THE BEHAVIOURAL INSIGHTS TEAM.

Counting Calories

How under-reporting can explain the apparent fall in calorie intake

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Contents

Executive Summary

Recently, several reports and media articles have noted that official statistics show a large decline in calorie consumption in the UK over the last 40 years.[1] At the same time, we have seen the population gain weight over this period. How has weight gone up, if we are eating less?

One response is that physical activity levels must have declined, leading us to expend much less energy. But this conclusion is at odds with the consensus of expert opinion, which points to rising calorie intake as the main cause of obesity.[2]

This question has major policy implications: the two schools of thought imply different approaches. One says that reducing calorie intake should be central to any obesity strategy; the other that calorie intake is falling without government activity, and therefore the rationale for policies aimed at reducing consumption is weak.

This report concludes that it is not plausible that large falls in calorie consumption, offset by even greater falls in physical activity, have caused the rise in obesity. Instead, we propose that the apparent fall in consumption can be explained by *an increase in under-reporting of calorie intake in official statistics*. In other words, calorie intake may not actually have declined.

Specifically, we conclude that:

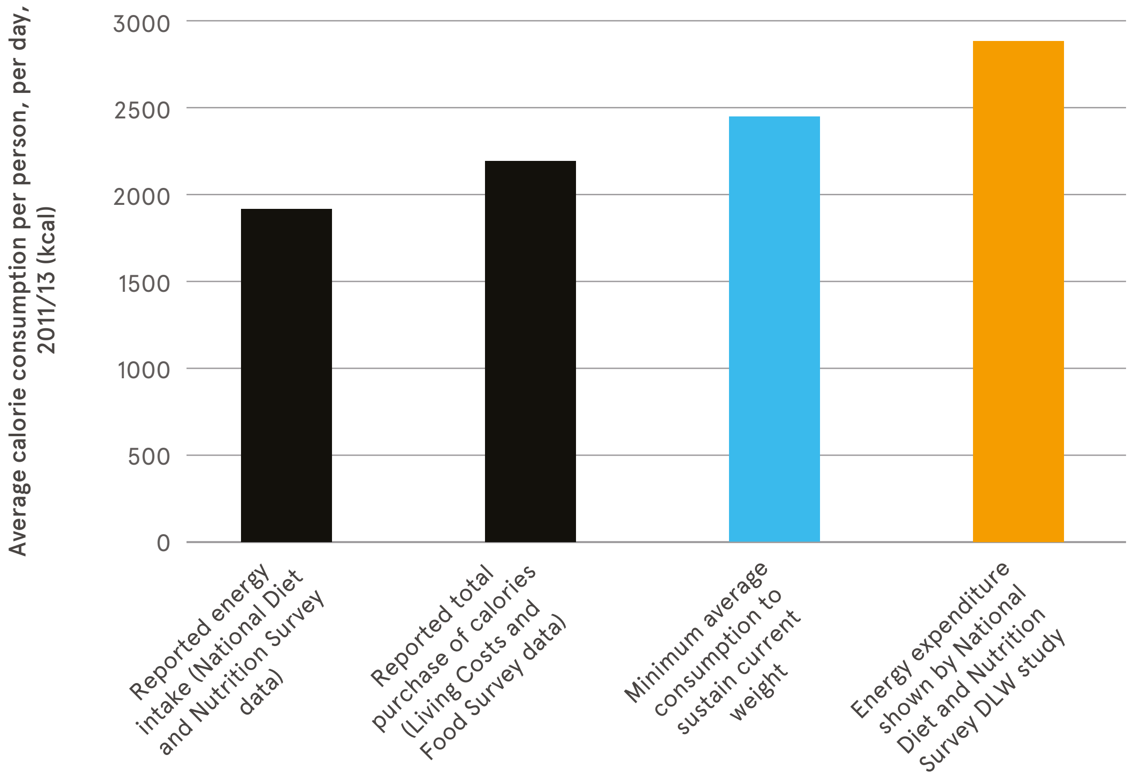
1. **National surveys are under-estimating our true calorie intake**. There are two main reasons why we believe this is the case:

    - The reported level of calorie consumption is too low to sustain our current weight even if we were only doing the minimum possible level of physical activity. In other words, if we were consuming this few calories, we would be losing weight as a nation, not gaining it.

    - The studies using Doubly Labelled Water, the gold standard for measuring energy expenditure, indicate that as a population we are consuming 30% to 50% more calories than the levels reported in official statistics (see Figure 1).

We also note that, while there has been a fall in official intake and purchasing figures, data from a commercial source - the Kantar Worldpanel - indicates a rise in calorie purchases over the last ten years.

Figure 1 Reported calorie intake versus estimated true calorie intake for adults



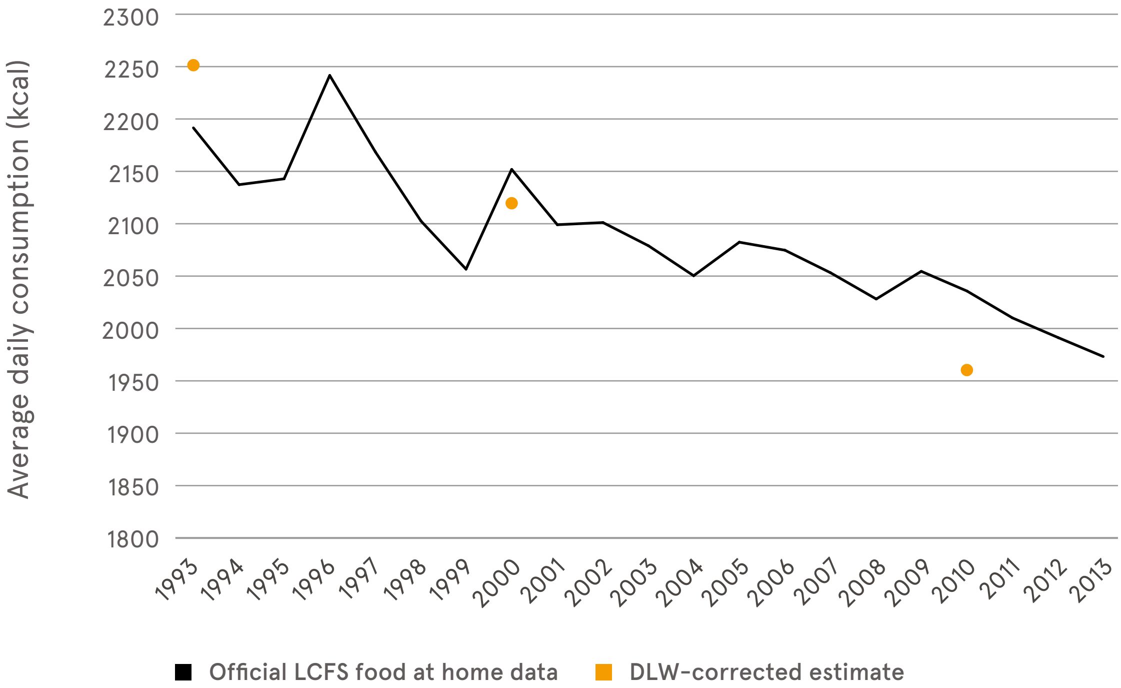
2. **Reductions in physical activity do not provide a realistic explanation for the change in weight.** The reported decline in calorie intake is so large that only an implausibly large reduction in physical activity could explain our weight gain. For example, the reduction is equivalent to every single adult in England jogging for around an hour less a day, every day, than they were in the 1970s (or half an hour less than in 1993). We show that falling levels of activity in the workplace do not provide the answer.

3. **Calorie intake appears to have fallen because under-reporting in surveys has increased over time.** If falling physical activity is not a realistic explanation for the increase in obesity, what is the real cause? We suggest that under-reporting of calories may have *increased over time*, to an extent that can explain the reported decline in calorie consumption.

We show this by estimating our true energy intake (using data from the National Diet and Nutrition Survey and Health Survey for England), and then applying the margins of under-reporting found in the DLW studies. The result is the calorie levels we would expect to see reported if people were consuming calories at a higher rate than in the official statistics, but were increasingly under-reporting these calories. We call these "DLW-corrected estimates". The graph below compares these estimates with official data.

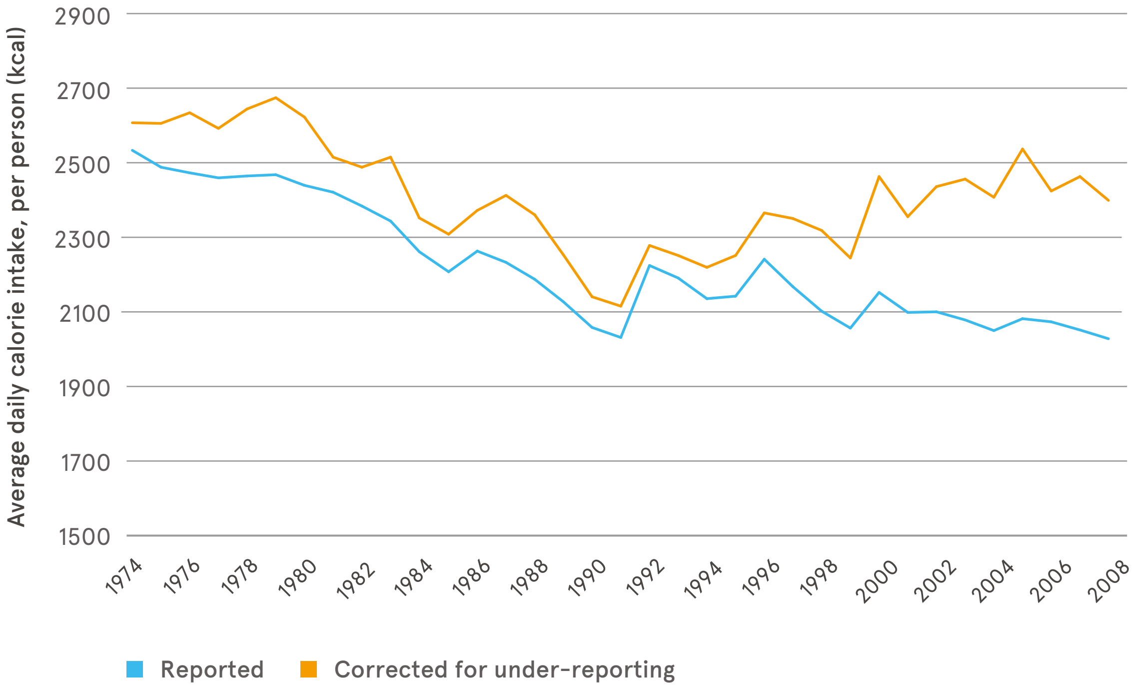
Over time the DLW-corrected estimates levels of reporting (which factor in under-reporting) are a very close match for the levels that were actually reported (Figure 2). We want to stress we have only a few data points available here, and comparing different studies is problematic. However, if these data and assumptions are reliable, they could potentially *explain the entire observed decrease in calories*.

Figure 2 **Calories reported in Living Costs and Food Survey compared with DLW-corrected estimates**



Importantly, we also see clear evidence of an increase in under-reporting using another approach. Economic studies have shown that the Living Costs and Food Survey (LCFS) is increasingly failing to match up with the economic activity shown in the national accounts. In other words, there is evidence that this and other surveys are increasingly failing to capture true purchasing levels. Studies have estimated that the percentage of economic activity not captured by the LCFS has increased from 2% in 1992 to around 16% in 2008. If we adjust the LCFS reported calorie figures to take this change into account, it appears that consumption has been increasing since the 1990s (see Figure 3).

Figure 3 **Calories consumed in the home (Living Costs & Food Survey), corrected and uncorrected for under-reporting**



We propose five main reasons why under-reporting may have increased:

- increasing levels of obesity (since obese people are more likely to under-report their intake);
- increased desire to lose weight (since this is associated with increased under-reporting);
- increased snacking and eating outside of the home;
- falling survey response rates;
- a growing discrepancy between reference data (used to calculate calories) and true portion sizes or food energy density.

Together, these factors point towards a serious increase in under-reporting. Finally, a trend to reduced food wastage suggests that people are consuming a larger proportion of the food they report purchasing.

Our first conclusion is that policies to reduce calorie consumption have an important part to play in an obesity strategy. Although attempts to increase physical activity should be part of the policy mix for obesity, they should not act as a distraction from the central importance of reducing calorie consumption.

Our second conclusion is that we need to revisit our methods for creating official statistics on calories. It may be possible, for example, to recalibrate current measures using estimates of under-reporting, as set out in this paper. We should also make wider use of DLW measures, in order to get more sophisticated estimates of under-reporting. In the context of the government's childhood obesity strategy, ensuring we have accurate measures of calorie intake is especially important: we need reliable measures for assessing the success of measures to reduce consumption.

We are optimistic about making progress towards this goal. The Government Statistical Service (GSS) has responded positively to this paper and has announced that a cross-departmental team is being established that will bring together new data sources in order to address under-reporting issues. The full response from the GSS is given in the `Policy Recommendations' section at the end of this report.

The following sections examine each of the points above in turn. This report is the work of the Behavioural Insights Team and should not be taken as the official position of the UK government.

