0 ≤ BMI < 23.5	4.99%	4.61%	4.27%	4.19%	4.12%	4.06%	3.86%
23.5 ≤ BMI < 24.0	4.95%	4.65%	4.31%	4.27%	4.22%	4.15%	3.93%
24.0 ≤ BMI < 24.5	4.85%	4.58%	4.33%	4.24%	4.24%	4.18%	3.93%
24.5 ≤ BMI < 25.0	4.66%	4.53%	4.34%	4.17%	4.26%	4.17%	3.89%
25.0 ≤ BMI < 25.5	4.46%	4.43%	4.21%	4.09%	4.18%	4.08%	3.81%
25.5 ≤ BMI < 26.0	4.20%	4.26%	4.07%	4.02%	4.04%	3.90%	3.69%
26.0 ≤ BMI < 26.5	3.94%	4.06%	3.91%	3.82%	3.86%	3.74%	3.57%
26.5 ≤ BMI < 27.0	3.61%	3.74%	3.64%	3.63%	3.60%	3.55%	3.42%
27.0 ≤ BMI < 27.5	3.32%	3.47%	3.44%	3.44%	3.37%	3.30%	3.26%
27.5 ≤ BMI < 28.0	3.01%	3.19%	3.24%	3.28%	3.20%	3.15%	3.09%
28.0 ≤ BMI < 28.5	2.75%	2.96%	3.02%	3.06%	2.99%	3.02%	2.92%
28.5 ≤ BMI < 29.0	2.45%	2.69%	2.82%	2.83%	2.79%	2.83%	2.76%
29.0 ≤ BMI < 29.5	2.26%	2.46%	2.66%	2.62%	2.63%	2.66%	2.60%
29.5 ≤ BMI < 30.0	2.03%	2.30%	2.46%	2.39%	2.49%	2.47%	2.44%
30.0 ≤ BMI < 30.5	1.85%	2.11%	2.22%	2.21%	2.32%	2.28%	2.29%
30.5 ≤ BMI < 31.0	1.68%	1.94%	2.02%	2.06%	2.12%	2.08%	2.15%
31.0 ≤ BMI < 31.5	1.53%	1.74%	1.81%	1.88%	1.97%	1.94%	2.01%
31.5 ≤ BMI < 32.0	1.38%	1.53%	1.59%	1.72%	1.80%	1.73%	1.87%
32.0 ≤ BMI < 32.5	1.22%	1.37%	1.43%	1.58%	1.64%	1.56%	1.74%

32.5 ≤ BMI < 33.0	1.05%	1.21%	1.32%	1.48%	1.43%	1.49%	1.60%
33.0 ≤ BMI < 33.5	0.91%	1.07%	1.22%	1.34%	1.30%	1.40%	1.46%
33.5 ≤ BMI < 34.0	0.77%	0.92%	1.13%	1.17%	1.20%	1.30%	1.33%
34.0 ≤ BMI < 34.5	0.69%	0.83%	1.03%	1.07%	1.13%	1.18%	1.21%
34.5 ≤ BMI < 35.0	0.59%	0.76%	0.95%	0.96%	1.02%	1.07%	1.11%
35.0 ≤ BMI < 35.5	0.55%	0.67%	0.89%	0.90%	0.91%	0.96%	1.02%
35.5 ≤ BMI < 36.0	0.51%	0.63%	0.82%	0.81%	0.84%	0.87%	0.94%
36.0 ≤ BMI < 36.5	0.49%	0.56%	0.72%	0.72%	0.80%	0.78%	0.87%
36.5 ≤ BMI < 37.0	0.45%	0.49%	0.64%	0.67%	0.74%	0.69%	0.82%
37.0 ≤ BMI < 37.5	0.41%	0.45%	0.58%	0.62%	0.67%	0.63%	0.76%
37.5 ≤ BMI < 38.0	0.36%	0.39%	0.51%	0.56%	0.56%	0.58%	0.70%
38.0 ≤ BMI < 38.5	0.32%	0.34%	0.43%	0.50%	0.52%	0.53%	0.64%
38.5 ≤ BMI < 39.0	0.28%	0.30%	0.37%	0.45%	0.46%	0.49%	0.58%
39.0 ≤ BMI < 39.5	0.24%	0.25%	0.31%	0.40%	0.40%	0.43%	0.53%
39.5 ≤ BMI < 40.0	0.22%	0.23%	0.27%	0.36%	0.34%	0.39%	0.47%
40.0 ≤ BMI < 40.5	0.18%	0.21%	0.25%	0.32%	0.29%	0.36%	0.43%
40.5 ≤ BMI < 41.0	0.15%	0.19%	0.23%	0.27%	0.28%	0.34%	0.38%
41.0 ≤ BMI < 41.5	0.14%	0.16%	0.20%	0.24%	0.26%	0.32%	0.34%
41.5 ≤ BMI < 42.0	0.11%	0.14%	0.19%	0.22%	0.24%	0.31%	0.31%
42.0 ≤ BMI < 42.5	0.10%	0.13%	0.17%	0.20%	0.21%	0.28%	0.28%
42.5 ≤ BMI < 43.0	0.08%	0.11%	0.15%	0.17%	0.19%	0.23%	0.25%
43.0 ≤ BMI < 43.5	0.08%	0.09%	0.13%	0.15%	0.18%	0.20%	0.22%
43.5 ≤ BMI < 44.0	0.08%	0.08%	0.11%	0.14%	0.17%	0.17%	0.20%
44.0 ≤ BMI < 44.5	0.07%	0.07%	0.10%	0.13%	0.14%	0.15%	0.19%
44.5 ≤ BMI < 45.0	0.06%	0.07%	0.09%	0.11%	0.12%	0.14%	0.17%
45.0 ≤ BMI < 45.5	0.05%	0.07%	0.09%	0.10%	0.12%	0.12%	0.15%
45.5 ≤ BMI < 46.0	0.04%	0.06%	0.08%	0.09%	0.10%	0.11%	0.14%
46.0 ≤ BMI < 46.5	0.03%	0.05%	0.08%	0.07%	0.09%	0.10%	0.12%
46.5 ≤ BMI < 47.0	0.03%	0.04%	0.07%	0.05%	0.08%	0.08%	0.11%
47.0 ≤ BMI < 47.5	0.03%	0.04%	0.06%	0.05%	0.06%	0.07%	0.09%
47.5 ≤ BMI < 48.0	0.02%	0.03%	0.05%	0.04%	0.05%	0.05%	0.08%
48.0 ≤ BMI < 48.5	0.02%	0.03%	0.04%	0.04%	0.05%	0.04%	0.07%
48.5 ≤ BMI < 49.0	0.02%	0.02%	0.03%	0.03%	0.04%	0.05%	0.06%
49.0 ≤ BMI < 49.5	0.02%	0.02%	0.03%	0.03%	0.04%	0.04%	0.06%
49.5 ≤ BMI < 50.0	0.01%	0.01%	0.03%	0.03%	0.03%	0.04%	0.05%
50.0 ≤ BMI < 50.5	0.01%	0.01%	0.02%	0.02%	0.03%	0.03%	0.05%
50.5 ≤ BMI < 51.0	0.01%	0.01%	0.02%	0.02%	0.03%	0.03%	0.05%
51.0 ≤ BMI < 51.5	0.01%	0.00%	0.02%	0.02%	0.02%	0.02%	0.05%
51.5 ≤ BMI < 52.0	0.01%	0.00%	0.01%	0.01%	0.02%	0.02%	0.04%
52.0 ≤ BMI < 52.5	0.00%	0.00%	0.01%	0.01%	0.02%	0.02%	0.04%
52.5 ≤ BMI < 53.0	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.03%
53.0 ≤ BMI < 53.5	0.00%	0.00%	0.01%	0.01%	0.01%	0.00%	0.02%
53.5 ≤ BMI < 54.0	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%
54.0 ≤ BMI < 54.5	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.02%
54.5 ≤ BMI < 55.0	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%
55.0 ≤ BMI < 55.5	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%
55.5 ≤ BMI < 56.0	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%

56.0 ≤ BMI < 56.5	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%
56.5 ≤ BMI < 57.0	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%
57.0 ≤ BMI < 57.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
57.5 ≤ BMI < 58.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
58.0 ≤ BMI < 58.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
58.5 ≤ BMI < 59.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
59.0 ≤ BMI < 59.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
59.5 ≤ BMI < 60.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
60.0 ≤ BMI < 60.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
60.5 ≤ BMI < 61.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
61.0 ≤ BMI < 61.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
61.5 ≤ BMI < 62.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
62.0 ≤ BMI < 62.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
62.5 ≤ BMI < 63.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
63.0 ≤ BMI < 63.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
63.5 ≤ BMI < 64.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
64.0 ≤ BMI < 64.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
64.5 ≤ BMI < 65.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
65.0 ≤ BMI < 65.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
65.5 ≤ BMI < 66.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
66.0 ≤ BMI < 66.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
66.5 ≤ BMI < 67.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
67.0 ≤ BMI < 67.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
67.5 ≤ BMI < 68.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
68.0 ≤ BMI < 68.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
68.5 ≤ BMI < 69.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
69.0 ≤ BMI < 69.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
69.5 ≤ BMI < 70.0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Appendix 14.IV Scaling models from 2013 to 2017

One way of assessing the scaling transformations for 2013 to 2017 (Section 14.5.1) is to compare the changes for the percentages in the BMI categories with the actual. For men, Figure 14.IV.1 shows the changes in category percentages for each actual distribution (the same as Figure 14.6) and Figure 14.IV.2 shows the changes in each scaling distribution from the previous actual. The scaling distribution can be assessed by comparing the two charts to see how similar the values are. They do look much the same which is further evidence of the scaling distributions doing well in modelling the changes.

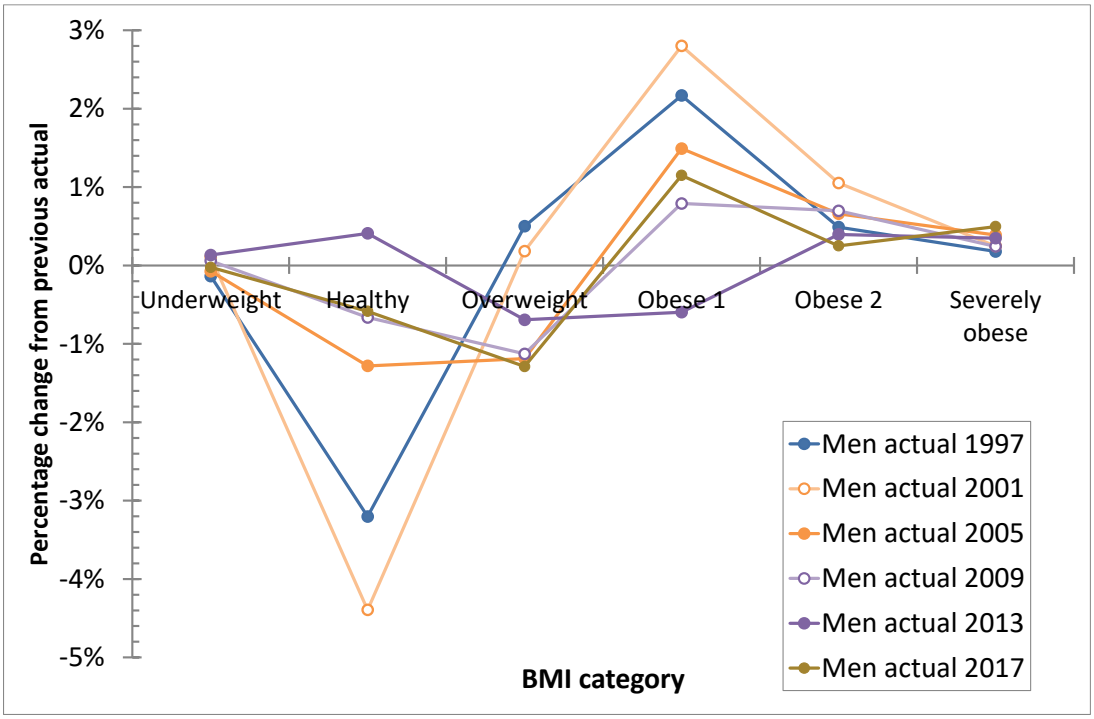

Figure 14.IV.1 Changes in the category percentages for the actual distributions for men.