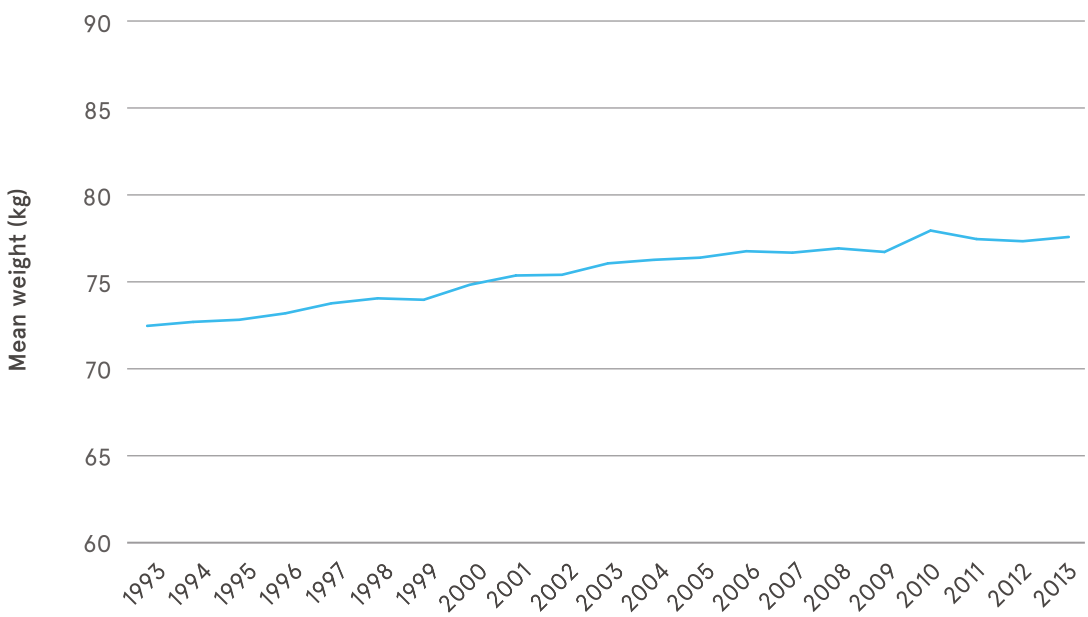
1. Data on body weight show that official statistics are under-estimating calorie consumption levels

We have been getting heavier

The Health Survey for England shows that our weight has been steadily increasing over the last 20 years (see Figure 4).[3] This will not be a surprise to many people. As a nation we are the heaviest we have ever been and this puts a severe strain on public resources.*

In order for an individual to be gaining weight over time they require a sustained excess of energy (i.e. to be consuming more energy than they are expending). Both how much we eat and how active we are play a role. If we are more active (or if we weigh more), we require more calories to maintain a stable weight.

Figure 4 Average weight in England, 1993-2013

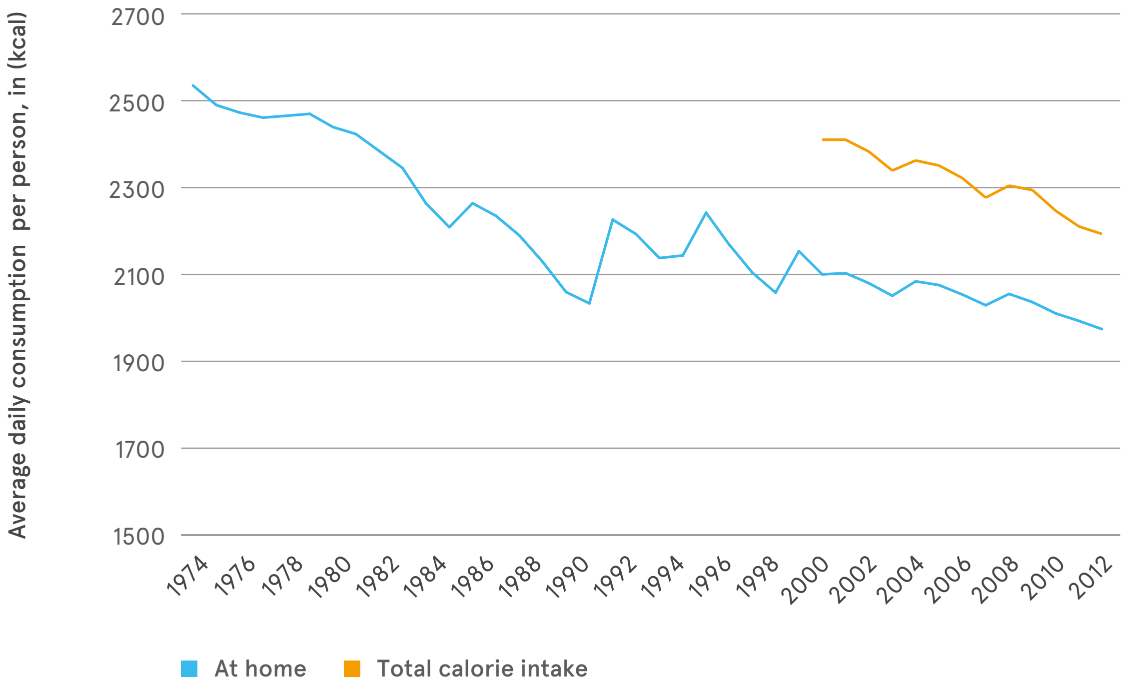


*Given that the debates about calorie reporting, calorie intake, and obesity have concerned the population as a whole, we focus on adults in this report and do not consider children separately.

Official data show a decline in consumption

The longest running source of data about how many calories we are consuming is the Living Costs and Food Survey (LCFS).[4] Historically this survey looked at food shopping, but more recently it has also incorporated eating out to give a fuller picture of food purchases. The LCFS clearly shows a consistent decline in the calories purchased over time, with estimates dropping to an average of 2192kcal per day in 2013 (Figure 5).* Importantly, this is a survey on food purchased rather than food consumed.

Figure 5 Average daily calorie consumption per person (Living Costs and Food Survey data)

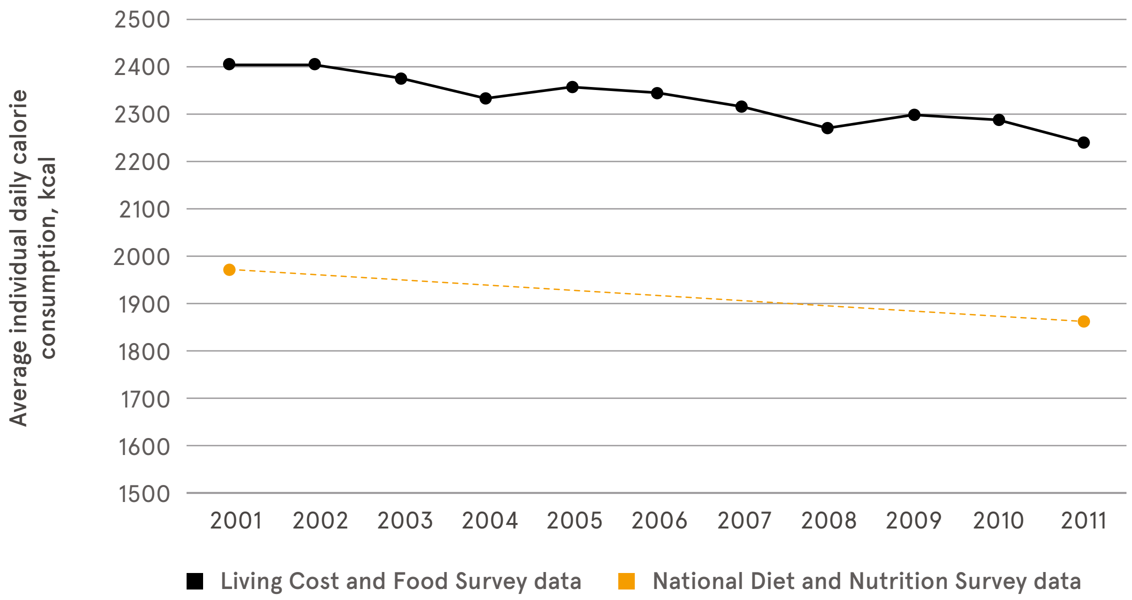


The other main official source of data paints a similar picture. The National Diet and Nutrition Survey (NDNS) measures reported food consumption, rather than purchases. The NDNS also shows a reduction in calorie consumption since it began in 2001, with average intake falling from 1972kcal in 2000-2001 to 1862kcal in 2011-2012.[5] This represents a 5.6% decline; the Living Costs and Food survey shows a 6.8% decline over the same period so, although the two data sources have different estimates of calorie intake, they are showing similar trends (see Figure 6). Interestingly, these estimates for calorie intake fall below the commonly-cited recommended daily allowance figures of 2500kcal for men and 2000kcal for women (for people of healthy bodyweight).**

*Food consumed outside the home was not measured by the LCFS until 2001.

**Indeed, the 2011 Scientific Advisory Committee on Nutrition Dietary Reference Values for Energy recommend higher intakes than the 2500kcal / 2000kcal level for those under 65 years of age. https://www.gov.uk/government/publications/sacn-dietary-reference-values-for-energy (Table 16, p.85).

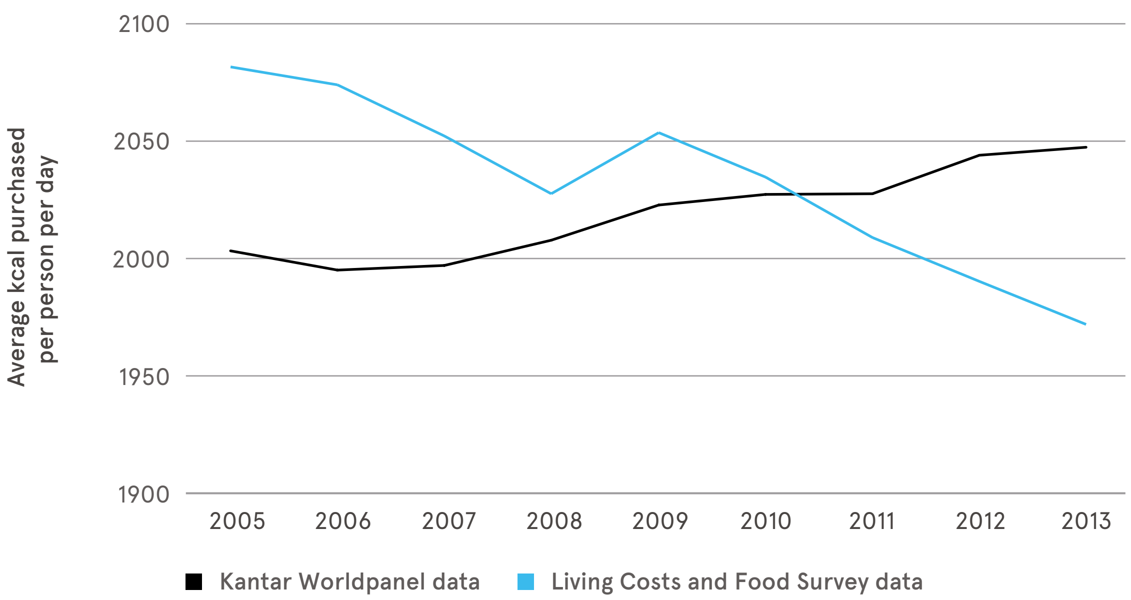
Figure 6 **Reported average daily calorie consumption from Living Costs and Food Survey and National Diet and Nutrition Survey**



Note: NDNS estimates are lower than LCFS estimates because they concern reported food consumption rather than reported food purchases.

However, we see a slightly different picture if we look at other data sources on calorie purchasing. The Kantar Worldpanel survey is a continuously reporting panel of 30,000 British Households.[6] The dataset available to us (which only starts in 2005) shows a 45kcal rise in purchases of calories, compared the 90kcal decline seen in the LCFS over the same period (Figure 7).