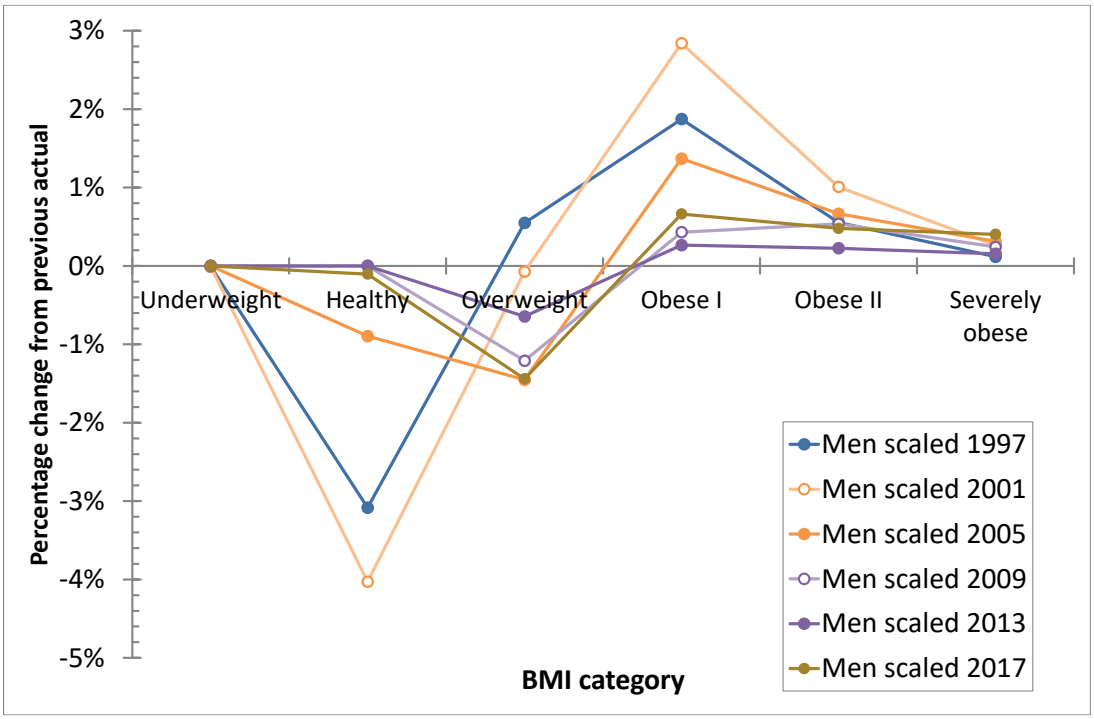

Figure 14.IV.2 Changes in the category percentages for the scaled distributions for men.

For women, the charts for the actual and scaling distributions are Figures 14.IV.3 (the same as Figure 14.7) and 14.IV.4. Again, the changes for the scaling distribution are very similar to those for the actual.

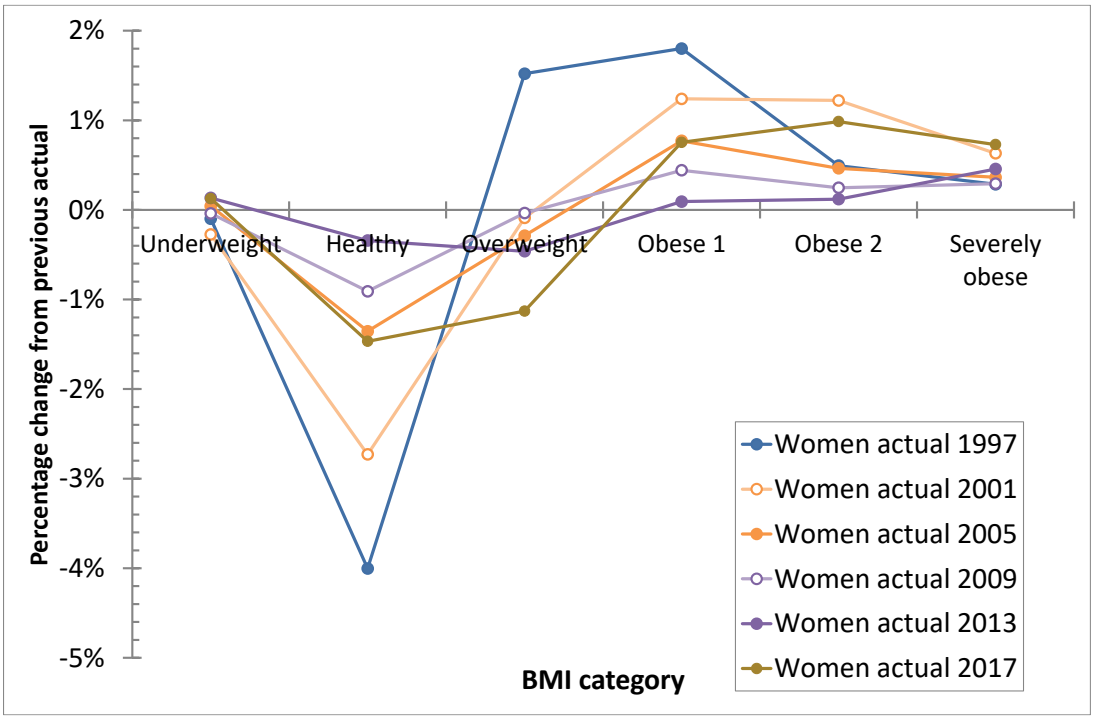

Figure 14.IV.3 Changes in the category percentages for the actual distributions for women.

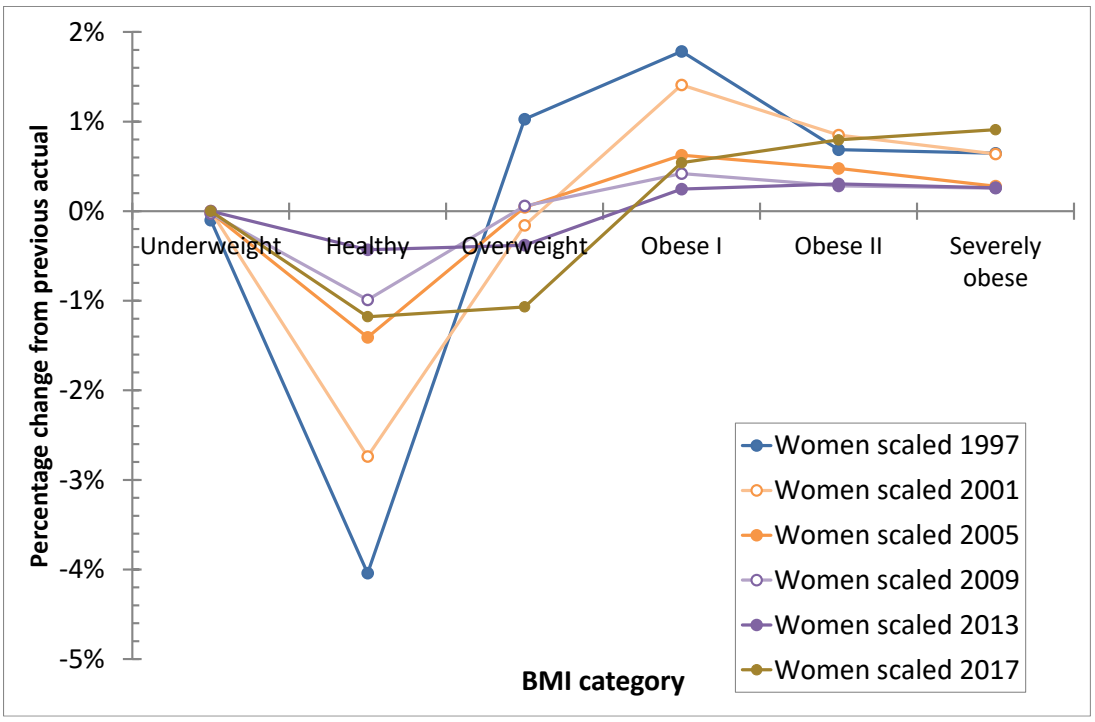

Figure 14.IV.4 Changes in the category percentages for the scaled distributions for women.

Appendix 14.V Scaling models from 1993 to 2017

Section 14.5.2 explains the different modelling approaches for modelling the whole time interval from 1993 to 2017. This appendix gives the results for each of the different models. Table 14.V.1 sets out the parameter values used and the fitness values of the models. The binomial model factors are expressed as 1 + increase in the mean per unit BMI, as this is the equivalent value to the scaling factor for the scaling models. The first five charts (Figures 14.V.1-5) show the model distributions and how they compare to the target 2017 distributions. Figures 14.V.6 and 14.V.7 show the BMI increases for men and for women for the different models. In each case, the various models all have similar values for the BMI increases, and these are also all similar to the percentile increases.

Table 14.V.1 Values for the scaling models from 1993 to 2017.

Model	Men	Women
Combined		
Fitness value	22.29×10^{-6}	10.98×10^{-6}
Single scaling		
Start point	20.25	19.25
Scaling factor	1.220	1.259
Fitness value	54.84×10^{-6}	17.15×10^{-6}
2-piece scaling		
Start point 1	19.25	19.25
Scaling factor 1	1.180	1.243
Start point 2	25.75	23.75
Scaling factor 2	1.323	1.308
Fitness value	18.44×10^{-6}	8.44×10^{-6}
Binomial linear		
Start point	19.25	18.75
Factor (=1+mean increase)	1.193	1.234
End point	35.75	33.25
Fitness value	27.21×10^{-6}	6.52×10^{-6}
Binomial 2-piece linear		
Start point	17.50	18.25
Factor 1 (=1+mean increase)	1.147	1.210
Factor 1 end point	25.50	23.50
Factor 2 (=1+mean increase)	1.284	1.275
Factor 2 end point	39.75	50.00
Fitness value	4.20×10^{-6}	2.61×10^{-6}

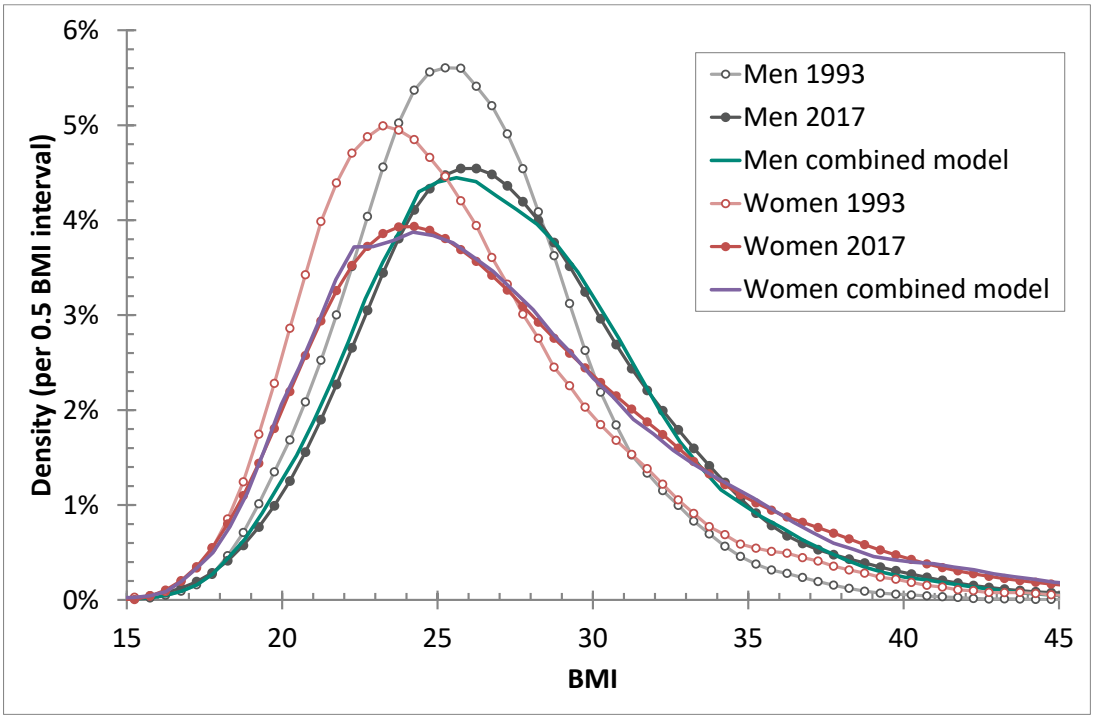

Figure 14.V.1 Combined scaling models for 1993 to 2017 for men and women.