Figure 7 **Comparison of LCFS and Kantar Worldpanel data on food purchased for home consumption, 2005-2013**



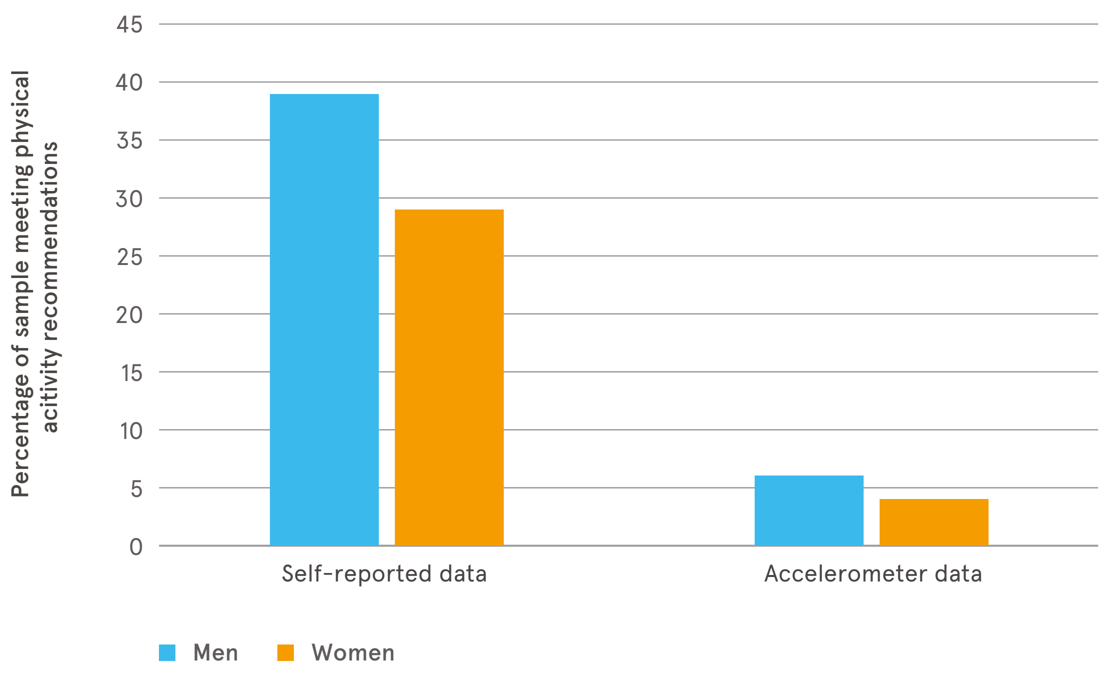
Nevertheless, our main purpose in this report is not to find competing data sources for the official statistics, but to examine if they are plausible. As a starting point, we suggest that the calorie intake levels shown in official data are implausibly low. We explore this point more in the next section.

Current consumption estimates are not plausible because they are too low to sustain our current weight

It is well known that survey participants can provide inaccurate responses, whether intentionally or not. For example, one recent study compared self-reported use by smartphone users with objective use data recorded by an app. The data revealed that owners were using their phones twice as much as they reported.[7]

Similar results are obtained for health behaviours. The 2008 Health Survey for England asked adults to recall how much physical activity they had performed over the previous four weeks.[8] A sub-sample of adults wore an accelerometer for the week following the survey. An accelerometer provides an objective measure of physical movement. The self-reported data indicated that 39% of men and 29% of women met the Chief Medical Officer's minimum recommendations for physical activity; the data from accelerometer indicated that the only 6% of men and 4% of women had done so (see Figure 8).

Figure 8 Comparison of physical activity from self-reported data and accelerometer-recorded data, Health Survey for England 2008



Most relevant is the under-reporting of calorie consumption documented in many scientific studies.[9] For food intake, as with many self-reported behaviours, there is likely to be both conscious and unconscious under-reporting. There will be items of food that people genuinely have no recollection of eating, and there will be accidental under-estimates of portion sizes. This is not a new problem. For example an academic paper from 1993 states *'our current techniques often do not obtain valid measures of habitual intake. This problem has been suspected, but because of lack of evidence, often conveniently ignored'*.[10]

However, there is at least one simple check for under-reporting. We can calculate the minimum level of calorie consumption that would be needed to maintain our current weight (i.e. our minimum energy requirement). We can use well-established equations to estimate this minimum level. Since the data show that our weight is not declining (at least at a population level), if the survey estimates are below this minimum level then they cannot be correct.

Energy requirement is a function of our basal metabolic rate (BMR) multiplied by our physical activity level (PAL).* BMR is a function of height, age and weight, and differs slightly by gender. People who are younger, taller and heavier have a higher BMR (and thus need more energy, all things being equal). In line with Public Health England, we use the Henry equations for calculating BMR.**

PAL serves as an estimate of daily physical activity, including both work and leisure time. We can use data from the Health Survey for England to accurately estimate the average BMR of the adult population over time, but what about physical activity? In an attempt to set the lowest possible minimum energy requirement, we adopt the lowest plausible limit of physical activity, which assumes the whole population lives a sedentary lifestyle. This produces a PAL estimate of 1.55, which is used in previous similar research and is reported by the International Obesity Task force.[11]

Multiplying BMR by this lowest plausible level of physical activity gives us the minimum average energy requirement. Using national average height, age and weight data for adults in 2013 gives an energy requirement of around 2446kcal per day to maintain our current weight (2755kcal for men and 2138kcal for women). This figure is substantially larger than estimates of calorie intake presented in official statistics (see Figure 9).

Therefore we can confidently say that the absolute level of calorie consumption cannot be as low as reported in the data. If this calorie level were true, then our weight would have to be decreasing, since we wouldn't be taking in enough calories to support our current weight, even at very low levels of physical activity. We therefore agree with a recent review of the US national diet survey, which found that "data on the majority of respondents... were not physiologically plausible.'[12]

*We are aware that the thermic effect of food (dietary induced thermogenesis) also affects energy expenditure, and will increase as the amount of food consumed increases. We do not factor in this phenomenon because of its complex relationship with obesity (Jonee, L., & Bray, G. A. (1997). The thermic effect of food and obesity: a critical review. Obesity Research, 5 (6), 622-631.).

**We have applied the equations in a simplified way – we have used population average values for height and weight, rather than values weighted by what proportion of the population fall into the 18-30, 30-60 and 60+ age brackets.

Other data sources show much higher levels of energy intake

We have already shown that the overall levels of calories reported in both the LCFS and NDNS are too low. To prove this, we used the lowest plausible level of physical activity. However, as a population we are not all entirely sedentary so the real level of energy requirement is likely to be substantially higher than 2446kcal. To estimate actual energy expenditure we can use data from Doubly Labelled Water (DLW) studies.

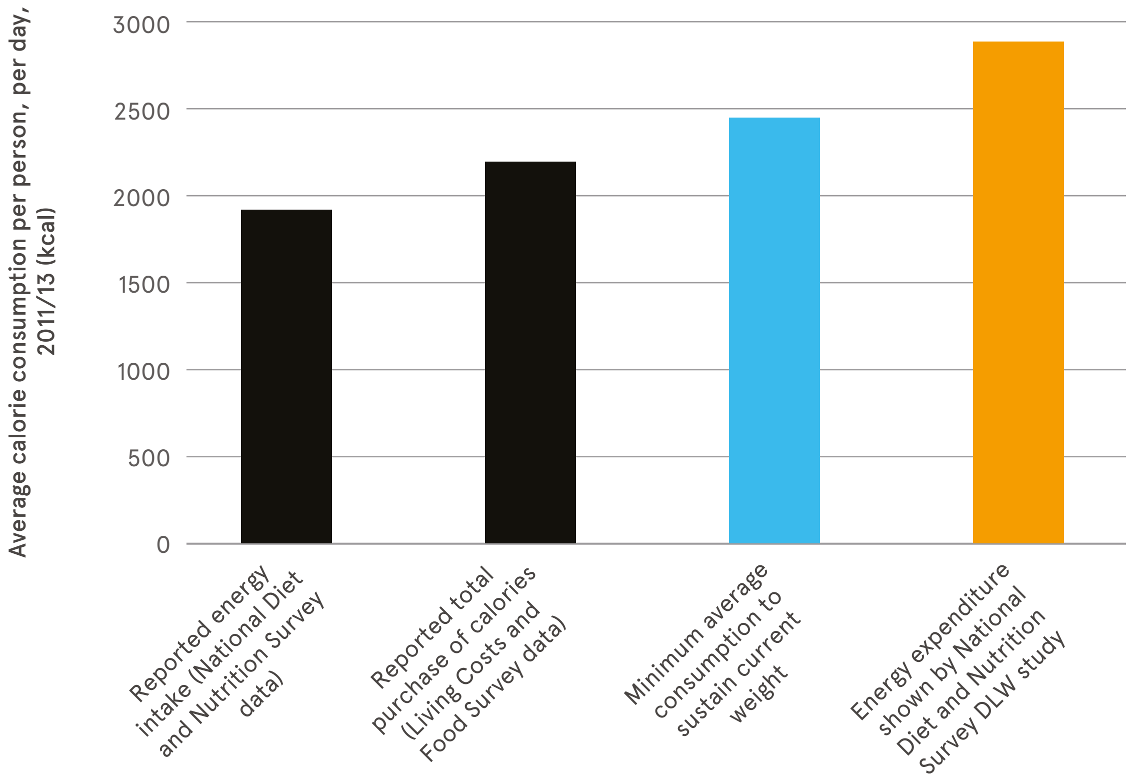
The DLW method is widely seen as the "gold standard" for measuring energy expenditure in humans.[13] DLW studies now provide increasing opportunities to compare reported intake with objective measures of energy expenditure (to reiterate: at a population level, we must be consuming more energy than we are expending, if we are gaining weight).

The method involves asking participants to drink 'doubly labelled water', which is water enriched with two naturally occurring stable isotopes. This enrichment process means that analysing urine samples from the participants reveals how much carbon dioxide they have produced – and therefore how much energy they have expended - since they drank the water. From this figure we can calculate a daily total energy expenditure. If we are gaining weight, then our calorie intake must be at least as large as this energy expenditure figure. The difference between the energy expenditure figure and reported calorie intake can therefore be used to identify calorie under-reporting.[14]

The UK's National Diet and Nutrition Survey (NDNS) includes a sub-sample of adults who also took part in a DLW study. This study indicates that energy expenditure was around 2880kcal for adults, which means that under-reporting in the main survey was substantial: around 32% for adults.[15] With this level of under-reporting, if real energy expenditure was 3000kcal it would be reported as only 2040kcal. Figure 9 compares reported calorie intake from official statistics with the minimum level of consumption required to sustain our weight and the energy expenditure indicated by the official DLW study.*

* We use the latest data available: 2011 for NDNS main survey and DLW study; 2013 for LCFS and minimum average consumption estimate.

Figure 9 Reported calorie intake versus estimated true calorie intake for adults



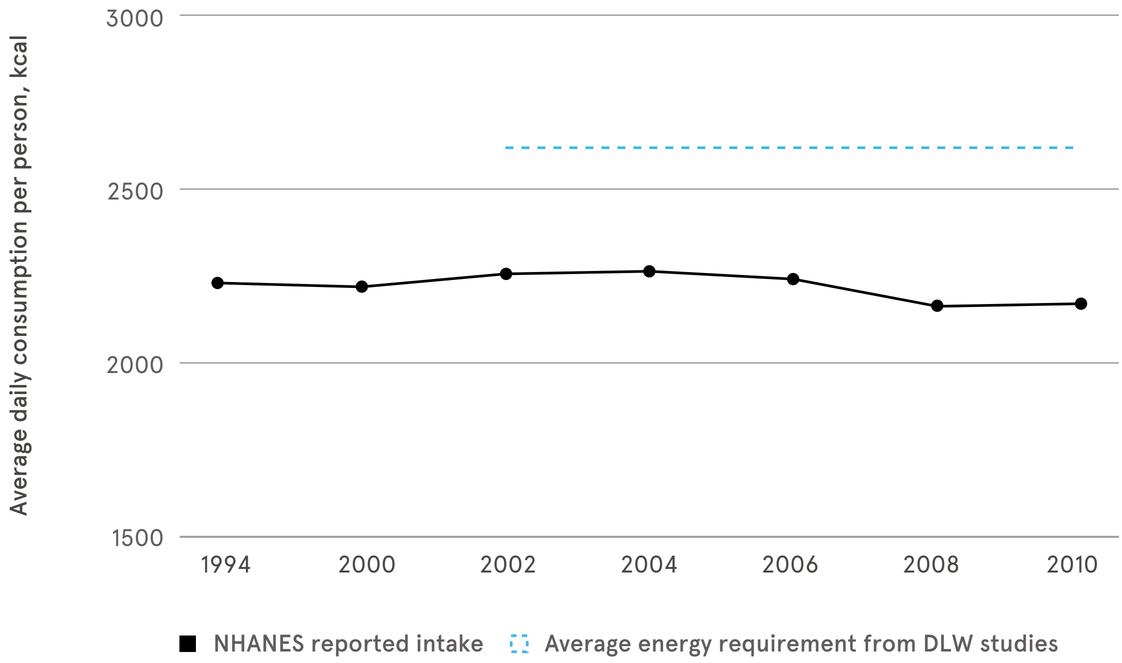
Note: This graph shows reported calorie intake versus estimated true calorie intake for adults, from NDNS and LCFS data, plus BIT calculations based on minimum average consumption to sustain current weight.

DLW is a reliable method, described in the NDNS as 'an established method widely agreed to be the most accurate way of measuring energy expenditure in free-living individuals over one to two weeks, and hence detecting misreporting of energy intake (EI)'.[16] DLW studies form the sole data source for the Scientific Advisory Committee on Nutrition's Dietary Reference Values, for example.

Nevertheless, it is worth noting the limitations of the DLW method. The DLW study did not take place over exactly the same period as energy intake in the NDNS. Given that the DLW method is expensive, the DLW part of the NDNS was conducted with a relatively small sub-sample. This sub-sample was found to be representative of the NDNS (which is in turn representative of the population) on observable characteristics.[17] However, the possibility of recruitment bias cannot be eliminated. Moreover, since participants are aware of the DLW study, this might lead to unrepresentative behaviour during the study period, possibly increasing physical activity and thus energy expenditure. The DLW method is explained in more detail in Appendix X of the 2011 Dietary Reference Values for Energy.[18]

Looking more widely, several other DLW studies show a similar level of under-reporting. For example, the United States' main nutrition survey is the National Health and Nutrition Examination Survey (NHANES). NHANES data also shows a small decline in calorie consumption. However, we can look at the best available DLW studies from the 2003-2008 period in the US (as selected by the Scientific Advisory Committee on Nutrition); these suggest that energy expenditure is much higher (Figure 10).[19]

Figure 10 US adult reported calorie intake compared to energy expenditure recorded in Doubly Labelled Water studies



Under-reporting is a substantial and serious problem

We believe that discussions of food consumption have not paid enough attention to the scale of under-reporting in national surveys of both food consumption and food purchases. Such a large under-estimate of calorie intake could misinform the policy debate and lead to less effective strategies to combat the current national obesity crisis.

Later in the document we address the objection that the *trend of decline* in calorie consumption may be real, even though the stated levels of consumption are unrealistically low. However, next we consider another argument that is has been advanced alongside the assertion that calorie intake has declined. The main claim is that the increase in weight has been driven primarily by falling physical activity levels over recent decades. We do not consider this to be a plausible argument.

2. Reductions in physical activity do not provide a realistic explanation for the change in weight

The previous sections established that we must be consuming more calories than official survey data state. But energy intake is only one half of the story; in order to understand our weight gain, we must also have an accurate figure for how much energy we are expending.

Some analyses have claimed that a significant decline in physical activity has led to a collapse in energy expenditure, and thus we have gained weight even though we are eating less. Initially this argument seems plausible: our jobs are now less physically demanding than they once were; household chores have become less strenuous; and people spend more time engaged in sedentary activities like watching television. However, as explained below, we do not consider this to be a plausible argument.

A very large decline in physical activity would have been required to offset the suggested decline in calories

Clearly, the required change in physical activity is dependent on whether our calorie intake has also changed. In the Annex, we show calculations that an initial energy excess of 86kcal would cause the observed weight gain between 1993 and 2013. An excess of 86kcal is a surprisingly small energy imbalance, less than an extra packet of crisps a day. Small changes in lifestyle could account for such an imbalance.

However, if calorie consumption had been *decreasing* over this time period, we would need to have seen a correspondingly even larger decline in physical activity to produce the weight gain we have observed. In other words, the relatively small 86kcal difference becomes much larger if we assume both calorie consumption and physical activity have declined.

We now briefly explore three different possible states of the world to estimate how large a change in physical activity would have been needed in each case. The three scenarios are: constant calorie consumption; the 220kcal decline in consumption from 1993-2013 shown in the LCFS; and the 562kcal reduction in consumption since 1974 shown in the LCFS.* Other studies based on official survey data have proposed larger falls in calorie consumption than these, so again we trying to create conservative estimates.[20] As before, we assume our current physical activity level to be sedentary at 1.55, providing a lowest plausible estimate.

*Note that we are using 'food consumed in the home' data only, since this is present over a longer period than the composite of food consumed in and out of the home. Since it has been recorded in 2001, food consumed out of the home is shown a similar to pattern to food consumed in the home.

Our analysis uses population average data, rather than focusing on men or women. The basic conclusions hold true if one considers men or women separately.

1. Assuming kcal consumption has **stayed the same** since 1993, a small reduction in Physical Activity Level (PAL) could have caused the observed weight gain (from 1.61 to 1.55).

2. Using the LCFS **220kcal** reduction since 1993, a significant reduction in PAL could have caused the observed weight gain (from 1.75 to 1.55).

3. Using the LCFS **562kcal** reduction in consumption since 1974, PAL would need to have decreased from 1.98 to 1.55. This is a very large shift at a population level.*

For some context, the FAO/WHO/UNU 1985 report identified the lower limit of PAL, a 'survival' value, to be 1.27.[21] The difference in PAL between generally sedentary and bedridden is 0.28. This is comparable to the required PAL reduction of 0.20 from 1993 to 2013 to counteract the suggested reduction in calorie consumption. In other words, a 220kcal reduction in calorie consumption would have required a change in physical activity similar to the UK population going from sedentary to bedridden. The 0.43 PAL reduction required to explain the reported 562kcal reduction in calorie consumption since the 1970s is considerably larger.

We now explore in more detail what such a reduction in PAL would mean in terms of changes to work life and leisure time.

What would this kind of decline mean in terms of changes in some typical activities, like walking or running? We can provide some estimates to see if the required changes seem realistic. In order to translate energy expenditure into physical activity levels, we use the 2011 SACN document on Dietary Reference Values for Energy, which provides a useful comparison table between measures of physical activity and energy expenditure (see Annex).[22] In the table below, we retain the three potential 'states of the world' that we introduced above: no change in calorie consumption; a 220kcal decline; and a 562kcal decline. The table below gives a few examples for each of these three states of the world.

* We do not have weight, height and age data from the 1970s. The earliest dataset we have is from HSE (1993). We have used these 1993 figures for this calculation as well. We believe this is justified because it gives us a more conservative estimate for the change in activity. Since we are using a heavier weight for 1974 than we actually were, we are underestimating the BMR for this year. This means that for a given calorie consumption, we would need to have a higher physical activity level to not gain weight. (Jogging for ten minutes burns more energy if you weigh more.) Therefore, in order to balance, the overall level of physical activity must be higher in 1974 than we are assuming – and so the difference in activity levels between that period and now is an underestimate.

Scenarios of consumption	Required difference in daily activity (average for men and women)		
	Walk (2mph)	Walk (3mph)	Jog (6mph)
a) Constant consumption (1993-2013)	41 minutes	28 minutes	7 minutes
b) 220kcal reduction (1993-2013)	2 hours 31 minutes	1 hours 41 minutes	26 minutes
c) 562kcal reduction (1974-2013)	5 hours 22 minutes	3 hours 35 minutes	56 minutes

This table suggests that if the most dramatic claimed changes in calorie consumption are true, then *every single adult in England* would have needed to have be doing the equivalent of an additional 56 minutes of jogging *every day* in the 1970s compared to today. Alternatively, given claims about the decline in active travel, every single adult nationally would need to have eliminated over 3.5 hours of daily walking commute to account for the changes. We do not think that a shift of this scale is realistic.

A possible response is that changes to physical activity have been driven by a reduction in the energy expended at work. We now use a new dataset to test whether this argument holds up.

Energy expenditure at work may not have declined

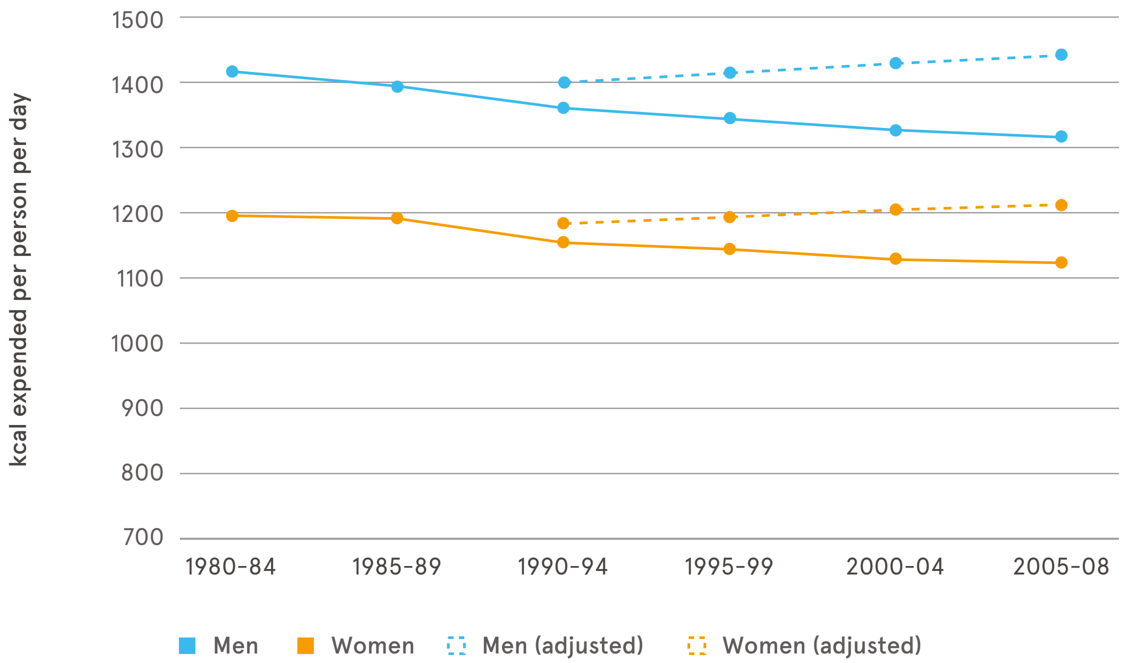
To calculate changes in energy expended at work, we use data from a recent in-depth report on the shift in the labour market from 1980-2008.[23] The authors use individual level nationally representative data from a number of surveys to document changes in activity levels, and strenuousness of work. The data presented are given in Metabolic Equivalent of Task (METs). This is a measure of the intensity of physical activity where:

1 MET = 1 kcal expended, per kg of bodyweight, per hour of activity

We have adopted the MET levels used by the authors in the existing report. In this analysis, lying or sitting completely still whilst awake has a MET of 1. A sedentary job sitting at a desk would have a MET of 1.5, whilst moving boxes is 8 METs. For ease of comparison we have converted METs into kcal using the equations above.

Figure 11, below, shows energy expended at work under two assumptions. The first is that our weight remained constant, which we know not to be the case; the second uses average weight data from HSE over time to give an adjusted energy expended figure (available from 1992 onwards). Clearly, it is more appropriate to adjust for the change in our weight, since if we weigh more we expend more energy just maintaining that weight. Based on the calculations in the Annex, we require an additional 86kcal per day to sustain our 2013 weight compared to our 1993 weight.

Figure 11 Calories expended at work, adjusted and unadjusted for changes in bodyweight



These calculations suggest that when weight change is taken into account we see a reversal of declining energy expenditure at work. Even though jobs have become less strenuous over time, the increase in people's body weight more than compensates for the ensuing decline in activity. Therefore we conclude that the necessary decline in physical activity to offset the suggested reduction in calorie consumption should not be attributed to changes in working conditions.

We use some crude assumptions when calculating the weight-adjusted energy expenditure figures. We assume an eight hour work day and – most importantly – we simply use the average body weight for a given year. It would be useful to conduct a more detailed analysis that: uses a figure for body weight that includes, for example, gender differences and the distribution of weight in the population; that considers body composition changes (e.g. lean vs fat mass); and that factors in the distribution of strenuousness across jobs.

However, we believe that the crude average is sufficient to show that the proposed change in activity levels actually translates into a relatively small change in calories over time, if we assume that weight has been constant. And if we factor in body weight, it is possible that energy expenditure has effectively remained constant over time.

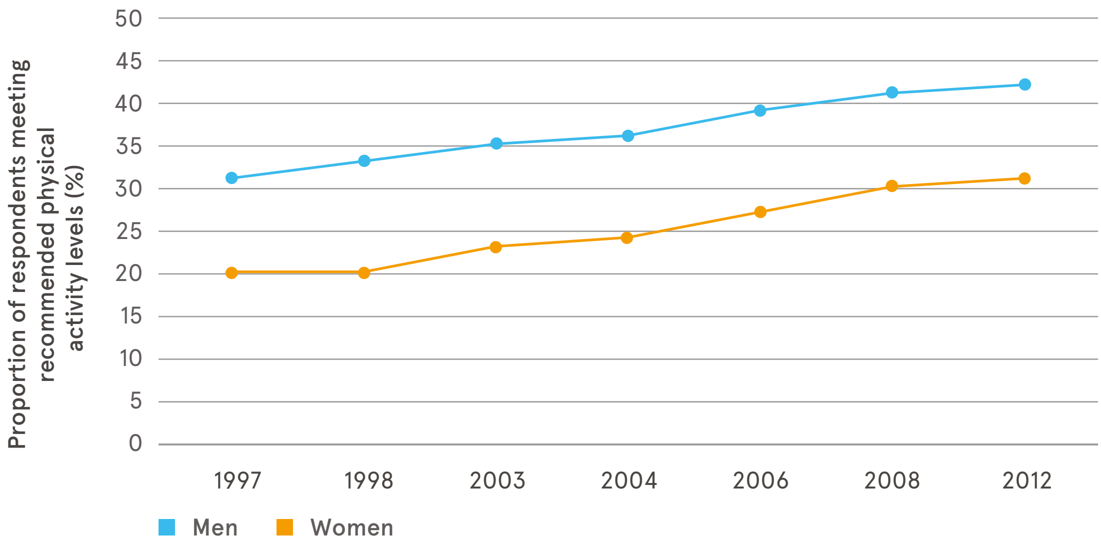
Survey data on physical activity do not provide clear conclusions

Now that we have established the scale of decline in physical activity that would be needed, we turn to existing data sources to establish whether there is any evidence that such a decline has indeed occurred.

Trends in physical activity are difficult to establish because data generally has not been collected as consistently - or over as long a period – as that for food consumption.[24] Therefore, our comparisons cannot extend over the same time period.