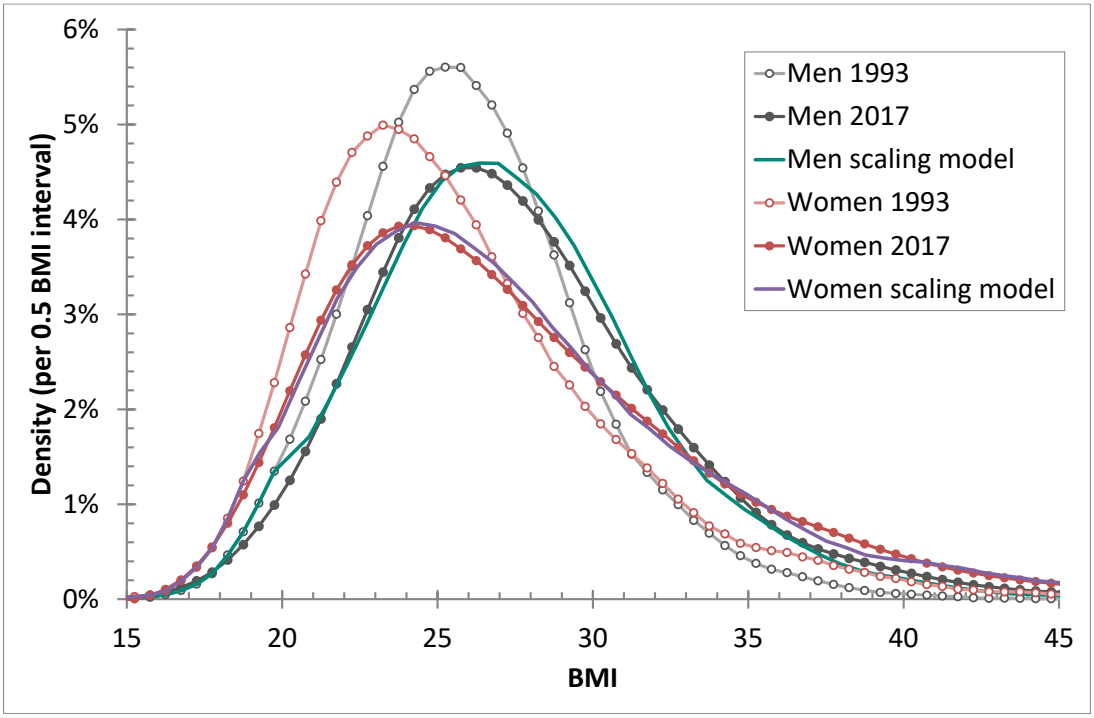

Figure 14.V.2 Single linear scaling models for 1993 to 2017 for men and women.

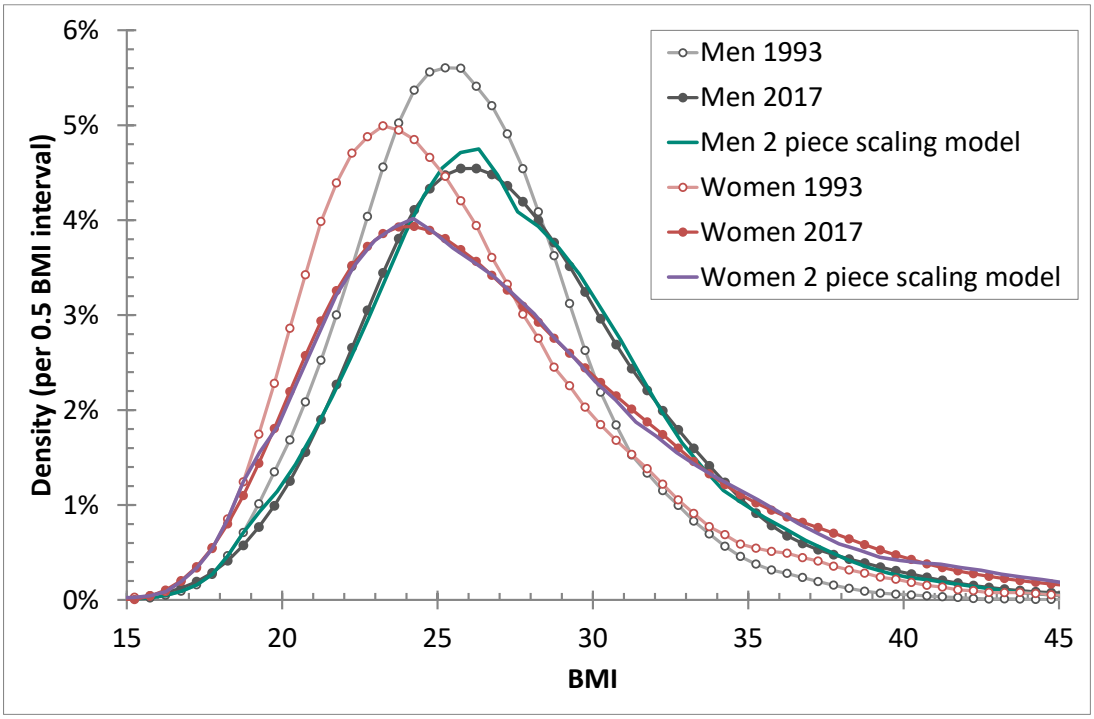

Figure 14.V.3 2 piece linear scaling models for 1993 to 2017 for men and women.

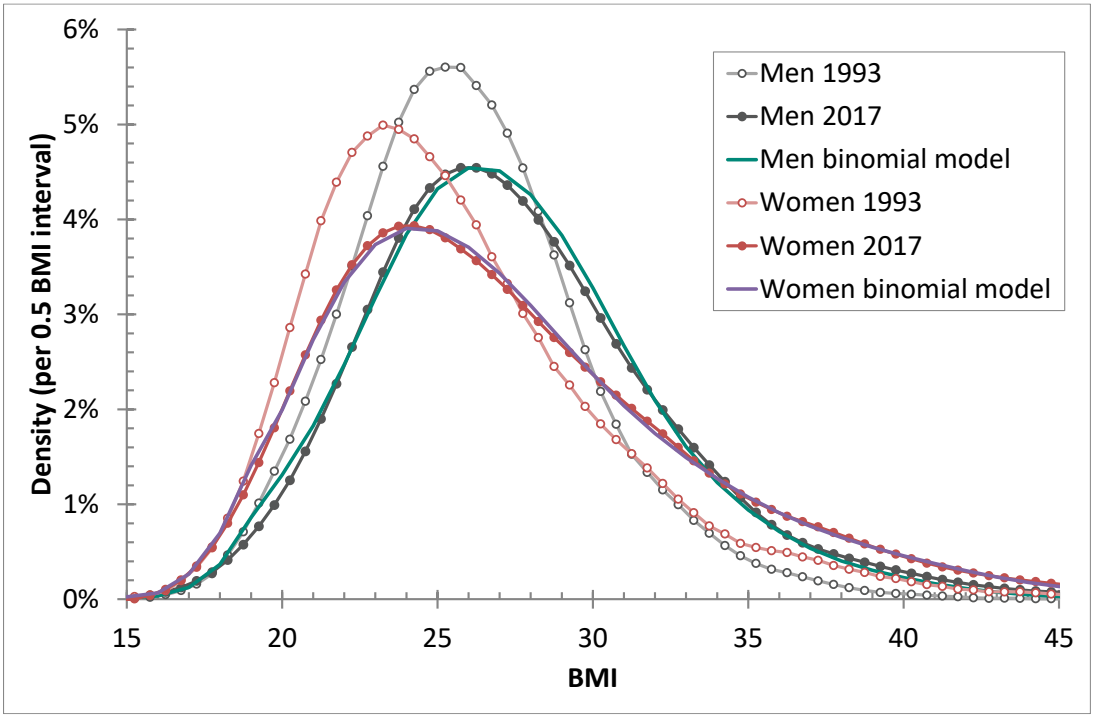

Figure 14.V.4 Binomial linear models for 1993 to 2017 for men and women.

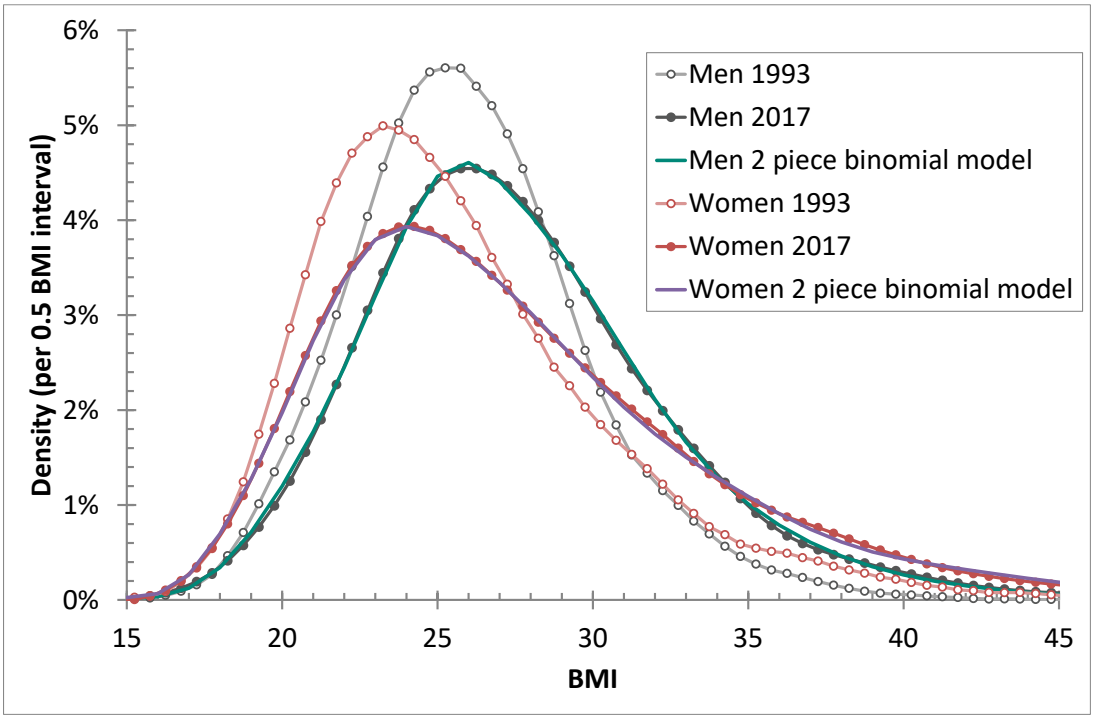

Figure 14.V.5 Binomial 2-piece linear models for 1993 to 2017 for men and women.

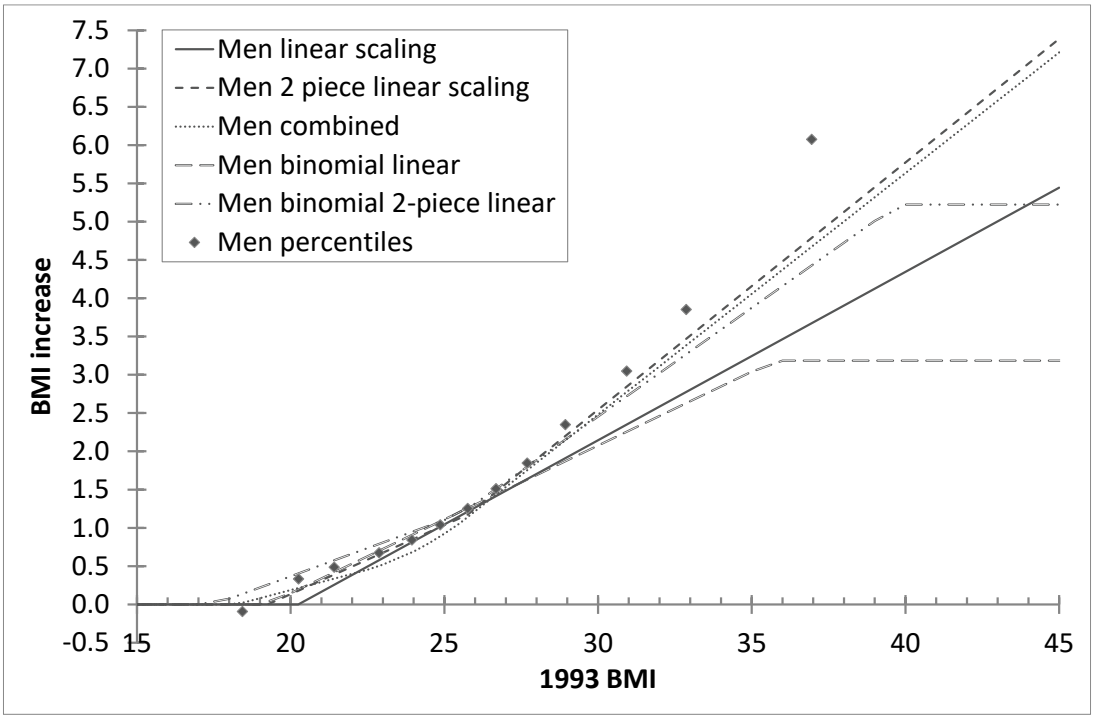

Figure 14.V.6 BMI increases for the models for 1993 to 2017 for men.

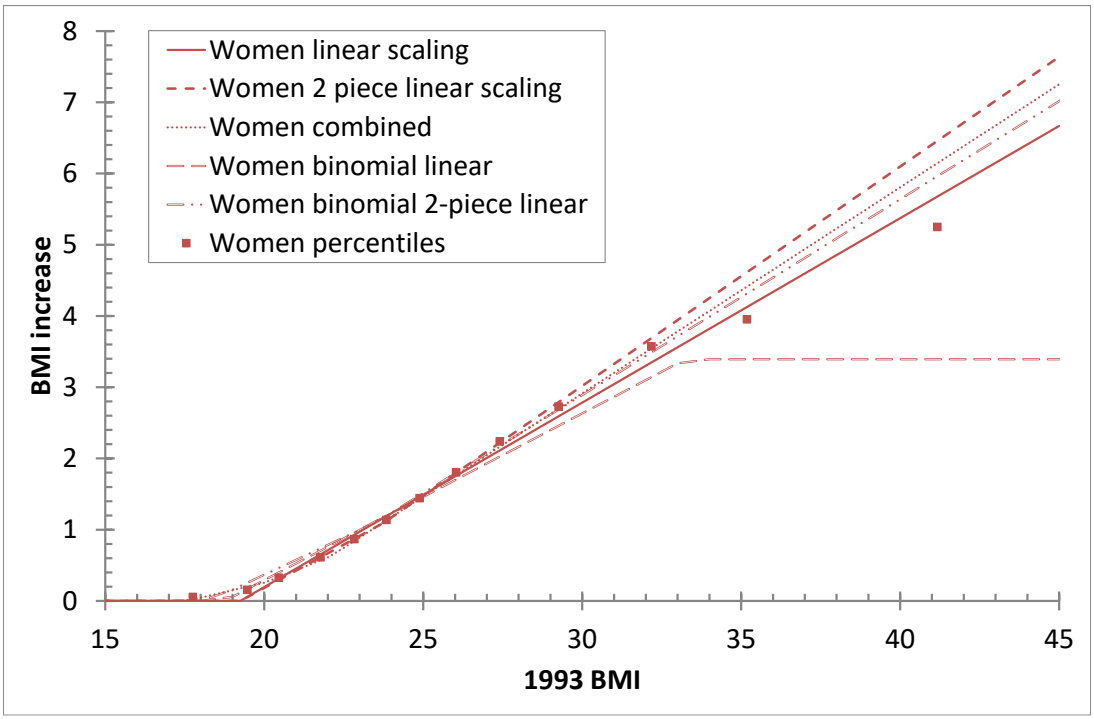

Figure 14.V.7 BMI increases for the models for 1993 to 2017 for women.

Appendix 14.VI Age group distributions

This appendix contains selected results for the age group distributions for the 2015-2018 data, as discussed in Section 14.7.2 of the main report. The descriptive statistics are shown in the two tables below. That is then followed by various charts. These include charts of how the mean, median, standard deviation and category percentages vary between the age groups. Also charts showing the changes in the mean, median, and category percentages compared to 2007-2014. Finally Figures 4.IV.11 and 4.IV.12 show the increases with age of the percentile values from one age group to the next (equivalent to Figures 8.10 and 9.10 in the main report for the earlier 20017-2014 data).

Table 14.VI.1 Descriptive statistics for the age group distributions for men for 2015-2018.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	1424	2065	2035	2097	1699	1336	988
Mean	24.98	26.46	27.78	28.73	28.94	28.60	27.67
Median	23.89	25.69	27.12	28.03	28.21	28.06	27.36
Modal interval mid-point	22.75	24.75	25.75	27.25	26.75	27.75	26.25
Standard deviation	5.31	4.80	4.85	5.04	4.99	4.65	4.03
Skewness	1.78	1.17	1.13	0.97	0.94	0.82	0.38
Underweight (BMI < 18.5)	4.6%	1.4%	0.7%	0.4%	0.3%	0.4%	0.6%
Healthy (18.5 ≤ BMI < 25.0)	55.7%	41.5%	29.1%	21.9%	19.9%	21.3%	25.0%
Overweight (25.0 ≤ BMI < 30.0)	26.1%	37.9%	43.0%	43.8%	45.0%	45.3%	48.3%
Obese I (30.0 ≤ BMI < 35.0)	8.3%	14.1%	20.2%	23.7%	23.7%	24.3%	21.7%
Obese II (35.0 ≤ BMI < 40.0)	3.7%	3.5%	4.7%	7.1%	7.9%	6.5%	4.0%
Severely obese (BMI ≥ 40.0)	1.6%	1.6%	2.3%	3.1%	3.2%	2.1%	0.4%

Table 14.VI.2 Descriptive statistics for the age group distributions for women for 2015-2018.

Age group	18-24	25-34	35-44	45-54	55-64	65-74	75+
Sample size of actual data	1606	2418	2402	2495	2043	1679	1654
Mean	25.36	26.59	27.30	28.45	28.36	28.35	27.59
Median	23.68	25.09	26.06	27.16	27.25	27.53	27.01
Modal interval mid-point	21.75	23.25	25.25	23.75	25.25	26.25	25.75
Standard deviation	6.22	6.25	6.11	6.40	6.05	5.76	5.11
Skewness	1.56	1.27	1.33	1.15	0.89	0.91	0.70
Underweight (BMI < 18.5)	5.2%	3.2%	1.6%	0.7%	1.1%	1.0%	1.4%
Healthy (18.5 ≤ BMI < 25.0)	54.6%	46.1%	39.7%	34.3%	31.7%	29.5%	31.3%
Overweight (25.0 ≤ BMI < 30.0)	22.0%	26.9%	31.9%	31.7%	33.4%	36.7%	39.1%
Obese I (30.0 ≤ BMI < 35.0)	10.0%	12.9%	16.4%	18.5%	20.2%	20.1%	19.6%
Obese II (35.0 ≤ BMI < 40.0)	4.5%	7.1%	6.4%	8.7%	8.7%	9.0%	6.7%
Severely obese (BMI ≥ 40.0)	3.7%	3.8%	4.0%	6.1%	4.9%	3.8%	1.9%

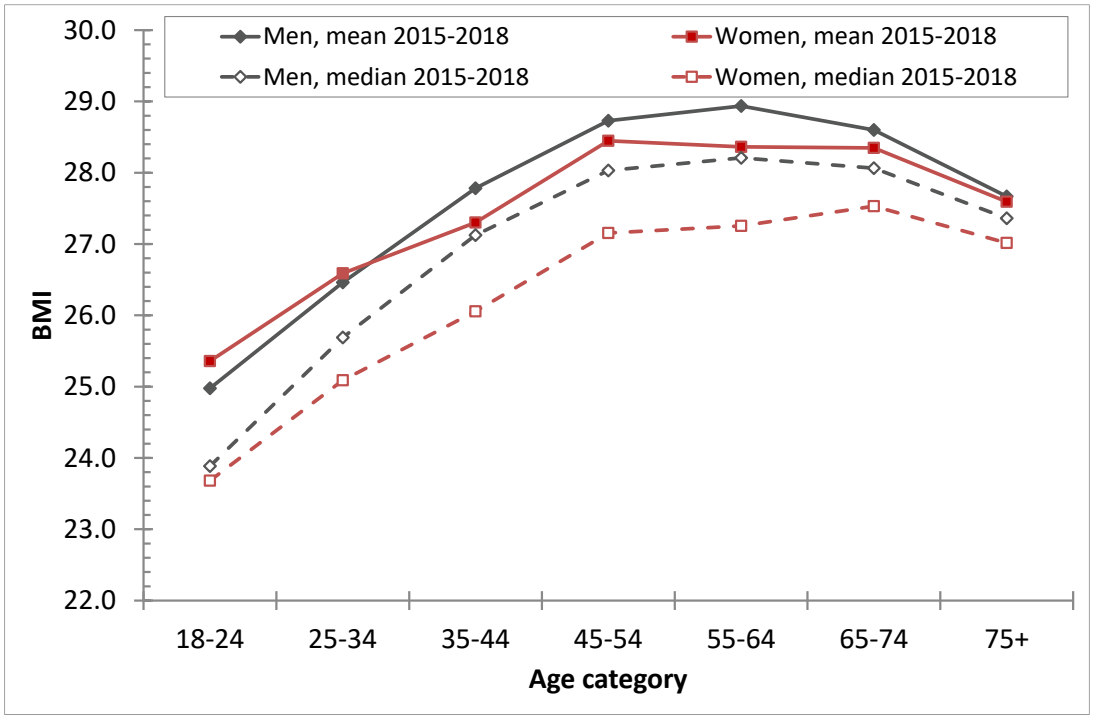

Figure 14.VI.1 Mean and median values for the age groups for 2015-2018.

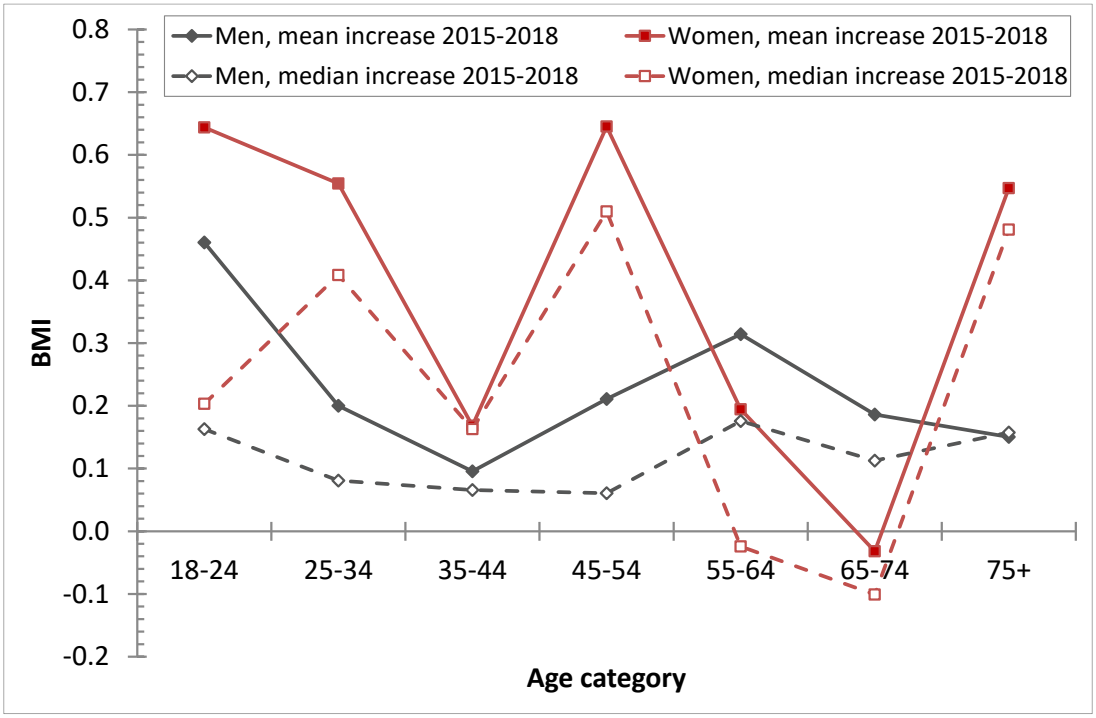

Figure 14.VI.2 Mean and median increases for age groups for 2015-2018 compared to 2007-2014.