We can start with self-reported data. As we state above, we believe there are serious problems with relying on self-reported data, given the prevalence of misreporting. It is worth, however, at least considering the reported trends. The 2012 Health Survey for England gives the most recent national picture of physical activity levels (although changes in survey methods and official guidelines make comparisons complicated).* The survey concludes that that the proportion of adults meeting recommended levels of physical activity has increased 'steadily' since 1997/1998 (Figure 13).[25] Interestingly, there was a statistically significant decrease in physical activity for boys between 2008 and 2012 (the years for which a comparison was possible) - although there was not a significant decrease for girls.

Figure 13 **Trend in those meeting the Chief Medical Officer's recommend physical activity levels (Health Survey for England data)**

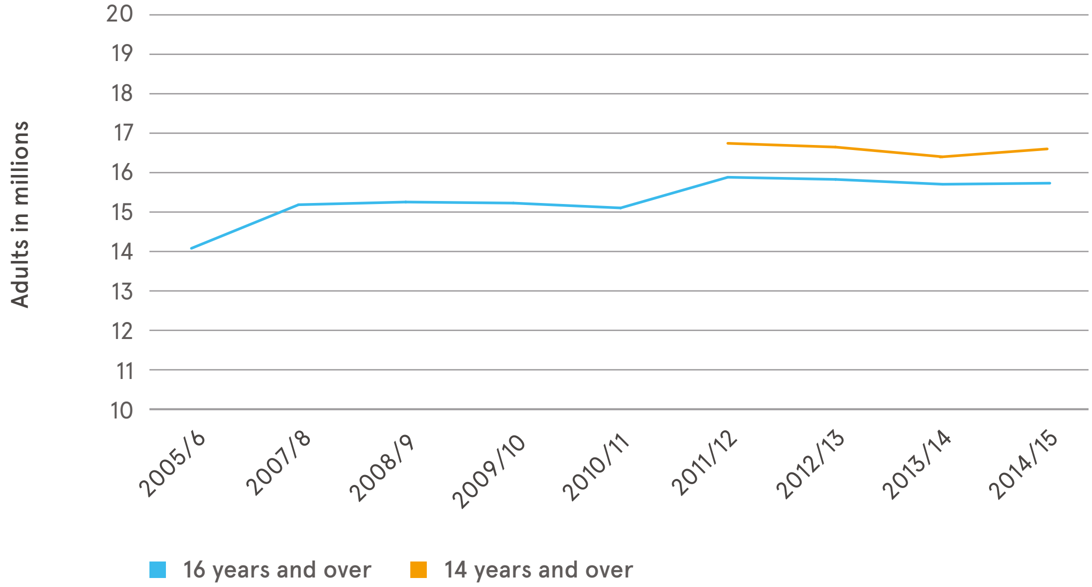


In terms of leisure time physical activity, the main source is the Active People Survey (APS), which has now been running since 2005. The latest overview of APS trends in physical activity concludes that 'the overall number of people playing sport is relatively stable', and that there was no clear trend in amount of sport they were taking part in.[26]

*For example, the Chief Medical Officer's physical activity guidelines changed in 2011 so any blocks of activity lasting 10 minutes or more counted, whereas before only blocks of 30 minutes or more were counted. In other words, the major problem with presenting the proportion of people meeting guidelines is that the guidelines may have become easier to fulfil.

The 2013/14 APS showed that 15.7m adults played sport at least once a week – an increase of 1.7m from 2005/6 (Figure 14).[27] Moreover, six of the nine English regions saw statistically significant increases in weekly sport participation 2005/6 to 2014/15.[28]

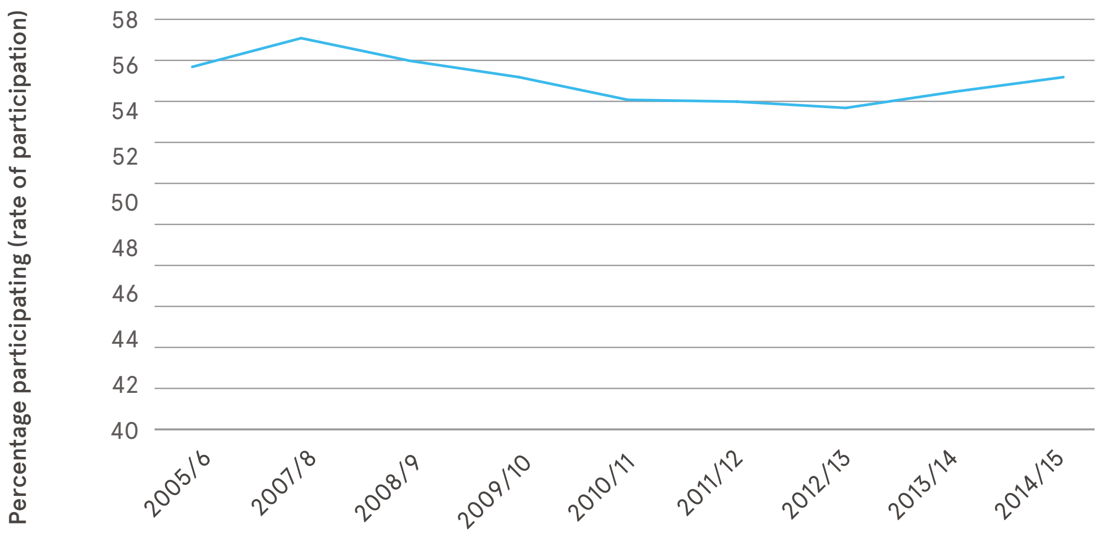
Figure 14 Adults participating in sport at least once a week



Source: Active People Survey. Participation is defined as 1 x 30 minutes moderate intensity physical activity.

Of course, simply presenting raw participation numbers (as above) does not account for the fact that population levels are increasing.[29] However, if we look at participation rates for 16-25 year olds, we can also see that they have been essentially flat over the lifetime of the APS (Figure 15).

Figure 15 Proportion of 16-25 year olds participating in sport at least once a week



Source: Active People Survey.

THE BEHAVIOURAL INSIGHTS TEAM.

Although these datasets only cover the last decade (and they do not reflect possible changes in the *intensity* of sport), the main physical activity surveys do not show evidence of the collapse in physical activity levels that would be necessary to account for our increase in weight.

We conclude that the reported decline in calorie consumption does not tally with the observed national weight gain and a realistic change in energy expended from physical activity. Given the factors presented above, we conclude that it is not credible to claim that a decline in physical activity is the sole (or primary) cause of our weight gain.

3. An increase in calorie under-reporting is a plausible explanation for the apparent decline in consumption

In Section One we showed that there is evidence that calories are being greatly under-reported. However, if levels of under-reporting are *consistent* over time then they cannot explain the reported reduction in calorie consumption since the 1980s. We now present evidence that the magnitude of under-reporting has notably increased over this time period. If this is true, then real calorie consumption could have stayed constant but appear to be decreasing in self-reported survey data.

Doubly Labelled Water studies show an increase in under-reporting

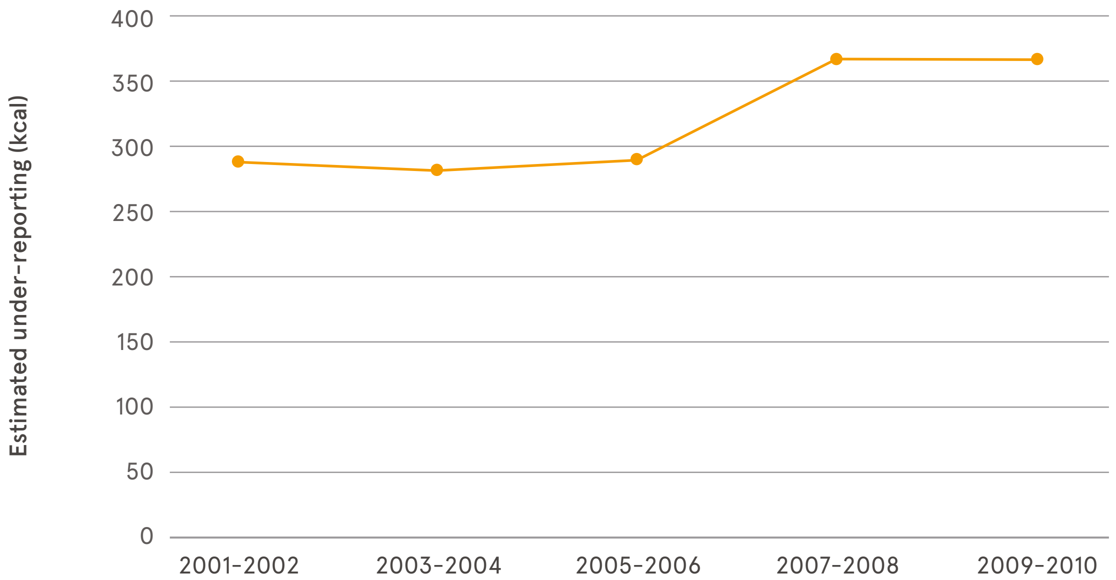
The most obvious step is to look at the Doubly Labelled Water studies discussed in Section One and see if there is a trend in the under-reporting they present. Unfortunately the current methods of DLW in the National Diet and Nutrition Survey have not been running for a very long time. We use estimates from 2008/11 and compare them with data from the 2000-2001 round. Going back earlier than this requires looking at the wider academic literature. We have identified one UK study, from 1993, that we believe is suitable for use in this way.

The headline figures from these studies are given below. We want to stress that there are difficulties with comparing these levels over time, since they come from different studies with different methodologies. Therefore, this exercise should be seen as indicative, rather than conclusive proof of a trend.

- The 2008/11 NDNS estimates under-reporting to be 32 per cent[30]
- The 2000 NDNS estimates under-reporting to be 25 per cent[31]
- Data from a 1993 study estimates under-reporting to be 19 per cent[32]

We are aware that there are only three available data points here, and therefore any conclusions need to be heavily caveated. However, we can look to US data to see if a similar trend is observable there. A recent study of NHANES data does indeed suggest that under-reporting also appears to have increased in recent years (Figure 16), which provides some support to our proposal.[33]

Figure 16 **Trend in under-reporting of calories, US NHANES data**



Source: Archer, E., Hand, G. A., & Blair, S. N. (2013) Validity of US nutritional surveillance: National Health and Nutrition Examination Survey caloric energy intake data, 1971–2010. PloS One, 8(10), e76632.

Taking these facts together, we think there is value in at least examining what impact this scale and trend of under-reporting might have on reported calorie levels. To do this, we apply these levels of under-reporting to the Living Costs and Food Survey results. Although this involves applying one set of survey data to another, we believe there are sufficient similarities (not least in the trends they are displaying) to justify this move. We could have applied the same process to NDNS calorie consumption data only (i.e. maintaining full congruency), but this would have limited value because NDNS figures are only available from 2000 to 2011.

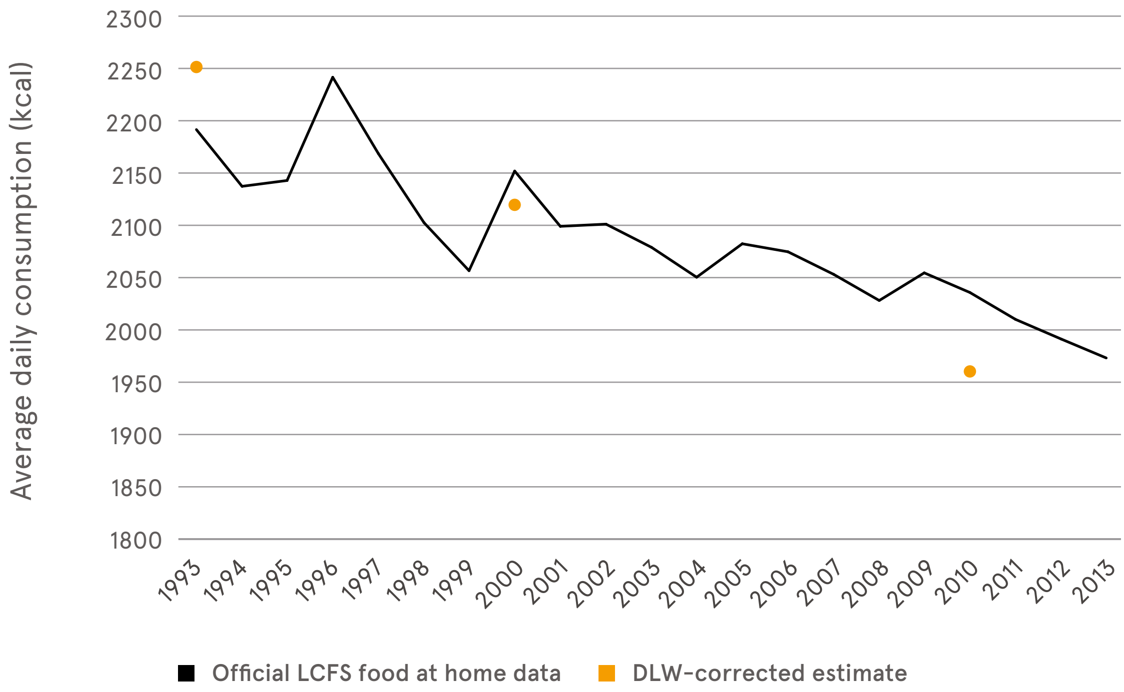
First we use DLW energy requirement data from the 2008/2011 NDNS to create a plausible estimate for Physical Activity Level (PAL) at this point in time.* We then apply this PAL estimate to the BMR for 1993 and 2000 to create a new estimated energy requirement, based on PAL remaining constant.** We apply the DLW under-reporting rates for 1993, 2000 and 2010 to these estimated energy requirements. *The result is the level of calorie reporting we would expect to see if we estimated our true energy intake and factored in under-reporting*. We call this the 'DLW-corrected estimate'.