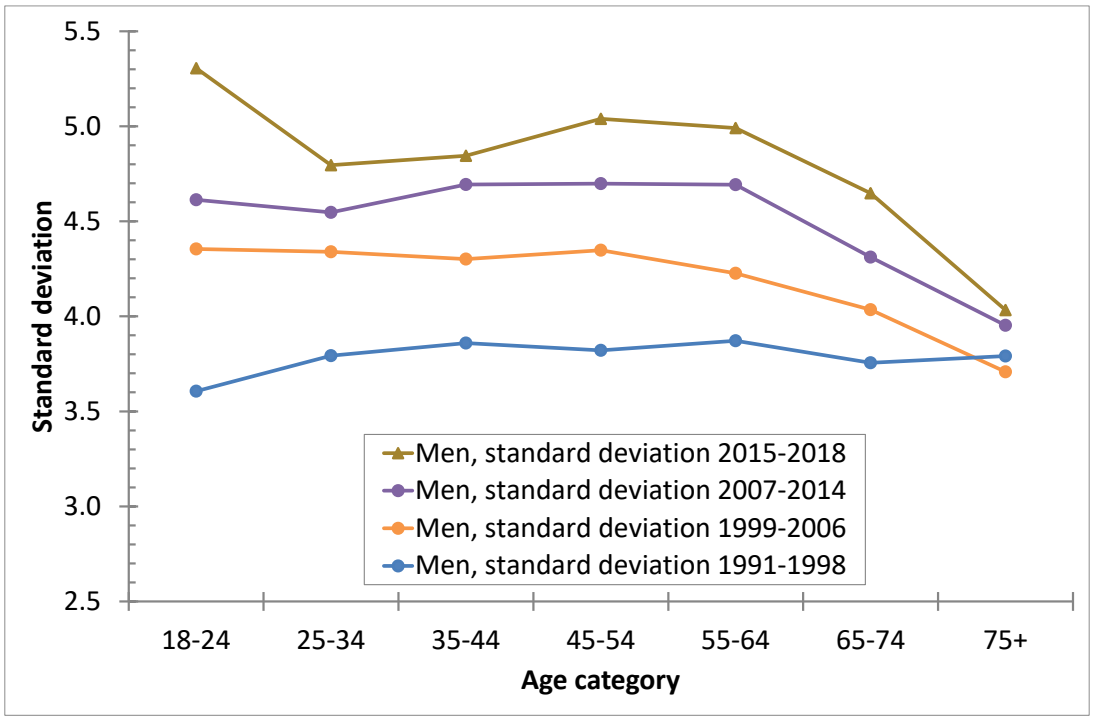

Figure 14.VI.3 Standard deviation for the age groups for men.

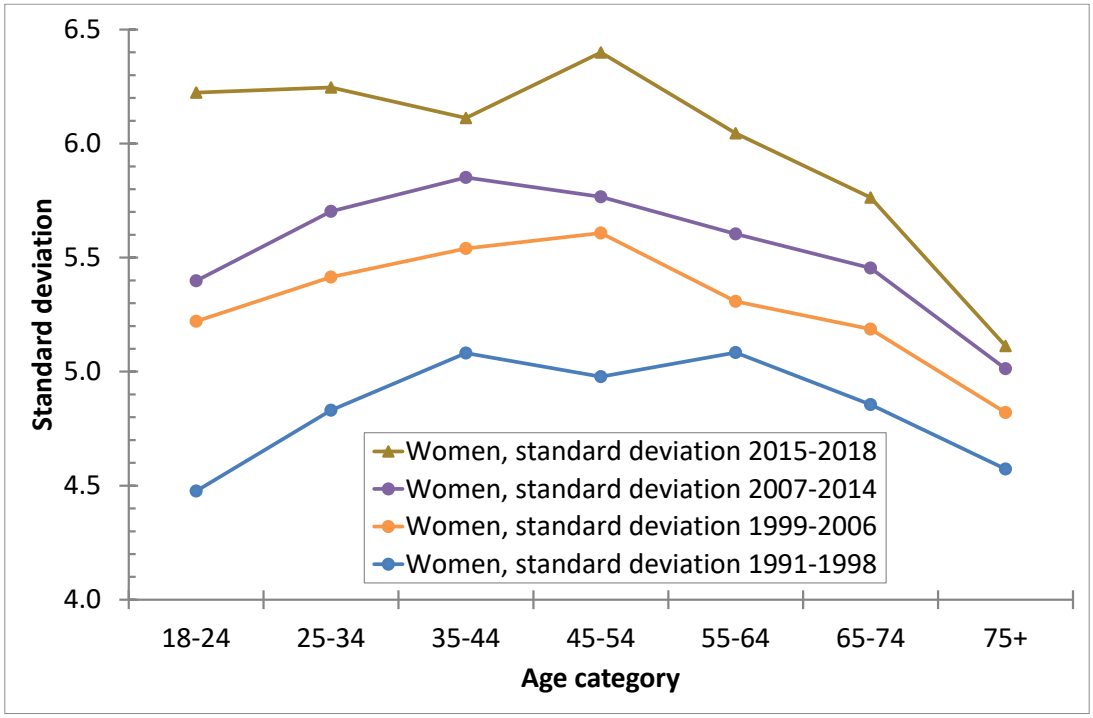

Figure 14.VI.4 Standard deviation for the age groups for women.

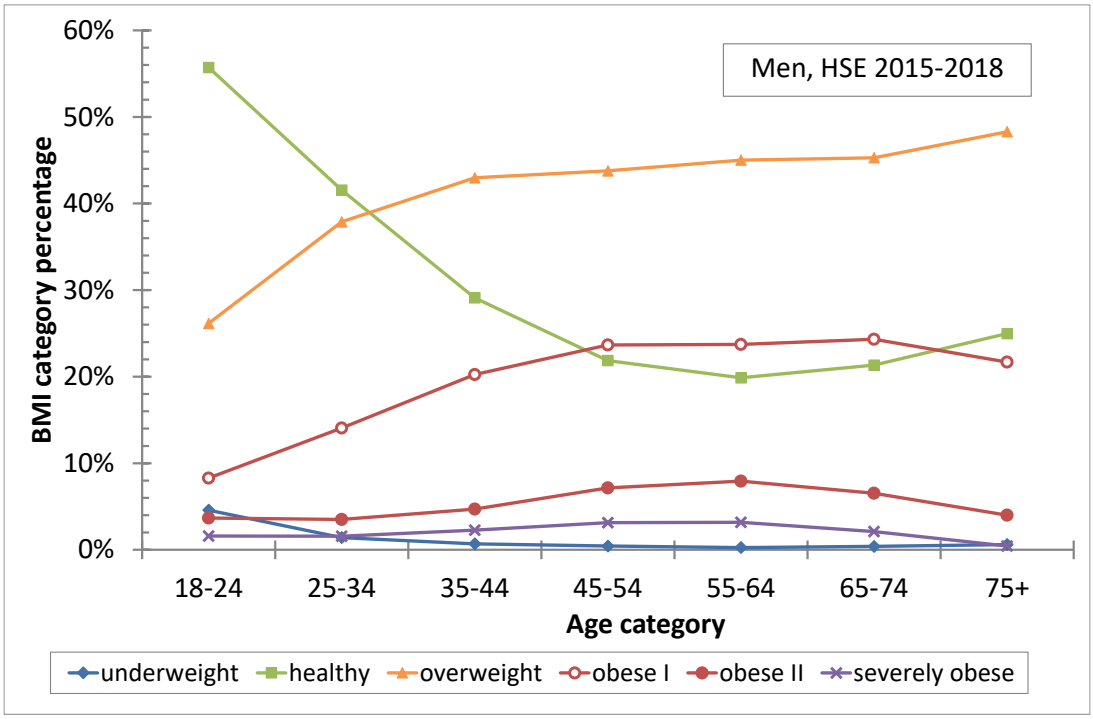

Figure 14.VI.5 BMI category percentages for the age groups for men for 2015-2018.

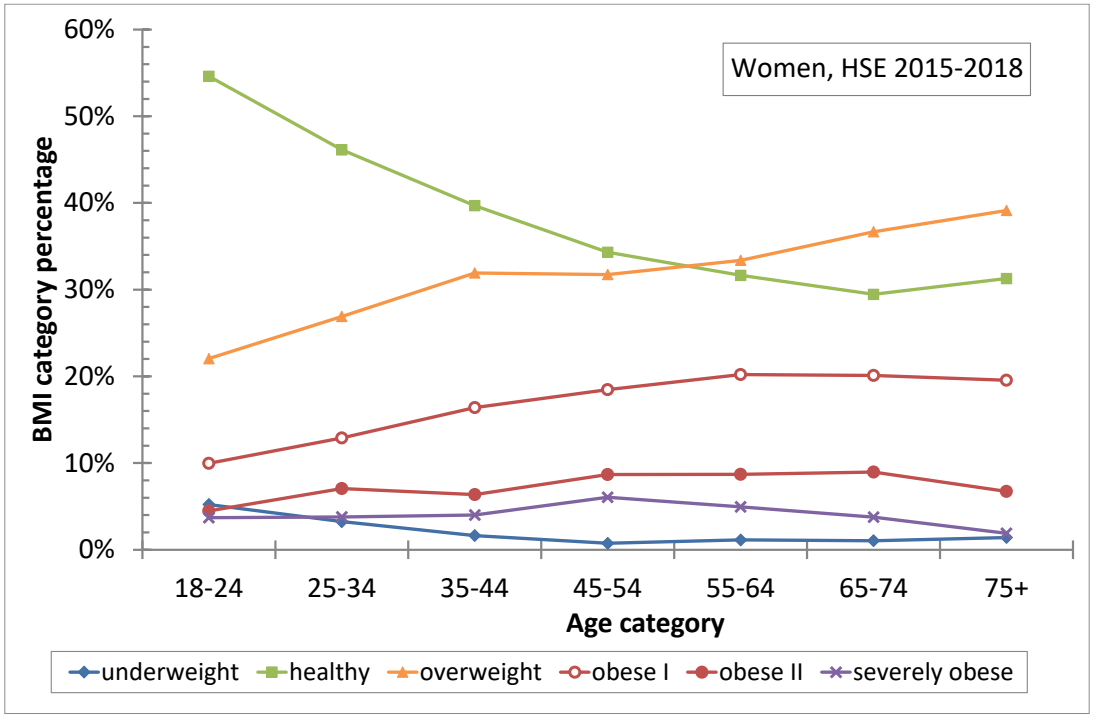

Figure 14.VI.6 BMI category percentages for the age groups for women for 2015-2018.

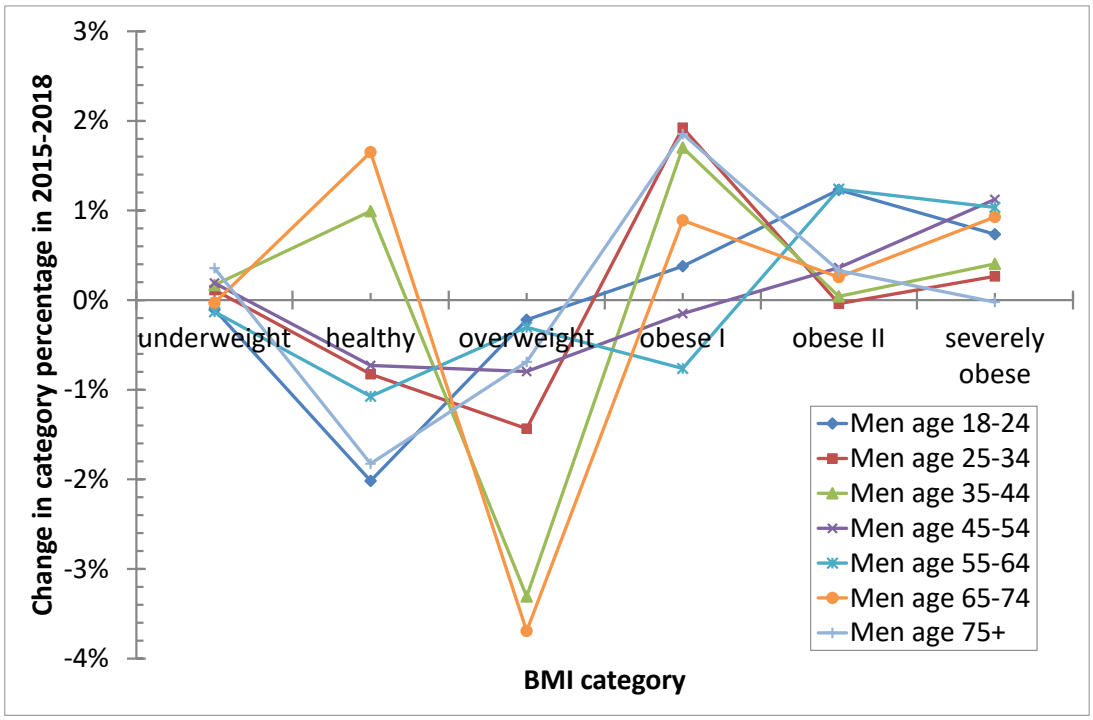

Figure 14.VI.7 Changes in category percentages, age groups for men 2007-2014 to 2015-2018.

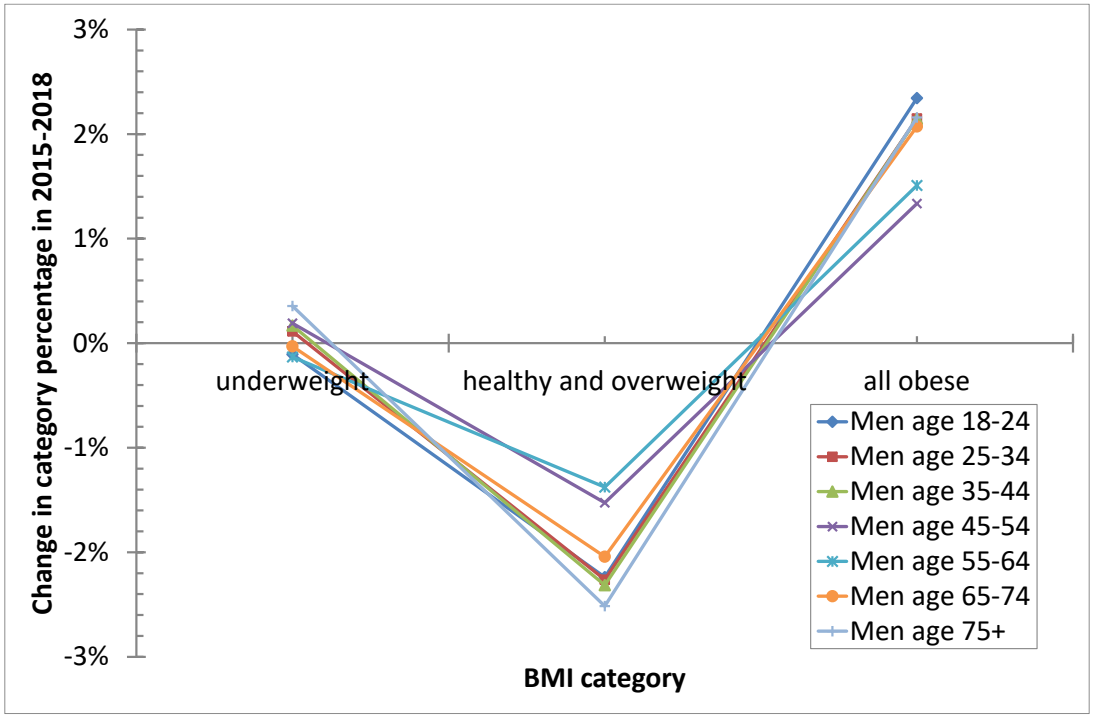

Figure 14.VI.8 Changes in amalgamated percentages, men age groups 2007-2014 to 2015-2018.

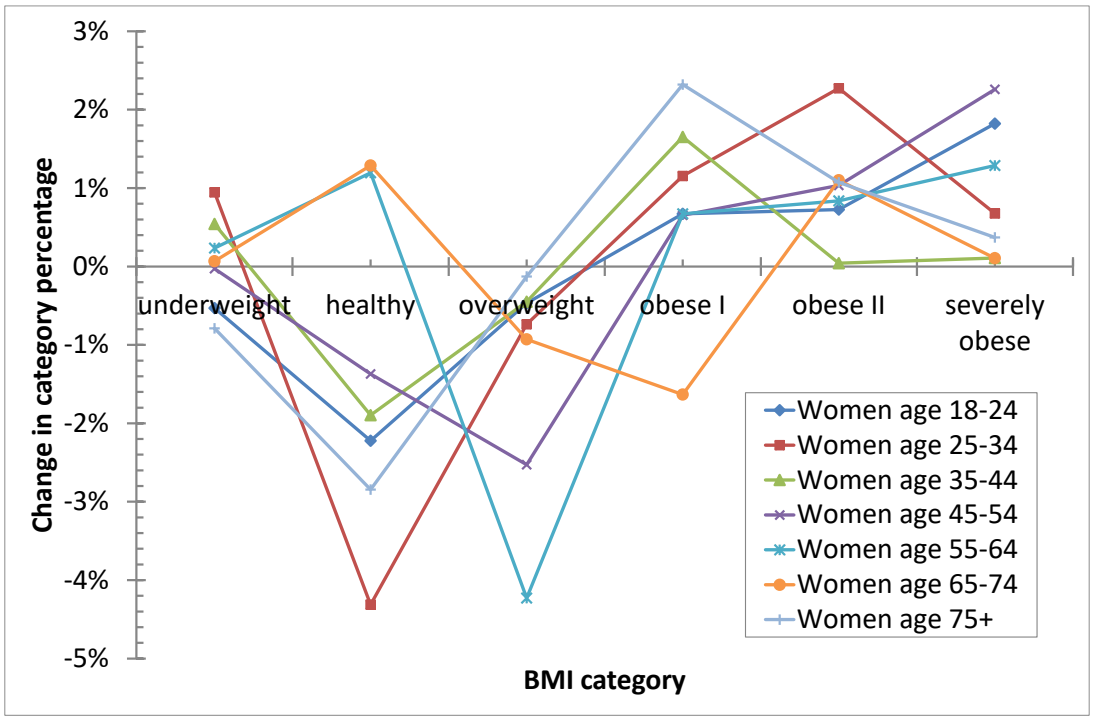

Figure 14.VI.9 Changes in category percentages, age groups for women 2007-2014 to 2015-2018.

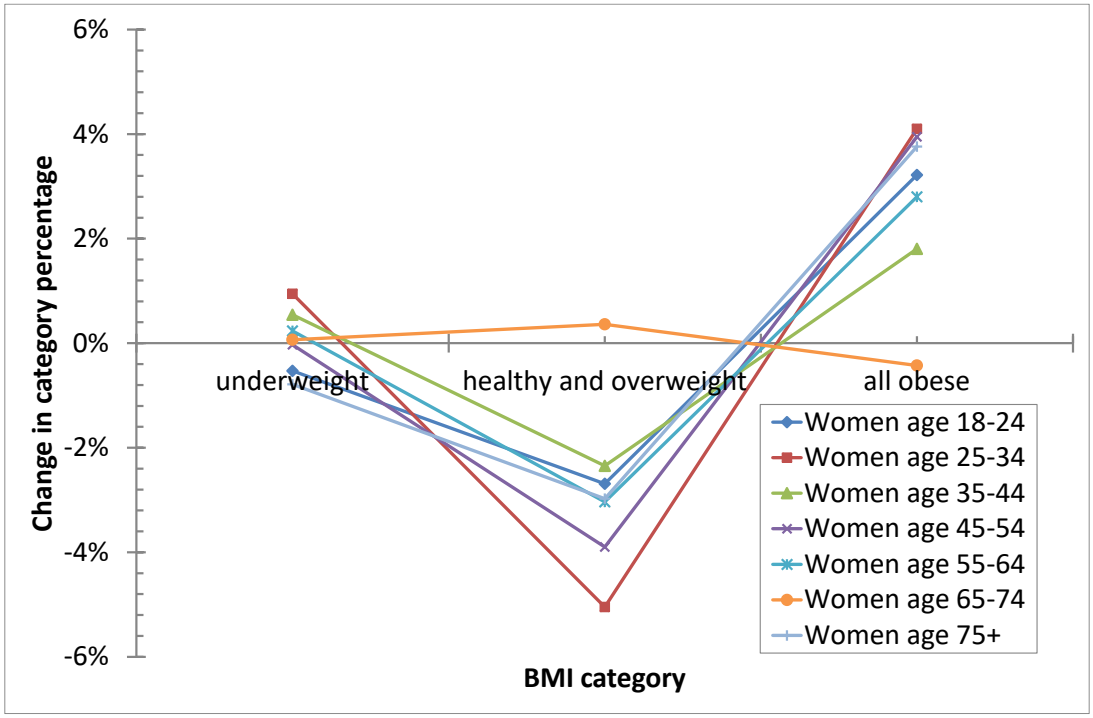

Figure 14.VI.10 Changes in amalgamated percentages, women age gps 2007-2014 to 2015-2018.

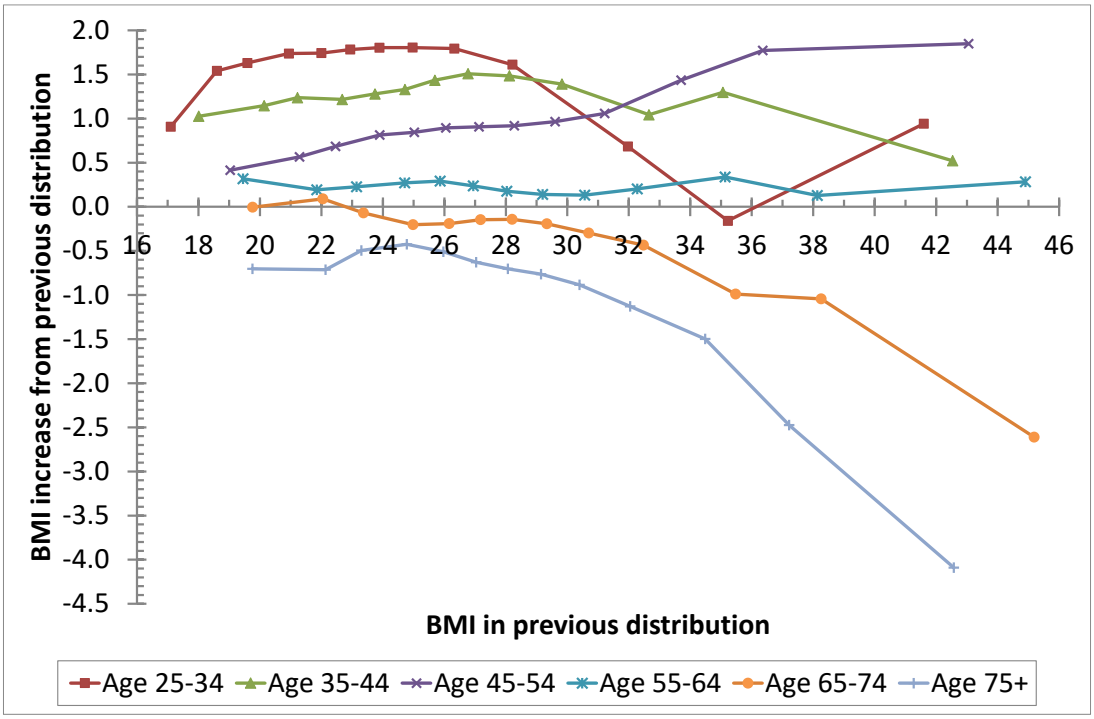

Figure 14.VI.11 Percentile changes for the age group distributions for men for 2015-2018.

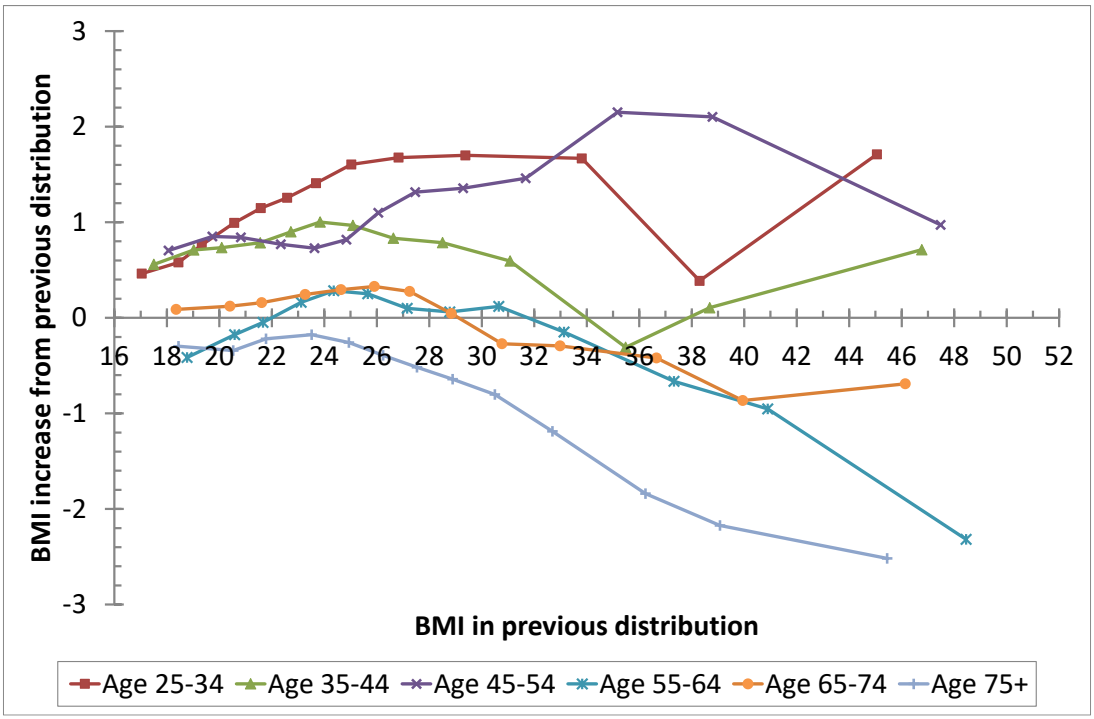

Figure 14.VI.12 Percentile changes for the age group distributions for women for 2015-2018.