*The PAL estimate is 1.80. This is calculated by dividing average ER (as measured by DLW in 2008/11 NDNS) by average BMR from 2010 (based on the stated equations and HSE population average data). It is worth noting that the average ER in the 2008/11 NDNS data is not weighted to be exactly representative of the general population.

**We do this in order to factor in changes in weight. We could have just assumed that energy requirements had remained the same over time. But if we weighed less in the past, this would mean that our energy requirement would have been lower, given the same level of physical activity. We have also calculated these figures assuming that energy requirements have remained constant; the resulting graph is very similar to the one included here.

We then compare the DLW-corrected estimates with the existing LCFS home consumption data. Figure 17 shows the results. Over time the corrected estimates (assuming under-reporting) are a very close match for the levels that were actually reported. If these data and assumptions are reliable, they could potentially explain the entire observed decrease in calories. At the very least, these figures show that the level of under-reporting is of such a magnitude that it *could* explain the apparent fall in calorie consumption.

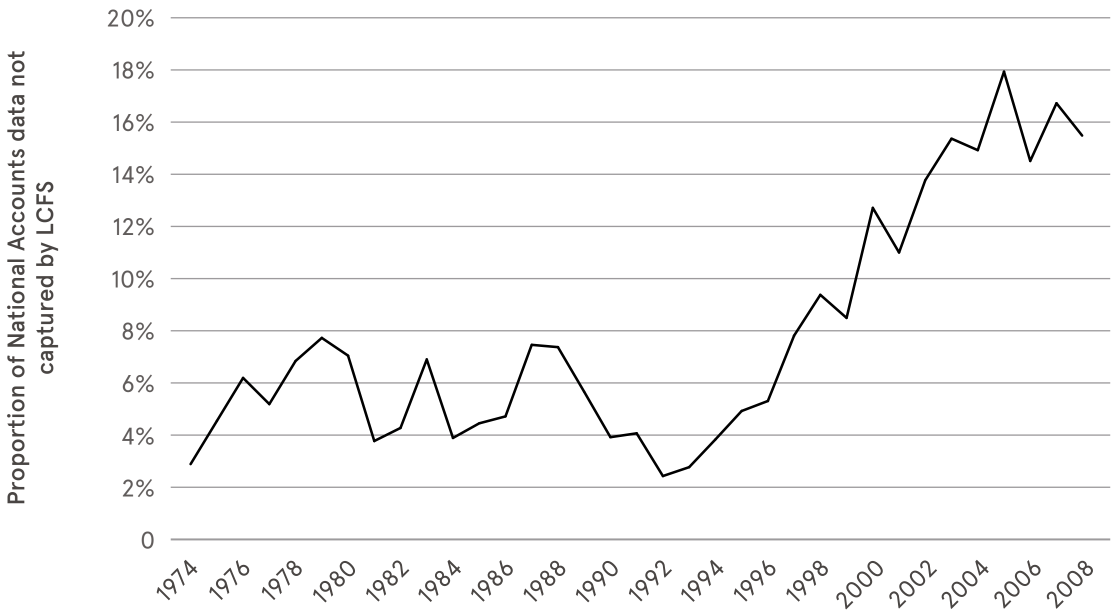
Figure 17 **Calories reported in Living Costs and Food Survey compared with DLW-corrected estimates**



Studies of National Accounts data also show an increase in under-reporting

We do not have to rely on Doubly Labelled Water studies alone. Another way to estimate changes in under-reporting over time is to compare the financial expenditure data collected in the LCFS with national accounts data.* Analysis by Barrett et al[34] looks at the proportion of expenditure seen in the national accounts that is covered by the LCFS. Figure 18 shows that, from the early 1990s, there is evidence of a substantial decline in the coverage provided by the LCFS, which suggests that it is failing to capture true economic activity.

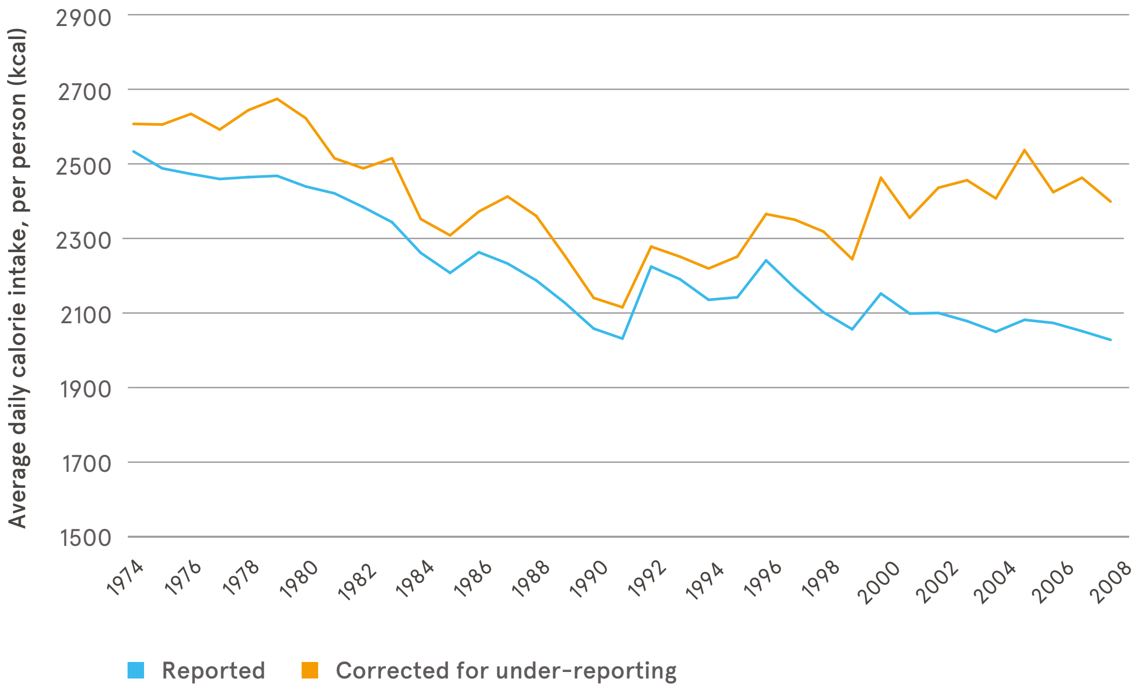
Figure 18 **Missing coverage from Living Costs and Food Survey data, compared to National Accounts data**



We can use Barrett et al.'s analysis to estimate a more realistic calorie consumption by correcting for the inferred under-reporting. (We assume that the missing items are of average calorie content.) As Figure 19 shows, accounting for this under-reporting reverses the reported decline in calorie consumption.[35] Indeed, correcting for under-reporting suggests that calories consumed in the home have actually been increasing since the 1990s, and the decline since 1974 is a lot smaller than previously stated - around 200kcal per day compared to around 400kcal.

*The national accounts are records that bring together data from many sources to measure economic transactions between 'units' (e.g. households or companies). These transactions include government expenditure, interest payments, capital expenditure, and a company issuing shares. The national accounts give a picture of the UK economy as a whole. We derived statistics such as GDP from the national accounts. More details are available at: http://www.ons.gov.uk/ons/guide-method/method-quality/specific/economy/national-accounts/a-guide-to-national-accounts/index.html.

Figure 19 Living Costs and Food Survey for calories in the home, corrected and uncorrected for under-reporting



We can identify at least five reasons why under-reporting may have increased

What could be causing this increase in under-reporting? We propose that several factors associated with increased under-reporting have increased over time. These include:

1. Increasing levels of obesity
2. Increased awareness of overweight, dieting and the desire to lose weight
3. An increase in snacking and food eaten outside the home
4. Falling survey response rates
5. A growing discrepancy between reference data (used to calculate calories) and true portion sizes or food energy density

We also note that decreasing food waste means that people may be consuming a larger proportion of the food they reporting purchasing.

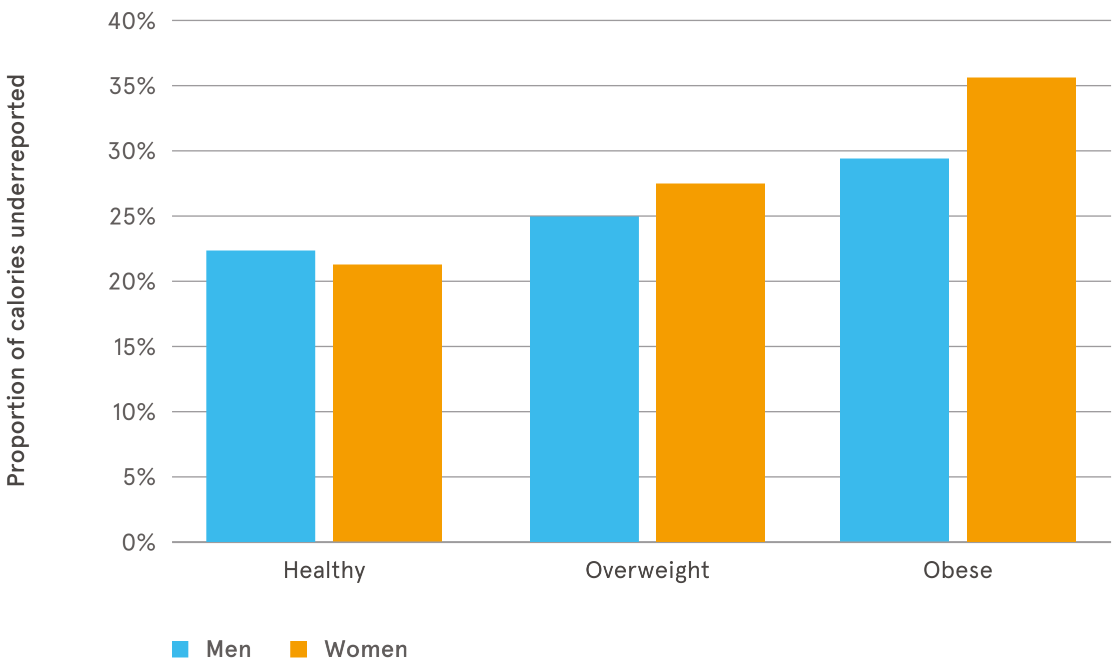
Although not individually conclusive, taken together these factors point towards a serious increase in under-reporting.

1. Increasing levels of obesity

The proportion of the population classified as obese has increased by ten percentage points since 1993. Obese people are likely to have higher levels of under-reporting than individuals of a normal weight. Based on 2000 NDNS data, Rennie et al. find that under-reporting is significantly higher in overweight and obese individuals, and that these effects are particularly pronounced for women (see Figure 20).[36] Using US data, Archer et al. represent these differences in terms of estimated under-reporting of calories, and also show changes between 2001 and 2010 (see Figure 21).[37]

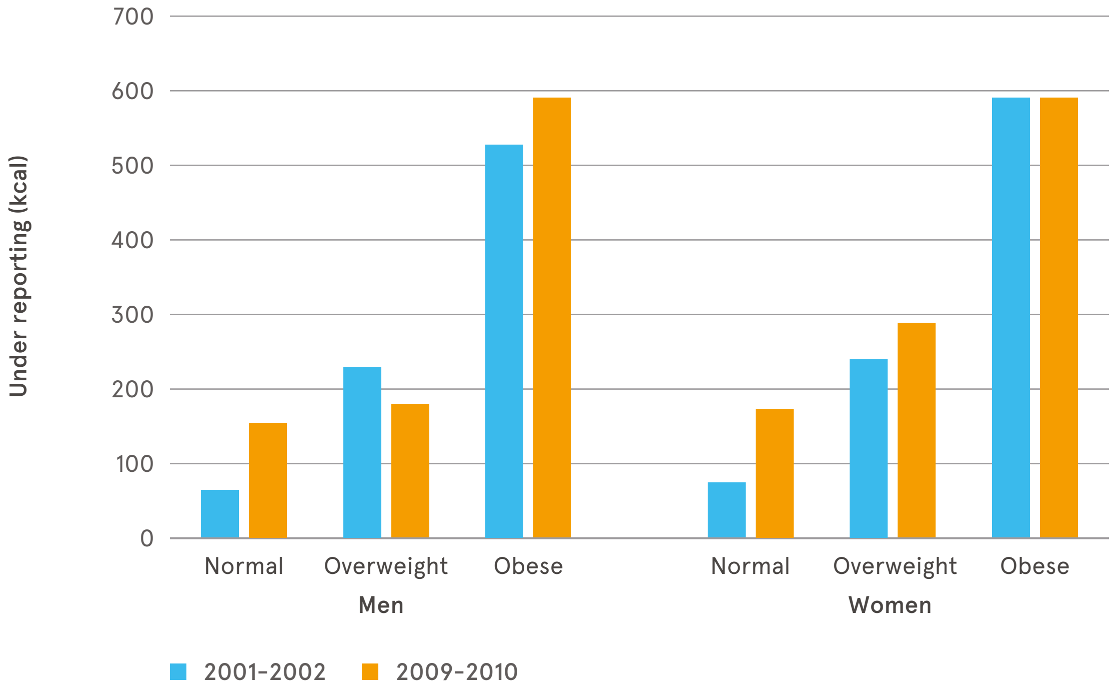
The relationship between weight and under-reporting is found in several other studies.[38] This suggests that average under-reporting should increase with rising levels of obesity. However, many different factors could be driving this relationship: for example, obese respondents could feel greater embarrassment at reporting accurately; they could become objectively worse at estimating intake, all things being equal; or they may simply find it more difficult to record accurately because they are eating more. Studies by Wansink and Chandon support the last reason. They find that the greater under-estimation of calories by overweight people results from their tendency to *eat larger meals*, rather than their ability to estimate the calories in their meals. In other words, inaccurate reporting is related to meal size, not body size.[39] [40]

Figure 20 **Levels of calorie under-reporting by BMI category and gender, UK data**



Source: Rennie, K. L., Coward, A., & Jebb, S. A. (2007) Estimating under-reporting of energy intake in dietary surveys using an individualised method. British Journal of Nutrition, 97(06), 1169-1176.

Figure 21 Levels of calorie under-reporting by gender and BMI category, US data



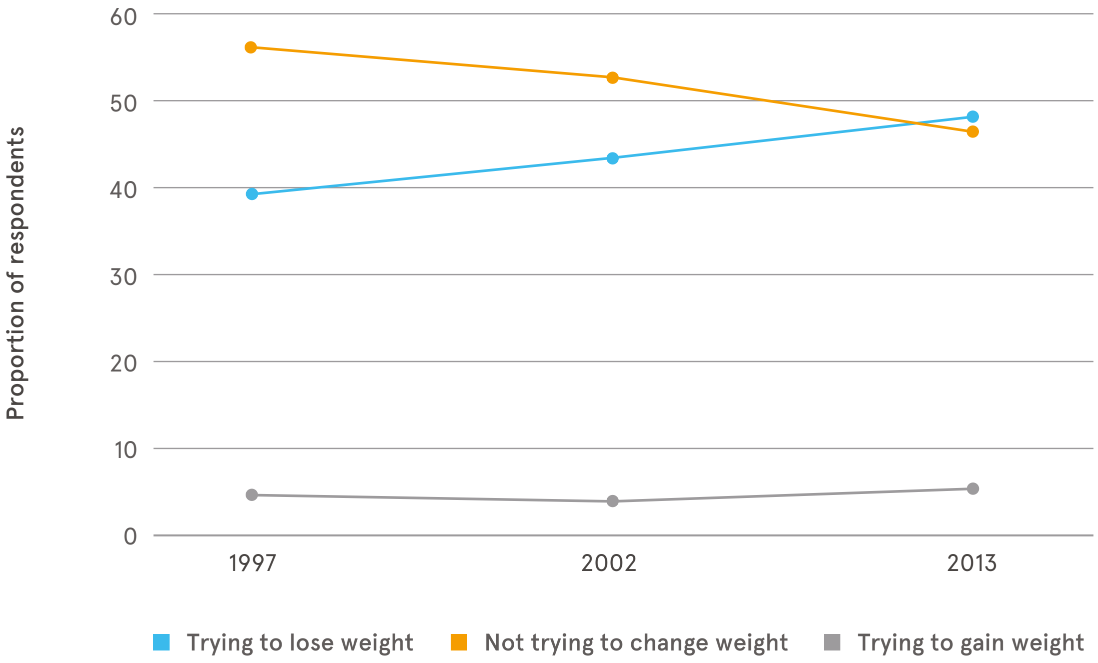
Source: Archer et al. 2013.

2. Increased awareness of overweight, dieting and the desire to lose weight

It's not just people's measured bodyweight that increases under-reporting. A person is also more likely to under-report if they *desire* to lose weight. Johansson et al. found a higher proportion of dramatic under-reporting in people who desired to lose weight across both healthy and overweight participants. If a person desired to lose weight, they were about 10 percentage points more likely to dramatically under-report their calorie intake.[41] It is plausible that this effect is a form of 'self-serving bias': the desire to interpret information to help maintain a positive self-image.[42]

As public health messaging around obesity has intensified over the years, it may be that more people now desire to lose weight. Obtaining data on this issue over multiple years is difficult, but the Health Survey for England in 1997, 2002 and 2013 did include a question on whether respondents were trying to lose weight. As Figure 22 shows, these data suggest that people are increasingly likely to say that they are trying to lose weight. Similarly, the market intelligence agency Mintel has provided figures that 44 per cent of men tried to lose weight in 2013, up from 24.8 per cent in 2003.[43]

Figure 22 Proportion of respondents saying that they are trying to lose weight, gain weight, or remain the same weight

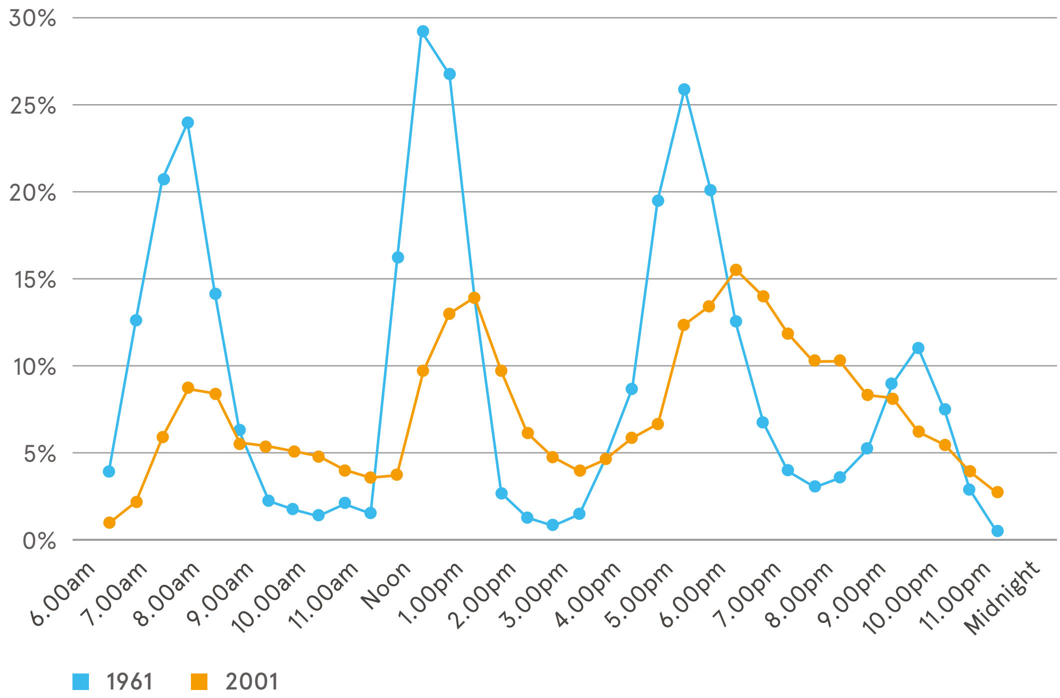


Source: Health Survey for England 1997, 2002, 2013.

3. An increase in snacking and food eaten outside the home

Evidence from the US shows that snacking has increased 'markedly' between the 1970s and the 2000s, for both adults and children, in terms of prevalence in the population, number of snacking events, and contribution of snacks to overall energy intake.[44] Evidence on the move away from a routine of three meals a day suggests that similar changes have occurred in the UK (see Figure 23).[45] Snacking now constitutes a $374bn worldwide industry.[46]

Figure 23 Proportion of eating or drinking, in or out of home, by time of day, all days



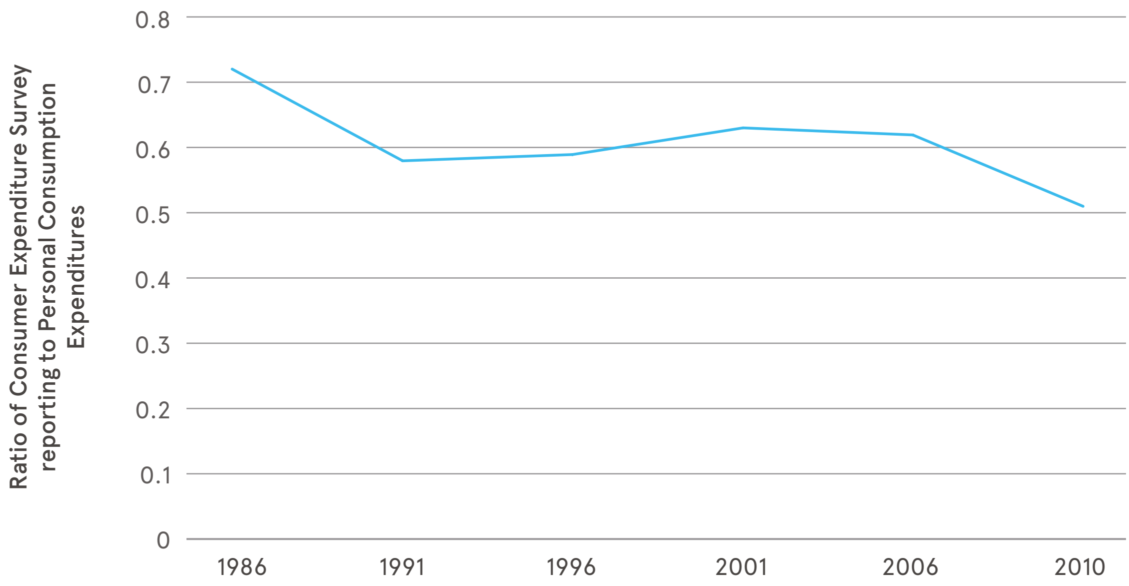
Source: Cabinet Office (2008) Food: An analysis of the issues. Citing research by the Future Foundation.

We propose that an increase in snacking is likely to make food consumption more difficult to track (not least because it increases the overall number of purchases), and therefore increase under-reporting. There is experimental work to support this assertion. Various studies have shown that we are less likely to remember eating food if it is easily accessible and eaten during other activities. For example, one study either placed sweets within reach in a transparent container (thus requiring no effort to bring them to mind and obtain them) or out of reach in an opaque container (thus requiring effort to remember their existence and access them). People were more likely to under-report how many they ate in the former condition: in other words, under-reporting increased when eating did not require conscious effort and attentive action.[47]

We are also eating out of the home than we used to: in fact, the amount of time spent on eating out doubled between 1975 and 2000.[48] A recent report from Public Health England states that around 18 per cent of meals were eaten out of the home during the year ending March 2015, which was a 5 per cent increase on the previous year. Additionally, 75 per cent of people reported eating out or buying takeaway food in 2014 compared to 68 per cent in 2010.[49] A systematic review shows that eating out of the home is associated with higher total energy intake; evidence from the US suggests that people dining out consume 200 more calories per day than when eating at home.[50 51]

Similarly, we propose that eating out increases the difficulty of describing exactly what was eaten. Convenience food items are less likely to be reported in expenditure surveys - like the Living Costs and Food Survey - because separate receipts would have to be kept (if a receipt is obtainable in the first place). Bee et al. present evidence that supports this argument. They also compare survey data with national accounts, this time for US data. They conclude that food consumed away from home is one of the categories that is particularly 'poorly reported' and its accuracy has declined since the 1980s (see Figure 24). The ratio of diary reporting to national accounts now stands at 0.5 – i.e. the reporting may only be capturing half the true expenditure.[52]

Figure 24 **Food away from home: coverage of Consumer Expenditure diary reports compared to US national accounts data**



Source: Bee, A., Meyer, B. D., & Sullivan, J. X. (2012) The Validity of Consumption Data: Are the Consumer Expenditure Interview and Diary Surveys Informative? National Bureau of Economic Research no. w18308. Appendix Table 2.