Appendix 15.I Deprivation categories

Mean BMI and age

The mean and median values for the 2017 BMI distributions for the deprivation categories given in the main report in Tables 15.1 and 15.2 are plotted in Figure 15.I.1. The mean and the median both increase with increasing deprivation category from D1 (least deprived) to D5 (most deprived), with the increases being much greater for women than for men. As discussed in Section 15.2.3, this reflects the deprivation category BMI distributions differing much more for women than for men.

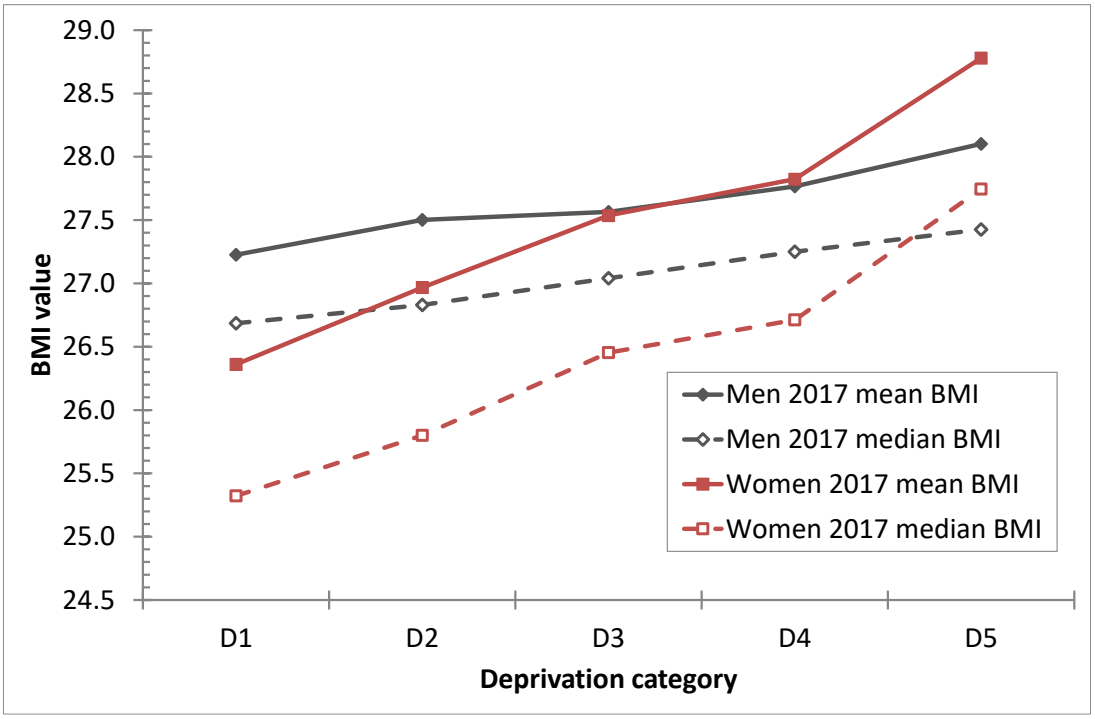

Figure 15.I.1 Mean and median BMI for the deprivation categories for men and women for 2017.

Mean BMI was calculated for each of the deprivation categories for each of the HSE age categories (18-19, 20-24, 25-29, etc.) for the 2015-2018 data. The results are shown in Figures 15.I.2 and 15.I.3, with the values plotted at the average of the integer age values in the age category (18.5, 22, 27, etc.). The aging model profile from Chapter 7 is also shown in each chart as the dashed line. As would be expected from the overall population mean values in Figure 15.I.1, the mean values by age differ between the deprivation categories more for women in Figure 15.I.3 than for men in Figure 15.I.2. Most of the values for women D5 are well above the aging model curve from Chapter 7.

In Figures 15.I.2 and 15.I.3 there are some quite big fluctuations in the values from one age to the next. This is as expected due to sampling variation because the sample sizes are very small. For example, for men D5 the sample sizes for the age categories between 20-24 and 70-74 are between 121 and 231 cases. The sample size for age 18-19 is even smaller being just two years of age with just 51 cases. The older ages above age 75 also have very small sample sizes, all of less than 100 cases with age 90+ having just 12 cases. The sample sizes for women are slightly larger but with a similar pattern. Women D5 has 65 cases for age 18-19, between 106 and 323 cases for age categories between 20-24 and 70-74, and less than 100 for ages above that. The other deprivation categories have similar numbers although the lower categories have slightly more older cases and slightly fewer younger cases with the different age profiles (discussed in Section 15.2.2).

Hence there is quite a lot of uncertainty regarding the mean values for each age category particularly for age 18-19 and for the older ages. For example, this is very likely the reason for the high mean value for women D5 age 18-19 in Figure 15.I.3.

The differences between the age mean values for D5 and D1 for men and women are shown in Figure 15.I.4. The dashed lines show the overall population differences of 0.88 for men and 2.42 for women (from Tables 15.1 and 15.2). There are sizable fluctuations but the differences are fairly consistent across the ages, particularly between ages 20-24 and 70-74 with the largest sample sizes. The difference for women for age 18-19 is particularly high but this is very likely due to sampling variation with the small sample size. Hence, the indication is that the differences between the deprivation categories apply similarly for most ages. Further analysis could be done to look at this with a wider range of HSE data to give larger sample sizes.

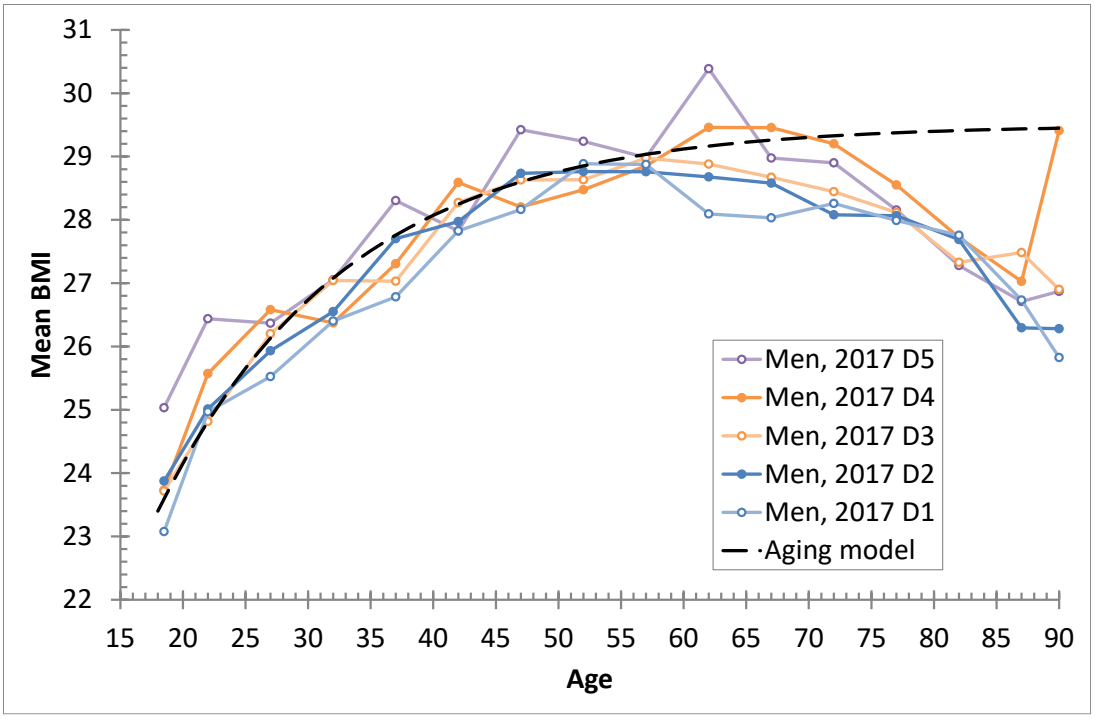

Figure 15.I.2 Mean BMI by age for the deprivation categories for men 2017.

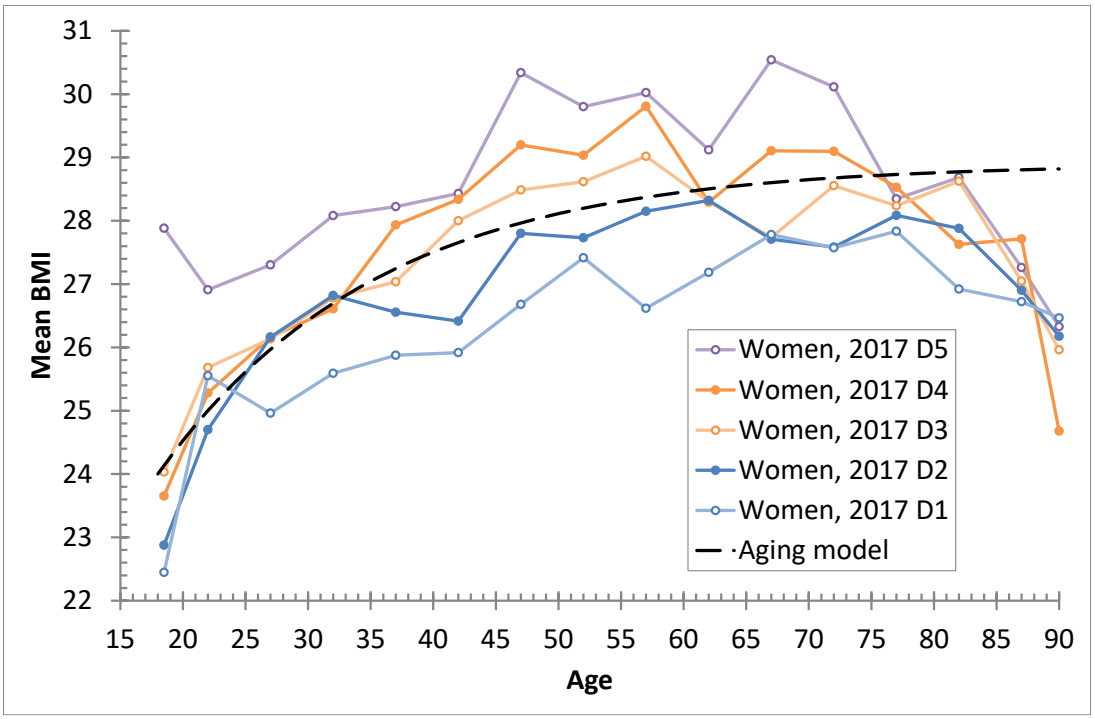

Figure 15.I.3 Mean BMI by age for the deprivation categories for women 2017.

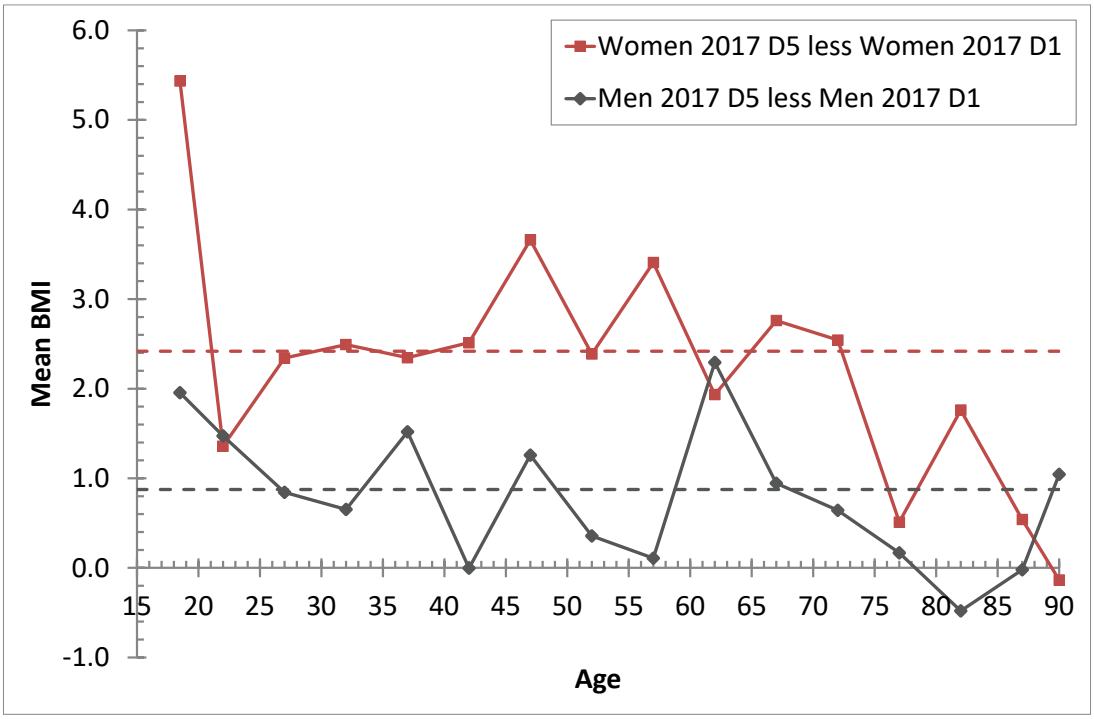

Figure 15.I.4 Differences in mean BMI by age between D5 and D1 for men and women for 2017.

Percentile increases

Figure 15.I.5 and Figure 15.I.6 are charts of the percentile increases for the deprivation quintile distributions from 2003 to 2017 including the 1% and 99% percentile values. These two end points are not included on the charts in Figures 15.5 and 15.6 in Chapter 15 of the main report so as to show the rest of the points more clearly without needing high values on the x-axis scale and the y-axis scale.

The dashed line in each case in the increase in the percentiles from the whole population distribution for 2003 to the percentiles for the whole population distribution for 2017.

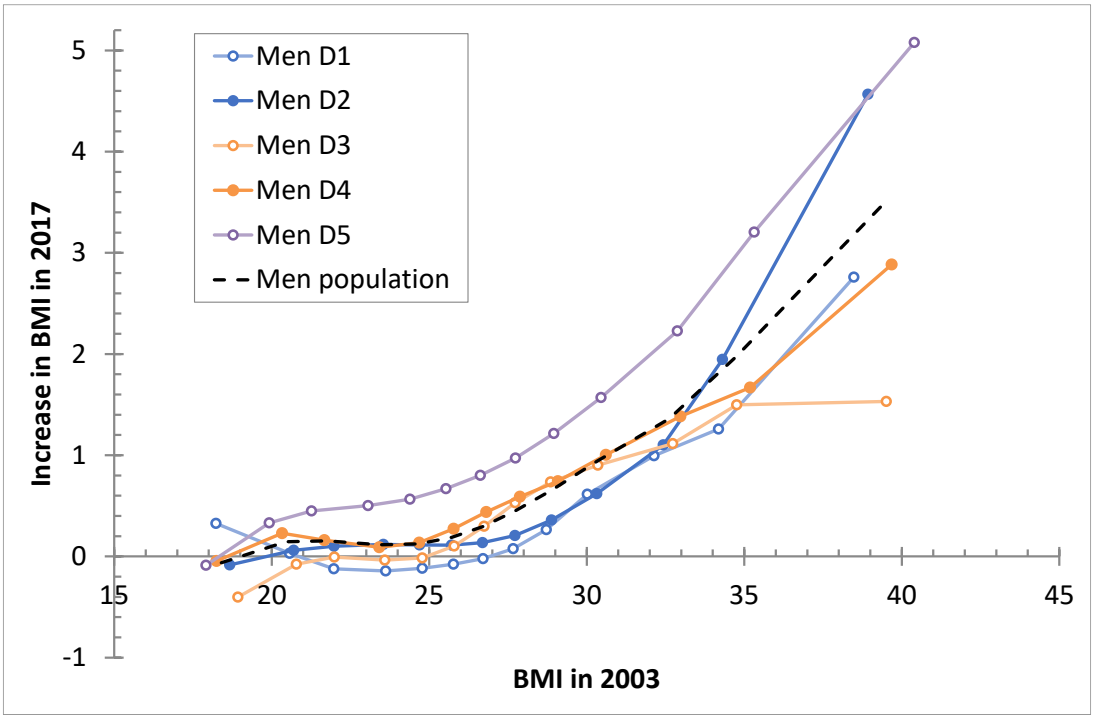

Figure 15.I.5 Percentile increases for deprivation BMI distributions for men from 2003 to 2017.

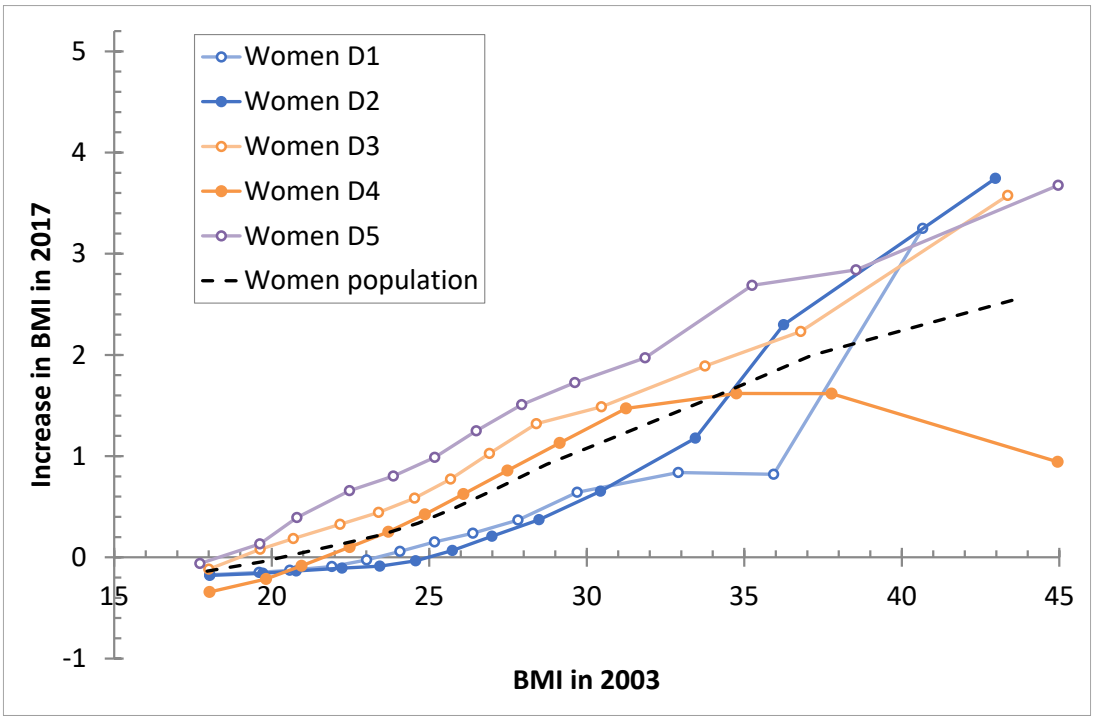

Figure 15.I.6 Percentile increases for deprivation BMI distributions for women from 2003 to 2017.

Appendix 15.II Height categories

Figure 15.II.1 and Figure 15.II.2 are charts of the percentile increases for the height category distributions from 1993 to 2017 including the 1% and 99% percentile values. These two end points are not included on the charts in Figures 15.13 and 15.14 in Chapter 15 of the main report so as to show the rest of the points more clearly without needing high values on the x-axis scale and the y-axis scale.

The dashed line in each case in the increase in the percentiles from the whole population distribution for 1993 to the percentiles for the whole population distribution for 2017.

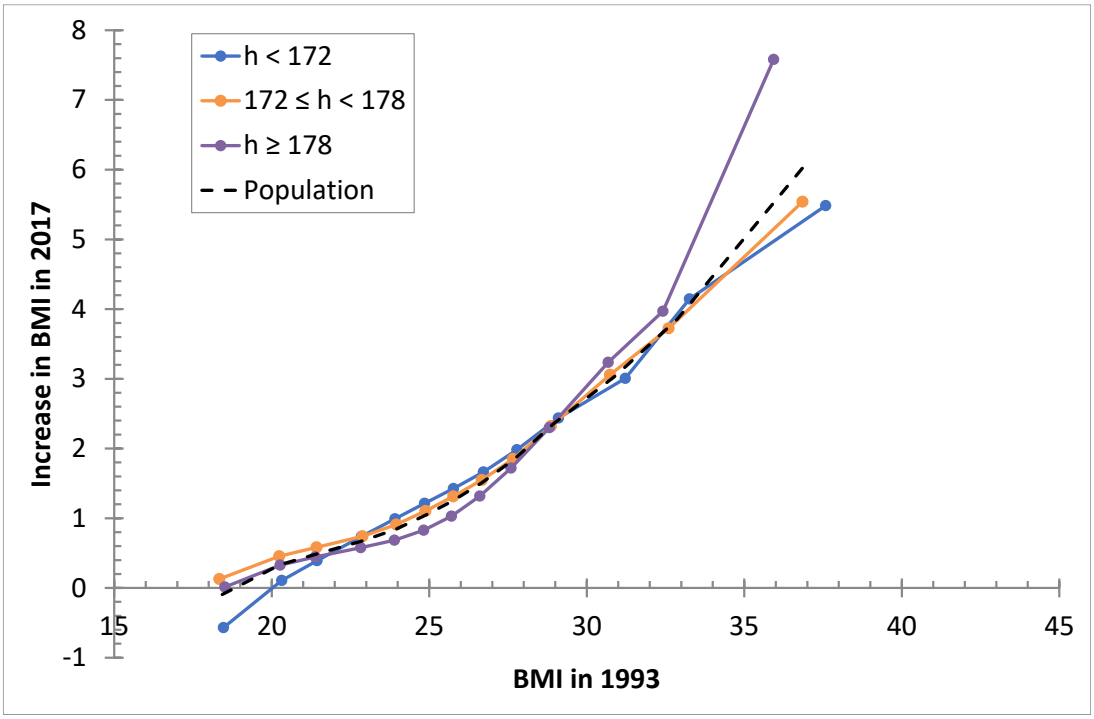

Figure 15.II.1 Percentile increases for height category distributions for men from 1993 to 2017.

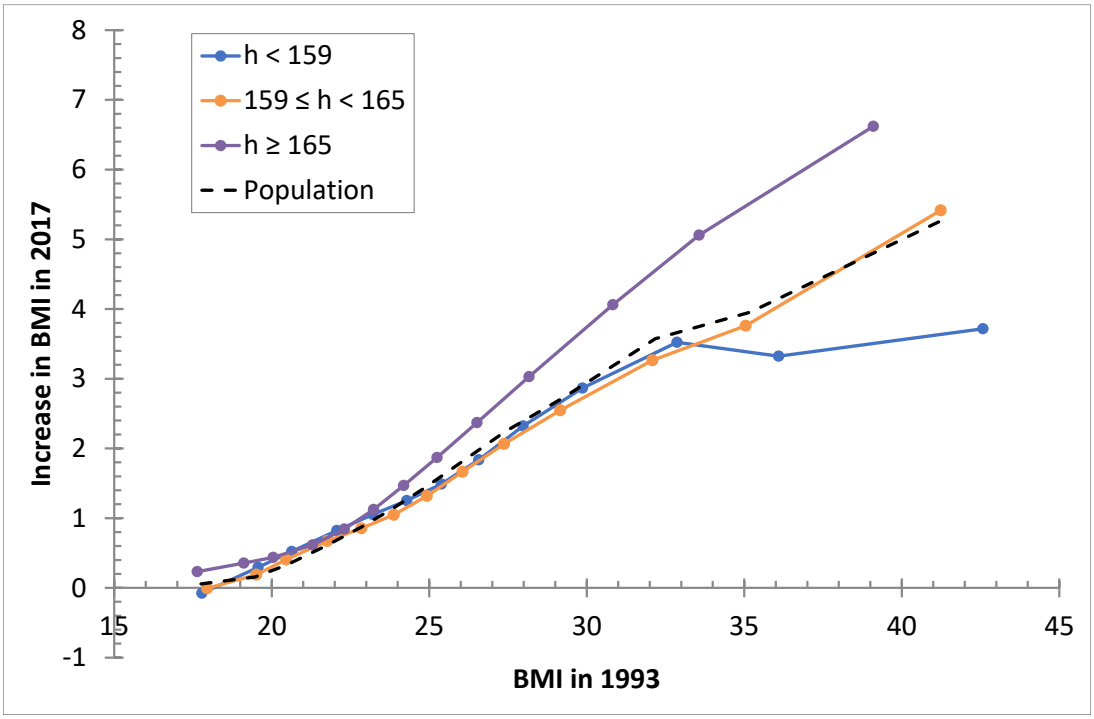

Figure 15.II.2 Percentile increases for height category distributions for women from 1993 to 2017.