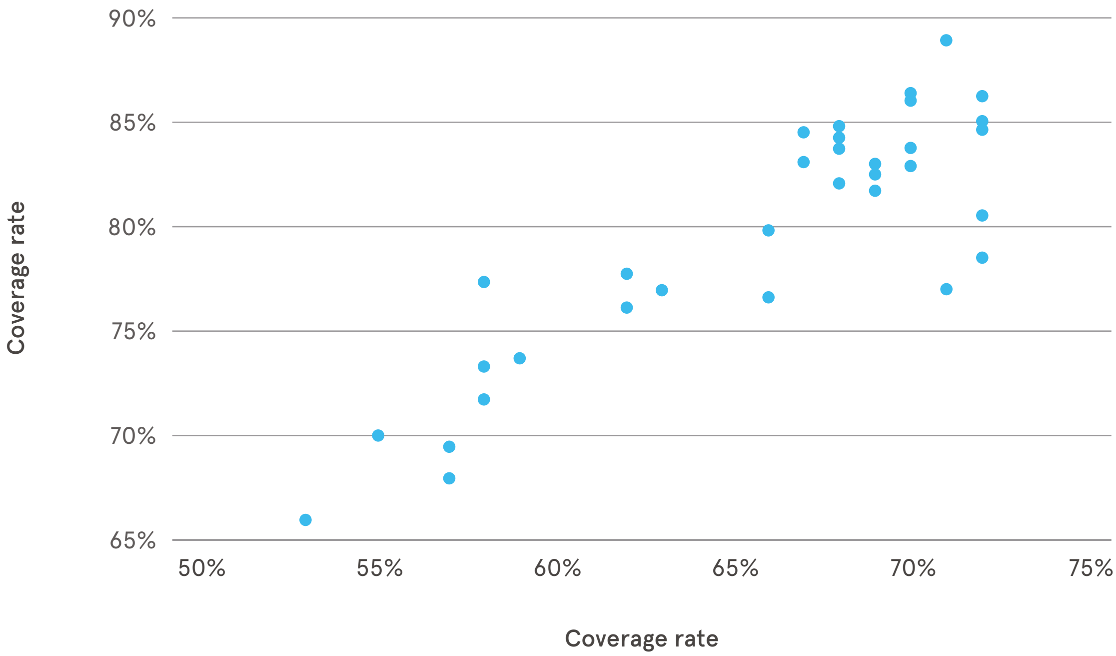
4. Falling survey response rates

The problems with recording food consumed outside the home are a specific example of broader, growing problems affecting surveys like the NDNS and LCFS. The most obvious one is that response rates are low and getting lower, as noted in Professor Charles Bean's independent review of economic statistics.[53] Barrett et al. show that response rates for the LCFS have fallen from over 70 per cent in 1975 to 50.4 per cent in 2009.[54] This decline is mirrored across many other countries and other surveys, leading one recent paper to claim that household surveys are 'in crisis'.[55]

There are two main problems associated with the declining engagement with surveys. The first concerns representativeness. Surveys try to represent the population as a whole. If the decline in responses is not distributed evenly across the population, then the survey will become less representative. There is evidence that non-responders are indeed different from those who respond.[56] Although the LCFS tries to correct for this non-response bias, it can only do so on observable characteristics.

The second concerns the quality of the information that is being provided. It could be that the same changes that lead some to not respond lead others to respond but provide worse quality data. For example, Bee et al. find 'a high and increasing fraction of respondents reporting zero for all categories' for US data: 11.9 per cent of 2010 diary respondents reported no spending for a whole week, compare to 4.5 per cent in 1991.[57] Barrett et al. find a strong correlation between declining response rates on the one hand and declining survey accuracy (compared to national accounts data) on the other (see Figure 25, below).[58] Of course, this is only a correlation: a third factor could be accounting for both declining coverage and falling response rates over time.

Figure 25 Correlation between LCFS response rates and LCFS coverage against national accounts



Source: Barrett, G., Levell, P., & Milligan, K. (2013) A comparison of micro and macro expenditure measures across countries using differing survey methods. National Bureau of Economic Research (No. w19544).

5. A growing discrepancy between reference data (used to calculate calories) and true portion sizes or food energy density

Work by the British Heart Foundation suggests that, for many products, the reference datasets used to calculate the calories of food items result in serious under-estimates. This is due to portion sizes increasing over time and the reference data not keeping up. Some examples are that individual chicken pies are now 40 per cent larger than in 1993, and individual chicken curry meals are 54 per cent larger.[59] In this case, people may be accurately reporting purchasing one chicken pie, but the calories attributed to it may be too low. This discrepancy is likely to have increased with the growth of eating out of the home, since it may be more difficult to keep records for this kind of food up to date.

Finally, it is important to consider trends in food waste when dealing with Living Costs and Food Survey data. If food waste is declining, then people will be consuming a larger proportion of the food they report purchasing. The LCFS has been using a waste estimate of 10 per cent for household food (based on a 1998 report), with no allowance for wastage of food eaten out.[60]

A report from 2012 estimated that household food waste had declined by 21 per cent over the five year period from 2007 to 2012 (saving consumers nearly £13 billion).[61] This decline was from quite a high level of food waste – in 2012, even after the decline, UK households were still making avoidable food and drink disposals totalling 4.2 million tonnes a year (equivalent to six meals every week for the average UK household). The latest *Food Statistics Pocketbook* represents this as 'a steady decrease in the total amount of food waste generated' since 2007.[62]

Limitations of this study

Our purpose in this study is to stress test arguments that calorie intake and/or physical activity levels have declined dramatically in recent decades. Therefore, we do not attempt to make precise calculations about exactly what has happened to our eating and exercise over time. It is perfectly possible to conduct more sophisticated analyses along the same lines, and we welcome attempts from others to do so.

We want to highlight the following issues:

- We use population average data in our calculations. We believe this average is suitable for our purposes, since we are concerned with the broad picture (and there has been weight gain across the population). However, we understand that this makes our conclusions less nuanced.
- People may change their consumption and/or energy expenditure when they know that either or both of these things are being measured, whether through surveys or measures like Doubly Labelled Water.
- Our analysis is only as accurate as the equations we are using. Notably the BMR equation does not take into account any difference in body composition (e.g. muscle vs fat).
- Office work may have become less strenuous in smaller ways (we might have to walk around less with email and so on). These kind of changes are not covered in the labour data we use - but their effect is likely to be very small.
- DLW only provides an estimate of energy expenditure and we cannot say where the under-reporting comes from exactly. Therefore it would be inappropriate to use the overall under-reporting figures for any specific nutrient group such as sugar or protein.
- We only have a limited number of data points from DLW studies to establish a trend in under-reporting over time. There are likely to be differences in methodology between these studies (although we are confident these are the most relevant studies available).
- We have not considered how the type of food consumed has changed – in other words, we have treated all calories as having the same impact on weight.
- Some experts have stated other reasons for increased weight gain – for example, antibiotics, antidepressants, hormones in water, plastics and so on. We do not consider any of these factors.

We do not believe that these limitations undermine the core conclusions in this document.

Conclusions

The absolute levels of calorie consumption reported in surveys are too low. We know this because they could not support our current weight. Studies using Doubly Labelled Water, the gold standard for measuring energy expenditure, also suggest that calories are being burnt at a much higher level than shown in official statistics.

Reductions in physical activity do not provide a realistic explanation for the change in weight. The estimates of the required decrease in physical activity to offset the recorded decline in calories, while also producing the observed weight gain, are implausibly large. Strenuousness of work decreasing over time also does not account for this imbalance.

Under-reporting of calorie consumption in surveys has increased over time. This has happened for a variety of reasons, including increasing obesity and falling survey response rates. Factoring in under-reporting using data from DLW studies produces figures that are similar to the reported reduction in calorie levels. If we accept the magnitude of under-reporting has increased over time, we are left with a much smaller energy imbalance to explain, which no longer requires unrealistic reductions in physical activity from the 1980s.

The two main implications of this finding are a) calorie consumption has not significantly decreased over time; b) the increase in under-reporting is sufficiently large that it could explain the entire reported decrease in calories.

Policy recommendations

Our conclusion is that policies to reduce calorie consumption have an important part to play in an obesity strategy. Although attempts to increasing physical activity should be part of the policy mix, they should not act as a distraction from the central importance of reducing calorie consumption.

We also need to revisit our methods for creating official statistics on calories. It could be possible, for example, to recalibrate current measures using estimates of under-reporting, as set out in this paper. We should also make wider use of DLW measures, in order to get more sophisticated estimates of under-reporting.

Reassuringly, the Government Statistical Service has responded positively to the concerns raised in this report. Below we give their response to the points we have made.

A GSS perspective on official estimates of calorie consumption

Understanding calorie intake is central to developing policies to tackle obesity. Whilst official statistics on diet and nutrition are based on best practice data collection methods, it has long been recognised that under-reporting in dietary surveys means that official estimates of calorie consumption are likely to be underestimates.

The approach to collecting data on food purchases and consumption is reviewed regularly, as are the methods used to translate this information into estimates of energy (calorie) and nutrient intake. New technologies such as web-scraping or using smart phones to record diet have the potential to deliver significant improvements. These are being considered but are not ready to be introduced in the near future.

However there are a range of data sources that could help improve our understanding of calorie intake. These include:

- Store scanner data
- Supermarket product information (which could be obtained via web scraping) linked to electronic receipts
- Information on food wastage
- Studies using Doubly Labelled Water or other biomarkers of energy and nutrient intake

Bringing these and other sources together would help our understanding of under-reporting and could improve the quality of official statistics. A cross-department team is being established to analyse these sources of information and how they relate to each other. We will publish plans for this work shortly.

Annex

What energy imbalance is required to produce the observed weight gain?

In Section One, we estimated the amount of energy we have to be taking in to sustain our current weight, assuming that we are doing the lowest plausible level of physical activity. This established that we must be consuming more calories than official survey data state. At a population level, we know that we must be taking in more calories than we are expending, since we are gaining weight.

We now estimate what energy imbalance would have been required to produce the observed weight gain. First we estimate the change over the past decades in the energy we require to sustain our weight – our 'energy requirement'. In other words: as our weight increases, we need more energy to sustain that weight.

Here we look at the change over a 20 year period from 1993 to 2013, as this is the time period for which Health Survey for England data are available for adult height, weight and age. The table below shows average BMR and Minimum Energy Requirement estimates for 1993 and 2013. This estimate assumes a constant sedentary physical activity level (PAL) of 1.55 at the population level over time.

	Basal Metabolic Rate (kcal)		Minimum Energy Requirement (kcal)	
	1993	2013	1993	2013
Men	1704	1777	2641	2754
Women	1341	1379	2079	2137
Average	1523	1578	2360	2446

The two most relevant cells in the table are highlighted in grey. These calculations show that we require around an additional 86kcal per day to sustain our current weight than we did in 1993, when we were 5.1kg lighter. To clarify, 86kcal is the rise from a daily Energy Requirement of 2360kcal in 1993 to one of 2446kcal in 2013.

As weight gain generally occurs slowly over a long period of time, an initial* energy excess of 86kcal would cause the observed weight gain.[63] Interestingly, this is similar to the 100kcal energy imbalance identified as problematic by the Calorie Reduction Expert Group.[64]

Notably this 86kcal is likely to be an underestimate because the calorie intake required to gain weight to a certain level is greater than the calories required to sustain it (assuming constant levels of physical activity).[65] Furthermore, if our physical activity level is higher than the minimum the difference in Energy Requirements would increase.

*That is to say: an increase in consumption of 86kcal assuming constant PAL. We say 'initial' as it would only be this large an excess in 1993 when weight was lowest; as weight increased, so would Energy Requirements, and the imbalance would gradually become smaller until it was just enough to sustain the 2013 weight levels.

Energy expended at work

Females	METs	Energy Expended (kcal)	Average weight (kg)	Adjusted energy expended (kcal)
1980-84	2.3	1196	na	na
1985-89	2.29	1191	na	na
1990-94	2.22	1154	66.6	1183
1995-99	2.2	1144	67.8	1193
2000-04	2.17	1128	69.4	1205
2005-08	2.16	1123	70.2	1213
Males				
1980-84	2.53	1417	na	na
1985-89	2.49	1394	na	na
1990-94	2.43	1361	72	1400
1995-99	2.4	1344	73.7	1415
2000-04	2.37	1327	75.4	1430
2005-08	2.35	1316	76.7	1442

Data taken from Griffith, Lluberas and Luhrmann (2016), Table 5.2, column 3.

Influence of activities on Physical Activity Levels

Activity	METs[a]	PAR[b] (kcal)	∆PAL/10 min	kJ(kcal)/10min		∆PAL/h	kJ(kcal)/10min	
				woman	man		woman	man
Walking (2mph)	2.5	2.9	0.013	71(17)	91(22)	0.08	436(104)	559(134)
Walking (3mph)	3.3	3.9	0.02	109(26)	140(33)	0.12	654(157)	839(201)
Walking (4mph)	4.5	5.3	0.03	164(39)	210(50)	0.18	981(235)	1258(301)
Tennis (doubles)	5	5.9	0.034	185(44)	238(57)	0.2	1091(261)	1398(335)
Dancing	6	7.1	0.042	229(55)	294(70)	0.25	1363(326)	1748(418)
Roller skating	6.5	7.7	0.046	251(60)	322(77)	0.28	1527(365)	1957(469)
Swimming	7	8.2	0.05	273(65)	350(84)	0.3	1636(392)	2097(502)
Walking (5mph)	8	9.4	0.059	316(76)	405(97)	0.35	1908(457)	2447(586)
Jogging (5mph)	10	12	0.08	436(104)	559(134)	0.46	2508(600)	3216(770)
Rope skipping	12	14.1	0.091	496(119)	636(152)	0.55	2999(718)	3845(920)
Squash	12	14.1	0.091	496(119)	636(152)	0.55	2999(718)	3845(920)

Source: Scientific Advisory Committee on Nutrition (2011) Dietary Reference Values for Energy.

Endnotes

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